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The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

Water Monitoring System Upgrade Plan

(Volume 1 - Upgrade Plan)

Science Applications International Corp.
Monitoring Network Working Group

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Table of Contents

Section — Page

List of Acronyms iii

1.0 Introduction 1

1.1 Overview 1
1.2 Water Monitoring System Program 2
1.3 Objectives of Upgrade Plan 3

2.0 Strategy and Technical Details for Water Monitoring System Upgrade Plan 4

2.1 Water Quality Sampling Procedures 5
2.2 Water Resources Measurement Procedures 7
2.3 Quality Assurance/Quality Control Procedures 8
2.4 Data Management Procedures 10
2.5 Surface Water Monitoring Programs for Zarqa River Basin 10
2.6 Ground Water Monitoring Programs for Amman-Wadi Sir (B2/A7) Aquifer in the Zarqa River Basin 11
2.7 General Database Management Practices for the Water Monitoring System 13

3.0 Recommendations 19

4.0 References 22

Table of Contents

Section

Appendices

A Volume 2 - Water Monitoring System Procedures
B Volume 3 - Zarqa River Basin Surface Water Quality Monitoring Program
C Volume 4 - Zarqa River Basin Surface Water Measurement Monitoring Program
D Volume 5 - Amman-Wadi Sir (B2/A7) Aquifer Water Quality Monitoring Program (for Amman-Zarqa Basin)
E Volume 6 - Amman-Wadi Sir (B2/A7) Aquifer Water Level Monitoring Program (for Amman-Zarqa Basin)

List of Acronyms

BGR	Deutsche Bundesanstalt fur Geowissenschaften und Rohstoffe
DQO	Data Quality Objectives
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
JVA	Jordan Valley Authority
KAC	King Abdullah Canal
KFW	Kreditanstalt fur Wiederaufbau
KTR	King Talal Reservoir
MIS	Management Information System
MMRA	Ministry of Municipal and Rural Affairs
MNOS	Monitoring Network Objectives Statement
MNSD	Monitoring Network Survey Document
MNWG	Monitoring Network Working Group
Ministry	Ministry of Water and Irrigation
MWI	Ministry of Water and Irrigation - Secretary General Organization
ODA	Overseas Development Agency
RSCN	Royal Society for the Conservation of Nature
RSS	Royal Scientific Society
SCP	Société du Canal de Provence et d'Arménagement de la Région Provençale
THM	Trihalomethanes
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USGS	United States Geological Survey
WAJ	Water Authority of Jordan
WERSC	Water and Environment Research and Study Center
WHO	World Health Organization
WQIC	Water Quality Improvement Project
WWTP	Wastewater Treatment Plant

1.0 Introduction

Optimal development and utilization of water resources in Jordan and the institution of associated water policy requires the establishment and implementation of several integrated resources, information, and management systems. The Ministry of Water and Irrigation (Ministry) is responsible at the national level for administering water policy and managing water resources. The Water Quality Improvement and Conservation (WQIC) Project provides a basis for addressing serious problems and issues identified in the Kingdom's national water management program relative to improving water quality and water conservation.

1.1 Overview

The WQIC Project developed as a result of the national water management program conducted during 1992. The initial work performed under the WQIC Project will provide a framework for the foundations of a comprehensive water management system, including water quality improvement and conservation, in Jordan. A national water monitoring system for collecting surface and ground water resources and quality data and information is a major component of the WQIC Project. Although the focus of the WQIC Project activities is the Zarqa River basin, the project goals are of national importance and the project will promote a national policy for water resources and water quality improvement and conservation.

In 1994 following initiation of the WQIC Project, a working group composed of representatives of the Ministry and WQIC Project Team was created to develop long-term and short-term objectives for the national water monitoring system. These initial objectives were formalized in the Monitoring Network Objectives Statement (MNOS) (MWI, 1994). The primary objective of the water monitoring system is to enhance the national water monitoring network program so it meets the needs and objectives of the Ministry. The objectives address water resources, water quality, data collection, data management, and organizational factors which are important in a functional water monitoring network system.

Subsequently, a detailed survey of water monitoring programs in Jordan was completed. Although the survey focused on the various water monitoring programs administered by the Ministry, the survey also attempted to identify other governmental organizations engaged in water monitoring and to obtain specific information about these monitoring programs. The findings of the survey were presented in the Monitoring Network Survey Document (MNSD) (MWI, 1994a).

In 1995 the water monitoring system adequacy evaluation was completed (MWI, 1995). The objective of the adequacy evaluation was to provide a detailed assessment of the existing water monitoring system programs within the Ministry. The adequacy evaluation critically assessed the specific details of each monitoring program and identified the changes needed to upgrade each program to current standards. These changes included relocation of water monitoring stations, addition of new monitoring stations, improvement of instrumentation for measuring water parameters or for collecting water samples, upgrading procedures for measuring water parameters, collecting samples, or for management of water related data, or modifying the frequency of data collection or the types of data obtained (particularly water quality data).

1.2 Water Monitoring System Program

The changes and modifications for upgrading the water monitoring system presented in the water monitoring system adequacy report (MWI, 1995) were prioritized for implementation. Priorities have been established for procuring and installing equipment by surface water basin and by subareas for ground water aquifers. In addition, several generic recommendations for establishing a unified water monitoring system program and for developing uniform and consistent monitoring techniques and protocols were specified.

Detailed development of the modifications and upgrades are to be presented in the Water Monitoring System Upgrade Plan which is outlined in this document. The focus of the Upgrade Plan is on the Zarqa River Basin (or Amman-Zarqa Basin) for surface water systems and on the portion of the Amman-Wadi Sir (B2/A7) aquifer which lies within the Zarqa River Basin. Following the water monitoring program model developed specifically for the Zarqa River Basin and the B2/A7 aquifer within the basin, the Long-Term Water Monitoring System Plan will address development of water monitoring programs for other

surface water basins and ground water aquifers in Jordan. The Long-Term Water Monitoring System Plan will be developed later in the WQIC Project after completion of the Upgrade Plan.

1.3 Objectives of Upgrade Plan

The objectives of the Water Monitoring System Upgrade Plan (WMSUP) are to present the technical details and specifications for standard data collection procedures, quality assurance/quality control procedures, and data management procedures to be followed by the water monitoring system program within the Ministry. The WMSUP also presents the detailed monitoring program plans for surface water resources and quality monitoring for the Zarqa River Basin. In addition, the WMSUP presents the detailed monitoring program plans for ground water resources and quality monitoring for that portion of the B2/A7 aquifer located within the Zarqa River Basin.

Section 2.0 presents the strategy and details for developing the WMSUP including detailed technical procedures and specific program plans for the Zarqa River Basin. Section 3.0 presents recommendations for developing the Long-Term Water Monitoring System Plan. Section 4.0 presents a list of references and resources used to prepare the WMSUP. The full details of the technical procedures and the Zarqa River Basin monitoring program plans are included as separate volume appendices to the WMSUP.

2.0 Strategy and Technical Details for Water Monitoring System Upgrade Plan

The Monitoring Network Survey Document (MNSD) (MWI. 1994a) and Water Monitoring System Adequacy Report (WMSAR) (MWI. 1995) present detailed evaluations of the existing water monitoring programs at the Ministry. The Water Monitoring System Upgrade Plan (WMSUP) is based on the recommendations presented in these documents. In addition, the WMSAR presents detailed recommendations for expanding the various monitoring programs as part of the Upgrade Plan and Long-Term Plan. These recommendations include specific monitoring stations for the various surface water basins and general well locations for the ground water aquifers.

Specific activities completed as part of the scope of work for preparing the Upgrade Plan included:

(1) Developing detailed procedures for collecting water quality samples
(2) Developing basic procedures applicable to Jordan's surface and ground water resources monitoring programs
(3) Developing procedures for maintaining quality assurance and quality control during sample collection and data measurement
(4) Developing procedures for data management associated with field collection of data
(5) Developing the surface water quality monitoring program plan for the Zarqa River Basin
(6) Developing the surface water resources monitoring program plan for the Zarqa River Basin
(7) Developing the ground water quality monitoring program plan for the B2/A7 aquifer within the Zarqa River Basin
(8) Developing the ground water potentiometric level monitoring program plan for the B2/A7 aquifer within the Zarqa River Basin
(9) Developing generic database management procedures for water monitoring system data collected by the Ministry's water monitoring programs

The scope of work for each of these activities is discussed in Section 2.0. The specific details of each of these activities is presented in Section 3.0.

2.1 Water Quality Sampling Procedures

Basic water quality monitoring activities in Jordan are conducted for surface waters (primarily wadis and some reservoirs) including spring discharges and ground waters. Associated with these activities are related but independent monitoring programs for drinking water distribution systems and wastewater treatment plant influent and effluent. Sampling procedures for each of these types of water quality monitoring activities were developed. The procedures include programmatic field sampling and handling techniques and media specific techniques. The detailed water quality sampling procedures are presented in Appendix A, Volume 2 of this report.

The water quality monitoring procedures are patterned on United States Environmental Protection Agency (USEPA) requirements for conducting water quality monitoring work under USEPA's programs for hazardous waste and abandoned chemical waste sites. These requirements provide state-of-the-art techniques and procedures for ensuring that: water quality data are collected using consistent and documented methods; properly calibrated and maintained field equipment are used for collecting data; samples are handled and transported to minimize potential contamination or deterioration of samples; and, samples follow documented chain-of-custody procedures to maintain sample integrity.

Surface Water Quality Sampling Procedures

Surface water sampling procedures primarily relate to the collection of grab samples. This also is the current, preferred technique for collecting surface water samples. This technique is appropriate considering the typical hydrologic characteristics of most surface water systems in Jordan. For reservoirs, depth specific sampling techniques using variable depth samplers (e.g., Kemmerer) have been developed.

Sampling procedures using automatic, composite samplers also have been developed and again are based USEPA recommendations and manufacturer procedures. Composite samplers can be used to collect water quality samples from a water source on a preselected schedule. These samples then can be analyzed to provide an understanding of the water quality characteristics or changes for a source over the course of a day. While they typically are used for wastewater monitoring, they can be used for routine monitoring of flowing surface water systems or with modification of production wells.

Ground Water Quality Sampling Procedures

For ground water aquifers, the sampling techniques are based primarily on use of production wells for collecting samples. This is because the majority of the existing wells in Jordan are large diameter wells with either lengthy screened zones across the aquifer or with open holes across the aquifer. Purging of these wells to obtain representative samples is considered problematic because of the amount of time required to adequately purge the well and the volume of water that would be lost. Consequently, use of operating production wells for sample collection is preferred.

Ground water sampling procedures have been developed for using bailers for collecting water samples from shallow, small diameter monitoring wells. These types of wells may be most suitable for monitoring water quality in some of the shallow alluvial aquifers in Jordan. Lastly, procedures for using packers to collect water quality samples from several hundred meters depth have been developed. Currently, it is unclear if Jordan generally would need to collect samples using packers as part of a routine ground water quality monitoring program. However, these procedures have been developed for completeness.

Drinking Water Quality Sampling Procedures

Typically, grab samples are collected for analysis from the pumping stations and water distribution systems. This is the preferred and appropriate technique for collecting such water samples. Only written procedures for the collection of drinking water samples have been developed. No program specific plans have been developed.

Wastewater Sampling Quality Procedures

Wastewater samples are collected from most of the municipal wastewater treatment plants in Jordan. Typically, grab samples are collected from the influent stream to the plant and from the effluent stream from the plant. Again, this is the preferred and appropriate technique for collecting such samples. Only written procedures for the collection of wastewater samples have been developed. No program specific plans have been proposed or developed.

Wastewater samples also may be collected using automated, composite samplers. Sampling procedures using automatic, composite samplers also have been developed based on USEPA recommendations and manufacturer procedures. Composite samplers can be used to collect

water quality samples from a wastewater source on a preselected schedule. These samples then can be analyzed to provide an understanding of the wastewater quality characteristics or changes for a source over the course of a day. Although the developed procedures apply only to wastewater treatment plant influent and effluent, the procedures can be modified slightly for use at industrial wastewater treatment plants.

2.2 Water Resources Measurement Procedures

Water resources monitoring activities in Jordan are conducted for surface water (wadis and reservoirs) discharges, including spring discharges, and ground waters. Data measurement and monitoring procedures for surface and ground waters were developed. Monitoring activities primarily focus on collection of water level data which then can be applied using hydrologic analytical tools to determine stream and spring discharge and ground water potentiometric surfaces. The procedures include programmatic field measurement techniques. The procedures do not include specialized testing protocols (e.g., aquifer pumping tests) or data reduction and evaluation techniques. The detailed water resources monitoring procedures are presented in Appendix A, Volume 2 of this report.

Water resources monitoring procedures for stream discharge and ground water level measurements are patterned on internationally accepted techniques which have been published in numerous technical manuals. Manuals published by the United States Geological Survey (USGS), United States Environmental Protection Agency (USEPA), and equipment manufacturers were used to develop the specific techniques for Jordan. The procedures provide the techniques and protocols for ensuring that: water resources data are collected using consistent and documented methods; properly calibrated and maintained field equipment are used for collecting data; and consistent data management and documentation is followed for field data collection.

Surface Water Resources Measurement

Surface water resources measurement procedures primarily relate to the collection of water level, water velocity, and cross-sectional areal data. Provided control points and structures (e.g., weirs, flumes) have been properly established and constructed, the water level behind such a structure can be used to calculate discharge from the structure. Water level recorders and staff gages typically are used to record these measurements. Water level

recorders provide a temporal record of water level changes which then can be used for analyses. An extensive network of mechanical surface water level recorders is planned for Jordan. Similarly, provided accurate cross-sectional information is available for a stream section, water velocity data can be used to calculate discharge through that section.

These techniques and others are well documented in the literature. Consequently, the focus of the procedures is to promote collection of consistent water level and water velocity data.

Ground Water Resources Measurement

Ground water resources measurement procedures primarily relate to the collection of water level data. Provided control points (e.g., ground surface elevations, measuring point elevations, and screened intervals of monitoring wells) have been properly established and constructed, the water level in a well can be used to evaluate the regional potentiometric conditions of the ground water aquifer system. Water level recorders, electronic data loggers and pressure transducers, and various types of portable water level measuring devices (e.g.,electronic M-scopes) typically are used to record these measurements. Water level recorders and data loggers provide a temporal record of water level changes which then can be used for analyses. An extensive network of mechanical and electronic ground water level recorders is planned for Jordan.

These techniques and others are well documented in the literature. Consequently, the focus of the procedures is to promote collection of consistent water level data.

2.3 Quality Assurance/Quality Control Procedures

Quality assurance (QA) and quality control (QC) procedures and protocols relate to the processes used to collect water data and samples to ensure that the resulting analytical data are scientifically valid, representative of natural conditions at a monitoring station site, defensible, and of known acceptable accuracy.

The QA/QC procedures provide instruction and guidance for data-gathering activities likely to be performed for water monitoring. The QA elements outline the system whereby the water monitoring organization will provide assurance, through planning, selection of appropriate data quality objectives, and proper record keeping and data management that

monitoring of water-related activities has occurred. The QC elements present instructions and procedures to be followed in order to ensure consistency of data gathered. Specific QA/QC requirements, based on this guidance and instruction, must be developed for each separate water monitoring program established in Jordan.

The QA/QC policies and procedures primarily are based on those described in the following sources:

- American Society of Testing Materials (ASTM). 1987. Annual Book of ASTM Standards, Section 4, v. 4.08.
- United States Environmental Protection Agency (USEPA), Region IV. 1991. Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.
- USEPA. 1988. Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9355.3-01.
- USEPA. 1987. RCRA Facility Investigation (RFI) Guidance, Volume I-IV, EPA 530/SW-87 001. Washington, D.C.
- USEPA. 1986. Characterization of Hazardous Waste Sites, A Methods Manual, Volume II-Available Sampling Methods (2nd ed.): EPA 600/4-84-076. Washington, D.C.
- United States Geological Survey. 1992. Guidelines for Preparing a Quality Assurance Plan for District Offices of the U.S. Geological Survey. Open-File Report 92-136. Denver, Colorado.

The QA/QC procedures primarily are patterned on USEPA requirements for conducting water quality monitoring work under USEPA's programs for hazardous waste and abandoned chemical waste sites. These requirements provide state-of-the-art techniques and procedures for ensuring that: water data are collected using consistent and documented methods; properly calibrated and maintained field equipment are used for collecting data; water quality samples are handled and transported to minimize potential contamination or deterioration of samples; and, samples follow documented chain-of-custody procedures to maintain sample integrity.

The detailed QA/QC procedures are presented in Appendix A, Volume 2 of this report.

2.4 Data Management Procedures

Data management procedures provide guidance on data management responsibilities of monitoring personnel and for recording and maintenance of data obtained from the water monitoring programs. The data management procedures outline necessary actions to ensure proper documentation, tracking, and managing of all field and laboratory data generated and identify and establish data documentation materials to be utilized during monitoring activities. Additional data management requirements and procedures may be added for specific water monitoring plans if changes in the scope of activities to be performed necessitate such revisions.

The data management procedures primarily are patterned on USEPA requirements for conducting water quality monitoring work under USEPA's programs for hazardous waste and abandoned chemical waste sites.

The detailed data management procedures are presented in Appendix A, Volume 2 of this report.

2.5 Surface Water Monitoring Programs for Zarqa River Basin

The Zarqa River Basin (or Amman-Zarqa Basin) extends from the Syrian border in northern Jordan to just south of Amman and westward to the Jordan Rift Valley and encompasses approximately 4154 square kilometers (3739 km^2 in Jordan. The basin contains the most heavily and densely populated areas of Jordan as well as major industrialized areas in Jordan. In addition, four major municipal waste water treatment plants (WWTPs) and several large municipal/industrial landfills or waste disposal sites are located in the basin. The King Talal Reservoir, the largest in Jordan, is located on the Zarqa River approximately 15 to 20 kilometers upstream of Deir Alla in the Jordan River Valley.

Surface water in the basin primarily is used for irrigation purposes or flows into the King Talal Reservoir. Water stored in the reservoir is channeled to irrigation projects in the Jordan River Valley. The Al-Samra WWTP contributes substantial, year-round flow to Wadi Dhuleil/Wadi Zarqa and ultimately to the King Talal Reservoir.

The Amman-Zarqa Basin is subjected to numerous potential sources which could impact water quality. These include the various waste water treatment plants in the basin, waste disposal sites and landfills, urbanization and related storm water runoff, industrial operations, irrigation return flows, and animal husbandry operations. In addition, because of general climatic conditions in Jordan, normal flow in the Zarqa River is predominantly influenced by waste water discharges throughout the year and precipitation events during the winter rainy season. Surface waters extracted from the Zarqa River are used almost exclusively for irrigation purposes.

The WMSUP presents the details for the surface water resources and quality monitoring programs for the Zarqa River Basin. Monitoring programs for the basin are required to monitor stream discharges and water quality changes and to provide the data for long-term water resources and water quality improvement planning. By establishing basin-wide monitoring programs, data and information will be obtained to evaluate more specifically the factors most affecting or influencing water resources availability and use and water quality in the basin. These analyses and associated conclusions and recommendations then can form the basis for establishing infrastructure or operational modifications which would contribute to the long-term improvement in water resources and water quality management.

The detailed Zarqa River Basin water quality monitoring program plan is presented in Appendix B (Volume 3) of this report. The detailed Zarqa River Basin water resources monitoring program plan is presented in Appendix C (Volume 4) of this report. These plans discuss: the objectives of the monitoring programs; instrumentation and types of data to be collected by the programs; the uses of the data; specific monitoring stations; frequency of monitoring and sample collection; and data management. These plans are the first of a set of similar documents which will present the details for the surface water monitoring requirements and programs for all surface water basins in Jordan.

2.6 Ground Water Monitoring Programs for Amman-Wadi Sir (B2/A7) Aquifer in the Zarqa River Basin

The Amman-Wadi Sir aquifer is composed of two hydrogeologic units, the B2 (Amman) and the A7 (Wadi Sir) and represents the principal aquifer system in Jordan. The main source of recharge is rainfall in the outcrop areas in the highlands where rainfall is relatively high

(250 to 500 mm/year). In Jordan, the B2/A7 aquifer has been pumped extensively for municipal, agricultural, and industrial purposes throughout its areal extent. The Wadi Sir-Amman (B2/A7) aquifer is used for drinking water as well as for industrial and irrigation purposes. The aquifer is exploited throughout Jordan but is most important in western Jordan and northern and central Jordan. These areas include the heavily populated and industrialized Zarqa River Basin. General information about the Zarqa River Basin is presented in Section 2.5 above.

The WMSUP presents the details for the ground water resources and quality monitoring programs for the B2/A7 aquifer within the Zarqa River Basin. Monitoring programs for the basin are required to monitor declines in the potentiometric surface for the B2/A7 aquifer and water quality changes associated with overpumping, irrigation return flows, potential municipal and industrial waste leachate or discharges to the aquifer, and to provide the data for long-term water resources and water quality improvement planning. A goal of the monitoring programs is to establish representative basin-wide coverage of the B2/A7 aquifer. By establishing the monitoring programs on a basin wide basis, data and information will be obtained to evaluate more specifically the factors most affecting or influencing water resources availability and use and water quality in the B2/A7 aquifer within the Zarqa River Basin. These analyses and associated conclusions and recommendations then can form the basis for establishing infrastructure or operational modifications which would contribute to the long-term improvement in water resources and water quality management.

The detailed ground water quality monitoring program plan for the B2/A7 aquifer in the Zarqa River Basin is presented in Appendix D (Volume 5) of this report. The detailed ground water resources monitoring program plan for the Zarqa River Basin is presented in Appendix E (Volume 6) of this report. These plans discuss: the objectives of the monitoring programs; instrumentation and types of data to be collected by the programs; the uses of the data; specific monitoring stations; frequency of monitoring and sample collection; and data management. These plans are the first of a set of similar documents which will present the details for the ground water monitoring requirements and programs for all ground water aquifers in Jordan.

2.7 General Database Management Practices for the Water Monitoring System

A number of water databases exist within the Ministry. The Water Monitoring System Adequacy Report (MWI, 1995) discusses the issues associated with general water database management practices in the Ministry and specific problems created by the multiple databases. In summary, there is no single formally established, managed, and operated water database system for the Ministry. This is an important issue that must be resolved prior to the successful operation of the upgraded water monitoring system. An additional issue is the validity of the base data or information in the water databases. The upgraded water monitoring system presented in this document can only be effective if the base information in the established databases is accurate.

In the absence of a clearly defined water databases management organization and function, development of detailed database management procedures for the water monitoring system is meaningless. Consequently, the WMSUP does not propose or present specific water databases management protocols. This is a serious limitation of the overall water monitoring system. The long-term success and value of the upgraded water monitoring system will depend on the maintenance and management of the monitoring programs, the operation and maintenance of the laboratory, and the management of the water related databases. However, resolution of the global water databases management function is outside the scope of the WQIC Project. The WMSUP presents general database management practices which would be necessary for a functional, operating, unified water database management system.

Types of Data Obtained from the Water Monitoring System

The water monitoring system programs primarily focus on collection of water quality data and basic water resources data. To some extent the existing UNDP project within the MWI already has attempted to establish the foundation for the water databases for the Ministry. However, for some of these existing databases, expansions or enhancements to the database may be desirable.

Water Resources Data

Basic water resources data will be obtained from the precipitation, evaporation, surface water, springs, and ground water monitoring programs. All databases must include base

data relating, at a minimum, to the location, elevation, name, and identification number, and other important characteristics of the monitoring station. In most cases, the raw data from the field, including strip charts or logger data, must be analyzed to obtain the hydrologic measurement data to be stored in the databases. All measurement data will be associated with time fields. Unless otherwise noted, raw data initially will not be stored in the database but instead will be retained as part of the program and monitoring station files.

For the precipitation monitoring program database, the data fields should include daily precipitation values as well as maximum 15 minute, 30 minute, 60 minute, 2 hour, 3 hour, 6 hour, 12 hour, and 24 hour values. In addition, the precipitation fields should include or be able to be queried for the number of rainy days, accumulative daily rainfall. For totalizers, the precipitation data would represent the period of recording.

For the evaporation monitoring program database, the data fields should include daily evaporation rates as well as associated meteorologic data. Because the meteorologic data vary throughout the day, it may not be possible to obtain a full range of data for a monitoring station particularly if there are no automatic recording devices at the station. To the extent that adequate data are available, minimum and maximum data for various meteorological parameters should be stored in the databases.

For the springs monitoring program database, the data fields should include the instantaneous spring discharge. Because most spring discharge values will be calculated using data collected from area-velocity techniques or portable weirs or flumes, most information in the database will be based on instantaneous measurements. Raw data initially are not planned for storage in the database. Raw data will be stored in the program and monitoring stations files.

For the surface water monitoring program database, the data fields should include the daily mean baseflow and the daily mean and hourly floodflow discharge. Most discharge values will be calculated from strip chart tracings or downloaded data loggers. The analyses of these raw data and the tracings will be stored in the program and monitoring station files. Raw data initially are not planned for storage in the database.

For the ground water monitoring program database, the data fields should include depth to the water surface and the water level referenced to mean sea level. Additional data fields of interest but not specifically related to the monitoring program include numerous fields relating to geologic, lithologic, and hydraulic properties at the monitoring well and aquifer test data. Other fields of interest include well discharge for producing wells.

Water Quality Data

Basic water quality data will be obtained from the surface water, springs, ground water, wastewater, and drinking water quality monitoring programs. All databases must include base data relating, at a minimum, to the location, elevation, name, identification number, and other important characteristics of the monitoring station. The basic type of measurement data for these monitoring programs are water quality parameters (i.e., chemical analyses data for the water quality samples). The water quality data will include general chemical or indicator data, metals data, organics data, nutrient data, and other classes of chemical data depending on the objective of the monitoring program. These parameters generally will be similar to each type of monitoring program and do not require elaboration for each program. All measurement data will be associated with time fields. Unless otherwise noted, raw data will be retained as part of the program and monitoring station files.

General Database Management Practices

Given the basic data and information requirements specified above for the water monitoring systems programs and other data needs necessary to support these requirements, substantial effort still is required to upgrade and enhance the water databases. In addition, detailed operating practices for the water databases are required to ensure proper entry of data and to maintain the integrity of the stored data. Development of detailed operating practices is outside the scope of work for the water monitoring system component. However, the following general ideas should be considered in the development of the water database management practices.

(1) Functionally, management of the water databases should be the responsibility of the water studies and analysis department. This group would work closely with the related monitoring group which is functionally responsible for operating the monitoring program.

(2) As new stations are added to the water monitoring system network, the new stations should be assigned a station identification number consistent with the current nomenclature scheme. This activity should be the responsibility of the water studies and analysis department which also manages the databases.

(3) Raw monitoring data collected by the monitoring function should be delivered to the studies and analysis function for review and evaluation. The studies and analysis function would be responsible for analyzing the data and determining water levels or discharge values based on the raw data and the monitoring methodologies.

(4) The derived data (i.e., calculated values based on the raw field data) then would be technically reviewed and QA checked by senior scientists and engineers in accordance with the procedures established by the studies and analysis function.

(5) Once the technical reviews and QA checks have been completed, the data then could be entered into the computerized water databases. Data entry forms would be completed by the originator of the derived data and reviewed by the senior staff prior to submittal to data entry technicians.

(6) The data entry technicians would enter the data into the water databases. Accurate data entry would be verified by personnel from an independent QA function within the studies and analysis department. Data entry errors should be immediately corrected and documented.

(7) All original (raw) data and derived data would be stored in the program files for the monitoring station. Data entry and QA verification forms would be stored in files maintained by the water database management function.

(8) Analytical data obtained from the laboratory could be handled more simply. In time, it is anticipated that these data could be entered into the water databases by direct data transfer from the laboratory computers. This practice

would improve the efficiency of data entry, but would require close coordination and cooperation between the water database management function and the laboratory.

(9) An administrator for the water databases must be selected. The administrator would have the ultimate authority for management of the database, for establishing data entry procedures, and for accessing and using the data in the databases. Access to the database information should not be restricted. However, the ability to enter data into or to modify data in the database must be closely restricted.

(10) Procedures for modifying data in the databases should be developed and must require the technical documentation to justify changes or corrections of data in the databases.

Required Future Actions

The WMSUP again recommends a project for validating the base information in the water databases. The objectives of this project would be to establish the water databases architecture (information fields), to validate existing base information for each water database, and to define the specific procedures for managing the databases including entry of data and correction of data in the databases. The principal goal of this project would be to establish validated water databases to support the planned long-term water monitoring system and database management system. The project would not include validation of measurement data.

The other required actions include the establishment of a single, unified, water databases management organization. It is extremely important a functioning organization be established and that all parties accept the importance of working according to very strict procedures and protocols because of the expectation for the long-term beneficial use of the databases. The basic procedures and protocols for this organization and management of databases would need to be established. If such procedures or organization are not instituted and followed, then within a short period of time the databases may become of limited value.

Completion of these activities before the merger of existing water databases and the integration of the existing computer systems is recommended and preferred. These activities must be completed before the upgraded water monitoring system is instituted and before the MIS is brought on-line. Otherwise, future water data will suffer from some of the same data management problems existing today.

3.0 Recommendations

Section 2.0 of this document and the associated appendices present detailed procedures and protocols for the water monitoring system programs. Both general monitoring protocols and specific procedures for different types of sampling and monitoring activities have been developed for the water monitoring system programs. In addition, specific water resources and water quality monitoring program plans have been developed for the Zarqa River Basin and for the Amman-Wadi Sir (B2/A7) aquifer located within the Zarqa River Basin. These specific water monitoring program plans will serve as models for similar plans to be developed for other surface water basins and ground water aquifers in Jordan.

The conclusions and associated recommendations developed from the WMSUP will be the foundation for the water monitoring system long-term plan. The upgrade plan responds to the short-term water monitoring system objectives and needs for Jordan. The long-term plan will address the long-term development, effectiveness, and maintenance and operation of the water monitoring system programs for Jordan.

Generic recommendations for proceeding with development of the water monitoring system long-term water monitoring plan are summarized as follows.

General Recommendations

1) Upgrading of the national water monitoring system should be completed in phases based on the conclusions of the adequacy evaluation (MWI, 1995). This is because of personnel, equipment, and financial constraints. The priorities are outlined in the adequacy evaluation report (MWI, 1995).

2) The highest priorities for development of the upgraded water monitoring system included the Zarqa River Basin (surface water) and the B2/A7 aquifer (ground water) within the Zarqa River Basin. These monitoring programs are presented in this document.

   Remaining high priorities to be addressed during subsequent phases of the upgrade plan and early in the long-term monitoring plan process are:

Surface Water Basins	Ground Water Aquifers
· Yarmouk Basin	· B2/A7 Aquifer (all of Jordan)
· Jordan River and Rift Side Wadis Basins	· Alluvium Aquifers
· Dead Sea, Wadi Mujib, and Wadi Hasa Basins	· B4 Aquifer

3) The long-term monitoring plan phase of the WQIC project should address the monitoring programs for the remaining surface water basins and ground water aquifers, the precipitation and evaporation program enhancements and optimization, drinking water program, municipal and industrial wastewater program, and stream sediment monitoring program. The basins and aquifers include:

Surface Water Basins	Ground Water Aquifers
· Wadi Araba Basin	· A4 Aquifer
· Azraq Basin	· Disi Aquifer
· Jafr Basin	· A2 Aquifer
· Hammad Basin	· Kurnub Aquifer
· Sirhan Basin	

4) Procurement of equipment to support the long-term operations and maintenance of the water monitoring system should be evaluated on an annual basis. As the water monitoring system matures and monitoring operations become more institutionalized and efficient, re-evaluation of the techniques and instrumentation should be promoted. Future planning should consider use of more automated data collection systems and data transfer systems. This would include: installation of remote transmission units; application of electronic water resources monitoring instrumentation, in-situ water quality monitoring instrumentation, data loggers and telemetry equipment; collection and transmittal of real time water resources and water quality data; and related instrumentation.

5) Proposed projects which will affect the water resources monitoring program should include monitoring equipment and installation requirements in the tender documents.

Design and installation of the monitoring stations and equipment should be coordinated with the water monitoring system program.

6) Major efforts continue to be required at the Ministry to support unification and streamlining of the water monitoring system and reduction in duplication among the existing programs. A strategy must be developed by the Ministry in the short-term to resolve this critical and important issue if the expected long-term success of the monitoring program is to be achieved.

7) Major efforts also are required at the Ministry to support and institutionalize unified and comprehensive data measurement/sampling procedures, data management protocols, and database management practices. Unless the Ministry develops the organizational structure, provides logistical resources, and employs qualified staff to support institutionalization of these procedures, the long-term success of the water monitoring system will be seriously challenged. The inconsistencies in the existing databases as well as the validity of the data in the databases must be resolved and corrected if the water monitoring system programs are to be effective once implemented. Otherwise, the data generated from the upgraded water monitoring system will become meaningless in the existing databases.

Subsequent Phases of Upgrade Plan and Long-Term Plan

8) The required training to develop uniformity and consistency of sample collection and handling and quality assurance protocols has been identified. Plans should be developed to institute the necessary training. This activity should be coordinated with the training component of the WQIC Project.

9) Further development of the national water resources and water quality monitoring program should continue according to the priorities established in the water monitoring system adequacy report (MWI, 1995).

10) The precipitation and evaporation monitoring programs should be evaluated to determine if any streamlining or optimization can be achieved as recommended in the adequacy report (MWI, 1995).

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The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

Water Monitoring System Upgrade Plan - Appendix A (Volume 2 - Monitoring System Procedures)

Science Applications International Corp.
Monitoring Network Working Group

Development Alternatives, Inc.

USAID

The Technical Assistance Team Includes:

Development Alternatives, Inc.
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United States Agency for International Development
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Water Quality Conservation and Improvement Project
Ministry of Water and Irrigation
The Hashemite Kingdom of Jordan

Table of Contents

Section — Page

1.0 **Introduction** 1

2.0 **Quality Assurance Procedures** 2

2.1 **Description of Monitoring Programs** 3
2.2 **General Program Organization/Responsibilities** 3
2.3 **Quality Assurance Objectives for Monitoring Programs** 4

2.3.1 Identification of Data Quality Objectives 4
2.3.2 QA/QC Objectives of Data 5

2.4 **Quality Control Procedures for Sampling Programs** 7
2.5 **Data and Sample Control, Field Records, and Sample Custody Procedures** 9

2.5.1 Sample Container Preparation 9
2.5.2 Field Log Book 9
2.5.3 Photographs 10
2.5.4 Sample Handling 10

2.6 **Field Analytical Equipment Calibration and Decontamination Procedures** 15

2.6.1 Equipment Calibration 15
2.6.2 Decontamination Procedures for Water Sampling Equipment . . 20

2.7 **Equipment Preventive Maintenance** 21
2.8 **Laboratory Analytical Procedures** 22
2.9 **Data Reduction and Validation** 22

Table of Contents (Continued)

Section Page

2.10 Data Assessment Procedures 22
2.11 Corrective Actions 22
2.12 Program Audits 23

3.0 Data Management Plan Procedures 25

3.1 Introduction 25
3.2 Personnel Data Management Responsibilities 25
3.3 Recording of Field Data 26
3.4 Recording of Laboratory Data 27
3.5 Water Monitoring System Databases 28
3.6 Document Control 28

4.0 Sampling Procedures - General Considerations 29

4.1 Introduction 29
4.2 General Considerations 29

5.0 Pre-Data Collection Trip Preparation 34

6.0 Surface Water/Stream Sediment Quality Sampling Procedures 36

6.1 General Considerations 36
6.2 Grab Samples for Shallow Surface Waters 39
6.3 Deep (Stratified) Water Sampling 41
6.4 Composite Samples 43
6.5 Stream Sediment Sampling 44
6.6 Collection of Quality Control Samples 46
6.7 Special Sample Collection Techniques 47
6.8 Field Equipment Cleaning Procedures 47
6.9 Field Log Book and Field Report Form 48

Table of Contents (Continued)

Section — Page

7.0 Ground Water Sampling 49

7.1 General Considerations 49
7.2 Sampling from Shallow Wells Using Bailers or Pumps 51

7.2.1 Water Level Measurement 51
7.2.2 Well Depth Measurement 51
7.2.3 Well Evacuation 52
7.2.4 Sample Collection 53

7.3 Sampling from Production Wells 55

7.3.1 Well Evacuation 55
7.3.2 Sample Collection 56

7.4 Sampling From Wells Using Packer Assemblies 56

7.4.1 Well Evacuation 57
7.4.2 Sample Collection 57

7.5 Collection of Quality Control Samples 57
7.6 Field Equipment Cleaning Procedures 58
7.7 Field Log Book and Field Report Form 58

8.0 Drinking Water Quality Sampling Procedures 59

8.1 General 59
8.2 Sample Site Stations 59

8.2.1 Production Wells 59
8.2.2 Water Works and Distribution Systems 60

Table of Contents (Continued)

Section Page

8.3 Sample Collection 60
8.4 Special Sample Collection Techniques 62
8.5 Collection of Quality Control Samples 62
8.6 Field Log Book and Field Report Form 63

9.0 Wastewater Quality Sampling Procedures 64

9.1 General Considerations 64
9.2 Site Selection 65
9.3 General Sampling Practices 66
9.4 Collection of Grab Samples 66
9.5 Sample Collection Using Automatic Samplers 68

9.5.1 General Equipment Installation 69
9.5.2 Sample Collection 69
9.5.3 Automatic Sampler Security 70
9.5.4 Special Maintenance, Calibration, and Quality Control Requirements 70

9.6 Collection of Quality Control Samples 71
9.7 Special Sample Collection Procedures 72

10.0 Surface Water Resources Monitoring Procedures 74

10.1 General Considerations 74
10.2 General Flow Measurement Practices 74

10.2.1 Volumetric Flow Techniques 76
10.2.2 Open Channel Flow Techniques 76

Table of Contents (Continued)

Section | Page

10.3 Hydrologic Data Measurement Practices 77

10.3.1 Staff Gages 78
10.3.2 Continuous Water Level Recorders 79
10.3.3 Current Meters 82
10.3.4 Cableways and Bridges 85
10.3.5 Portable Weirs 85

10.4 Quality Assurance Practices 87

10.4.1 General 87
10.4.2 Continuous Recorders 87
10.4.3 Vertical Staff Gages 88
10.4.4 Current Meters 88
10.4.5 Measuring Tapes and Tag Lines 89
10.4.6 Portable Weirs and Flumes 89

11.0 Ground Water Level Monitoring Procedures 90

11.1 General Considerations 90
11.2 Ground Water Level Measurement Techniques 91

11.2.1 Electric Water Level Indicators 91
11.2.2 Continuous Mechanical Recorders 93
11.2.3 Pressure Sensor Recorders 95

11.3 Total Well Depth Measurement Techniques 97

Table of Contents (Continued)

Section Page

11.4 Quality Control Procedures 98

11.4.1 General 98
11.4.2 Continuous Recorders 98
11.4.3 Pressure Transducers 99

12.0 References 100

List of Exhibits

Appendix A Recommended Sample Collection Parameters

WATER MONITORING SYSTEM PROCEDURES

1.0 Introduction

This document presents general and programmatic field measurement, water quality sampling and handling, and field data management techniques to be used by Ministry of Water and Irrigation (Ministry) personnel for conducting water resources and quality monitoring. The field techniques presented in this document are categorized as follows:

Section	
2.0	Quality Assurance Procedures
3.0	Data Management Procedures
4.0	Sampling Procedures (General Considerations)
5.0	Presampling Trip Preparation
6.0	Surface Water/Sediment Quality Sampling Procedures
7.0	Ground Water Quality Sampling Procedures
8.0	Drinking Water Quality Sampling Procedures
9.0	Waste Water Quality Sampling Procedures
10.0	Surface Water Resources Monitoring Procedures
11.0	Ground Water Level Monitoring Procedures
12.0	References

This document is intended to present general operational procedures for collecting hydrologic related data in Jordan through the Ministry's water monitoring programs. As such, the document is oriented toward the specific procedures and techniques used in Jordan for water monitoring purposes. The document does not provide detailed technical information or specifications for hydrologic monitoring. Numerous technical manuals and guidelines exist which provide substantial theoretical and practical information about monitoring programs and practices, equipment, and procedures. These references may be consulted for additional information.

36

2.0 Quality Assurance Procedures

This section describes general data collection quality assurance (QA) and quality control (QC) procedures for water resources and water quality monitoring programs. The purpose of these QA/QC procedures is to provide generic guidance so that the data collected or measured are scientifically valid, representative of water resources or quality conditions at a monitoring station site, defensible, and of known acceptable accuracy.

This section focuses on instruction and guidance for data-gathering activities likely to be performed for water resources and water quality monitoring. The QA discussions outline the system whereby the water monitoring system organization will provide assurance, through planning, selection of appropriate data quality objectives, and proper record keeping and data management that monitoring activities have been completed in accordance with accepted guidelines. The QC discussions present instructions and procedures to be followed in order to ensure consistency of data gathered. Specific QA/QC requirements, based on this guidance and instruction, must be developed for each separate water resources or water quality monitoring program established in Jordan.

The QA/QC policies and procedures are based primarily on the following sources:

- American Society of Testing Materials (ASTM). 1987. Annual Book of ASTM Standards, Section 4, v. 4.08.
- United States Environmental Protection Agency (USEPA), Region IV. 1991. Environmental Compliance Branch. Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.
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Subsequent sections of the quality assurance plan procedures present generic guidance and instruction for key elements of a QA plan for a specific water resources or water quality monitoring program.

2.1 Description of Monitoring Programs

The water resources and water quality monitoring programs for Jordan are anticipated to be the function of a Water Monitoring Systems Division. The Division will be responsible for conducting water monitoring and data collection activities throughout Jordan. To optimize use of field and personnel resources, water quality monitoring activities may be coordinated with those for water resources. Each surface water basin will have separate water resources and water quality monitoring programs. These independent programs will be designed specifically for each surface water basin. Similarly, each ground water aquifer will have separate water level and water quality monitoring programs. To improve the manageability of the ground water aquifer monitoring programs, each aquifer will be subdivided (as necessary) into geographic areas which are generally equivalent to the surface water basins.

2.2 General Program Organization/Responsibilities

The water monitoring programs for Jordan are anticipated to be organized as part of a Water Monitoring Systems Division possibly within a larger directorate of the Ministry of Water and Irrigation. This Division will serve as the primary point of contact for administrative and programmatic related elements of data collection for the water quality monitoring programs and will ensure that the monitoring activities are performed in a

technically sound manner and in adherence with the established technical specifications and quality assurance protocols. The Director of the Division, or possibly subdivision managers, will be a senior scientist or engineer with experience in water resources and water quality monitoring and data collection. A quality assurance function within the Division and organization also must be established and defined as the monitoring function develops.

Program coordinators for specific water resources and water quality monitoring programs will ensure that all monitoring activities for each program are performed in a technically sound manner in accordance with the provisions of the approved monitoring program plan. The program coordinators also will maintain coordination of field activities performed by field personnel. Monitoring activities will be performed largely by the field managers and staff with experience in water resources and water quality monitoring techniques. The field managers will provide day-to-day supervision of monitoring activities.

Program coordinators will be the point of contact for actual data collection. Specific technical design aspects of a monitoring program or plan may be the responsibility of a water studies/analytical function (another Division) within the Ministry.

2.3 Quality Assurance Objectives for Monitoring Programs

2.3.1 Identification of Data Quality Objectives

The identification of data needs is an important aspect of the planning process for water monitoring programs. The data needs are the basis for data collection strategies and development of a monitoring program plan. During this process the data and information needed to meet the program objectives are identified and the purpose for the data is defined.

Data quality objectives (DQOs) are qualitative and quantitative specifications for ensuring that data of known quality are obtained during monitoring programs. Data collected may include water measurements such as water levels, water samples, and general monitoring station information. The techniques used to collect measurement data or samples may limit the subsequent uses of the generated analytical data. DQOs are based on the concept that different data uses may require different data quality.

2.3.2 QA/QC Objectives of Data

As the data quality objectives (DQOs) are established, the data requirements are determined. The level of confidence, precision, and accuracy required for each type of data are evaluated to achieve a balance between requirements and time and cost constraints. In addition, the identification of monitoring requirements involves specifying the sampling method, design, number of samples to be obtained, sample types and locations and the level of quality control required. The manner in which monitoring and sampling equipment are cleaned also may affect the quality of the data. As data needs are established or refined, logistical planning can be completed to ensure that data are obtained expeditiously and cost effectively. DQOs must constantly be re-evaluated and refined throughout the monitoring program as information are collected and evaluated.

Data quality is the degree of certainty of data with respect to precision, accuracy, reproducibility, comparability, and completeness. Several qualitative and quantitative levels have been defined by the United States Environmental Protection Agency (USEPA) for data quality for environmental monitoring (USEPA, 1991). Typically, three levels of data quality would be appropriate for water quality monitoring in Jordan:

- Level I -- **Screening**: This level provides the lowest data quality and rapid results. Data are not quantitative and generally are not compound-specific. Level I data typically are used for health and safety monitoring in the field.
- Level II -- **Field Analyses**: This level provides rapidly generated field data. The level involves the use of portable or transportable instruments. Level II data are used for on-site screening, baseline data development, and determination of the general distribution of water quality conditions.
- Level III -- **Laboratory/Confirmational**: This level provides data of high quality but at a rate slower than provided by Levels I and II. It utilizes approved, standardized laboratory testing procedures which may be equivalent to those used for international testing including USEPA procedures for analyses of water, waste water, or hazardous wastes.

Level I data typically would consist of health and safety field measurements using combustible gas indicators, oxygen detectors, and field screening for organic vapors. This level of data generally would not be collected in Jordan. Level II data would consist of field measurements of surface and ground waters for parameters such as pH, temperature,

40

specific conductance, turbidity, and dissolved oxygen, and in the future possibly specific chemicals (e.g., nitrate, chloride). Level III data would consist of results of laboratory analyses of surface and ground waters and sediment samples for substances defined in the specific water quality monitoring programs. Higher level data typically would be associated with comprehensive QA/QC requirements for reporting laboratory results (Level IV) (e.g., USEPA Contract Laboratory Program Routine Analytical Service (CLP-RAS) with extensive CLP-required documentation), and using non-standard analytical procedures for laboratory analysis (Level V). Typically these DQO levels would not be appropriate to Jordan.

QA/QC objectives for data include representativeness, completeness, comparability, precision, and accuracy:

Representativeness

Samples collected for a monitoring program must be representative of the station or sample location. Observable variations, matrix differences, or environmental conditions during measurements or sampling should be noted in a field log book or field report form. For water quality samples, irregularities in the samples (stones, sticks, etc.) should be rejected.

Completeness

For water quality monitoring, the completeness of analyses is evaluated by comparing the number of samples and analytical parameters requested with the number of analyses completed. Loss of samples due to container breakage, spillage, or leakage should be documented. Quality control data should be recorded and if data are rejected on the basis of quality control sample results, the reason for data rejection and corrective action taken should be documented in the analytical report.

Comparability

Consistency in the acquisition, handling and analysis of measurement data and samples is necessary for the comparison of results to be meaningful. To achieve comparability, acceptable methods for the measurement of data and the collection and preservation of samples, sample holding times, and sample analyses, as described in the protocols presented in subsequent sections, must be closely followed.

Precision and Accuracy

Precision refers to the reproducibility of a methodology to yield consistent results when the methodology is repeated in a homogeneous population. Precision does not depend on whether the results are representative of the true value and can be expressed by standard deviation. Accuracy refers to the agreement between the amount of a component measured by a method and the actual amount of the component present in the sample. Precision and accuracy are evaluated by the laboratory analyzing the samples.

2.4 Quality Control Procedures for Sampling Programs

To verify the quality of the data collection and analysis processes, several types of quality control samples may be obtained during the collection of water samples. These samples include duplicates samples, trip blanks, field blanks, split samples, and equipment rinsate samples.

For the purposes of water quality monitoring, these samples are defined as follows:

- Duplicate samples are blind quality control samples which are duplicates of field samples, and which are submitted to the laboratory for analyses. Analytical results of duplicate samples will be compared with those of the original samples for final data verification. Duplicate samples for volatile organic analyses should be grab samples as opposed to composite samples. Collection of duplicate samples is recommended as follows:

  - Ground or surface waters: duplicate samples collected at a frequency of one per ten samples sent to the laboratory;
  - Sediments: duplicate samples collected at a frequency of one per 10 samples sent to the laboratory.

- Split samples are samples which have been collected and portioned into two or more containers from a single sample. The samples are submitted to the respective laboratory of each party. Analytical results of split samples can be compared to provide a general indication of the variability among laboratories.

- Trip blank samples are prepared by the laboratory and are used for volatile organic samples only. The samples are submitted blind to the laboratory with each cooler containing samples for analysis of volatile organics. Trip blanks accompany the field samples during sampling, storage, and transportation to the laboratory. The containers are filled with material appropriate to the media sampled, as follows:

  - Ground or surface waters: organic-free water;
  - Sediments: native soil free of contamination.

- Field blanks are quality control samples used for data validation purposes. At least one field blank should be taken per day of sampling, and additional samples will be taken as appropriate. Field blanks are collected in the field by pouring organic-free water from sealed containers into a sample container. Field blanks are recommended for areas which may affect the quality of samples by solution of compounds (in the air) into water during sampling. Blanks based on site and meteorological conditions will consist of materials appropriate to the media sampled, as follows:

  - Ground or surface waters: organic-free water;
  - Sediments: background soils.

- Rinsate samples (or equipment blanks) consist of organic-free rinse water which has been poured over decontaminated sampling equipment to determine the effectiveness of decontamination procedures. The samples are submitted blind to the laboratory.

  - Surface or ground waters: rinsate samples are recommended at a frequency of one per each ten samples if decontamination of sampling equipment is performed in the field;
  - Sediments: rinsate samples are recommended at a frequency of one per each ten samples.

2.5 Data and Sample Control, Field Records, and Sample Custody Procedures

This subsection addresses general data and sample control procedures applicable to water resources measurement and water quality sampling which may be performed for various water monitoring programs administered by the Ministry of Water and Irrigation.

2.5.1 Sample Container Preparation

All containers (regardless of age) used in the sampling of ground water, surface water and sediment shall be cleaned and certified clean by the laboratory providing the analytical services or containers. The container type and preservative requirements should follow the specifications of accepted international standards and the analytical laboratory. Container cleaning procedures and container type and preservative recommendations have been summarized in the USEPA standard operating procedures manual (USEPA, 1991).

2.5.2 Field Log Book

A bound field log book is recommended for each water monitoring system program. The logbook should be maintained by the monitoring program coordinator and must accompany the field manager during measurement or sampling events to provide a record of activities.

Field log books are recommended as the primary means of recording all data regarding measurement and sample collection activities at a monitoring site. Entries should be described in as much detail as possible so that essential information if properly documented. All documentation in field books should be in black or blue ink. If an error is make, corrections should be made by crossing a line through the error and entering the correct information. Corrections should be dated and initialed. No entries should be obliterated or rendered unreadable.

In addition to the field log book, data measurement or sampling forms may be used and completed as described in subsequent sections to record basic information regarding the data measurement or field sampling activities.

For long-term data retention, the cover of each log book used should contain:

- Person and organization to whom the log book is assigned
- Book number

- Monitoring program name
- Starting date of log
- Ending date of log

At the beginning of each day's entry, the following information should be recorded in the field log:

- Date and time
- Meteorological conditions
- Field personnel present
- List of on-site visitors
- Signature of the person making the entry

Entries in the field log book are recommended for each monitoring station from which data or a sample is collected and should include the sample identification number and labeling as discussed in Section 2.5.4 below.

2.5.3 Photographs

Photographs may be taken as necessary to document unusual conditions and/or techniques employed. The name of the photographer, date, time, site location and site description should be entered sequentially in the field log book as photos are taken.

Special lenses, films, filters, or other image enhancement techniques should be noted in the field log book. The following items should be noted with regard to accurate photography:

- 35 mm color slides should be used unless noted in the field log book
- Photos should show surrounding area and/or reference objects for scale
- Picture number, roll number (if more than one roll of film is used), and description of picture should be logged in the field log book
- Film roll number, type film (e.g. ASA-100), date, and location of pictures should be identified in the field log book.

2.5.4 Sample Handling

Specific sample collection procedures for water quality samples are presented in subsequent sections of this document. In general, personnel collecting water quality samples should

take the following precautions to minimize sample contamination or cross-contamination between samples:

- At a minimum, latex surgical gloves should be used while taking all samples, disposed of after equipment has been decontaminated, and a clean pair should be used for the next sample
- Sampling personnel should not touch the inside of the sampling container
- Sampling personnel should not walk through areas where samples will be taken

Immediately following the collection of a sample, the container should be sealed and the sample should be labelled and entered in the field sampling log book as described below. At this time, the Chain-of-Custody form (Exhibit A) (two models of form presented) should be completed to note the acquisition of the sample. The sample then should be placed in the shipping container and preserved according to the directions of the laboratory.

Sample Identification and Labeling

It is recommended that each sample be identified in the field log book and on the sample container label. Immediately after the sample is collected, the following documentation should be provided:

Label each sample container with the following information:

- Date and time of collection
- Monitoring program name
- Sample station name and station ID number
- Sample ID number
- Sampler (name)
- Preservative (if any)
- Matrix type (e.g., surface water, ground water, sediment)

Sample identification (ID) numbers should accompany all samples submitted to the laboratory. A recommended system for labeling samples is presented as follows. The sample ID number should consist of a sample identification and a sample matrix type designation. The sample identification should consist of the date the sample was collected in the format "daydaymonthmonthyearyear" and the station identification number. For

surface water samples the matrix designation will be SW, for ground water samples GW, and for sediments, SS. For example, for a surface water sample collected on 15 June 1995 from the station AL0061, the sample number would be as follows: SWAL0061-150695.

The following letters should be appended to the sample designation with a dash (-) to denote various types of quality control samples:

-a	field duplicate	-d	equipment blank
-b	field split	-e	field blank
-c	trip blank		

Enter sample information in the field log book:

At a minimum, entries in the log book are recommended to include the following for each sample collected:

- Site station name and identification number
- Location of sampling point
- References to photographs taken and a brief sketch of areas photographed
- Sample identification number
- Number of containers filled
- Time of sample collected
- Number of QC samples taken
- Collectors' names
- Field observations
- Sample distribution (e.g., laboratory, splits)
- All field measurements made (e.g., pH, temperature, specific conductance)

If no map of sampling locations is available, a simple drawing of the site (not to scale) should be included in the field log book to illustrate all sampling points.

Sample Chain-of-Custody and Chain-of-Custody Record Form

Exhibit A is an example of a Chain-of-Custody form to be used for ensuring the integrity of samples from the time of collection until delivery to the laboratory. The Chain-of-Custody form will be signed by each individual who has the samples in his or her possession.

Fill out the sample Chain-of-Custody form:

In order to maintain an accurate record of sample collection, transport, analysis and disposal, the following guidelines and methodology are recommended:

- Samples must be accompanied at all times by a Chain-of-Custody form.
- The Chain-of-Custody form should be signed by each individual who has the samples in their possession.
- The Chain-of-Custody form should be initialed in the field by the person collecting the sample, for every sample. Every sample should be assigned a unique identification number, to be entered on the Chain-of-Custody form. Several samples can be listed on a single form.
- The record should be completed in the field to indicate the monitoring program, sampling team, etc.
- If the person collecting the sample does not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished by _____," "Received by _____" will be completed in the field.
- The person transporting the samples to the laboratory or delivering them for shipment will sign the record form as "Relinquished by ___."
- If the samples are shipped to the laboratory by commercial carrier, the Chain-of-Custody form will be sealed in a watertight container, placed in the shipping container, and the shipping container sealed prior to being given to the carrier.
- If the samples are transported directly to the laboratory, the Chain-of-Custody form will be kept in the possession of the person delivering the samples.
- For samples shipped by commercial carrier, the waybill will serve as an extension of the Chain-of-Custody record between the final field custodian and receipt in the laboratory.
- Upon receipt in the laboratory, the sample recipient will open the shipping containers, compare the contents with the Chain-of-Custody record, ensure that document control information is accurate and complete, and sign and date the record. Any discrepancies will be noted on the Chain-of-Custody form.
- In the event of the discrepancies, the samples in question will be segregated from normal sample storage and the field personnel immediately notified.
- The Chain-of-Custody form is completed upon receipt of the samples by the analytical service. The completed Chain-of-Custody form will be returned to

the program coordinator for the specific monitoring program and maintained in the program file.

Sample Packaging

Samples collected at the site should be immediately placed in the sample cooler. Samples should be shipped in such a manner as to ensure their arrival at the laboratory as soon as possible and well before the time limits specified by the analytical procedures to be conducted. Once a cooler is filled, it should be locked and securely positioned until the completion of the day's sampling activities.

Place sample in cooler immediately:

The following protocol will be used for packaging of samples:

- Samples will be packed properly for shipment so that bottles will not dislodge and/or break during shipment.
- Only waterproof metal or equivalent strength plastic ice chests and coolers will be used.
- The volume level will be marked on each bottle with a grease pencil.
- Inert cushioning material will be placed in the bottom of the cooler.
- The sample containers will be placed upright in the cooler in such a way that they do not touch and will not touch during shipment.
- Additional inert packing material will be placed in the cooler to partially cover the sample containers. Freeze packs will be placed around, among, and on top of the sample containers.
- Each cooler will be filled with additional cushioning materials to prevent movement of samples during shipment.
- The Chain-of-Custody form will be placed in a waterproof plastic bag and placed just under the lid of the cooler. The method of shipment, courier name(s), and other pertinent information will be recorded on the chain-of-custody form.
- If the cooler is equipped with a drain plug, it will be taped shut.
- The lid will be secured with strapping tape at a minimum of two locations. No labels will be covered.
- The completed shipping label, as appropriate, will be attached to the top of the cooler.

- "This Side Up" arrow labels will be placed on two sides of the cooler, and "Fragile" labels will be placed on all four sides.
- Numbered and signed custody seals will be placed on the front right and back left of each cooler. These seals will be covered with clear tape.
- Samples will be transported by courier in an approved, cooled shipping container, ensuring that the maximum holding times between sample collection and analysis will not be violated.

2.6 Field Analytical Equipment Calibration and Decontamination Procedures

Field analytical equipment used by monitoring personnel should be suitable for the measurement or analysis intended and should be properly calibrated. This section outlines:

- Calibration concepts for typical field analytical equipment;
- General field analytical techniques;
- General quality control procedures and calibration techniques for field analytical equipment;
- Calibration and maintenance intervals;
- General calibration standards and conditions requiring recalibration; and
- Use of reagents and standards for field analyses or calibrating field analytical equipment.

Quality assurance procedures for field analysis, and for calibrating field analytical and test instrumentation, are essential to water quality monitoring programs. Field analytical measurements should be conducted in duplicate at least 10 percent of the time. A record of these duplicate analyses shall be kept in the field log books. Significant differences in the replicate analyses should result in recalibration of the instrument or examination of the sampling location.

2.6.1 Equipment Calibration

The calibration policies and procedures described in the following sections apply to water quality measuring and monitoring equipment. This includes tools, gauges, instruments, standards and other devices used to make measurements. Equipment requiring calibration should have an identification number affixed to the instrument. For measurement and test

equipment requiring periodic calibration, a label should be affixed to each instrument showing:

- Description
- Model and serial numbers
- Date of last calibration or maintenance
- Person who calibrated/maintained
- Due date of next scheduled calibration

A master list of all portable equipment used by the water monitoring system function should be prepared and maintained with the above information.

Calibration reports and compensation or correction figures should be maintained with the instrument, and copies should be kept in the files. Thermometers are exempted from the labeling requirements, but not from the calibration requirements.

A written calibration procedure should be available and followed for measurement and test equipment. Any instrument which is not calibrated to within the required specifications should display a warning tag to prevent the use of the equipment. Equipment unable to meet approved calibration specifications should not be used. The required calibration ranges and uncertainties for each measuring and test device should be documented.

Calibration Identification

Instruments past due for calibration or maintenance should be immediately removed from service, either physically or (if this is impractical) by tagging, sealing, labeling, or other means. All equipment should be maintained and calibrated according to the manufacturer specifications.

Calibration Standards

All physical, electronic, or chemical measurements or calibrations performed should be traceable through an unbroken chain of properly conducted calibrations supported by reports or data sheets. All measurements and calibrations should be referenced to recognized standards or physical constants or to standards prepared by nationally recognized procedures. Reports for each reference standard and each subordinate standard used for calibration should be kept up to date. All standards should have an uncertainty rating of

no more than one-fourth of the specified uncertainty for the measuring or test equipment under calibration.

Calibration Frequency

At a minimum, calibration and maintenance intervals for field instruments should be those recommended by the respective manufacturers, unless experience dictates a shorter interval. When the manufacturer has not specified a calibration interval for the equipment, a written policy for recalibration should be established. A field instrument calibration notebook containing the instrument operation manual and specific calibration procedure for the instrument should be maintained. In addition, the following information should be noted in the notebook on a log sheet such as the example shown in Exhibit B:

- Equipment type (e.g., pH meter, Ec meter)
- Manufacturer and model number
- Serial number
- Recommended calibration frequency
- Date of latest calibration
- Dates of field measurement (use)
- Name of person who calibrated instrument
- Calibration standards used
- Source of calibration standards

Entries in the log book will be made at the beginning of each sampling or measuring effort and when each instrument is calibrated. Records will be kept for all instruments requiring calibration.

Thermometers

All thermometers should be calibrated against a national standard certified thermometer or one traceable to a national certification. Glass mercury filled thermometers should be inspected before each field trip for cracks and air space in the mercury column. If a mechanical dial-type thermometer is used, it should not have a broken face cover or otherwise show damage. A cross-check with a calibrated certified thermometer should be made at least semi-annually. Thermistors and electronic readout units should be calibrated in the same manner. Recording thermometers should be checked for recording accuracy before each use. The recorder time scale accuracy should be checked semi-annually.

Before using a thermometer in the field, a visual observation should be made to assure that it has not been damaged. If a thermistor is used, the instrument shall be checked against a thermometer before field use. Cross-checks and duplicate field analyses should agree within $\pm 0.5^{o}C$.

A logbook should be maintained with each thermometer number. All calibration information including individuals making the calibrations and dates of calibration should be recorded.

pH Meters

Only electronic (portable) pH meters with automatic temperature compensation (ATC) should be used. Temperature resistant, combination electrodes should be employed in conjunction with the meters. pH test paper may be used only for determining pH ranges or for determining approximate pH values.

The pH meter should be checked before each field trip for mechanical or electrical failures, weak batteries, and cracked or fouled electrodes. The slope scale should be checked initially with three fresh standard pH buffer solutions (e.g., 4, 7, and 10). In the field, meters should be calibrated daily before use with two buffers bracketing the expected sample pH. The meters should be checked against two buffers when moving to a new sample location. Fresh buffer solutions should be used for each field trip. Duplicate tests should agree within 0.1 standard unit.

Dissolved Oxygen (DO) Meters

Membrane electrode DO meters should be used. DO meters should be checked before each field trip by inspecting the membrane for air bubbles and holes. Dry membranes should be replaced and soaked in water before calibrating. Calibration should be made against the modified Winkler test or according to the manufacturer's recommendations. DO kits should be refilled with new standardized sodium thiosulfate before each field trip. Each solution shall be checked for clarity and volume.

While using the DO meter, the instrument should be recalibrated at least twice per day or if a change in water quality is noted. If the sample temperature is $5^{0}C$ greater than the calibration temperature, the meter should be recalibrated. Duplicate analyses should agree with $\pm$ 0.1 mg/l.

Specific Conductance Meters

A portable specific conductance meter. Wheatstone bridge type or equivalent should be used. Each conductivity meter should be checked before each field trip. Batteries shall be checked, and conductivity cells should be cleaned and checked against known conductivity standards (KCl).

Before use in the field, the instrument should be checked with known standards. The instrument instructions should be consulted for temperature conductance calculations. Duplicate field analyses should agree within $\pm$ 10 percent.

Total Chlorine Residual Meters

The iodimetric back titration method with a starch-iodide end point or amperometric end point or a Hach DR 100 colorimetric (DPD) kit is recommended for total residual chlorine. Titration kits or meters should be checked before each field trip by inspecting the meter for battery strength and fresh reagents. The normality of the iodate should be checked with a distilled water blank to establish a correction factor for the titrant. Duplicate chlorine residual analyses should agree within $\pm$ 0.01 mg/l.

If the Hach DR 100 colorimeter kit is used, the method must agree with the requirements of Method 408E, "Standard Methods," 18th Edition, or USEPA Method 330.5 "Methods for Chemical Analysis of Water and Wastes," and calibration scales must be calibrated on site at a minimum of three points (blank and two standards) that bracket the expected sample concentration.

Equipment Standards

All chemicals used in test kits and with field analytical instruments as reagents and standards should be supplied and standardized by the Central Laboratory or manufacturer. Certified pH buffer solutions may be purchased from chemical supply houses. All reagents and solutions should have expiration dates attached to the containers. All out-of-date reagents, buffers, and chemical solutions should be properly disposed of by their expiration date. All field reagent containers should be identified with the chemical name, concentration, and date prepared.

2.6.2 Decontamination Procedures for Water Sampling Equipment

Cleaning and decontamination of field monitoring equipment should be conducted in a uniform manner. Cleaning is most important for water quality monitoring equipment used for the water quality monitoring programs. Any deviations from the procedures should be thoroughly documented in the field log book. The following procedure is recommended for the thorough cleaning and decontamination of water quality monitoring equipment:

a. Clean sample equipment with potable water and as recommended by the equipment manufacturer to remove particulate matter and surface films.
b. Wash with laboratory soap solution (Alconox, Liquinox, TSP);
c. Rinse thoroughly with potable (tap) water.
d. Rinse thoroughly with deionized water.
e. Rinse thoroughly with isopropyl alcohol rinse.
f. Triple rinse with deionized water.
g. Allow to air dry.
h. Wrap with manufacturer recommended material to prevent contamination if equipment is to be stored or transported prior to immediate use.

If decontamination is performed in the field, rinse water should be contained in a manner which prevents the spread of contaminants. Sampling personnel should avoid contacting bailers or pumps with the surrounding soils or unprotected hands. All bailers or pumps which have contacted any soil, unprotected hands, or anything which may contaminate the equipment should be decontaminated according to the above procedures.

Probes for analytical instruments used in the field (e.g., pH, specific conductance meters) should be rinsed with deionized or distilled water prior to each use. Electric water level probes should be cleaned with laboratory grade soap and water and triple rinsed with distilled water between wells.

Bottles should be cleaned prior to delivery to the field by the chemical laboratory. For safety reasons and to minimize contamination, preservatives may be added to the sample bottles prior to delivery to the site. Container cleaning procedures and container type and

preservative recommendations have been summarized in the USEPA standard operating procedures manual (USEPA, 1991).

Sampling personnel should wear new, laboratory quality disposable gloves. These gloves should be replaced as necessary during the sampling procedure and must always be changed between sampling stations.

2.7 Equipment Preventive Maintenance

All analytical and test instruments and kits should be inspected on a semi-annual basis, whether used during the intervening period or not. The purpose of the semi-annual inspection is to maintain the equipment in a ready-to-use condition. This inspection should consist of a general examination of the electrical system (including batteries) and a calibration against standards. Any expired reagents, broken glassware, or parts should be replaced.

Prior to any sample collection or field measurement activities, all field and laboratory equipment should be inspected to ensure tools, gauges, and other items requiring preventive maintenance have been serviced in strict accordance with the manufacturers' recommendations.

The program coordinator is responsible for ensuring adherence to the maintenance schedule and to arrange for prompt service of all equipment for which he is responsible. Service to all equipment, instruments, tools, gauges, etc., should be performed only by qualified personnel.

Maintenance logs should be established for key pieces of equipment to record and control maintenance and service procedures and schedules. Entries in the instrument logbook should include the following:

- Date of entry
- Symptoms
- Disposition of problem
- Name of analyst responsible for correcting problem
- Typical instrumental response to standard concentrations of analyte.

2.8 Laboratory Analytical Procedures

Laboratory analyses should be performed by a water quality laboratory qualified to do the required analyses. For water quality samples collected by the Ministry of Water and Irrigation, water quality analyses will be performed by the Central Laboratory of the Water Authority of Jordan. Analytical procedures used for performing the analyses will be consistent with standard procedures accepted by the international community such as those of the WHO and USEPA and Standard Methods.

2.9 Data Reduction and Validation

General guidelines for data management including data reduction and validation are described in Section 4.0 below. Data Management Plan. Specific data management procedures should be specified for each water monitoring program in the plan for the specific program.

2.10 Data Assessment Procedures

Data assessment is highly dependent on the objectives for the water monitoring program. Specific data assessment procedures should be specified for each water monitoring program in the plan for the specific program.

2.11 Corrective Actions

This section outlines procedures to assure that conditions adverse to quality, such as malfunctions, deficiencies, deviations, and errors are promptly investigated, documented, evaluated, and corrected. When a significant condition adverse to quality is noted, the cause of the condition should be determined and corrective action should be taken to preclude repetition of the same condition. Identification of the condition and the cause, documents utilized, and corrective action should be documented and reported to the program coordinator. Implementation of corrective action should be verified by documented follow-up action. All monitoring personnel have the responsibility, as part of the normal work duties, to promptly identify and report conditions adverse to quality.

Corrective actions may be initiated, at a minimum, in response to the following:

- Failure to attain predetermined data acceptance standards;
- Failure to follow procedures;
- Equipment or instrumentation that is not in proper calibration or is not functioning correctly;
- Samples and test results that are not traceable;
- Failure to meet QC requirements;
- Lack of designated approvals;
- System and performance audits; and
- Management assessment of program QA.

Program management and staff, including field monitoring teams, will continuously monitor ongoing work performance in the normal course of daily responsibilities. Work for the monitoring program will be reviewed for quality control by the program coordinator. This individual will monitor sample collection, labeling, and handling activities, and will obtain samples for use as blanks, spiked blanks, and matrix blanks in laboratory QA activities.

It is the Division's Quality Assurance Officer's (QAO) responsibility to ensure that all corrective actions are completed in a timely manner. The QAO must approve all corrective action requests issued by the staff prior to commencement of the action. An example corrective action request (Exhibit C) identifies the adverse condition, references any document utilized, and recommends the corrective action to be administered. The issued corrective action request is directed first to the QAO and subsequently to the person in charge of the item or activity for action. This person oversees the corrective action itself, and returns the request response promptly to the QAO, affixing his signature and date to the corrective action block, after stating the cause of the conditions and corrective action taken.

The QAO maintains a log for status control of corrective action requests and responses, confirms the adequacy of each corrective action, and verifies its implementation.

2.12 Program Audits

QA Audits

Quality Assurance audits may be performed by the QAO or designee. These audits may be conducted to evaluate the capability and performance of monitoring personnel, sampling and

analysis procedures, and documentation of adherence to the QA plan for a monitoring program. The QAO may request personnel with specific expertise to assist him in the conducting of performance audits or other QA/QC duties. However, these personnel will not have participated in, nor have had responsibility for, the analytical work associated with the performance audits. QA audits should be performed at least once a year for each monitoring program.

The QAO coordinates and monitors the QA programs for all on-site activities. This channels the responsibility for all aspects of the QA program through a single individual and provides an effective avenue for response to any QA problems that may be identified. Implementing prompt, effective, and accurate corrective action in response to non-compliances that may occur is also the responsibility of the QAO.

System Audit

A system audit refers to a detailed evaluation of the program performance in conformance with the quality assurance plan and standard monitoring procedures.

Performance Audit

A performance audit may be conducted for field activities by the QAO or designee to determine if the field procedures conform to the procedures specified in the monitoring program plan. This audit is a check for the adequacy and effectiveness of the operating procedures, chain-of-custody, and documentation utilized by the field personnel.

Quality Assurance Reports to Management

Periodic QA reports may be submitted to the program coordinator by the QAO. These reports may apprise program management of the QA status of measurement systems and data quality, and would identify problem areas and potential trends ascertained during audits. These QA reports may contain the following:

- Periodic assessment of the accuracy of field data;
- Completeness;
- Results of QA system audits;
- Results of QA performance audits;
- Significant QA problems and recommendations; and
- Results of laboratory QA audits.

3.0 Data Management Plan Procedures

These data management procedures provide guidance on data management responsibilities of monitoring personnel and for recording and maintenance of data obtained from the water resources and water quality monitoring programs.

3.1 Introduction

These data management procedures outline necessary actions to ensure proper documentation, tracking, and managing of field and laboratory data. These procedures also identify and establish data documentation materials to be used during monitoring. Additional data management requirements and procedures may be added to specific water monitoring plans if changes in the scope of activities to be performed necessitate such revisions.

3.2 Personnel Data Management Responsibilities

Monitoring program personnel having responsibility for data management will be the program coordinator and the field manager. These individuals will have the responsibilities listed below:

- Program Coordinator: responsible for ensuring that program monitoring data are recorded accurately and completely

- Field Manager: responsible for maintaining and recording information and data generated on-site including information to be recorded in the field log book and on appropriate forms

The program coordinator or designee will establish and maintain the document control system for the monitoring program. Data obtained from field operations and the laboratory will be screened and validated with respect to applicable QA/QC criteria, to identify and flag anomalous data or errors. The data will then be prepared, sorted, and entered (computerized or manually) into the data storage files for the project.

3.3 Recording of Field Data

The field manager will be responsible for recording field data for a monitoring program. Data checklists, photographs, calibration logs, etc., generated during the course of the monitoring program will be included as part of the field log books.

Field Log Book Data

All data recorded in the field log book will be printed in a legible manner using waterproof ink. All log book entries will contain accurate and inclusive documentation of project activities, specifically daily activities, including a record of visitors to the site. The field log book will contain that information, at a minimum, specified in Section 2.5.2 above.

All field instrument calibration forms will be completed as necessary and maintained in the program files.

Additional Field Data

During the course of the monitoring activities, additional field data will be generated which may not be directly entered into the field log book, but will eventually become an integral part of the program files. The additional information and data may include, but is not limited to, the following:

- Chain-of-Custody Form (Exhibit A)
- Calibration Log Forms (Exhibit B)
- Monitoring Station Data Report Form (Exhibit D)
- Water Sampling Report Form (Exhibit E)

Copies of these forms are described in the following sections and are included as exhibits at the end of this document. These data will be entered or included as part of the program files.

Photographs

Photographs may be used to provide visual evidence of unusual items and anomalies. Such photographs will only be taken with the knowledge and approval of appropriate monitoring personnel. These photographs will be referenced in the field log book. Photographs will be taken in accordance with the requirements specified in Section 2.5.3.

3.4 Recording of Laboratory Data

Sample labeling and chain-of-custody forms (or related analysis request forms) delivered to the analytical laboratory should not be included as part of the field log book, but should be part of the laboratory data received and included as part of the program files. The program coordinator will be responsible for storing all information and data received from the laboratory related to the monitoring program. These information and data include the following:

- Chain-of-custody forms
- Laboratory notes and laboratory analysis ID numbers
- Internal laboratory performance audits
- Chromatograms
- Raw data printouts
- Tabulated data printouts
- Laboratory QA/QC data

These data should be maintained in the program file.

Field Laboratory Data Requirements

Field instrument calibration logs, containing the field instrument calibration forms shown as Exhibit B should be maintained in the program files. Reference to these logs will be made in the field log book. The log book will include information documenting the field analyses performed. It will also document the dates and results of any calibration of portable equipment.

Off-Site Laboratory Data Requirements

The program coordinator will be responsible for ensuring the proper recording of laboratory data generated from the analyses of water samples. The program coordinator also will be responsible for maintaining and storing the data in an acceptable, environmentally-controlled manner to prevent any degradation there of.

3.5 Water Monitoring System Databases

All primary and development data generated by the water monitoring system program and related functions should be stored in computerized databases. Development data are identified as that information (such as stream discharge calculations, isopleths, potentiometric diagrams, etc.) generated from primary input data and information gathered from field- or laboratory-based activities. Development data may be included in program reports or technical studies or evaluation reports.

All screened and validated primary data and development data should be entered into an appropriate database by a qualified technician. The data should be carefully reviewed to ensure that they have been accurately transferred. The studies/analytical function is anticipated to become responsible for management of the water databases. Separate procedures and protocols for management and operation of the water resources and water quality databases used to store primary data and development data must be established by the database management function.

3.6 Document Control

Document control generally refers to the maintenance of program files. All program files typically should be maintained by the program coordinator. The documents identified below should be kept in the program files. All official and original documents relating to the monitoring programs should be placed in the official program files.

- Copy of the monitoring program plan:
- Original Chain-of-Custody form:
- Bound field logbooks:
- All records obtained for the monitoring program:
- Complete copy of the analytical data and reports transmitting analytical data:
- Official correspondence relating to the monitoring program:
- Copy of draft reports:
- Copy of the final reports; and
- Other relevant documents related to the monitoring program.

4.0 Sampling Procedures - General Considerations

4.1 Introduction

This section discusses general practices and procedures for field operations to ensure the collection of representative data and samples. Data and sample collection generally involve:

- Ensuring that the sample taken is representative of the water source being sampled;
- Using proper sampling, sample handling, preservation, and quality control techniques;
- Properly identifying collected samples and documenting their collection in permanent field records (e.g., field log books, chain-of-custody records); and
- Maintaining sample chain-of-custody.

4.2 General Considerations

The following factors and procedures shall be considered in planning and conducting all water quality sampling operations.

Selection of Representative Sampling Sites

Representative sampling sites are dependent on the specific monitoring program.

Selection and Proper Preparation of Sampling Equipment

The type of sampling equipment is dictated by the purpose of the monitoring program.

Sampling Equipment Construction Material

The material used in the construction of sampling equipment can affect sample analytical results. Materials must not contaminate the sample being collected and must be readily cleaned so that samples are not cross-contaminated. The standard materials for equipment used to collect samples for trace organic compounds or metals analyses are, in order of decreasing desirability: Teflon®, glass, stainless steel, and steel.

Selection of Parameters to be Measured

Parameters to be measured are determined by the purpose of the monitoring program and are based on required monitoring conditions.

Required Sample Volumes

The volume of sample obtained should be sufficient to perform all required analyses with an additional amount collected to provide for quality control needs, split samples, or repeat examinations. Although the volume of sample required by the laboratory depends on the analyses to be performed, the amount of sample required for a complete water or wastewater analysis, including potential re-analysis, is normally about eight liters. The laboratory should be consulted for any specific volume requirements.

Samples collected for purgeable organic analyses (VOA) or dissolved gases must completely fill the container.

Selection and Proper Preparation of Sample Containers

The type of sample container is dictated by the analyses required. Standard sample containers used for monitoring are presented in Appendix A.

Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected by monitoring personnel are given in Appendix A. All chemical preservatives used by monitoring personnel will be supplied by the laboratory. All samples requiring preservation should be preserved immediately upon collection in the field.

All samples preserved with chemicals shall be clearly identified by indicating on the sample label or colored label that the sample is preserved. If samples normally requiring preservation were not preserved, field records shall indicate why.

Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for all routine samples collected by monitoring personnel are shown in Appendix A.

Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per trillion range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern:

- A clean pair of new, disposable gloves should be worn each time a different location is sampled. Gloves should be donned immediately prior to sampling.

- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, preserving, tagging, etc.

- All ambient samples should be collected first and placed in separate ice chests or shipping containers. Highly contaminated samples should never be placed in the same ice chest as ambient samples. It is good practice to enclose highly contaminated samples in a plastic bag before placing them in ice chests. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants should be lined with new, clean plastic bags.

- If possible, one member of the field team should take all the notes, fill out labels, etc., while the other members collect the samples.

- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed from the suspected least contaminated area to the suspected most contaminated area, as appropriate.

- Branch personnel should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned for collecting samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC shall <u>not</u> be used to collect samples for trace organic compounds analyses.

Sample Handling and Mixing

After collection, all sample handling should be minimized. Monitoring personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags, should be used when small sample containers (e.g.,VOA's or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be split into separate containers for different analyses. The best way to split liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing. Teflon® should be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment. However, samples collected for purgeables organic compounds analyses may not be split using this procedure.

Purgeable Organic Compounds Sampling (VOA)

Water samples to be analyzed for purgeable organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure. Since the VOA vials are pre-preserved, extreme caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for purgeable organic compounds, triplicate samples should always be collected from each location. Three 40-ml vials containing four drops of concentrated HCl should be filled with the sample.

Sample Identification

All samples will be fully documented, as outlined in Section 2.5.4, in the field records, on the field sample chain-of-custody record, and on the sample tags.

Collection of Auxiliary Data

All auxiliary data such as flow measurements, photographs of sampling sites, meteorological conditions, and other observations shall be entered onto the field records when the auxiliary data are collected. Auxiliary data relative to a particular sampling location should be collected as close to the sample collection time as possible.

Transporting and Shipping of Samples

Samples may be hand delivered to the laboratory or they may be shipped by common carrier.

Sample Chain-of-Custody

Monitoring personnel shall maintain sample chain-of-custody during all field investigations for all samples collected. The standard sample chain-of-custody procedures used by personnel are given in Section 2.5.4.

5.0 Pre Data Collection Trip Preparation

Adequate preparations for data measurement and sampling trips should be made by monitoring personnel to ensure that activities are performed as efficiently and cost effectively as possible. Proper protocols should be followed to ensure that representative data are collected and water samples are provided for analysis, and that the act of sampling does not contribute to further contamination at the site or cross-contamination of samples. All techniques employed should be thoroughly documented to ensure the technical defensibility of the data.

The field manager and monitoring technicians performing the data measurement or sampling are responsible for review of available information and preparation of equipment to ensure that the sampling trip is performed as efficiently as possible. Thorough preparation will reduce lost time during monitoring episodes and will ensure that monitoring personnel have the proper equipment available on-site to follow established protocols.

Three to five days prior to the scheduled monitoring date, a vehicle and all necessary equipment should be signed out by the monitoring personnel. Equipment calibration logs must be reviewed to ensure that the equipment to be used is properly calibrated and in good repair. Expendable field supplies should be checked to determine whether adequate quantities of all supplies are available.

For sampling events, sample bottles must be ordered from the laboratory. Ordering of sample bottles is recommended a minimum of seven days prior to the sampling date. When ordering sampling bottles, bottles for blanks and duplicates must be obtained, and the type of blanks to be obtained must be specified. Reagent grade water for equipment blanks must be provided by the laboratory.

At least one day prior to the scheduled monitoring date, the equipment to be used should be gathered together and checked. Exhibit E is a water monitoring equipment checklist and includes the necessary supplies for most water monitoring activities. As much of the data collection sheets as possible shall be filled out prior to the monitoring event. The order of monitoring shall be determined. For example, for sampling the least contaminated sites should be sampled first. Sample bottles obtained from the laboratory must be checked to ensure that all necessary sample bottles have been provided. Depending on the distance to

the sampling location and expected time necessary to perform the sampling, same day shipment of samples should be considered.

For sampling events, on the day of sampling on-site weather conditions should be evaluated to determine whether they are suitable for sample collection. Water samples must not be collected in weather conditions that may affect the integrity of the samples (i.e. rain, high winds). Upon arrival at the site, the location of and access to the monitoring stations should be verified. Monitoring stations should be inspected to determine the condition of the station. Any abnormalities or problems with the station should be recorded in the field log book.

6.0 Surface Water/Stream Sediment Quality Sampling Procedures

This section describes procedures for collection of surface water and stream sediment samples. Surface water and sediment sampling shall be conducted in accordance with the generic methods and specific procedures described in this section. The surface water and sediment sampling methods and procedures described in this section apply to all Ministry personnel responsible for the collection of surface water/sediment samples. Deviations from these methods and procedures because of site-specific conditions should be documented in the Field Log book.

Sampling procedures for all surface water bodies will be conducted in an effective, step-wise manner. Equipment used to conduct surface water sampling will be properly decontaminated as described in Section 2.6.2 above. Sampling procedures will be documented. Appropriate surface water/sediment sampling procedures will be used at all times to ensure that the samples are representative of the surface water or sediment matrix. All sampling and monitoring techniques employed will be documented on the Water Monitoring Report form (Exhibit E) and in the Field Log book, as appropriate, to ensure data collection is properly documented.

6.1 General Considerations

Surface water quality sampling stations should be selected based on several factors, including: sampling objectives; type of water body and water use; location of point and nonpoint source discharges and tributaries; stream characteristics, stream bed, stream depth, turbulence; presence of structures (weirs, dams, etc.); and, accessibility. In estuarine systems, tidal effects must be considered when establishing sampling stations. The general guidelines described below are presented for information purposes. Detailed technical considerations can be found in several technical manuals and guidance documents.

Sample Site Selection

In Jordan, generally fresh water bodies typically include: (1) wadis (rivers and streams) or canals; and (2) reservoirs and oasis (lakes, pools). The general physical characteristics of these water bodies typically differ considerably, and sampling sites must be selected accordingly.

Wadis (Rivers and Streams) and Canals

For surface waters, areas that represent cross-sectional homogeneity typically should be selected as sampling sites. Bridges often provide good locations because of accessibility and because many points across the width of the water course may be sampled. However, these structures influence water flow patterns and sediment deposition. They also may not be suitable for specific wastewater or tributary source monitoring requirements. Wading to collect water samples in slow-moving wadis may result in increased sediment in the water column. Potential sampling locations should be well mixed or vertically or horizontally stratified. Because turbulence and water velocity affect mixing, sampling sites located immediately downstream of turbulent areas generally will insure good vertical mixing. If turbulent areas are not available, the sampling sites should be away from immediate sources locations (e.g., tributaries and industrial and municipal effluents).

Other general guidelines for sampling stations include:

- Sampling stations should be spaced with respect to time-of-water-travel instead of distance. USEPA guidelines (USEPA Region IV, 1992) suggest sampling stations should be located about one-half day time-of-water-travel for the first three days downstream of a waste source.

- Sampling stations for enhanced monitoring programs should be retained from the original program, if appropriate, so data from the two different programs can be compared.

- Sampling stations should be located where marked physical changes in the wadi channel exist.

- Sampling stations should be selected for major wastewater discharges and for major tributaries.

- Sampling stations should be established within reservoirs because time-of-water-travel through reservoirs generally is lengthy.

- Dams generally result in reaeration of oxygen deficient water. Stations therefore should be located immediately upstream and downstream from the dam structure so increases in dissolved oxygen (DO) can be measured.

- To study the effects of wastewater discharges or of tributary wadis, sampling stations should be located on the main wadi both upstream and downstream of the tributary or discharge. Extremely turbulent flow in the wadi is necessary to collect representative samples to measure the effect of a waste discharge or tributary immediately downstream of the source or tributary.

- Sampling stations at a location may vary depending on the width of the wadi and turbulence of the water in the wadi. Most flowing wadis in Jordan will have significant volumes of water and great width only after major precipitation events in the winter. Typically, the wadis will have narrow or shallow depth flow characteristics. If a wadi is less than 10 meters wide, a single grab sample collected from the middle of the wadi channel at mid-depth probably is adequate to represent the cross-section of the wadi. Sediment samples also may be collected from the middle of the wadi channel. For deeper water flow, a vertical composite sample may be collected from mid-stream, with samples collected from just below the surface, from mid-depth, and from just above the wadi bed. Dissolved oxygen, pH, temperature, specific conductance, and other in-situ measured parameters should be measured for each aliquot of the vertical composite. If broad water courses are encountered, samples should be collected from several locations across the channel width.

Reservoirs and Pools

Reservoirs are more likely to stratify with respect to water quality than wadis because of the lack of turbulent mixing and thermal differences. Because stratification predominantly is a result of water temperature differences, the cooler water is beneath the warmer water. A temperature profile of the reservoir water column will demonstrate the different thermal layers which should be sampled independently.

The number of sampling sites for a reservoir depends on the objectives of the monitoring program or investigation and the size and shape of the reservoir. For purposes of general water quality monitoring programs in Jordan, a single location generally is suitable for collecting samples from each stratified layer at or close to the deepest point of the reservoir. Measurements of DO, pH, temperature, specific conductance, and other parameters etc., should be conducted for an aliquot from each thermal layer. Typically for reservoirs constructed in wadi beds, the deepest point usually is near the dam.

For detailed comprehensive reservoir studies, multiple vertical sampling locations may be established across the reservoir. In reservoirs with protected bays or coves, additional sample locations may be established. Also, sample locations may be required where major tributaries enter the reservoir.

For sediment samples in reservoirs, the sampling locations should be near the center of water mass. Generally, coarser grained sediments are deposited near the headwaters of the reservoir, and finer grained sediments are deposited near the center of the water mass.

6.2 Grab Samples for Shallow Surface Waters

All sampling personnel should wear clean rubber gloves while sampling surface waters. Specific conductance and pH of the water should be measured and recorded on the Water Sampling Report form (Exhibit E) during the sampling process. The time and appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

For collecting grab samples from shallow surface waters, the following procedures should be followed:

1. Remove the sample bottles for the site from the coolers. All information indicated on the bottle label should be completed with an indelible ink marker or ball point pen.

2. Do not mix the caps or rinse the sample containers.

3. Measure in-situ field parameters and record the data in the Field Log book and Water Sampling Report form (Exhibit E).

4. Surface grab samples may be collected directly in the sample container. The risk of sample contamination can be reduced by sampling against the stream flow.

5. Carefully open and fill the bottles to the desired level. Some bottles may contain precisely measured amounts of chemical preservatives; care must be taken to avoid loss of preservative. Do not overfill containers unless specifically sampling for volatile organic compounds (VOCs).

6. Replace the cap and seal the containers tightly. Place the sample containers in a sealable plastic bag, if appropriate.

7. Immediately after the sample is collected, provide the following documentation as required:

   a. Label the sample bottle as specified in Section 2.5.4 above.

   b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

   c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

8. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

9. Discard contaminated personal protective clothing, as required.

6.3 Deep (Stratified) Water Sampling

Stratified waters or waters too deep to sample using the procedure in Section 6.2 above will be sampled using a Kemmerer bottle or equivalent method (e.g., Van Dorn sampler) as indicated below. The Kemmerer sampler is a cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position to allow free passage of water through the cylinder. The Van Dorn sampler is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample bottles. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

All sampling personnel should wear clean rubber gloves while sampling surface waters. Specific conductance and pH of the water should be measured and recorded on the Water Sampling Report form (Exhibit E) during the sampling process. The time and appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

1. Inspect the sampler bottle for thorough cleaning and ensure that the sample drain valve is closed (if bottle is so equipped).

2. Measure and then mark sample line at the desired sampling depth.

3. Open the bottle by lifting top stopper-trip head assembly.

4. Gradually lower the bottle until the desired level is reached (predesignated mark from Step 2).

5. Place the messenger on sample line and release.

6. Retrieve the sampler; hold the sampler by center stem to prevent accidental opening of bottom stopper.

7. Rinse and wipe off exterior of sampler body (wear proper gloves and protective clothing).

8. Recover the sample by grasping lower stopper and sampler body with one hand (gloved); transfer the sample by either (a) lifting top stopper with other hand and carefully pouring contents into sample bottles, or (b) holding drain valve (if present) over sample bottle and opening valve.

9. Allow the sample to flow slowly down the inside of sample bottle with minimal disturbance.

10. Preserve the sample, as appropriate.

11. Check that a Teflon liner is present in the cap if required. Secure the cap tightly.

12. Immediately after the sample is collected, provide the following documentation as required:

    a. Label the sample bottle as specified in Section 2.5.4 above.

    b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Monitoring Report form (Exhibit E).

    c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

13. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

14. Discard contaminated personal protective clothing, as required.

15. Decontaminate the sampler and messenger in accordance with procedures outlined in Section 2.6.2 above.

6.4 Composite Samples

A composite sample is a water quality sample collected over time. The sample typically consists of several separate (or discrete) samples which are combined or "composited" into a single sample. The USEPA Region IV (1992) identifies three types of composite samples for water quality monitoring:

- Time Composite (TC): A sample composed of a number of discrete samples collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.

- Flow Proportioned Composite (FPC): A sample collected proportional to the flow rate during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions discretely collected samples. The FPC is used when sampling wastewaters.

- Vertical Composite: A sample composed from grab samples collected from a vertical cross-section. Vertical composites should be composed of equal volumes of grab samples. Each grab sample should be collected in an identical manner.

Time composite and vertical composite samples typically will be based on the collection of individual grab samples. Specific procedures for collection of grab samples are presented in Section 6.2 and 6.3, above. These procedures should be followed when collecting each individual grab sample which will be used in the composite sample. These procedures apply whether a time composite or a vertical composite sample is desired.

The individual grab samples must be combined on an equal volume basis into a larger sample container (i.e., the composited sample). The composite sample container must be sufficiently large to hold the total volume of the composite sample and must be cleaned in accordance with established procedures for all sample containers. During collection the composite sample must be properly preserved and refrigerated to ensure the integrity and representativeness of the sample. This is particularly critical for time dependent composite

samples (e.g., 24 hour composite sample). Provisions must be made during the planning stages of the sampling program to provide for adequate refrigeration or cooling of the sample during the collection period. Once collected, the composite sample must be treated as any other sample with respect to labeling, preservatives and refrigeration, chain-of-custody procedures, and related.

Procedures for collecting flow proportioned composite samples which are representative of wastewater discharges or streams are presented in Section 9.0, below.

6.5 Stream Sediment Sampling

To collect sediment samples from a streambed, a variety of methods can be used. Dredging (Peterson, Eckman, Ponar), coring, and scooping (BMH-60) methods are available. Precautions should be taken to insure that the sample collected is representative of the streambed. These methods are discussed in the following paragraphs.

For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches the wadi bottom, because it can displace and miss lighter materials if allowed to drop freely. The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical approach to sediment deposition is desired for they preserve the sequential

layering of the deposit. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to weight- or gravity- driven devices. Coring devices are particularly useful in pollutant monitoring because the "shock wave" created by descent is minimal, thus the fines of the sediment-water interface are only minimally disturbed.

Caution should be exercised not to disturb the area to be sampled when the sample is obtained by wading in shallow water. The core tube is pushed into the substrate until only 10 centimeters or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is pushed will facilitate greater penetration and cut down on core compaction. The tube is then capped with a plug or a sheet held in place by a rubber stopper or cork. After capping, the tube is slowly extracted, the negative pressure and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too is capped.

All sampling personnel should wear clean rubber gloves while sampling stream sediments. The time and appearance of the sediment sample and odor should be recorded on the Water Sampling Report form (Exhibit E). Cofferdam and core barrel device techniques as discussed below for shallow stream beds can be used for collection of stream sediment samples.

1. Set a precleaned, one meter length of casing pipe (20 cm diameter) on the stream bottom to be sampled. Remove the bottom plug from the device.

2. Set the precleaned 5-centimeter diameter core sampler inside the 20 cm diameter casing and push into the stream bottom a distance of 20 to 40 cm.

3. Close the air escape vent on the core sampler and retract the sampler from the stream bottom and casing pipe. Remove casing pipe.

4. Place the core sample onto a stainless steel or Teflon tray and remove the sediment contents with a precleaned stainless steel lab spoon or equivalent and place the sample into appropriate containers.

5. Check for a Teflon liner in the cap if required and secure cap tightly.

6. Immediately after the sample is collected, provide the following documentation as required:

   a. Label the sample bottle as specified in Section 2.5.4 above.

   b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

   c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

7. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

8. Discard contaminated personal protective clothing, as required.

9. Decontaminate the sampler in accordance with procedures outlined in Section 2.6.2, above.

Regardless of the method of collection, sediment samples collected for chemical analysis should be thoroughly mixed (except for purgeable organic compounds analysis) before being placed in the appropriate sample containers.

6.6 Collection of Quality Control Samples

Quality control samples will be collected for all surface water and sediment sampling events. At a minimum, one equipment blank should be collected each day of sampling, or one equipment blank should be collected for every ten samples, whichever is greater. Equipment blanks are taken in the field by pouring reagent grade water provided by the laboratory through the sampling device prior to sampling. The blank is immediately poured into the sample bottles, which are preserved and labeled as ordinary ground-water samples.

Field blanks should be collected wherever ambient sources of contamination, such as heavy industrial traffic, chemical storage in tanks or holding ponds, etc., exist, as such conditions may affect the quality of the samples collected.

Trip blanks will be provided by the laboratory and will accompany sample shipments of volatile organic compounds.

A duplicate sample should be obtained for every 10 samples collected or for each periodic sampling event for each sampling program.

More detailed discussion of quality control samples is presented in Section 2.4.

6.7 Special Sample Collection Techniques

Samples for microbiological (bacteriological) analyses must be collected in bottles properly sterilized and protected from contamination. The preferred collection method is to scoop up the water with the open bottle just below the surface. While the bottle is open, both bottle and stopper must be protected against contamination. A small amount of water should be poured from the bottle after filling to leave an air space for subsequent shaking in the laboratory. The bottle should be closed at once.

When sampling from a bridge, the sterilized sample bottle can be placed in a weighted frame; opened; and then lowered to the water with a string or rope. The bottle also can be lowered by attaching rope or string directly to it. Care should be taken not to dislodge dirt or other material from the bridge that may fall into the open bottle. The mouth of the bottle may be faced upstream by swinging the bottle downstream under the bridge and dropping it quickly but without excessive slack in the rope. The bottle is then pulled upstream and out of the water.

6.8 Field Equipment Cleaning Procedures

If needed, field decontamination procedures should be the same as the equipment decontamination procedures specified in Section 2.6.2 above. Sampling personnel should always attempt to sample the least contaminated stations first (if known), as an additional precaution against introducing contaminants into samples. If decontamination is performed

in the field, all rinse water should be contained in a manner which prevents the introduction of contamination to surface water, boreholes, and adjacent areas. All rinsate should be collected in a compatible container and properly disposed of to prevent contamination of adjacent areas.

6.9 Field Log Book and Field Report Form

In addition to the standard sample entries in the Field Log book, the following information should be entered using waterproof ink:

- Sample station identification number
- Sample volume and method
- Surface water station sampling sequence
- Analyses requested

7.0 Ground Water Sampling

This section describes procedures for collection of ground water samples. Ground water sampling shall be conducted in accordance with the generic methods and specific procedures described in this section. The ground water sampling methods and procedures described in this section apply to all Ministry personnel responsible for the collection of ground water samples. Deviations from these methods and procedures because of site-specific conditions should be documented in the Field Log book.

Sampling procedures for all ground water aquifers will be conducted in an effective, step-wise manner. Equipment used to conduct ground water sampling will be properly decontaminated as described in Section 2.6.2 above. Sampling procedures will be documented. Appropriate sampling procedures will be used at all times to ensure that the samples are representative of the ground water conditions in the aquifer. All sampling and monitoring techniques employed will be documented on the Water Sampling Report form (Exhibit E) and in the Field Log book, as appropriate, to ensure data collection is properly documented.

7.1 General Considerations

Ground water quality monitoring wells typically are selected based on several factors, including: sampling objectives; ground water aquifer and ground water use; location of potential sources which may impact ground water quality; aquifer characteristics and depth to ground water; presence of pumps or other devices for recovering water from the well; and, accessibility. The general guidelines described below are presented for information purposes. Detailed technical considerations can be found in several technical manuals and guidance documents.

Ground water usually is sampled from a well installed into the aquifer being monitored. However, ground water may be sampled if present in a pit or a hole. Ground water quality monitoring wells should be selected considering the following factors:

- Direction of ground water flow, depth to ground water, thickness of the aquifer (if applicable);

- Topography, surface drainage patterns, and land use;
- Stratigraphy and depth to bedrock;
- Surface features such as rock outcrops, seeps, springs, wadis, and wet areas;
- Locations of potential pollution sources.

Generally, wells should be purged before ground water samples are collected from the well in order to remove stagnant water from the well. Stagnant water is not representative of aquifer conditions. Typically, three to five volumes of standing water in the well are removed during the purging process until the specific conductance, temperature, and pH of the ground water stabilizes. Normally, a combination of these two practices is used (i.e., specific conductance, temperature, and pH are measured at intervals; and three to five volumes are purged). For a well pumped dry during purging, the well may be sampled following recovery.

A variety of techniques may be used to purge a monitoring well. Monitoring wells may be purged using in-place plumbing/pumps. In wells where in-place pumps are not common, other techniques may be used including: peristaltic, turbine, bladder, centrifugal, or other pumps, depending on well depth; bailers or Kemmerer type samplers; or, depending on applicability, packer and pump systems.

Regardless of the method used for purging, techniques should be applied to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during purging or should they accidentally come into contact with the ground surface. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool, both during transporting and during field use, to further minimize contamination from the transporting vehicle or ground surface.

Typically in Jordan, most ground water aquifers are located at substantial depth generally exceeding 100 meters. In addition, most ground water quality monitoring wells are large production wells (approximately 25 cm diameter) and have extensive open intervals or screened length. For routine ground water quality monitoring, the purging process can be problematic. For these reasons use of bailers and many pumps is not suitable for purging of the water column. In addition, substantial volumes of water would be lost in the purging process.

Consequently, the ground water quality monitoring procedures specified in this section consider application of three sampling techniques: (1) sampling from operating production wells; (2) sampling from shallow (< 100 meters), small diameter, short screen length wells using bailers or pumps; and (3) sampling from moderate depth (< 200 meters) small diameter wells using packer assemblies and suitable submersible pumps.

7.2 Sampling from Shallow Wells Using Bailers or Pumps

This section describes the general technique for sampling ground water aquifers accessible from shallow, small diameter monitoring wells. The general procedure is to measure the depth to the water level and total well depth to calculate the volume of water to be purged prior to sample collection. Then, the sample is collected and labeled for proper handling and transport.

7.2.1 Water Level Measurement

The water level in the well will be measured using an electric water level indicator or equivalent device. This is accomplished by inserting the electric probe into the well, lowering the probe until ground water is encountered (as signaled by the indicator or device), and recording the depth to ground water. The depth to ground water measurement will be recorded on the Water Sampling Report form (Exhibit E). All measurements should be made and recorded to the nearest centimeter (cm), if possible.

In cases where immiscible phase constituents may be found (if any) and must be measured, a water-product interface probe should be used. Measurement of depth to product and depth to water must be made carefully by slowly lowering the probe until the signal on the water level meter sounds. This technique should be repeated to ensure accuracy, and the measurement should be recorded on the Water Sampling Report form (Exhibit E).

7.2.2 Well Depth Measurement

The total depth of each well sampled using this technique should be measured annually. The measurement will be used in the calculation of the volume of water standing in the well casing. The depth will be measured utilizing either an electric water level indicator or, if contamination is known or suspected, a weighted, disposable line.

The weight will be lowered slowly into the well until the bottom is encountered. The weight will be raised and lowered until it is resting on the well bottom and tension on the tape/line is maintained. The total well depth from the top of the casing should be measured to the nearest centimeter. If a disposable line is used, the line should be marked at the well measuring point and the total length of the line and weight should be measured using a steel tape. The measurement should be recorded on the Water Sampling Report form (Exhibit E).

7.2.3 Well Evacuation

All monitoring wells should be purged before taking samples in order to remove stagnant water from the well casing and to assure that water removed for analysis is representative of true water quality in the aquifer. For moderate to high yield wells (i.e., wells that are not purged to dryness), a minimum of three well volumes will be evacuated from the well. Additional water will be removed from the well, if necessary, until three consecutive measurements of pH and specific conductivity from successive purge volumes vary by 10% or less, or until five well volumes have been removed. If a well is evacuated to dryness the well will be sampled following recovery.

To determine the volume of water standing in the well, the following metric formula is used:

$$V=0.314\, d^2\, h$$

where: h = water column length (meters) [well depth - depth to water]
d = diameter of well (centimeters)
V = volume of water (liters)

Well evacuation can be accomplished using a variety of pumps or by bailers. If pumps are lowered into the water column (e.g., submersible pumps), the pump must be cleaned as specified in Section 2.6.2. For suction lift or centrifugal pumps only the intake line is placed into the water column. For pumps, a check valve must be installed along the intake purge line to minimize back wash of water. To minimize the possibility of contamination, the line placed into the water should be either cleaned teflon or stainless steel.

Teflon, PVC or stainless steel bailers also can be used for evacuation. All bailers should be raised and lowered into the well using new nylon line, which will be disposed of between

wells. The evacuation point should be near the bottom of the well when the screen is set above the bottom of the well and just below the water surface when the screen is set near the bottom of the well.

All sampling personnel should wear clean rubber gloves while evacuating and sampling a monitoring well. After water evacuation and sampling, all hoses or bailers that come in contact with the water should be decontaminated. The evacuated water should be discharged away from the well or should be containerized and properly disposed if site conditions warrant this degree of handling. Specific conductance and pH of the water should be measured and recorded on the Water Monitoring Report form (Exhibit E) after each well volume has been evacuated. This will serve as an indicator of purging completeness. For low yield wells, indicator parameters should be measured again just prior to sample collection after the well has recovered. The time, volume purged, appearance of water and odor should be recorded on the Water Monitoring Report form (Exhibit E) along with indicator parameters measurements for each measurement event.

7.2.4 Sample Collection

As soon as sufficient recharge has occurred or at the end of evacuation, the samples will be collected using an acceptable bailer, or a suitable pump. For samples collected by bailers, the procedure will be as follows:

1. Remove the sample bottles for the site from the coolers. All information indicated on the bottle label should be completed with an indelible ink marker or ball point pen.

2. Do not mix the caps or rinse the sample containers.

3. The sample bailer used for well evacuation will be used to obtain the samples for the well. For sample collection, the bailer will be lowered with minimum splash to just below the water surface and allowed to fill.

4. The bailer then will be removed and sample bottles will be filled in the following order. The bailer may be lowered several times into the well to collect sufficient volume for the required analyses:

- volatile organic compounds (VOC)
- purgeable organic carbon (POC)
- purgeable organic halogens (POX)
- total organic halogens (TOX)
- total organic carbon (TOC)
- semi-volatile (extractable) organic compounds
- total metals
- dissolved metals
- phenols
- cyanide
- sulfate and chloride
- turbidity
- nitrate and ammonia
- other parameters
- radionuclides

5. Carefully open and fill the bottles to the desired level. Some bottles may contain precisely measured amounts of chemical preservatives; care must be taken to avoid loss of preservative. Do not overfill containers unless specifically sampling for volatile organic compounds (VOCs).

6. Replace the cap and seal the containers tightly. Place the sample containers in a sealable plastic bag, if appropriate.

7. Immediately after the sample is collected, provide the following documentation as required:

   a. Label the sample bottle as specified in Section 2.5.4 above.

   b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

   c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

8. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

9. Discard contaminated personal protective clothing, as required.

For samples collected by pumps, the general procedure specified above for bailers will be followed except the sample bottles may be filled directly from the pump discharge tubing.

7.3 Sampling from Production Wells

This section describes the general technique for sampling ground water aquifers accessible from production wells. The principal difference between these procedures and those for sampling using bailers or portable pumps is the purging process. Generally, it will not be possible to measure the depth to the water level and the purging process may be very limited. In addition, substantially less purging and sampling field equipment may be required to collect the sample or to purge the well prior to sample collection.

7.3.1 Well Evacuation

The objective of purging or well evacuation for production wells is the same as with monitoring wells where portable pumps or bailers are used. That is, the ultimate purpose is to collect a sample representative of the ground water in the aquifer. The volume of water to be purged depends on several factors. These include whether the production pumps are running continuously or intermittently, whether the sample can be collected close to the source, and whether any storage/pressure tanks exist between the sampling point and the pump. If storage/pressure tanks are present, an adequate volume must be purged to totally exchange the volume of water in the tanks.

If the production pump runs continuously, and the sample can be collected prior to a storage/pressure tank, no extensive purging is required. Generally, the only purging required is to open the sampling valve to allow the water to flush through the valve for a few minutes.

If the pump runs intermittently, it is necessary to determine the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump then should be run continuously until the required volume has been purged.

All sampling personnel should wear clean rubber gloves while evacuating and sampling the production well. The evacuated water should be discharged away from the well or should be containerized and properly disposed if site conditions warrant this degree of handling. Specific conductance and pH of the water should be measured and recorded on the Water Sampling Report form (Exhibit E) during evacuation. This will serve as an indicator of purging completeness. The time, volume purged, appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

7.3.2 Sample Collection

After the production well has been purged, the sample may be collected. The sample may be collected directly into the sample bottles as described in Section 7.2.4 above for shallow wells. Samples should be collected following purging from a valve or cold water tap as near to the well as possible. Samples should be collected directly into the appropriate containers. Also, refer to the Drinking Water Quality Sampling Procedures described in Section 8.0.

7.4 Sampling From Wells Using Packer Assemblies

Packers may be used down a borehole or well to seal off a specified section for collection of ground water samples. In Jordan, use of double packer assemblies may provide a means to collect representative ground water samples from deep wells (> 150 meters) which have lengthy screened intervals or open hole sections. In these situations, the use of downhole, inflatable packers would permit collection of representative samples with minimal purging requirements. Typically, the difficulty with packers is the extensive field support and potential heavy equipment required for their use.

This section outlines the general technique for sampling ground water aquifers from monitoring wells or boreholes using double packer assemblies. Because packer assemblies typically are designed for specific uses, detailed instructions for using these techniques to collect a representative ground water sample must be developed after the assembly is designed and constructed. Typically, however, the packer assembly is lowered to the desired depth in a well or borehole. The lower and upper packers are inflated using air or nitrogen gas. Inflating the packers seals off the zone or section of the well casing or borehole to be sampled.

7.4.1 Well Evacuation

The sealed-off zone of the well or borehole then is purged through a tube connected through an opening in the upper packer. The tube connects to the land surface. Purging typically is assisted using a pump. The objective of purging or well evacuation is the same as when sampling shallow monitoring wells using portable pumps or bailers. That is, the ultimate purpose is to collect a sample representative of the ground water in the aquifer. The volume of water to be purged can be calculated based on the diameter of the borehole or well casing and the length of the section separated by the upper and lower packers. The same general principles regarding purging using a pump with packers apply as for using a pump in a shallow monitoring well without packers.

All sampling personnel should wear clean rubber gloves while evacuating and sampling the monitoring well. The evacuated water should be discharged away from the well or should be containerized and properly disposed if site conditions warrant this degree of handling. Specific conductance and pH of the water should be measured and recorded on the Water Sampling Report form (Exhibit E) during evacuation. This will serve as an indicator of purging completeness. The time, volume purged, appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

7.4.2 Sample Collection

As soon as the monitoring well has been sufficiently purged, the sample may be collected. The sample may be collected from the discharge tubing directly into the sample bottles as described in Section 7.2.4 above for shallow wells.

7.5 Collection of Quality Control Samples

Quality control samples will be collected for all ground water sampling events. At a minimum, one equipment blank should be collected each day of sampling, or one equipment blank should be collected for every ten samples, whichever is greater. Equipment blanks are taken in the field by pouring reagent grade water provided by the laboratory through the bailer or other sampling device prior to sampling. The blank is immediately poured into the sample bottles, which are preserved and labeled as ordinary ground-water samples.

Field blanks should be collected wherever ambient sources of contamination, such as heavy industrial traffic, chemical storage in tanks or holding ponds, etc., exist, as such conditions may affect the quality of the samples collected.

Trip blanks will be provided by the laboratory and will accompany sample shipments of volatile organic compounds.

A duplicate sample should be obtained for every 10 samples collected or for each periodic sampling event for each sampling program.

7.6 Field Equipment Cleaning Procedures

If needed, field decontamination procedures should be the same as the equipment decontamination procedures specified in Section 2.6.2 above. Sampling personnel should always attempt to sample the least contaminated wells first (if known), as an additional precaution against introducing contaminants into wells/samples. If decontamination is performed in the field, all rinse water should be contained in a manner which prevents the introduction of contamination to surface water, boreholes, and adjacent areas. All rinsate should be collected in a compatible container and properly disposed of to prevent contamination of adjacent areas.

7.7 Field Log Book and Field Report Form

In addition to the standard sample entries in the Field Log book, the following information should be entered using waterproof ink:

- Well identification number
- Total depth of well (if measured)
- Depth to water, measurement technique
- Well yield
- Purge volume and method
- Sample volume and method
- Well sampling sequence
- Analyses requested

8.0 Drinking Water Quality Sampling Procedures

8.1 General

Water quality samples collected from drinking water supplies must be representative of the water supply being sampled. As with other water quality monitoring programs, poor sampling techniques may produce inaccurate data. Generally, the same care and techniques used for collecting water quality samples from surface waters or ground waters (including sample collection documentation) described in Sections 6.0 and 7.0, above, also apply to drinking water quality monitoring.

8.2 Sample Site Stations

In Jordan, drinking water sources are sampled at production wells, water works facilities (reservoirs, pumping stations, transfer stations), and from within the water distribution system or network. This section outlines the general techniques for sampling drinking water supplies from these types of facilities and systems.

8.2.1 Production Wells

When water samples are collected from wells, the wells must be purged before the sample is collected. Section 7.3 provides general information and techniques for collecting ground water samples from production wells. These procedures are designed to ensure that ground water representative of the aquifer is collected and not the standing water in the well casing or borehole and associated pipes or holding tanks. These procedures should be followed when collecting drinking water samples from production wells.

Typically, at least one volume of water in the well casing or borehole and storage tank must be evacuated prior to sample collection. After one well volume is purged, the pH, specific conductivity, and temperature in the water stream should be measured until constant values are obtained. If a tap is used for collecting the sample after the well is purged, the tap should be left open for several minutes with the water running to ensure that any chemical contaminants that may be in the area of the tap due to external sources have been removed.

8.2.2 Water Works and Distribution Systems

Potable water samples should be representative of the water quality within the water works facility or for a given segment of a distribution network. Taps selected for sample collection should be supplied with water from a service pipe connected directly to the water works facility or to a water main in the segment of interest of the distribution system. The taps should not be separated from the water works facility or segment of interest by a storage tank.

The tap used for sampling must be protected from any exterior contamination associated with being too close to a sink bottom or to the ground. Chemically contaminated water or soil from the faucet (tap) exterior may enter the bottle during the collecting procedure because it is often difficult to place a bottle under a tap close to the ground or a sink without grazing the bottle's neck interior against the outside surface of the faucet. In addition, leaking taps which allow water to flow out from around the stem of the valve handle and down the outside of the faucet must be avoided as sampling locations. Taps in which water tends to run up on the outside of the lip also must be avoided as sampling locations. Aerator, strainer, and hose attachments on the tap must be removed before sampling. These devices can harbor bacterial populations particularly if they are not cleaned regularly or replaced when worn or cracked. If a steady stream of water cannot be obtained from a tap, after these devices have been removed, a more suitable tap should be used for collecting the water quality sample.

Taps where the flow of water is not steady should be avoided because fluctuations in line pressure may cause sheets of microbial growth that are lodged in some pipe section or faucet connection to break loose. The tap should be opened for several (two or three) minutes or for sufficient time to permit clearing the service line until a smooth-flowing stream of water at moderate pressure without splashing is achieved. Then, without changing the water flow, the samples can be collected.

8.3 Sample Collection

All sampling personnel should wear clean rubber gloves while cleaning sample taps or faucets, while purging the water line, and during sampling. Specific conductance and pH of the water should be measured and recorded on the Water Sampling Report form (Exhibit E). The time, volume of water purged, and appearance of water and odor should be

recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

Samples should be collected using the following procedure:

1. Remove the sample bottles for the site from the coolers. All information indicated on the bottle label should be completed with an indelible ink marker or ball point pen.

2. Do not mix the caps or rinse the sample containers.

3. After the water line has been purged, the outside surface of the tap or faucet should be decontaminated with alcohol. A cotton swab soaked with alcohol may be used to wipe the outside surface of the tap or water. Then the water should be allowed to flow freely again for two or three minutes.

4. The sample bottles then should be filled.

5. Carefully open and fill the bottles to the desired level. Some bottles may contain precisely measured amounts of chemical preservatives; care must be taken to avoid loss of preservative. Do not overfill containers unless specifically sampling for volatile organic compounds (VOCs).

6. Replace the cap and seal the containers tightly. Place the sample containers in a sealable plastic bag, if appropriate.

7. Immediately after the sample is collected, provide the following documentation as required:

   a. Label the sample bottle as specified in Section 2.5.4 above.

   b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

8. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

9. Discard contaminated personal protective clothing, as required.

8.4 Special Sample Collection Techniques

Occasionally, samples are collected to determine the contribution of transmission pipes to the quality of water in private residences or other end users. For example, the purpose of a study may be to determine if lead is being dissolved into the potable water supply. In these cases, the water source should not been used for a specific time interval (e.g., over a weekend or a three- or four-day holiday period). Samples may be collected of the initial release of water, after several minutes, and after the system has been completely purged.

During sample collection, the bottle cap should not be placed on the ground or in a pocket. The bottle should be held in one hand and the cap in the other, using care not to touch the inside of the cap. The same care applies to Teflon® liners found in certain bottle caps. The inside of the sample bottle should not come into contact with fingers or the faucet. If microbiological samples are being collected, the sample bottle should not be rinsed before use. This may contaminate the bottle and also will remove the thiosulfate dechlorinating agent (if used). Care should be taken so that drops of water splashing from the ground or sink do not enter into either the bottle or cap. To prevent dislodging of particles in the pipe or valve, the stream flow should not be adjusted while sampling.

At water treatment plants, water quality samples should be collected both from the raw water supply and after chlorination.

8.5 Collection of Quality Control Samples

Quality control samples will be collected for all drinking water sampling events. Generally equipment blanks will not be collected because no sampling equipment is used to collect these samples. Field blanks should be collected wherever ambient sources of contamination.

such as heavy industrial traffic, chemical storage in tanks or holding ponds, etc., exist, as such conditions may affect the quality of the samples collected. Trip blanks will be provided by the laboratory and will accompany sample shipments of volatile organic compounds.

A duplicate sample should be obtained for every 10 samples collected or for each periodic sampling event for each sampling program. Triplicate samples should be collected for purgeable organic compounds analyses and duplicate samples for bacterial analyses.

8.6 Field Log Book and Field Report Form

In addition to the standard sample entries in the Field Log book, the following information should be entered using waterproof ink:

- Station name and identification number
- Well identification number (as appropriate)
- Well yield (as appropriate)
- Purge volume and method
- Sample volume and method
- Sampling sequence
- Analyses requested

9.0 Wastewater Quality Sampling Procedures

This section describes procedures for collection of wastewater quality samples. Wastewater quality sampling shall be conducted in accordance with the generic methods and specific procedures described in this section. The wastewater quality sampling methods and procedures described in this section apply to all Ministry personnel responsible for the collection of wastewater samples. Deviations from these methods and procedures because of site-specific conditions should be documented in the Field Log book.

Sampling procedures for wastewaters will be conducted in an effective, step-wise manner. Equipment used to conduct wastewater sampling will be properly decontaminated as described in Section 2.6.2 above. Sampling procedures will be documented. Appropriate wastewater quality sampling procedures will be used at all times to ensure that the samples are representative of the wastewater stream. All sampling and monitoring techniques employed will be documented on the Water Sampling Report form (Exhibit E) and in the Field Log book, as appropriate, to ensure data collection is properly documented.

9.1 General Considerations

The collection of wastewater quality samples is highly dependent on the wastewater stream to be sampled, the process generating the wastewater, and how a representative sample of the wastewater can be obtained. These section provides some basic principles and procedures for the collection of wastewater quality samples. More detailed procedures may be found in technical manuals such as the USEPA's NPDES Compliance Inspection Manual and Monitoring Industrial Wastewater. The following factors should be considered when collecting a representative wastewater sample:

- Sampling sites must be selected were the wastewater is well mixed. These locations tend to be near the center of the flow channel where turbulence is great and solids settling is minimal. Skimming the water surface or dragging the channel bottom should be avoided.

- If the wastewater stream is in a wide channel, cross-sectional sampling should be considered as is discussed for surface water sample collection (Section 6.0).

- If manual compositing is planned, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

9.2 Site Selection

To the extend possible, wastewater samples should be collected from the location specified in the municipal or industrial wastewater discharge authorization, if applicable. Otherwise the following general locations represent typical sampling sites for wastewater quality studies:

Influent

Influent wastewaters generally are sampled at locations of highly turbulent flow into a wastewater treatment facility in order to ensure good mixing. Preferred influent wastewater sampling locations include: (1) the upflow siphon following a comminutor (in absence of grit chamber); (2) the upflow distribution box following pumping from main plant well; (3) flume throat; or (4) pump well when the pump is operating. In industrial plants, different wastewater streams may be of interest for water quality purposes. These independent streams may be sampled after the process generating the wastewater and before the stream mixes with other process streams.

Effluent

Effluent wastewaters from treatment processes should be sampled at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters or dry wadi bed.

Pond and Basin Sampling

Effluent wastewater samples from ponds and basins generally should be composite samples. Composite sampling is preferred because ponds and basins may have flow paths that short circuit the theoretical detention time for the basin or pond. Grab samples may be collected if the discharge from the pond or basin has been determined to be representative of the waste stream.

100

9.3 General Sampling Practices

The objectives of a wastewater monitoring program must be established prior to conducting sampling activities. Routine monitoring may be performed by collecting grab samples. However, if detailed characteristics of the wastewater stream or the performance of wastewater treatment are of interest, then composite sampling typically is required. Both sample collection and flow measurement must be conducted for a complete evaluation of a wastewater treatment plant. The wastewater flow variability must be established before such a sampling strategy can be determined.

A composite sampling strategy typically will be based on collection of flow proportional or time composite samples. The specific strategy will depend on the variability of the wastewater flow, the concentration variations in the flow (if known), equipment, and sampling site. Generally, flow proportional sample will be collected if little is known about the wastewater treatment facility or if there is significant variability in the wastewater flow. If there is not significant variability in the wastewater flow patterns, time composite samples may be collected.

Typically time composite samples are collected with a constant time interval between samples. Time composite samples may be collected manually or with automatic samplers. Flow proportional samples also may be collected automatically with an automatic sampler or manually. If an automatic sampler is used, then a flow measuring device must be used concurrently to ensure proper collection of proportional samples.

9.4 Collection of Grab Samples

Grab samples may be collected for routine monitoring and for immediate in-situ field analyses. Grab samples also may be collected instead of using automatic sampling equipment for composite sampling, especially when unusual wastewater stream conditions are observed.

Grab samples should be collected into the actual sample container sent to the laboratory for analysis. This is particularly important for collection of samples to be analyzed for microbiological parameters. An intermediate sampling container may be used to collect the wastewater sample with subsequent redistribution to the sample containers to be delivered

to the laboratory. If an intermediate container is used, the container must be properly cleaned as discussed in general terms in Section 2.6.2. The container also should be constructed of materials suitable for sampling purposes. Separate containers should be used for each sampling station to prevent cross-contamination between sampling stations.

Grab samples should be collected by tipping the sample container in the wastewater stream so that the mouth of the container faces upstream. The container should be rinsed at least twice using this procedure before the sample is collected. Sample containers with preservatives should not be rinsed prior to collection of the sample.

All sampling personnel should wear clean rubber gloves during sampling. The time/volume of sample collection and appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

Samples should be collected using the following procedure:

1. Remove the sample bottles for the site from the coolers. All information indicated on the bottle label should be completed with an indelible ink marker or ball point pen.

2. Do not mix the caps or rinse the sample containers.

3. Tip the sample container in the wastewater stream so that the mouth of the container faces upstream. The container should be rinsed at least twice using this procedure before the sample is collected. Sample containers with preservatives should not be rinsed prior to collection of the sample. Fill the bottles to the desired level. Do not overfill containers unless specifically sampling for volatile organic compounds (VOCs).

4. Replace the cap and seal the containers tightly. Place the sample containers in a sealable plastic bag, if appropriate.

5. Immediately after the sample is collected, provide the following documentation as required:

a. Label the sample bottle as specified in Section 2.5.4 above.

b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

6. Place the sample in the cooler and prepare for shipping as specified in Section 2.5.4 above.

7. Discard contaminated personal protective clothing, as required.

9.5 Sample Collection Using Automatic Samplers

Automatic samplers typically are used when a station is to be sampled at frequent intervals or when a continuous sample is desired. Basic requirements for automatic samplers include:

- Sampling equipment must be properly cleaned to avoid cross-contamination from prior use;
- No plastic/metal parts of the sampler should contact the wastewater stream when parameters to be analyzed could be impacted by these materials;
- Adequate refrigeration (electrically supplied or ice) is required for the automatic sampler during the sampling period;
- Sufficient sample must be collected using the automatic sampler for all parameters to be analyzed;
- A minimum of 100 milliliters should be collected each time the sampler is activated if a peristaltic pump is used.
- The intake line to the pump must be purged before each sample is collected.

- An adequate power source should be available to operate the sampler for 48 hours at a 30-minute sampling interval.

The specific operating instructions, installation requirements, capabilities, and related technical information for the automatic samplers are presented in the manufacturer's specifications and operations and maintenance manuals.

9.5.1 General Equipment Installation

Automatic samplers may be used to collect time composite or flow proportional samples. When flow proportional samples are collected, the samplers are activated by a compatible flow meter. Alternatively, flow proportional samples may be collected using a discrete sampler and a flow recorder and then manually compositing the individual aliquots in flow proportional amounts. New tubing for the pump and the sample train) should be used each time the sampler is installed. Specific installation procedures include tubing preparation, sampler positioning in the wastewater stream, and sampler programming. These procedures are described in the manufacturer's operations manual.

For time composite sampling, the sampler typically would be programmed to collect 200 mls at 30-minute intervals or 100 mls at 15-minute intervals into a refrigerated 3-gallon glass jug. For a 5-gallon compositing container, the volume should be increased accordingly.

For flow proportional sampling, the sampler typically would be programmed to collect a minimum of 100 mls for each sample interval. The sample interval will be based on the flow of the waste stream.

9.5.2 Sample Collection

All sampling personnel should wear clean rubber gloves during sampling. The time of sample collection, volume sampled, and appearance of water and odor should be recorded on the Water Sampling Report form (Exhibit E) along with the indicator parameters measurements for each measurement event.

After the 24-hour sampling period, the sample contents of the compositing container should be stirred and siphoned or poured (if visible solids are noted) into the respective containers,

followed by immediate preservation, if required. Immediately after the sample is collected, provide the following documentation as required:

a. Label the sample bottle as specified in Section 2.5.4 above.

b. Enter the sample information in the Field Log book as specified in Section 2.5.2 above and complete the Water Sampling Report form (Exhibit E).

c. Fill out the Chain-of-Custody form (Exhibit A) as specified in Section 2.5.4 above.

The samples should be placed in the cooler and prepared for shipping as specified in Section 2.5.4 above.

Contaminated personal protective clothing should be discarded, as required.

9.5.3 Automatic Sampler Security

Consistent with all water quality sampling programs, sample documentation and integrity must be maintained throughout the composite sampling process. All monitoring personnel involved in supervising and operating the composite sampling event should be informed of this requirement. A lock or seal may be placed on the automatic sampler to detect tampering. However, tampering with the sample collection tubing also must be prevented.

9.5.4 Special Maintenance, Calibration, and Quality Control Requirements

This subsection outlines general practices applicable to automatic samplers.

Prior to each sampling event, sampler operation should be thoroughly checked. The desiccant should be checked and replaced, if necessary. The batteries or other power source should be checked. Three cycles of purge-pump-purge for the forward, reverse, and automatic operating cycles should be checked.

In the field prior to initiating sampling, the purge-pump-purge cycle shall be checked at least once. The constant pumping volume should be checked at least twice using a calibrated

container, and the flow pacer that activates the sampler shall be checked for proper operation.

After the sampling event, the sampler should be re-examined for damage and repair, if necessary. The desiccant should be checked and replaced, if appropriate. Sampler operation (forward, reverse, automatic) should be checked. The sampler should be cleaned consistent with procedures outlined in Section 2.6.2 and the manufacturer's manual.

The automatic sampler should be maintained in accordance with the manufacturer's specifications and maintenance schedule. These checks and required calibrations should be documented in accordance with the procedures specified in Section 2.6.

9.6 Collection of Quality Control Samples

Quality control samples will be collected for all wastewater sampling events. At a minimum, one equipment blank should be collected each day of sampling, or one equipment blank should be collected for every ten samples, whichever is greater. Equipment blanks are taken in the field by pouring reagent grade water provided by the laboratory through the sampling device prior to sampling. The blank is immediately poured into the sample bottles, which are preserved and labeled as ordinary ground-water samples.

Field blanks should be collected wherever ambient sources of contamination, such as heavy industrial traffic, chemical storage in tanks or holding ponds, etc., exist, as such conditions may affect the quality of the samples collected.

Trip blanks will be provided by the laboratory and will accompany sample shipments of volatile organic compounds.

A duplicate sample should be obtained for every 10 samples collected or for each periodic sampling event for each sampling program.

More detailed discussion of quality control samples is presented in Section 2.4.

9.7 Special Sample Collection Procedures

Personnel collecting wastewater samples always should wear a new pair of disposable surgical gloves with each set of samples collected and change the gloves as often as needed. This is necessary to prevent cross-contamination.

Trace Organic Compounds and Metals

Detection limits for organic compounds and metals typically are in the micrograms per liter (parts per billion) range. Consequently, extreme care must be exercised to insure sample integrity. All containers, composite bottles, tubing, etc., used in collecting samples for analyses of organic compounds and metals should be prepared as generally described in Section 2.5.1 and Section 2.6.2.

Samples should be collected directly into the sample container. Intermediate collection device should be constructed of Téflon®, glass, or stainless steel vessel.

Microbiological

Samples for bacterial analysis always should be collected directly into the prepared glass sample bottle. The sample bottle should be kept unopened until it is to be filled. When the cap is removed, care should be taken not to contaminate the cap or the inside of the bottle. The bottle should be held near the base and filled to within about two centimeters of the top without rinsing and recapped immediately. The bottle should be plunged, neck downward, below the surface and turned until the neck points slightly upward. The mouth should be directed toward the current.

Immiscible Liquids/Oil and Grease

Oil and grease may be present in wastewater as a surface film, an emulsion, a solution, or as a combination of these forms. Since it is very difficult to collect a representative sample for oil and grease analysis, carefully evaluation of a sampling point is required. Locations of significant mixing of the wastewater stream are preferred. Because losses of oil and grease will occur on sampling equipment, the collection of a composite sample is impractical.

Volatile Organic Compounds (VOC)

Samples for analysis of volatile organic compounds should be collected in 40-ml septum vials with screw caps with a Teflon® lined silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program. Triplicate samples should be collected from each location. If the water contains no chlorine, three 40-ml vials containing four drops of concentrated HCl should be filled with the sample. The samples may be held up to 14 days before analysis. When preservation (HCl) is not feasible, samples can be held up to 7 days before analysis for volatile aromatic hydrocarbons and 14 days for volatile hydrocarbons compounds.

If the water contains chlorine, the following sampling and preservation procedure should be followed:

> Fill an 8-ounce VOC sampling container with 8 drops of a 25% ascorbic acid solution and the water sample. Cap and mix thoroughly but gently by swirling to eliminate residual chlorine. Transfer the sample to three 40-ml VOC vials containing four drops of concentrated HCl*. Label each 40-ml vial with "P" (preserved/ascorbic acid).
>
> * The ascorbic acid and acid preservatives must be added in this order and in two separate steps.

The volatile organics vials (40-ml) should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles: if any are present, repeat the procedure using a new 40-ml vial.

Sampling containers with preservatives should be prelabeled (i.e., P) prior to any field activities. This will reduce the chances of confusion during sampling activities.

10.0 Surface Water Resources Monitoring Procedures

Stream discharge data are critical for water resources studies and planning as well as for water quality or pollution control activities. This section describes general practices for measurement of stream flow, or flow associated with wastewater streams. This section does not attempt to present comprehensive descriptions of techniques or practices for determination of stream discharge or to discuss the theory for these determinations. In addition, installation of flow control structures or continuous measurement stations is not discussed. A list of references is included in Section 12.0 and detailed descriptions of flow measurement techniques may be found in the references.

Data collection procedures associated with stream discharge analysis should be conducted in an effective, step-wise manner. Equipment used to collect stream data should be properly decontaminated as described in Section 2.6.2 above. Measurement procedures shall be documented. Appropriate procedures should be used at all times to ensure that the data collected are representative of the stream or wadi. All measurement techniques employed should be documented on the Water Monitoring Report form (Exhibit E) and in the Field Log book, as appropriate, to ensure data collection is properly documented.

This section presents general procedures for using basic hydrologic equipment associated with the surface water resources monitoring programs in Jordan. Collection of basic hydrologic data required for stream discharge analyses should be conducted in accordance with the general practices described in this section. Deviations from these methods and procedures because of site-specific conditions should be documented in the Field Log book.

10.1 General Considerations

In Jordan, surface water resources data collection relating to discharge for major wadis and reservoirs typically are made using classical stream gaging techniques. These measurements typically are made using open channel flow measurement techniques based on velocity-area relationships. These techniques are outlined in a United States Geological Survey publications entitled "Discharge Measurements at Gaging Stations" (USDI, 1968a) and Stage Measurement at Gaging Stations" (USDI, 1968c).

At permanent gaging stations, a water stage - discharge relationship is established. At these stations, the discharge or flow of the wadi is obtained from water stage (level) measurements. Staff gages or recorders are used to monitor the water stage at these stations. The water stage or level then may be converted to flow by using the rating curve for the respective gaging station. Ultimately, a permanent gaging station will lead to a long-term flow record at the station. Long-term flow records are essential for studying and planning water resources and water quality management practices.

At stations where permanent gaging stations are not established, several traditional measurement techniques can be used to collect stream velocity and cross-sectional area data. A rating curve for a station also can be developed if flow measurements are to be collected at the station on a regular basis. At some locations portable weirs or flumes may be used to establish the discharge.

10.2 General Flow Measurement Practices

In Jordan, basic flow measurement practices include use of permanent gaging stations and rating curves, use of portable weirs and flumes, and application of velocity-area method techniques. Permanent stream gaging stations are located throughout Jordan and new stations are proposed to enhance the existing network. Permanent gaging stations may be equipped with staff gages, continuous mechanical chart recorders, or ultrasonic devices and recorders. In addition, cable-ways are established at a few locations for measurement of flood flow.

Stream flow may be measured on an instantaneous or a continuous basis. Continuous measurement systems typically consist of a flow control structure, a flow sensor, transmitting equipment, and a recorder. The flow control structure (e.g., weir, flume) is constructed to produce a defined hydraulic response which then can be related to the flow rate of water through the structure. These devices, such as weirs and flumes, relate the water level (head) behind the structure to the discharge or water flow through the structure. The flow sensor is used to measure the specific hydraulic responses at the flow control structure. These responses typically are then transmitted to a recording device or system. A variety of sensors are available including floats, pressure transducers, ultrasonic, electromagnetic cells, and others. The signal from the sensor is recorded on a moving chart or transmitted into a data logging system. Data also can be displayed on a real time basis.

Instantaneous flow measurements typically can be made with portable equipment. Consequently, measuring and processing equipment requirements may be less than for the continuous flow measurement systems.

10.2.1 Volumetric Flow Techniques

Volumetric flow measurement techniques generally are simple to perform and provide a high degree of accuracy. Volumetric techniques are based on measuring the time required to fill a container of known volume.

Filling of Containers Method

Flow of water is diverted into a container of known dimensions and volume. The time to fill the container and the container volume then are used to calculate the discharge rate of the water stream. The only data requirements are accurate measurements of the container volume and the time to fill the container. Required field equipment includes an accurate tape to verify container dimensions and a stop watch to record time.

Bucket and Stop Watch Method

The bucket and stop watch method is appropriate primarily for the measurement of small stream flows. The method is considered very simple to use and accurate. Equipment requirements include a calibrated small container (bucket, drum, tank) and a stop watch. Generally, the small container should not be filled in less than 10 seconds. Three time-volume measurements should be recorded and the results should be averaged.

10.2.2 Open Channel Flow Techniques

Open channels techniques apply to open conduits (e.g, wadi or flume) or to a closed conduit (e.g., pipe) which is not flowing full.

Weirs

A weir is a flow control structure constructed across an open channel according to very specific design standards. Weirs are used to measure the flow of water over the weir. Discharge over the weir is calculated using equations for weirs of specific geometry. The equations relate static head behind the weir to water flow (discharge) over the weir. Two general categories of weirs are used for flow measurements: broad crested and sharp crested.

Weir tables are required to calculate flow over the weir. These tables can be found in: (1) United States Department of Interior Water Measurement Manual, (2) Stevens Water Resource Data Book, and (3) ISCO Open Channel Flow Measurement Handbook.

Flumes

The conditions for use of flumes are similar to those for weirs or spillway crests because the determination of discharge through the devices is based on specific design standards and the static water level behind the structure. In addition, water passing through the throat of the flume should not be impeded by downstream conditions (constrictions, bends in channel, obstructions). There are several types of flumes including Palmer-Bowlus, Cutthroat, H, and Trapezoidal. The most widely used is the Parshall flume.

Flume tables are required to calculate flow through the flume. These tables can be found in: (1) United States Department of Interior Water Measurement Manual, (2) Stevens Water Resource Data Book, and (3) ISCO Open Channel Flow Measurement Handbook.

Velocity-Area Method

This method is based on the principle that flow in a stream channel is equal to the cross-sectional area perpendicular to the channel times the average water velocity across the cross-section. The velocity of the water is determined with a current meter. The cross-sectional area of the channel may be measured or calculated using approximation methods. Methods used by the United States Geological Survey are described in the manual title "Discharge Measurements at Gaging Stations" (USDI, 1968a).

10.3 Hydrologic Data Measurement Practices

The basic hydrologic data measurement practices used in Jordan do not require elaborate procedures. For most monitoring stations, recording of data or changing of recorder chart paper from installed instruments is required. However, the ease with which these data are obtained requires that the instruments have been properly installed and maintained. Guidance and instruction for instrument installation is outside the scope of these procedures.

10.3.1 Staff Gages

Typically vertical staff gages are used in Jordan to monitor the water level or stage in the pool behind a dam, weir, or other flow control structure. The basic premise for using these devices is that they have been properly installed and anchored with respect to reference elevations. The water stage - discharge relationship is dependent upon accurate references to established measuring points. Staff gages should be referenced to a National Geodetic Vertical Datum (NGVD). The NGVD is an established datum and can provide correlation of the water surface to flow control structures. For staff gages, the datum is established in relation to the flow control structure reference point. Rectangular and V-notch weirs, for example, are referenced to the weir crest.

All staff gage measurements should be recorded on the Water Monitoring Report form (Exhibit E). The day and time of the measurement and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E). Typically staff gage measurements will be obtained on a daily basis from the monitoring stations.

The following general practice should be followed for recording staff gage measurements:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the flow control structure to verify that it is properly anchored and in good operating condition and that flow is not be impeded by upstream or downstream conditions (constrictions, bends in channel, obstructions). Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Check the staff gage to verify that it is properly anchored and that there are no obstructions which block flow or the water pool around the staff gage. Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Read the water stage (level) from the staff gage and record the value in the Field Log book and Water Monitoring Report form (Exhibit E). The reading

should be made twice and both measurements should be recorded. The water stage should be recorded to the nearest 0.5 centimeters, where possible.

5. Maintenance needs for the flow control structure or staff gage should be made, if possible, and noted in the Field Log book and Water Monitoring Report form (Exhibit E). Maintenance which cannot be completed, should be noted and upon return to the office should be scheduled with the appropriate resources.

6. If maintenance is required prior to obtaining accurate water stage measurements, the maintenance should be completed first and the flow should be allowed to stabilize prior to the measurement. When to take the measurement then becomes a subjective decision. In these cases, water stage should be recorded several times over a period of time until the water stage stabilizes.

7. Immediately after the water stage measurements are completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

   c. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

8. The documentation should be returned to the appropriate organization for evaluation and analysis and for filing in the program files.

10.3.2 Continuous Water Level Recorders

Continuous water level recorders can be used to provide a time series record of water levels at the station. Typically, the continuous recording instrument is used in conjunction with a weir or other flow control device to establish a water stage - discharge relationship. Standard USGS staff gages also should be employed at each water level recorder site to provide a reference and check on the recorder trace. Water stage should be recorded to

the nearest 0.5 centimeters, where possible. The basic premise for using these instruments is that they have been properly installed and anchored with respect to reference elevations.

The water stage - discharge relationship is dependent upon accurate references to established measuring points. Where possible, these instruments should be referenced to a National Geodetic Vertical Datum (NGVD). The NGVD is an established datum and can provide correlation of water surface recordings to engineering structures. For water level recording equipment, the datum is established in relation to the flow device reference point. Rectangular and V-notch weirs, for example, are referenced to the weir crest. For water level recorders associated with flow control structures, the reference or datum is the weir crest.

In Jordan, equipment typically used for surface water flow measurements include the Stevens Type A-71 continuous strip chart, water level recorders. Ultrasonic water level recorders and ISCO-type recording flow meters have been planned for the upgraded water monitoring system network. The ultrasonic water level devices recorder water levels based on the measured return of an emitted ultrasonic impulse. The ISCO-type recording flow meters record water level based on the hydrostatic pressure measured above a pressure transducer placed in the water column. The Stevens Type A-71 recorder records the water level on a paper tracing. The other devices are linked to data loggers and the water level is stored electronically by the data logger.

Detailed procedures for installation and use of these instruments are included in the respective operations manual. The USGS presents a detailed discussion of strip chart recorders in the report titled "Stage Measurement at Gaging Stations" (USDI, 1968c).

Monitoring activities associated with use of water level recording instruments should be recorded on the Water Monitoring Report form (Exhibit E). Because these instruments may be left unattended for long periods of time, basic monitoring activities focus on periodically replacing chart paper or downloading data from a data logger. The day and time of the monitoring activities and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E). In addition, staff gage measurements for stations where recording equipment and staff gages are collocated will be obtained when the instruments are monitored.

The following general practice should be followed for monitoring activities at continuous recording stations:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the flow control structure to verify that it is properly anchored and in good operating condition and that flow is not be impeded by upstream or downstream conditions (constrictions, bends in channel, obstructions). Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Check the recording instrument and associated staff gage, if present, to verify that they are properly anchored and that there are no obstructions which block flow or the water pool around instruments. Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Check the recording instrument to verify that it is properly installed and operating. Any conditions which affect the operation of the instrument should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

5. Replace the chart paper for the continuous strip recorder according to the manufacturers recommendations. For data logging devices, download the data from the data logger according to the manufacturers recommendations. When staff gages are present, read the water stage (level) from the staff gage and record the value in the Field Log book and Water Monitoring Report form (Exhibit E). Staff gage readings should be made twice and both measurements should be recorded. The water stage should be recorded to the nearest 0.5 centimeters, where possible.

   All water level chart (tracings) should be noted with the beginning and ending date and time, site location, stage scale, and time scale. The chart (tracing)

should be initialed by the monitoring personnel. The beginning date and time should be noted on the new chart place on the strip recorder.

6. Maintenance needs for the flow control structure, continuous recording instrument, or staff gage should be made, if possible, and noted in the Field Log book and Water Monitoring Report form (Exhibit E). Maintenance which cannot be completed, should be noted and upon return to the office should be scheduled with the appropriate resources.

7. If maintenance is required prior to obtaining accurate water stage measurements, the maintenance should be completed first and the flow should be allowed to stabilize prior to the measurement. When to take the measurement then becomes a subjective decision. In these cases, water stage should be recorded several times over a period of time until the water stage stabilizes.

8. Immediately after the water level chart (tracing), downloaded data, or water stage measurements are completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

   c. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

9. The documentation including tracings and downloaded data should be returned to the appropriate organization for evaluation and analysis and for filing in the program files.

10.3.3 Current Meters

At monitoring stations where staff gages or continuous recording instruments and associated flow control structures have not been established, flow data generally are determined using velocity-area measurements. A number of techniques are available for obtaining these data

and are discussed in detail in the USGS publication "Discharge Measurements at Gaging Stations (USDI, 1968a). Basic equipment requirements include a suitable current meter, a stopwatch, and sounding and measurement tapes. The current meter is used to measure the velocity of water flowing at the station. The sounding equipment is used to determine the depth of the water column for the cross-section perpendicular to the wadi at the station. The measurement tape is used to measure the cross-sectional distance across the wadi at the monitoring station.

Numerous techniques are available for obtaining the required data and generally depend on the site specific conditions at the monitoring station including the cross-section width of the flowing water in the wadi, the depth of the water column, and the velocity of the water. The flowing general procedure is outlined for these types of measurements. The practices outlined below assume that the wadi is wadable at the monitoring station.

Monitoring activities associated with use of velocity-area measurements using current meters should be recorded on the Water Monitoring Report form (Exhibit E). The day and time of the monitoring activities and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E). The following general practices should be followed for monitoring activities at these stations:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the station location to verify that it is not impeded by upstream or downstream conditions (constrictions, bends in channel, obstructions). Any impediments should be removed if possible and the water flow allowed to stabilize prior to collecting data. Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Establish the cross-sectional location perpendicular to the wadi flow where the measurements will be made. Both sides of the wadi should be staked and the distance across the flowing wadi should be measured using a measuring tape. Intermediate measuring locations across the wadi should be established.

These locations should be established consistent with guidelines for velocity measurements (e.g, USDI, 1968a).

A sketch of the monitoring station showing the flowing wadi, stakes, cross-sectional distance, and intermediate measuring locations should be prepared and included with the Field Log book and Water Monitoring Report form (Exhibit E). All measurement data should be entered in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Depth soundings should be made at the intermediate measuring locations to establish a profile of the wadi bed. A cross-sectional area sketch of the monitoring station perpendicular to the flowing wadi should be prepared and included with the Field Log book and Water Monitoring Report form (Exhibit E). All measurement data should be entered in the Field Log book and Water Monitoring Report form (Exhibit E).

5. Velocity measurements should be made at the intermediate measuring locations following the operating instructions of the manufacturer. Velocity measurements should be made concurrent with the depth sounding measurements. Measurements should be made consistent with guidelines for velocity measurements such as the USGS (USDI, 1968a). Velocity measurements should be made twice at each point where monitored. All measurement data should be entered in the Field Log book and Water Monitoring Report form (Exhibit E).

6. Immediately after the measurements have been completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

   c. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

10.3.4 Cableways and Bridges

Cableways and bridges provide means of collecting water velocity data where streams are not wadable. This may occur because the stream is too deep or too wide for wading or where the velocity of the water is too great. The use of cable ways is more complicated than the methods discussed in Section 10.3.3 above. A major assumption is that the cableway has been properly installed to permit use for hydrologic data collection purposes. Collection of hydrologic data from bridges does not typically present any special problems. However, whether to collect these data from the upstream or downstream side of the bridge must be decided based on site specific conditions. In both cases, heavier equipment may be required to accurately measure the required data and the monitoring personnel must be aware of potential influences of high velocity water in ensuring accurate depth measurements.

Generally, for low velocity waters, the procedures outlined under Section 10.3.3 for current meters will be adequate for using cableways or for obtaining measurements from bridges. For high velocity waters, more detailed planning is required to compensate for drift particularly of the sounding depth equipment. Specialized equipment assemblies may permit more efficient data collection. In these situations, more detailed technical references should be consulted prior to conducting the monitoring.

10.3.5 Portable Weirs

For very shallow streams or where the flow is characterized by low velocities, it may not be possible to obtain accurate data, particularly velocity data. In these situations, use of portable weirs or Parshall flumes may be appropriate for obtaining flow data. Detailed use of and the theory for these devices may be found in reference manuals. The practices outlined below assume that these devices have been properly installed.

All measurements should be recorded on the Water Monitoring Report form (Exhibit E). The day and time of the measurement and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E).

The following general practice should be followed for portable weir measurements:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the station location to verify that it is not impeded by upstream or downstream conditions (constrictions, bends in channel, obstructions). Any impediments should be removed if possible and the water flow allowed to stabilize prior to collecting data. Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Install the portable flow control structure and check to verify that it is properly anchored and in good operating condition and that flow is not impeded by upstream or downstream conditions (constrictions, bends in channel, obstructions). Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Install the staff gage upstream consistent with general guidelines and check to verify that it is properly anchored and that there are no obstructions which block flow or the water pool around the staff gage or that it is within the drawdown area of the flow control device. Any conditions which affect the free flow of water should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

5. Read the water stage (level) from the staff gage and record the value in the Field Log book and Water Monitoring Report form (Exhibit E). The reading should be made at least five (5) times and all measurements should be recorded. The water stage should be recorded to the nearest 0.5 centimeters, where possible.

6. Immediately after the water stage is measurements are completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

c. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

7. The documentation should be returned to the appropriate organization for evaluation and analysis and for filing in the program files.

10.4 Quality Assurance Practices

Water flow may be expressed in cubic meters per day (m^3/day) or liters per second. Flow measurements should be thoroughly documented in field records as discussed in Section 10.3 above. All measurements should be traceable both to the individual making the measurements and the equipment utilized. The specific piece of equipment (name, model, serial number) used for the measurements should be recorded on the Water Monitoring Report form (Exhibit E) and in the Field Log book.

10.4.1 General

In Jordan, equipment typically used for surface water flow measurements include water level/stage recorders (Stevens Type A-71 continuous strip chart recorders), staff gages, velocity measuring equipment (current meters), and portable weirs. Ultrasonic water level recorders and ISCO-type recording flow meters have been planned for the upgraded water monitoring system network.

A log of all maintenance, calibration, and repair for each piece of flow measuring equipment should be established. The log should be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized.

10.4.2 Continuous Recorders

Stage recorders should be maintained and calibrated in accordance with the manufacturers's instructions and recommendations:

- At least once yearly, each unit should be operated and calibration re-established, as necessary. Each unit should be accurate and should record to within 0.3 centimeters of the Invar steel surveyor's chain, or equivalent.

- Be checked in the field by comparison with a staff gage. During field measurements, the vertical accuracy should check within 1.5 centimeters, and

- Be cleaned and maintained before storage.

10.4.3 Vertical Staff Gages

Staff gages should be:

- Be checked on receipt from the vendor. Any staff gage not accurate to within 0.3 centimeters when compared with the Invar steel surveyor's chain, or equivalent, should be discarded. Gages should be labeled as acceptable upon calibration.

- Be checked for damage, warpage, legibility, etc., before use. Any damaged or illegible staff gages shall be discarded.

- Be cleaned after use before being stored.

10.4.4 Current Meters

All current meters should be:

- Recalibrated once every five years or more frequently as necessary in accordance with the manufacturer's recommendations.

- Examined before and after each discharge measurement. The examination should include the meter cups or vanes, pivot and bearing, and shaft for damage, wear, or faulty alignment.

- Meter balance and alignment should be checked prior to each use in the field.

- Meters should be cleaned and oiled daily when in use. Surfaces that should be cleaned and oiled on a yearly basis are the pivot bearing, pentagear teeth and shaft, cylindrical shaft bearing, and thrust bearing at the cap.

10.4.5 Measuring Tapes and Tag Lines

These equipment should be inspected for damage and cleaned before and after each discharge measurement. The accuracy of the equipment should be checked initially and then once per year utilizing the Invar steel surveyors chain, or equivalent. The equipment should be accurate to 0.1 meter per 100 meters. Any equipment that does not conform to this accuracy specification should be repaired, recalibrated, or discarded. Yearly maintenance should include an inspection for potential breaks, a thorough washing, and a finish oiling, as appropriate.

10.4.6 Portable Weirs and Flumes

These equipment should be cleaned and examined before and after each field installation. Construction and condition of the equipment should conform to recognized standards. The equipment should be cleaned with a soapy wash water, followed by a distilled water rinse. The equipment should be inspected to insure that the upstream edge of the equipment remains sharp.

11.0 Ground Water Level Monitoring Procedures

Ground water level data are important for ground water resources studies, analyses, and planning as well as for ground water quality monitoring activities. This section describes procedures which support the ground water level monitoring programs in Jordan. Water level measurements shall be conducted in accordance with the generic methods and specific procedures described in this section. These methods and procedures apply to all personnel responsible for the collection of ground water level data. Deviations from these methods and procedures because of site-specific conditions should be documented in the Field Log book.

This section does not attempt to present comprehensive techniques or theory. In addition, the design and installation of monitoring wells required to obtain ground water level data is not discussed. Rather, general procedures for measuring ground water levels in monitoring wells in Jordan are presented. A list of references is included in Section 12.0 and detailed descriptions of measurement techniques and monitoring wells installation procedures may be found in the references.

Ground water level measurement procedures for ground water aquifers shall be conducted in an effective, step-wise manner. Equipment used to measure ground water levels shall be properly decontaminated as described in Section 2.6.2above. Measurement procedures will be documented. Appropriate procedures will be used at all times to ensure that the data collected are representative of the aquifer being monitored. All measurement techniques employed will be documented on the Water Monitoring Report form (Exhibit E) and in the Field Log book, as appropriate, to ensure data collection is properly documented.

11.1 General Considerations

In Jordan, the measurement of the ground water level in monitoring wells typically is conducted using either electronic water level meters or continuous recording devices. The continuous recording devices generally are of two types: mechanical (Stevens Type F-68 continuous chart recorder) or pressure sensing (a variety of pressure transducers electronically combined with data loggers). These applications generally are used for ground water resources management studies. Water level data are required to determine the

potentiometric surface in aquifers and ground water zones as well as for establishing ground water flow directions and gradients.

Typically, measurement of ground water levels has not been conducted in Jordan in conjunction with ground water sampling activities because most ground water samples are collected from production wells. However, in the upgraded water monitoring system, water level measurement data may be required for some water quality monitoring wells to determine the static water level for calculating volumes of water to be purged from the well prior to collection of a water sample. Both total well depth and ground water level measurements are necessary to determine the volume of water in a well casing prior to purging the well during ground water sampling.

Ground water level and total depth of well measurements must be made with respect to an established reference point on the well casing. The reference point must be documented in the field records. In order to establish true potentiometric surfaces and ground water gradients, the reference point should be related to a national geodetic vertical datum).

11.2 Ground Water Level Measurement Techniques

In Jordan, the depth to the ground water surface typically is measured using the techniques described below.

11.2.1 Electric Water Level Indicators

These instruments consist of a spool of dual conductor wire combined with a measuring tape graduated in meters and centimeters, a probe attached to the end of the wire, and an audible or visual indicator. The probe is lowered into the well to the water surface. When the probe contacts the surface of the water, an electric circuit is closed and a meter light and/or buzzer attached to the spool signals. The scale on the measuring tape is read from a reference point on the well and the depth to water length measurement is recorded. Measurements should be made and recorded to the nearest two centimeters. The measurement is then subtracted from the surveyed elevation of the reference point of the well to compute the true elevation of the water surface in the well. Batteries are used as the power source for the indicators.

All monitoring personnel should wear clean rubber gloves while measuring the ground water level in monitoring or production if the ground water is known or suspected of being contaminated. This is particularly important for those wells specifically designed and intended to monitor water quality degradation associated with industrial or municipal waste management activities. All data should be measured and recorded on the Water Monitoring Report form (Exhibit E) during the monitoring process.

For measuring the ground water level in suitable monitoring wells or production wells, the following procedures should be followed:

1. Existing water level data for the well should be reviewed during planning activities to ensure that a water level indicator of adequate length will be used to make the measurements.

2. Verify the well identification (typically by the well number) and open the well cap or water level access port.

3. Reverify the location of the reference point on the well. All measurements must be made with respect to the reference point

4. Reverify that the electronic water level recorder is working by testing the device with the test button.

5. Begin to lower the measurement probe and cable/tape down the well either directly or through the monitoring access port.

6. Continue lowering the probe and cable/tape down the well by unrolling the cable/tape from the instrument spool. Lower the probe/tape until the probe encounters ground water. This is indicated by an audible (i.e., loud buzzer) or visual (i.e., light meter) attached to the spool.

7. By hand, gently raise and lower the portion of the cable/tape entering the well casing or access port to determine the water surface. This is done by raising and lower the cable/tape several times noting when the signal is absent and when the signal is observed.

8. When the water surface is determined with certainty relative to the cable/tape, read the graduated measurement value on the cable/tape and record the value on the Water Monitoring Report form (Exhibit E). The value should be measured from the reference point for the well. This value is the depth to ground water from the reference point for the well. All measurements should be made and recorded to the nearest two centimeters, if possible.

9. Gradually raise the probe/cable assembly from the well by rewinding on the instrument spool.

10. Replace the well cap or water level access port.

11. Immediately after the measurement is made, the following documentation should be completed as required:

    a. Complete the Water Monitoring Report form (Exhibit E).

    b. Enter the water level measurements and field information in the Field Log book as specified in Section 2.5.2 above.

12. Decontaminate the cable/tape, as required, and discard any contaminated personal protective clothing.

11.2.2 Continuous Mechanical Recorders

Continuous water level recorders can be used to provide a time series record of water levels and associated potentiometric surface at the monitoring well. Water levels should be recorded to the nearest 0.5 centimeters, where possible. The basic premise for using these instruments is that they have been properly installed and anchored with respect to reference elevations.

Where possible, these instruments should be referenced to a National Geodetic Vertical Datum (NGVD). The NGVD is an established datum and can provide correlation of water

surface recordings to engineering structures such as wells. For water level recording equipment, the datum is established in relation to the monitoring well reference point.

In Jordan, equipment typically used for ground water flow measurements include the Stevens Type F-68 chart, water level recorders. The Stevens Type F-68 recorder records the water level on a paper tracing. Detailed procedures for installation and use of these instruments are included in the respective operations manual.

Monitoring activities associated with use of water level recording instruments should be recorded on the Water Monitoring Report form (Exhibit E). Because these instruments may be left unattended for long periods of time, basic monitoring activities focus on periodically replacing chart paper. The day and time of the monitoring activities and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E). In addition, level measurements for wells where recording equipment and electronic water level meters are collocated should be obtained when the instruments are monitored.

The following general practice should be followed for monitoring activities at continuous recording stations:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the recording instrument and associated floats to verify that they are properly anchored and that there are no obstructions which block the float action. Any conditions which affect the float action should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Check the recording instrument to verify that it is properly installed and operating. Any conditions which affect the operation of the instrument should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Replace the chart paper for the continuous strip recorder according to the manufacturers recommendations. When electronic water level meters are available, take a water level reading using the meter and record the value in

the Field Log book and Water Monitoring Report form (Exhibit E). The water level should be recorded to the nearest 0.5 centimeters, where possible.

All water level chart (tracings) should be noted with the beginning and ending date and time, site location, stage scale, and time scale. The chart (tracing) should be initialed by the monitoring personnel. The beginning date and time should be noted on the new chart place on the strip recorder.

5. Maintenance needs for the continuous recording instrument or well should be made, if possible, and noted in the Field Log book and Water Monitoring Report form (Exhibit E). Maintenance which cannot be completed, should be noted and upon return to the office should be scheduled with the appropriate resources.

6. Immediately after the water level chart (tracing) or water level measurements are completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

   b. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

7. The documentation including tracings and downloaded data should be returned to the appropriate organization for evaluation and analysis and for filing in the program files.

11.2.3 Pressure Sensor Recorders

Pressure sensor recorders provide an electronic continuous water level record and a time series record of water levels at the a monitoring well. Water levels should be recorded to the nearest 0.5 centimeters, where possible. The basic premise for using these instruments is that they have been properly installed and anchored with respect to reference elevations.

Where possible, these instruments should be referenced to a National Geodetic Vertical Datum (NGVD). The NGVD is an established datum and can provide correlation of water surface recordings to engineering structures such as wells. For water level recording equipment, the datum is established in relation to the monitoring well reference point.

In Jordan, ground water flow measurements may be made with a variety of pressure transducers and data logger systems. Detailed procedures for installation and use of these instruments are included in the respective operations manual.

Monitoring activities associated with use of water level recording instruments should be recorded on the Water Monitoring Report form (Exhibit E). Because these instruments may be left unattended for long periods of time, basic monitoring activities focus on periodically downloading water level data from the data logger. The day and time of the monitoring activities and other general observations also should be recorded on the Water Monitoring Report form (Exhibit E). In addition, level measurements for wells where recording equipment and electronic water level meters are collocated should be obtained when the instruments are monitored.

The following general practice should be followed for monitoring activities at continuous recording stations:

1. Record general station information in the Field Log book and Water Monitoring Report form (Exhibit E).

2. Check the data logger and associated pressure transducer to verify that they are properly anchored and that there are no conditions which would affect the recording of data. Any conditions which affect the instrument should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

3. Check the pressure transducer to verify that it is properly installed and operating. Any conditions which affect the operation of the instrument should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

4. Download the data from the data logger according to the manufacturers recommendations. When electronic water level meters are available, take a water level reading using the meter and record the value in the Field Log book and Water Monitoring Report form (Exhibit E). The water level should be recorded to the nearest 0.5 centimeters, where possible.

5. Maintenance needs for the pressure transducer or data logger or well should be made, if possible, and noted in the Field Log book and Water Monitoring Report form (Exhibit E). Maintenance which cannot be completed, should be noted and upon return to the office should be scheduled with the appropriate resources.

6. Immediately after the data have been downloaded or water level measurements are completed, provide the following documentation as required:

   a. Enter the information in the Field Log book as specified in Section 2.5.2above and complete the Water Monitoring Report form (Exhibit E).

   b. The monitoring technician should initial the measurements Field Log book, and Water Monitoring Report form.

7. The documentation including tracings and downloaded data should be returned to the appropriate organization for evaluation and analysis and for filing in the program files.

11.3 Total Well Depth Measurement Techniques

A weighted tape or the electric water level indicator (described above) may be used to determine the total depth of a well. The total depth is measured by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with lengthy water columns, determining when the tape end is touching the bottom of the well may be difficult to judge.

Care must be taken in these situations to ensure accurate measurements. All measurements should be recorded in the Field Log book and Water Monitoring Report form (Exhibit E).

11.4 Quality Control Procedures

Water level should be measured to the nearest 0.01 meters or better, if possible. Measurements should be thoroughly documented in field records as discussed in Sections 11.2. and 11.3 above. All measurements should be traceable both to the individual making the measurements and the equipment utilized. The specific piece of equipment (name, model, serial number) used for the measurements should be recorded on the Water Monitoring Report form (Exhibit E) and in the Field Log book.

11.4.1 General

All devices used to measure ground water levels shall be calibrated against an Invar steel surveyor's chain, or equivalent. These devices should be calibrated to 0.01 meter per 10 meters length. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. These devices should be decontaminated according to the procedures specified in Section 2.6.2prior to use at the next well, as appropriate. All calibration and maintenance data shall be recorded.

A log of all maintenance, calibration, and repair for each piece of flow measuring equipment should be established. The log should be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized.

11.4.2 Continuous Recorders

Water level recorders should be maintained and calibrated in accordance with the manufacturers's instructions and recommendations:

- At least once yearly, each unit should be operated and calibration re-established, as necessary. Each unit should be accurate and should record to within 0.3 centimeters of the Invar steel surveyor's chain, or equivalent.

- Be checked in the field by comparison with a electronic water lever meter. During field measurements, the vertical accuracy should check within 1.5 centimeters, and

- Be cleaned and maintained before storage.

11.4.3 Pressure Transducers

Pressure transducers and data loggers should be maintained and calibrated in accordance with the manufacturers's instructions and recommendations:

- At least once yearly, each unit should be operated and calibration re-established, as necessary. Each unit should be accurate and should record to within 0.3 centimeters of the Invar steel surveyor's chain, or equivalent.

- Be checked in the field by comparison with a electronic water lever meter. During field measurements, the vertical accuracy should check within 1.5 centimeters, and

- Be cleaned and maintained before storage.

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Exhibit A

WATER SAMPLE CHAIN-OF-CUSTODY RECORD

Ministry of Water and Irrigation
Hashemite Kingdom of Jordan

Revision No.: 0
1 September 1995

Monitoring Program Name						Remarks							
MWI Sample Types 1. Surface Wat 3. Drinking Water 2. Ground Wat 4. Wastewater 5. Sediment		**Samplers (Signature)**					ANALYSES						
Station ID Number	Date / Time	Sample Type	Comp	Grab	Station Location	Number of Containers							COMMENTS
RELINQUISHED BY: (PRINT) (SIGNATURE)		Date	Time		RECEIVED BY (PRINT) (SIGNATURE)	RELINQUISHED BY: (PRINT) (SIGNATURE)				Date	Time		RECEIVED BY: (PRINT) (SIGNATURE)
RELINQUISHED BY (PRINT) (SIGNATURE)		Date	Time		RECEIVED BY (PRINT) (SIGNATURE)	RELINQUISHED BY (PRINT) (SIGNATURE)				Date	Time		RECEIVED BY: (PRINT) (SIGNATURE)

LIST OF EXHIBITS

Exhibit

A Chain-of-Custody

B Calibration Log

C Corrective Action Log

D Water Monitoring Station Data Form

E Water Monitoring Report Form

F Water Monitoring Equipment Checklist

Exhibit A(model #2)

WAJ / L & F - A 7

بسم الله الرحمن الرحيم

MINISTRY OF WATER AND IRRIGATION
WATER AUTHORITY
Laboratories & Environment Control
Analytical Services Request Form

Chem. Section ☐
Toc Lab. ☐
Organic Lab. ☐
Inorganic Lab. ☐

Biology Section ☐
Biochem. Lab. ☐
Micro. Lab. ☐
Isotope Section ☐

Department..... Project ..... Collector .....

Remarks / Water Use .....

Sample		Sampling			Source & Location	Analysis Required
No.	Ref.	Date	Time	T C°		

Total number of sample bottles with this request :

Signed by : ..... Date : ..... Recieved by : ..... Date : .....

Exhibit B

EQUIPMENT CALIBRATION FORM

Make_____
Model #_____
Serial #_____

1. Recommended Calibration Frequency:

2. Last Calibration Date:

3. Calibrated By:

4. Calibration Standards Used:

5. Source of Calibration Standard:

6. Calibration Procedure Used <u>if more than one method in manual</u>

7. Usage Date _____ Sample ID Number _____ Location _____

Exhibit C

CORRECTIVE ACTION REQUEST FORM

Originator Section

1. Date: _____ 2. Originator: _____ 3. Date Adverse Condition Noted: _____

4. Adverse Condition: _____

_____

_____

5. Documents Referenced: _____

6. Corrective Action Recommended: _____

_____

_____

_____

Quality Assurance Officer Section

7. Action Recommended by QAO: _____

_____

8. Responsible Person for Corrective Action: _____

9. Signature of QAO: _____ 10. Date: _____

Responsible Person for Corrective Action Section

11. Cause of Adverse Condition: _____

_____

_____

12. Corrective Action Taken: _____

_____

_____

13. Further Recommendations: _____

14. Signature of Responsible Person: _____ 15. Date: _____

Concurrences for Corrective Action Taken

16. QAO Signature: _____ 17. Originator Signature: _____

18. Date: _____ 19. Date: _____

Exhibit D

Completed By: _____ File Code: _____
Checked By: _____ Date _____

Water Monitoring Station Data Form

Ministry of Water and Irrigation
Hashemite Kingdom of Jordan

Date/Time of Station Visit: _____

Weather Conditions: _____

1. STATION IDENTIFICATION

Name: _____ ID Number: _____ Governorate: _____ City: _____

Coordinates: _____ Elevation: _____ Measuring Point Elevation: _____
(Bench Mark)

Coordinates/Elevation By (circle): Survey GPS Topographic Map Topographic Map: _____
(Name/Number)

Date Established: _____ Dates of Active Use: _____

Owner: _____ Address: _____ Telephone: _____

Status (circle): Active Inactive Instrument Broken Instrument Missing Station Damaged Other: _____

Status Explanation: _____
_____

2. STATION TYPE

Surface Water: ___ Ground Water: ___ Spring: ___ Meteorologic: _____ Other: _____

Surface Water Basin: _____ Drainage Basin: _____

Ground Water Aquifer: _____

3. STATION PURPOSE

Water Resources: _____ Water Quality: _____

Data Collected: (circle) SW Stage SW Velocity/Area GW Level Ppt. Evap. Other: _____

General Chemistry (pH.Ec.BOD.COD) Microbiological (TC. FC. etc.) Nutrients (N. P. etc.) Metals Organics Other: _____

Frequency: (1) Continuous ___ (2) Noncontinuous (circle) Daily Weekly Monthly Quarterly Semi-Annually Annually

Rationale for Station/Location: _____
_____
_____

4. STATION/LOCATION DESCRIPTION

Topography: (circle) wadi channel | reservoir | sea | flood plain | terrace | hill-side | hill-top | plateau (flat) | fan | depression | qa

Surrounding Land Use: (circle) Urban | Agricultural | Industrial | Commercial | Pastoral | Other: _____

Instruments: (1) Flow Control Structure Type: _____ (2) Recorder/Logger Type: _____ (3) Manual: _____ (4) Other: _____

(5) Staff Gauge (6) Cable Way (7) Observation House

Security: (1) Station (circle) Locked Fence | Guard | Other _____ | None

(2) Instruments (circle) Locked Fence | Guard | Other _____ | None

General Description: _____

_____

_____

Detailed construction information and diagrams for station and instruments should be attached to this form.

5. DIRECTIONS TO STATION (include sketch)

Accessibility: _____

_____

_____

_____

_____

_____

6. REMARKS and COMMENTS

Exhibit E

Ministry of Water and Irrigation
Hashemite Kingdom of Jordan

Revision No.: 0
1 September 1995

Water Monitoring Report Form
Water Quality Data & Sample Collection

1. Station Identification Date/Time _____

Monitoring Program: _____ Station: _____ ID Number: _____

Surface Water: ___ Ground Water: ___ Spring: ___ Meteorologic: _____ Other: _____

Sampled by: _____

2. Sampling Location/Conditions

Weather: Clear Pt Cloudy Cloudy Rainy Windy Breezy Calm

Sample Site: Bridge (upstream, downstream) Boat Cable Pole Wading Shore

Water Conditions: Open Channel Pool (Lake) Riffle Area Backwater Area Braided Channel

Water Color: Clear Turbid Green Blue Gray Brown Other _____

Bottom Conditions: Bedrock Rock Gravel Sand Silt/Clay Mud Other _____

Other Observations: _____

3. Field Measurements

Sample Type: (1) Grab (2) Composite: Horizontal Vertical

Sample Depth(s): Surface, _____, _____, _____, _____, _____

(1) **Water Temperature** _____ °C (2) **Air Temperature** _____ °C (3) **Gage Height** _____ m

(4) **pH** _____ units Meter Make/Model _____ Meter No. _____ ATC Performed? _____

pH Calibration

pH Buffer	Initial Reading	Final (Adjusted) Reading	Comments

(5) **Elect. Conduct.** _____ uS/cm Meter Make/Model _____ Meter No. _____ ATC Performed? _____

Electrical Conductivity Calibration

Ec Standard	Initial Reading	Final (Adjusted) Reading	Comments

(6) **Dissolved Oxygen** _____ mg/L Meter Make/Model _____ Meter No. _____

DO Calibration Method _____ DO Zero Check _____ Thermistor Check _____

Calibration Correction Factor _____

4. Samples Collected

Sample Type: (1) Grab (2) Composite - Horizontal Vertical

Sample Depth(s): Surface, _____, _____, _____, _____, _____

Sampling Device: Sample Bottle Large Container Kemmerer Sampler Composite Sampler Other _____

Composite Sampler: Make/Model _____ Sampler No. _____

Sampler Settings: _____

Samples: Biological ___ Nutrients ___ BOD ___ COD ___ TOC ___ Chloroform ___

Nematodes ___ Gen. Chemistry ___ Misc. Chemistry: ABS ___ TS ___ TSS ___ Oil & Grease ___

Metals _____ Special Metals (As, Hg, Pb, Se) _____ Cyanide _____

Volatile Organics _____ Pesticides/Herbicides _____ BNA Semivolatile Organics _____

QA Samples: Duplicate ___ Field Blank ___ Equipment Blank ___ Trip Blank ___ Split Samples ___

5. Ground Water Sampling

Type of Well (circle): Observation Production (Municipal, Agricultural, Industrial) Status: Pumping, Nonpumping

Static Water Level: ____ m Ht. of Measuring Point above Ground Surface: _____ m Description of Measuring Point: _____ Measuring Method: _____

Evacuation Method: Pumping Well Bailer Portable Pump Packer Other _____

If pumping well: sample collected from _____ after water has flowed for ___ minutes

If evacuated well: total well depth: _____ m casing diameter: ___ cm length of water column (or packer length): ___ m

Volume of Water in Well (or Packer Interval): _____ liters

Record of Well Evacuation

Time					
Volume Purged (liters)					
Water Temp (°C)					
Elect. Cond. (uS/cm)					
pH (std. units)					

6. Remarks

107

Exhibit E

Ministry of Water and Irrigation
Hashemite Kingdom of Jordan

Revision No.: 0
1 September 1995

Water Monitoring Report Form
Water Resources Data Collection

1. Station Identification Date/Time _____

Monitoring Program: _____ Station: _____ ID Number: _____
Surface Water: ___ Ground Water: ___ Spring: ___ Meteorologic: _____ Other: _____

Measured by: _____

2. Measurement Location/Conditions

Weather: Clear Pt Cloudy Cloudy Rainy Windy Breezy Calm
Other Observations: _____

3. Surface Water/Spring Measurements

Measurement Type: (circle) AGS Fixed Staff Gage Cableway Velocity Area Portable Weir/Flume Other _____
Water Conditions: Open Channel Pool (Lake) Riffle Area Backwater Area Braided Channel
Bottom Conditions: Bedrock Rock Gravel Sand Silt/Clay Mud Other _____

(1) AGS Recorder/ Logger: Make/Model: _____ Recorder No.: _____ Chart Starting Date/Time: _____ Chart Ending Date/Time: _____

(2) Fixed Staff Gage: Gage Height _____ m Discharge from Standard Tables _____ cubic meters/second

(3) Portable Weir/Flume: Type _____ Size ____ Gage Height ____ m Discharge ____ liters/second

Reading Number	1	2	3	4	5
Time					
Gage Height (meters)					
Discharge (liters/sec)					

(4) Velocity/Area: & Cableway Distance Across Stream: ____ m Stream Reach for Velocity: ____ m Travel Time for Reach: ____ sec

Velocity Meter: Type _____ Model _____ Meter No.: _____

Stream Cross-Section Subareas	1 (Left Bank)	2	3	4	5	6	7	8	9
Distance Between Subareas (meters)									
Depth of Water Column (meters)									
Velocity at 0.2 Total Depth (m/sec)									
Velocity at 0.5 Total Depth (m/sec)									
Velocity at 0.8 Total Depth (m/sec)									

Cross-Sectional Area: _____ m^2 Average Velocity: _____ m/sec Discharge: _____ m^3/sec

148

4. Ground Water Measurements

Type of Well (circle): Observation Production (Municipal, Agricultural, Industrial Status: Pumping, Nonpumping

Measurement Type: (circle) Chart Recorder Data Logger Electric Water Level Meter Other _____

Chart Recorder/ Data Logger: Make/Model _____ Recorder/Logger No. _____

Chart/Logger Starting Date/Time: _____ Chart/Logger Ending Date/Time: _____

Water Level Meter: Method _____ Ht. of Measuring Point above Land Surface: ____ m Description of Measuring Point: _____ Depth to Ground Water: ____ m

5. Precipitation Measurements

Measurement Type: (circle) Automatic Recorder Totalizer Manual Gauge Other _____

Automatic Recorder/ Totalizer: Make/Model _____ Recorder/Totalizer No. _____

Recorder/Totalizer Starting Date/Time: _____ Recorder/Totalizer Ending Date/Time: _____ Totalizer Volume: ____ millimeters

Manual Gauge:

Reading Number	1	2	3	4	5	6	7	8	9	10	11	12
Date/Time												
Precipitation (mm)												

Reading Number	13	14	15	16	17	18	19	20	21	22	23	24
Date/Time												
Precipitation (mm)												

6. Evaporation Measurements

Measurement Type: (circle) Automatic Recorder Manual Station Other _____

Automatic Recorder: Make/ Model _____ Recorder No. _____ Starting Date/Time: _____ Ending Date/Time: _____

Manual: Air Temp. ___ °C Dry-Bulb Temperature ___ °C Wet-Bulb Temperature ___ °C Sunshine ___

Wind Direction ___ Wind Speed ___ Class A Pan Loss ___ mm Albedometer Reading ____ Solar Radiation ____

7. Remarks

Exhibit F

Ministry of Water and Irrigation
Hashemite Kingdom of Jordan

Revision No.: 0
1 September 1995

WATER MONITORING EQUIPMENT CHECKLIST

Water Resources Monitoring Equipment

- Ground Water Level Meter
- Surface Water Staff Gage
- Velocity Meter
- Surface Water Sounding/Measuring Tape
- Portable Crane
- Portable Weirs/Flumes
- Measuring Buckets
- Stop Watches
- Global Positioning Satellite Units
- Spare Parts for Installed Instruments
  - Surface Water Recorders
  - Ground Water Data Loggers
  - Precipitation Totalizers
  - Ground Water Recorders
  - Precipitation Recorders
  - Evaporation Stations

Water Quality Monitoring Equipment

- pH Meter
- Temperature Meter
- Conductivity Meter
- Dissolved Oxygen Meter
- Secchi Disk

Water Quality Sampling Equipment/Supplies

- Kemmerer Sampler
- Bailers and cable/rope
- Portable Pump and Generator
- Composite Sampler & Flow Meter
- Coolers/Blue Ice
- Packing for Samples
- Zip Lock Bags
- Paper Towels/Garbage Bags
- Knife or Scissors

Health and Safety

- Latex/surgical gloves
- Hard Hat
- Coveralls (Tyvek Suits)
- First Aid Kit

Measurement/Sample Documentation Supplies

- Field Log Book
- Water Monitoring Report Forms
- Chain-of-Custody Forms and Seals
- Sample Bottle Labels & Marker
- Keys to Monitoring Stations
- Pens (black/blue ballpoints)
- Clip Board
- Water Monitoring Program Plan
- Measurement/Sampling Procedures

Decontamination Supplies

- Scrub Brush
- Washing Buckets
- Alconox (or equivalent)
- Distilled Water
- Tap (drinking water)
- Isopropyl Alcohol

Sample Containers and Preservatives

- Sample containers (per analytical parameter requirements)
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
  - _____
- Preservatives (per analytical parameter requirements)

....\monitor\upgrade\equip.frm

APPENDIX A

RECOMMENDED SAMPLE COLLECTION PARAMETERS

Recommended Sample Containers, Sample Preservation, Sample Holding Times, and Sample Type

Parameter	Container	Preservative	Holding Time	Sample Type	Ref.
Water - Low to Medium Concentration Samples					
Alkalinity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	14 days	G or C	C
Acidity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	14 days	G or C	C
Bacteriological	250-ml. glass with glass closure or plastic capable of being autoclaved	Cool, 4°C	6 hours	G	C
Static Bioassay	1-gal. amber glass (not solvent rinsed)	Cool, 4°C	48 hours	G or C	D
Biochemical Oxygen Demand (BOD)	1/2-gal. polyethylene[3] with polyethylene closure	Cool, 4°C	48 hours	G or C	C
Chlorine	500-ml or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	None	28 days	G or C	C
Chlorine Residual	In-situ, beaker or bucket	None	Analyze Immediately	G	C
Conductivity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	28 days (determine on site if possible)	G or C	C
Chromium, Hexavalent	1-liter polyethylene with Polyethylene closure	Cool, 4°C	24 hours	G	C
Cyanide	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Ascorbic acid[4,5] Sodium Hydroxide, pH >12, Cool, 4°C	14 days	G	C
Dissolved Oxygen (Probe)	In-situ, beaker or bucked	None	Determine on site	G	C
Dissolved Oxygen (Winkler)	300-ml glass BOD bottle (store in dark if possible)	Fix on site	8 hours (determine on site	G	C
EP Toxicity	1-gal. glass (amber) with Teflon® liner	Cool, 4°C	Not Specified	G or C	B
TCLP Extractable Organics (VOA)	3 40-ml VOA containers with Teflon® lined Septum sealed caps	None	28 days[2]	G	

Recommended Sample Containers, Sample Preservation, Sample Holding Times, and Sample Type

Parameter	Container	Preservative	Holding Time	Sample Type	Ref.
Water - Low to Medium Concentration Samples (continued)					
TCLP Extractable Organics, Herbicides, and Pesticide/PCBs	1-gal amber glass with Teflon® liner	None	54 days[2]	G or C	-
TCLP Metals except Mercury	1-gal amber glass with Teflon® liner	None	360 days[2]	G or C	-
TCLP Mercury	Samples will be taken from TCLP Metals container	None	56 days[2]	G or C	-
		Permissible			
Fluoride	1-liter polyethylene[3] or 1/2-gal. polyethylene with polyethylene or polyethylene lined closure	None	28 days	G or C	C
Hardness	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	50% Nitric Acid[4], pH <2	6 months	G or C	C
LAS	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	48 hours	G or C	C
Metals	1-liter polyethylene with polyethylene lined closure	50% Nitric Acid[4], pH <2	6 months	G or C	C
Metals, Dissolved	1-liter polyethylene with polyethylene lined closure	Filter on site[4] 50% Nitric Acid, pH <2	6 months	G	C
Nutrients[6]	1-liter polyethylene or 1/2-gal. polyethylene with polyethylene or polyethylene lined closure	50% Sulfuric Acid[4], pH <2, Cool, 4°C	28 days	G or C	C
Oil and Grease	1-liter widemouth glass with Teflon® lined cap	50% Sulfuric Acid[4], pH <2, Cool, 4°C	28 days	G	C
Organic Compounds - Extractable and Pesticide Scan					
No Residual Chlorine Present	1-gal. amber glass or 2.5-gal. amber glass with Teflon® lined cap	Cool, 4°C	47 days[7]	G or C	A or C
Residual Chlorine Present	1-gal. amber glass or 2.5-gal. amber glass with Teflon® lined cap	Add 3 mls. 10% Sodium Thiosulfate per gallon, cool, 4°C	47 days[7]	G or C	A or C
Organic Compounds - Purgeable (VOA)					

53

Recommended Sample Containers, Sample Preservation, Sample Holding Times, and Sample Type

Parameter	Container	Preservative	Holding Time	Type	Ref.
Water - Low to Medium Concentration Samples (continued)					
No Residual chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	4 drops 1+1 HCl Cool, 4°C	14 days	G	A or C
No Residual Chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	Cool, 4°C	7 days	G	A or C
Residual Chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	Footnote 8	14 days	G	A or C
Organic Compounds - Specified and Pesticides (Non-Priority Pollutants such as Herbicides	1-gal. glass (amber) or 2.5-gal. glass (amber) with Teflon® lined closure	Footnote 9	47 days[7]	G or C	A or C
Organic Halides - Total (TOX)	250-ml amber glass with Teflon® lined septum closure	Cool, 4°C H_2SO_4 to pH <2	28 days	G	A or E
pH	In-situ, beaker or bucket	None	Analyze Immediately	G	C
Phenols	1-liter amber glass with Teflon®lined closure	50% H_2SO_4, ph <2, Cool, 4°C	28 days	G	C
Phosphate - Ortho	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	Filter on site, Cool, 4°C	48 hours	G	C
Phosphorus, Total Dissolved	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	Filter on site, 50% H_2SO_4, pH <2, Cool, 4°C	28 days	G	C
Solids, Settleable	1/2-gal. polyethylene with polyethylene closure	Cool, 4°C	48 hours	G or C	C
Solids (Total and Suspended, etc.)	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	7 days	G or C	C
Sulfates	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	28 days	G or C	C
Sulfides	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	2-ml. Zinc Acetate[4], Conc NaOH to pH >9, Cool, 4°C	7 days	G	C
Temperature	In situ, beaker or bucket	None	Determine on site	G	C
Turbidity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	48 hours	G or C	C

Abbreviations: G = Grab
C = Composite
ASAP = As Soon As Possible
NS = Not Specified

Footnotes:

1. The TCLP method requires the leaching of 25 grams of solid for volatile organics and 100 gram of solids for all other parameters. If the sample is low in solids, additional sample containers may be required to provide sufficient sample for the TCLP leach extraction.

2. These are total holding times for TCLP that cover sampling through analysis. The holding times are broken down as follows: TCLP volatile organics - 14 days from collection to TCLP extraction plus 14 days from leach extraction to analysis; extractable organics, pesticides & herbicides - 7 days from collection to TCLP extraction plus 7 days to solvent extraction of leachate plus 40 days to analysis of extract; mercury - 28 days from collection to TCLP extraction plus 28 days to analysis; metals except mercury - 180 days from collection to TCLP extraction plus 180 days to analysis.

3. Use indicated container for single parameter requests or 1/2-gallon polyethylene container for multiple parameter requests except those including BOD. Use a 1-gallon polyethylene container for multiple parameter requests which include BOD.

4. Must be preserved in the field at time of collection.

5. Use ascorbic acid only if the sample contains residual chlorine. Test a drop of sample with potassium iodide-starch test paper; a blue color indicates need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume.

6. May include nitrogen series (ammonia, total Kjeldahl nitrogen, nitrate-nitrite), total phosphorus, chemical oxygen demand and total organic carbon.

7. Samples must be extracted within seven days and extract must be analyzed within 40 days.

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155

PN-ABY-060

The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

Water Monitoring System Upgrade Plan - Appendix B

(Volume 3 - Zarqa River Basin Surface Water Quality Monitoring Program)

Science Applications International Corp.
Monitoring Network Working Group

WATER QUALITY IMPROVEMENT AND CONSERVATION PROJECT

Development Alternatives, Inc.

USAID

The Technical Assistance Team Includes:

Development Alternatives, Inc.
Science Applications International Corp.
Harza Environmental Services, Inc.
Development Associates, Inc.

United States Agency for International Development
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154

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

Table of Contents

Section — Page

List of Tables ii
List of Figures ii

1.0 Introduction 1

1.1 Background 1
1.2 Zarqa River Basin 3

2.0 Monitoring Program Objectives 4

2.1 Overview 4
2.2 Program Objectives 4

3.0 Monitoring Network Design 9

3.1 Status of Existing Monitoring System 9
3.2 Proposed Monitoring Station Locations 9
3.3 Monitoring Station Design 10
3.4 Surface Water Monitoring Parameters and Frequency 10
3.5 Sampling and Quality Assurance Protocols 11

4.0 Data Evaluation 13

5.0 References 14

Table of Contents (Continued)

Appendices

A **Jordanian Water Quality Standards**
B **Surface Water Quality Monitoring Station Description**

List of Tables

Table

2-1 General Classes of Water Quality Parameters for Surface Water Quality Monitoring Programs
3-1 Surface Water Monitoring Stations and Schedule
3-2 Water Quality Monitoring Parameters and Sampling and Preservation Procedures

List of Figures

Figure

1-1 Zarqa River Basin Location Map
3-1 Zarqa River Basin Surface Water Monitoring Stations Network

Zarqa River Basin
Surface Water Quality Monitoring Program

1.0 Introduction

The Ministry of Water and Irrigation (Ministry) is responsible at the national level for administering water policy and managing water resources in Jordan. A major component of the Water Quality Improvement and Conservation (WQIC) Project is to assist the Ministry in establishing a national water monitoring system for collecting surface and ground water resources and quality data and information. This program will contribute to the framework for improving serious water quality and water conservation problems and issues identified in the Kingdom's national water management plan.

Although the focus of the WQIC Project activities is the Zarqa River basin, the project goals are of national importance and will promote a national policy for water resources and water quality improvement and conservation.

This document presents the details for the surface water quality monitoring program for the Zarqa River Basin. The document discusses: the objectives of the monitoring program; the types of data to be collected by the program; the uses of the data; specific monitoring stations; frequency of monitoring and sample collection; and data management. This document is the first of a set of similar documents which will present the details for the surface water quality monitoring requirements and programs for all surface water basins in Jordan. Other documents will present water quality monitoring programs for:

- Yarmouk River Basin
- Wadi Mujib/Dead Sea Basins
- Wadi Araba Basins
- Jafr Basin
- Jordan River Valley and Rift Side Wadis Basins
- Azraq Basin
- Sirhan and Hammad Basins

1.1 Background

The primary objective of the water quality monitoring program is to enhance the national water monitoring system operated by the Ministry. The objectives for the national water

monitoring system address both water resources and water quality, and include data collection, data management, and organizational factors important for overall water resources management operations and planning.

Existing water monitoring programs in Jordan and data collection practices were reviewed as part of the comprehensive evaluation which produced the Monitoring Network Survey Document (MNSD) (MWI, 1994a). The responsibility for water management data collection within the Ministry has been shared by two independent organizations, the Jordan Valley Authority (JVA) and the Water Authority of Jordan (WAJ). The Ministry of Health, the Ministry of Municipality and Rural Affairs, and the Greater Amman Municipality Laboratory also monitor water resources primarily associated with drinking water quality. The WAJ-Laboratory Directorate (Central Laboratory) administers 12 separate water quality monitoring programs. Several water quality monitoring programs within the Jordan Valley are administered by the JVA Laboratory Directorate. The various WAJ-Governorates also maintain water monitoring activities. Sampling programs have been initiated in most of the Governorates to monitor water quality but without specific objectives. The Governorates sample from the same stations as the WAJ-Central Laboratory representing duplicate effort. The WQIC Project has recommended that these various programs be combined into a single, unified comprehensive water monitoring system program (Water Monitoring System Adequacy Report: MWI, 1995).

The existing streams, wadis, dams and reservoirs monitoring program administered by the WAJ-Central Laboratory is designed to monitor major surface waters which receive water directly from treatment plant effluents. The objective of the existing monitoring program is to measure the pollution loads in these surface waters in order to minimize the effects of the effluents on water resources and the environment. Stations have been established along Wadi Dhuleil, Wadi Zarqa, Wadi Birein, Wadi Shueib, and for the King Talal and Shueib Reservoirs.

The Laboratory Directorate of JVA maintains water quality monitoring programs for the King Talal Reservoir, King Abdullah Canal, and other surface water systems in the Jordan River Valley. The programs focus on the water quality for irrigation purposes in the Jordan River Valley. The samples primarily are collected for analysis of specific conductance (Ec) and pH. Since 1981, the JVA has been monitoring the water quality in the King Talal Reservoir using the Royal Scientific Society (RSS) as a subcontractor.

1.2 Zarqa River Basin

The Zarqa River Basin (or Amman-Zarqa Basin) extends from the Syrian border in northern Jordan to just south of Amman and westward to the Jordan Rift Valley and encompasses approximately 4154 square kilometers (3739 km^2 in Jordan) (Figure 1-1). The western third of the basin receives moderate to heavy amounts of precipitation for Jordan (300 to 600 mm/year). The eastern portions of the basin receive 100 to 200 mm/year of precipitation.

The basin contains the most heavily and densely populated areas of Jordan which include Amman, Zarqa, Jerash, and adjacent urban areas. The basin also includes the most heavily industrialized areas of Jordan as well as four major municipal waste water treatment plants (WWTPs). These WWTPs are located near Al-Samra, Abu Nusier, Baq'a, and Jerash. The Al-Samra WWTP services the population of Amman and Zarqa. In addition, several large municipal/industrial landfills or waste disposal sites are located in the basin. The King Talal Reservoir, the largest in Jordan, is located on the Zarqa River approximately 15 to 20 kilometers upstream of Deir Alla in the Jordan River Valley. For planning purposes, the discharge (outlet) from the King Talal Reservoir essentially defines the downstream end of the Zarqa River Basin.

Surface water in the basin primarily is used for irrigation purposes or flows into the King Talal Reservoir. Water stored in the reservoir is channeled to irrigation projects in the Jordan River Valley. The Al-Samra WWTP contributes substantial, year-round flow to Wadi Dhuleil/Wadi Zarqa and ultimately to the King Talal Reservoir. Water quality issues primarily relate to the use of treated waste water for irrigation purposes. In addition because of the heavy industrialization and urbanization of the Amman-Zarqa area, potential urban and industrial water quality concerns are important.

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2.0 Monitoring Program Objectives

2.1 Overview

The Amman-Zarqa Basin is subjected to numerous potential sources which could impact water quality. These include the various waste water treatment plants in the basin, waste disposal sites and landfills, urbanization and related storm water runoff, industrial operations, irrigation return flows, and animal husbandry operations. In addition, because of general climatic conditions in Jordan, normal flow in the Zarqa River is predominantly influenced by waste water discharges throughout the year and precipitation events during the winter rainy season. Surface waters extracted from the Zarqa River are used almost exclusively for irrigation purposes. A monitoring program for the basin is required to monitor water quality changes and to provide the data for long-term water quality improvement and environmental planning.

2.2 Program Objectives

Objectives

The principal objectives for the program are to monitor water quality changes in the Zarqa River Basin and to provide data for long-term planning for improving the water quality. Secondarily, by establishing a basin-wide monitoring program, greater data and information will be obtained to evaluate more specifically the factors most affecting or influencing water quality and related environmental conditions in the basin. These analyses and associated conclusions and recommendations then can form the basis for establishing infrastructure or operational modifications which would contribute to the long-term improvement in water quality.

Decision Statements

The fundamental water quality management questions and issues to be addressed by the Zarqa River Basin Water Quality Monitoring Program include:

(1) Does the water quality throughout the Basin (or in a general geographic area) meet the established water quality standards?

(2) Does the quality of water leaving the Basin meet the water quality provisions of international agreements to which Jordan is a signatory?

162

(3) Is the water quality throughout the Basin (or in a general geographic area) acceptable for irrigation uses for agriculture? Should this use be restricted or unrestricted?

(4) Is the water quality throughout the Basin (or in a general geographic area) acceptable for potable uses (e.g., drinking water)?

(5) What practices are contributing most significantly to poor water quality or to the deterioration of water quality throughout the Basin?

(6) Is water quality improving throughout the Basin (or in a general geographic area)?

These questions and issues are not necessarily independent events either spatially or temporally. The water quality monitoring program is part of a dynamic process that must be sufficiently comprehensive and flexible to account for both spatial and temporal changes in water quality which may result from many different sources. Data collected from the monitoring program will be used to evaluate these questions and will provide the basis for determining future actions required to improve water quality and the environment.

Data Requirements

The basic data and information required to support assessment of water quality conditions in the Zarqa River Basin are mainly chemical data. Because of the variety of populations or sources which affect water quality in the basin, the spatial distribution of these sources, the physical processes affecting the flow in the Zarqa River, and the potential uses of the water, several categories of chemical data were identified during the water monitoring system adequacy evaluation process (MWI, 1995). Water samples will be collected for chemical analysis from various stations throughout the basin. Classes of water quality parameters of interest have been specified for different monitoring stations. The general classes of water quality parameters are identified in Table 2-1.

In addition to the basic water chemistry data, information about the volumes of water discharged in the various wadis and catchment areas also is critical to a comprehensive understanding of water quality in the basin. These data will be collected under an independent program which is associated with surface water resources monitoring.

Water quality data collected by this program will be evaluated in part against various established water quality standards or criteria. These standards/criteria include Jordanian

163

water quality standards for various uses. World Health Organization standards, and possibly other international standards, as appropriate and necessary. Appendix A presents a summary of the Jordanian water quality standards.

The major constraint to collecting water samples and analyzing the samples for chemical and microbiological parameters will be the actual occurrence of water in the wadis and catchment areas. Because of the climate, the wadi courses generally are dry throughout most of the year with the exception of Wadi Dhuleil downstream of the Al-Samra waste water treatment plant and Zarqa River downstream of its confluence with Wadi Dhuleil. The water chemistry data may be evaluated on a frequent basis or only occasionally, such as seasonally, depending on the occurrence of flowing water. The frequency generally will be a function of the technical knowledge of the overall water quality conditions in the basin and the various relevant water quality standards/criteria. General trends which may be developing relative to water quality, or specific programs which may be initiated to monitor or improve water quality also will influence the frequency of monitoring.

Decision Rules

The use of water in Jordan is a very dynamic process dictated by water requirements and water availability. Currently, the surface water in the Zarqa River Basin is used only for irrigation purposes. The surface water is not suitable as a potable water source. As such, there are no critical requirements for decision rules which would govern 'real time' management actions based on the water quality data obtained from the program.

Generally, if the water meets established water quality standards/criteria, then the water can be used for the purpose defined by the standards. Current standards basically allow only restricted agricultural use of the water flowing in the Zarqa River to the King Talal Reservoir. Statistical analyses of water quality data are not planned in the short-term.

After the program begins to generate reliable and adequate data, then a more specific evaluation can be completed to define decision rules. This evaluation initially should be conducted at least annually. If water quality improves significantly or continues to deteriorate, then more detailed assessment of potential uses can be completed and more specific decision rules can be developed for use of the water.

Data Quality

Data Quality Objectives (DQOs) are qualitative and quantitative statements specified to ensure that data of known quality are obtained during monitoring programs. In addition, the identification of monitoring requirements involves specifying the sampling method, design, number of samples to be obtained, sample types and locations and the level of quality control required. As data needs are established or refined, logistical planning will be conducted to ensure that data can be acquired expeditiously and cost effectively.

The objectives for the Zarqa River Basin Surface Water Quality Monitoring Program are discussed above. Data quality objectives for a monitoring program must constantly be re-evaluated and refined as new information is obtained.

Data quality is the degree of certainty of data with respect to precision, accuracy, reproducibility, comparability, and completeness. Several levels of qualitative and quantitative specificity have been defined for data quality. Two Data Quality Levels (DQLs) have been identified for the Zarqa River Basin Surface Water Quality Monitoring Program. The two DQLs are defined as follows:

- Level I -- **Field Analyses**: This level provides rapidly generated data for ongoing field activities or the basis for seeking laboratory analytical support. It involves the use of portable or transportable instruments. Level I data are used for onsite screening, baseline data development, and determination of the general distribution of water quality conditions.

- Level II -- **Laboratory/Confirmational**: This level provides data of high quality but at a rate slower than provided by Level I. It utilizes approved, standardized testing procedures which may be equivalent to those used for international testing potentially including United States Environmental Protection Agency (USEPA) procedures specified for analyses of water and waste water or hazardous wastes.

Level I data will consist of field measurements of surface water for parameters such as pH, temperature, specific conductance, turbidity, and dissolved oxygen. Level II data will consist of results of analyses of surface water and sediment samples for the substances listed in Table 2-1 and discussed in Section 3.0 of this document.

The quality assurance/quality control objectives for all measurements include representativeness, completeness, comparability, precision, and accuracy. The definition of these terms and the criteria used for their evaluation are listed below.

Representativeness

Samples collected during performance of the tasks for this program must be representative of the area under investigation. Any observable parameter variations, matrix differences, and environmental conditions will be noted in the field log book. Any obvious irregularities in samples (stones, sticks, etc.) will be rejected and the sample will be thoroughly mixed.

Completeness

The completeness of the analyses will be assessed by comparison of the number of samples and analytical parameters requested with the number completed. Loss of samples due to container breakage, spillage, or leaking will be documented. Quality control data will be recorded and if data are rejected on the basis of quality control sample results, the reason for data rejection and corrective action taken should be documented in the analytical report.

Comparability

Consistency in the acquisition, handling and analysis of samples is necessary for the comparison of results to be meaningful. To achieve optimum comparability, acceptable methods for the collection and preservation of samples, sample holding times, and sample analyses, as described in the protocols presented in the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures), are closely followed.

Precision and Accuracy

Precision refers to the reproducibility of a method when it is repeated in a homogeneous sample regardless of whether or not the observed values are representative of the true values. Precision can be expressed by standard deviation.

Accuracy refers to the agreement between the amount of a component measured by a method and the actual amount of the component present in the sample.

Measurements of precision and accuracy should be calculated by the laboratory performing the chemical analyses.

3.0 Monitoring Network Design

3.1 Status of Existing Monitoring System

Eight (8) surface water resources monitoring stations have been established in the Amman-Zarqa Basin. At the present time only three of the stations are operational. Extensive and continued urbanization of the basin has affected several stations either because of public works activities, vandalism, or overall development of the basin. Maintenance of the stations also has been deficient.

Sixteen (16) surface water quality monitoring stations have been established in the Amman-Zarqa Basin. The stations primarily have been established along Wadi Dhuleil, Wadi Zarqa, and Wadi Birein for monitoring the discharges from municipal waste water treatment plants (WWTP). The chemical parameters monitored are typical of those for municipal WWTP effluent. No surface water quality monitoring is conducted in urban areas or industrialized areas.

3.2 Proposed Monitoring Station Locations

The Water Monitoring System Adequacy Report (MWI, 1995) recommended expansion of the surface water resources monitoring stations for the Amman-Zarqa Basin. Figure 3-1 depicts the general locations of the expanded water resources station network. Table 3-1 presents a summary of the purpose, equipment requirements, and station requirements for the Zarqa River Basin water resources monitoring stations. This monitoring program is discussed in detail in a separate monitoring document.

Because of the currently independent monitoring programs of WAJ and JVA, duplicate monitoring at two stations at the King Talal Reservoir have been combined in this document. New stations have been added on Wadi Zarqa at Ein Ghazal, near Ruseifa springs, Awajan bridge, and Zarqa bridge, and on Wadi Ishsha near Wadi Zarqa primarily to monitor urban and industrial source areas. A new station has been added on Wadi Sleihi downstream of the Baq'a waste water treatment plant. In addition, a monitoring station has been added on Wadi Dhuleil just upstream of the Al-Samra WWTP to provide background water quality data for the basin. In summary, a total of 23 stations is planned for the Zarqa

River Basin. Table 3-1 presents a summary of the purpose, equipment requirements, and station requirements for the surface water quality monitoring stations. Figure 3-1 depicts the general locations of the proposed stations.

Appendix B includes a general description of each station, general location, directions for finding the station, and related information for identifying the station.

3.3 Monitoring Station Design

The surface water quality monitoring scheme is based on collection of grab samples on a periodic basis from each monitoring station. The grab samples will be returned to the water quality laboratory for chemical and microbiological analysis. Composite samples will be collected, as needed, from locations throughout the basin. As such, there is no specific design for the surface water quality monitoring stations. Sampling procedures are presented in Section 3.5 below.

As possible, surface water quality monitoring stations for the Zarqa River Basin have been co-located with surface water resources monitoring stations. This design has been pursued to benefit from the control features required for establishing a surface water resources monitoring station as well as for potential future correlation of water quality and stream discharge data. This design is believed to minimize the overall number of monitoring station locations within the basin and to promote more efficient use of technical field resources and staff. However, there are still many more surface water quality stations than water resources stations.

3.4 Surface Water Monitoring Parameters and Frequency

Surface water monitoring will be conducted in accordance with the guidelines outlined in Table 3-1. Table 3-1 lists the general categories of parameters to be monitored at each station and the frequency of monitoring. Table 2-1 lists the specific chemicals associated with the general parameter categories specified in Table 3-1. Surface water samples collected at most of the monitoring stations will be analyzed for various suites of parameters typically associated with municipal waste water sources or urban/industrial sources. Because Wadi Dhuleil and the Zarqa River are not significantly affected by continuous discharge

108

from tributary wadis or catchment areas. samples are not required for full suites of parameters at each station.

3.5 Sampling and Quality Assurance Protocols

Consistent sampling, quality assurance, and data management protocols will be followed throughout the monitoring program to ensure that the analytical results provide an accurate representation of surface water quality at the background station and throughout the basin. These procedures are presented in detail in the Water Monitoring System Upgrade Plan Appendix A (Volume 2) and include:

(i) Surface water sample collection (Section 6.0);
(ii) Sample preservation and shipment (Section 2.0);
(iii) Chain-of-custody control (Section 2.0);
(iv) Quality assurance (Section 2.0); and
(v) Data management (Section 3.0).

Sample Collection

Surface water samples will be obtained in accordance with internationally accepted procedures. Samples will be handled and transported with full chain-of-custody. Section 6.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) presents detailed descriptions of the sampling procedures to be followed for the surface water monitoring program. Specific conductance, temperature, and pH will be analyzed and recorded in the field. Table 3-2 presents a generic summary of information relating to container type and volume, preservation technique, and holding time for chemical parameters for which samples will be collected.

Section 4.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) presents general practices and procedures for field operations to ensure collection of representative data and samples. Section 5.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) presents general information for planning a water quality sampling event.

109

Quality Assurance

Quality assurance protocols for the monitoring program are presented in Section 2.4 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures). These protocols describe the system to promote collection of representative and defensible data, use of field instrumentation, equipment calibration, sample documentation and record keeping requirements, and quality control samples. Use of field logs and field report forms is specified to maintain proper sample documentation.

Quality control samples shall be collected in accordance with the quality assurance guidelines described in Section 2.4 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures). Field, equipment, and trip blanks and duplicate samples will be used to provide field quality assurance for surface water samples. A minimum of one field blank and one equipment blank will be collected each day surface water samples are obtained for chemical analysis. One duplicate sample will be collected for every 10 samples or a minimum of one each day surface water samples are collected. A minimum of one trip blank shall be obtained each day samples are collected for analysis of volatile organic compounds.

Sample Analysis

Samples will be analyzed for the specific list of parameters according to the master categorization and schedule presented in Tables 2-1 and 3-1. Parameters include microbiological indices, general water quality constituents, typical water quality nutrients, metals, general organic constituents, and special organic constituents. Analyses of samples will be performed by the Central Laboratory of the Water Authority of Jordan within the Ministry of Water and Irrigation. Surface water samples will be analyzed following established international procedures such as USEPA procedures.

Data Management

Data management protocols for the monitoring program are presented in Section 3.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures). These protocols provide guidance on data management responsibilities of monitoring personnel and for recording and maintenance of data obtained from the monitoring program.

4.0 Data Evaluation

Data, including quality control data, reported by the Central Laboratory will be reviewed for reasonableness and general consistency with water quality conditions in the Basin. Significant discrepancies will be discussed with the monitoring team and laboratory to determine if unusual conditions occurred during the sampling event or if laboratory reporting errors may exist. After review, field and laboratory reported analytical data will be entered into a computerized water quality database. Data entered into the computerized database will be checked for entry and keying errors consistent with data management and database management procedures established for the overall monitoring program. Original field forms, laboratory analytical reports, and computer entry forms will be maintained in the project files.

Water quality data will be reviewed with respect to Jordanian and international (e.g., WHO and USEPA) water quality standards. These standards provide the bases for the acceptable use of water. The data also will be evaluated with respect to the program objectives and decision statements outlined in Section 2.2. The decision statements establish the basic water quality management objectives for the program. As noted in Section 2.2, no decision rules have been defined for the Zarqa River Basin water quality monitoring program. Sophisticated data evaluation techniques and tools have not been recommended initially for purposes of evaluating the water quality data. Such tools or techniques may become appropriate as the monitoring program and water quality database develop and as water management requirements change.

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Tables

Table 2-1. General Classes of Parameters for Surface Water Quality Monitoring Categories

Category 1 - Municipal Chemical Parameter Suites (wadis affected by municipal wastewater discharges)

Subcategory Municipal 1 -

- Monthly Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
  - Misc.- Total solids, total suspended solids, ABS
- Quarterly Parameters
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Volatile Organic Compounds (e.g., USEPA Method 8240)
  - Nematodes
- Semi-annual Parameters
  - Pesticides (e.g., USEPA Method 8080)
  - Herbicides (e.g., USEPA Method 8150)
  - Special Metals - As, Hg, Pb, Se

Subcategory Municipal 2 -

- Monthly Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
  - Misc.- Total solids, total suspended solids, ABS
- Quarterly Parameters
  - No special quarterly monitoring proposed
- Semi-annual Parameters
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Volatile Organic Compounds (e.g., USEPA Method 8240)
  - Nematodes
- Annual Parameters
  - Pesticides (e.g., USEPA Method 8080)
  - Herbicides (e.g., USEPA Method 8150)
  - Special Metals - As, Hg, Pb, Se

Subcategory Municipal 3 -

- Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$

Table 2-1. General Classes of Parameters for Surface Water Quality Monitoring Categories (cont'd)

Category 2 - Urban/Industrial Chemical Parameter Suites (wadis affected by urban/industrial discharges)

Subcategory Urban/Industrial 1 -

- Quarterly Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
  - Oil & Grease
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Special Metals - As, Hg, Pb, Se
  - Volatile Organic Compounds (e.g., USEPA Method 8240)
  - Misc. - Total solids, total suspended solids, ABS
- Annual Parameters
  - Semi-volatile Organic Compounds (e.g., USEPA Method 8270)

Subcategory Urban/Industrial 2 -

- Quarterly Parameters
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl)
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn

Category 3 - Drinking Water Chemical Parameter Suites (wadis supplying water for municipal uses)

Subcategory Drinking Water 1 -

- Monthly Parameters
  - Biological - total coliform, fecal coliform, algae, plankton
  - General - (BOD, COD, TOC, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl, CO_3)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
  - Misc.- Bromide, fluoride, turbidity
- Quarterly Parameters
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Volatile Organic Compounds (e.g., USEPA Method 8240)
  - Special Metals - As, Hg, Pb, Se
- Semi-annual Parameters
  - Pesticides (e.g., USEPA Method 8080)
  - Herbicides (e.g., USEPA Method 8150)
  - Cyanide
- Annual Parameters
  - Semi-volatile Organic Compounds (e.g., USEPA Method 8270)

Table 2-1. General Classes of Parameters for Surface Water Quality Monitoring Categories (cont'd)

Subcategory Drinking Water 2 -

- Monthly Parameters
  - Biological - total coliform, fecal coliform, algae, plankton
  - General - (BOD, COD, TOC, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl, CO_3)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$

Subcategory Drinking Water 3 -

- Monthly Parameters
  - General - (BOD, COD, TOC, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl, CO_3)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
- Annual Parameters
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Special Metals - As, Hg, Pb, Se

<u>Category 4 -</u> <u>**Irrigation Water Chemical Parameter Suites**</u> (wadis supplying water for irrigation uses)

Subcategory Irrigation Water 1 -

- Twice Monthly Parameters
  - Electrical conductivity, pH
- Semi-annual Parameters (April, October)
  - Ca, Mg, K, Na, Cl, SO_4, CO_3, HCO_3, NO_3

Subcategory Irrigation Water 2 -

- Twice Daily Parameters
  - Electrical conductivity, pH, TDS
- Weekly Parameters
  - Na, Cl, B
- Semi-annual Parameters (April, October)
  - Ca, Mg, K, Na, Cl, SO_4, CO_3, HCO_3, NO_3

Subcategory Irrigation Water 3 -

- Monthly Parameters
  - Electrical conductivity, pH
- Semi-annual Parameters (April, October)
  - Ca, Mg, K, Na, Cl, SO_4, CO_3, HCO_3, NO_3

Table 2-1. General Classes of Parameters for Surface Water Quality Monitoring Categories (cont'd)

Category 5 - Atypical Sites Water Chemical Parameter Suites (remote wadis or limited access wadis)

Subcategory Atypical 1 - (e.g., Yarmouk River)

- Quarterly Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TOC, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl, CO_3)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
  - Special Metals - As, Hg, Pb, Se
  - Volatile Organic Compounds (e.g., USEPA Method 8240)
- Semi-annual Parameters
  - Pesticides (e.g., USEPA Method 8080)
  - Herbicides (e.g., USEPA Method 8150)
  - Cyanide
- Annual Parameters
  - Semi-volatile Organic Compounds (e.g., USEPA Method 8270)

Subcategory Atypical 2 - (e.g., Wadi Mujib, Wadi Wala)

- Quarterly Parameters
  - Biological - total coliform, fecal coliform
  - General - (BOD, COD, TDS, electrical conductivity, pH, temperature, dissolved oxygen, SO_4, Cl, CO_3)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$
- Semi-annual Parameters
  - Metals - B, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Na, Ni, Zn
- Annual Parameters
  - Pesticides (e.g., USEPA Method 8080)
  - Herbicides (e.g., USEPA Method 8150)

Subcategory Atypical 3 - (e.g., remote wadis)

- Parameters
  - Biological - total coliform, fecal coliform
  - Modified General - (BOD, COD, TDS, electrical conductivity, pH, temperature)
  - Nutrients - NH_4, NO_3, PO_4, $PO_{4(total)}$

14

Table 3-1. Zarqa River Basin Surface Water Resources and Quality Monitoring Stations

MAP ID #	WAJ ID #	SITE NAME	STATION PURPOSE	MONITORING FREQUENCY	STATION NEEDS	COMMENTS
		Surface Water Resources Monitoring Stations				
1	AL 0040	Wadi Um Dananeer	Base and flood flow discharge (AGS)	Continuous	Rehabilitate	Protect from vandalism (AGS still at site)
2	AL 0060	Wadi Zarqa (at New Jerash Road Bridge)	Base and flood flow discharge (AGS, CW, CM)	Continuous	None	
3	AL 0061	Wadi Sleihi	Base and flood flow discharge (AGS)	Continuous	Rehabilitate	Protect from vandalism
4	AL 0062	Wadi Zarqa at Ain Ghazal	Base and flood flow discharge (AGS)	Continuous	Reconstruct	
5	AL 0063	Wadi Zarqa (at Sukhaneh)	Base and flood flow discharge (AGS)	Continuous	Construct	Relocated to new bridge crossing W. Zarqa
6	AL 0064	Wadi Dhuleil (at Sukhaneh)	Base and flood flow discharge (AGS)	Continuous	Construct	Relocated to new bridge crossing W. Dhuleil
7	AL 0065	Wadi Abdoun (at Ras Al Ain Bridge)	Flood flow discharge (upper Amman) (AGS)	Continuous	Reconstruct	Reset because of concrete conduit construction at site
8		King Talal Reservoir	Reservoir storage (AGS ?)	Continuous	Construct	
9		Rukban Station	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
10		Za'tri Station	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
11		Khaldiya Station (at Khaldiya Reservoir)	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
12		Wadi Sa'ida (near Wadi Dhuleil)	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
13		Wadi Rumeimin	Flood flow discharge (AGS)	Continuous	Construct	Just upstream of King Talal Reservoir
		Surface Water Quality Monitoring Stations				
1		Wadi Dhuleil (Station #5)	Category Municipal 1	M, Q, SA	None	Relocate to nearby downstream bridge crossing
2		Wadi Zarqa (Station #6)	Category Municipal 1	M, Q, SA	None	
3		Wadi Zarqa (Station after confluence with W. Dhuleil)	Category Municipal 3	Monthly	None	
4		Wadi Zarqa (Adwan Station)	Category Municipal 1	M, Q, SA	None	
5		Wadi Zarqa (New Jerash Road Bridge Station) (Station 7)	Category Municipal 1	M, Q, SA	None	
6		Wadi Zarqa (Site 100 downstream of Jerash Bridge Road)	Category Municipal 3	Monthly	None	
7		King Talal Reservoir Inflow	Category Municipal 1 (+ additional parameters)	M, Q, SA	None	M (algae, plankton, cholophyll)
						JVA Station 100 combined with WAJ Station
8		King Talal Reservoir Outflow	Category Municipal 1	M, Q, SA	None	JVA Station 600 combined with WAJ Station
9		King Talal Reservoir (Station 200 - Wadi Er Rumeimin)	Category Municipal 2	M, Q, SA, A	None	
10		King Talal Reservoir (Station 300 - middle of reservoir)	Category Municipal 1 (+ additional parameters)	M, Q, SA	None	M (algae, plankton, cholorphyll); A (semi-volatiles)
11		Wadi Birein (2 km downstream Abu Nusier WWTP)	Category Municipal 2	M, Q, SA, A	None	
12		Wadi Birein (Um Uruq Village)	Category Municipal 2	M, Q, SA, A	None	
13		Wadi Birein (Birein Village)	Category Municipal 2	M, Q, SA, A	None	
14		Wadi Jerash (downstream of Jerash WWTP)	Category Municipal 2	M, Q, SA, A	None	
15		Wadi Sleihi (downstream of Baq'a WWTP)	Category Municipal 2	M, Q, SA, A	None	
16		Wadi Zarqa (at Ain Ghazal)	Category Urban Industrial 1	Q, A	None	
17		Wadi Zarqa (at Ruseifa Springs)	Category Urban Industrial 2	Q	None	
18		Wadi Zarqa (at Zarqa Bridge)	Category Urban Industrial 1	Q, A	None	
19		Wadi Ishsha (near Wadi Zarqa)	Category Urban Industrial 1	Q, A	None	
20		Wadi Ishsha (near SulfoChemical Plant)	Category Urban Industrial 1	Q, A	None	
21		Wadi Birein (near Wadi Zarqa) (Khalah Spring)	Category Municipal 2	M, Q, SA, A	None	
22		Wadi Dhuleil (upstream of Al Samra WWTP)	Category Atypical 2	Q, SA, A	None	Background water quality
23		Wadi Zarqa (at Awajan Bridge)	Category Urban Industrial 2	Q	None	

NOTES: CM = current meter to measure baseflow; AGS = automatic gauging station; CW = cable way; EM = electromagnetic; M = monthly, Q = quarterly, SA = semi-annually, A = annually; Water quality sampling frequency dependent on whether there is flow in the stream channel

Table 3-2. Water Quality Monitoring Parameters and Sampling and Preservation Procedures

Parameter	Container	Preservative	Holding Time	Sample Type	Ref.
Water - Low to Medium Concentration Samples					
Alkalinity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	14 days	G or C	C
Acidity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	14 days	G or C	C
Bacteriological	250-ml. glass with glass closure or plastic capable of being autoclaved	Cool, 4°C	6 hours	G	C
Static Bioassay	1-gal. amber glass (not solvent rinsed)	Cool, 4°C	48 hours	G or C	D
Biochemical Oxygen Demand (BOD)	1/2-gal. polyethylene[3] with polyethylene closure	Cool, 4°C	48 hours	G or C	C
Chlorine	500-ml or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	None	28 days	G or C	C
Chlorine Residual	In-situ, beaker or bucket	None	Analyze Immediately	G	C
Conductivity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	28 days (determine on site if possible)	G or C	C
Chromium, Hexavalent	1-liter polyethylene with Polyethylene closure	Cool, 4°C	24 hours	G	C
Cyanide	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Ascorbic acid[4,5] Sodium Hydroxide, pH >12, Cool, 4°C	14 days	G	C
Dissolved Oxygen (Probe)	In-situ, beaker or bucked	None	Determine on site	G	C
Dissolved Oxygen (Winkler)	300-ml glass BOD bottle (store in dark if possible)	Fix on site	8 hours (determine on site	G	C
EP Toxicity	1-gal. glass (amber) with Teflon® liner	Cool, 4°C	Not Specified	G or C	B
TCLP Extractable Organics (VOA)	3 40-ml VOA containers with Teflon® lined Septum sealed caps	None	28 days[2]	G	-

Table 3-2. Water Quality Monitoring Parameters and Sampling

Parameter	Container	Preservative	Holding Time	Sample Type	Ref.
Water - Low to Medium Concentration Samples (continued)					
TCLP Extractable Organics, Herbicides, and Pesticide/PCBs	1-gal amber glass with Teflon® liner	None	54 days[2]	G or C	-
TCLP Metals except Mercury	1-gal amber glass with Teflon® liner	None	360 days[2]	G or C	-
TCLP Mercury	Samples will be taken from TCLP Metals container	None	56 days[2]	G or C	-
		Permissible			
Fluoride	1-liter polyethylene[3] or 1/2-gal. polyethylene with polyethylene or polyethylene lined closure	None	28 days	G or C	C
Hardness	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	50% Nitric Acid[4], pH <2	6 months	G or C	C
LAS	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	48 hours	G or C	C
Metals	1-liter polyethylene with polyethylene lined closure	50% Nitric Acid[4], pH <2	6 months	G or C	C
Metals, Dissolved	1-liter polyethylene with polyethylene lined closure	Filter on site[4] 50% Nitric Acid, pH <2	6 months	G	C
Nutrients[6]	1-liter polyethylene or 1/2-gal. polyethylene with polyethylene or polyethylene lined closure	50% Sulfuric Acid[4], pH <2, Cool, 4°C	28 days	G or C	C
Oil and Grease	1-liter widemouth glass with Teflon® lined cap	50% Sulfuric Acid[4], pH <2, Cool, 4°C	28 days	G	C
Organic Compounds - Extractable and Pesticide Scan					
No Residual Chlorine Present	1-gal amber glass or 2.5-gal. amber glass with Teflon® lined cap	Cool, 4°C	47 days[7]	G or C	A or C
Residual Chlorine Present	1-gal. amber glass or 2.5-gal. amber glass with Teflon® lined cap	Add 3 mls. 10% Sodium Thiosulfate per gallon, cool, 4°C	47 days[7]	G or C	A or C
Organic Compounds - Purgeable (VOA)					

Table 3-2. Water Quality Monitoring Parameters and Sampling

Parameter	Container	Preservative	Holding Time	Type	Ref.
Water - Low to Medium Concentration Samples (continued)					
No Residual chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	4 drops 1+1 HCl Cool, 4°C	14 days	G	A or C
No Residual Chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	Cool, 4°C	7 days	G	A or C
Residual Chlorine Present	3 40-ml vials with Teflon® lined septum sealed caps	Footnote 8	14 days	G	A or C
Organic Compounds - Specified and Pesticides (Non-Priority Pollutants such as Herbicides	1-gal. glass (amber) or 2.5-gal. glass (amber) with Teflon® lined closure	Footnote 9	47 days[7]	G or C	A or C
Organic Halides - Total (TOX)	250-ml amber glass with Teflon® lined septum closure	Cool, 4°C H_2SO_4 to pH <2	28 days	G	A or E
pH	In-situ, beaker or bucket	None	Analyze Immediately	G	C
Phenols	1-liter amber glass with Teflon® lined closure	50% H_2SO_4, ph <2, Cool, 4°C	28 days	G	C
Phosphate - Ortho	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	Filter on site, Cool, 4°C	48 hours	G	C
Phosphorus, Total Dissolved	500-ml. or 1-liter polyethylene with polyethylene or polyethylene lined closure	Filter on site, 50% H_2SO_4, pH <2, Cool, 4°C	28 days	G	C
Solids, Settleable	1/2-gal. polyethylene with polyethylene closure	Cool, 4°C	48 hours	G or C	C
Solids (Total and Suspended, etc.)	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	7 days	G or C	C
Sulfates	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	28 days	G or C	C
Sulfides	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	2-ml. Zinc Acetate[4], Conc NaOH to pH >9, Cool, 4°C	7 days	G	C
Temperature	In-situ, beaker or bucket	None	Determine on site	G	C
Turbidity	500-ml. or 1-liter polyethylene[3] with polyethylene or polyethylene lined closure	Cool, 4°C	48 hours	G or C	C

Abbreviations: G = Grab
C = Composite
ASAP = As Soon As Possible
NS = Not Specified

Footnotes:

1. The TCLP method requires the leaching of 25 grams of solid for volatile organics and 100 gram of solids for all other parameters. If the sample is low in solids, additional sample containers may be required to provide sufficient sample for the TCLP leach extraction.

2. These are total holding times for TCLP that cover sampling through analysis. The holding times are broken down as follows: TCLP volatile organics - 14 days from collection to TCLP extraction plus 14 days from leach extraction to analysis; extractable organics, pesticides & herbicides - 7 days from collection to TCLP extraction plus 7 days to solvent extraction of leachate plus 40 days to analysis of extract; mercury - 28 days from collection to TCLP extraction plus 28 days to analysis; metals except mercury - 180 days from collection to TCLP extraction plus 180 days to analysis.

3. Use indicated container for single parameter requests or 1/2-gallon polyethylene container for multiple parameter requests except those including BOD. Use a 1-gallon polyethylene container for multiple parameter requests which include BOD.

4. Must be preserved in the field at time of collection.

5. Use ascorbic acid only if the sample contains residual chlorine. Test a drop of sample with potassium iodide-starch test paper; a blue color indicates need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume.

6. May include nitrogen series (ammonia, total Kjeldahl nitrogen, nitrate-nitrite), total phosphorus, chemical oxygen demand and total organic carbon.

7. Samples must be extracted within seven days and extract must be analyzed within 40 days.

References

1. USEPA. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition. Office of Solid Waste and Emergency Response, Washington, DC. November 1986.

2. 40 CFR Part 136, Federal Register, Vol. 49, No. 209, October 26, 1984.

3. USEPA Region IV. 1991. Environmental Compliance Branch, Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

Figures

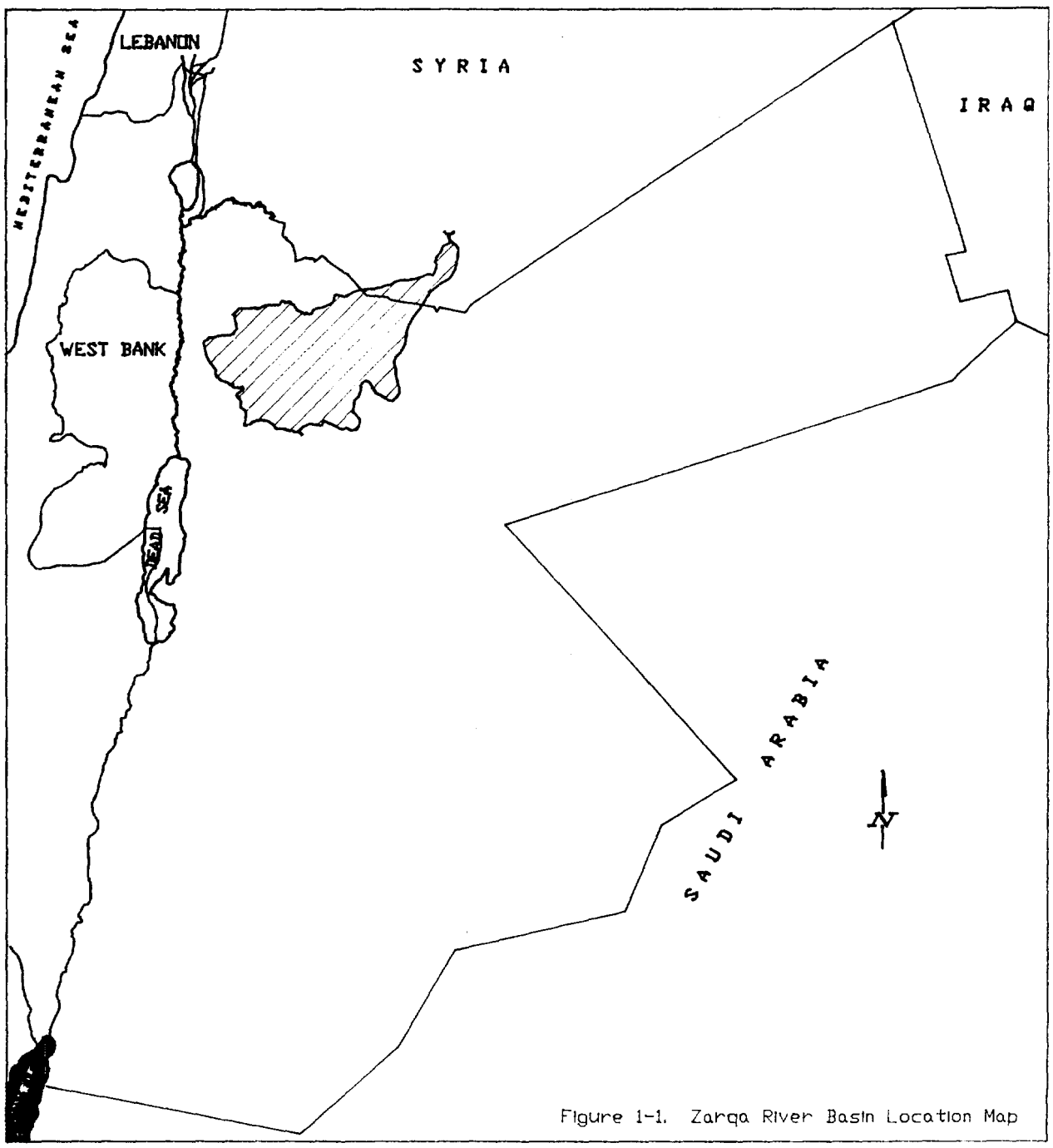

Figure 1-1. Zarqa River Basin Location Map

ZARQA RIVER BASIN

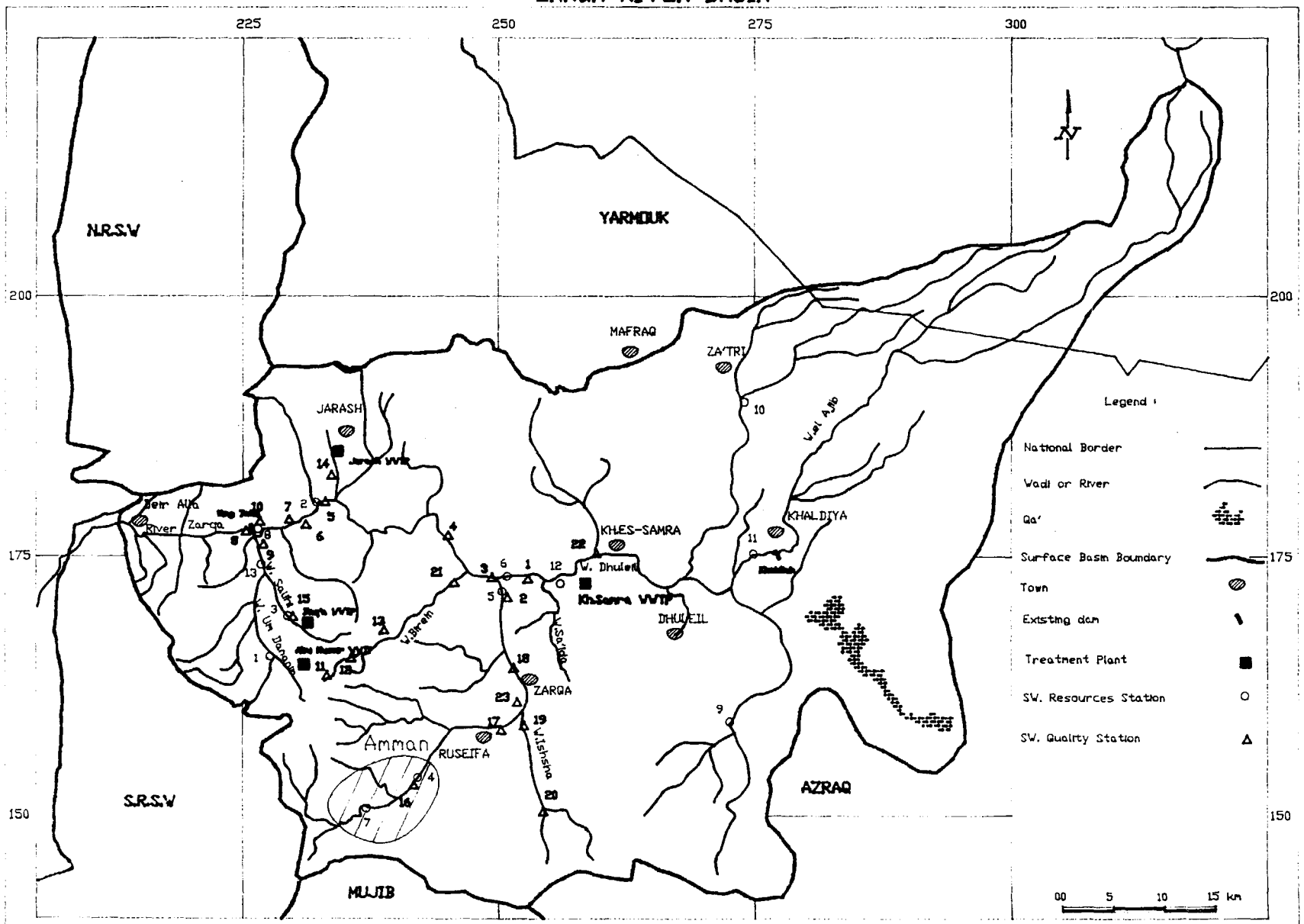

Figure 3-1 Zarqa River Basin Surface Water Monitoring Network

APPENDIX A

Jordanian Water Quality Standards

Appendix A.1: Industrial Wastewater Regulations
Ministry of Industry of Trade
Standards and Measurement Directorate
Hashemite Kingdom of Jordan, Amman
Document Number: JS/202/1991

Table of Contents

Page No.

Scope A-2

Definitions A-2

General Conditions A-2

Standard Conditions A-3

Technical Expressions A-3

References A-4

1. SCOPE

This standard deals with requirements and properties that industrial wastewater must meet before being discharged to any receiving body or reused for agriculture.

2. DEFINITIONS

Industrial wastewater is defined as the water produced after being used for industrial purposes, either processing, cooling or cleaning, regardless of whether or not treatment is performed.

3. GENERAL CONDITIONS

The conditions listed below must be met :

3.1 The industrial wastewater coming out of the factories should not adversely affect the environment. To safeguard health and human safety, such water should not adversely affect the economic and social development in the area or the water basins.

3.2 The end use of such water defines the characteristics (quality) of the industrial water and the guidelines that must be implemented. These are illustrated in the attached table, with the condition that the environmental balance in the susceptible area should not be disturbed.

3.3 The industrial wastewater should not adversely affect the ground water quality in the watershed (catchment area).

3.4 The industrial wastewater should neither adversely affect the quality of the receiving water body nor the biota.

3.5 In case of reusing the industrial wastewater in any processing stages in the factory (cooling , washing , cleaning, etc.) or for agriculture, it should not adversely affect the health or safety of employees or consumers.

3.6 In case of reusing the industrial of wastewater for irrigation, the FAO guidelines concerning wastewater and related regulations must be taken into consideration.

3.7 In case of discharging the industrial wastewater into the public sewer system, discharge should comply with regulations set by the Water Authority and any modifications that might come up.

4. STANDARD CONDITIONS

The parameters listed in the table below must be met and the accepted results depend on :

4.1 The samples tested must be composite and number of samples should not be less than one per week (for water quality assessment).

4.2 If the samples is not composite, grab samples should be taken according to type and continuity of effluent with an average of at least 3 samples per week (more is preferable).

4.3 Samples taken should be kept and analyzed using American Standard Methods and American Association for Water Research and Water Pollution Monitoring 1989, and its modification, and or any other reliable method of testing.

4.4 The general conditions and the comprehensive Environmental Impact Assessment should be followed to identify the quality of the water allowed to be discharged from any industry in the area especially for the parameters that are not mentioned or value of which are not mentioned in the table.

5. TECHNICAL EXPRESSIONS

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Dissolved Oxygen (DO)
- End use
- Faecal Coliform
- Grab Samples
- Intestinal nematodes
- Oil Content
- Phenol
- Suspended Solids (SS)
- Total Dissolved Solids (TDS)

190

6. REFERENCES

1. Water Reuse and Recycling Technology.

2. Water Quality for discharge to the Arabian Gulf-Codes of Practice & Environmental Guidelines-Kuwait.

3. FAO Guidelines for agriculture.

4. Jordanian standard for drinking water 286.

5. Regulation for wastewater reuse and discharge Sultanate of Oman. Ministry of Environmental & water resources.

6. Recommended Water quality for Reuse. KISR-Kuwait.

7. Reuse of Effluent. methods of Wastewater Treatment & Health Safeguards by World Health Organization (WHO).

191

TABLE A.1-1
INDUSTRIAL WASTEWATER QUALITY STANDARD (202 REGULATION 1990)

PARAMETER	REUSED FOR IRRIGATION [1]	NATURALLY RECHARGED TO UNDERGROUND WATER	DISCHARGED TO SEA	DISCHARGED TO WADIS, RIVERS, AND DAMS
BOD	-	50	-	50
COD	-	150	200	150
DO	>1	>1	>5	>1
TDS	2000[3]	1500[2]	-	3000[2]
TSS	100[4]	-	-	50
pH	6.5-8.4	6.5-9.0	5.5-9.0	6.5-9.0
Color	-	15 NTU	75 NTU	15 NTU
Temperature	-	-	4C	-
Fats, Oil, and Grease	5	NO.O.G	10	15
Phenol	0.002	0.002	1	0.002
MSAS	-	15	-	15
NO_3 - Nitrogen	30	12	-	12[5]
NH_3	5	5	12	5
Total Nitrogen	50		125	-
PO_4 - Phosphorous	-			15
Chlorine (Cl)	350[4]	500	-	500
Sulfate (SO_4)	400	500	-	500
Fluorine (F)	-	1.5		1.5
HCO_3	500		-	-
Sodium (Na)	-	400		-
Magnesium (Mg)	-	-	-	-
Calcium (Ca)	-	-	-	-
SAR	9	-	-	-
Aluminum (Al)	5	0.3	-	0.5
Arsenic (As)	0.1	0.05	0.1	0.05
Boron (B)	0.1[6]	1.0	-	1.0
Total Chromium (Cr)	0.1	0.05	0.3	0.1
Total Copper (Cu)	0.2	2.0	0.1	2.0
Iron (Fe)	5.0	1.0	2.0	1.0
Manganese (Mn)	0.2	0.2	0.2	0.2
Nickel (Ni)	0.2	0.1	0.02	0.2
Lead (Pb)	1.0	0.1	0.1	0.1
Selenium (Se)	0.02	0.05	0.02	0.02
Cadmium (Cd)	0.01	0.02	0.07	0.01
Zinc (Zn)	2.0	15.0	-	15.0
Cyanide (CN)	0.1	0.1	1	0.1
Mercury (Hg)	0.001	0.001	0.001	0.001
Coliform (MPN/100 ml)	-	-	5000	-
Faecal Coliform (MPN/100 ml)	1000[7]	1000[7]	-	1000[7]
Helminth Eggs/L	1	-	-	1

- All measurements are in mg/L unless otherwise stated.
- All values mentioned in this table are the maximum acceptable values.

1. Depends on the plant type, irrigation method, soil type, underground water and Climate.
2. Depends on the TDS in the source water.
3. Depends on the degree of restriction according to plant type.
4. Depends on the irrigation method.
5. Depends on NO_3 concentration in the underground water affected.
6. Up to 3 mg/l.
7. Arithmetic mean.

Appendix A.2: **Jordanian Standard No. 286**
Ministry of Industry of Trade
Directorate of Standards and Specifications
Hashemite Kingdom of Jordan, Amman
Document Number: JS/282/1990

Table of Contents

Page No.

Scope A-7

Definitions A-7

Properties A-7

Technical Expressions A-10

References A-11

1. SCOPE

This standard concerns the requirements and physical, chemical and biological properties of drinking water.

2. DEFINITIONS

drinking water is defined as the water that can be used for drinking and domestic purposes and for food processing industries and at the same time fulfills this standard.

3. PROPERTIES

3.1 Microbiological Properties

a. Total coliform 2.2/100 ml (MPN) 0/100 ml (membrane Filtration)
b. Faecal Coliform 0/100 ml
c. In case of presence of non-faecal coliform, lab-test might be identified to detect other bacteria such as streptococci and Clostridium perfringens
d. Extensive and more frequent tests must be conducted on points where total bacterial count exceeds 1.000/ml

3.2 Biological Content

Drinking Water must be free from :

a. Protozoa
b. Infectious nematodes
c. Free living organisms including fungi or any other organisms that affect the human health or produce poisonous substances harmful to humans

3.3 Physical Properties

TABLE A.2-1

PARAMETER	ALLOWABLE LIMIT	MAXIMUM ALLOWABLE IN ABSENCE OF OTHER SOURCES
Taste	Acceptable to most consumers	
Oder	Acceptable to most consumers	
Color	10 Units (CoPt Colorimetry)	15 Unit
Turbidimetry	1 Unit (Jackson Kandel or equivalent)	5
pH	6.5 to 9.0	
Temperature	8 to 25 °C	

3.4 Chemical Properties

3.4.1 Poisonous Matter :

The percentage of poisonous substances should not exceed the below stated limits:

TABLE A.2-2

SUBSTANCES	SYMBOL	MAXIMUM LIMIT MG/L
Lead	Pb	0.05
Selenium	Se	0.01
Arsenic	As	0.05
Chromium	Cr	0.05
Cyanide	CN	0.10
Cadmium	Cd	0.005
Mercury	Hg	0.001
Antimony	Sb	0.01
Silver	Ag	0.01

3.4.2 Substances having special effect on water quality and human health : Substances having health effect or considered indicator for pollution should not exceeds the below listed limits.

TABLE A.2-3

SUBSTANCE	SYMBOL	MAXIMUM ALLOWABLE LIMIT (MAL) mg/l	MAL IN ABSENCE OF OTHER SOURCES mg/l	TYPE OF EFFECT WITHIN MAL
Total Dissolved Solids	TDS	500	1500	No Effect
Total Hardness	$CaCO_3$	100	500	No Effect
ABS	ABS	0.5	1.0	Pollution
Aluminum	Al	0.2	0.3	Indicator No
Iron	Fe	0.3	1.0	Effect
Manganese	Mn	0.1	0.2	No Effect
Copper	Cu	1.0	1.5	No Effect
Zinc	Zn	5.0	15	No Effect
Sodium	Na	200	400	No Effect
Nickel	Ni	0.05	0.1	No Effect
Chloride	Cl	200	500	Health Effect
Fluoride	F	1.0	1.5	No Effect
Sulfate	SO_4	200	500	Health Effect
Nitrate	NO_3	45	70	No Effect
				Health Effect

3.4.3 Radioactive Substances
Radioactive substances should not exceed limits authorized as indicated in Table 4 below. and in case of higher concentrations than acceptable. specialized body must conduct further analysis to identify the radioactive elements. the cause and its effect on health.

TABLE A.2-4

SUBSTANCES	MAXIMUM LIMIT
Alpha emitters	< 0.1 Bq/L (not including Radon)
Beta emitters	< 1.0 Bq/L

3.4.4 Organic Substances

3.4.4.1 The Organic substances concentrations should not exceed the limits stated in table 5 below :

TABLE A.2-5

SUBSTANCES	MAXIMUM ALLOWABLE LIMIT MG/L
A. Chlorinated Hydrocarbons	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
B. Chlorophenoxys	
2.4-D	0.1
2,4,5-TP	0.01

3.4.4.2 Other Organic pollutants not mentioned in table 5 should not exceed the limits acceptable by the WHO

4. TECHNICAL EXPRESSIONS

- Alpha Emitters
- Beta Emitters
- Chlorinated Hydrocarbons
- Clorophenoxys
- 2.4 Di-Chloro-Phenoxy Acetic Acid
- Endrin
- Free Living Organisms
- Lindane
- Methoxychlor
- Membrane Filter Test
- Multiple Tube Test
- Toxaphene
- Total Hardness

- 2,4,5 Tri-Chloro Phenoxy Propionic Acid

5. REFERENCES

1. Saudi Standard, 409/1989.
2. Saudi Standard, 45/1973.
3. OMAI Standard, 8/1978.
4. Lebanese Standard, 75/1970.
5. Egyptian Standard, 1589/1986.
6. Guidelines for Drinking Water Quality, VOL.1,2,3.
7. ECC Standards 1975.
8. U.S Environmental Protection Agency (USEPA), Primary Drinking Water Regulation, 1986.
9. Canadian Drinking Water Quality Criteria.
10. Drinking Water Standards of Germany.

APPENDIX B

Surface Water Quality Monitoring Stations Description

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Dhuleil Station 5 (Sukhaneh)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located on Wadi Dhuleil before the confluence of Wadi Zarqa and Wadi Dhuleil. The station provides a final indication of the general water quality coming from Al Samra WWTP before mixing with water from industrial and urban sources in Amman and Zarqa.

Data Collected

The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basisPropose to relocate station 5 to this location

4. Physical Description of Station

Wadi bed at station at upstream side of bridge crossing

5. Directions to Location of Station

Bridge near hygienic paper factory on road between Om Salieh and Sukhaneh. The site is relocated from the former Station 5 to the nearby bridge to identify a more consistent sampling point.

6. Proposed Action for Water Monitoring System Station

Relocate to new bridge on Om Salieh - Sukhaneh highway near hygienic paper factory

7. Other Observations:

Water observed flowing in wadi with a dark color

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Zarqa Station 6 (Sukhaneh)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located on Wadi Zarqa just before the confluence of Wadi Zarqa and Wadi Dhuleil. The station provides a final indication of the general water quality coming from industrial and urban sources in Amman and Zarqa before mixing with water from the Al Samra WWTP.

Data Collected

The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis

4. Physical Description of Station

Wadi bed at station; just before confluence of wadis

5. Directions to Location of Station

On Wadi Zarqa just upstream of confluence with Wadi Dhuleil. Station is accessed from along road between Sukhaneh to the Wadi. Dhuleil / Wadi Zarqa confluence

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water was observed flowing in the wadi

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Zarqa / Dhuleil confluence

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located after the confluence of Wadi Zarqa and Wadi Dhuleil. This provides a good location for initial mixing of water from the Al Samra WWTP and metropolitan Amman.

Data Collected

The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed at station: the stream flows year-round at this location primarily because of the discharge from Al Samra WWTP.

5. Directions to Location of Station

The station is located about 200 meters downstream of Wade Zarqa and Wadi Dhuleil confluence near Taha Murad well.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Adwan Station

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station is located several kilometers downstream of the confluence of Wadi Zarqa and Wadi Dhuleil and after Wadi Birein discharges into Wadi Zarqa. It is the last station prior to the New Jerash Bridge station.

Data Collected

The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed at station; the stream flows year-round at this location because of the discharge from Al Samra WWTP.

5. Directions to Location of Station

The station is located upstream near the water mills about 1 km upstream of the Adwan bridge; the station could be moved to the Adwan bridge for easier access

6. Proposed Action for Water Monitoring System Station

Relocate to Adwan Bridge near mill over Wadi Zarqa

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: Zarqa at New Jerash Bridge Rd.

ID Number: AL0060

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station represents a long-term control point on Wadi Zarqa and is reasonably accessible. The station is located after the confluence of Wadi Zarqa and Wadi Jerash

Data Collected

A long record of water resources (stream discharge) data have been collected from the site. The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis from the station.

4. Physical Description of Station

Water quality data are collected from the wadi bed upstream of the bridge crossing. Water resources data are collected with a water level recorder/ cableway in the vicinity of the bridge.

5. Directions to Location of Station

At new Jerash road bridge

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

The stations were not directly inspected on this date.

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: Wadi Zarqa (Site 100)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station represents a long-term control point for water quality on Wadi Zarqa.

Data Collected

The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed at station

5. Directions to Location of Station

The site is located downstream of new Jerash road bridge toward King Talal Reservoir

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

The station was not directly inspected on this date

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: King Talal Reservoir Inflow

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station represents a long-term control point for water quality on Wadi Zarqa at King Talal Reservoir.

Data Collected

The station is part of an active monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

General area of upstream portion of King Talal Reservoir

5. Directions to Location of Station

The station is located at the headwaters of the King Talal Reservoir.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: King Talal Reservoir Outflow

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station represents a long-term control point for water quality on Wadi Zarqa downstream of King Talal Reservoir.

Data Collected

The station is part of an active monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed after the discharge from King Talal Reservoir

5. Directions to Location of Station

The station is located near the hydroelectric plant / spillway on Wadi Zarqa immediately downstream of the discharge from the King Talal Reservoir.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: King Talal Reservoir (Site 200)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station represents a long-term control point for water quality for a major tributary to the King Talal Reservoir.

Data Collected

The station is part of an active monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

General area of King Talal Reservoir where Wadi Er Rumeimin enters the reservoir.

5. Directions to Location of Station

The station is accessible by boat where Wadi Er Rumeimin enters the King Talal Reservoir.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: King Talal Reservoir (Site 300)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station represents a long-term control point for water quality in the central area of the King Talal Reservoir.

Data Collected

The station is part of an active monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

General central area of King Talal Reservoir close to discharge pipe structure on left side of reservoir (from dam looking over reservoir) not far from the spillway

5. Directions to Location of Station

The station is accessible by boat.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Birein (2 km site)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station represents water quality of the discharge from Abu Nusier WWTP before mixing with springs which discharge to Wadi Birein

Data Collected

The station is part of an active Abu Nusier WWTP monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed at station; water generally flows year-round at the station because of the discharge from the Abu Nusier WWTP.

5. Directions to Location of Station

General location is 2 km (by car odometer) downstream of Abu-Nusier WWTP outfall.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Birein (Um Uruq village)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station is located on Wadi Birein downstream of the Abu Nusier WWTP. The station provides coverage for assessing water quality changes associated with the discharge.

Data Collected

The station is part of the active Abu Nusier WWTP monitoring program. A broad spectrum of data has been collected on a regular basis

4. Physical Description of Station

Wadi bed at station upstream of bridge crossing Wadi Birein

5. Directions to Location of Station

Um Uruq village bridge over Wadi Birein

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Birein (Birein Village)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station is located on Wadi Birein downstream of the Abu Nusier WWTP. The station provides coverage for assessing water quality changes associated with the discharge.

Data Collected

The station is part of the active Abu Nusier WWTP monitoring program. A broad spectrum of data has been collected on a regular basis.

4. Physical Description of Station

Wadi bed at station upstream of bridge crossing.

5. Directions to Location of Station

Wadi Birein bridge crossing near school (Birein secondary school) in Birein villate.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: Wadi Jerash at WWTP

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located downstream of the Jerash WWTP. The station will provide general water quality data for Wadi Jerash prior to its confluence with Wadi Zarqa.

Data Collected

Some limited general water quality data have been collected by JVA.

4. Physical Description of Station

Wadi bed near white house and collection well about 200m downstream of outfall from Jerash WWTP.

5. Directions to Location of Station

Off old Jerash - Amman road; find WWTP outfall to Wadi Jerash and locate white house and collection well.

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

Water flowing in wadi at sampling station

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 13 Feb 1995

Weather Conditions: Clear, sunny, windy

1. Station Identification

Name: Wadi Sleihi (at AL0061 location)

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

The station is located downstream of Baq'a WWTP at the site of water resources station AL0061

Data Collected

None to date

4. Physical Description of Station

Wadi bed at free flowing stream at water resources gauging station

5. Directions to Location of Station

At Wadi Sleihi surface water gauging station some kilometers downstream of Baq'a WWTP

6. Proposed Action for Water Monitoring System Station

Potential

7. Other Observations:

Water flowing in wadi at station

214

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:	11 Feb 1995
Weather Conditions:	Clear, sunny

1. Station Identification

Name:	Ain Ghazal
ID Number:	AL0062
Basin:	Amman-Zarqa
Aquifer:	
Status:	Not working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Long-term water resources monitoring station near Ain Ghazal WWTP; good historical record of discharge data for Wadi Zarqa after downtown Amman. Potential location for water quality monitoring for downtown Amman.

Data Collected

Stream discharge data using a water level recorder. No water quality data collected to date.

4. Physical Description of Station

Automatic gauging station at Ain Ghazal WWTP. Wadi Zarqa is confined to a concrete channel in this area. Stilling well has been closed off due to installation of concrete channel.

5. Directions to Location of Station

At Ain Ghazal near WWTP facility.

6. Proposed Action for Water Monitoring System Station

The station was affected when the concrete channel was constructed to replace the bed of Wadi Zarqa. The stilling well and bottom opening for displacement of water are still visible but are elevated above the bottom of the channel. The AGS has been removed.

The station can be rehabilitated with a new AGS. Possible hydraulic connection with the stilling well is possible through the concrete channel. Rehabilitation needs to be discussed with organization installing the concrete channel.

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Water Zarqa at Ruseifa Springs

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station is located immediately downstream of the Ruseifa springs and the nearby yeast factory. The station provides for general water quality in Wadi Zarqa originating from Amman but prior to industrial activities near Zarqa.

Data Collected

None to date

4. Physical Description of Station

Stream bed at bridge over Wadi Zarqa near old phosphate mine

5. Directions to Location of Station

First bridge over Wadi Zarqa downstream of Ruseifa springs and yeast factory. There is a new bridge located just upstream of yeast factory which should not be confused with the old bridge

6. Proposed Action for Water Monitoring System Station

Potential.

7. Other Observations:

Flow in wadi at this point was estimate at > 1m**3/sec

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 Feb 1995

Weather Conditions: sunny, clear

1. Station Identification

Name: Wadi Zarqa at Zarqa bridge

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

The station is located after the principal industrial sources between Ruseifa and Zarqa and provides a point for assessment of water quality after these industrial sources and major portions of metropolitan Zarqa

Data Collected

None to date

4. Physical Description of Station

Wadi bed at station located on upstream side of Zarqa bridge over Wadi Zarqa. The site is located near the pumping station for a former spring

5. Directions to Location of Station

Zarqa bridge

6. Proposed Action for Water Monitoring System Station

Potential

7. Other Observations:

Flow in wadi was observed.

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 Feb 1995

Weather Conditions: Clear. sunny

1. Station Identification

Name: Wadi Ishsha bridge near Awajan bridge

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

The station is located downstream on the wadi which flows through a major industrial area.

Data Collected

None to date

4. Physical Description of Station

Wadi bed at Wadi Ishsha bridge crossing.

5. Directions to Location of Station

First bridge upstream on Wadi Ishsha before confluence with Wade Zarqa

6. Proposed Action for Water Monitoring System Station

Sample from station only when water is present

7. Other Observations:

No flow observed in wadi

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Ishsha near sulfo-chemical plant

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

___ Ground Water
___ Springs
___ Surface Water
___ Other

Other

3. Station Purpose

___ Water Resources
___ Water Quality

Rationale for Station / Location

Monitor potential industrial sources on Wadi Ishsha.

Data Collected

None to date

4. Physical Description of Station

Wadi bed at bridge crossing station immediately downstream of sulfo-chemical plant; station may need to be located closer to plant.

5. Directions to Location of Station

Take road through industries along Wadi Ishsha ; continue toward sulfo-chemical plant. First bridge downstream of plant.

6. Proposed Action for Water Monitoring System Station

Rely on effluent sampling at plant ; sample from Wadi Ishsha only at downstream location when water is present.

7. Other Observations:

No flow in wadi observed. Far downstream and just prior to the wadi flowing under the new Amman-Zarqa highway a small reservoir was observed. Someone had constructed a small barrier across the wadi to capture the water. This is a potential water quality monitoring point.

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Berein at Khalah Springs

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

__ Ground Water
__ Springs
__ Surface Water
__ Other

Other

3. Station Purpose

__ Water Resources
__ Water Quality

Rationale for Station / Location

Station is located on Wadi Birein at Khalah springs and just before confluence with Wadi Zarqa

Data Collected

None to date

4. Physical Description of Station

Wadi bed at bridge crossing on Wadi Birein immediately upstream of confluence with Wadi Zarqa

5. Directions to Location of Station

After Khalah springs, at bridge over Wadi Birein for road from Zarqa-Jerash road to Berein

6. Proposed Action for Water Monitoring System Station

Potential

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Dhuleil upstream of Al Samra WWTP

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located upstream of the initial major wastewater discharge source on Wadi Dhuleil. The station will provide background water quality data

Data Collected

None to date

4. Physical Description of Station

Wadi bed at bridge crossing in agriculture / cattle farm area.

5. Directions to Location of Station

First bridge on Wadi Dhuleil upstream of the confluence of Wadi Dhuleil with the Al Samra WWTP (upstream of railroad bridge)

6. Proposed Action for Water Monitoring System Station

Potential

7. Other Observations:

Very little standing water was observed at the site. No flowing water was observed.

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 Feb 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Zarqa at Awajan bridge

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- Ground Water
- Springs
- Surface Water
- Other

Other

3. Station Purpose

- Water Resources
- Water Quality

Rationale for Station / Location

The station is located after the confluence of the major metopolitan Amman tributaries and Wadi Ishsha with Wadi Zarqa.

Data Collected

None to date

4. Physical Description of Station

Wadi bed at station located on upstream side of Awajan bridge over Wadi Zarqa

5. Directions to Location of Station

Awajan bridge over Wadi Zarqa

6. Proposed Action for Water Monitoring System Station

Potential

7. Other Observations:

Good flow was observed in Wadi Zarqa just after Wadi Ishsha confluence

PA-ABY-060

The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

Water Monitoring System Upgrade Plan - Appendix C

(Volume 4 - Zarqa River Basin Surface Water Resources Monitoring Program)

Science Applications International Corp.
Monitoring Network Working Group

Development Alternatives, Inc.

USAID

The Technical Assistance Team Includes:

Development Alternatives, Inc.
Science Applications International Corp.
Harza Environmental Services, Inc.
Development Associates, Inc.

United States Agency for International Development
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Water Quality Conservation and Improvement Project
Ministry of Water and Irrigation
The Hashemite Kingdom of Jordan

Table of Contents

Section — Page

List of Tables ii
List of Figures ii

1.0 Introduction 1

1.1 Background 1
1.2 Zarqa River Basin 3

2.0 Monitoring Program Objectives 4

2.1 Overview 4
2.2 Program Objectives 4

3.0 Monitoring Network Design 10

3.1 Status of Existing Monitoring System 10
3.2 Monitoring Station Locations 10
3.3 Monitoring Station Design 11
3.4 Surface Water Flow Measurements and Frequency 12
3.5 Hydrologic Measurements and Quality Assurance Protocols 12

4.0 Data Evaluation 14

5.0 References 15

326

Table of Contents (Continued)

Appendices

A **Surface Water Resources Monitoring Station Description**
B **Design Drawings and Specifications for Surface Water Monitoring Stations**

List of Tables

Table

3-1 Zarqa River Basin Surface Water Resources and Quality Monitoring Stations

List of Figures

Figure

1-1 Zarqa River Basin Location Map
3-1 Zarqa River Basin Surface Water Monitoring Stations Network

Zarqa River Basin
Surface Water Resources Monitoring Program

1.0 Introduction

The Ministry of Water and Irrigation (Ministry) is responsible at the national level for administering water policy and managing water resources in Jordan. A major component of the Water Quality Improvement and Conservation (WQIC) Project is to assist the Ministry in establishing a national water monitoring system for collecting surface and ground water resources and quality data and information. This program will contribute to the framework for improving water resources and water quality management and conservation planning and operations in the Kingdom.

Although the focus of the WQIC Project activities is the Zarqa River basin, the project goals are of national importance and will promote a national policy for water resources and water quality improvement and conservation.

This document presents the details for the surface water resources monitoring program for the Zarqa River Basin. The document discusses: the objectives of the monitoring program; the types of data to be collected by the program; the uses of the data; specific monitoring stations; frequency of monitoring and sample collection; and data management. This document is the first of a set of similar documents which will present the details for the surface water resources monitoring requirements and programs for all surface water basins in Jordan. Other documents will present water resources monitoring programs for:

- Yarmouk River Basin
- Wadi Mujib/Dead Sea Basins
- Wadi Araba Basins
- Jafr Basin
- Jordan River Valley and Rift Side Wadis Basins
- Azraq Basin
- Sirhan and Hammad Basins

1.1 Background

The primary objective of the water resources monitoring program is to enhance the national water monitoring system operated by the Ministry. The objectives for the national water

monitoring system address both water resources and water quality, and include data collection, data management, and organizational factors important for overall water resources management operations and planning.

Existing water monitoring programs in Jordan and data collection practices were reviewed as part of the comprehensive evaluation which produced the Monitoring Network Survey Document (MNSD) (MWI, 1994a). The responsibility for water management data collection within the Ministry has been shared by two independent organizations, the Jordan Valley Authority (JVA) and the Water Authority of Jordan (WAJ). The Ministry of Health, the Ministry of Municipality and Rural Affairs, and the Greater Amman Municipality Laboratory also monitor water resources primarily associated with drinking water quality. The WAJ-Water Resources Studies Directorate administers several water resources related monitoring programs. These include surface water and spring discharge, ground water level, precipitation, evaporation, and sediment monitoring programs. In addition, the Basins Project within the Directorate also conducts ground water level monitoring. Two organizations within the Jordan Valley Authority administer water resources monitoring programs for reservoirs and for the King Abdullah Canal and principal rift side wadi tributaries. The WQIC Project has recommended that these various programs be combined into a single, unified, comprehensive water monitoring system program (Water Monitoring System Adequacy Report: MWI, 1995).

The existing monitoring programs administered by WAJ are designed to obtain basic information about water resources in Jordan. The objective of the existing monitoring programs is to determine the quantity of water resources available in Jordan during a water year for both short-term and long-term water management purposes. Various types of monitoring stations have been established throughout Jordan with primary emphasis on the highlands and wadis along the eastern side of the Jordan Rift Valley.

The JVA maintains water resources monitoring programs for all reservoirs in Jordan (primarily five Jordan Valley reservoirs, King Talal, Wadi Arab, Ziglab, Shueib, Kafrein), the Jordan River, the King Abdullah Canal, and the Rift Side wadis. The programs focus primarily on water resources for irrigation uses in the Jordan River Valley. The King Abdullah Canal also serves to transport water to the Deir Alla pumping station and from there to the Zai water treatment plant and then onto Amman.

229

1.2 Zarqa River Basin

The Zarqa River Basin (or Amman-Zarqa Basin) extends from the Syrian border in northern Jordan to just south of Amman and westward to the Jordan Rift Valley. The Basin encompasses approximately 4154 square kilometers (3739 km^2 in Jordan) (Figure 1-1). The western third of the basin receives moderate to heavy amounts of precipitation for Jordan (300 to 600 mm/year). The eastern portions of the basin receive 100 to 200 mm/year of precipitation.

The basin contains the most heavily and densely populated areas of Jordan which include Amman, Zarqa, Jerash, and adjacent urban areas. The basin also includes the most heavily industrialized areas of Jordan as well as four major municipal waste water treatment plants (WWTPs). These WWTPs are located near Al-Samra, Abu Nusier, Baq'a, and Jerash. The Al-Samra WWTP services the population of Amman and Zarqa. In addition, several large municipal/industrial landfills or waste disposal sites are located in the basin. The King Talal Reservoir, the largest in Jordan, is located on the Zarqa River approximately 15 to 20 kilometers upstream of Deir Alla in the Jordan River Valley. For planning purposes, the outfall from the King Talal Reservoir essentially defines the downstream end of the Zarqa River Basin.

Surface water in the basin primarily is used for irrigation purposes or flows into the King Talal Reservoir. Some of the major springs (e.g., Ras Al Ain) are used for drinking water purposes, but the volumes of water from these sources are very limited compared to the total water flow in the basin. The Al-Samra WWTP contributes substantial, year-round flow to Wadi Dhuleil/Wadi Zarqa and ultimately to the King Talal Reservoir. Discharge from the Al-Samra WWTP constitutes the primary surface water source in the basin. Water stored in the King Talal Reservoir (capacity in excess of 85 MCM) is channeled to irrigation projects in the Jordan River Valley.

Water quality issues in the Zarqa River Basin significantly influence water resources management decisions. The primary issues relate to the use of treated waste water as a water resource. Present policy is to use treated waste water for irrigation purposes. In addition, the heavy industrialization and urbanization of the Amman-Zarqa area potentially may affect surface water quality.

2.0 Monitoring Program Objectives

2.1 Overview

The Amman-Zarqa Basin is a major surface water basin in Jordan. Water resources demands on the Basin are intensive. In addition, the Basin is subjected to numerous potential sources which could impact water quality. Because of general climatic conditions in Jordan, normal flow in the Zarqa River is predominantly influenced by waste water discharges throughout the year and precipitation events during the winter rainy season.

2.2 Program Objectives

Objectives

The principal objectives for the program are to monitor surface water resources conditions and discharges in the Zarqa River Basin and to provide data for long-term planning for both water resources and water quality management. By establishing a basin-wide monitoring program, greater data and information will be obtained to evaluate more specifically the hydrologic and associated land use factors most affecting or influencing water resources and quality in the basin. These analyses and associated conclusions and recommendations then can form the basis for establishing and developing new policy for contributing to the long-term increase in available water resources as well as improvement in water quality.

The surface water resources program is complemented by other hydrologic monitoring programs (e.g., precipitation, ground water) and a water quality monitoring program. The water quality program is designed to monitor water quality changes and to provide data for long-term water quality improvement and planning.

Decision Statements

The fundamental water resources management questions and issues to be addressed by the Zarqa River Basin Water Resources Monitoring Program include:

(1) What is the daily, monthly, and annual discharge of surface water throughout the Basin, in major catchments, and in general geographic areas?

(2) What is the variation in discharge at principal locations in the Basin and how does this relate to precipitation events and general climatic conditions?

231

(3) How are land-use practices affecting surface water resources in the Basin?

(4) Are surface water discharges increasing or decreasing spatially or temporally? How does this affect water resources planning and management?

(5) What hydrologic conditions should dictate water resource management practices for the King Talal Reservoir?

(6) What are the relationships between the Basin and underlying ground water aquifer systems?

The hydrologic cycle is a dynamic process and the water resources monitoring program must be sufficiently comprehensive and flexible to account for both spatial and temporal changes in surface water conditions. Data collected from the monitoring program will be used to evaluate and answer these questions. In addition, these data will provide the basis for determining future actions required to improve water resources and related water quality management and planning.

Data Requirements

Water resources data will be measured or obtained for various stations throughout the Basin. The basic data and information required to support assessment of surface water resources conditions in the Zarqa River Basin are mainly discharge (flow) data. To support different data evaluation techniques and practices, discharge data may be required on an instantaneous, hourly, or daily basis. Consequently, different types of monitoring equipment and measurement practices may be necessary. In general, when flow control structures are established and used to determine discharge, the basic field data are water levels (i.e., stage) at the structures. These data then are converted to discharge values using tables or rating curves. At other stations, discharge may be determined based on field measurements of water velocity and area relationships.

In addition to the water resources data for the various wadis and catchment areas, basic water chemistry data are critical to a comprehensive understanding of water quality in the basin. These data will be collected under an independent program which is associated with surface water quality monitoring.

Water resources data obtained by this program will be analyzed and evaluated using a variety of standard techniques and tools. These practices generally are applicable and consistent world-wide and frequently have been formalized by the United States Geological

Survey, the World Meteorological Organization, or other professional organization. Section 12.0 in the Water Monitoring System Procedures document (Volume 2, Appendix A of the Water Monitoring System Upgrade Plan) includes a detailed list of technical references for evaluating and analyzing hydrologic data for streams and river systems.

The major constraint to obtaining water resources data will be the actual occurrence of water in the wadis and catchment areas. Because of the climate, many wadi courses are dry or contain limited flow throughout much of the year. The major exception in the Basin is Wadi Dhuleil downstream of the Al-Samra waste water treatment plant and Zarqa River downstream of its confluence with Wadi Dhuleil.

As designed, the water resources monitoring stations provide for continuous recording of water levels (i.e., stage). However, data for the wadis may be obtained only seasonally depending on the occurrence of flowing water. The frequency generally will be a function of the technical knowledge of the water resources and discharge characteristics of the wadi. General trends which may be developing relative to water resources, or specific programs which may be initiated to monitor or improve water resources or water quality also will influence the frequency of monitoring.

Decision Rules

The use of water in Jordan is a very dynamic process dictated by water requirements and water availability. Much of the water in the Zarqa River Basin can be considered imported for municipal purposes. This water is manifest in the Basin as treated effluent from the Al-Samra waste water treatment plant. Currently, surface water in the Zarqa River Basin is used only for irrigation purposes. Surface water is not suitable as a source of potable water. Consequently, there are no major diversions or uses of surface water prior to its collection and storage in the King Talal Reservoir. As such, there generally are no critical requirements for decision rules which would govern 'real time' management actions based on the water resources data obtained from the program.

However, decision rules may be appropriate for management of surface water discharges from the King Talal Reservoir. For water resources planning and management, this may be most critical for extreme conditions associated with low annual flow or excessive flow. In extremely wet years when the capacity of the King Talal Reservoir may be exceeded, decision rules could be important in defining how releases from the reservoir will be

managed. These may be needed to optimize downstream water usage and storage, to improve water quality in the King Talal Reservoir, to modify water quality conditions downstream, to promote leaching of salts accumulated in the soils of agricultural fields, to provide for sediment management or removal from the reservoir, or other reasons. These decision rules have not been established. Any set of rules may require more formal development of overall water policy in Jordan. Statistical analyses of surface water resources data are not planned in the short-term.

After the program begins to generate reliable and adequate data, then a more specific evaluation can be completed to define decision rules. This evaluation initially should be conducted at least annually. If water resources or water quality conditions improve significantly or continue to deteriorate, then more detailed assessment of potential uses can be completed and more specific decision rules can be developed for use of the water.

Data Quality

Data Quality Objectives (DQOs) are qualitative and quantitative statements specified to ensure that data of known reliability are obtained from a monitoring program. In addition, the identification of monitoring requirements involves specifying the data measurement techniques/methods, monitoring station design, number of stations, data measurement frequency, types of data to be measured, and the level of quality control required. As data needs are established or refined, logistical planning can be conducted to ensure that data are acquired expeditiously and cost effectively. Data quality objectives constantly must be re-evaluated and refined as new information is obtained.

The objectives for the Zarqa River Basin Surface Water Resources Monitoring Program are discussed above.

Data quality is the degree of certainty of data with respect to precision, accuracy, reproducibility, comparability, and completeness. Several levels of qualitative and quantitative specificity have been defined for data quality. Two Data Quality Levels (DQLs) have been identified for the Zarqa River Basin Surface Water Resources Monitoring Program. The two DQLs are defined as follows:

- Level I -- **Field Measurements**: This level includes hydrologic data which generally can be quickly obtained from field measurement activities. Data

measurement typically involves use of portable or transportable instruments. Level I data are used for on-site screening, baseline data development, and rapid field determination of the general characterization of hydrologic conditions associated with surface waters.

- Level II -- **Flow Control Structures Measurements**: This level provides data of greater completeness and reproducibility from stations located at flow control structures, including properly installed portable weirs and flumes. Flow control structures are engineered devices to provide a high level of reliability and reproducibility in the data measured. Typically the data are obtained at a rate slower than provided by Level I. However, the data present a more complete description of the hydrologic processes at a station.

Level I data will consist of field measurements such as water level or stage, water velocity, cross-sectional area, travel distance, and related. Level II data typically will consist of water level or stage measured with continuous recording equipment (charts or data loggers) and portable flumes and weirs.

The quality assurance/quality control objectives for all measurements include representativeness, completeness, comparability, precision, and accuracy. The definition of these terms and the criteria used for their evaluation are listed below.

Representativeness

Data measured during performance of the tasks for this program must be representative of the surface waters under investigation and must be obtained using accepted and valid techniques. Any variations in measurement techniques, required field conditions, or environmental conditions should be noted in the field log book.

Completeness

The completeness of the data set for a particular hydrologic need will be assessed by comparison of the amount of data required with the amount of data obtained. Loss of data due to equipment or station malfunction should be documented. Quality control data, as appropriate, will be recorded and if data are rejected on the basis of quality control results, the reason for data rejection and corrective action taken should be documented in the analytical report.

235

Comparability

Consistency in the acquisition, measurement, or analysis of data is necessary for the comparison of results to be meaningful. To achieve optimum comparability, acceptable methods for the measurement and analysis of data as described in the protocols presented in the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures), should be closely followed.

Precision and Accuracy

Precision refers to the reproducibility of a measurement method when it is repeated in a homogeneous environment regardless of whether or not the observed values are representative of the true values. Precision can be expressed by standard deviation.

Accuracy refers to the agreement between the value of a parameter measured by a method and the actual value of the parameter.

Precision and accuracy of data may be enhanced by using calibrated instrumentation, proper measurement techniques for given hydrologic conditions, and by repeating measurements.

3.0 Monitoring Network Design

3.1 Status of Existing Monitoring System

Eight (8) surface water resources monitoring stations have been established in the Amman-Zarqa Basin. At the present time only three of the stations are operational. Extensive and continued urbanization of the basin has affected several stations either because of public works activities, vandalism, or overall development of the basin. Maintenance of the stations also has been deficient.

Sixteen (16) surface water quality monitoring stations have been established in the Amman-Zarqa Basin. The stations primarily have been established along Wadi Dhuleil, Wadi Zarqa, and Wadi Birein for monitoring the discharges from municipal waste water treatment plants (WWTP). The chemical parameters monitored are typical of those for municipal WWTP effluent. No surface water quality monitoring is conducted in urban areas or industrialized areas.

3.2 Monitoring Station Locations

The Water Monitoring System Adequacy Report (MWI, 1995a) recommended expansion of the surface water resources monitoring stations for the Amman-Zarqa Basin. Rehabilitation or reconstruction of seven existing monitoring stations is proposed. Stations to be reconstructed include Wadi Zarqa at Sukhaneh, Wadi Dhuleil at Sukhaneh, and King Talal Reservoir. Existing stations to be rehabilitated include Wadi Zarqa at Ain Ghazal, Wadi Sleihi, Wadi Abdoun at Ras Al Ain bridge, and Wadi Um Dananeer. New stations have been proposed at five locations. A new station is planned on Wadi Rumeimin upstream from the King Talal Reservoir. Four former Ministry of Agriculture Experimental Stations located on tributaries to Wadi Zarqa have been recommended for rehabilitation.

Figure 3-1 depicts the general locations of the expanded water resources station network. Table 3-1 presents a summary of the purpose, equipment requirements, and station requirements for the Zarqa River Basin water resources monitoring stations.

Appendix A includes a general description of each water resources monitoring station, general location, directions for finding the station, and related information for identifying the station.

A total of 23 water quality monitoring stations is planned for the Zarqa River Basin. Table 3-1 presents a summary of the purpose, equipment requirements, and station requirements for the surface water quality monitoring stations. Figure 3-1 depicts the general locations of the proposed stations. The water quality monitoring program is discussed in detail in a separate monitoring document.

3.3 Monitoring Station Design

The surface water resources monitoring scheme is based on measurement of water levels on a continuous basis from each monitoring station. Each station includes the required flow control structure constructed across the wadi at the station and the automatic gaging station equipment for continuously recording water levels. The flow control structure at each station has been or will be designed specifically for that location to ensure water level (stage) - discharge relationships accurately represent actual conditions at the station.

For flood conditions, a cableway is constructed at the New Jerash Road Bridge station. The cableway provides a mechanism for obtaining stream velocity data and water depth data at intervals across the stream channel. These data then can be used to calculate stream discharge at the station using velocity - area relationships.

Detailed design drawings and specifications for each surface water resources measurement station and the associated water level (stage) - discharge relationships will be prepared for the stations to be rehabilitated or constructed. Similar information for existing stations which do not require enhancement or upgrading need to be obtained from the responsible monitoring authority or construction organization. These drawings and specifications ultimately should be incorporated into this document as Appendix B.

As possible, surface water resources monitoring stations for the Zarqa River Basin have been co-located with surface water quality monitoring stations. This design has been pursued to benefit from the control features required for establishing a surface water resources monitoring station as well as for potential future correlation of water quality and

stream discharge data. This design is believed to minimize the overall number of monitoring station locations within the basin and to promote more efficient use of technical field resources and staff. However, there are still several more surface water quality stations than water resources stations.

3.4 Surface Water Flow Measurements and Frequency

Surface water resources monitoring will be conducted in accordance with the guidelines outlined in Table 3-1. Table 3-1 lists the purpose of each monitoring station, the associated equipment, and the frequency of monitoring. As noted in Section 3.3, automatic gaging station equipment are proposed at each monitoring station. These stations will provide a continuous record (paper chart tracing) of the water level behind the flow control structure constructed at the station. Because Wadi Dhuleil and the Zarqa River are not significantly affected by continuous discharge from tributary wadis or catchment areas, the recording equipment at tributary stations may only be operated during the period of the year when surface water flows are observed. These data and tracings then will be returned to the analysis/studies function of the Ministry for evaluation.

For the cableway station, velocity - area data will be measured on an as-needed basis. This may occur a few times during the rainy season for a water year.

3.5 Hydrologic Measurements and Quality Assurance Protocols

Consistent hydrologic measurements, quality assurance, and data management protocols will be followed throughout the monitoring program to ensure that the data and associated analyses provide an accurate representation of surface water resources throughout the basin. These procedures are presented in detail in the Water Monitoring System Upgrade Plan Appendix A (Volume 2) and include:

(i) Surface water resources measurement procedures (Section 10.0);
(ii) Quality assurance (Section 2.0); and
(iii) Data management (Section 3.0).

Data Measurement

Surface water resources data will be obtained in accordance with internationally accepted procedures. Section 10.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) presents detailed descriptions of data measurement techniques and procedures to be followed for the surface water resources monitoring program. Primarily, water level (stage), water velocity, and cross-sectional area data will be measured and recorded in the field.

Section 5.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) presents general information for planning a water measurement event.

Quality Assurance

Quality assurance protocols for the monitoring program are presented in Section 2.4 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures). These protocols describe the system to promote measurement of representative and defensible data. Section 10.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures) provides general information about use of field instrumentation, equipment calibration, data documentation and record keeping requirements. Use of field logs and field report forms is specified to maintain proper documentation of measurement data.

Data Management

Data management protocols for the monitoring program are presented in Section 3.0 of the Water Monitoring System Upgrade Plan Appendix A (Volume 2 - Water Monitoring System Procedures). These protocols provide guidance on data management responsibilities of monitoring personnel and for recording and maintenance of data obtained from the monitoring program.

4.0 Data Evaluation

Data, including quality control data, recorded and collected by the monitoring team will be reviewed for reasonableness and general consistency with water resources conditions in the Basin and recent data trends. Significant discrepancies will be discussed with the monitoring team and laboratory to determine if unusual conditions occurred during the measurement event or if recording errors may exist. After review, field data will be analyzed using appropriate techniques by the analysis section in accordance with established organizational procedures. The data then will be entered into a computerized water resources database. Data entered into the computerized database will be checked for entry and keying errors consistent with data management and database management procedures established for the overall monitoring program. Original field forms and computer entry forms will be maintained in the project files.

The analyzed data and resulting discharge and related information also will be evaluated with respect to the program objectives and decision statements outlined in Section 2.2. The decision statements establish the basic water resources management objectives for the program. As noted in Section 2.2, no decision rules have been defined for the Zarqa River Basin water resources monitoring program. Sophisticated data evaluation techniques and tools have not been recommended initially for purposes of evaluating the water resources data. Such tools or techniques are readily available depending on specific need and may become appropriate as the monitoring program and water resources database develop and as water management requirements change.

5.0 References

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Tables

Table 3-1. Zarqa River Basin Surface Water Resources and Quality Monitoring Stations

MAP ID #	WAJ ID #	SITE NAME	STATION PURPOSE	MONITORING FREQUENCY	STATION NEEDS	COMMENTS
		Surface Water Resources Monitoring Stations				
1	AL 0040	Wadi Um Dananeer	Base and flood flow discharge (AGS)	Continuous	Rehabilitate	Protect from vandalism (AGS still at site)
2	AL 0060	Wadi Zarqa (at New Jerash Road Bridge)	Base and flood flow discharge (AGS, CW, CM)	Continuous	None	
3	AL 0061	Wadi Sleihi	Base and flood flow discharge (AGS)	Continuous	Rehabilitate	Protect from vandalism
4	AL 0062	Wadi Zarqa at Ain Ghazal	Base and flood flow discharge (AGS)	Continuous	Reconstruct	
5	AL 0063	Wadi Zarqa (at Sukhaneh)	Base and flood flow discharge (AGS)	Continuous	Construct	Relocated to new bridge crossing W. Zarqa
6	AL 0064	Wadi Dhuleil (at Sukhaneh)	Base and flood flow discharge (AGS)	Continuous	Construct	Relocated to new bridge crossing W. Dhuleil
7	AL 0065	Wadi Abdoun (at Ras Al Ain Bridge)	Flood flow discharge (upper Amman) (AGS)	Continuous	Reconstruct	Reset because of concrete conduit construction at site
8		King Talal Reservoir	Reservoir storage (AGS)	Continuous	Construct	
9		Rukban Station	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
10		Za'tri Station	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
11		Khaldiya Station (at Khaldiya Reservoir)	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
12		Wadi Sa'ida (near Wadi Dhuleil)	Flood flow discharge (AGS)	Continuous	Rehabilitate	Former Ministry of Agriculture Experimental Station
13		Wadi Rumeimin	Flood flow discharge (AGS)	Continuous	Construct	Just upstream of King Talal Reservoir
		Surface Water Quality Monitoring Stations				
1		Wadi Dhuleil (Station #5)	Category Municipal 1	M, Q, SA	None	Relocate to nearby downstream bridge crossing
2		Wadi Zarqa (Station #6)	Category Municipal 1	M, Q, SA	None	
3		Wadi Zarqa (Station after confluence with W. Dhuleil)	Category Municipal 3	Monthly	None	
4		Wadi Zarqa (Adwan Station)	Category Municipal 1	M, Q, SA	None	
5		Wadi Zarqa (New Jerash Road Bridge Station) (Station 7)	Category Municipal 1	M, Q, SA	None	
6		Wadi Zarqa (Site 100 downstream of Jerash Bridge Road)	Category Municipal 3	Monthly	None	
7		King Talal Reservoir Inflow	Category Municipal 1 (+ additional parameters)	M, Q, SA	None	M (algae, plankton, cholorphyll)
						JVA Station 100 combined with WAJ Station
8		King Talal Reservoir Outflow	Category Municipal 1	M, Q, SA	None	JVA Station 600 combined with WAJ Station
9		King Talal Reservoir (Station 200 - Wadi Er Rumeimin)	Category Municipal 2	M, Q, SA, A	None	
10		King Talal Reservoir (Station 300 - middle of reservoir)	Category Municipal 1 (+ additional parameters)	M, Q, SA	None	M (algae, plankton, cholorphyll), A (semi-volatiles)
11		Wadi Birein (2 km downstream Abu Nusier WWTP)	Category Municipal 2	M, Q, SA, A	None	
12		Wadi Birein (Um Uruq Village)	Category Municipal 2	M, Q, SA, A	None	
13		Wadi Birein (Birein Village)	Category Municipal 2	M, Q, SA, A	None	
14		Wadi Jerash (downstream of Jerash WWTP)	Category Municipal 2	M, Q, SA, A	None	
15		Wadi Sleihi (downstream of Baq'a WWTP)	Category Municipal 2	M, Q, SA, A	None	
16		Wadi Zarqa (at Ain Ghazal)	Category Urban Industrial 1	Q, A	None	
17		Wadi Zarqa (at Ruseifa Springs)	Category Urban Industrial 2	Q	None	
18		Wadi Zarqa (at Zarqa Bridge)	Category Urban Industrial 1	Q, A	None	
19		Wadi Ishsha (near Wadi Zarqa)	Category Urban Industrial 1	Q, A	None	
20		Wadi Ishsha (near SulfoChemical Plant)	Category Urban Industrial 1	Q, A	None	
21		Wadi Birein (near Wadi Zarqa) (Khalah Spring)	Category Municipal 2	M, Q, SA, A	None	
22		Wadi Dhuleil (upstream of Al Samra WWTP)	Category Atypical 2	Q, SA, A	None	Background water quality
23		Wadi Zarqa (at Awajan Bridge)	Category Urban Industrial 2	Q	None	

NOTES: CM = current meter to measure baseflow
AGS automatic gauging station; CW = cable way

M = monthly, Q = quarterly, SA = semi-annually, A = annually
Water quality sampling frequency dependent on whether there is flow in the stream channel

Figures

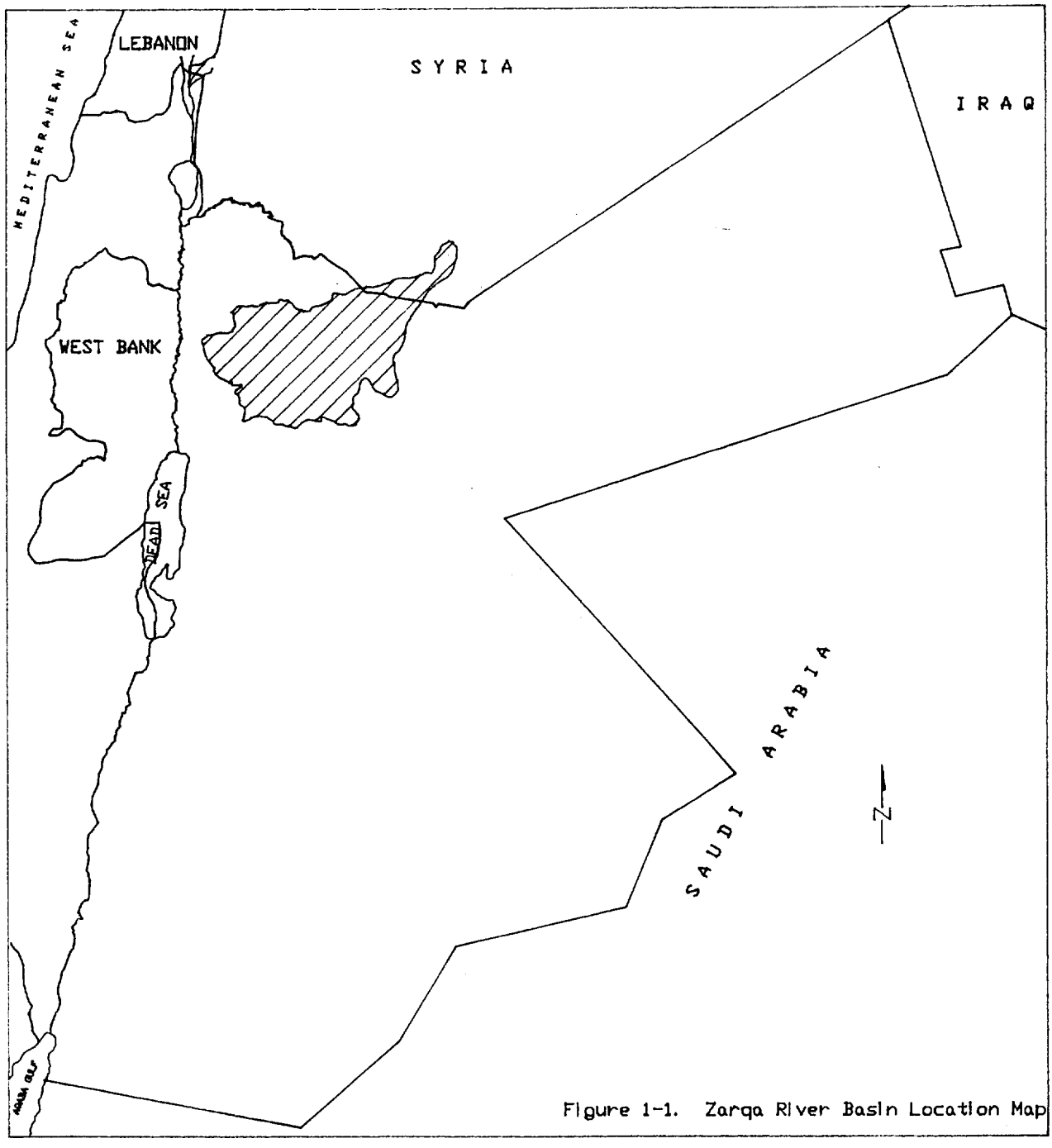

Figure 1-1. Zarqa River Basin Location Map

ZARQA RIVER BASIN

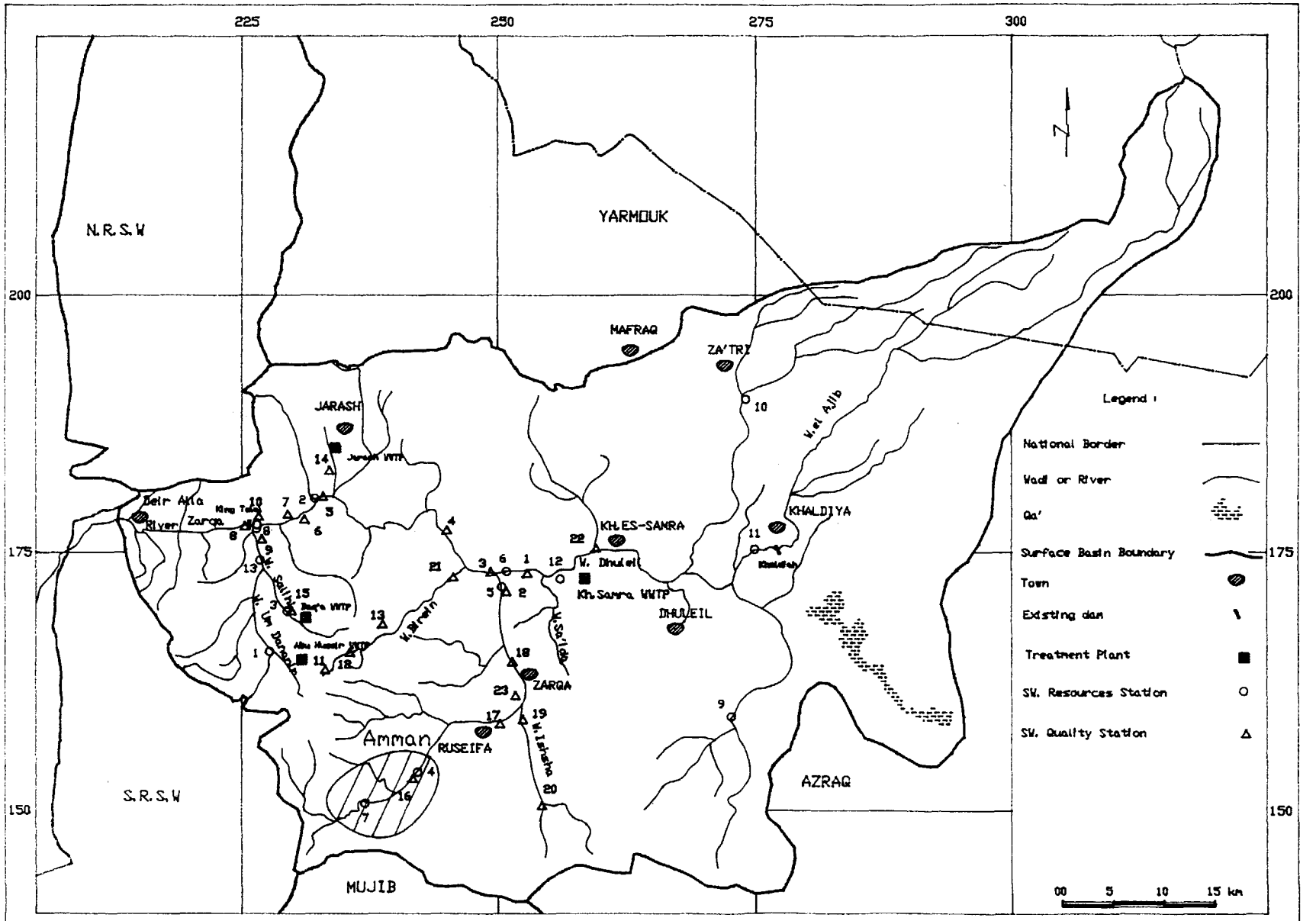

Figure 3-1 Zarqa River Basin Surface Water Monitoring Network

APPENDIX A

Surface Water Resources Monitoring Stations Description

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:	13 February 1995
Weather Conditions:	Clear, sunny, breezy

1. Station Identification

Name:	Um Dananeer
ID Number:	AL0040
Basin:	Amman Zarqa
Aquifer:	
Status:	Not working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Headwater area of Wadi Um Dananeer near Baq'a

Data Collected

Stream Discharge (base flow and flood flow)

4. Physical Description of Station

Free flowing site just upstream of small waterfall and below Sweilah Flexure

5. Directions to Location of Station

The site is located a couple of kilometers from the new Amman-Jerash highway along Wadi Um Dananeer and just below the prominant geological structure which is part of the Sweilah Flexure

6. Proposed Action for Water Monitoring System Station

Upgrade and rehabilitate the station

7. Other Observations:

There is good flow over the small falls at the site. The AGS recorder still is at the site but needs upgrading and maintenance.

49

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 Feb 1995

Weather Conditions:

1. Station Identification

Name: Zarqa at New Jerash Bridge Rd.

ID Number: AL0060

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

Ground Water

Springs

Surface Water

Other

Other

3. Station Purpose

Water Resources

Water Quality

Rationale for Station / Location

The station represents a long-term control point on Wadi Zarqa and is reasonably accessible. The station is located after the confluence of Wadi Zarqa and Wadi Jerash

Data Collected

A long record of water resources (stream discharge) data have been collected from the site. The station is part of the active Al Samra WWTP monitoring program. A broad spectrum of data has been collected on a regular basis from the station.

4. Physical Description of Station

Water quality data are collected from the wadi bed upstream of the bridge crossing. Water resources data are collected with a water level recorder/ cableway in the vicinity of the bridge.

5. Directions to Location of Station

At new Jerash road bridge

6. Proposed Action for Water Monitoring System Station

Continue

7. Other Observations:

The stations were not directly inspected on this date.

240

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 13 Feb 1995

Weather Conditions: Clear, sunny, windy

1. Station Identification

Name: Wadi Sleihi (at AL0061 location)

ID Number: AL0061

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

The station is located downstream of Baq'a WWTP at the site of water resources station AL0061. The station is part of the headwater areas that flow into Wadi Rumeimin

Data Collected

Stream discharge (base flow and flood flow). No water quality data have been collected to date.

4. Physical Description of Station

Wadi bed at free flowing stream at water resources gauging station

5. Directions to Location of Station

At Wadi Sleihi surface water gauging station about 1 kilometer downstream of Baq'a WWTP

6. Proposed Action for Water Monitoring System Station

Rehabilitate water resources station; potential water quality station

7. Other Observations:

Water flowing in wadi at station

251

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:	11 Feb 1995
Weather Conditions:	Clear, sunny

1. Station Identification

Name:	Wadi Zarqa at Ain Ghazal
ID Number:	AL0062
Basin:	Amman-Zarqa
Aquifer:	
Status:	Not working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Long-term water resources monitoring station near Ain Ghazal WWTP: good historical record of discharge data for Wadi Zarqa after downtown Amman. Potential location for water quality monitoring for downtown Amman.

Data Collected

Stream discharge data using a water level recorder. No water quality data collected to date.

4. Physical Description of Station

Automatic gauging station at Ain Ghazal WWTP. Wadi Zarqa is confined to a concrete channel in this area. Stilling well has been closed off due to installation of concrete channel.

5. Directions to Location of Station

At Ain Ghazal near WWTP facility.

6. Proposed Action for Water Monitoring System Station

The station was affected when the concrete channel was constructed to replace the bed of Wadi Zarqa. The stilling well and bottom opening for displacement of water are still visible but are elevated above the

bottom of the channel. The AGS has been removed. The station can be rehabilitated with a new AGS. Possible hydraulic connection with the stilling well is possible through the concrete channel. Rehabilitation needs to be discussed with organization installing the concrete channel.

7. Other Observations:

253

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:	12 February 1995
Weather Conditions:	Clear, sunny

1. Station Identification

Name:	Wadi Zarqa at Sukhaneh
ID Number:	AL0063
Basin:	Amman-Zarqa
Aquifer:	
Status:	Not Working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Long-term water resources monitoring station near Sukhaneh. Good historical record of discharge data for Wadi Zarqa prior to confluence with Wadi Dhuleil

Data Collected

Stream discharge data using water level recorder and cableway

4. Physical Description of Station

Two older stations have been used. The oldest station was found, but the newer station could not be located. The oldest station was just upstream of the confluence with Wadi Dhuleil. The suggestion is to move the station to the bridge near Sukhaneh on Sukhaneh- Jerash road.

5. Directions to Location of Station

New road linking Jerash - Sukhaneh at bridge over Wadi Zarqa

6. Proposed Action for Water Monitoring System Station

Relocate current monitoring station to bridge over Wadi Zarqa and equip with automatic recorder. If the bridge is chosen for the station, a cableway may not be required.

254

7. Other Observations:

Good flow in wadi at this general location.

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 31 July 1995

Weather Conditions: Clear, sunny, hot

1. Station Identification

Name: King Talal Reservoir

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Active

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Major reservoir in Jordan; data used for monitoring volume of water in reservoir

Data Collected

Water level using staff gage

4. Physical Description of Station

Staff gage attached to concrete abutment at entrance to dam spillway

5. Directions to Location of Station

King Talal Reservoir; access from road across dam and spillway

6. Proposed Action for Water Monitoring System Station

Upgrade station to include automatic gaging station; consider ultrasonic equipment

7. Other Observations:

254

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 11 February 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Abdoun

ID Number: AL0065

Basin: Amman-Zarqa

Aquifer:

Status: Working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Major tributary for Wadi Zarqa; urban area runoff; location good for total discharge from Wadi Abdoun and several upstream tributaries. Historical data record available.

Data Collected

Stream discharge (base flow and flood flow)

4. Physical Description of Station

Located at Ras Al Ein bridge; flow in wadi now through cement conduits (subsurface). Sewer system beneath bed of conduit sometimes backs up into Wadi Abdoun and mixes with water flowing in conduit

5. Directions to Location of Station

At Ras Al Ein bridge

6. Proposed Action for Water Monitoring System Station

Relocate upstream of current site or rebuild within new concrete conduit

7. Other Observations:

Some flow in wadi; bridge ultimately will be raised to accommodate completion of concrete conduit. Also

visited end of concrete conduit for Wadi Abdoun about 2-3 km upstream. This is a potential site for new gaging station but is not as good as existing site.

24

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:

Weather Conditions:

1. Station Identification

Name: Rukban Station

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Not working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

Former Ministry of Agriculture experimental station

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Located on subcatchment area in Wadi Dhuleil watershed. Former experimental station established by Ministry of Agriculture in eastern portion of Amman-Zarqa Basin.

Data Collected

Unknown; automatic recording station established

4. Physical Description of Station

5. Directions to Location of Station

6. Proposed Action for Water Monitoring System Station

Attempt to reactivate under Ministry of Water and Irrigation authority

7. Other Observations:

Did not visit station

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:

Weather Conditions:

1. Station Identification

Name: Za'tri Station

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Not Working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

Former Ministry of Agriculture experimental station.

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Located on subcatchment area in Wadi Dhuleil watershed. Former experimental station established by Ministry of Agriculture in northeastern portion of Amman-Zarqa Basin.

Data Collected

Unknown; automatic recording station established

4. Physical Description of Station

5. Directions to Location of Station

6. Proposed Action for Water Monitoring System Station

Attempt to reactivate under Ministry of Water and Irrigation authority

7. Other Observations:

Did not visit station

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 13 February 1995

Weather Conditions: Clear, sunny, windy

1. Station Identification

Name: Wadi Rumeimin

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Potential

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

Proposed station

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Located downstream of Wadis Sleihi and Um Dunaneer just before inflow to King Talal Reservoir. Important for recording flow from Baq'a & Sweileh into King Talal Reservoir. High precipitation area.

Data Collected

None to date

4. Physical Description of Station

Wadi bed just upstream of King Talal Reservoir. Seen only from mountain top; need to survey closely

5. Directions to Location of Station

Difficult to access; maybe must access by boat from King Talal Reservoir. Need to identify access site below Ruman village; or access from southside of wadi (very difficult in winter)

6. Proposed Action for Water Monitoring System Station

Propose to add automatic gaging station.

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:

Weather Conditions:

1. Station Identification

Name: Khaldiya Station

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Not Working

2. Station Type

___ Ground Water
___ Springs
___ Surface Water
___ Other

Other

Former Ministry of Agriculture experimental station

3. Station Purpose

___ Water Resources
___ Water Quality

Rationale for Station / Location

Located on subcatchment area in Wadi Dhuleil watershed. Former experimental station established by Ministry of Agriculture in northeastern portion of Amman-Zarqa Basin.

Data Collected

Unknown; automatic recording station established

4. Physical Description of Station

5. Directions to Location of Station

6. Proposed Action for Water Monitoring System Station

Attempt to reactivate under Ministry of Water and Irrigation authority

7. Other Observations:

Did not visit station

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit:	12 February 1995
Weather Conditions:	Clear, sunny

1. Station Identification

Name:	Wadi Dhuleil at Sukhaneh
ID Number:	AL0064
Basin:	Amman-Zarqa
Aquifer:	
Status:	Not Working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Long-term water resources monitoring station near Sukhaneh. Good historical record of discharge for Wadi Dhuleil. Last major crossing prior to confluence with Wadi Zarqa

Data Collected

Stream discharge data using water level recorder and cableway

4. Physical Description of Station

Automatic gaging station on free flowing section of wadi just upstream of confluence with Wadi Zarqa.

5. Directions to Location of Station

Near Husah Bridge (new over Wadi Dhuleil) on road from Sukhaneh to Jerash.

6. Proposed Action for Water Monitoring System Station

Rehabilitate station and relocate downstream 300m to new bridge (north route road between Sukhaneh and Jerash) (Husah Bridge) near confluence of Wadis Zarqa and Dhuleil.

7. Other Observations:

Water Monitoring Station Field Review

Water Quality Improvement and Conservation Project
Ministry of Water And Irrigation

Date of Time of Visit: 12 February 1995

Weather Conditions: Clear, sunny

1. Station Identification

Name: Wadi Saida

ID Number:

Basin: Amman-Zarqa

Aquifer:

Status: Not Working

2. Station Type

- ___ Ground Water
- ___ Springs
- ___ Surface Water
- ___ Other

Other

Former Ministry of Agriculture experimental station

3. Station Purpose

- ___ Water Resources
- ___ Water Quality

Rationale for Station / Location

Located on major subcatchment area in Wadi Dhuleil watershed. Former experimental station established by Ministry of Agriculture.

Data Collected

Unknown; automatic recording station established

4. Physical Description of Station

Wadi bed at overhead Al-Samra WWTP wastewater pipeline crossing Wadi Saida

5. Directions to Location of Station

Wadi Saida just upstream of confluence with Wadi Dhuleil

6. Proposed Action for Water Monitoring System Station

Reactivate under Ministry of Water and Irrigation authority

7. Other Observations:

APPENDIX B

Design Drawings and Specifications for Surface Water Monitoring Stations