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Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

Artificial Recharge Data Needs Document

Artificial Recharge Working Group

Development Alternatives, Inc.

USAID

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Water Quality Improvement and Conservation Project

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ARTIFICIAL RECHARGE DATA NEEDS DOCUMENT

Water Quality Conservation and Improvement Project

Ministry of Water and Irrigation

Executive Summary

The Ministry of Water and Irrigation (MWI) is responsible for administering water policy and managing water resources in the Kingdom of Jordan. The water resources monitoring and management component of the Water Quality Improvement and Conservation (WQIC) Project focuses on strengthening the MWI's capabilities in developing and managing the water resources of Jordan. Methods for reducing water losses from natural processes (e.g., evaporation, runoff) and for augmenting water supplies are important for long-term water planning and management in Jordan. Artificial recharge techniques offer the potential for reducing water losses by enhancing ground water resources through increased recharge to aquifers. This report summarizes artificial recharge data for Jordan. The data will be used to develop a proposal for comprehensive artificial recharge pilot studies. The survey findings presented in this report required the extensive involvement and contribution of the Artificial Recharge Working Group composed of representatives of the MWI.

A principal objective of the artificial recharge program is to evaluate the feasibility of enhancing ground water resources by increasing recharge to ground water aquifers and to promote establishment of a long-term artificial recharge strategy for Jordan. Such a strategy would be beneficial to the long-term water resources management needs of Jordan. Artificial recharge objectives also are interrelated with other components of the water resources monitoring and management component of the WQIC Project.

1. Scope of Effort for the Artificial Recharge Data Needs Survey

Existing geologic, hydrologic, and water resources databases and proposed or completed artificial recharge studies and programs for Jordan were reviewed as part of the survey. This included discussions with scientists and engineers involved with artificial recharge projects or related studies within the Ministry of Water and Irrigation, Natural Resources Authority, and University of Jordan. Members of the Artificial Recharge Working Group compiled data from their respective organizations regarding generally available water

resources databases, water monitoring system networks, geological databases, and completed or proposed studies for artificial recharge projects. Several field trips were completed to observe the regional geology and ground water aquifer systems, ground water recharge areas, and reservoir sites where artificial recharge and water storage projects have been attempted. Specific activities completed as part of the survey included:

(1) Surveying the water resources databases and artificial recharge data;
(2) Reviewing planned artificial recharge projects;
(3) Reviewing artificial recharge practices in Jordan and nearby countries; and
(4) Identifying data needs for future artificial recharge studies.

2. Summary of Findings from the Artificial Recharge Data Needs Survey

Water Resources and Geologic Databases

Substantial water resources and geologic databases exist for Jordan. These include precipitation, evaporation, stream and flood flow, spring flow, ground water potentiometric levels, and reservoir levels and discharges (for some reservoirs only). Several comprehensive water resources investigations have been completed since 1950 and provide more location-specific information to complement the databases.

Substantial data and information regarding the geology of Jordan has been published over the past 100 years and further studies are in progress by the Natural Resources Authority.

The existing databases support a good general knowledge of the hydrologic and geologic characteristics of Jordan. Site specific hydrologic, geologic, water quality, and related data needs for evaluating artificial recharge practices will depend on the sites selected for pilot testing. Site specific geologic and geohydrologic data generally would be limited for most potential study locations. Surface water discharge data also generally would be limited for the subcatchments of the larger basins. Consequently, field data collection programs may be necessary to acquire these data.

Site specific land use and ownership constraints generally are not known and these types of information will be important to the study. Access limitations also must be evaluated for

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sites potentially selected for more detailed assessments. Data collection efforts therefore also must address these information needs.

Planned Artificial Recharge Projects

Three artificial recharge projects currently are underway in Jordan. One project is a component of the USAID/MWI WQIC Project. The second project focuses on capability development and involves the Water Authority of Jordan (WAJ) as the lead Jordanian organization. The selected site for the WAJ project is the Siwaqa reservoir. The third project is part of a broader environmental study and involves the Water and Environment Research and Study Center (WERSC) as the lead organization for the artificial recharge component. The selected site for the WERSC project is in the Azraq Basin.

The Wadi Wala reservoir site in the Dead Sea Basin has been identified for artificial recharge purposes and limited studies have been completed. This project is awaiting funding. In addition, several reservoirs have been constructed to provide potential for recharge of stored water to ground water aquifers. Several reservoirs have been proposed for artificial recharge and more detailed studies are necessary.

Existing Artificial Recharge Practices

Of the existing dams, very limited data have been obtained to monitor or assess the actual degree of recharge to the respective ground water aquifer. Based on visual observations only, extensive recharge seems to be occurring from the Shueib, Siwaqa, and Khaldiyeh dams. Several dams intended to be used for recharge have accumulated significant amounts of silt and the recharge potential has been lost or seriously reduced. The storage reservoirs behind the Sultanah and Bowaydah dams have been filled with silt and sediment and no longer provide short-term storage capacity. Accumulation of silt will be a major factor to be considered in the evaluation and design of artificial recharge systems in Jordan.

Except as noted for the existing reservoirs, very limited feasibility studies or pilot testing have been conducted to evaluate artificial recharge techniques in Jordan. Some small scale studies have been conducted in the Azraq Basin which also is the location of the current study under the direction of the WERSC.

More extensive artificial recharge studies and practices have been undertaken in neighboring countries and in North Africa. Several large artificial recharge studies have been completed in Morocco involving the Charf Akab confined and the Haouz aquifers, Algeria involving the Mitidja alluvial aquifer, and Tunisia involving the Souhil and Teboula coastal aquifers.

3. Recommendations for Subsequent Program Development

A proposal for conducting artificial recharge feasibility studies and pilot testing will be developed immediately. The proposal will present the specific details for collection of required geologic and hydrologic data and evaluation and screening of candidate sites. Once candidate sites have been identified, detailed feasibility studies and pilot testing of artificial recharge strategies will be completed.

- The ground water basins which should be considered for high priority for artificial recharge studies and projects are the Amman-Zarqa, Yarmouk, Azraq, Jafer, and Dead Sea (Mujib and Hasa). Ground water deficits are greatest in these areas. However, site selection and proposed pilot study must consider the precipitation, hydrogeologic, hydrologic, water quality, and soil regimes.

- A review of the water use and availability data as well as the hydrogeologic data indicates that the Quaternary alluvium deposits, Basalt aquifer, Rijam aquifer (B4), Amman-Wadi Sir aquifer (B2/A7), Hummer aquifer (A4), and Naur aquifer (A2) represent the most important ground water aquifer systems which are suitable for artificial recharge.

- For the Kurnub and Zarqa aquifers, artificial recharge is not feasible generally because of high salinities. These formations also typically occur at great depth in Jordan except at a few locations. The Disi aquifer is nonrenewable and is situated in a region of minimal precipitation.

- A screening process would be appropriate for proceeding toward more detailed and comprehensive characterization as test sites are identified and selected. Early in the screening process, site selection criteria relating to hydrologic, geologic, and water

quality data needs as well as land use and site assess should be established to assist in the evaluation of the sites.

- As sites are identified and visited and site data are reviewed, various artificial recharge techniques which may be suitable for a site should be considered. Application of different artificial recharge techniques will require different types of field and engineering data.

- Once a site is selected for detailed feasibility studies or pilot testing, complete meteorological and hydrologic data would be necessary to properly evaluate the success of the pilot test.

- Cooperative efforts with other governmental and non-governmental organizations involved in artificial recharge studies should be initiated and coordinated to develop uniformity and consistency of methodology (as possible) to avoid duplication of effort, to promote the exchange of information, data, and ideas, and to provide a mechanism for training and development of professionals involved in the design and study of artificial recharge programs and projects.

Water Quality Conservation and Improvement Project
Ministry of Water and Irrigation

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List of Acronyms

ACSAD	Arab Center for the Studies of Arid Zones and Drylands
AROS	Artificial Recharge Objectives Statement
ARDND	Artificial Recharge Data Needs Document
BGR	Deutsche Bundesanstalt fur Geowissenschaften und Rohstoffe
DQO	Data Quality Objectives
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
KAC	King Abdullah Canal
KTR	King Talal Reservoir
MCM	Million Cubic Meters
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
MWI	Ministry of Water and Irrigation
Mwi	Ministry of Water and Irrigation - Secretary General Organization
RSS	Royal Scientific Society
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
WQIC	Water Quality Improvement Project

1.0 Introduction

Optimal development and utilization of water resources in the Kingdom of Jordan and instituting associated water policy requires the establishment and implementation of several integrated resources, information, and management systems. The Ministry of Water and Irrigation (MWI) 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. This initial work performed under the WQIC Project will provide the foundation for more comprehensive water resources planning and management. An artificial recharge pilot study to evaluate the feasibility of enhancing ground water resources by increasing recharge to ground water aquifers country-wide is a major component of the WQIC Project.

1.1 Background

During 1992, the United States Agency for International Development (USAID) provided assistance to the Government of Jordan to develop a national water management program. A conclusion of this study was that the water deficit in the Kingdom of Jordan was more serious than had been realized and was progressing toward a crisis situation. The study recommended that priority be given to developing and implementing a comprehensive strategy for increasing water supply and reducing water demand. The initial focus of the strategy should be the Zarqa River basin which includes approximately 65-70 percent of the population of Jordan.

The WQIC Project, which developed as a result of the national water management program, provides a framework for the foundations of a comprehensive water management system, including water quality improvement and conservation, in Jordan. The project, administered through the MWI, is intended to promote more sustainable water conservation programs. 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 quality improvement and conservation.

1.2 Overview of WQIC Project and Artificial Recharge Task

The goal of the WQIC Project is to improve the overall management and conservation of the water resources of Jordan. Objectives of the WQIC Project include: (1) improving water quality; (2) reducing demand for water; (3) augmenting water supply; and (4) building a sustainable water use system. The initial focus of the project is to increase and improve the quality and quantity of water available in the Zarqa River basin.

Achievement of the goals and objectives of the WQIC Project will be realized through the development and implementation of several technical programs (or components). These include: (1) water resources monitoring and management; (2) water pollution prevention and cleanup; (3) irrigation water management; and (4) water management education. Each technical program contributes to the overall goals and objectives of the WQIC Project and each relies on water resources and water quality information available for the country and in particular the Zarqa River basin.

The water resources monitoring and management component of the WQIC Project focuses on strengthening the Ministry of Water and Irrigation's (MWI) capabilities in developing and managing the water resources of Jordan. Several tasks of this component are related to the collection, management, storage, and retrieval of high quality data, both water resources and water quality. One task focuses on enhancing ground water resources by evaluating artificial recharge of aquifers. These tasks include:

- Establishing a Monitoring Network;
- Upgrading and Improving the Central Laboratory;
- Establishing a Water Management Information System; and
- Completing Aquifer Recharge Studies.

Each of these tasks constitutes an independent subprogram of the overall WQIC Project although the tasks are related. Detailed development and planning for each of these tasks is presented in a separate paper or report. This document discusses the artificial recharge component of the WQIC Project.

Early in the development of the artificial recharge program, a working group composed of representatives of the Ministry of Water and Irrigation, the Water Authority of Jordan, and the Jordan Valley Authority was established. A goal of the working group was to identify and develop the detailed objectives of the artificial recharge program. The organizational objectives of all participating working group members were to be met by a proposed artificial recharge program. As a result of the working group's efforts, an Artificial Recharge Objectives Statement was drafted which outlined in detail the principal objectives for the artificial recharge program.

1.3 Artificial Recharge Objectives

The Artificial Recharge Objectives Statement (AROS) serves as the framework for developing the overall goals and strategy for an artificial recharge program. Alternative methods for reducing water losses through natural processes (e.g., evapotranspiration, runoff) and augmenting available water supplies in the Kingdom are important components for water planning and management purposes. The primary objective of the artificial recharge task is to establish a program to evaluate the feasibility of augmenting water supplies through artificial recharge of aquifers. To varying degrees, the objectives are interrelated with other components of the water resources monitoring and management component of the WQIC Project.

The objectives attempt to address available water resources and climatological data, water use demands and information, soil, geological and geomorphological data, water quality data, institutional issues, and organizational factors which are important in evaluating the potential feasibility of pursing artificial recharge studies. The goal is to define and develop an artificial recharge feasibility study program which is responsive to the water resources needs and water availability constraints of the Kingdom. Ultimately, an artificial recharge program may become an integral component of the national water management plan so that the water resources needs and objectives of the MWI and Kingdom of Jordan can be achieved.

Specific objectives of the artificial recharge task are identified in Tables 1-1 and 1-2.

1.4 Purpose of Artificial Recharge Data Needs Document

The Artificial Recharge Data Needs Document provides a summary of the existing geologic, hydrologic, and water resources data and previously attempted artificial recharge studies and programs for Jordan including within the Ministry of Water and Irrigation, Natural Resources Authority, or other governmental or nongovernmental organizations. The document attempts to summarize available data so that a basis for development of a proposal for a comprehensive artificial recharge study program including pilot studies can be completed. The proposal will present the specific details for collection of required data and evaluation and screening of candidate sites and ultimately will lead to feasibility studies. Following site selection, comprehensive data monitoring and collection programs will be initiated at the selected sites. Based on the comprehensive data, final designs for pilot testing artificial recharge projects at representative sites will be developed.

The scope of work for this document and the methods of investigation that were used to collect the data are discussed in Section 2.0. Section 3.0 presents a summary of the findings of the survey including geologic and hydrologic data, previously attempted artificial recharge programs, ongoing artificial recharge programs, and other relevant information. Section 4.0 presents a summary of the survey and recommendations for developing the Artificial Recharge Proposal and study plans. Section 5.0 presents a lists of references and resources used to prepare the data needs document.

2.0 Scope of Work and Methods of Investigation

Existing summaries of water resources data for Jordan and artificial recharge programs attempted or in progress in Jordan were reviewed as part of the comprehensive evaluation for preparing the Artificial Recharge Data Needs Document. Members of the Artificial Recharge Working Group compiled data regarding various aspects of water resources availability and use for inclusion in the data needs document. Several field trips were completed to observe the regional geology and ground water aquifer systems, ground water recharge areas, and dam sites where artificial recharge and water storage projects have been attempted. Specific details of the scope of work for the artificial recharge data needs survey are presented in the 1994 Annual Workplan for the Water Quality Improvement and Conservation Project (MWI, June 1994).

Specific activities completed as part of the scope of work for preparing the data needs document included:

(1) Survey the existing artificial recharge data;
(2) Survey existing artificial recharge plans;
(3) Survey existing artificial recharge practices; and
(4) Identify artificial recharge data needs.

Specific details of the scope of work for each of these activities are discussed in Section 2.0. The findings of the survey for these activities are presented in detail in Section 3.0.

2.1 Existing Water Resources Databases

Some artificial recharge studies have been initiated in Jordan. Generally these have been small scale efforts for very specific purposes. The foundation for any comprehensive artificial recharge program in Jordan is based in the water resources and geological databases for the country as well as evaluations of actual and planned water uses and deficits. The water resources and geological databases for Jordan are extensive and generally well documented.

Water resources data were summarized based on the various databases maintained by the MWI. The data summarizes were extracted from available reports and generally represent water resources information for the past several years. No data analyses were completed to prepare the summaries. In addition, geological information was obtained from numerous references and maps prepared through the National Resources Authority of Jordan. The geological information has been extracted from these references and reports prepared by the MWI to present an overview of the hydrogeologic setting, ground water aquifer systems, and general hydraulic properties of the aquifers.

Section 3.1 of the data needs document presents a discussion and summary of the water resources and hydrogeologic information for Jordan.

2.2 Existing Artificial Recharge Plans

Three organizations currently are engaged in artificial recharge studies or programs in Jordan. These organizations are the Ministry of Water and Irrigation - Secretary General organization (Mwi), the Ministry of Water and Irrigation - Water Authority of Jordan Studies Department (WAJ), and the University of Jordan Water and Environment Research and Study Center (WERSC). For the data needs document, each organization was contacted and the ongoing and planned artificial recharge projects were discussed. In addition, because of the mutual interest in artificial recharge applications in Jordan, the three parties are developing a cooperative arrangement for exchanging information and sharing technical resources and for minimizing duplication of effort in their artificial recharge studies.

Section 3.2 of the data needs document presents a discussion and summary of the existing artificial recharge plans for Jordan.

2.3 Existing Artificial Recharge Practices

Several artificial recharge projects have been attempted in Jordan. Reports describing these projects and technical information obtained from project studies were reviewed for the data needs document. Particular attention was focused on problems or difficulties encountered

during the studies or as part of the overall artificial recharge project so that the design of future study efforts would benefit from the earlier studies.

Section 3.3 of the data needs document presents a discussion and summary of the artificial recharge projects previously attempted in Jordan. Several reports of these studies have not yet been obtained. Consequently, improvement of the existing artificial recharge information database will be an ongoing activity.

2.4 Artificial Recharge Study Data Needs

Available information compiled during the conduct of tasks described in Sections 2.1, 2.2, and 2.3 were evaluated collectively to identify data or information deficiencies. Data deficiencies or data needs will need to be addressed as part of any comprehensive field testing or study program during the artificial recharge study. Typically these data will be needed prior to the development of site specific feasibility or pilot study plans.

Section 3.4 of the data needs document presents a discussion of the artificial recharge data needs for planning site specific feasibility or pilot study plans.

3.0 Summary of Information and Findings

Alternative methods for reducing water losses from natural processes (e.g., evapotranspiration, runoff) and augmenting available water supplies are important components in optimizing water planning and management in Jordan. Application of artificial recharge techniques offers the potential for reducing water losses by enhancing ground water resources through increased recharge to ground water aquifers country-wide. A principal objective of the artificial recharge program is to evaluate the feasibility of enhancing ground water resources by increasing recharge to ground water aquifers country wide and to promote establishment of a long-term artificial recharge strategy for Jordan. Such a strategy would be beneficial to the long-term water resources management needs of Jordan.

Section 3.0 summarizes the basic findings of the artificial recharge data needs survey for Jordan based on the scope of work outlined in Section 2.0.

3.1 Existing Water Resources Databases

Section 3.1 presents general summaries of the basic hydrologic and geologic information for Jordan that will be important in development of the artificial recharge program and pilot studies. This information includes precipitation and evaporation data, stream flow data, hydrogeology data, and ground water aquifer characteristics and basin data. A map depicting key features of Jordan is presented as Figure 3-1. More than 90 percent of Jordan is classified as desert with rainfall averaging less than 200 millimeter annually. Water quality data will be addressed in more detail during the feasibility study.

Jordan has been divided into 15 surface water management regions (basins) and 95 sub-basins for water resources and water quality monitoring purposes. Figure 3-2 depicts the water management basins and sub-basins. Table 3-1 lists the water management basins and sub-basins. Jordan has been classified into 12 geographically defined ground water basins (GTZ, 1977). Figure 3-3 identifies and depicts the locations of the ground water basins.

3.1.1 Meteorological Data

There are 292 rainfall measurement stations located in Jordan which are the responsibility of WAJ. These include 34 dual precipitation and evaporation stations. Most of the stations are concentrated in the northern and western parts of the country where the annual precipitation is most intense. Ninety-five (95) of the stations are not working currently. Figure 3-4 presents the location and distribution of the stations and Table 3-2 identifies each station. In addition, the Ministry of Transport maintains a network of meteorological stations. A summary of the annual rainfall totals for the water year periods 1975/1976 through 1992/1993 is presented as Table 3-3. Figure 3-5 presents a distribution map of the 50 year (1937 - 1987) average precipitation for Jordan.

There are 32 evaporation stations administered under the authority of the WAJ. The stations are distributed throughout Jordan. Eleven (11) of the stations are not working currently. Figure 3-6 presents the location and distribution of the stations and Table 3-5 identifies each station. Figure 3-7 depicts the average potential evaporation for the wet season (November - April) for the period 1975 - 1990.

3.1.2 Surface Water Data

Surface water monitoring primarily is concerned with the Zarqa River, Yarmouk River, Mujib Basin, and Jordan Valley and associated wadis because these represent the areas with the greatest record or potential for stream flow. Approximately 60 gauging stations have been established by WAJ. Another 30 stations have been established in the Jordan Valley by JVA. Several of the stations are used to measure base flow, however, most of these stations have significant gaps in the period of record and there are no continuous records. Four stations are still used for flood flow measurements, but flood flow at the other stations is determined by a variety of analytical methods. Monitoring of reservoirs (e.g.,King Talal Reservoir) is administered under the surface water programs. Figures 3-8a and 3-8b present the locations and distribution of the stations and Tables 3-6a and 3-6b identify the stations.

Surface water resources information for specific basins for the years 1989 through 1993 are summarized in Tables 3-7 through 3-11. Long-term average data are summarized in Table 3-12.

3.1.3 Ground Water Data

Ground water resources in Jordan typically are discussed in terms of 12 ground water basins (GTZ, 1977) (Figure 3-3). The total number of wells in Jordan, both private and governmental, is approximately 3,800 wells. These wells serve a number of purposes ranging from municipal water supply, agricultural water supply, industrial water supply, as well as for observational or monitoring purposes. Wells are being installed at an alarming rate within Jordan as overall water supplies decrease and needs increase. Comprehensive records of the wells installed or planned are limited because not all wells are registered with the appropriate authorities. Most of these wells are concentrated in the Amman-Zarqa, Yarmouk, Dead Sea, and Azraq Basins.

Approximately 110 wells have been designated for and are used for water level monitoring purposes. To date, 66 wells have been equipped with automatic, continuous water level recorders. Measurement of water levels is done manually at the other wells. Approximately 150 wells have been designated for water quality monitoring purposes. Table 3-13 lists the water level measurement wells in the monitoring network. Table 3-14 lists the water quality monitoring wells. Figures 3-9 and 3-10 depict the locations of the wells.

<u>Ground Water Aquifer Systems and Hydrogeologic Data</u>

A comprehensive discussion of the geology of Jordan is found in Bender (1974) and Burdon (1959). Technical ground water reports for various areas of the country also present discussions of the specific geologic characteristics of the area being investigated. The data summarized in this section represent the collective knowledge and experience of the ARWG representatives. The data summary is intended to be generic in focus and not specifically referenced to the findings of the number of studies which have been conducted in Jordan.

The main hydrogeologic strata and aquifers in Jordan are:

- A - Quaternary alluvium deposits
- B - Basalt group
- C - Balqa group (B1-B5)
- D - Ajlun group (A1-A7)
- E - Kurnub

- F - Zarqa
- G - Disi

Figure 3-11 presents a generalized stratigraphic column for Jordan identifying key formations and aquifer groups. Significant efforts currently are in progress by the German Institute for Geosciences and Natural Resources (BGR) to identify ground water monitoring systems particularly in northern Jordan. As part of this process, geologic and hydrogeologic data obtained during installation of ground water wells are being re-evaluated to better understand the ground water systems for purposes of establishing better monitoring programs (BGR, 1994). Maps depicting the occurrence of various geological formations, ground water aquifer systems, surface geology, and outcrop areas are presented in the National Water Master Plan (GTZ, 1977).

Quaternary Alluvium Deposits

These deposits and associated aquifers are found mainly in the Jordan Valley and Sukhaneh near Zarqa, Wadi Yutum in the south, and Wadi Araba. Generally these deposits are exposed at the ground surface and therefore present a good potential for recharge of the associated aquifers. The basic properties of the deposits are summarized in Table 3-15.

Basalt Aquifer

Basalt covers approximately 11,000 square kilometers of Jordan primarily in the eastern and northern parts of the country. The basalts are of Pleistocene Age and are composed of massive alkali layers separated by clays, sand, and gravel. The depth to the top of the Basalt aquifer generally ranges from 5 to 400 meters in Jordan. The recharge potential from the land surface in Jordan generally has not been established. The aquifer outcrops in Syria and is recharged in the Jebel Druse region of Syria. The basic properties of the Basalt aquifer are summarized in Table 3-15.

Balqa Group (B1-B5)

The Balqa group includes the Amman aquifer (B2) and the Rijam aquifer (B4). The B2 aquifer is composed of chert limestone and marl with chalk. The thickness of the aquifer varies from approximately 50 meters to more than 150 meters. Generally, it is more practical to discuss the B2 aquifer along with the Wadi Sir (A7) aquifer. A more detailed discussion of the Amman-Wadi Sir aquifer system is presented in the following subsection.

The Rijam aquifer (B4) is found in the Azraq, Sirhan, and Jafer Ground Water Basins. In the Jafer Basin the aquifer is composed of limestone, marl, and marly limestone. In the Azraq Basin, the Rijam aquifer is recharged directly from the overlying basalt. The principal properties of the aquifer are summarized in Table 3-15.

Ajlun Group (A1-A7)

The Ajlun group includes three aquifer systems: Wadi Sir aquifer, Hummer Formation, and the A2 aquifer.

The Amman-Wadi Sir aquifer is composed of two hydrogeologic units, the B2 (Amman) and the A7 (Wadi Sir). The A7 aquifer is composed of carbonate rocks, limestone, marl, and marly limestone. The thickness of the A7 aquifer varies from approximately 40 meters to more than 250 meters in the Yarmouk River Basin. In general, the A7 aquifer ranges in thickness from 90 to 120 meters. To the southeast the A7 aquifer becomes sandier and eventually the Ajlun series becomes one unit to the south-southeast near the Jafer Ground Water Basin.

In general, it is more practical to deal with the Amman-Wadi Sir aquifers as one unit since they are hydraulically interconnected. The maximum thickness of the B2/A7 system is approximately 350 meters in Azraq and 200 to 250 meters in the highlands along the east face of the Jordan Rift Valley. In the Yarmouk River Basin, thickness reaches approximately 450 meters. The main source of recharge is rainfall in the outcrop areas in the highlands where rainfall is relatively high (250 to 500 mm/year). The main hydraulic properties of the B2/A7 aquifer system vary from location to location and are summarized in Table 3-15.

The Hummer Formation aquifer (A4 aquifer) is composed of dolomitic and marly limestone. The Hummer Formation is missing in the Sirhan, Hammad, and Jafer Basins. The depth to the aquifer ranges from approximately 150 to 300 meters in Zarqa, to 244 to 800 meters in Yarmouk, to 830 to 3300 meters in Azraq (Hamzah oil well). The potentiometric surface has declined significantly in this area in some cases exceeding 40 to 50 meters. Table 3-15 summarizes the hydraulic properties of the aquifer.

The A2 aquifer is composed of dolomitic limestone with some chert, shale, marl, and sandy marl. Practical economic use of the A2 aquifer for ground water resources at the present time ranges from the land surface to a depth of approximately 250 meters. The formation outcrops in the western highlands from Ajlun to east of Ras En Nagab. Because the A2 aquifer outcrops along the face of the escarpment below the crest, most of the recharge is rejected as discharge from springs. Table 3-15 summarizes the hydraulic properties of the aquifer.

Kurnub Aquifer

The Kurnub aquifer is composed of sandstone with clay and silt. In the Amman-Zarqa Basin, the aquifer is found at depths ranging from approximately 20 to 70 meters in Baq'a due to water bearing lenses of varying depth to 300 meters near Sukhaneh, to 530 meters near Zarqa, to 900 meters near Qastal. The aquifer also is found in the Jafer, Dead Sea (Mujib and Lajjon), and Azraq Basins at depths ranging from approximately 400 meters to more than 1,000 meters. The Kurnub aquifer outcrops near Jerash and the King Talal Reservoir and Zai treatment plant but is characterized by relatively high salinities at depth which possibly may be influence by the underlying Zarqa aquifer. Table 3-15 summarizes the hydraulic properties of the aquifer.

Zarqa Aquifer

The Zarqa aquifer is composed of dolomitic limestone, sandy dolomite, sand, shale, and marl and underlies the Kurnub aquifer at depth. The depth to the aquifer ranges from approximately 26 meters near the mouth of Wadi Husban to more than 300 meters below the land surface near Baq'a. In other areas the aquifer is very deep (approximately 800 meters at Amman to 1,100 meters at Ramtha near the Syrian border). The aquifer thickness ranges from approximately 60 to 220 meters. The aquifer outcrops along the eastern side of the Jordan Valley escarpment. Table 3-15 summarizes the hydraulic properties of the aquifer.

Disi Aquifer

The Disi aquifer is composed of coarse and medium sandstone. The aquifer occurs at significant depth in the southeastern portion of Jordan and extends into Saudi Arabia and is considered non-renewable. Table 3-15 summarizes the hydraulic properties of the aquifer.

Other Ground Water Sources

Recent interest has been expressed in the potential for ground water to occur in the Rum Formation (i.e., a Rum aquifer) which underlies the Zarqa Formation in the Wadi Araba portion of the Jordan Rift Valley. This potential sandstone unit would contain water under artesian pressure which possibly recharges the Zarqa aquifer. Exploratory drilling in Wadi Araba has been proposed to determine the occurrence of the formation.

Ground Water Basins

Twelve ground water basins have been designated in Jordan for water management planning purposes (GTZ, 1977). These are:

- Amman-Zarqa
- Yarmouk
- Jordan River Valley Floor
- North Wadi Araba
- Jafer
- Sirhan
- Azraq
- North Rift Side Wadis (W. Arab to W. Husban)
- Dead Sea (Mujib and Hasa)
- South Wadi Araba
- Disi and South Desert
- Hammad

These basins differ in geologic, hydrogeologic, and hydrologic characteristics, relative stratigraphy, lithologic properties, hydraulic properties, potential and safe yield, storage, and general water quality. Precipitation and recharge characteristics for each differ and affect whether the basin is being dewatered and the magnitude of any water deficits.

In some basins (e.g., Disi), the ground water is non-renewable. In the Jordan River Side Wadis, North Wadi Araba, South Wadi Araba, Hammad, and Sirhan Basins, the annual abstraction does not exceed the safe yield. From the perspective of artificial recharge need, the ground water basins which are most subject to extensive abstraction exceeding the safe yield and causing a water deficit are the Jafer Basin, the Amman-Zarqa Basin, Yarmouk Basin, and the Dead Sea Basin.

A brief description of the ground water basins as related to potential artificial recharge studies is presented below. Ground water resources data for each basin for the years 1989 through 1993 are summarized in Tables 3-16, 3-17, 3-18, 3-19, and 3-20, respectively.

Hammad Basin and Sirhan Basin

Presently the annual abstraction from these basins does not exceed the safe yield. In addition, precipitation averages for the geographical areas within which these basins are located are very low (< 50 millimeter (mm)). The Ministry of Agriculture constructed the Ruwaished Dam which has a storage capacity equal to 10 million cubic meters in the Hammad Basin. Plans are to construct a second dam (Abu Hifna) in the near future.

For these reasons, the Hammad and Sirhan Basins are not considered during the initial artificial recharge screening and feasibility studies.

North Rift Side Wadis Basin

The greatest potential for ground water in Jordan is located along and near the escarpment east of the Jordan Valley floor. The Ajlun series aquifers consist primarily of limestone and generally dip to the north and northwest in this area. The average annual precipitation for the basin ranges from 400 to 600 mm. The aquifers in the area currently are not overdrafted. Dams constructed or planned for the North Rift Side Wadis Basin can provide surface water storage capacity and are operated by the JVA. Proposed surface water storage sites include wadis Kufrinja, Yabis, and Rajib.

For these reasons, the North Rift Side Wadis Basin is not a high priority for initial artificial recharge screening and feasibility studies. Consideration could be given to use the water stored in the dams for artificial recharge purposes in nearby areas (e.g., Amman-Zarqa, Jordan River Valley, or Dead Sea Ground Water Basins). However, this strategy may be costly and therefore currently is not a primary objective for the artificial recharge study program.

Disi and South Desert Basin

Ground water in this basin is not renewable. Average annual precipitation is less than 50 mm. If storm floods do occur in the area, the predictability is low, dams would need to be constructed, and the cost for injecting the water to the depths of the Disi Aquifer would be great.

For these reasons, the Disi and South Desert Basin is not considered during the initial artificial recharge screening and feasibility studies.

Several dams have been constructed in part to provide potential for recharge of stored water to ground water aquifers. These dams include Khaldiyeh in the Amman-Zarqa Basin, Shueib (Rift Side Wadis Basin), Sultanah, Qatranah, and Siwaqa (Dead Sea Basin), Ghdeer Al Abyad (Yarmouk Basin), and Rajil (Azraq Basin). In addition, several dams are proposed at least in part for artificial recharge (Table 3-21).

Of the existing dams potentially suitable for artificial recharge purposes, very limited data have been obtained to monitor or assess the actual degree of recharge to the respective ground water aquifer. Based on visual observations only, recharge seems to be occurring from the Shueib, Siwaqa, and Khaldiyeh dams. Water stored by the dams generally is lost more quickly than could be expected from normal evaporation rates and the loss is not due to visual evidence of seepage under the dam or discharge from the dam. Rijal dam is too new and essentially no data are available to evaluate actual recharge. In addition, the Rijal site is not instrumented to accurately assess actual recharge.

Several dams intended to be used for recharge have accumulated significant amounts of silt and the recharge potential has been lost or seriously reduced. The storage reservoir behind the Sultanah dam has been fully filled with silt and sediment and no longer provides even short-term storage capacity. The reservoirs of the Qatranah, Siwaqa, and Khaldiyeh dams also are accumulating silt. Accumulation of silt will be a major factor to be considered in the evaluation and design of artificial recharge systems in Jordan.

The three dams in the Yarmouk Basin (Sama Al-Sarhan, Ghadeer Al Abyad, Bowaydah) were constructed mainly for livestock although there is potential for artificial recharge due to the geological setting in outcrop areas for the respective aquifer systems. However, the sites are not instrumented to accurately assess actual recharge.

3.2 Existing Artificial Recharge Plans

Three artificial recharge projects currently are underway in Jordan. One project is developing out of the current data needs survey reported in this document and is funded under the auspices of the United States Agency for International Development. The second study is funded by the United Nations Development Programme (UNDP) and involves the participation of Jordan, Syria, Iraq, Tunisia, Algeria, and Morocco. The third project also

is funded by the UNDP as part of a broader environmental study for the Conservation of the Dana and Azraq Protected Areas and involves the cooperation of several organizations. The University of Jordan, Water and Environmental Research and Study Center is the lead organization for the artificial recharge component of this project.

In addition to these projects, WAJ has investigated the potential for artificial recharge to the aquifer systems in the Mujib Basin through construction of dams in Wadi Mujib and Wadi Wala. Two project sites have been proposed and construction is planned pending negotiation of funding.

Mashreq and Maghreb Project

The Water Authority of Jordan - Studies Department is actively engaged in an artificial recharge task for a project funded by the UNDP. The project titled "Current Technologies in Water Resources Management in the Mashreq and Maghreb" has the objective of building regional technical capability in water management resources through networking of the six participating countries (UNDP, undated). These countries are Jordan, Syria, Iraq, Tunisia, Algeria, and Morocco. The focus of the project is on training and capability development of local water scientists, engineers, and administrators with limited opportunity for comprehensive field studies and investigations.

Jordan is involved in an artificial recharge project as part of the overall program and is developing capability based on work previously done in the Maghreb (Tunisia, Algeria, and Morocco). The artificial recharge project site in Jordan is the Siwaqa Dam, a desert dam located in central Jordan within the larger Wadi Mujib Basin of the Dead Sea Ground Water Basin. Some limited field studies are planned to provide data on the potential recharge of the B2/A7 aquifer from water stored in the reservoir of the dam. A detailed work plan is not available. Installation of monitoring wells sponsored by the WAJ Drilling Department is anticipated in the future. The study is in progress and will continue into 1996.

Azraq Conservation Project

The Water and Environment Research and Study Center (WERSC) of the University of Jordan is engaged in various research programs and projects relating to water resources. Currently, the WERSC is conducting an artificial recharge study in the Azraq Basin with

funding through a UNDP project (UNDP, undated). The overall focus of this UNDP_ project is environmental and water conservation issues in the Azraq Basin. However, the artificial recharge aspects of the project will provide data and information regarding the application of the technology in the Azraq Basin and potentially other sites in Jordan.

The artificial recharge project currently is in progress. Field work and instrumentation at the project site have been completed and with the start of the rainy season field data are being collected. The project will continue into 1995. The project document (UNDP, 1993) identifies the scope of work for the artificial recharge component to include:

- Establishment of a research area(s) (i.e.,compile data, prepare site including construction of dikes, install hydrologic instrumentation, install soil/ground water monitoring systems, install leaching testing equipment)

- Collection and analysis of data and establishment of a rainfall/runoff model (i.e.,surface water, meteorologic, soil, determination of water harvesting and artificial recharge potential)

- Assessment of use of treated waste water for artificial recharge (i.e., vadose zone and ground water quality, leaching requirements, changes in water quality due to infiltration of recharge water)

- Establishment of guidelines for water harvesting through artificial recharge practices in arid and semi-arid regions (i.e., prepare guidelines and field investigation requirements, perform environmental impact assessments, assess practices regarding design/construction/operation/maintenance of artificial recharge options, conduct/participate in local and international seminars and training courses, document study findings, prepare special publication on guidelines)

Proposed Wadi Wala Reservoir

Abu-Obeid in a paper presented in the Proceedings of The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) referenced a report prepared by Howard Humphreys and Partners in 1992 regarding the construction of a

proposed dam on Wadi Wala in the Dead Sea Ground Water Basin. The study presented a comprehensive water balance to evaluate and select potential sites for dams to store flood waters for later injection by wells into the underlying ground water aquifers. A two-dimensional ground water flow model was established for the site area. The modeling results indicated that 4.2 MCM of water could be injected annually into the ground water aquifer using injection wells. However, non-settleable solids would need to be treated prior to injection of the water. More details of the study are being researched.

The inception report for this reservoir (Howard Humphreys, 1989) presents a survey of potential dam sites in the Mujib Surface Water Basin, water availability, site characteristics and construction constraints. Recommendations for feasibility studies at two sites one on Wadi Wala and the other on Wadi Mujib are presented.

3.3 Existing Artificial Recharge Practices

As noted briefly in Section 3.1.4,several dams have been constructed in geological settings with the potential for artificial recharge to associated aquifer systems. In addition, other studies have been performed to evaluate or research the potential for artificial recharge to ground water aquifers in Jordan. This section presents an overview of the most significant efforts to date in Jordan for studying or evaluating the potential application of artificial recharge technology and practices. A conference was held in Amman in December 1993 sponsored by the University of Jordan, Water and Environment Research and Study Center and the Canadian government on the topic of artificial recharge of ground water. The Proceedings of The Regional Seminar on The Potential of Artificial Recharge of Groundwater (WERSC, 1993) presents a number of papers which outline conceptual and theoretical considerations relating to hydrologic and hydrogeologic conditions as well as decision theory, multiobjective planning, and legal and administrative topics relevant to ground water aquifer artificial recharge practices.

3.3.1 Amman-Zarqa Basin

Khaldiyeh Reservoir

Kilani (1985) reported an attempt at artificial recharge in Jordan at the Khaldiyeh reservoir in the Amman-Zarqa Basin. Data for volume storage and losses for the Khaldiyeh reservoir

for several months in late 1984 and early 1985 were reviewed to determine potential infiltration rates to the associated ground water aquifer. Of the 0.78 MCM filling the reservoir over the 30-31 October 1984 flood event, approximately 0.40 MCM was estimated to have infiltrated to the aquifer by 31 December 1984. Approximately 0.35 MCM remained in storage and the balance of 0.03 MCM was lost to evaporation. Further efforts at evaluating the potential artificial recharge at this site have not been attempted.

Abu-Obeid in a paper presented in the Proceedings of The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) indicated that a pilot project was planned to study injection of water stored in the Khaldiyeh reservoir to the underlying aquifer. A 20-inch production well and associated piezometers were installed near the intake of the dam and a pumping test was performed to establish the parameters of the aquifer. Prior to pilot testing injection of water to the aquifer, however, technical problems associated with the degree of suspended solids in the water were encountered and the pilot test was not performed.

During a field trip to the site on 1 November 1994, thicknesses of silt and sediment in excess of one meter were observed in the bottom of the reservoir. The sediments had dried creating large, deep cracks and fissures and the sediments had solidified and hardened to a siltstone-like lithology.

3.3.2 Dead Sea Basin

Qatranah and Sultanah Reservoirs

Al-Labadi (1993) reported on past water harvesting projects in Jordan with particular attention to the water resources, land classifications, and related agricultural suitability from construction and operation of the Qatranah and Sultanah dams within the Wadi Mujib system of the Dead Sea Basin. The objective of constructing these dams was to reduce the flooding of extensive areas of cultivable land and to promote the infiltration of the runoff water into the soils for later use by crops. The annual rainfall over the catchment areas is approximately 100 mm and rainfall patterns and intensity are erratic. However, rainfall intensities for these types of areas typically are high.

In general, the flood waters impounded by the dams greatly exceeded the expectations which again highlights the highly variable and erratic nature of rainfall events in arid areas. Low level earthen dams may need to be constructed on upstream subcatchments to reduce the velocity of the runoff water, excess water and sediment load, and to prevent reduction in the life of the main dam and reservoir. Because the projects are not typical of irrigation farming, consideration needed to be given to how land should be brought into use. A scheme was developed to prioritize agricultural practices on land impounded in the reservoirs.

During the visit to the Sultanah reservoir in October 1994, the reservoir was observed to be full of silt (to the top of the spillway). Bulldozers and heavy equipment had been used in the past to remove silt from the reservoir and piles of removed silt can be observed on the landscape beside the dam.

Siwaqa Reservoir

Al-Momani et al. (1994) reported on the influence of the Siwaqa dam on recharge to ground water aquifers within the Wadi Mujib system of the Dead Sea Basin. The catchment area is approximately 450 square kilometers and precipitation averages approximately 130 mm annually (57.6 MCM). Hydrologic studies were reported to indicate the flood flow for storage would be approximately 2.5 MCM. The Siwaqa reservoir is constructed into the underlying Wadi Sir Formation (A7 aquifer) which is approximately 120 meters thick in the area. The saturated thickness of the aquifer ranges from approximately 100 to 120 meters.

Declines in the potentiometric surface of the A7 aquifer in the area were reported to have reached 16 to 18 meters at Siwaqa well #2 from 1986 to 1992. Data collected during 1993 and 1994 shortly after the dam became operational indicated a rise in the potentiometric surface of approximately five to eight meters for wells in the immediate vicinity of the dam. The reservoir of the dam covers the former Siwaqa well #2. Ground water quality data were reported to indicate fluctuations in specific conductivity. However, the data were not sufficiently complete to make any definitive conclusions.

Substantial additional investigation has been recommended at the site to better assess the artificial recharge potential from the reservoir. The area needs to be instrumented with a surface water gauging station, additional observation or monitoring wells, water level

recorders, and flow meters on production wells. The artificial recharge potential of the Siwaqa dam currently is being studied. by the WAJ - Studies Department under funding from the United Nations Development Programme.

Proposed Wadi Karak Weirs

Salameh (WERSC, 1993) briefly discussed the potential for artificial recharge to ground water aquifers in Wadi Karak based on hydrologic conditions in the surface water basin. Four sites were identified where weirs could be constructed. The preferred sites were located where the geologic conditions are characterized by joints and fractured limestone and dolomite. Potential infiltration rates were computed for the four reservoirs created by the weirs based on the data obtained from the study conducted in the Muwaqqar catchment. Use of weirs for artificial recharge to ground water aquifers was advocated because of the reduced potential for negative environmental effects compared to large dams and because of the potential for minimizing soil erosion and desilting retained waters.

3.3.3 Azraq Basin

Several papers were presented at The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) regarding artificial recharge considerations and potential practices in the Azraq Basin. Rimawi et al. (WERSC, 1993) discussed the physical characteristics pertinent to artificial recharge practices and the occurrence of these factors in the Azraq Basin. Based on the comparisons, they recommended deep, long narrow trenches filled with basalt boulders and gravel and volcanic ash as an appropriate method to induce artificial recharge in the Azraq Basin. As noted previously in Section 3.2, a UNDP funded study regarding ecological and environmental factors in the Azraq Basin is in progress and artificial recharge is a component of that study.

Muwaqqar Catchment

Awwad et al. (WERSC, 1993) discussed water harvesting techniques for promoting artificial recharge in the Azraq Basin and referenced a 1988 - 1991 study in the Muwaqqar catchment of the basin. More details of the study are being researched.

Saleh et al. (WERSC, 1993) discussed an optimization technique using dynamic programming to obtain the optimal strategy for artificial recharge from a network of

reservoirs (three small dams each with a capacity of approximately 15,000 cubic meters) in the Muwaqqar catchment of the Azraq Basin to the underlying ground water aquifer. The modeling effort considered a seven month period including crop water demands for wheat and barley. A seven month period was used because it best represented the rainfall and runoff pattern for the area (i.e., no rainfall in the summer) and to allow for removal of sediments which have accumulated at the bottom of the reservoirs and which would reduce infiltration rates.

Salameh (WERSC, 1993) discussed in more detail the ground water artificial recharge project in the Muwaqqar catchment of the Azraq Basin. The infiltration potential from three small dams (essentially weirs) each with an approximate storage capacity of 15,000 cubic meters was assessed over a period of several years from 1987 to 1990. Infiltration rates were computed based on hydrographic measurements of the water levels in each reservoir and average evaporation rates for the period of study during which the reservoirs contained water. The infiltration rates were noted to decrease from the beginning of the rainy season to the end of the season. The decrease in the infiltration rates was believed to result as a consequence of the accumulation of silts in the bottom of the reservoirs. Infiltration rates generally approached a low-end value of 1×10^{-5} centimeters per second (cm/sec) which was considered probably to be representative of the permeability of the silt sediments.

Over the study period, the calculated amount of recharge was reported to be several times greater than the storage volume of each reservoir indicating that the reservoirs were effective in promoting recharge to the ground water aquifer. The study was reported to demonstrate that rainfall intensities of less than one millimeter per hour (mm/hr) did not result in any runoff. Intensities greater than two mm/hr resulted in runoff over the entire basin. Silt accumulation in the basins was measured and for each flood event, each meter depth of water was determined to result in the deposit of 1.5 cm of silt composed of clayey materials, limestone, dolomite, and sandstone. Infiltration tests were conducted in excavated areas of the catchment using runoff. The tests indicated that for shallow (< 60 cm) and deep (100 cm) excavated areas, infiltration rates decreased over time by 30% to 80% as a result of the accumulation of silt. The deeper excavated areas generally had the greater infiltration rates over the period of time.

Wadi Al-Butum

Otova and Ayed (1988) presented a detailed conceptual design for an artificial recharge project in the Wadi Al-Butum catchment of the Azraq Basin. The basic concept for the project was the construction of a 12 meter high earthen dam with settling tanks, an injection well system, and three eight meter deep subsurface dams constructed in the alluvium downstream of the main dam to be used for storage of water. Essentially, sediments in the water received by the main earthen structure dam constructed across the wadi would settle out and then would be transferred to behind the underground dams by a subsurface system or by injection wells. Water also would be stored in the Rijam aquifer (B4) which underlies the alluvium and outcrops in the area. Injection wells would be used to recharge the Rijam aquifer.

Comprehensive hydrologic analyses were completed to determine runoff and flood flow potentials and discharge volumes. Because of the lack of actual hydrologic data, synthetic hydrographs and flood frequency analyses and double mass curve comparisons were computed using Soil Conservation Service techniques for the hydrologic evaluations. The proposed strategy for using water from the system was first from the B4 aquifer, then from the main reservoir, and lastly from the subsurface reservoirs created by the underground dams.

3.3.4 Jordan River Side Wadis

Shueib Reservoir

El-Naser and Gedeon (WERSC, 1993) briefly discussed some qualitative observations regarding the Shueib reservoir and the implication with respect to artificial recharge of the underlying aquifer. The Shueib reservoir catchment area is approximately 185 square kilometers and the mean annual precipitation ranges from approximately 200 to 600 mm. The site area is underlain by aquifers of the Ajlun group and has been subject to faulting.

Ground water potentiometric data for a downstream observation well have indicated a rise of approximately 28 meters over a period of 12 years. The increase in the potentiometric surface is believed attributable to the reservoir. In addition, for some downgradient wells, water quality has improved over the years with a decrease in the salinity.

3.3.5 Sites in Other Countries in the Middle East

Al-Hiebe in a paper presented in the Proceedings of The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) referenced several artificial recharge projects conducted in North Africa. These included projects in Morocco involving the Haouz aquifer, Algeria involving the Mitidja alluvial aquifer, Tunisia involving the Souhil coastal aquifer, Morocco involving the Charf Akab confined aquifer, and Tunisia involving the Teboula coastal aquifer. More details of these studies are being researched.

Sadek et al. in a paper presented in the Proceedings of The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) referenced preliminary artificial recharge testing conducted in Beirut, Lebanon in the late 1960s. The purpose of the testing was to study the potential for winter storage of excess water for use during the dry season and to reduce the potential for saltwater intrusion in the coastal area. Only preliminary testing was completed and significantly more studies are needed to explore the application of artificial recharge in this area.

Attia in a paper presented in the Proceedings of The Regional Seminar on the Potential of Artificial Recharge of Groundwater (WERSC, 1993) mentions that two pilot sites have been identified in Egypt to evaluate the potential for artificial recharge. One site is adjacent to the Mediterranean coast and the second site is within the Moghra aquifer. More details of any proposed studies are being researched.

Al-Muttair et al. (1994) reported on the management of recharge reservoirs and dams in Saudi Arabia. Five management strategies were used for two recharge reservoirs in central Saudi Arabia to attempt to increase the ground water recharge efficiencies. Comparisons of the strategies on recharge efficiencies were conducted using simulations. The strategy based on silt removal and scratching the bed of the reservoir was reported to substantial increase the recharge efficiency.

3.4 Artificial Recharge Study Data Needs

The water resources databases for Jordan demonstrate significant hydrologic data that would be critical for evaluation of potential artificial recharge projects. Substantial data and

information regarding the geology of Jordan have been published over the past 100 years and further studies are in progress by the Natural Resources Authority. Several comprehensive water resources investigations have been completed since 1950 which would provide more location specific information to complement the databases. In general, the existing databases support a good general knowledge of the hydrologic and geologic characteristics of Jordan.

This subsection outlines the basic data needs that generally would be required to proceed with field implementation of artificial recharge practices.

3.4.1 Data Need Objectives

Objectives for the artificial recharge task of the WQIC Project have been established as outlined in Section 1.0 and listed in Tables 1-1 and 1-2. Specific hydrologic, geologic, water quality, and related data needs for evaluating artificial recharge practices will depend on the sites selected for pilot testing. Site specific geologic and geohydrologic data generally would be limited for most potential study locations. Surface water discharge data also generally would be limited for the subcatchments of the larger basins. Consequently, field data collection programs may be necessary to acquire these data.

Once a site is selected for detailed feasibility studies or pilot testing, complete meteorological, hydrologic, and water quality data would be necessary to properly evaluate the success of pilot tests.

3.4.2 Meteorological Data Needs

The meteorological databases (i.e.,precipitation and evaporation) are based on long records of data. As such, the databases generally provide the necessary meteorological data required for artificial recharge evaluations. Further analysis of existing data may be necessary to evaluate such factors as rainfall duration and intensity variations and resulting flood flow discharges for specific water basins. These analyses and evaluations would more properly be completed during site screening and detailed site characterization.

3.4.3 Hydrologic Data Needs

Stream flow measurements for some wadis are of long duration. In recent years the recording equipment for several stations has been lost to floods or is no longer working. Several comprehensive water resources investigations have been completed since 1950 which would provide more location specific information to complement the databases. Further analysis of existing data or additional data collection would be necessary to evaluate such factors as flood flow discharge rates for smaller wadis or catchments, suspended sediment loads in floods, and potential flood flow occurrences suitable for artificial recharge applications. These analyses and evaluations would more properly be completed during site screening and detailed site characterization.

3.4.4 Geologic and Soil Data Needs

Geologic data are fairly comprehensive for Jordan. Site specific conditions, however, would require a field survey and probably more detailed investigations. Further analysis of existing data or additional data collection would be necessary to evaluate such factors as the geologic structure, outcrop areas, and soil conditions. More detailed evaluations of geologic, as necessary, typically would be conducted concurrently with geohydrologic investigations. These analyses and evaluations would more properly be completed during site screening and detailed site characterization.

3.4.5 Geohydrologic Data Needs

Ground water potentiometric data are fairly comprehensive over the past several years for the major aquifers and well fields. Several comprehensive ground water resources investigations have been completed since 1950 which would provide more location specific information to complement the databases. More detailed evaluations of geohydrologic conditions would be necessary to properly evaluate such factors as depth to the aquifer, aquifer thickness, hydraulic head relationships, and the hydraulic properties of the aquifer for a specific location. These analyses and evaluations would more properly be completed during site screening and detailed

3.4.6 Land Use and Ownership Constraints

Land use and ownership constraints generally are not known and these types of information will be important to the study. Agricultural land or important environmental resources should not be affected by artificial recharge practices. Similarly, artificial recharge projects typically would not be suitable for major urban areas. Information and data collection efforts therefore must address these information needs.

3.4.7 Site Access Constraints

Access limitations must be evaluated for sites potentially selected for more detailed assessments. In addition, availability of natural resources that may be needed or suitable for the artificial project should be considered. Data collection efforts therefore also must address these information needs.

3.4.8 Water Quality Data Needs

Water quality data both relative to the ground water aquifer and potential source waters will be important in determining the suitability of water for various types of recharge programs. Some data are available on a regional scale for the various ground water aquifers. However, data for specific locations generally are unavailable and data for potential water sources also must be obtained.

4.0 Summary and Recommendations

The survey of the water resources data and artificial recharge practices and programs in Jordan discussed in this document represents an initial effort toward conducting feasibility studies and pilot testing of artificial recharge projects in Jordan. This forum also presents an opportunity to establish an artificial recharge strategy for contributing to the long-term water resources management planning for Jordan. The information summarized in this document will be used to prepare a proposal for conducting an artificial recharge study as a component to the WQIC project.

4.1 Summary

A brief summary of the findings of the survey of water resources data and artificial recharge practices in Jordan as related to potential feasibility studies is presented below.

1) Substantial water resources and geologic databases exist for Jordan. These include precipitation, evaporation, stream and flood flow, spring flow, ground water potentiometric levels, and reservoir levels and discharges (for some reservoirs only). Several comprehensive water resources investigations have been completed since 1950 and provide more location specific information to complement the databases.

2) Substantial data and information regarding the geology of Jordan has been published over the past 100 years and further studies are in progress by the Natural Resources Authority.

3) The existing databases support a good general knowledge of the hydrologic and geologic characteristics of Jordan.

4) Site specific hydrologic, geologic, water quality, and related data needs for evaluating artificial recharge practices will depend on the sites selected for pilot testing. Site specific geologic and geohydrologic data generally would be limited for most potential study locations. Surface water discharge data also generally would be limited for the subcatchments of the larger basins. Consequently, field data collection programs may be necessary to acquire these data.

5) Site specific land use and ownership constraints generally are not known and these types of information will be important to the study. Access limitations also must be evaluated for sites potentially selected for more detailed assessments. Data collection efforts therefore also must address these information needs.

6) Three artificial recharge projects currently are underway in Jordan. One project is a component of the USAID/MWI WQIC Project. The second project focuses on capability development and involves the MWI-WAJ as the lead Jordanian organization. The selected site for the MWI-WAJ project is the Siwaqa reservoir. The third project is part of a broader environmental study and involves the WERSC as the lead organization for the artificial recharge component. The selected site for the WERSC project is in the Azraq Basin.

7) Several dams have been constructed to provide potential for recharge of stored water to ground water aquifers. Several dams are proposed for artificial recharge. Of the existing dams, very limited data have been obtained to monitor or assess the actual degree of recharge to the respective ground water aquifer. Based on visual observations only, extensive recharge seems to be occurring from the Shueib, Siwaqa, and Khaldiyeh dams.

8) Several dams intended to be used for recharge have accumulated significant amounts of silt and the recharge potential has been lost or seriously reduced. The storage reservoirs behind the Sultanah and Bowaydah dams have been filled with silt and sediment and no longer provide short-term storage capacity. Accumulation of silt will be a major factor to be considered in the evaluation and design of artificial recharge systems in Jordan.

9) Except as noted for the existing reservoirs, very limited feasibility studies or pilot testing have been conducted to evaluate artificial recharge techniques in Jordan. Some small scale studies have been conducted in the Azraq Basin which also is the location of the current study under the direction of the WERSC.

10) More extensive artificial recharge studies and practices have been undertaken in neighboring countries and in North Africa. Several large artificial recharge studies

have been completed in Morocco involving the_Charf Akab confined and the Haouz aquifers, Algeria involving the Mitidja alluvial aquifer, and Tunisia involving the Souhil and Teboula coastal aquifers. More details of these studies are being researched.

4.2 Recommendations

The data and information presented in Section 3.0 of this document summarize the status of the water resources databases and artificial recharge plans and practices in Jordan. Following this document, a proposal for conducting artificial recharge feasibility studies and pilot testing will be developed. The proposal will present an outline and strategy for screening and selecting candidate sites for detailed feasibility studies and pilot testing of artificial recharge strategies.

Specific recommendations for proceeding with development of the artificial recharge proposal are summarized as follows.

1) The ground water basins which should be considered for high priority for artificial recharge studies and projects are the Amman-Zarqa, Yarmouk, Azraq, Jafer, and Dead Sea (Mujib and Hasa). Ground water deficits are greatest in these areas. However, actual pilot study and project selection must consider the precipitation, hydrogeologic, hydrologic, water quality, and soil regimes for a project to be successful.

2) A review of the water use and availability data as well as the hydrogeologic data indicates that the Quaternary alluvium deposits, Basalt aquifer, Rijam aquifer (B4), Amman-Wadi Sir aquifer (B2/A7), Hummer aquifer (A4), and Naur aquifer (A2) represent the most important ground water aquifer systems which are suitable for artificial recharge.

3) For the Kurnub and Zarqa aquifers, artificial recharge is not feasible generally because of high salinities. These formations also typically occur at great depth in Jordan except at a few locations. The Disi aquifer is nonrenewable and is situated in a region of minimal precipitation.

4) A screening process would be appropriate for proceeding toward more detailed and comprehensive characterization as test sites are identified and selected. Early in the screening process, site selection criteria relating to hydrologic, geologic, and water quality data needs as well as land use and site assess should be established to assist in the evaluation of the sites.

Site selection criteria that will be important in evaluation and screening of candidate artificial recharge sites include:

- Need for water in basin (i.e., water demand is greater than supply, ground water deficit exists)
- Adequate precipitation and acceptable evaporation rates
- Adequate stream discharge or source water quantity characteristics
- Low silt and suspended solids loads
- Suitable geologic conditions (e.g.,aquifer outcrop and areal extent of recharge zone, type of surface deposits, joints, fractures, and related features which would improve infiltration of water)
- Suitable hydrogeologic conditions (e.g., shallow depth to aquifer, adequate aquifer thickness and permeability/transmissivity, suitable hydraulic head relationships)
- Distance to aquifer recharge zone from water source
- Suitable water quality conditions (e.g.,consider both the water to be used for recharge and the effect to the aquifer recharged)
- Environmental effects will be minimal or can be mitigated (e.g., consider agricultural land, forest land, animal life)
- Institutional constraints (e.g., land use would support artificial recharge)
- Site access is feasible for required heavy equipment
- Needed natural construction materials are readily available
- Social conditions
- Potential mining and industrial purposes

5) As sites are identified and visited and site data are reviewed, various artificial recharge techniques which may be suitable for a site should be considered.

Application of different artificial recharge techniques will require different types of data.

6) Once a site is selected for detailed feasibility studies or pilot testing, complete meteorological and hydrologic data would be necessary to properly evaluate the success of the pilot test.

7) Cooperative efforts with other governmental and non-governmental organizations involved in artificial recharge studies should be initiated and coordinated to develop uniformity and consistency of methodology (as possible) to avoid duplication of effort, to promote the exchange of information, data, and ideas, and to provide a mechanism for training and development of professionals involved in the design and study of artificial recharge programs and projects.

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TABLES

Table 1-1. Artificial Recharge Long-Term Objectives

(1) Consistent with the National Water Management Study, study the feasibility of enhancing ground water resources nationwide by applying artificial recharge techniques for ground water aquifers.

(2) Develop a detailed plan for and conduct artificial recharge pilot studies based on existing information and data and the feasibility study process described in the 1994 work plan.

(3) Select artificial recharge candidate sites based on locations with the greatest water use demands and management deficits. As appropriate, basins with deteriorating ground water quality should be considered as critical location priorities.

(4) Select artificial recharge candidate sites based on locations with the greatest potential for producing water which may be suitable for recharge (i.e., hydrologic, hydrogeologic, climatologic factors, water quality).

(5) Selected sites should be integrated into the monitoring network programs (i.e.,water resources and water quality) for Jordan.

(6) Minimize duplication of effort with other organizations evaluating artificial recharge potential for various areas of Jordan. Coordinate WQIC Project activities with these other organizations.

(7) Integrate artificial recharge feasibility study efforts into the long-term water resources planning and responsibilities for the various organizations within the MWI.

(8) Consider the use of wastewater receiving advanced treatment (i.e, tertiary treatment) for artificial recharge purposes.

(9) Promote and coordinate training programs which focus on increasing the technical capabilities of Jordanian professionals involved in artificial recharge studies.

Table 1-2. Artificial Recharge Short-Term Objectives

(1) Survey and compile existing data for Jordan which supports the artificial recharge program. Collect background information about existing artificial recharge studies and plans for Jordan.

(2) Survey the hydrological, hydrogeological, land use, and meteorological data and site characterization data available for Jordan.

(3) Survey existing artificial recharge studies and proposed study plans in order to avoid duplication of effort.

(4) Contact other competent organizations (e.g.,University of Jordan, Natural Resources Authority) and discuss and review artificial recharge studies or plans to promote cooperation among the organizations and to avoid duplication of effort.

(5) Survey existing artificial recharge methodologies attempted to date in Jordan. Review project reports to develop an understanding of the difficulties encountered and to establish a more ideal feasibility study program.

(6) Identify data deficiencies and needs required to support full development of the artificial recharge feasibility study.

(7) Prepare an artificial recharge survey document which summarizes available information to achieve data requirements and support a feasibility study.

Table 3-1. Water Management Regions and Sub-Basins

Water Management Basin and Sub-Basins	Basin and Sub-Basin Identification Number	Rank and Size of Area (km^2) 1	2	3
YARMOUK BASIN	AD	6974		
Jordan Part		1426		
Syrian Part		5548		
AREA BETWEEN STATIONS AD5 AND AD 2 (ADASTIA)	AD 2		865	
(JORDAN TERRITORY)				
AREA BETWEEN STATION AD 5 & WADI RAQQAD	AD 21			130
WADI RAQQAD CATCHMENT	AD 22			590
AREA DOWNSTREAM OF WADI RAQQAD CONFLUENCE	AD 23			145
AREA UPSTREAM OF MAQARIN STATION (AD 5)	AD 5		6109	
SYRIAN TERRITORY	AD 51			4918
JORDAN TERRITORY	AD 52			1191
JORDAN VALLEY BASIN (EAST BANK)	AB		780	
AREA BETWEEN YARMOUK RIVER & WADI YABIS	AB 12			182
AREA BETWEEN WADI YABIS & WADI ZARQA	AB 13			231
AREA BETWEEN WADI ZARQA & WADI SHUEIB	AB 14			198
AREA BETWEEN WADI SHUEIB & DEAD SEA	AB 15			169
NORTH RIFT SIDE WADIS BASIN	AB	946		
AREA BETWEEN WADI ARAB & WADI ZIGLAB	AB 21			111
AREA BETWEEN WADI ZIGLAB & WADI JURUM	AB 22			49
AREA BETWEEN WADI JURUM & WADI YABIS	AB 23			31
AREA BETWEEN WADI YABIS & WADI KUFRINJA	AB 24			66
WADI ARAB	AE			246
WADI ZIGLAB	AF			100
WADI JURUM	AG			23
WADI YABIS	AH			122
WADI KUFRINJA	AJ			103
WADI RAJIB	AK			95
SOUTH RIFT SIDE WADIS BASIN	AB & OTHERS	736		
AREA BETWEEN WADI ZARQA & WADI SHUEIB	AB 25			144
AREA BETWEEN WADI HISBAN & DEAD SEA	AB 26			56
AREA BETWEEN DEIR ALLA & JORDAN VALLEY	AL 0			96
WADI SHUEIB	AM			193
WADI KAFREIN	AN			159
WADI HISBAN	AP			88
WADI ZARQA BASIN	AL	4154		
AREA BETWEEN JARASH ROAD BRIDGE AND DEIR ALLA	AL 2		341	
WADI UM DANANEER (STATION AL 9)	AL 21			36
WADI SELAIHI (STATION AL 8)	AL 22			35
LOWER WADI CATCHMENTS	AL 23			270
WADI ZARQA BETWEEN STATIONS AL 3 AND AL 4	AL 3		518	
WADI MURUJ	AL 31			27
OTHER TRIBUTARY CATCHMENTS	AL 32			491
WADI ZARQA UPSTREAM OF AIN GHAZAL (STATION AL 4)	AL 4		180	
WADI ABDOUN (STATION AL 10)	AL 41			77
AMMAN REGION (BETWEEN STATIONS AL4 AND AL10)	AL 42			103
WADI DHULEIL UPSTREAM SUKHANEH (STATION AL 7)	AL 7		2241	
SYRIAN TERRITORY	AL 71			415
EASTERN DESERT AREA (QA KANNA)	AL 72			484
LOWER CATCHMENT	AL 73			1342
AREA BETWEEN SUKHANEH STATIONS (A 7 & A 3) AND JARASH ROAD BRIDGE STATIONS (A 1 & A 11)	AL 11		874	
DEAD SEA BASIN	C	1508		
AREA BETWEEN WADI ZARQA MAIN & JORDAN VALLEY	CA 1			234
AREA BETWEEN WADI ZARQA MAIN & WADI MUJIB	CA 2			98
AREA BETWEEN WADI MUJIB & WADI KARAK	CA 3			314
AREA BETWEEN WADI KARAK & WADI HASA	CA 4			394
WADI ZARQA MAIN	CC			269
WADI KARAK	CE			199
WADI MUJIB BASIN	CD	6727		
WADI MUJIB CATCHMENT AT KARAK ROAD BRIDGE	CD 1	4388		
WADI QATRANAH	CD 5		1460	
AREA UPSTREAM OF QA EL HAFIRA	CD 51			1340
AREA BETWEEN QA EL HAFIRA & STATION CD 5	CD52			120
WADI SULTANAH AT DAM SITE (STATION CD 8)	CD 8		1088	
EAST AREA	CD 81			577
WEST AREA	CD 82			511
WADI SIWAQA	CD 9		451	
AREA BETWEEN KARAK ROAD BRIDGE & UPPER TRIBUTARY	CD 11		1389	
LOWER CATCHMENTS	CD 3	429		
AREA DOWNSTREAM OF KARAK ROAD BRIDGE (ST. CD 1)	CD 31			159
AREA BETWEEN STATION CD 4 & WADI HIDAN	CD 32			270
WADI WALA AT KARAK ROAD (STATION CD 4)	CD 4	1910		

Table 3-1. Water Management Regions and Sub-Basins

— Water Management Basin and Sub-Basins	Basin and Sub-Basin Identification Number	Rank and Size of Area (km^2) 1	2	3
WADI HASA BASIN	CF	2603		
AREA UPSTREAM OF TANNOUR (STATION CF 1)	CF 1		2010	
EASTERN AREA	CF 11			1620
WESTERN AREA	CF 12			390
LOWER WADI HASA BETWEEN TANNOUR (CF 1) AND SAFI	CF2		593	
WADI ARABA NORTH BASIN	D	2953		
WADI ARABA VALLEY REGION	DA 1	874		
AREA BETWEEN SAFI & WADI KHUNEIZER	DA 11		75	
AREA BETWEEN WADI KHUNEIZER & WADI FIDAN	DA 12		212	
AREA BETWEEN WADI FIDAN & WADI HUWAR	DA 13		468	
AREA BETWEEN WADI HUWAR & WADI ARABA SOUTH BASIN	DA 14		119	
WADI ARABA HILL REGION	DA 2	2079		
AREA BETWEEN WADI HASA & WADI FIFA	DA 21		46	
AREA BETWEEN WADI FIFA & WADI KHUNEIZER	DA 22		24	
AREA BETWEEN WADI KHUNEIZER & WADI DAHEL	DA 23		25	
AREA BETWEEN WADI DAHEL & WADI GHAUBA	DA 24		38	
WADI GHAUBA	DA 25		122	
AREA BETWEEN WADI MUSA & WADI HUWAR	DA26		128	
WADI FIFA	DB		162	
WADI KHUNEIZER	DC		217	
WADI KHUNEIZER UPPER AREA	DC 1			175
WADI KHUNEIZER LOWER AREA	DC 2			42
WADI DAHEL	DD		107	
WADI FIDAN	DE		287	
WADI BUWEIRIDA	DF		513	
WADI BUWEIRIDA UPPER CATCHMENT	DF 1			258
WADI BUWEIRIDA LOWER CATCHMENT	DF 2			255
WADI MUSA CATCHMENT	DG		165	
AREA UPSTREAM OF PETRA STATION DG 2.	DG 2			77
AREA BETWEEN WADI ARABA & STATION DG 2	DG 3			88
WADI HUWAR CATCHMENT	DH		245	
WADI HUWAR	DH 1			201
WADI HUWAR LOWER AREA	DH 2			44
WADI ARABA SOUTH BASIN	E	3742		
WADI ARABA VALLEY REGION	EA 1		550	
WADI ARABA HILL REGION	EA 2		869	
AREA BETWEEN WADI ABU BARQA & WADI ES. SIK	EA 21			56
WADI ES. SIK	EA 22			61
WADI NUKEILA AREA	EA 23			45
WADI TURBAN	EA 24			53
WADI DARABA	EA 25			105
AREA BETWEEN WADI DARABA & WADI YUTUM	EA 26			198
WADI RAKIYA/AHEIMIR	EC			210
WADI ABU BARQA CATCHMENT	EB			141
LOWER AREA BETWEEN STATIONS EB 1 & EB 2	EB 1			63
UPPER AREA WADI DLIAGHAN	EB 2			78
WADI YUTUM CATCHMENT	ED		2323	
AREA BETWEEN STA. ED 1 & WADI ARABA VALLEY REGION	ED 2			46
AREA UPSTREAM OF STATION ED 1	ED 1			2277
WADI RUMMAN	ED 11			1398
WADI YUTUM AT STATION ED 1	ED 13			879
AZRAQ BASIN	F	13173		
SYRIAN PART			773	
JORDANIAN PART			12400	
JAFER BASIN	G	12364		
JERDAN AREA	G 1		213	
REMAINDER OF BASIN	G 2		12151	
HAMMAD BASIN	H	18047		
DISI & S.DESERT BASIN	K	6296		
QA DISI AREA	ED 12		1745	
SOUTHERN DESERT AREA	K		4551	
DURRAH	K 1			627
SOUTH OF JAFER BASIN	K 2			3924
SIRHAN BASIN	J	15733		

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
1	SHUNA (W.ARAB)	A 0001	208.000	224.000	M	NW	
2	JISR SHEIKH HUSSEIN	A 0002	204.300	211.500	M	NW	
3	DAMIYA	A 0003	202.500	168.000	M	NW	
4	KING HUSSEIN BR.GAUGING ST.	A 0006	201.500	143.000	M	NW	
5	R.J.WAHADINA GAUGING STATION	A 0007	202.500	193.700	M	NW	
6	AL-TAIYIBA	AB0001	217.500	216.500	M		
7	DEIR ABI SAID (SCHOOL)	AB0002	214.500	211.500	M,R		
8	EL-QARN	AB0003	204.500	195.300	M	NW	
9	KH.EL-WAHADNEH	AB0004	210.800	192.800	M		
10	GHOR KABID	AB0005	203.500	149.000	M	NW	
11	KUFR AWAN	AB0008	214.800	203.700	M		
12	DEIR ABI SAID	AB0010	215.100	211.700	A		Evaporation station; two separate locations (also AB0002)
13	MUKHEIBA	AD0001	214.000	234.000	M	NW	
14	HARTHA	AD0002	229.500	233.300	M		
15	KUFR SAUM	AD0003	225.200	232.300	M		
16	SAMAR	AD0004	224.000	231.500	M		
17	UM QEIS	AD0005	214.000	229.000	M,R		
18	ADASIYA SCHOOL	AD0006	207.200	230.300	M	NW	
19	BAQURA AGR. STATION	AD0007	208.000	226.000	M	NW	
20	KHARJA	AD0008	233.500	229.500	M		
21	HAWWARA	AD0009	235.500	215.500	M		
22	HUSN	AD0010	233.000	210.500	M,R		
23	EN NUEIYIME	AD0011	236.000	202.800	M,R		
24	RAMTHA BOYS SCHOOL	AD0012	244.500	218.800	M,R		
25	KHANASIRA	AD0013	248.500	200.300	M		
26	MAFRAQ POLICE POST	AD0016	264.000	195.000	M,R		
27	RIHAB	AD0017	253.000	192.800	M,R		
28	IBBIN	AD0018	226.800	196.500	M		
29	MAFRAQ AIR PORT	AD0019	266.600	192.500	M		
30	MAQARIN GAUGING STATION	AD0020	230.000	237.000	M		
31	TURRA	AD0021	243.300	226.600	M		
32	HOSHA	AD0022	250.000	206.600	M		
33	JABER MUGHAYYIR	AD0023	263.000	213.300	M		
34	ADASIYA GAUGING STATION	AD0024	210.100	231.000	M	NW	
35	WADI KHALID RAILWAY STATION	AD0025	221.000	238.000	M	NW	
36	SAMU-IRBID	AD0026	219.000	213.000	M	NW	
37	SAMA ER ROSAN EVAP.STATION	AD0027	228.700	227.900	M	NW	Evaporation station transferred to Samar Evap. Sta. (AD0034)
38	JABER-ES-SIRHAN	AD0029	262.400	213.700	M	NW	
39	KHALID IBN AL-WALEED DAM	AD0031	214.600	234.400	M	NW	
40	BAQURA MET.STATION	AD0032	206.300	224.300	M		
41	SAMAR EVAP. STATION	AD0034	222.000	231.900	M,R,A		Evaporation station
42	UNIV. OF SCIENCE & TECHNOLOGY	AD0036	242.300	209.800	A		Evaporation station
43	RAMTHA GIRLS SCHOOL	AD0112	245.000	219.300	M	NW	
44	IZRA'A	AD0400	268.000	252.000	SYRIAN		
45	NAWA	AD0401	248.000	255.000	SYRIAN		

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
46	RAFEED	AD0402	235.000	265.000	SYRIAN		
47	SANMEIN	AD0403	263.000	273.000	SYRIAN		
48	KUNEITRA	AD0404	227.000	280.000	SYRIAN		
49	SHAHBA	AD0405	302.000	252.000	SYRIAN		
50	FIQ	AD0406	217.000	243.000	SYRIAN		
51	EL HIMMA	AD0407	213.000	233.000	SYRIAN		
52	TELL SHIHAB	AD0408	241.000	234.000	SYRIAN		
53	SUWEIDA'A	AD0409	297.000	236.000	SYRIAN		
54	EIN ELARAB	AD0410	303.000	238.000	SYRIAN		
55	RUSHEIDAH	AD0411	323.000	232.000	SYRIAN		
56	DARA'A	AD0412	253.000	225.000	SYRIAN		
57	MSEIFRAH	AD0413	276.000	228.000	SYRIAN		
58	BUSRAL SHAM	AD0414	289.000	215.000	SYRIAN		
59	IRBID SCHOOL	AE0001	230.000	218.500	M,R		
60	IRBID AGR.STATION	AE0002	230.300	217.000	M		
61	KAFR YUBA	AE0003	225.300	216.700	M		
62	KAFR ASAD	AE0004	217.000	223.000	M		
63	QUMEIM	AE0005	219.000	219.600	R	NW	
64	WADI ZIQLAB	AF0001	207.300	214.500	M		
65	RIHABA	AF0002	224.000	204.800	M,R		
66	WADI JURUM	AG0001	206.800	205.800	M	NW	
67	ISHTAFEINA	AH0001	220.400	196.500	M		
68	WADI EL-YABIS	AH0002	207.000	199.500	M		
69	RAS MUNEIF EVAP.STATION	AH0003	226.800	198.800	M,R,A	NW (M)	Evaporation station
70	IRJAN	AH0004	219.000	200.100	R		
71	AJLUN POLICE POST	AJ0001	221.000	193.500	M,R		
72	KUFRINJA	AJ0002	216.400	189.400	M,R		
73	WADI KUFRINJA	AJ0003	206.800	186.000	M	NW	
74	AJLUN TEACHERS INSTITUTE	AJ0004	221.070	191.800	M	NW	
75	AIN KHUNEIZIR	AL0001	249.000	190.500	M	NW	
76	MIDWAR	AL0002	244.000	188.500	M		
77	BAL'AMA	AL0003	252.700	182.800	M		
78	JARASH	AL0004	234.500	187.500	M,R		
79	KITTA	AL0005	229.500	187.000	M		
80	DIBBIN NATIONAL PARK	AL0006	229.000	184.800	M	NW	
81	JARASH BR.(OLD ROAD)	AL0007	228.300	177.800	M	NW	
82	ALUK	AL0008	237.200	174.800	M,R		
83	DEIR ALLA (NRA)	AL0009	209.500	178.500	M	NW	
84	DEIR ALLA AGR. STATION	AL0010	208.500	178.000	M		
85	RUMMAN	AL0011	228.500	174.300	M		
86	SUKHNA	AL0012	250.700	171.000	M		
87	NAWASIF	AL0013	267.500	166.500	M		
88	KHAW	AL0014	258.000	166.000	M	NW	
89	ZARQA	AL0015	253.000	163.800	M,R		
90	RUSEIFA	AL0016	248.500	158.500	M		

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
91	SWEILIH	AL0017	229.500	159.000	M,R		
92	JUBEIHA	AL0018	232.000	159.200	M		
93	AMMAN AIN GHAZAL	AL0020	240.800	153.000	M	NW	
94	AMMAN JABEL TAJ	AL0021	240.000	151.500	M	NW	
95	AMMAN HUSSEIN COLLEGE	AL0022	238.200	152.000	M		
96	AMMAN JABEL AMMAN (DEV.DEPT.)	AL0023	238.000	150.500	M	NW	
97	AMMAN LANDS DEPARMENT	AL0024	238.000	150.750	M	NW	
98	AMMAN JABEL LUWEIBDA NRA	AL0025	237.700	150.700	M	NW	
99	BURMA	AL0026	224.000	181.000	M		
100	SUBEIHI	AL0027	216.500	173.000	M		
101	RUMEIMIN	AL0028	225.500	168.500	M		
102	TAB QIRA'	AL0029	234.000	162.500	M	NW	
103	RUJM ESH-SHOUK (BADRAN)	AL0030	238.500	165.000	M	NW	
104	AIN ZARBI	AL0031	243.000	159.500	M	NW	
105	YAJUZ	AL0032	237.000	160.000	M	NW	
106	AMMAN RADIO STATION	AL0033	238.500	146.000	M	NW	
107	K.H.NURSERY EVAP.ST. (BAQ'A)	AL0035	230.000	165.400	M,A		Evaporation station
108	PRINCE FEISAL NURSERY	AL0036	234.500	180.500	M		
109	AMMAN CIGARETTE COMPANY	AL0037	239.900	151.300	M	NW	
110	AMMAN ALWIHDAT	AL0038	238.500	149.000	M	NW	
111	ABU HAMID	AL0039	233.500	165.000	M	NW	
112	W.UM AL-DANANIR	AL0040	227.300	165.900	M	NW	
113	AIN AL-BASHA	AL0041	228.800	162.800	M	NW	
114	AMMAN JABEL AMMAN (NRA)	AL0042	235.500	151.300	M	NW	
115	ABU ALANDA	AL0043	241.300	145.500	M		
116	MAJDAL	AL0044	229.300	181.700	M		
117	UM JAUZA	AL0045	220.000	167.000	M		
118	EL-'AL	AL0046	228.600	136.300	M	NW	
119	SIHAN	AL0047	221.600	171.800	M		
120	KHALDIYA	AL0048	276.000	177.000	M		
121	QASR EL-HALLABAT	AL0049	275.400	167.200	M,R		
122	QAFQAFA	AL0050	238.800	195.300	M		
123	WADI ZARQA GAUGING STATION	AL0051	232.300	180.400	M	NW	
124	BEIR EL-AD'AM	AL0052	268.200	150.200	T		
125	KING TALAL DAM (BURMA)	AL0053	228.600	178.000	M		Evaporation station (JVA)
126	HASHIMIYA	AL0054	255.200	171.700	M		
127	WADI DHULEIL NURSERY	AL0055	271.000	174.000	M		
128	WADI ES-SIR (NRA)YARD	AL0057	230.200	151.600	M,R		
129	SABHA AND SUBHIYEH	AL0058	291.800	194.000	M		
130	UM EL-JUMAL EVAP.STATION	AL0059	276.800	190.400	M,R,A		Evaporation station
131	KHIRBET ES SAMRA EVAP.ST.	AL0066	258.250	173.500	M,A		Evaporation station
132	SALKHAD	AL0400	311.000	211.000	SYRIAN		
133	SALT	AM0001	219.000	160.500	M,R		
134	W.SHU,EIB AGR.STATION	AM0002	218.000	152.800	M		
135	W.SHU,EIB KM.47	AM0003	217.000	151.500	M	NW	

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
136	SHUNET NIMRIN EVAP.ST.	AM0004	209.500	146.000	M	NW	Evaporation station; transferred to South Shuna (AM 0007)
137	HUMMAR	AM0005	227.000	158.800	M		
138	IRA	AM0006	213.000	157.000	M		
139	SOUTH SHUNA(W.SHUIB DAM EV.ST)	AM0007	210.500	146.000	M,R,A		Evaporation station
140	KAFREIN	AN0001	213.800	140.000	M		
141	WADI ES-SIR	AN0002	227.500	151.000	M		
142	NA'UR	AN0003	228.500	142.500	M,R		
143	ADASIYA JANOUBIYA	AN0004	222.700	140.600	M	NW	
144	KAFREIN DAM	AN0005	213.800	139.300	M	NW	
145	ER-RAMA	AP0001	214.800	137.000	M	NW	
146	KHANZIRA (TAIYBAT EL-KARAK)	CA0002	207.300	051.800	M,R		
147	MUREISED	CA0003	200.300	060.500	M	NW	
148	AIY	CA0004	211.000	060.300	M,R		
149	AL-AINA	CA0005	224.000	042.200	M	NW	
150	MUHAI	CA0006	231.800	044.500	M		
151	MADABA	CC0001	225.500	125.000	M,R		
152	MA'IN	CC0002	219.900	120.800	M	NW	
153	MUSHAQQAR EVAP ST.	CC0004	226.200	132.900	M,R,A		Evaporation station
154	SAHAB	CD0001	245.000	142.500	M		
155	YADUDA	CD0002	236.500	139.500	M	NW	
156	EL-MUWAQQAR	CD0003	255.000	136.500	M		
157	BEIR EL-TUNEIB	CD0004	239.500	134.300	M	NW	
158	JIZA	CD0005	241.000	123.000	M	NW	
159	WADI WALA	CD0006	223.000	107.500	M,R		
160	DHIBAN	CD0007	224.000	100.800	M,R		
161	WADI MUJIB GAUGING STATION	CD0008	226.500	950.000	R		
162	HEMUD	CD0009	226.000	078.000	M		
163	RABBA	CD0010	220.500	075.500	M,A		Evaporation station
164	QATRANA POLICE POST	CD0011	249.500	072.500	M,R		
165	BIR HAFIRA	CD0012	265.000	060.000	M	NW	
166	MAZAR	CD0013	216.500	052.000	M,R		
167	QASTAL	CD0014	239.000	128.300	M	NW	
168	DHABA' NURSERY	CD0015	250.500	111.600	M,R		
169	JUDAYDA	CD0016	211.500	105.000	M,R		
170	UM EL-RISAS	CD0017	237.500	101.000	M		
171	KHANEZ-ZABEEB	CD0018	255.000	097.800	M	NW	
172	JADA'	CD0019	222.000	089.500	M		
173	SIWAQA EVAP. STATION	CD0020	253.700	086.800	M	NW	Evaporation station (closed)
174	MANZIL	CD0021	247.000	051.500	M	NW	
175	QASR EL-MUSHEISH	CD0022	254.000	038.000	M	NW	
176	QASR EVAP. STATION	CD0023	221.000	080.900	M	NW	Evaporation station; transferred to Rabbah (CD 0010)
177	YADUDA FAHID ABU JABER	CD0024	236.500	139.500	M		
178	UM EL-AMAD	CD0025	235.000	132.000	M	NW	
179	EZ-ZEITUNA EVAP. STATION	CD0026	235.700	129.700	M	NW	Evaporation station; transferred to Mushaqqar (CC0004)
180	ZABAYIR EL-ADWAN	CD0027	236.000	128.000	M	NW	

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
181	MULEIH	CD0028	228.000	110.900	M		
182	SIRFA	CD0029	212.500	081.600	M		
183	JABEL ABU HALLUFA	CD0030	272.900	086.000	T		
184	WADI EL-JINZ	CD0031	276.000	054.500	T		
185	UM AL-KINDOM	CD0032	233.800	138.900	M	NW	
186	JABEL SAKHRIYAT	CD0033	274.000	026.600	T		
187	QATRANA EVAP. STATION	CD0034	249.500	073.600	M,A	NW (M)	Evaporation station
188	RAKIN	CE0001	217.500	070.000	M		
189	AIN BISAS	CE0002	213.500	067.800	M,R		
190	RAS ABU HAMMUR	CE0003	220.000	066.000	M	NW	
191	KARAK	CE0004	217.000	066.000	M,R		
192	QABR MADHA	CE0005	234.000	069.300	M	NW	
193	GHOR ES-SAFI P.POST	CF0001	194.800	049.500	M		
194	QAL'AT AL-HASA	CF0002	239.000	027.800	M	NW	
195	JURF ED-DARAWISH	CF0003	233.000	011.800	M,R		
196	LA'ABAN	CF0004	217.000	035.000	M	NW	
197	HASA POLICE POST	CF0005	243.000	025.800	M	NW	
198	GHOR ES-SAFI MET. STATION	CF0006	193.000	051.000	M,R,A		Evaporation station; Potash Company station
199	HASA EVAP. STATION	CF0007	243.600	030.600	M,R		Evaporation station
200	HASA GAUGING STATION	CF0008	220.400	041.600	R		
201	SHAUBAK SCHOOL	DA0001	202.000	992.000	M		
202	SHAUBAK AGR.STATION	DA0002	200.500	991.500	M		
203	BEIR ED-DABBAGHAT	DA0003	198.000	980.000	M		
204	IFJEIJ	DA0004	209.000	994.000	M		
205	UNEIZA RAILWAY STATION	DA0005	226.500	989.000	R		
206	AL-HUSEINIYA SCHOOL	DA0006	226.200	999.400	M		
207	FEEDAN	DA0007	187.300	003.750	M		Evaporation station
208	TAFILE	DB0001	208.000	027.500	M,R		
209	PRINCE HASAN NURSERY (ABUR)	DB0002	218.200	023.300	M,R		
210	BUSEIRA	DC0001	208.000	017.000	M,R		
211	RASHADIYA P.POST	DC0002	210.000	012.500	M,R		
212	AIN LAHDHA	DD0001	207.300	012.800	M	NW	
213	DHAHAL	DD0002	189.000	027.000	M	NW	
214	DANA	DE0001	208.300	009.500	M,R		
215	BEIR MADKHUR	DF0001	183.000	978.700	M	NW	
216	UM METLA	DF0002	177.600	987.100	M		Evaporation station
217	WADI MOUSA	DG0001	196.000	970.000	M,R		
218	HAY	DG0002	197.000	974.000	M		
219	PETRA	DG0003	192.000	972.000	M		
220	TAIYIBA JANOUBIYA	DH0001	194.000	963.000	M		
221	DILAGHA	DH0002	189.000	949.300	M		
222	RAJIF	DH0003	193.000	956.000	M,R		
223	GHARANDAL	EA0001	169.000	945.000	M	NW	
224	RAHMA	EA0002	162.000	926.000	M		Evaporation station
225	AQABA	ED0001	150.000	881.500	M		

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
226	RAS EN-NAQB	ED0002	197.000	935.000	M,R		
227	RAM P.POST	ED0003	191.000	887.500	M	NW	
228	QUWEIRA EVAP.STATION	ED0004	181.000	914.000	M	NW	Evaporation station (closed)
229	AL-KHALDY	ED0006	172.000	896.500	M	NW	
230	JABEL BAKIR	ED0009	163.500	887.000	M	NW	
231	WADI YUTM GAUGING STATION	ED0010	160.300	880.600	M	NW	
232	RAM(QA'DISI) EVAP. STATION	ED0012	199.800	896.000	M	NW	Evaporation station
233	FASSU'A ST.	ED0015	236.200	908.500	T		
234	WADI RATMA	ED0016	193.000	915.000	T		
235	WADI NASIFA	ED0017	209.000	902.000	T		
236	WADI MAS'ADA	ED0018	177.000	896.000	T		
237	WADI ARADA	ED0019	225.000	899.000	T		
238	QA'KHREIM	ED0020	220.000	882.000	T		
239	WADI SABIT	ED0021	173.000	872.000	T		
240	WADI MUQUR	ED0022	193.000	872.000	T		
241	QA'EL-GHAL	ED0023	208.000	882.400	T		
242	AQABA EVAP ST.	ED0026	148.000	887.000	M		Evaporation station
243	UM EL-QUTTEIN	F 0001	303.500	192.500	M		
244	H5 EVAPORATION STATION	F 0002	348.500	180.000	M,R		
245	AZRAQ POLICE POST	F 0003	321.000	139.500	M	NW	
246	DEIR EL-KAHF	F 0004	325.000	185.000	M,R		
247	AZRAQ PROJECT	F 0005	348.500	180.000	M	NW	
248	AL-QARYATEIN	F 0006	330.000	170.000	M		
249	AL-WISAD	F 0007	435.000	144.800	M		
250	QASR EL-HAMMAM	F 0008	280.000	167.000	M	NW	
251	AZRAQ EVAP.STATION	F 0009	320.000	141.500	M,R,A		Evaporation station
252	ESH-SHAUMARI	F 0010	317.000	130.500	M	NW	
253	EL-UMARI	F 0011	342.000	107.300	M,R		
254	QASR TUBA	F 0012	300.000	083.000	M,R	NW	
255	WADI SALAHIB	F 0013	381.500	159.700	T		
256	TULLUL EL-KHURISHA	F 0014	303.000	156.000	T		
257	TULLUL EL-GHAR	F 0015	404.800	151.500	T		
258	QA'SAMIKA	F 0016	370.200	187.000	T		
259	GADIR EL MALLAH	F 0017	358.200	163.800	T		
260	JABEL ASEIKHIM	F 0018	334.700	151.600	T	NW	Totalizer closed
261	JABEL MUDAYSISAT	F 0019	268.000	119.200	T		
262	QASR EL-KHARRANA	F 0020	288.500	127.000	T,R		
263	IMTAN	F 0400	321.000	203.000	SYRIAN		
264	KHIRBET AWAD	F 0401	310.000	194.000	SYRIAN		
265	UDRUH SCHOOL	G 0001	207.000	971.200	M	NW	
266	JAFR P.POST	G 0002	269.000	969.000	M	NW	
267	MA'AN	G 0003	221.000	956.500	M,R		
268	BASTA	G 0004	201.800	960.300	M		
269	SADAQA	G 0005	196.500	952.500	M		
270	QUREIN	G 0006	195.000	945.300	M		

Table 3-2. Distribution of Precipitation Monitoring Stations
WAJ - Studies Department

	SITE NAME	WAJ ID #	COORDINATES EAST	COORDINATES NORTH	STATION TYPE	OPERATIONAL STATUS	COMMENTS
271	MA'AN RAIL WAY STATION	G 0007	223.000	954.000	M		
272	JAFR EVAP. STATION	G 0008	267.000	970.000	M	NW	Evaporation station (closed)
273	UDRUH EVAP. STATION	G 0009	206.300	973.600	M,R		Evaporation station
274	JORDHAN GAUGING STATION	G 0010	221.900	965.900	M	NW	
275	JABEL QUZEMEH	G 0011	284.300	995.500	T		
276	QABR ES-SAWW	G 0012	247.000	984.000	T		
277	ABU TARAFA	G 0013	239.000	935.000	T		
278	INAB	G 0014	331.400	932.200	T		
279	KABID	G 0015	296.200	929.500	T		
280	JABLEL BATRA	G 0016	210.000	924.000	T		
281	HUMEIMA	G 0017	183.300	929.200	M,T	NW	Totalizer closed
282	H4 EVAP.ST.	H 0001	450.500	216.000	M,R,A		Evaporation station; Department of Meteorology Station (M); WAJ (A)
283	TARABEEL	H 0002	527.800	245.000	T		
284	KH.UM RUJEIM	H 0003	486.800	228.800	T		
285	TULLUL EL-ASHQAF	H 0004	389.200	193.000	T		
286	BAYIR EVAP. STATION	J 0001	310.500	020.000	M	NW	Evaporation station (closed)
287	EL-KHERQA	J 0002	333.000	076.000	T		
288	WADI BAYIR	J 0003	359.600	042.400	T		
289	QA'ES-SIQ	J 0004	365.400	972.500	T		
290	EL-MUDAWWARA EVAP. STATION	K 0001	249.000	859.000	M	NW	Evaporation station (closed)
291	DURRAH EVAP. STATION	K 0002	147.000	867.500	M	NW	Evaporation station (closed)
292	MUHEISH	K 0003	234.000	866.000	T		
293	WADI DUREIBA	K 0004	215.000	866.000	T		

NOTES

M= Manual (daily)
R = Recorder (Italian SIAP, UK Casella)
T = Totalizer
A = Automatic (US Weathertronics)
NW = Not Working

Table 3-3. Annual Precipitation Totals (1976 - 1994)

ANUAL RAINFALL TOTALS (IN MMS)

CODE	1975 — 1976	1976 — 1977	1977 — 1978	1978 — 1979	1979 — 1980	1980 — 1981	1981 — 1982	1982 — 1983	1983 — 1984	1984 — 1985	1985 — 1986	1986 — 1987	1987 — 1988	1988 — 1989	1989 — 1990	1990 — 1991	1991 — 1992	1992 — 1993	1993 — 1994
AB0001	405.9	525.3	363.3	345.0	*	507.4	322.7	522.9	404.3	*	391.9	469.2	576.6	294.6	330.9	474.2	885.8	450.0	X
AB0002	382.2	467.2	*	272.2	684.9	453.5	252.8	498.9	326.4	406.8	332.0	478.2	577.7	313.3	412.0	436.5	942.6	441.0	X
AB0003	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	521.5	X
AB0004	436.9	393.4	266.4	278.0	616.4	410.3	139.3	535.4	278.2	287.9	337.8	453.9	416.0	341.9	424.1	358.0	957.2	X	X
AB0008	409.5	443.9	*	*	599.1	394.9	*	572.5	X	391.1	334.9	465.2	652.2	403.5	451.2	436.3	1084.5	515.0	X
AD0001	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AD0002	401.5	446.9	306.0	177.6	625.5	421.1	233.1	551.8	450.7	365.2	266.6	564.1	572.4	248.4	410.0	379.5	807.2	418.5	X
AD0003	374.0	*	447.4	187.7	774.9	585.6	285.5	591.0	483.3	423.6	265.8	503.8	530.5	275.9	435.7	441.0	936.6	637.4	X
AD0004	447.4	544.6	522.3	310.8	875.6	483.2	249.7	573.0	549.8	435.2	361.7	579.7	X	X	X	X	X	X	X
AD0005	372.1	471.0	*	*	624.3	480.1	230.7	561.2	320.8	376.2	323.6	507.5	442.4	270.3	468.1	382.3	831.0	449.5	X
AD0008	418.7	*	*	228.2	755.3	407.4	254.7	459.9	356.1	328.8	305.0	571.5	505.6	289.2	367.0	411.4	793.6	391.1	X
AD0009	316.5	271.0	265.5	184.6	560.6	303.8	281.1	*	286.5	307.7	252.3	453.1	445.3	184.7	378.1	334.5	665.8	341.2	X
AD0010	342.2	294.6	*	*	639.2	*	*	*	328.5	414.7	287.1	534.1	482.9	264.2	361.9	302.3	701.8	335.0	X
AD0011	284.7	257.4	277.0	144.5	479.3	268.2	250.6	356.5	268.5	285.0	204.2	335.8	364.5	198.5	246.0	189.4	490.6	266.0	X
AD0012	241.2	191.0	206.3	*	395.7	218.5	235.4	253.1	221.7	223.3	199.5	338.9	328.6	189.3	334.9	260.7	479.7	210.1	X
AD0013	X	134.8	141.0	96.5	406.6	189.5	141.8	249.5	141.5	197.8	166.3	268.6	254.8	124.7	152.7	145.0	306.0	138.0	X
AD0016	125.9	*	*	69.6	301.3	162.4	107.2	216.4	51.0	182.5	107.3	191.5	287.1	132.0	137.0	125.3	163.8	80.5	X
AD0017	171.5	97.0	133.4	133.4	335.3	209.5	121.0	262.2	132.5	225.2	128.5	264.7	382.8	171.8	204.7	214.8	453.8	234.3	X
AD0018	438.9	424.9	405.2	270.5	748.0	287.9	421.8	*	X	*	*	560.6	454.5	553.6	553.2	493.5	1166.0	614.0	X
AD0019	150.4	88.5	108.6	69.3	300.0	183.2	116.8	129.6	114.2	174.6	88.1	198.3	258.7	211.2	171.5	130.4	430.5	133.9	X
AD0020	342.0	435.3	443.8	253.0	715.5	509.6	264.1	536.8	447.1	336.6	297.6	537.9	491.5	220.7	270.1	244.7	866.5	466.8	X
AD0021	285.9	257.7	*	133.3	454.5	270.2	X	X	X	211.0	181.4	338.4	342.3	183.4	286.5	279.5	509.7	261.9	X
AD0022	X	X	X	X	X	*	108.5	161.1	129.5	*	91.1	242.8	227.8	96.7	146.0	93.3	243.3	117.8	X
AD0023	X	X	X	X	X	X	X	X	X	X	95.7	158.7	X	93.5	196.7	117.4	270.0	89.1	X
AD0027	413.4	513.5	452.1	304.1	801.2	474.5	316.7	519.2	405.7	110.6	X	X	X	X	X	428.5	X	X	X
AD0029	X	X	X	X	X	X	X	X	X	X	X	X	115.0	X	X	X	X	X	X
AD0032	327.4	376.8	*	278.1	631.5	418.1	215.7	*	260.7	276.6	337.9	446.2	432.2	288.2	508.6	351.9	859.5	439.9	X
AD0034	X	X	X	X	X	X	X	X	X	*	359.5	556.8	539.6	273.1	446.1	388.7	900.8	461.2	X
AE0001	297.8	307.2	250.0	206.6	638.8	364.5	311.5	412.4	344.1	327.5	285.1	454.3	450.4	236.7	404.6	434.6	744.0	341.0	X
AE0002	453.4	346.2	406.3	226.4	705.7	438.2	352.1	618.7	464.3	485.0	349.8	602.5	562.5	297.5	453.7	434.3	908.9	460.2	X
AE0003	437.5	348.1	*	294.5	766.2	485.8	358.9	590.3	458.2	531.0	435.9	595.7	618.9	315.3	495.6	475.4	891.0	429.4	X
AE0004	400.7	487.2	466.5	240.4	784.0	487.5	352.7	*	*	*	*	428.3	525.4	305.6	523.4	473.7	1088.3	444.1	X
AF0001	246.5	*	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X
AF0002	534.6	636.7	538.1	252.0	708.3	595.0	226.1	*	399.7	578.8	560.6	646.5	738.9	458.5	530.6	506.9	1157.5	661.8	X
AH0001	2.0	547.7	559.5	358.9	939.6	528.1	471.0	488.9	404.8	516.9	461.4	754.0	634.9	471.3	487.6	474.0	1053.4	684.2	X
AH0002	1.8	275.4	189.7	152.5	393.7	275.4	198.3	346.1	233.0	210.7	272.8	340.4	461.4	257.7	357.0	279.6	706.2	361.7	X
AH0003	474.9	494.0	439.3	285.5	586.0	478.4	469.1	527.1	468.6	494.3	444.7	670.1	691.4	449.3	532.5	495.1	1151.4	615.3	X
AJ0001	521.0	541.3	465.1	381.9	863.4	581.0	533.8	836.6	496.3	631.4	475.3	776.1	749.9	571.7	620.5	547.5	1125.0	681.9	X
AJ0002	507.4	545.3	426.1	367.1	918.8	654.5	531.9	781.3	490.3	558.4	545.7	715.1	699.4	552.0	524.9	569.9	1135.5	703.3	X
AJ0003	*	*	*	*	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X

* - incomplete records
x - no records

Table 3-3. Annual Precipitation Totals (1976 - 1994)

ANNUAL RAINFALL TOTALS (IN MMS)

CODE	1975 — 1976	1976 — 1977	1977 — 1978	1978 — 1979	1979 — 1980	1980 — 1981	1981 — 1982	1982 — 1983	1983 — 1984	1984 — 1985	1985 — 1986	1986 — 1987	1987 — 1988	1988 — 1989	1989 — 1990	1990 — 1991	1991 — 1992	1992 — 1993	1993 — 1994
AL0002	199.8	200.9	122.4	201.2	401.2	200.9	123.0	*	139.8	232.5	148.9	233.4	217.9	210.6	229.1	162.6	331.7	86.0	X
AL0003	187.9	155.3	157.9	125.1	377.2	213.2	160.4	*	147.1	222.3	132.3	242.9	324.0	200.0	140.6	87.4	239.5	138.0	X
AL0004	263.6	264.8	267.1	145.0	564.7	324.0	266.3	421.9	323.6	285.0	189.5	352.2	526.8	297.2	277.8	241.5	668.7	462.9	X
AL0005	578.6	335.1	*	215.1	807.6	612.3	522.5	709.9	499.3	524.5	345.8	515.6	584.8	473.5	483.6	356.6	1014.0	534.5	X
AL0006	*	X	X	*	*	X	X	X	X	X	X	X	X	X	447.9	X	1257.6	622.5	X
AL0008	*	X	X	*	*	X	X	X	X	X	190.2	379.5	446.1	151.2	288.4	X	X	X	X
AL0009	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0010	138.2	256.3	217.5	171.3	431.1	255.7	246.7	426.6	183.5	166.7	235.5	344.2	350.6	255.6	308.7	252.3	599.6	287.3	X
AL0011	263.3	190.3	229.4	160.5	511.3	291.7	341.8	541.2	334.1	195.4	179.4	348.8	417.3	245.4	215.3	205.1	390.8	372.8	X
AL0012	141.7	94.4	76.2	*	303.9	184.6	*	*	112.1	154.8	119.7	145.6	243.5	153.9	130.3	132.0	228.7	X	X
AL0013	*	X	94.8	69.8	245.0	*	144.2	205.6	*	237.4	75.3	194.5	211.0	182.8	130.7	121.9	233.5	101.7	X
AL0014	*	*	X	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0015	*	*	X	*	X	154.7	119.5	193.7	86.3	*	*	172.7	230.1	149.8	130.3	88.1	258.2	97.9	X
AL0016	*	85.4	*	54.8	334.8	165.9	129.7	216.8	110.7	152.6	80.7	131.7	266.0	161.2	125.4	140.2	291.4	124.2	X
AL0017	383.5	*	*	*	*	529.0	471.5	*	481.6	497.6	273.5	601.0	683.3	411.5	420.0	481.6	1258.3	635.6	X
AL0018	*	428.7	544.7	283.1	771.9	557.9	314.3	668.4	432.9	432.1	301.1	559.7	625.2	540.4	414.8	451.0	1150.8	546.4	X
AL0019	195.0	190.4	248.6	134.2	504.0	301.1	194.9	422.0	200.2	279.5	109.0	284.2	359.3	243.7	156.2	197.9	539.9	256.8	X
AL0022	315.1	350.2	418.5	232.5	671.1	413.4	462.5	593.5	232.8	439.4	186.9	330.2	534.1	313.9	265.0	355.0	903.3	433.1	X
AL0025	318.9	334.1	340.1	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0026	*	*	*	*	*	X	X	X	X	X	*	323.2	584.3	241.1	391.6	326.6	775.7	355.3	X
AL0027	344.4	296.8	*	236.9	630.0	*	*	*	*	279.1	*	267.7	462.9	372.0	319.8	344.1	999.1	527.6	X
AL0028	310.1	255.0	260.0	244.9	705.4	416.8	341.6	195.8	291.0	260.1	317.5	472.3	528.2	309.8	291.9	292.4	794.0	407.2	19.0
AL0029	*	*	X	*	*	*	X	*	X	X	X	X	X	X	X	X	X	X	X
AL0030	*	*	X	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0032	*	*	*	X	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0033	310.9	264.4	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0035	249.9	246.3	340.9	197.8	613.6	258.2	341.8	539.0	305.6	357.1	232.7	406.0	475.6	286.1	308.4	240.7	806.6	391.4	X
AL0036	267.6	257.8	286.3	175.5	676.9	385.0	291.0	521.3	286.4	287.0	226.9	424.2	500.0	357.9	311.2	254.1	770.2	360.0	X
AL0037	*	*	X	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0039	*	*	X	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0040	*	242.0	251.7	171.2	569.7	363.7	322.4	*	74.3	*	*	X	*	X	X	X	X	X	X
AL0042	351.9	391.1	374.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0043	219.1	268.7	239.2	140.3	443.3	*	*	*	*	142.9	*	*	*	X	X	X	X	X	X
AL0044	344.8	365.8	383.0	201.1	810.3	353.4	383.5	577.8	286.5	X	356.6	*	*	361.5	439.0	347.5	974.2	279.2	X
AL0045	437.1	415.5	419.0	248.7	675.4	*	448.6	781.8	457.0	524.4	420.6	586.5	621.4	506.5	460.3	373.9	1242.3	629.6	X
AL0046	251.5	323.6	339.5	*	*	X	X	X	X	*	190.0	278.2	502.1	X	X	X	X	X	X
AL0047	321.2	271.0	314.5	229.4	611.4	362.5	422.1	561.7	304.1	356.7	247.6	348.3	579.6	283.4	321.5	281.6	707.7	525.6	X
AL0048	107.8	*	*	70.0	308.0	101.6	125.8	*	101.7	136.8	60.4	169.4	254.8	157.6	110.4	94.8	245.4	108.4	X
AL0049	*	*	X	56.0	200.5	150.3	104.4	*	11.4	108.7	60.8	107.1	189.4	176.6	99.8	82.6	205.1	X	X
AL0050	263.3	251.5	313.2	185.8	465.2	343.1	285.4	411.0	227.1	265.7	146.4	451.0	439.0	328.2	245.6	214.4	518.5	254.6	X
AL0051	274.1	267.0	272.6	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AL0053	*	*	*	168.0	433.8	264.7	280.0	427.0	269.5	277.3	282.8	300.5	301.2	207.1	284.4	230.3	610.6	307.9	X
AL0054	85.0	48.3	75.9	44.8	222.2	*	116.9	7.0	130.1	136.4	61.8	123.2	231.0	169.0	157.5	86.2	277.0	*	X
AL0055	116.2	92.1	96.6	63.4	261.0	146.0	132.2	210.5	112.2	213.0	94.6	172.8	244.8	165.5	133.2	112.6	272.1	97.3	X
AL0057	X	X	X	*	880.3	613.0	458.1	738.6	466.4	433.9	343.3	595.1	577.8	X	438.6	318.1	975.3	442.8	X
AL0058	131.6	*	*	79.0	222.7	155.5	93.7	*	98.0	120.1	X	185.0	199.9	150.8	170.8	228.2	131.8	87.0	X
AL0059	*	*	*	70.7	216.1	118.5	118.7	144.8	104.8	161.7	46.9	148.2	219.7	101.5	117.9	114.7	191.4	92.9	X

Table 3-3. Annual Precipitation Totals (1976 - 1994)

ANNUAL RAINFALL TOTALS (IN MMS)

CODE	1975 — 1976	1976 — 1977	1977 — 1978	1978 — 1979	1979 — 1980	1980 — 1981	1981 — 1982	1982 — 1983	1983 — 1984	1984 — 1985	1985 — 1986	1986 — 1987	1987 — 1988	1988 — 1989	1989 — 1990	1990 — 1991	1991 — 1992	1992 — 1993	1993 — 1994
AM0001	472.6	417.3	510.3	400.8	914.2	640.3	494.1	829.2	482.3	542.6	396.6	599.2	696.7	568.7	512.5	535.7	1190.7	666.5	X
AM0002	345.6	298.9	256.4	355.9	622.0	424.6	*	*	201.1	344.9	237.1	371.7	441.1	374.0	407.6	364.0	766.4	406.6	X
AM0005	384.6	455.7	551.5	394.7	902.9	621.7	514.9	766.3	322.1	441.7	353.8	597.3	692.5	559.5	627.5	559.8	1164.0	649.0	X
AM0006	*	237.5	X	X	X	X	X	X	X	X	246.4	297.9	419.1	339.0	307.9	320.2	617.8	394.8	X
AM0007	189.7	102.5	205.6	153.2	240.8	200.4	138.6	213.4	81.5	134.0	148.0	154.9	200.8	173.1	168.5	141.4	341.4	146.1	X
AN0002	468.8	558.4	567.6	447.3	960.1	644.7	465.8	657.9	389.2	496.4	315.0	611.8	702.4	452.9	427.7	434.6	1176.8	608.3	X
AN0003	401.8	406.1	411.0	342.6	805.9	535.0	372.8	676.9	453.0	368.2	238.8	409.2	507.4	401.2	389.2	275.5	774.3	376.2	X
AN0004	282.2	207.9	255.5	248.5	*	*	*	*	270.1	310.7	124.5	283.5	264.5	246.0	210.1	149.3	X	241.5	X
OA0001	58.8	*	50.6	*	92.7	120.9	121.9	*	*	*	X	X	X	X	X	X	X	X	X
OA0002	152.6	141.5	122.6	202.7	286.7	180.6	369.8	467.0	*	275.3	262.8	238.5	460.9	254.6	253.8	502.0	305.5	227.0	X
OA0004	175.2	184.6	233.8	145.7	384.8	314.5	*	478.2	144.0	311.1	162.7	227.3	456.6	278.9	245.5	468.5	494.8	390.9	X
OA0006	64.1	139.7	121.8	83.6	242.8	53.4	91.8	211.6	99.4	110.2	84.6	94.9	230.4	187.1	127.3	208.5	207.1	95.0	X

Table 3-3. Annual Precipitation Totals (1976 - 1994)

ANNUAL RAINFALL TOTALS (IN MM)

CODE	1975 — 1976	1976 — 1977	1977 — 1978	1978 — 1979	1979 — 1980	1980 — 1981	1981 — 1982	1982 — 1983	1983 — 1984	1984 — 1985	1985 — 1986	1986 — 1987	1987 — 1988	1988 — 1989	1989 — 1990	1990 — 1991	1991 — 1992	1992 — 1993	1993 — 1994
000001	195.6	284.3	246.5	136.9	514.0	388.0	*	330.0	111.8	351.0	182.1	331.7	440.7	252.9	261.3	233.1	755.5	254.9	X
000002	174.5	162.5	201.6	201.0	527.6	96.6	*	242.3	110.0	*	123.0	271.6	419.7	310.5	257.2	287.3	476.5	254.3	X
000004	X	X	X	X	X	X	X	X	X	*	216.1	372.6	435.2	343.0	239.6	272.8	685.4	331.8	X
000013	189.1	129.0	145.5	87.8	*	193.2	138.0	129.0	62.0	148.3	75.9	91.0	209.7	140.0	133.7	81.0	301.6	124.4	X
000015	86.0	82.0	126.5	107.5	*	*	*	157.0	100.0	*	54.0	111.1	193.0	73.5	110.0	75.5	287.2	111.1	X
000016	122.3	205.8	237.1	179.5	440.8	268.6	184.5	388.8	151.0	335.0	137.0	246.0	330.1	248.4	182.9	192.8	299.8	233.1	X
000017	132.7	232.4	247.0	193.9	412.1	113.5	213.0	304.0	174.3	242.0	110.3	205.6	455.3	331.3	256.6	303.5	383.2	196.2	X
000018	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
000019	140.8	196.7	241.1	204.3	534.2	237.5	*	369.7	131.8	312.6	156.5	225.3	312.0	295.0	222.0	340.0	305.5	121.0	X
000010	255.6	275.4	258.7	240.1	580.0	*	253.3	480.4	113.7	345.3	195.4	291.6	430.1	372.7	305.7	409.8	507.2	346.3	X
000011	*	*	55.3	56.8	59.3	98.2	*	105.8	*	*	64.5	122.8	124.1	114.4	90.6	120.5	93.1	63.5	X
000013	161.8	215.6	188.8	300.0	392.8	463.3	167.4	249.2	*	309.9	171.7	212.7	512.5	375.0	291.0	468.0	498.0	300.3	X
000015	105.5	117.1	128.5	76.8	224.9	119.7	116.3	180.5	74.5	191.6	82.4	145.4	186.5	113.7	126.2	92.1	284.7	129.5	X
000016	147.7	*	188.4	190.0	*	*	198.0	219.0	139.2	120.3	*	133.2	318.0	228.5	192.6	186.0	348.5	177.9	X
000017	45.0	X	238.0	99.7	373.8	*	*	287.0	147.0	211.0	*	221.7	138.0	129.5	124.0	129.1	*	*	X
000018	126.7	87.0	104.1	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X
000019	178.5	289.4	329.0	203.6	*	X	*	284.5	169.0	340.8	135.0	305.9	345.8	343.2	209.2	306.7	499.0	254.0	X
000020	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
000023	176.1	281.3	249.4	219.1	636.9	349.7	303.2	512.8	224.2	317.2	X	X	X	X	X	X	X	X	X
000024	246.1	295.8	265.1	123.6	347.9	300.0	250.3	346.0	204.3	299.5	203.5	310.7	440.5	X	X	X	X	368.6	X
000025	185.8	222.8	213.6	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
000026	162.0	181.0	191.1	136.3	184.4	247.7	69.2	325.3	149.2	34.4	X	X	X	X	X	X	X	X	X
000028	102.9	194.0	183.9	158.0	316.8	222.8	113.4	*	153.6	257.2	87.1	147.3	307.9	X	198.3	232.7	358.3	210.8	X
000029	200.2	240.3	326.1	280.7	646.8	339.8	203.9	477.3	160.6	286.8	172.9	320.0	431.9	400.8	230.6	485.8	433.5	279.5	X
000034	*	*	99.0	56.7	*	110.0	32.5	75.7	*	69.5	X	X	X	X	X	X	X	X	X
000001	206.6	217.4	270.5	273.5	486.1	233.3	175.2	469.3	133.9	330.9	101.3	221.7	315.8	189.9	261.4	281.3	*	352.3	X
000002	180.4	202.0	243.1	231.7	478.1	280.5	141.0	498.7	187.9	258.9	156.4	298.4	389.6	255.3	272.5	433.5	*	189.1	X
000004	202.6	255.5	302.0	262.0	619.4	425.7	195.7	528.4	201.1	327.2	232.9	356.9	452.0	331.4	299.2	525.5	549.5	297.7	X
000001	*	*	41.4	*	111.3	X	X	X	X	X	X	X	*	X	X	X	X	X	X
000013	*	30.3	53.0	37.0	89.3	59.7	*	55.8	X	*	65.7	15.3	106.9	156.7	95.7	108.0	X	X	X
000015	*	X	X	X	X	X	X	X	X	X	X	X	X	238.4	77.4	75.0	192.7	X	X
000016	X	X	X	X	X	X	X	X	X	X	95.0	59.3	86.2	109.9	85.9	101.7	113.2	37.5	X
000017	15.1	28.8	46.2	*	*	*	*	83.2	28.5	50.3	71.3	57.5	X	X	X	56.1	37.2	26.5	X
000018	*	*	*	96.9	237.5	*	*	205.9	98.7	97.9	*	101.2	221.6	X	X	X	X	64.0	X

Table 3-3. Annual Precipitation Totals (1976 - 1994)

ANUAL RAINFALL TOTALS (IN MMS)

CODE	1975 — 1976	1976 — 1977	1977 — 1978	1978 — 1979	1979 — 1980	1980 — 1981	1981 — 1982	1982 — 1983	1983 — 1984	1984 — 1985	1985 — 1986	1986 — 1987	1987 — 1988	1988 — 1989	1989 — 1990	1990 — 1991	1991 — 1992	1992 — 1993	1993 — 1994
DA0001	168.2	257.2	197.5	302.7	347.2	259.9	177.0	359.8	X	X	X	X	X	X	X	X	X	X	X
DA0002	182.8	268.0	229.7	307.3	374.4	292.4	256.2	432.2	95.0	225.2	279.0	209.1	421.4	305.4	222.0	488.2	420.5	222.7	X
DA0003	*	221.0	158.0	249.0	422.0	225.5	160.5	389.2	62.2	212.4	304.3	189.8	369.9	305.2	173.9	423.4	227.5	178.0	X
DA0004	*	*	124.9	140.9	173.0	172.2	159.4	212.3	58.3	*	*	X	X	X	X	X	X	X	X
DA0006	*	65.3	82.0	47.6	X	74.2	X	X	190.4	59.3	*	X	X	X	X	X	X	X	X
DA0007	X	X	X	X	X	X	X	X	X	X	66.2	69.9	113.5	86.5	84.5	125.4	28.1	23.3	X
DB0001	117.1	243.6	168.9	188.5	366.7	316.4	175.1	353.0	94.7	201.7	228.0	211.2	370.3	274.4	156.5	346.2	318.7	198.8	X
DB0002	105.1	182.9	152.4	166.3	350.5	276.3	183.1	272.9	162.1	168.6	207.1	163.0	289.8	172.1	144.3	308.6	234.9	179.0	X
DC0001	105.2	225.8	156.2	253.4	423.7	265.5	*	339.5	77.5	205.4	236.3	168.8	357.0	154.4	142.1	350.1	311.2	217.9	X
DC0002	X	223.5	179.7	197.2	240.6	179.6	*	253.8	55.3	*	191.6	128.2	406.2	200.2	159.9	344.0	*	412.7	X
DE0001	*	*	186.7	270.7	360.1	336.0	206.7	289.3	102.4	193.0	263.4	154.1	326.2	262.0	238.6	398.5	370.5	324.3	X
DD0001	117.0	129.0	83.0	141.9	245.9	126.6	136.0	244.0	58.2	152.0	147.5	142.5	286.0	115.4	157.2	257.6	173.8	150.2	X
DD0002	*	133.4	131.0	180.2	262.8	197.1	112.2	217.5	52.5	143.2	*	X	*	X	X	X	X	X	X
DD0003	94.8	141.9	65.5	118.7	180.1	*	*	18.8	48.0	92.2	43.1	43.9	129.0	111.4	140.1	237.8	X	141.0	X
DH0002	*	80.8	62.8	125.2	115.4	*	49.3	126.0	*	154.6	101.0	66.0	350.6	225.4	139.4	177.1	106.0	32.0	X
DH0003	*	96.2	139.2	131.7	225.8	169.7	113.9	226.2	50.7	151.5	163.5	156.0	254.0	190.0	146.9	214.0	220.2	146.9	X
ED0001	23.6	14.4	36.5	36.5	4.6	47.3	43.1	25.2	8.6	*	42.3	30.1	69.4	10.4	21.9	18.4	13.4	21.0	X
ED0002	75.3	94.1	82.9	86.1	143.8	*	77.0	65.5	24.5	130.5	133.5	104.4	175.6	46.2	59.4	97.2	65.1	51.0	X
ED0003	*	X	X	1.7	77.3	*	*	142.0	6.0	97.0	X	X	X	X	22.0	38.3	X	16.6	X
ED0004	49.2	X	55.2	*	*	6.4	*	61.8	44.8	62.2	96.0	47.4	54.5	61.0	28.0	28.0	49.1	22.5	X
ED0006	*	31.8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ED0012	*	X	X	5.0	X	X	X	X	X	X	X	X	X	20.9	13.5	40.0	21.0	17.3	X
F 0001	*	*	95.1	*	255.2	158.6	*	116.0	107.0	182.3	124.9	129.6	190.8	97.6	168.2	148.0	162.5	127.0	X
F 0002	73.0	27.6	25.6	18.2	90.4	*	67.8	49.0	37.7	57.1	105.4	66.9	105.3	188.7	84.2	116.5	46.7	15.5	X
F 0007	*	*	26.7	101.8	80.0	60.5	*	*	*	*	42.5	X	64.4	112.6	42.8	47.3	*	16.5	X
F 0009	60.3	10.1	40.3	29.8	48.9	79.4	60.4	74.0	20.5	55.3	43.6	42.1	93.0	149.0	92.5	83.3	43.8	X	X
F 0011	*	*	*	*	*	*	*	*	15.0	12.8	70.6	31.8	78.2	67.1	24.9	76.0	16.6	10.5	X
F 0012	X	X	X	X	X	X	X	X	X	X	48.2	36.2	78.4	X	X	X	X	X	X
F 0020	X	X	X	X	X	X	X	X	X	X	28.8	57.2	100.5	X	95.4	78.0	64.8	X	X
G 0002	*	8.0	9.6	18.1	52.0	*	*	*	*	*	X	X	X	X	25.2	X	X	X	X
G 0003	*	16.0	14.7	36.1	37.4	71.4	14.2	58.4	16.1	23.9	38.7	24.9	108.4	56.0	27.7	55.3	33.1	11.6	X
G 0004	*	77.5	129.1	140.8	*	12.0	41.2	427.0	81.0	129.0	269.1	114.0	321.5	220.0	99.7	166.5	134.5	96.0	X
G 0005	*	74.4	165.4	144.5	*	174.1	168.7	202.7	64.5	169.9	176.5	154.5	297.6	194.7	31.6	200.0	243.5	70.9	X
G 0006	*	97.2	174.1	136.5	213.0	*	57.2	X	*	137.2	148.9	142.9	245.0	237.2	123.4	185.5	*	65.4	X
G 0007	*	23.0	14.1	23.0	62.3	67.3	11.1	57.6	12.3	14.1	53.1	33.1	106.2	38.1	28.3	53.7	32.6	11.1	X
G 0008	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
G 0009	60.6	106.1	208.7	118.6	212.9	86.2	124.0	90.2	12.3	79.0	90.9	88.5	156.6	225.1	64.4	253.1	194.7	114.4	X
H 0001	111.3	41.2	63.2	18.0	42.0	72.5	155.7	*	41.2	77.0	51.9	75.7	99.1	100.9	78.4	79.5	55.3	58.3	X

Table 3-4. List of Evaporation Monitoring Stations

WAJ - Studies Department

	ID #	SITE NAME	COORDINATES EAST	NORTH	TYPE	OPERATIONAL STATUS	COMMENTS
1	AB0010	DEIR ABI SAID	215.100	211.700	A		Also precipitation station at another location
2	AD0027	SAMA ER ROSAN EVAP.STATION	228.700	227.900	M	NW	
3	AD0034	SAMAR EVAP. STATION	222.000	231.900	M,A		
4	AD0036	UNIV. OF SCI. & TECH	242.300	209.800	A		
5	AH0003	RAS MUNEIF EVAP.STATION	226.800	198.800	M,A	NW (M)	
6	AL0019	AMMAN AIRPORT	243.500	153.800	M		Dept. of Meteorology Station
7	AL0035	K.H.NURSERY EVAP.ST. (BAQ'A)	230.000	165.400	M,A		
8	AL0053	KING TALAL DAM (BURMA)	228.600	178.000	M		
9	AL0059	UM EL-JUMAL EVAP.STATION	276.800	190.400	M,A		
10	AL0066	KHIRBET ES SAMRA EVAP.ST.	258.250	173.500	M,A		
11	AM0004	SHUNET NIMRIN EVAP.ST.	209.500	146.000	M	NW	Station transferred to South Shuna (AM 0007)
12	AM0007	SOUTH SHUNA(W.SHUIB DAM EV.ST)	210.500	146.000	M,A		
13	CC0004	MUSHAQQAR EVAP ST.	226.200	132.900	M,A		
14	CD0010	RABBA	220.500	75.500	M,A		
15	CD0020	SIWAQA EVAP. STATION	253.700	086.800	M	NW	
16	CD0023	QASR EVAP. STATION	221.000	080.900	M	NW	Station transferred to Rabbah (CD 0010)
17	CD0026	EZ-ZEITUNA EVAP. STATION	235.700	129.700	M	NW	
18	CD0034	QATRANA EVAP. STATION	249.500	073.600	M,A	NW (M)	
19	CF0006	GHOR ES-SAFI MET. STATION	193.000	051.000	M,A		Potash Company Station
20	CF0007	HASA EVAP. STATION	243.600	030.600	M		
21	DA0007	FEEDAN	187.300	003.750	M		
22	DF0002	UM METLA	177.600	987.100	M		
23	EA0002	RAHMA	162.000	926.000	M		
24	ED0004	QUWEIRA EVAP.STATION	181.000	914.000	M	NW	
25	ED0012	RAM(QA'DISI) EVAP. STATION	199.800	896.000	M	NW	
26	ED0026	AQABA EVAP ST.	148.000	887.000	M		
27	F0002	H5 EVAP.STATION	348.500	180.000	M		Department of Meteorology Station
28	F0009	AZRAQ EVAP.STATION	320.000	141.500	M,A		
29	G0008	JAFR EVAP. STATION	267.000	970.000	M	NW	
30	G0009	UDRUH EVAP. STATION	206.300	973.600	M		
31	H0001	H4 EVAP.ST.	450.500	216.000	M,A		Department of Meteorology Station (M); WAJ (A)
32	J0001	BAYIR EVAP. STATION	310.500	020.000	M	NW	
33	K0001	EL-MUDAWWARA EVAP. STATION	249.000	859.000	M	NW	
34	K0002	DURRAH EVAP. STATION	147.000	867.500	M	NW	

NOTES

A = Automatic
M= Manual
NW = Not Working
Data include daily measurements
Stations also include rainfall gauges

Table 3-5. Average Annual Evaporation Totals (Class A Pan, millimeters /day)

Station Name	Daily Averages for Each Month												ANNUAL DAILY AVERAGE
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	
EL.MUDAW	3.9	5.4	7.7	11.2	13.5	16.3	16.8	16.2	11.3	9.3	4.8	4	10.03
SWAQA	2.6	4.2	6	8.2	11.7	13	13.5	13.2	10.4	7.5	4.5	3.2	8.17
DEIR ALLA	3.1	3.2	3.9	6.2	7.8	8.9	9.3	8.8	7.8	6.5	5.2	3.2	6.16
RAS MUNEIF	3	3.6	4.6	6.4	8.6	9.4	10.5	10.4	8.6	6.7	4.1	2.6	6.54
UM JIMAL	2.7	4	5.9	9.3	12.1	14.6	15.3	13.6	11.4	8.6	6.1	3.4	8.92
AL HASA	4.2	5.8	8.1	11.7	14.9	17.1	17.1	16.3	13.2	9	5.4	4.3	10.59
AL ZIETONH	2.4	3.6	4.7	6.8	9.7	12.2	12.4	11.7	10	7.5	4.4	2.6	7.33
AL BAQAH	2.3	3.3	4.5	6.8	9	11.2	11.7	10.8	9.1	6.7	4.2	2.6	6.85
AMM.AIRPORT	2.8	3.6	4.8	7	9.6	11.6	12	10.9	9.1	6.9	4.5	2.8	7.13
S.SHUNH	3.7	4.4	6.3	9.6	11.6	14.4	14.5	13.6	12.1	9.7	6.7	4.9	9.29
AL KASER	3.5	4.3	5.8	7.4	10.4	13.3	14	12.6	10.9	8.5	5	3.3	8.25
S.AL RUSAN	3.3	3.9	5	7.1	10	12.7	12.7	11.6	10.5	7.8	4.9	3.1	7.72
H-5	3.3	4.8	7.2	11.4	13.9	16.6	18	16.4	13.8	9.2	5	3.3	10.24
H-4	3.3	5.7	7.4	10.6	13.8	15.9	15.9	14.3	12.3	9.5	5.4	4.5	9.88
UDRUH	3.3	4.3	6.7	9.3	12.1	15	16.7	16.7	12.5	8.9	4.7	3.5	9.48
W.DULAIL	1.8	2.6	4	6.1	8.4	9.6	9.9	8.9	7.3	5.4	3.2	1.8	5.75
IRBID	2.4	2.9	3.9	5.3	7.9	10.6	10.4	9.8	8.1	6.6	4.2	2.7	6.23
W.YABIS	1.9	2.3	3.2	5.5	7.7	9	9.4	8.9	7.5	5.2	3.2	1.9	5.48
BAQURA	2.3	2.6	3.5	5.2	7.2	8.4	8.7	8	6.8	4.9	3.7	2.5	5.32
MAAN	3.9	5.2	7	10.9	13.1	14.4	15.9	13.9	11.5	8.7	5.2	3.6	9.44

Table 3-6a. List of Surface Water Monitoring Stations
WAJ - Studies Department

	WAJ ID #	SITE NAME	COORDINATES EAST	NORTH	ALTITUDE	EQUIPMENT STATUS	COMMENTS
1	A 0001	KING HUSSEIN BRIDGE	201.500	143.000	372	CW (NW)	Closed; JVA to reactivate
2	A 0003	WAHADNEH 35	202.500	193.700		CW (NW)	Closed; JVA to reactivate
3	AB 0009	WAQQAS	208.250	216.000	-155	CM	
4	AB 0526	WADI EL BEIDA	212.400	209.200		CM	For springs
5	AD 0003	HEMMEH	212.400	232.600	-175		Closed; JVA to reactivate
6	AD 0020	MAQARIN GAUGING STATION	230.000	237.000	120	CM, AGS, CW	
7	AD 0033	ADASIYA GAUGING STATION	209.200	231.500	-210	CM, AGS, CW	
8	AE 0400	WADI AL ARAB	207.500	222.500	-210	CM, AGS (NW)	Dam site
9	AF 0003	WADI ZIGLAB	206.600	213.000	-205	CM, AGS (NW)	Dam site
10	AG 0002	WADI JURUM	206.800	205.500	-180	CM	
11	AH 0005	WADI YABIS	206.000	199.000	-180	CM	
12	AJ 0005	WADI KUFRINJA	205.200	185.000	-180	CM, AGS (NW)	
13	AK 0003	WADI RAJIB	211.200	183.200	-80	CM	
14	AL 0040	UM DANANEER	227.300	165.000		AGS (NW)	Closed (vandalized)
15	AL 0060	WADI ZARQA AT NEW JERASH BRIDGE	232.000	180.000	150	CM, AGS, CW	
16	AL 0061	WADI SLEIHI	229.600	168.800	530	AGS (NW)	
17	AL 0062	WADI ZARQA AT AIN GHAZAL	241.900	153.700	700	AGS (NW)	
18	AL 0063	WADI ZARQA NEAR SUKHANEH	250.200	171.300	515	CM (NW), AGS (NW), CW (NW)	
19	AL 0064	WADI DHULEIL NEAR SUKHANEH	250.600	173.000	490	AGS (NW), CW (NW)	
20	AL 0065	WADI ABDOUN	236.800	150.700	780	AGS	
21	AL 0068	WADI ZARQA AT DEIR ALLA	212.100	178.400	-190	CM (NW), AGS (NW), CW (NW)	
22	AM 0008	WADI SHUEIB AT SHUNET NIMRIN	208.000	147.000	-190	CM, AGS (NW)	
23	AN 0006	WADI KAFREIN	210.000	139.000	-160	CM	
24	AP 0002	WADI HISBAN	210.200	137.000	-140	CM	
25	CA 0001	WADI KARAK AT GHOR MAZRA'A	200.000	78.400	-300	CW (NW)	Closed & moved to CE 0006
26	CA 0007	EIN AL-MAGARAH	201.500	78.500	-330	CM	For springs
27	CA 0008	WADI IBN HAMMAD	206.000	79.500	-160	CM	For springs
28	CA 0009	EIN EL-SIKKEEN NORTH	201.200	76.200	-300	CM	For springs
29	CA 0010	WADI ISSAL	202.400	66.800	-260	CM	
30	CA 0011	WADI NUMEIRA	201.000	60.000	-300	CM	
31	CA 0624	WADI HIRRAH	212.800	130.900		CM	For springs
32	CA 0668	ZARAH SPRINGS	211.900	87.200		CM	For springs
33	CA 0686	WADI ZARQA MA'IN	207.100	113.700		CM, AGS	For springs; AGS (1994)
34	CD 0035	WADI MUJIB AT KARAK ROAD	226.500	96.600	120	CM, AGS, CW	

Table 3-6a. List of Surface Water Monitoring Stations
WAJ - Studies Department

	WAJ ID #	SITE NAME	COORDINATES EAST	NORTH	ALTITUDE	EQUIPMENT STATUS	COMMENTS
35	CD 0036	WADI SULTANI DAM	245.000	55.500	820	AGS (NW)	Closed due to dam
36	CD 0037	WADI QATRANI AT QATRANI DAM	246.400	72.200	760	AGS (NW)	Closed due to dam
37	CD 0038	WADI WALA AT KARAK ROAD	223.300	106.500	440	CM AGS, CW	
38	CD 0039	WADI SIWAQA	250.000	87.000	740	AGS	For spillway flow from dam
39	CD 0041	MALAQI	216.250	96.000	-150	CM	
40	CE 0006	WADI EL KARAK	205.900	75.500	-150	CM, AGS	
41	CE 0007	WADI DREA'A	205.050	72.550	-40	CM	
42	CF 0009	WADI HASA AT KARAK-TAFILEH ROAD	218.000	43.400	360	CM, AGS , CW (NW)	
43	CF 0010	WADI HASA AT GHOR SAFI	196.000	47.500	-300	CM, AGS	
44	DA 0008	WADI FEIFA	194.800	38.800	-280	CM, AGS	
45	DA 0009	WADI TLAH	189.600	26.400	-106	CM	
46	DA 0010	WADI UMRUQ	195.000	35.300	-260	CM	
47	DC 0004	KHNEIZIRA	191.400	32.500	-142	CM, AGS	
48	DD 0003	WADI DAHAL	190.400	24.400	-40	AGS	
49	DE 0002	WADI DANA	197.700	4.800	290	AGS	
50	DE 0003	WADI FINAN	198.100	3.700	310	CM, AGS	
51	DG 0004	WADI MUSA CULVERT	189.000	972.500	1050	AGS (NW)	Closed
52	DH 0004	WADI HUWWAR	170.900	962.000	340	AGS	
53	EA 0003	WADI RUQIYA	166.000	934.900	195	AGS	
54	EA 0004	WADI SIQ	169.400	940.000	270	AGS	
55	EA 0006	WADI DARBA	165.600	921.700	485	AGS	
56	EB 0001	WADI DHLAGHA	183.000	947.000	1100	AGS	
57	EB 0002	WADI ABU BARQA	172.700	952.400	240	AGS	
58	EC 0001	WADI MUSA	186.300	934.300	410	AGS	
59	ED 0024	WADI YUTUM	160.000	887.000	350	AGS (NW)	Closed
60	G 0018	WADI JURDHAN	221.000	966.150	1070	AGS	
61	H 0005	WADI RUWEISHED	459.500	219.800	697	AGS (NW)	Closed (vandalized)

NOTES: BASE FLOW MEASURED DAILY
CM = CURRENT METER TO MEASURE BASEFLOW
AGS = AUTOMATIC GAUGING STATION
CW = CABLE WAY
NW = NOT WORKING

REFERENCES: CWA (1964), GTZ (1977),UNDP (1992), WAJ (1986)

Table 3-6b. Jordan Valley Surface Water Monitoring Stations
Jordan Valley Authority

SEQUENCE NUMBER	SITE NAME	LOCATION			PURPOSE/PROJECT	STATUS	FREQUENCY	METHOD	EQUIPMENT	DATA MEASURED
		EAST	NORTH	ALTITUDE						
1	Adasyia Drop				KAC from Yarmouk River	Working	Daily, Monthly	Manual	Staff Gage	Water level then water flow
2	Abu Ezzigan				KAC from King Talal Dam	Working	Daily, Monthly	Manual	Staff Gage	Water level then water flow
3	Mukhaibeh canal				KAC from M. Canal	Working	Daily	Manual	Staff Gage	Water level then water flow
4	Adasyia private pumps				Farmers consumptions		once/season	Manual	Current meter	Discharge liter/second
5	Adasyia spring				Farmers consumptions		once/season	Manual		Discharge liter/second
6	Adasyia wells				KAC from wells		as needed	Manual		Discharge liter/second
7	Baqura wells				KAC from wells		as needed	Manual		Discharge liter/second
8	W Arab Hot Spring				Flow measure	Working	Weekly/Monthly	Manual	Current meter	Flow liter/second
9	W Arab seepage from dam				Flow measure	Working	Weekly/Monthly	Manual	Current meter	Flow liter/second
10	W. Arab into KAC				Flow measure	Working	Weekly/Monthly	Manual	Current meter	Flow liter/second
11	W. Taybeh				Flow measure	Working	Weekly	Manual	Current meter	Water level to calculate the flow
12	W. Abu Ziad well				Farmers consumptions	Working	Weekly	Manual		Discharge liter/second
13	W. Abu Ziad into KAC				KAC from Wadi Abu Ziad	Working	Weekly	Manual	Current meter	Flow liter/second
14	W. Ziglab into dam				Flow into Ziglab Dam	Working	Monthly	Manual	Current meter	Flow liter/second
15	Ziglab Dam into seepage				Flow of seepage	Working	as needed	Manual	Current meter	Flow liter/second
16	W. Ziglab into KAC				Flow into KAC	Working	as needed	Manual	Current meter	Flow liter/second
17	W. Jurum into diversion				W. Jurm flow	Working	Weekly/Monthly	Manual	Current meter	Flow liter/second
18	W. Jurum into KAC				W. Jurm flow into KAC	Working	Weekly	Manual	Current meter	Flow liter/second
19	W. Yabis into KAC				W. Yabis into KAC	Working	Weekly	Manual	Current meter	Flow liter/second
20	W. Kufranja crossing				W.Kufranja int RIAD crossing	Not working				
21	W. Rajib diversion				W. Rajib diversion	Working	Weekly	Manual	Current meter	Flow liter/second
22	Zarqa River at Tal Eddahb diversion				Flow from Talal Dam	Working	Monthly	Manual	Current meter	Flow liter/second
23	ZCI				Flow into ZCI	Not working			Flow meter	Flow liter/second
24	ZCII				Flow into ZCII	Not working			Flow meter	Flow liter/second
25	Zarqa salt spring				Springs flow	Not working				
26	W. Shuieb into dam				W. shueib flow	Working	Weekly	Manual	Current meter	Flow liter/second
27	W. Shueib dam outflow				W. shueib dam outflow	Working	Weekly	Manual	Current meter	Flow liter/second
28	W Kafrein into dam				W. kafrein flow	Working	Weekly	Manual	Current meter	Flow liter/second
29	Kafrein dam course				Kafrein dam course	Working	Weekly	Manual	Current meter	Flow liter/second
30	W. Hisban diversion				W. Hisban flow	Working	Weekly	Manual	Current meter	Flow liter/second

Table 3-7. SURFACE WATER RESOURCES AND USES IN 1993

Basin Name	Basin IDN	Total Resources (MCM)	Remarks	Uses (MCM)			Total Uses (MCM)
				Municipal	Irrigation	Industry	
1.YARMOUK AT ADASIYA	AD	316.06	(1)MUN.W.	29.16	86.69	0.61	116.46
2.GHOR -JORDAN VALLEY	AB1	27.69		0.11	0.00	0.00	0.11
3.N.JORDAN R.SIDE WADIS	A1	73.83		4.47	35.97	0.00	40.44
-INTER CATCHMENT	AB2	5.01		0.00	0.39	0.00	0.39
-WADI ARAB	AE	4.79		0.00	13.53	0.00	13.53
-WADI ZIGLAB	AF	14.51		0.00	8.94	0.00	8.94
-WADI JURAM	AG	10.89		1.24	8.10	0.00	9.34
-WADI YABIS	AH	10.31		2.21	2.66	0.00	4.87
-WADI KUFRINJA	AJ	15.96		1.02	0.00	0.00	1.02
-WADI RAJIB	AK	12.36		0.00	2.35	0.00	2.35
4.S.JORDAN R.SIDE WADIS	A2	61.33		10.35	28.13	0.00	38.48
-INTER CATCHMENTS	AB3	1.79		0.00	0.00	0.00	0.00
-WADI SHUEIB	AM	21.48		7.24	8.05	0.00	15.29
-WADI KAFRAIN	AN	32.17		3.11	17.30	0.00	20.41
-WADI HISBAN	AP	5.89		0.00	2.78	0.00	2.78
5. ZARQA RIVER	AL	147.03		10.95	103.97	0.00	114.92
6.DEAD SEA	C	58.85		1.47	13.06	0.94	15.47
-INTER CATCHMENTS	CA	32.16	(2)IND.W.	0.05	8.97	0.94	9.96
-ZERQA MAEIN	CC	19.27		0.00	0.00	0.00	0.00
-KARAK	CE	7.42		1.42	4.09	0.00	5.51
7.MUJIB	CD	54.34		0.00	0.00	0.00	0.00
8.HASA	CF	31.78	(3)IND.W.	0.51	23.14	1.02	24.67
9.N. WADI ARABA	D	17.29		0.00	4.38	0.00	4.38
-INTER CATCHMENTS	DA	5.00		0.00	0.00	0.00	0.00
-FEIFA	DB	4.08		0.00	3.08	0.00	3.08
-KHANZERA	DC	2.19		0.00	1.30	0.00	1.30
-DAHEL	DD	0.31		0.00	0.00	0.00	0.00
-FIDAN	DE	2.11		0.00	0.00	0.00	0.00
-BOWEIRDA	DF	1.58		0.00	0.00	0.00	0.00
-MUSA	DG	1.27		0.00	0.00	0.00	0.00
-HAWOR	DH	0.75		0.00	0.00	0.00	0.00
10.S. WADI ARABA	E	1.03		0.00	0.00	0.00	0.00
-INTER CATCHMENTS	EA	0.26		0.00	0.00	0.00	0.00
-ABU BARQA	EB	0.14		0.00	0.00	0.00	0.00
-ROUKAIA	EC	0.05		0.00	0.00	0.00	0.00
-WADI YUTUM	ED	0.58		0.00	0.00	0.00	0.00
11.SOUTHERN DESERT	K+ED12	0.61		0.00	0.00	0.00	0.00
12.AZRAQ	F	7.19		0.00	0.00	0.00	0.00
13.SIRHAN	J	4.88		0.00	0.00	0.00	0.00
14.HAMAD	H	12.62		0.00	0.00	0.00	0.00
15.JAFER	G	7.62		0.00	0.00	0.00	0.00
TOTAL		822.15		57.02	295.34	2.57	354.93

(1)28.87 MCM FROM KAC TO AMMAN.
(2)WATER FROM CA.CATCHMENT FOR POTASH INDUSTRY
(3) WATER USED FROM W. HASA FOR POTASH INDUSTRY
NOTE: WASTEWATER INCLUDED IN IRRIGATION USES = 47.3 MCM

Table 3-8. SURFACE WATER RESOURCES AND USES IN 1992

Basin Name	Basin IDN	Total Resources (MCM)	Remarks	Uses (MCM)			Total Uses (MCM)
				Municipal	Irrigation	Industry	
1.YARMOUK AT ADASIYA	AD	657.10	(1)	30.87	95.98	0.93	127.78
2.GHOR -JORDAN VALLEY	AB1	31.21		0.11	25.50	0.00	25.61
3.N.JORDAN R.SIDE WADIS	A1	134.76		4.26	51.24	0.00	55.50
-INTER CATCHMENT	AB2	12.80		0.00	12.80	0.00	12.80
-WADI ARAB	AE	16.94		0.00	16.94	0.00	16.94
-WADI ZIGLAB	AF	17.00		0.00	9.67	0.00	9.67
-WADI JURAM	AG	4.43		1.24	3.19	0.00	4.43
-WADI YABIS	AH	19.46		1.89	2.41	0.00	4.30
-WADI KUFRINJA	AJ	38.18		1.13	2.03	0.00	3.16
-WADI RAJIB	AK	25.95		0.00	4.20	0.00	4.20
4.S.JORDAN R.SIDE WADIS	A2	114.05		9.37	23.01	0.00	32.38
-INTER CATCHMENTS	AB3	8.64		0.00	0.30	0.00	0.30
-WADI SHUEIB	AM	43.43		6.32	8.00	0.00	14.32
-WADI KAFRAIN	AN	52.27		3.05	12.18	0.00	15.23
-WADI HISBAN	AP	9.71		0.00	2.53	0.00	2.53
5. ZARQA RIVER	AL	190.40		12.82	52.36	0.00	65.18
6.DEAD SEA	C	75.79		1.38	27.14	0.89	29.41
-INTER CATCHMENTS	CA	28.54	(2)	0.04	15.79	0.89	16.72
-ZERQA MAEIN	CC	30.62		0.00	0.00	0.00	0.00
-KARAK	CE	16.63		1.34	11.35	0.00	12.69
7.MUJIB	CD	373.34		0.00	14.68	0.00	14.68
8.HASA	CF	40.12	(3)	0.50	16.69	1.29	18.48
9.N. WADI ARABA	D	25.47		0.00	6.96	0.00	6.96
-INTER CATCHMENTS	DA	1.59		0.00	0.30	0.00	0.30
-FEIFA	DB	8.20		0.00	2.80	0.00	2.80
-KHANZERA	DC	4.32		0.00	0.93	0.00	0.93
-DAHEL	DD	0.86		0.00	0.03	0.00	0.03
-FIDAN	DE	4.18		0.00	1.30	0.00	1.30
-BOWEIRDA	DF	3.78		0.00	0.15	0.00	0.15
-MUSA	DG	2.03		0.00	1.30	0.00	1.30
-HAWOR	DH	0.51		0.00	0.15	0.00	0.15
10.S. WADI ARABA	E	2.22		0.00	1.66	0.00	1.66
-INTER CATCHMENTS	EA	0.12		0.00	0.12	0.00	0.12
-ABU BARQA	EB	0.33		0.00	0.15	0.00	0.15
-ROUKAIA	EC	0.16		0.00	0.09	0.00	0.09
-WADI YUTUM	ED	1.61		0.00	1.30	0.00	1.30
11.SOUTHERN DESERT	K+ED12	1.54		0.00	0.08	0.00	0.08
12.AZRAQ	F	13.60		0.00	0.00	0.00	0.00
13.SIRHAN	J	12.32		0.00	0.00	0.00	0.00
14.HAMAD	H	29.51		0.00	2.00	0.00	2.00
15.JAFER	G	33.51		0.00	0.85	0.00	0.85
TOTAL		1733.40		59.31	318.07	3.11	380.49

(1)30.9 MCM FROM KAC TO AMMAN.
(2)WATER FROM W.NUMEIRA FOR POTASH INDUSTRY
(3)WATER USED FROM W. HASA FOR POTASH INDUSTRY
NOTE: WHEN BASE FLOW = ZERO, SPRING DISCHARGE IS CONSIDERED
NOTE: WASTEWATER NOT INCLUDED FOR IRRIGATION

Table 3-9. SURFACE WATER RESOURCES AND USES IN 1991

Basin Name	Basin IDN	Total Resources (MCM)	Remarks	Uses (MCM)			Total Uses (MCM)
				Municipal	Irrigation	Industry	
1.YARMOUK AT ADASIYA	AD	151.90	4.26(1)	4.26	94.43	0.51	99.20
2.GHOR -JORDAN VALLEY	AB1	20.00		0.11	17.72	0.00	17.83
3.N.JORDAN R.SIDE WADIS	A1	38.20		3.38	40.23	0.00	43.61
-INTER CATCHMENT	AB2	9.30		0.00	14.00	0.00	14.00
-WADI ARAB	AE	1.80		0.00	15.86	0.00	15.86
-WADI ZIGLAB	AF	8.90		0.00	4.43	0.00	4.43
-WADI JURAM	AG	5.60		1.29	3.51	0.00	4.80
-WADI YABIS	AH	2.46		1.21	0.25	0.00	1.46
-WADI KUFRINJA	AJ	4.40		0.87	0.96	0.00	1.83
-WADI RAJIB	AK	4.27		0.00	1.23	0.00	1.23
4.S.JORDAN R.SIDE WADIS	A2	27.19		7.64	17.09	0.00	24.73
-INTER CATCHMENTS	AB3	3.57		0.00	0.00	0.00	0.00
-WADI SHUEIB	AM	5.08		4.89	4.22	0.00	9.11
-WADI KAFRAIN	AN	9.55		2.74	9.73	0.00	12.47
-WADI HISBAN	AP	3.68		0.00	3.14	0.00	3.14
5. ZARQA RIVER	AL	56.04		6.51	56.04	0.00	62.55
6.DEAD SEA	C	59.52		1.20	27.41	2.48	31.09
-INTER CATCHMENTS	CA	24.19	2.48(2)	0.08	15.79	2.48	18.35
-ZERQA MAEIN	CC	13.42		0.00	0.00	0.00	0.00
-KARAK	CE	10.46		1.13	11.61	0.00	12.74
7.MUJIB	CD	50.78		0.00	7.27	0.00	7.27
8.HASA	CF	42.32	1.66(3)	0.39	14.94	1.66	16.99
9.N. WADI ARABA	D	11.97		0.00	5.55	1.35	6.90
-INTER CATCHMENTS	DA	2.52		0.00	0.21	1.35	1.56
-FEIFA	DB	5.35		0.00	2.38	0.00	2.38
-KHANZERA	DC	3.52		0.00	0.79	0.00	0.79
-DAHEL	DD	0.69		0.00	0.03	0.00	0.03
-FIDAN	DE	3.38		0.00	1.20	0.00	1.20
-BOWEIRDA	DF	3.62		0.00	0.13	0.00	0.13
-MUSA	DG	0.42		0.00	0.70	0.00	0.70
-HAWOR	DH	0.42		0.00	0.12	0.00	0.12
10.S. WADI ARABA	E	3.07		0.00	3.07	0.00	3.07
-INTER CATCHMENTS	EA	0.32		0.00	1.85	0.00	1.85
-ABU BARQA	EB	0.09		0.00	0.07	0.00	0.07
-ROUKAIA	EC	0.04		0.00	0.00	0.00	0.00
-WADI YUTUM	ED	2.12		0.00	1.15	0.00	1.15
11.SOUTHERN DESERT	K+ED12	1.51		0.00	0.06	0.00	0.06
12.AZRAQ	F	16.06		0.00	2.35	0.00	2.35
13.SIRHAN	J	2.32		0.00	0.00	0.00	0.00
14.HAMAD	H	22.50		0.00	0.00	0.00	0.00
15.JAFER	G	10.58		0.00	0.82	0.00	0.82
TOTAL		513.96		23.49	286.98	6.00	316.47

NOTE: WHEN BASE FLOW = ZERO, SPRING DISCHARGE CONSIDERED
NOTE: WASTEWATER INCLUDED WITHIN BASE FLOW MEASURMENTS
(1) 4.26 MCM FROM KAC TO AMMAN
(2) WATER FROM W.NUMEIRA FOR POTASH INDUSTRY
(3) WATER FROM W.HASA FOR POTASH INDUSTRY

Table 3-10. SURFACE WATER RESOURSES AND USES IN 1990

Basin Name	Basin IDN	Total Resources (MCM)	Uses (MCM)			Total Uses (MCM)	Remarks
			Municipal	Irrigatior	Industry		
1.YARMOUK AT ADASIYA	AD	174.70	9.39	82.40	0.51	92.30	9.39(1)
2.GHOR -JORDAN VALLEY	AB1	21.95	0.10	17.72	0.00	17.82	
3.N.JORDAN R.SIDE WADIS	A1	45.71	4.95	52.64	0.00	57.59	
-INTER CATCHMENT	AB2	8.52	0.00	15.00	0.00	15.00	
-WADI ARAB	AE	4.43	0.00	25.45	0.00	25.45	
-WADI ZIGLAB	AF	7.38	0.00	6.51	0.00	6.51	
-WADI JURAM	AG	6.36	1.21	3.83	0.00	5.04	
-WADI YABIS	AH	2.36	1.31	0.23	0.00	1.54	
-WADI KUFRINJA	AJ	4.68	2.42	0.96	0.00	3.38	
-WADI RAJIB	AK	4.10	0.00	0.66	0.00	0.66	
4.S.JORDAN R.SIDE WADIS	A2	31.39	8.75	15.43	0.00	24.18	
-INTER CATCHMENTS	AB3	3.64	0.00	0.00	0.00	0.00	
-WADI SHUEIB	AM	6.85	6.18	3.19	0.00	9.37	
-WADI KAFRAIN	AN	10.36	2.57	9.07	0.00	11.64	
-WADI HISBAN	AP	4.37	0.00	3.17	0.00	3.17	
5. ZARQA RIVER	AL	61.43	6.50	77.22	0.00	83.72	
6.DEAD SEA	C	60.11	1.22	31.09	2.55	34.86	
-INTER CATCHMENTS	CA	23.85	0.07	17.99	2.55	20.61	2.55(2)
-ZERQA MAEIN	CC	13.96	0.00	0.00	0.00	0.00	
-KARAK	CE	9.68	1.15	13.10	0.00	14.25	
7.MUJIB	CD	46.39	0.00	8.27	0.00	8.27	
8.HASA	CF	35.89	0.25	19.64	1.45	21.34	1.45(3)
9.N. WADI ARABA	D	15.07	0.00	7.24	1.31	8.55	
-INTER CATCHMENTS	DA	1.78	0.00	0.20	1.31	1.51	
-FEIFA	DB	5.02	0.00	3.63	0.00	3.63	
-KHANZERA	DC	3.13	0.00	1.20	0.00	1.20	
-DAHEL	DD	0.48	0.00	0.02	0.00	0.02	
-FIDAN	DE	3.00	0.00	1.14	0.00	1.14	
-BOWEIRDA	DF	2.10	0.00	0.13	0.00	0.13	
-MUSA	DG	0.81	0.00	0.80	0.00	0.80	
-HAWOR	DH	0.32	0.00	0.12	0.00	0.12	
10.S. WADI ARABA	E	5.74	0.00	3.03	0.00	3.03	
-INTER CATCHMENTS	EA	2.71	0.00	1.84	0.00	1.84	
-ABU BARQA	EB	0.14	0.00	0.07	0.00	0.07	
-ROUKAIA	EC	0.05	0.00	0.00	0.00	0.00	
-WADI YUTUM	ED	2.32	0.00	1.12	0.00	1.12	
11.SOUTHERN DESERT	K+ED12	1.69	0.00	0.05	0.00	0.05	
12.AZRAQ	F	14.01	0.00	2.32	0.00	2.32	
13.SIRHAN	J	4.45	0.00	0.00	0.00	0.00	
14.HAMAD	H	24.61	0.00	0.00	0.00	0.00	
15.JAFER	G	5.92	0.00	0.81	0.00	0.81	
TOTAL		549.06	31.16	317.86	5.82	354.84	

NOTE: WHEN BASE FLOW = ZERO, SPRING DISCHARGE CONSIDERED
NOTE: WASTEWATER INCLUDED WITHIN BASE FLOW MEASURMENTS
(1)9.39 MCM FROM KAC TO AMMAN
(2)WATER FROM W.NUMEIRA FOR POTASH INDUSTRY
(3)WATER FROM W.HASA FOR POTASH INDUSTRY

Table 3-11. SURFACE WATER RESOURCES AND USES IN 1989

Basin Name	Basin IDN	Total Resources (MCM)	Uses (MCM)			Total Uses (MCM)	Remarks
			Municipal	Irrigation	Industry		
YARMOUK	AD	204.48	10.76	83.64	0.51	94.91	9.5 (1)
GHOR NEAR J. RIVER	AB1	23.73	0.08	15.13	0.00	15.21	
RIFT-SIDE WADIS near ZARQA RIVER	A1	43.98	3.63	34.46	0.00	38.09	
RESTRICTED AREAS	AB2	7.90	0.00	9.64	0.00	9.64	
B W.ARAB	AE	6.57	0.00	13.19	0.00	13.19	
C W.ZIGLAB	AF	8.15	0.00	5.97	0.00	5.97	
D W.JURUM	AG	9.49	1.13	3.46	0.00	4.59	
E W.YABIS	AH	3.45	1.49	0.25	0.00	1.74	
F W.KUFRINJA	AJ	4.33	1.01	1.02	0.00	2.03	
G W.RAJIB	AK	4.09	0.00	0.93	0.00	0.93	
S.WADIS S.ZERQA RIVER	A2	24.34	8.14	15.54	0.00	23.68	
A RESTRICTED AREAS	AB3	3.50	0.08	0.00	0.00	0.08	
B W.SHUIB	AM	6.69	4.98	3.30	0.00	8.28	
C W.KAFREIN	AN	9.98	3.08	6.12	0.00	9.20	
D W.HISBAN	AP	4.17	0.00	6.12	0.00	6.12	
R.ZERQA	AL	65.31	7.60	72.78	0.00	80.38	
DEAD SEA S.WADIS	C	63.05	0.97	28.48	2.33	31.78	
A RESTRICTED AREAS (I.HAM & O.)	CA	32.40	0.15	17.18	2.33	19.66	2.33(2)
B Z.MAEIN	CC	21.96	0.00	0.00	0.00	0.00	
C W.KARAK	CE	8.69	0.82	11.30	0.00	12.12	
MUJIB & WALA	CD	80.49	0.00	6.00	0.00	6.00	
HASA	CF	43.84	0.48	17.67	1.48	19.63	1.48(3)
N.W.ARABA	D	11.97	0.00	6.01	0.99	7.00	
A REISTRICTED AREAS	DA	0.99	0.00	0.17	0.99	1.16	
B W. FEIFA	DB	4.79	0.00	2.89	0.00	2.89	
C W.KUNEIZERH	DC	1.90	0.00	0.96	0.00	0.96	
D W.DAHEL	DD	0.10	0.00	0.02	0.00	0.02	
E W.FIDAN	DE	2.37	0.00	1.14	0.00	1.14	
F W.BWEIRDH	DF	0.96	0.00	0.13	0.00	0.13	
G W.MUSA	DG	1.30	0.00	0.58	0.00	0.58	
H W.HUWWAR	DH	0.28	0.00	0.12	0.00	0.12	
0 S.W.ARABA	E	5.01	0.00	2.87	0.00	2.87	
A REISTRICTED AREAS	EA	2.64	0.00	1.84	0.00	1.84	
B W.ABU BARQA	EB	0.19	0.00	0.07	0.00	0.07	
C W.RUKAYA	EC	0.35	0.00	0.00	0.00	0.00	
D W.YUTUM	ED	1.83	0.00	0.91	0.00	0.91	
.1 S.DESEARTS & Q. DISI	K & ED12	2.15	0.00	0.05	0.00	0 05	
.2 AZRAQ	F	22.14	0.00	2.32	0.00	2.32	
.3 SIRHAN	J	5.95	0.00	0.00	0.00	0.00	
.4 HAMAD	H	27.33	0.00	0.00	0.00	0.00	
.5 JAFER	G	7.55	0.00	0.64	0.00	0.64	
TOTAL		631.32	31.66	285.59	5.31	322.56	

NOTE: WHEN BASEFLOW = ZERO, SPRING DISCHARGE CONSIDERED
NOTE: WASTEWATER INCLUDED WITHIN BASEFLOW MEASURMENTS
(1) 9.5 MCM FROM KAC TO AMMAN
(2) WATER FROM W.NUMEIRA FOR POTASH INDUSTRY
(3) WATER FROM W.HASA FOR POTASH INDUSTRY
NOTE: MUN. WATER USED FROM SPRINGS NOT INCLUDED IN WATER RESOURCES

Table 3-12. LONG TERM AVERAGE SURFACE WATER RESOURCES AND USES (1963-1989)

	Basin Name	Basin IDN	Basin Area KM*2	Precipitation (MCM)	Base Flow (MCM)	Flood Flow (MCM)	Spring Flow (MCM at source)(1)	Wastewater Return Flow (MCM)(2)	Remarks	Total Resources (MCM)	Uses (MCM) Municipal	Uses (MCM) Irrigation	Uses (MCM) Industry	Total Use (MCM)	Remarks
	RESOURCES										*USES*				
1	YARMOUK	AD	6974.00	2738.00	273.00	147.00	21.40	0.47		420.00	9.65	115.00	0.00	124.65	9.65(3)
A)	SYRIAN PART		5548.00												
B)	JORDAN PART		1426.00												
2	GHOR NEAR JORDAN RIVER	AB1	780.00	140.00	0.00	2.40	19.30	0.00	19.30(1)	21.70	0.08	19.00	0.00	19.08	
3	RIFT SIDE WADIS near ZARQA RIVER	A1	946.00	442.80	36.07	13.91	49.33	1.32		49.98	3.63	56.26	0.00	59.89	
A	RESTRICTED AREAS	AB2	257.00	80.00	5.10	4.54	8.33	0.00		9.64	0.00	13.50	0.00	13.50	
B	W.ARAB	AE	246.00	130.60	1.15	5.00	0.34	1.18		6.15	0.00	6.49	0.00	6.49	
C	W.ZIGLAB	AF	100.00	49.00	7.63	0.23	0.05	0.00		7.86	0.00	7.86	0.00	7.86	
D	W.JURUM	AG	23.00	9.00	10.27	0.20	10.27	0.00		10.47	1.13	9.14	0.00	10.27	
E	W.YABIS	AH	122.00	65.40	2.62	1.63	4.57	0.00		4.25	1.49	3.08	0.00	4.57	
F	W.KUFRINJA	AJ	103.00	61.20	5.88	1.00	12.70	0.14		6.88	1.01	11.69	0.00	12.70	
G	W.RAJIB	AK	95.00	47.60	3.42	1.31	2.10	0.00		4.73	0.00	4.50	0.00	4.50	
4	SIDE WADIS south of ZARQA RIVER	A2	736.00	241.20	24.76	8.47	28.90	1.24		33.23	6.98	31.87	0.00	38.85	
A	RESTRICTED AREAS	AB3	296.00	64.80	1.40	2.13	0.00	0.00		3.53	0.00	1.40	0.00	1.40	
B	W.SHUIB	AM	193.00	76.80	5.60	1.80	9.10	1.24		7.40	3.90	8.26	0.00	12.16	
C	W.KAFREIN	AN	159.00	75.60	13.44	3.53	12.30	0.00		16.97	3.08	14.71	0.00	17.79	
D	W.HISBAN	AP	88.00	24.00	4.32	1.01	7.50	0.00		5.33	0.00	7.50	0.00	7.50	
5	R.ZARQA	AL	4154.00	980.00	33.51	25.67	38.91	31.11		59.18	7.60	61.18	0.00	68.78	
A)	SYRIAN PART		415.00												
B)	JORDAN PART		3739.00												
6	DEAD SEA SIDE WADIS	C	1508.00	303.70	53.95	7.20	57.60	0.17		61.15	1.25	28.19	0.00	29.44	
A	RESTRICTED AREAS (LUAM & C)	CA	1040.00	184.50	29.88	1.03	29.30	0.00		30.91	0.76	17.18	1.64	19.58	1.64(4)
B	Z.MAEIN	CC	269.00	70.70	17.74	3.00	17.00	0.00		20.74	0.00	0.00	0.00	0.00	
C	W.KARAK	CE	199.00	48.50	6.33	3.17	11.30	0.17		9.50	0.49	11.01	0.00	11.50	
7	MUJIB & WALA	CD	6727.00	899.00	38.10	45.54	16.00	0.25		83.64	0.00	6.00	0.00	6.00	
8	HASA	CF	2603.00	296.00	27.40	9.04	3.90	0.00		36.44	0.48	30.80	0.08	31.36	0.08(5)

Table 3-12. LONG TERM AVERAGE SURFACE WATER RESOURCES AND USES (1963-1989)

	Basin Name	Basin IDN	Basin Area KM*2	Precipitation (MCM)	Base Flow (MCM)	Flood Flow (MCM)	Spring Flow (MCM at source)(1)	Wastewater Return Flow (MCM)(2)	Remarks	Total Resources (MCM)	Uses (MCM) Municipal	Uses (MCM) Irrigation	Uses (MCM) Industry	Total Use (MCM)	Remarks
			RESOURCES								USES				
9	NORTH WADI ARABA	D	2953.00	494.00	8.99	2.57	15.63	0.12		18.20	0.00	15.75	0.00	15.75	
A	RESTRICTED AREAS	DA	1257.00	91.40	0.80	0.19	3.10	0.00		3.29	0.00	3.10	0.00	3.10	
B	W. FEIFA	DB	162.00	52.00	4.31	0.26	7.43	0.12		7.69	0.00	7.55	0.00	7.55	
C	W.KUNEIZERH	DC	217.00	49.20	1.44	0.42	2.32	0.00		2.74	0.00	2.32	0.00	2.32	
D	W.DAHEL	DD	107.00	22.50	0.00	0.23	0.03	0.00		0.26	0.00	0.03	0.00	0.03	
E	W.FIDAN	DE	287.00	72.80	1.64	0.38	1.70	0.00		2.08	0.00	1.70	0.00	1.70	
F	W.BWEIRDH	DF	513.00	132.70	0.80	0.16	0.08	0.00		0.96	0.00	0.08	0.00	0.08	
G	W.MUSA	DG	165.00	32.00	0.00	0.70	0.88	0.00		1.58	0.00	0.88	0.00	0.88	
H	W.HUWWAR	DH	245.00	41.40	0.00	0.23	0.09	0.00		0.32	0.00	0.09	0.00	0.09	
10	SOUTH WADI ARABA	E	3742.00	234.50	0.00	3.16	2.44	1.37		5.60	0.00	3.06	0.00	3.06	
A	RESTRICTED AREAS	EA	1068.00	62.20	0.00	0.80	1.84	0.00		2.64	0.00	1.84	0.00	1.84	
B	W.ABU BARQA	EB	141.00	18.40	0.00	0.37	0.60	0.00		0.97	0.00	0.60	0.00	0.60	
C	W.RUKAYA	EC	210.00	22.80	0.00	0.19	0.00	0.00		0.19	0.00	0.00	0.00	0.00	
D	W.YUTUM	ED	2323.00	131.10	0.00	1.80	0.00	1.37		1.80	0.00	0.62	0.00	0.62	
11	SOUTH DESERTS & Q. DISI	K & ED12	6296.00	240.90	0.00	2.15	0.05	0.00		2.20	0.00	0.05	0.00	0.05	
12	AZRAQ	F	13173.00	839.00	0.00	25.80	8.00	0.00		34.80	0.00	0.00	0.00	0.00	
A)	SYRIAN PART		773.00												
B)	JORDAN PART		12400.00												
13	SIRHAN	J	15733.00	353.00	0.00	10.00	0.00	0.00		10.00	0.00	0.00	0.00	0.00	
14	HAMAD	H	18047.00	1968.00	0.00	13.00	0.00	0.00		13.00	0.00	0.00	0.00	0.00	
15	JAFER	G	12363.00	552.00	0.00	10.00	1.92	0.00		11.29	0.00	1.29	0.00	1.29	
	TOTAL JORDAN PART		90000.00												
	TOTAL BASINS AREA		96735.00	10722.00	495.78	326.91	263.38	36.05	36.05(2)	860.41	29.67	368.45	1.72	399.84	

NOTE: MUNICIPAL WATER USED FROM SPRINGS NOT INCLUDED IN WATER RESOURCES

(1) WHEN BASE FLOW = ZERO, SPRING DISCHARGE CONSIDERED IN TOTAL RESOURCES

(2) WASTEWATER INCLUDED WITHIN BASE FLOW MEASUREMENTS

(3) 9.5 MCM FROM KAC TO AMMAN

(4) WATER FROM W.NUMEIRA FOR POTASH INDUSTRY

(5) WATER FROM W.HASA FOR POTASH INDUSTRY

Table 3-13. Ground Water Monitoring Wells for Static Water Level Measurements

SEQUENCE NUMBER	WELL NAME	WAJ ID #	COORDINATES East	North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	MEASUREMENT METHOD	GROUND WATER BASIN
1	ADAYSIYA NO. 19	AB 1164	205.400	225.720	-216.0	85.0	18.76	1056	Alluvium	MANUAL	JORDAN VALLEY
2	ADAYSIYA NO. 2	AB 1166	208.060	231.500	-270.0	140.0	5.03	2688	Alluvium	MANUAL	JORDAN VALLEY
3	ADAYSIYA NO. 23	AB 1168	204.070	225.440	-214.3	171.0	21.80	4480	Alluvium	MANUAL	JORDAN VALLEY
4	DEIR ALLA NO. 6	AB 1170	208.370	177.069	-216.0	65.0	13.90	4800	Alluvium	MANUAL	JORDAN VALLEY
5	RAMA/NAUR ROAD WELL	AB 1338	211.740	136.090	-211.0				Alluvium		JORDAN VALLEY
6	S. SHOONEH WELL	AB 1340	206.900	144.630	-250.0	97.0		633	Alluvium		JORDAN VALLEY
7	KARAMEH WELL	AB 1341	205.250	149.550	-258.0	105.0			Alluvium		JORDAN VALLEY
8	SUWEIMA NO. 11	AB 1342	206.525	128.415					Alluvium		JORDAN VALLEY
9	DEIR ALLA NO. 7	AB 1343	208.915	177.145	-221.6	60.0	39.00		Alluvium	MANUAL	JORDAN VALLEY
10	WADI AL YABIS NO. 1	AB 1364	215.250	201.300	340.0	560.0	FLOWING	441	A2		SIDE CATCHMENTS
11	SOMAYA 4	AD 1122	266.790	207.260	601.0	246.0	115.00	422	B2/A7		YARMOUK
12	SOMAYA 1 (MOQBEL)	AD 1148	264.360	204.060	622.0	250.0	138.79	592	B2/A7	RECORDER	YARMOUK
13	SOMAYA 2 (TORQY)	AD 1149	264.840	208.590	596.0	289.0	111.89	969	B2/A7	RECORDER	YARMOUK
14	SOMAYA 3 (WARWEER)	AD 1150	264.860	206.090	608.3	265.0	126.29		B2/A7	RECORDER	YARMOUK
15	YAMMON	AD 1233	235.884	200.679	782.7	267	137.6	422	A7	MANUAL	YARMOUK
16	MAQARIN NO. 2	AD 1277	232.600	236.988	91.0	247.0	51.05	1216	B2	RECORDER	YARMOUK
17	MUKHEIBA (JRV NO. 1)	AD 1284	214.700	234.500	-70.0	1238.0	11.08	797	B2/A7	MANUAL	YARMOUK
18	JABER	AD 1327	263.000	213.000	610.0	264.0	112.88	621	B2/A7	RECORDER	YARMOUK
19	KUFR ASAD NO. 1	AE 1003	217.050	225.750	106.0	263.0	46.30	557	B2/A7	RECORDER	SIDE CATCHMENTS
20	T. FAHEL NO. 2	AG 1003	208.800	207.600	-20.0	210.0	37.28	1150	B1/B2	MANUAL	SIDE CATCHMENTS
21	D.P.5/DHULEIL	AL 1006	263.800	177.200	569.7	200.0	68.42		B2/A7	RECORDER	AMMAN-ZERQA
22	T.W.5/DHULEIL	AL 1040	271.100	177.900	595.6	165.0	90.30		B2/A7	RECORDER	AMMAN-ZERQA
23	T.W.6/DHULEIL	AL 1041	272.400	171.450	567.6	155.0	50.00		B2/A7	RECORDER	AMMAN-ZERQA
24	T.W.15/DHULEIL	AL 1043	267.100	171.500	557.6	234.0	45.75		B2/A7	RECORDER	AMMAN-ZERQA
25	BAQ'A (2) EAST	AL 1425	229.770	165.403	633.4	214.0	119.6		K	MANUAL	AMMAN-ZERQA
26	BAQ'A(3)	AL 1430	229.021	165.035	631.0	276.0	151.45		K	RECORDER	AMMAN-ZERQA
27	RUSEIFA SPRING(8)	AL 1444	245.970	158.550	646.0		6.73		Alluvium	RECORDER	AMMAN-ZERQA
28	BAEJI(HUSSEIN AIRFORCE BASE)	AL 1521	270.660	193.480	629.0	246.0	168.00		B2/A7	RECORDER	AMMAN-ZERQA
29	BAQ'A(11)	AL 1539	230.160	162.620	700.0	252.0	158.30		K	MANUAL	AMMAN-ZERQA
30	BAQ'A(9)	AL 1541	231.100	164.530	678.6	202.0	153.30		K	MANUAL	AMMAN-ZERQA
31	AWAJAN	AL 1734	255.050	157.750	595.0	155.0	22.38		B2/A7	RECORDER	AMMAN-ZERQA
32	BAQ'A(A6)	AL 1892	230.300	163.750	622.0	180.0	28.40		K	MANUAL	AMMAN-ZERQA
33	KM 97.5	AL 1928	287.650	186.500	748.4	480.0	227.42		Basalt	RECORDER	AMMAN-ZERQA
34	SEBAQ CLUB(13)	AL 2333	247.300	155.100			101.58		A4	RECORDER	AMMAN-ZERQA
35	KM 107	AL 2689	298.800	182.700	790.0	395.0	245.00		Basalt/B2/A7	MANUAL	AMMAN-ZERQA
36	BA'E J2	AL 2695	279.000	200.030	718.5	261.0	223.57		B2/A7	MANUAL	AMMAN-ZERQA
37	HOSSAYNIAT	AL 2697	275.200	189.940	651.7	270.0	138.25		B2/A7	RECORDER	AMMAN-ZERQA
38	HALLABAT OWI	AL 2698	281.000	169.120	590.0	120.0	65.22		Basalt	RECORDER	AMMAN-ZERQA
39	HASHEMIYA(6)	AL 2699	256.860	170.340			54.90		B2/A7	RECORDER	AMMAN-ZERQA
40	SAMRA 1	AL 2700	258.190	173.100	524.3	92.0	16.60		Alluvium/B2/A7	RECORDER	AMMAN-ZERQA

Table 3-13. Ground Water Monitoring Wells for Static Water Level Measurements

SEQUENCE NUMBER	WELL NAME	WAJ ID #	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	MEASUREMENT METHOD	GROUND WATER BASIN
41	SAMRA 3	AL 2702	255.760	172.120	506.2	95.0	19.52		Alluvium/B2/A7	RECORDER	AMMAN-ZERQA
42	BAQ'A (12)	AL 2719	230.100	164.550	624.0	159.0	96.95		K	MANUAL	AMMAN-ZERQA
43	KAFRAIN WELL	AM 1032	210.600	139.560	-228.6	73.0			K		JORDAN VALLEY
44	SIWAQA 2	CD 1005	254.350	86.200	747.0	400.0	100.30		B2/A7	RECORDER	DEAD SEA (MUJIB)
45	SIWAQA-3	CD 1010	252.700	88.870		108.0	78.76	612	B2/A7	MANUAL	DEAD SEA (MUJIB)
46	QATRANA-9	CD 1012	249.440	76.120	780.0	223.0	102.62	632	B2/A7	MANUAL	DEAD SEA (MUJIB)
47	QATRANA 14	CD 1013	249.500	75.750	765.0	232.0	97.55	770	B2/A7	MANUAL	DEAD SEA (MUJIB)
48	SIWAQA-1	CD 1114	251.330	86.900	719.0	74.0	57.65	608	B2/A7	MANUAL	DEAD SEA (MUJIB)
49	SIWAQA-7	CD 1120	252.950	87.050	727.0	246.0	63.30	563	B2/A7	MANUAL	DEAD SEA (MUJIB)
50	SIWAQA-5	CD 1118	253.300	86.870	727.0	170.0	79.15	832	B2/A7	MANUAL	DEAD SEA (MUJIB)
51	EAST QATRANA-2	CD 1026	249.340	72.400	805.0	314.0	98.00		B2/A7	MANUAL	DEAD SEA (MUJIB)
52	QASTAL-6	CD 1074	242.750	131.700	734.0	363.0	151.75	480	B2/A7	RECORDER	DEAD SEA (MUJIB)
53	QASTAL-7	CD 1075	238.300	131.400	750.0	325.0	175.00		B2/A7	RECORDER	DEAD SEA (MUJIB)
54	WALA-11	CD 1097	219.900	107.530	344.0	200.5	9.20		B2/A7	RECORDER	DEAD SEA (MUJIB)
55	WALA-14	CD 1100	223.900	107.050	476.5	246.0	26.23	864	B2/A7	RECORDER	DEAD SEA (MUJIB)
56	DHAB'A-S70	CD 1136	249.800	104.040	740.0	201.0	153.00	1400	B2/A7	RECORDER	DEAD SEA (MUJIB)
57	WADI EL HAMMAM	CD 1137	246.280	110.430	710.0	170.0	90.00	1154	B2/A7	MANUAL	DEAD SEA (MUJIB)
58	LAJJUN-2	CD 1153	224.940	67.710	873.0	235.0	121.00		B2/A7	RECORDER	DEAD SEA (MUJIB)
59	SOLTANI-S66	CD 1174	246.280	59.080	835.1	97.0	84.75	732	B2/A7	MANUAL	DEAD SEA (MUJIB)
60	WADI AL ABIAD NO. 3	CD 1182	248.800	46.000	855.0	232.0	95.79	729	B2/A7	RECORDER	DEAD SEA (MUJIB)
61	ERNEIBEH NO. 4	CD 1197	242.400	118.410	714.0	305.0	166.65		B2/A7	RECORDER	DEAD SEA (MUJIB)
62	BREAKA NO. 1	CD 1212	253.600	115.500	709.0	347.0	161.40	1619	B2/A7	RECORDER	DEAD SEA (MUJIB)
63	UM RASSAS NO. 1	CD 1213	243.000	98.000	767.0	320.0	195.80		B2/A7	RECORDER	DEAD SEA (MUJIB)
64	QATRANA-S124	CD 1214	249.300	73.250	800.0		94.56		B2/A7	RECORDER	DEAD SEA (MUJIB)
65	SIWAQA 23	CD 1377	251.400	80.800		350.0	115.37	653	B2/A7	MANUAL	DEAD SEA (MUJIB)
66	UM HL-BASATIN	CD 3116				220.0	130.40		B2/A7	MANUAL	DEAD SEA (MUJIB)
67	FALIQ 3	CD 3182	258.500	88.500		202.0			B2/A7	RECORDER	DEAD SEA (MUJIB)
68	HASA-15	CF 1074	248.300	27.200	903.0	230.0	106.00	4350	B2/A7	RECORDER	DEAD SEA (HASA)
69	TELL BURMA (S121)	CF 1078	228.700	2.080	1046.0	171.0	58.18	422	B2	RECORDER	DEAD SEA (HASA)
70	FEIFA NO. 11	DA 1019	192.440	38.640	-340.0	54.0	21.65	665	Alluvium	RECORDER	JORDAN VALLEY
71	WADI MUSA NO. 5	DA 1023	180.490	977.090	251.8	341.0	80.48	717	Alluvium	RECORDER	JORDAN VALLEY
72	WADI MUSA NO. 9	DA 1026	179.450	987.300	213.0	150.0	72.22		Alluvium	RECORDER	JORDAN VALLEY
73	SAFI NO. 7	DA 1033	195.610	48.060	-342.0	82.0	24.40	742	Alluvium	RECORDER	JORDAN VALLEY
74	SAFI NO. 3	DA 1038	194.480	50.650	-376.5	46.0	0.80	544	Alluvium	RECORDER	JORDAN VALLEY
75	UM MITHLA NO. 4	DF 1000	180.820	981.200	178.2	208.0	111.53	1516	Alluvium/B2/K	RECORDER	JORDAN VALLEY
76	UM MITHLA 1-B	DF 1003	178.900	986.300	110.0	89.0	42.66	1350	Alluvium	RECORDER	JORDAN VALLEY
77	QA'ASAID NO. 5	EA 1011	170.750	951.950	202.0				Alluvium		JORDAN VALLEY
78	YUTUM-8	EA 1018	157.130	887.140	233.0	49.5	17.30	672	Alluvium	RECORDER	S. WADI ARABA (YUTOM
79	AQABA-8	EA 1019	147.930	886.740	23.3	40.0	4.62		Alluvium	RECORDER	S. WADI ARABA (YUTOM
80	AQABA-7	EA 1020	149.050	886.020	23.0	40.0	7.78		Alluvium	RECORDER	S. WADI ARABA (YUTOM

Table 3-13. Ground Water Monitoring Wells for Static Water Level Measurements

SEQUENCE NUMBER	WELL NAME	WAJ ID #	COORDINATES East	North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	MEASUREMENT METHOD	GROUND WATER BASIN
81	DISI-M2	ED 1202	205.950	895.410	801.1	342.0	76.82	240	DISI	RECORDER	S. WADI ARABA (YUTOM
82	DISI-M3	ED 1203	214.400	887.350	820.2	270.0	87.60	192	DISI	RECORDER	S. WADI ARABA (YUTOM
83	DISI-M4	ED 1204	196.270	897.040	789.9	224.0	76.73	202	DISI	RECORDER	S. WADI ARABA (YUTOM
84	SAHL SUWAN S3	ED 1303	217.500	884.500	825.0	163.0	85.50	237	DISI	RECORDER	S. WADI ARABA (YUTOM
85	QA'A KHRAIM S28	ED 1328	223.900	877.900	850.0	157.0	96.75	233	DISI	RECORDER	S. WADI ARABA (YUTOM
86	AZ-11/AZRAQ	F 1022	320.300	141.340	520.0	88.0	13.43		B5/B4	RECORDER	AZRAQ
87	AZ-12/AZRAQ	F 1043	322.395	149.404	517.0	255.0	4.50	510	B5/B4	RECORDER	AZRAQ
88	AZ-10/AZRAQ	F 1060	336.710	140.290	521.0	116.0	4.95	1056	B5/B4	RECORDER	AZRAQ
89	KM 136	F 1125	323.900	173.850	802.0	310.0	306.00		Basalt/B2/A7	MANUAL	AZRAQ
90	OB.2/AZRAQ	F 1280	323.783	147.863	514.0	195.3	1.30		B5/B4	RECORDER	AZRAQ
91	WADI AL BUSHRIYA	F 1308	320.920	165.870	710.0	275.0	184.20		B5/B4	MANUAL	AZRAQ
92	UTHRUH NO. 4 (S118)	G 1345	206.790	969.710	1302.0	259.0	38.68	774	B2	RECORDER	JAFR
93	HAMMAD PRODUCTION NO. 3	H 1006	448.500	199.300					B4	MANUAL	HAMMAD
94	HAMMAD PRODUCTION NO. 2	H 1055	440.500	223.500	670.0				B4	MANUAL	HAMMAD
95	CHINESE CO.	H 1058	470.900	220.100					B4	MANUAL	HAMMAD
96	ROWAISHED BR 3	H 1060	453.000	217.800					B4	MANUAL	HAMMAD
97	WADI AL GOSEAN	H 1116	417.930	203.060					B4	MANUAL	HAMMAD
98	HAMMAD PRODUCTION NO. 4	H 2011	435.000	186.500	721.0				B4	MANUAL	HAMMAD
99	ROWAISHED BR 2	H 1012	459.100	221.620					B4	MANUAL	HAMMAD
100	H4M2	H 2017	437.725	211.650	670.9	180.0	138.66		B4	RECORDER	HAMMAD
101	MOHAISH S36	K 1005	234.000	866.000	816.0	264.0	67.00	249	DISI	RECORDER	EAST DESERT

NOTES 10 Electronic recorders have been installed in Azraq for monitoring the deep aquifer (B2/A7)
Those wells are not included in Table 3-13.

Table 3-14. Ground Water Quality Monitoring Wells

SEQUENCE NUMBER	Well ID #	WELL NAME	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	ANALYSIS TYPE
1	AD 1105	TAWEELEH	263.975	200.015	656.00	334	106.80	806	B2/A7	BIO&CHEM
2	AD 1120	SAMA EL SIRHAN WSC 2	264.840	202.555	610.20	240	127.00	467	B2/A7	CHEMICAL
3	AD 1121	SAMA EL SIRHAN WSC 3	266.440	207.265	598.00	248	113.60	425	B2/A7	CHEMICAL
4	AD 1123	SAMA EL SIRHAN WSC 5	266.340	207.715	596.00	215	110.80	467	B2/A7	CHEMICAL
5	AD 1124	SAMA EL SIRHAN WSC 6	265.980	207.685	597.10	221	113.88	480	B2/A7	CHEMICAL
6	AD 1126	SAMA EL SIRHAN WSC 8	267.550	207.660	605.00	223	113.96	420	B2/A7	CHEMICAL
7	AD 1127	SAMA EL SIRHAN WSC 9	267.500	207.040	608.60	222	120.70	416	B2/A7	CHEMICAL
8	AD 1219	NAYMEH 1	232.200	208.800	680.00	196	173.50	380	A7	CHEMICAL
9	AD 1239	SAHAM	221.870	234.340	335.00	305	13.40	397	B4	CHEMICAL
10	AD 1262	SWEALMEH	258.860	211.775	631.00	385	169.60	518	B2/A7	CHEMICAL
11	AD 1273	SOHAEL TAL	264.160	203.700	619.00	270		512	B2/A7	BIO&CHEM
12	AD 0536	RAHOOB SPRING	237.600	223.600	450.00			300	B4	CHEMICAL
13	AE 1001	KUFOR YOUBA	224.000	215.150	495.00	287	160.04	301	A7	CHEMICAL
14	AE 1004	FOARA	224.350	223.350	380.00	370		422	A7	CHEMICAL
15	AE 1007	WADI AL ARAB 1	211.947	224.188	11.00				B2/A7	CHEM&BIO
16	AE 1008	WADI AL ARAB 2	212.150	225.150	-26.00				B2/A7	CHEM&BIO
17	AE 1009	WADI AL ARAB 3	212.650	225.600	-20.00				B2/A7	CHEM&BIO
18	AE 1010	WADI AL ARAB 4	213.300	226.500	27.00				B2/A7	CHEM&BIO
19	AE 1011	WADI AL ARAB 5	212.850	222.550	50.00				B2/A7	CHEM&BIO
20	AF 1001	DIER ABU SAID SPRING	216.300	212.600	200.00	326	33.19	492	B2/A7	CHEMICAL
21	AJ 0520	QANTARA SPRING	220.100	192.100	680.00			450	A7	CHEMICAL
22	AL 1004	DP 3	260.072	176.300	560.00	175	33.70	350	A7	CHEMICAL
23	AL 1022	DHULEIL 16	273.377	175.329	582.20	165	114.60	307	Basalt	CHEMICAL
24	AL 1023	DHULEIL 17	272.636	175.165	582.20	100	58.62	320	Basalt	CHEMICAL
25	AL 1026	DHULEIL 20	273.651	174.611	578.30	100	62.20	2755	Basalt	CHEMICAL
26	AL 1030	DHULEIL 24	276.450	173.739	522.20	100	69.12	301	Basalt	CHEMICAL
27	AL 1032	DHULEIL 25	274.316	173.938	584.00	150	78.00		Basalt	CHEMICAL
28	AL 1033	DHULEIL 26	275.524	173.121	585.70	98	61.39	429	Basalt	CHEMICAL
29	AL 1156	KM95(BAKDAD6)	285.000	186.500	732.40	725	211.73	269	Basalt/B2/A	CHEMICAL
30	AL 1193	KM94(AQIB2)	283.545	188.075	723.00	305	183.25	382	Basalt/B2	CHEMICAL
31	AL 1225	KM104(BAQDAD4)	294.600	184.300	789.70	374	268.00	237	Basalt/B2/A	CHEMICAL
32	AL 1235	KM109(AQIB5)	299.220	182.600	788.40	344	264.40	224	Basalt/B2/A	CHEMICAL
33	AL 1265	KM101(AQIB7)	287.500	186.500	750.00	339	239.30	250	Basalt/B2/A	CHEMICAL
34	AL 1273	KM 102 (AQIB8)	291.250	185.350	750.00	400	243.75	200	Basalt/B2/A	CHEMICAL
35	AL 1274	KM106(AQIB10)	295.600	183.900	775.00	407	276.33	243	Basalt/B2/A	CHEMICAL

Table 3-14. Ground Water Quality Monitoring Wells

SEQUENCE NUMBER	Well ID #	WELL NAME	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	ANALYSIS TYPE
36	AL 1410	GHALIB ABO ARABI 1	228.260	166.745	655.00	202	145.60	343	B2/A7	CHEM&BIO
37	AL 1428	BAQ'A 1	230.550	164.300	681.00	194	140.40	380	K	CHEMICAL
38	AL 1432	BAQ'A 5	229.680	162.080	710.00	125	56.36	336	K	CHEMICAL
39	AL 1485	KM93(AQIB1)	282.680	186.530	708.00	268	170.93	356	B/B2	CHEMICAL
40	AL 1489	ZAATRY (3) KAZEYEH	273.060	192.700	654.00	290	211.85		B2/A7	CHEMICAL
41	AL 1493	SABHA	291.420	193.370	832.00	400	305.00	297	Basalt/B2	CHEMICAL
42	AL 1494	KM91.5	281.260	188.750	705.00			979	B2/A7	CHEMICAL
43	AL 1522	KM81	272.350	192.440	656.00	293			B2/A7	CHEMICAL
44	AL 1542	AL YAZEADYEH 3	223.500	164.000	735.00	285	22.80	380	A4	CHEMICAL
45	AL 1558	KM90	281.250	188.770	691.00	293	168.95	435	B2/A7	CHEMICAL
46	AL 1627	AL YAZEADYEH 2	223.160	163.450	860.00	252	83.00	380	A4	CHEMICAL
47	AL 1628	AL YAZEADYEH 1	221.100	162.700	860.00	276	144.89	380	A4	CHEMICAL
48	AL 1716	TANNOR SPRING	220.500	201.600	450.00			385	A4	CHEMICAL
49	AL 1720	SOOF3.CA	234.025	190.150	620.00	131	32.25	450	A1/2	CHEMICAL
50	AL 1890	ABO NSEAR (HOUSING WELL	236.000	170.000	750.00	412	147.10	470	K	CHEMICAL
51	AL 2306	JAMAL AL'BSHARAT	234.100	138.550	839.00	213	109.60		B2/A7	CHEM&BIO
52	AL 2312	SA'UD SHAHIR	240.670	126.710	710.00	245	155.70	310	B2/A7	CHEM&BIO
53	AL 2360	RAYASHY 2	237.200	184.750	519.00	360	79.20	580	A2	CHEMICAL
54	AL 2709	ALHARARA	290.080	191.300	710.00			288	Basalt/B2/A	CHEMICAL
55	AL 2717	EAST SOOF 3	224.300	190.150	625.00	131	32.25	405	A2	CHEMICAL
56	AL 3004	KM94.5	285.050	178.500	726.50	450		250	Basalt/B2	CHEMICAL
57	AL 3027	AM ALJAMAL (4)	277.840	190.024	662.00	290	141.90	454	B2/A7	CHEMICAL
58	AL 3126	EAST HALABAT 2	278.896	166.428	590.00	134	74.16		B2	CHEMICAL
59	AL 3127	EAST HALABAT 3	278.400	166.400	590.00	160	77.00		B2	CHEMICAL
60	AM 1512	HEZEAR SPRING	219.600	158.400	560.00			450	A4	CHEMICAL
61	AM 1526	AL AZRAQ SPRING	222.050	158.810	750.00			250	A7	CHEMICAL
62	AM 1528	AL SHRAYEA SPRING	221.050	157.750	595.00			350	A4	CHEMICAL
63	AM 1530	AL BQOOREHEH SPRING	219.400	155.300	390.00			420	A4	CHEMICAL
64	CD 1005	SIWAQA 2	254.120	86.200	747.00	170	60.79	616	B2/A7	CHEM&BIO
65	CD 1006	QASTAL 2	240.630	129.650	783.00	266	98.00		B2/A7	CHEM&BIO
66	CD 1010	SIWAQA 3A	252.700	88.200	750.00	103	78.76	612	B2/A7	CHEM&BIO
67	CD 1012	QATRANA 9	249.440	76.120	780.00	104			B2/A7	CHEM&BIO
68	CD 1114	SIWAQA 1	251.330	86.900	727.00	74	67.65	608	B2/A7	CHEM&BIO
69	CD 1120	SIWAQA 7	252.950	87.360		264	63.30	563	B2/A7	CHEM&BIO
70	CD 1024	SIWAQA 5	253.300	86.870	715.00	170	79.15	832	B2/A7	CHEM&BIO

Table 3-14. Ground Water Quality Monitoring Wells

SEQUENCE NUMBER	Well ID #	WELL NAME	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	ANALYSIS TYPE
71	CD 1026	QATRANA S (2)	249.340	72.400	805.00	314	98.00		B2/A7	CHEM&BIO
72	CD 1027	SOLAYMAN M.BARBAKH	251.490	114.880		290	156.90	940	B2/A7	CHEM&BIO
73	CD 1029	SULTANI S83	246.014	56.700	829.00	187	80.00	896	B2/A7	CHEM&BIO
74	CD 1041	MAMDOOH EL FAYIZ	241.600	120.850		243	155.50	439	B2/A7	CHEM&BIO
75	CD 1046	MOTEB Z.KNAIA'N	247.790	117.595		200	139.50	576	B2/A7	CHEM&BIO
76	CD 1047	MAH'D HAMED	249.320	116.600		210	136.00	620	B2/A7	CHEM&BIO
77	CD 1051	KHOLAEF AS SA'AD	241.540	116.550		267	130.50		B2/A7	CHEM&BIO
78	CD 1055	RAKAN EL FAYIZ	245.030	119.460		243	150.80	505	B2/A7	CHEM&BIO
79	CD 1060	ALI EL FAYIZ	234.275	134.260	775.00	270	152.20	730	B2/A7	CHEM&BIO
80	CD 1064	FAWAZ ABO JABIR	235.670	135.670		263	146.00	409	B2/A7	CHEM&BIO
81	CD 1065	MONERA EL FAYIZ	235.260	130.850		236	182.40	339	B2/A7	CHEM&BIO
82	CD 1068	A'KIF EL FAYIZ	240.700	129.700		300	148.70		B2/A7	CHEM&BIO
83	CD 1070	TALAL EL FAYIZ	241.500	119.500	710.00	248	145.70	470	B2/A7	CHEM&BIO
84	CD 1072	QASTAL 4	239.080	129.340	730.00	288	156.00	416	B2/A7	CHEM&BIO
85	CD 1073	QASTAL 5	239.550	128.760	725.00	202	149.00	384	B2/A7	CHEM&BIO
86	CD 1079	QASTAL 11	239.250	130.700		205	162.42	396	B2/A7	CHEM&BIO
87	CD 1083	QASTAL 15	239.050	132.000	745.00	224	167.00		B2/A7	CHEM&BIO
88	CD 1110	QATRANA 15	248.950	75.900	780.00	233	95.79	838	B2/A7	CHEM&BIO
89	CD 1107	QATRANA 11	248.500	76.100	780.00	263	103.50	640	B2/A7	CHEM&BIO
90	CD 1144	GHUWAIR 4	220.750	62.100	1000.00	156	94.74	600	B2/A7	CHEM&BIO
91	CD 1173	SULTANI -E3	248.930	55.011	837.00	147	79.00	896	B2/A7	CHEM&BIO
92	CD 1181	ABYADH 4	247.380	47.800	850.00	180	98.40		B2/A7	CHEM&BIO
93	CD 1310	NASHMI EL-FAYIZ	233.700	131.850		227	189.10	332	B2/A7	CHEM&BIO
94	CF 1016	HASA 20	249.400	26.800	880.00	132	86.00		B2/A7	CHEM&BIO
95	CF 1017	HASA 21	250.400	26.500					B2/A7	
96	CF 1024	HASA 17	248.824	26.120		154	59.46		B2/A7	CHEM&BIO
97	CF 1056	HASA 19	249.125	26.848	848.00				B2/A7	
98	CF 1076	AL FOJAIJ 3(P55)	223.170	0.487	1116.00	229	128.00	352	B2/A7	CHEM&BIO
99	CF 1079	TELL BORMA SOUTH (S80)	229.290	1.130	1045.00	159	57.00	384	B2/A7	CHEM&BIO
100	CF 1080	TELL BORMA NORTH (S79)	228.480	2.900	1045.00	88	57.00	384	B2/A7	CHEM&BIO
101	ED 1023	AL-MORAIGHA	202.000	947.000	1400.00	247	49.20	816	B2/A7	CHEM&BIO
102	ED 1307	AL GHAL S7	208.000	882.440	805.00	692	66.68	214	DISI	CHEM&BIO
103	ED 1319	DISI S19	198.940	895.400	800.00	406	79.80	243	DISI	CHEM&BIO
104	ED 1402	DISI-IM'NESHIR 2	207.450	891.200	806.00	403	81.41	233	DISI	CHEM&BIO
105	ED 1403	DISI 3	207.160	888.320	799.00	403	72.94	320	DISI	CHEM&BIO

Table 3-14. Ground Water Quality Monitoring Wells

SEQUENCE NUMBER	Well ID #	WELL NAME	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	ANALYSIS TYPE
106	ED 1406	DISI W6	209.000	886.520	797.00	407	70.28	219	DISI	CHEM&BIO
107	ED 1408	DISI W8	211.180	887.380	798.00	402	68.81	236	DISI	CHEM&BIO
108	ED 1409	DISI W9	210.720	895.250	799.00	411	67.53	233	DISI	CHEM&BIO
109	ED 1411	DISI W11	213.120	885.460	799.00	412	67.53	204	DISI	CHEM&BIO
110	ED 1515	QUAIRA 2.PP9	181.600	909.900	773.00	227	153.00	691	DISI	CHEM&BIO
111	ED 1560	WADI YUTOM 12	159.900	885.960	338.00	73	42.00	704	SS&GR.	CHEM&BIO
112	ED 1570	WADI YUTOM 10	158.500	885.700	300.00	41	23.00	652	SS&GR.	CHEM&BIO
113	ED 1576	WADI YUTOM 16	162.600	885.000	332.00	39	36.00	640	SS&GR.	CHEM&BIO
114	ED 1585	WADI YUTOM 11.PP70	157.700	886.000	285.00	44	21.00	652	SS&GR.	CHEM&BIO
115	ED 1626	WADI YUTOM 15	162.200	884.850	422.00	121	85.34	640	SS&GR.	CHEM&BIO
116	F 1028	AZRAQ 1	321.477	150.502	537.00	203	24.76	270	B5/B4	CHEMICAL
117	F 1029	AZRAQ 2	322.143	150.334	527.00	212	14.43	278	B5/B4	CHEMICAL
118	F 1030	AZRAQ 3	322.157	149.842	521.00	210	8.48	281	B5/B4	CHEMICAL
119	F 1031	AZRAQ 4	321.861	150.959	536.00	206	24.06	297	B5/B4	CHEMICAL
120	F 1032	AZRAQ 5	321.232	151.204	541.00	204	28.45	290	B5/B4	CHEMICAL
121	F 1033	AZRAQ 6	321.828	151.459	548.00	206	29.34	250	B5/B4	CHEMICAL
122	F 1034	AZRAQ 7	323.259	149.360	516.00	204	4.58	384	B5/B4	CHEMICAL
123	F 1035	AZRAQ 8	321.508	152.443	553.00	202	41.83	332	B5/B4	CHEMICAL
124	F 1036	AZRAQ 9	323.217	150.188	525.00	204	13.00	390	B5/B4	CHEMICAL
125	F 1037	AZRAQ 10	322.749	149.872	521.00	203	7.78	473	B5/B4	CHEMICAL
126	F 1038	AZRAQ 11	322.425	149.139	517.00	61	4.86	336	B5/B4	CHEMICAL
127	F 1039	AZRAQ 12	321.723	147.792	528.00	209	16.07	288	B5/B4	CHEMICAL
128	F 1040	AZRAQ 13	321.195	148.359	532.00	205	20.70	672	B5/B4	CHEMICAL
129	F 1042	AZRAQ 15	321.182	146.909	524.00	210	12.94	281	B5/B4	CHEMICAL
130	F 1124	KM124	312.200	177.850	825.00	436	302.10	192	Basalt/B2/A	CHEMICAL
131	F 1297	KM 111	300.540	182.020	779.80	395	254.14	202	Basalt/B2/A	CHEMICAL
132	F 1305	KM134	322.300	174.500	710.90	432		333	Basalt/B2/A	CHEMICAL
133	F 1310	KM114	303.500	181.200	783.00	400	260.30	198	Basalt/B2/A	CHEMICAL
134	F 1312	KM112	301.400	181.800	787.80	400	264.85	250	Basalt/B2/A	CHEMICAL
135	CF 1027	ABOUR 1	217.450	22.250	1185.00	205	54.00	326	B2/A7	CHEM&BIO
136	CF 1037	ABOUR 2	218.300	22.900	1235.00	180	53.09		B2/A7	CHEM&BIO
137	G 1215	UDHROH 7	205.600	970.300	1325.00	259	13.78	380	B2/A7	CHEM&BIO
138	G 1220	ABUL-LASAN-S100	196.130	941.720	1450.00	165	31.00	448	B2/A7	CHEM&BIO
139	G 1230	Q'A MA'AN 1	202.800	996.300	1322.00	151	71.32	339	B2/A7	CHEM&BIO
140	G 1231	Q'A MA'AN 2	202.900	996.100	1302.00	101	54.00	345	B2/A7	CHEM&BIO

Table 3-14. Ground Water Quality Monitoring Wells

SEQUENCE NUMBER	Well ID #	WELL NAME	COORDINATES East	COORDINATES North	ELEVATION (M)	TOTAL DEPTH (M)	STATIC WATER LEVEL (M)	TDS (PPM)	AQUIFER	ANALYSIS TYPE
141	G 1235	SHOUBAK 1	203.610	991.930	1342.00	97	34.00	315	B2/A7	CHEM&BIO
142	G 1240	AL ARJA S34	214.900	982.160	1150.00	281	FLOW	473	B2/A7	CHEM&BIO
143	G 1245	TAHOONA 1	211.750	962.000	1186.00	144	95.42	576	B2/A7	CHEM&BIO
144	G 1250	ABUL-LASAN-S94	196.230	941.340	1483.00	104	20.00	640	B2/A7	CHEM&BIO
145	G 1255	AL-QORAIN	196.300	945.160	1400.00	259	19.54	480	B2/A7	CHEM&BIO
146	G 1399	UWHAIDA S60	204.100	950.500	1320.00	103	46.00	710	B2/A7	CHEM&BIO
147	G 1400	UWHAIDA S61	204.630	951.550	1322.00	95	38.00	774	B2/A7	CHEM&BIO
148	G 1315	SHOUBAK AGRICULTURE	200.700	989.400	1520.00	214	73.42	336	B2/A7	CHEM&BIO
149	G 1325	TAHOONA 2	211.550	961.100	1125.00	104	22.00	608	B2/A7	CHEM&BIO
150	G 1407	SHOUBAK 3	200.200	992.800	1455.00	106	50.75	358	B2/A7	CHEM&BIO
151	H 1012	ROWAISHED 2/H4	459.100	221.800	700.00	315	162.70		B4	CHEMICAL
152	H 2015	ROWAISHED 1/H4	457.800	221.620	694.00	315	202.05		B4	CHEMICAL

NOTES

Sampling frequency about 4 samples per year
Samples collected using manual methods
Complete chemical analysis = pH, Ec, Ca, Mg, K, Na, Cl, SO4, CO3, HCO3, NO3
Biological = coliform, fecal coliform
Aquifers: B = basalt; SS & GR = alluvium
Table includes the wells currently in the ground water quality monitoring program

Table 3-15. Basic Hydraulic Properties of the Aquifer Systems in Jordan

Aquifer Name	Symbol	Depth to Aquifer (meters)	Aquifer Thickness (meters)	Transmissivity (meters^2/day)	Permeability (meters/day)	Storage Coefficient	Specific Capacity (m^3/hr/m)	Well Yield (m^3/hr)	Water Quality (Salinity ppm)	Comments
Quaternary Alluvium	Qal									
Jordan Valley Group										
Alluvial Fans										
Sukhaneh			18 -32				2 - 6	8 -25	600 - 800	
Yutum		20 - 40	20 - 75	800 - 3800	8 - 700	0.013 - 0.04	1 - 25	30 - 100	650 - 700	
Wadi Araba		40 - 120	170			0.001 - 0.1	2 - 10		600 - 2750	
Basalt	Basalt	3 - >400	5 - 165	100 - 10,000	4 - 100				300 - 3000	High salinity after long-term production.
Balqa Group										
Amman	B2		See data for Amman-Wadi Sir aquifer system listed under the Ajlun Group							
Rijam	B4									
Jafer Basin		20 - 60	50 - 100	700 - 1609	0.4 - 733		1.3 - 367		600+	
Azraq Basin		10 - 60	50 - 60	16 - 876	0.2 - 27.9		0.7 -108		300 - 500	Salinity > 1000 in some wells.
Sirhan Basin		15 - 60	50 - 60	< 244	<6.9		0.7 - 8		850 - 1470	
Ajlun Group										
Amman - Wadi Sir	B2/A7						0.04 - 400		600 - 2000	Salinity > 2000 in some wells.
Yarmouk Basin			30 - 450	700 - >10,000				20 - 60		
Azraq Basin			100 - 1904					6 - 58		
Sirhan Basin			46 - 163							
Jafer Basin			23 - 250	40 - 1750				50 - 108		
Dead Sea Basin			15 - 189	10 - 500						
Amman/Zarqa Basin			55 - 150	9 - 900				12 - 200		
Hummer	A4	150 - >3360	45 - 60	230 - 2800	0.5 - 60	0.0001 - 0.001	0.2 - 40	30 - 130	300 - 400	
Naur	A2	0-250	100 - 150		< 6			10 -30	400 - 600	
Kurnub	K	22 - > 1000	187 - 360	< 1700	< 48		1 - 33.5	20 - 110	300 - 3000	
Zarqa	Z	26 - 1122	60 - 220	27 - 255	1.4	0.012	1 - 44	8 - 8000	3300 - 6100	
Disi	D		30 - 360			0.0018 - 0.25				

Notes:

(1) The listed data are considered representative of the characteristics of the various aquifer systems and are based on accepted knowledge and experience of the Artificial Recharge Working Group members.
The hydrologic and geologic literature and reports for Jordan should be consulted for more exact data and information regarding the hydraulic properties of the aquifer systems.

(2) The data do not include the properties for hydraulically interconnected aquifers.

(3) Exploratory efforts have been proposed to investigate the potential for a Rum formation aquifer system between the Zarqa and Disi formations in Wadi Araba.

Table 3-16. Ground Water Resources Data for 1993

Basin No.	Ground Water Basin	Safe Yield (mcm/year)		Municipal		Industrial		Irrigation		Pastoral		Total Use (mcm)		Negative Balance (mcm)		Total No. of Wells
		Non-Ren.	Renew.	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	Non-Ren.	Renew.	Non-Ren.	Renew.	
1	Yarmouk		40.00	26	26.39	1	0.13	127	40.52	0	0.00		67.04		-27.04	154
2	Jordan River Side Wadis		15.00	5	1.76	0	0.00	6	1.20	0	0.00		2.96			11
3	Jordan River Valley		21.00	16	5.31	1	0.04	160	36.80	0	0.00		42.15		-21.15	177
4	Amman-Zarqa		87.50	111	57.58	47	7.79	463	118.15	0	0.00		183.52		-96.02	621
5	Dead Sea		57.00	57	28.99	31	17.19	219	45.96	2	0.04		92.18		-35.18	309
6	Disi and Southern Desert	125.00	0.00	10	6.76	0	2.62	54	56.83	4	1.24	67.45	0.00	-67.45		68
7	North Wadi Araba		3.50	0	0.00	0	0.00	5	0.90	5	0.11		1.01			10
8	South Wadi Araba		5.50	8	1.56	0	0.00	24	2.80	4	0.07		4.43			36
9	Jafer	18.00	9.00	9	3.36	3	0.86	74	12.26	13	3.66		20.14		-11.14	99
10	Azraq		24.00	29	24.39	2	0.06	408	25.00	10	0.36		49.81		-25.81	449
11	Sarhan		5.00	0	0.00	0	0.00	0	0.00	3	0.15		0.15			3
12	Hammad		8.00	2	0.44	0	0.00	5	0.69	5	0.72		1.85			12
	Total	143.00	275.50	273.00	156.54	85	28.69	1545	341.11	46	6.35	67.45	465.24	-67.45	-216.34	1949

Notes:

Total safe yield is 418.5 MCM/year including nonrenewable resources from Disi and Jafer
Total safe yield without nonrenewable resources is 275.7 MCM/year
Total overdraft (mining) from ground water resources is 283.77 MCM/year.
Ground water for industrial use in Disi and Southern Desert comes from municipal wells.

Data from the UNDP project database.

Table 3-17. Ground Water Resources Data for 1992

Basin No.	Ground Water Basin	Safe Yield (mcm/year)		Municipal		Industrial		Irrigation		Pastoral		Total Use (mcm)		Negative Balance (mcm)		Total No. of Wells
		Non-Ren.	Renew.	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	Non-Ren.	Renew.	Non-Ren.	Renew.	
1	Yarmouk		40.00	26	24.55	0	0.00	157	36.93	0	0.00		61.48		-21.48	183
2	Jordan River Side Wadis		15.00	6	1.63	0	0.00	6	1.01	0	0.00		2.64			12
3	Jordan River Valley		21.00	13	4.40	0	0.00	178	36.00	0	0.00		40.40		-19.40	191
4	Amman-Zarqa		87.50	103	57.09	46	9.41	433	106.77	0	0.00		173.27		-85.77	582
5	Dead Sea		57.00	51	25.06	30	15.92	237	45.79	2	0.06		86.83		-29.83	320
6	Disi and Southern Desert	125.00	0.00	10	6.56	0	3.01	70	60.39	6	1.06	71.02	0.00	-71.02		86
7	North Wadi Araba		3.50	3	1.28	0	0.00	6	0.83	5	0.12		2.22			14
8	South Wadi Araba		5.50	8	1.39	0	0.00	22	3.34	4	0.09		4.82			34
9	Jafer	18.00	9.00	9	2.05	1	0.32	60	16.43	11	2.96		21.76		-12.76	81
10	Azraq		24.00	30	23.06	4	0.51	558	24.53	10	0.31		48.41		-24.41	602
11	Sarhan		5.00	0	0.00	0	0.00	0	0.00	1	0.03		0.03			1
12	Hammad		8.00	2	0.29	0	0.00	5	0.69	3	0.22		1.20			10
	Total	143.00	275.50	261	147.36	81	29.17	1732	332.71	42	4.84	71.02	443.06	-71.02	-193.65	2116

Notes:

Total safe yield is 418.5 MCM/year including nonrenewable resources from Disi and Jafer
Total safe yield without nonrenewable resources is 275.7 MCM/year
Total overdraft (mining) from ground water resources is 264.66 MCM/year.
Ground water for industrial use in Disi and Southern Desert comes from municipal wells.

Data from the UNDP project database.

Table 3-18. Ground Water Resources Data for 1991

Basin No.	Ground Water Basin	Safe Yield (mcm/year)		Municipal		Industrial		Irrigation		Pastoral		Total Use (mcm)		Negative Balance (mcm)		Total No. of Wells
		Non-Ren.	Renew.	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	Non-Ren.	Renew.	Non-Ren.	Renew.	
1	Yarmouk		40.00	22	23.82	0	0.00	157	45.18	0	0.00		69.00		-29.00	179
2	Jordan River Side Wadis		15.00	6	1.58	0	0.00	6	1.01	0	0.00		2.59			12
3	Jordan River Valley		21.00	13	4.04	0	0.00	178	36.00	0	0.00		40.04		-19.04	191
4	Amman-Zarqa		87.50	98	61.45	52	7.16	412	102.63	0	0.00		171.24		-83.74	562
5	Dead Sea		57.00	48	25.47	26	19.95	217	42.09	1	0.04		87.55		-30.55	292
6	Disi and Southern Desert	125.00	0.00	9	5.86	0	3.15	61	55.30	6	1.24	65.56	0.00	-65.56		76
7	North Wadi Araba		3.50	2	1.95	0	0.00	6	0.83	4	0.12		2.90			12
8	South Wadi Araba		5.50	10	1.18	0	0.00	17	2.52	3	0.09		3.79			30
9	Jafer	18.00	9.00	8	1.75	1	0.27	59	16.52	7	2.84		21.38		-12.38	75
10	Azraq		24.00	27	22.35	1	0.30	551	23.15	6	0.22		46.03		-22.03	585
11	Sarhan		5.00	0	0.00	0	0.00	0	0.00	1	0.03		0.03			1
12	Hammad		8.00	2	0.27	0	0.00	5	0.69	6	0.23		1.20			13
	Total	143.00	275.50	245	149.72	80	30.83	1669	325.93	34	4.82	65.56	445.73	-65.56	-196.73	2028

Notes:

Total safe yield is 418.5 MCM/year including nonrenewable resources from Disi and Jafer
Total safe yield without nonrenewable resources is 275.7 MCM/year
Total overdraft (mining) from ground water resources is 262.29 MCM/year.
Ground water for industrial use in Disi and Southern Desert comes from municipal wells.

Data from the UNDP project database.

Table 3-19. Ground Water Resources Data for 1990

Basin No.	Ground Water Basin	Safe Yield (mcm/year)		Municipal		Industrial		Irrigation		Pastoral		Total Use (mcm)		Negative Balance (mcm)		Total No. of Wells
		Non-Ren.	Renew.	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	Non-Ren.	Renew.	Non-Ren.	Renew.	
1	Yarmouk		40.00	21	22.14	0	0.00	150	49.27	0	0.00		71.41		-31.41	171
2	Jordan River Side Wadis		15.00	6	1.71	0	0.00	6	1.01	0	0.00		2.72			12
3	Jordan River Valley		21.00	14	4.20	0	0.00	166	35.00	0	0.00		39.20		-18.20	180
4	Amman-Zarqa		87.50	94	66.08	52	6.57	408	101.75	0	0.00		174.40		-86.90	554
5	Dead Sea		57.00	50	23.19	26	18.95	216	42.39	1	0.04		84.57		-27.57	293
6	Disi and Southern Desert	125.00	0.00	9	5.87	0	3.07	61	55.18	6	1.25	65.37	0.00	-65.37		76
7	North Wadi Araba		3.50	2	2.13	0	0.00	7	0.87	4	0.07		3.07			13
8	South Wadi Araba		5.50	10	1.38	0	0.00	18	2.42	3	0.15		3.95			31
9	Jafer	18.00	9.00	5	1.56	1	0.25	59	18.08	8	2.73		22.62		-13.62	73
10	Azraq		24.00	20	18.18	1	0.30	549	22.78	6	0.22		41.48		-17.48	576
11	Sarhan		5.00	0	0.00	0	0.00	0	0.00	1	0.02		0.02			1
12	Hammad		8.00	0	0.20	0	0.00	5	0.69	8	0.77		1.66			13
	Total	143.00	275.50	231	146.64	80	29.14	1645	329.44	37	5.26	65.37	445.10	-65.37	-195.18	1993

Notes:

Total safe yield is 418.5 MCM/year including nonrenewable resources from Disi and Jafer
Total safe yield without nonrenewable resources is 275.7 MCM/year
Total overdraft (mining) from ground water resources is 260.55 MCM/year.
Ground water for industrial use in Disi and Southern Desert comes from municipal wells.

Data from the UNDP project database.

Table 3-20. Ground Water Resources Data for 1989

Basin No.	Ground Water Basin	Safe Yield (mcm/year)		Municipal		Industrial		Irrigation		Pastoral		Total Use (mcm)		Negative Balance (mcm)		Total No. of Wells
		Non-Ren.	Renew.	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	No. of Wells	Pumpage (mcm/year)	Non-Ren.	Renew.	Non-Ren.	Renew.	
1	Yarmouk		40.00	21	22.11	0	0.00	150	50.05	0	0.00		72.16		-32.16	171
2	Jordan River Side Wadis		15.00	6	2.14	0	0.00	6	0.88	0	0.00		3.02			12
3	Jordan River Valley		21.00	14	3.83	0	0.00	166	35.00	0	0.00		38.83		-17.83	180
4	Amman-Zarqa		87.50	94	59.63	52	6.09	396	98.94	0	0.00		164.66		-77.16	542
5	Dead Sea		57.00	50	21.51	26	18.70	215	41.59	1	0.05		81.85		-24.85	292
6	Disi and Southern Desert	125.00	0.00	9	6.46	0	3.74	61	46.58	6	1.15	57.93	0.00	-57.93		76
7	North Wadi Araba		3.50	2	2.11	0	0.00	7	1.17	4	0.10		3.38			13
8	South Wadi Araba		5.50	10	1.88	0	0.00	18	1.98	3	0.06		3.92			31
9	Jafer	18.00	9.00	5	1.38	1	0.25	59	18.08	8	3.86		23.57		-14.57	73
10	Azraq		24.00	20	17.06	1	0.30	549	20.44	6	0.58		38.38		-14.38	576
11	Sarhan		5.00	0	0.00	0	0.00	0	0.00	1	0.02		0.02			1
12	Hammad		8.00	0	0.20	0	0.00	5	0.69	8	0.10		0.99			13
	Total	143.00	275.50	231	138.31	80	29.08	1632	315.40	37	5.92	57.93	430.78	-57.93	-180.95	1980

Notes:

Total safe yield is 418.5 MCM/year including nonrenewable resources from Disi and Jafer
Total safe yield without nonrenewable resources is 275.7 MCM/year
Total overdraft (mining) from ground water resources is 238.88 MCM/year.
Ground water for industrial use in Disi and Southern Desert comes from municipal wells.

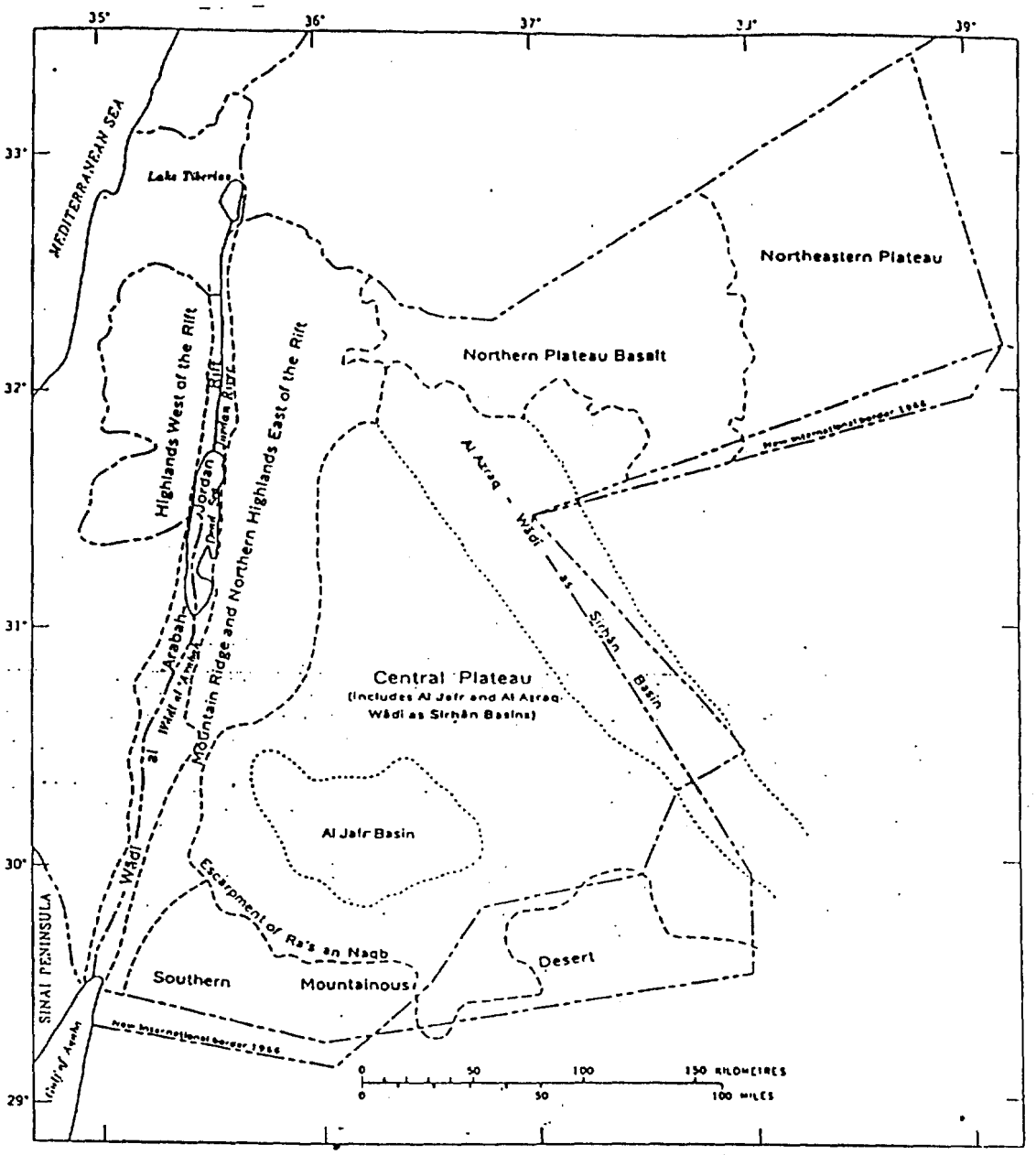
Data from the UNDP project database.

Table 3-21. Existing and Proposed Dams

Dam Name	Sequence # for Map	Year Constructed	Coordinates East	Coordinates North	Storage (MCM)	Ground Water Basin	Associated Aquifer	Artificial Recharge Potential
Existing Dams								
King Talal	1	1979	225.729	177.692	78.00	Amman - Zarqa	-	No
Khaldiyeh	2	1983	276.550	175.250	1.10	Amman - Zarqa	B2/A7; Basalt	Yes
Wadi Arab	3	1985	209.851	224.625	16.90	Rift Side Wadis	-	No
Ziglab	4	1967	208.750	214.500	3.00	Rift Side Wadis	-	No
Shueib	5	1969	209.800	145.900	1.50	Rift Side Wadis	Alluvium	Yes
Kafrein	6	1968	213.400	139.850	2.50	Rift Side Wadis	Alluvium	Yes
Al-Karama	7	UC	202:218	157.803	55.00	Jordan River Valley	-	No
Sama Al Sarhan	8	1963	268.250	209.800	1.70	Yarmouk	-	No
Ghdeer Al Abyad	9	1963	264.175	200.700	0.70	Yarmouk	B2/A7	Yes
Bowaydah	10	1963	248.800	207.775	0.70	Yarmouk		No
Sultanah	11	1962	245.500	57.800	1.20	Dead Sea	B2/A7	Yes
Qatranah	12	1962	240.000	74.000	1.80	Dead Sea	B2/A7	Yes
Siwaqa	13	1993	252.300	87.225	2.50	Dead Sea	B2/A7	Yes
Rajil	14	1993	354.650	137.290	3.50	Azraq	Basalt; Alluvium	Yes (?)
Ruweished	15	1992	433.200	241.100	10.70	Hammad	-	No
Burq	16	1960	428.600	227.600	1.50	Hammad	-	No
Proposed Dams								
Wehdeh	1		232.006	237.650	225.00	Yarmouk	-	No
Wadi Wala	2		226.366	108.622	9.30	Dead Sea	B2/A7	Yes
Mujib	3		227.718	94.900	35.00	Dead Sea	B2/A7	Yes
Tamour	4		209.850	44.600	16.80	Dead Sea	-	No
Jordana	5		220.283	S 965.686	2.30	Jafer	B4	Yes
Abu Hifna	6		461.500	186.500	2.60	Hammad	-	No
Kafrein Extension	7		213.400	139.850	7.10	Rift Side Wadis	Alluvium	Yes
Fidan	8		186.800	9.250	6.00	Wadi Araba	-	No
Qa'a	9		217.700	S 968.950	0.53	Jafer	B4	Yes
Waheydah	10		214.465	S 956.099	1.77	Jafer	B4	Yes

Notes: MCM - million cubic meters
UC = under construction

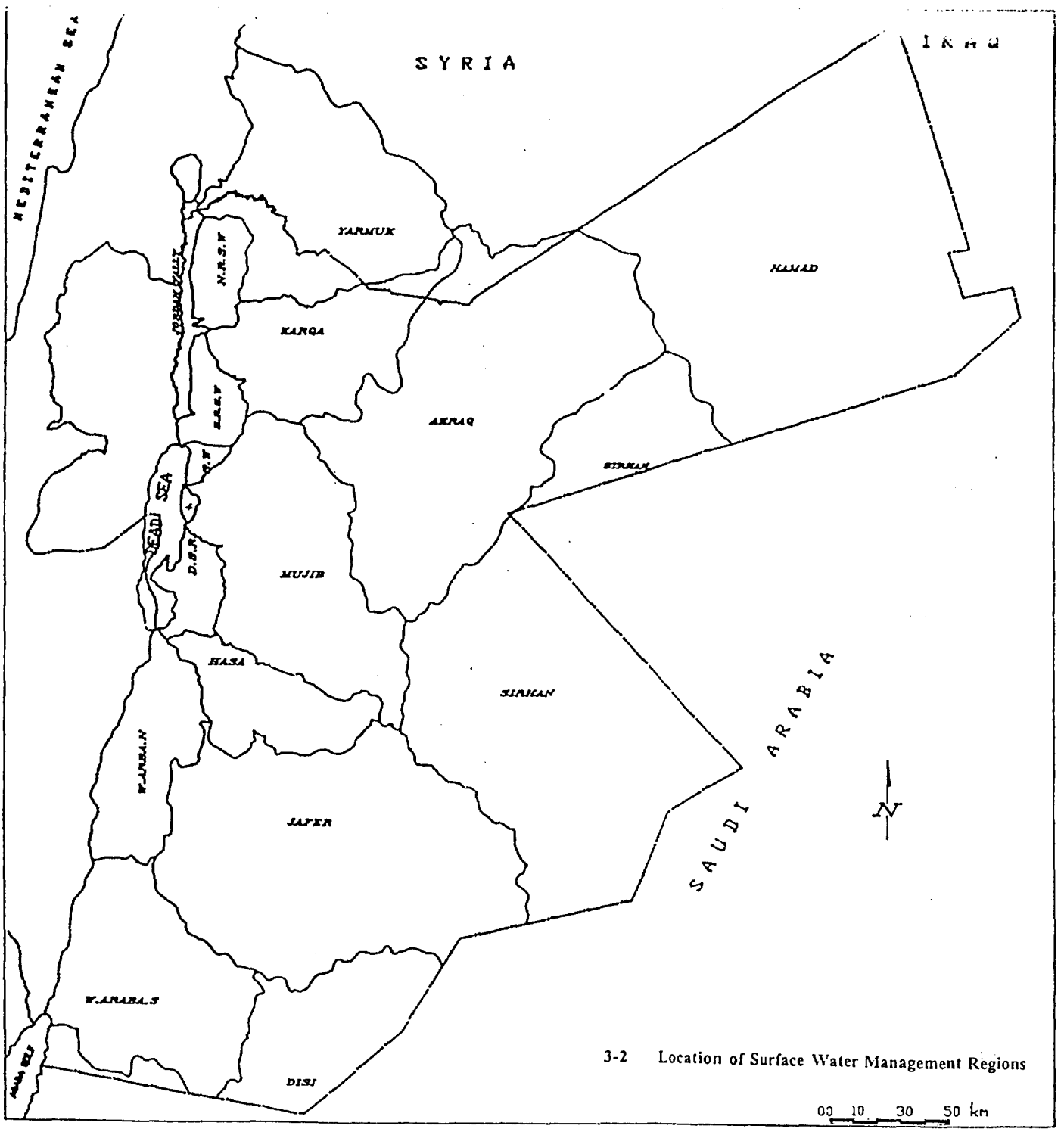
FIGURES



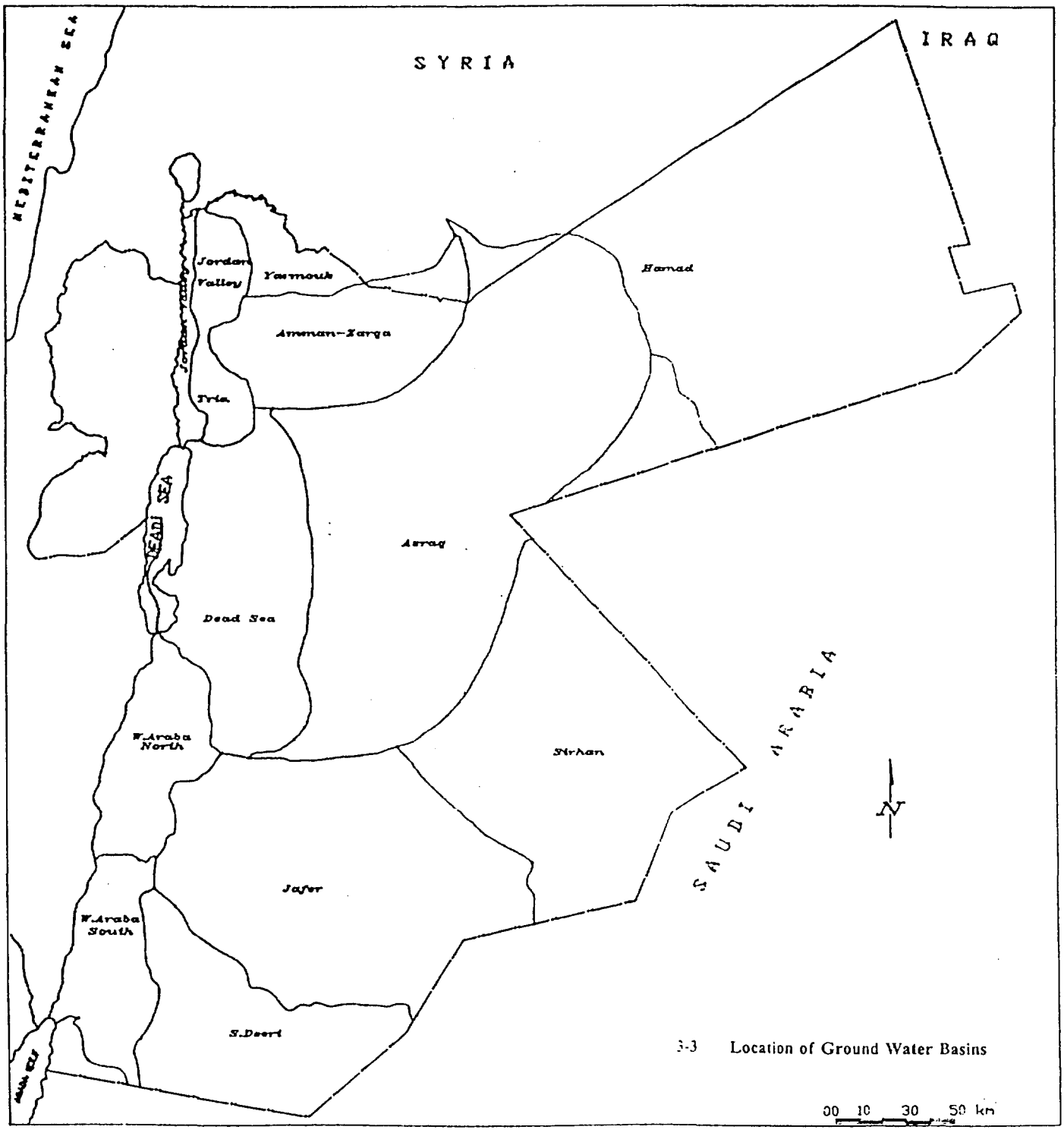
Source : Geology of the Arabian Peninsula Jordan
By FRIEDRICH BENDER (1975)

Modified by Japan International Cooperation Agency, 1990

3-1 Map of Jordan



3-2 Location of Surface Water Management Regions



3-3 Location of Ground Water Basins

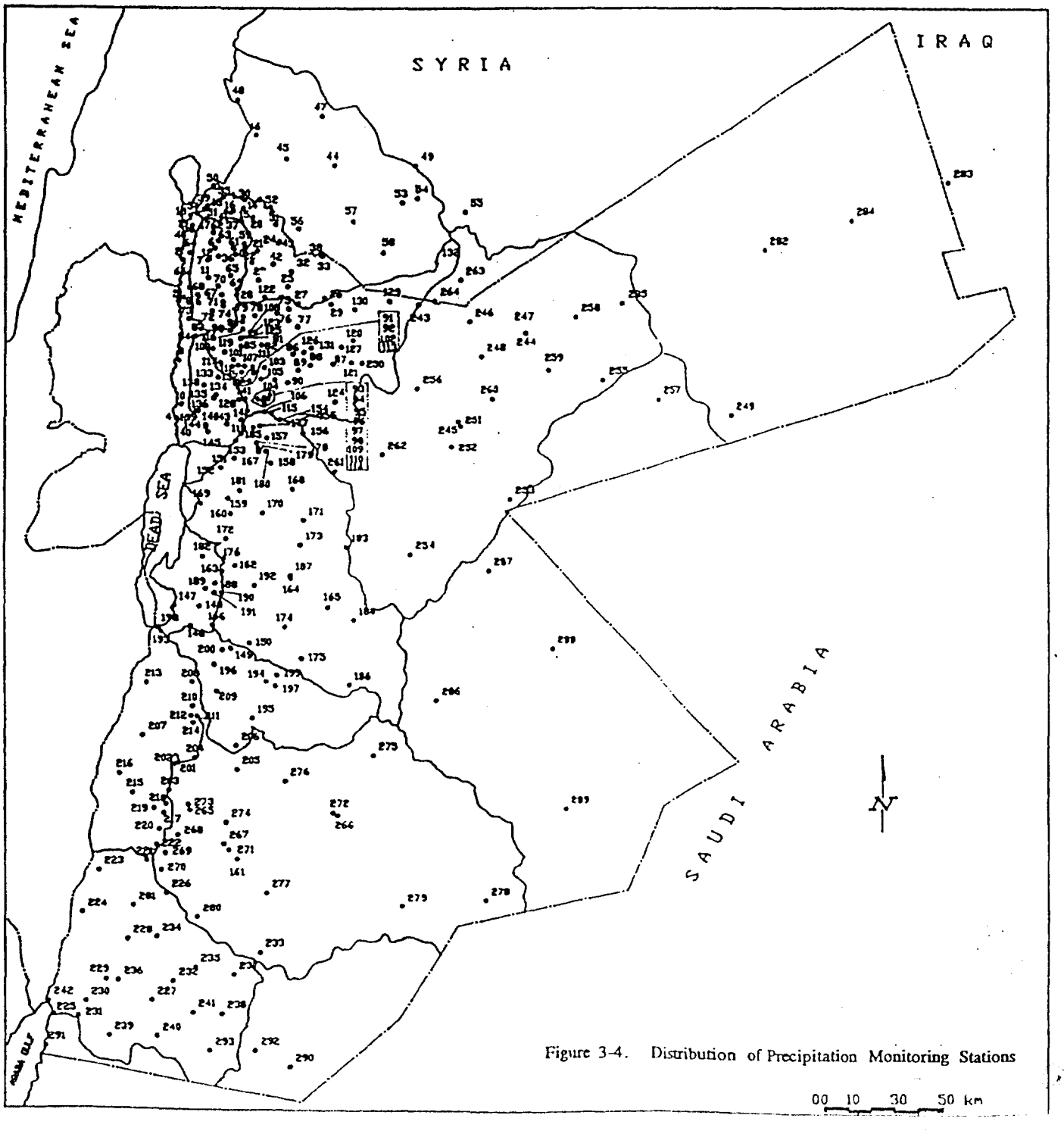


Figure 3-4. Distribution of Precipitation Monitoring Stations

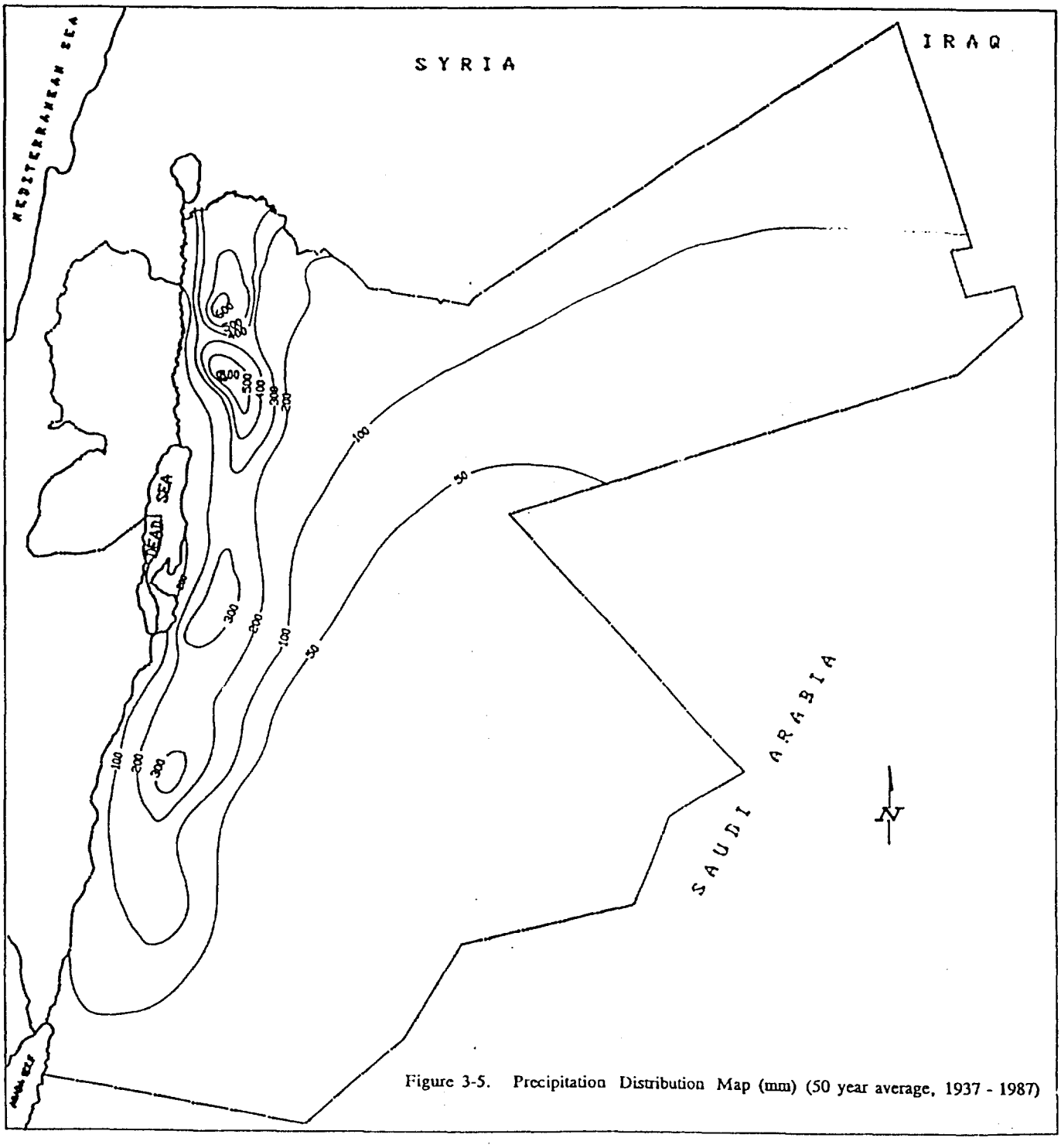


Figure 3-5. Precipitation Distribution Map (mm) (50 year average, 1937 - 1987)

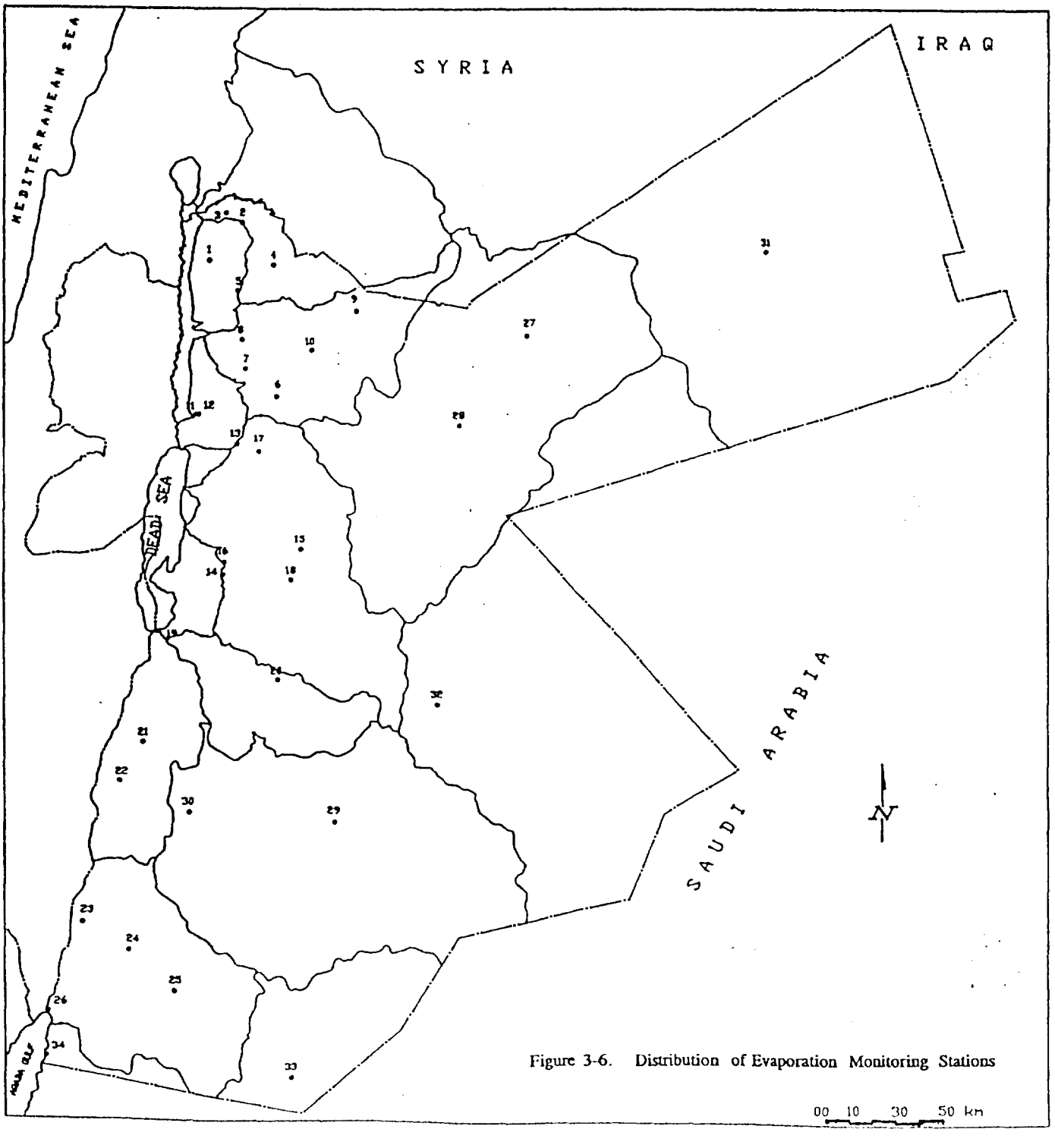


Figure 3-6. Distribution of Evaporation Monitoring Stations

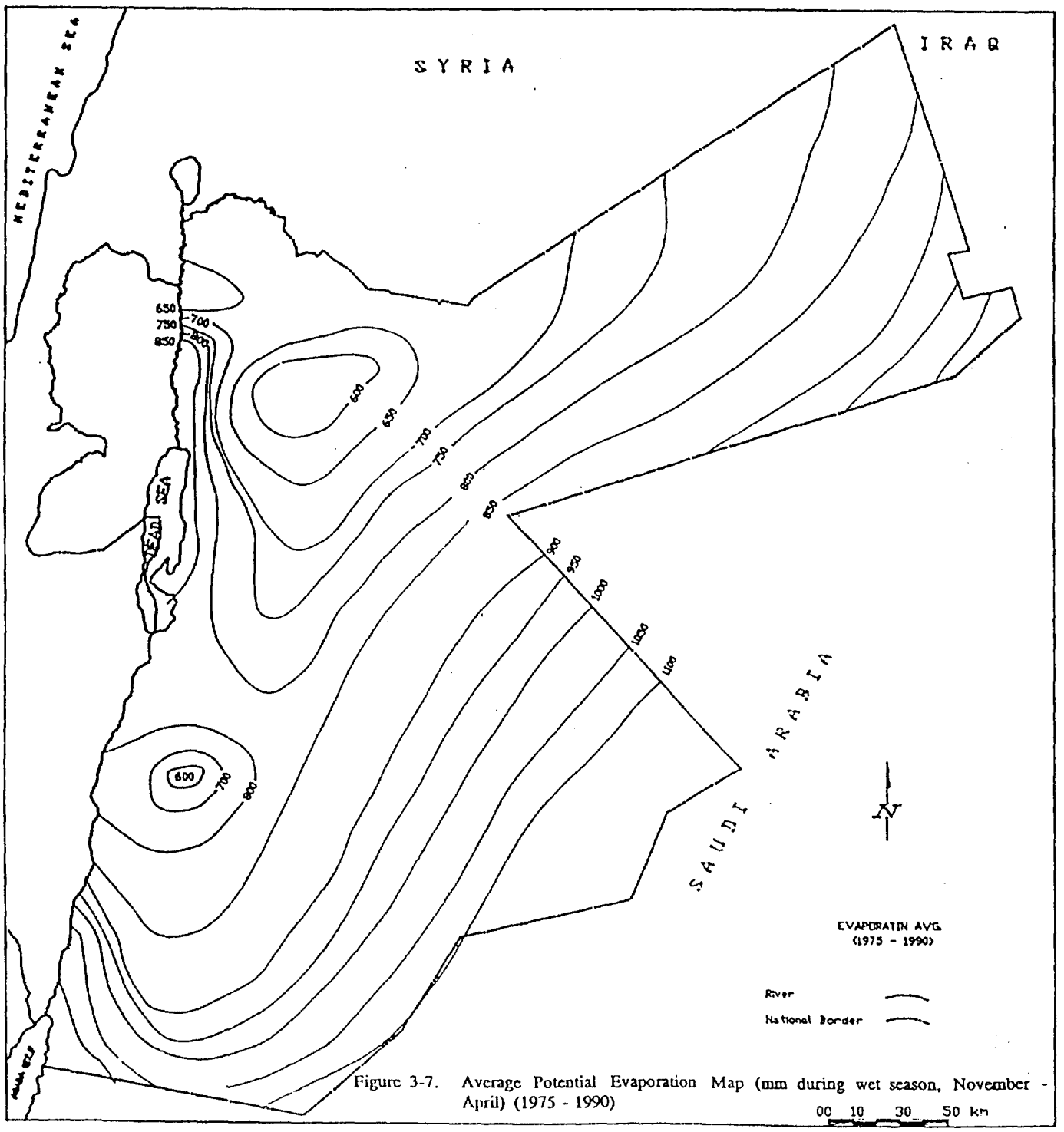


Figure 3-7. Average Potential Evaporation Map (mm during wet season, November - April) (1975 - 1990)

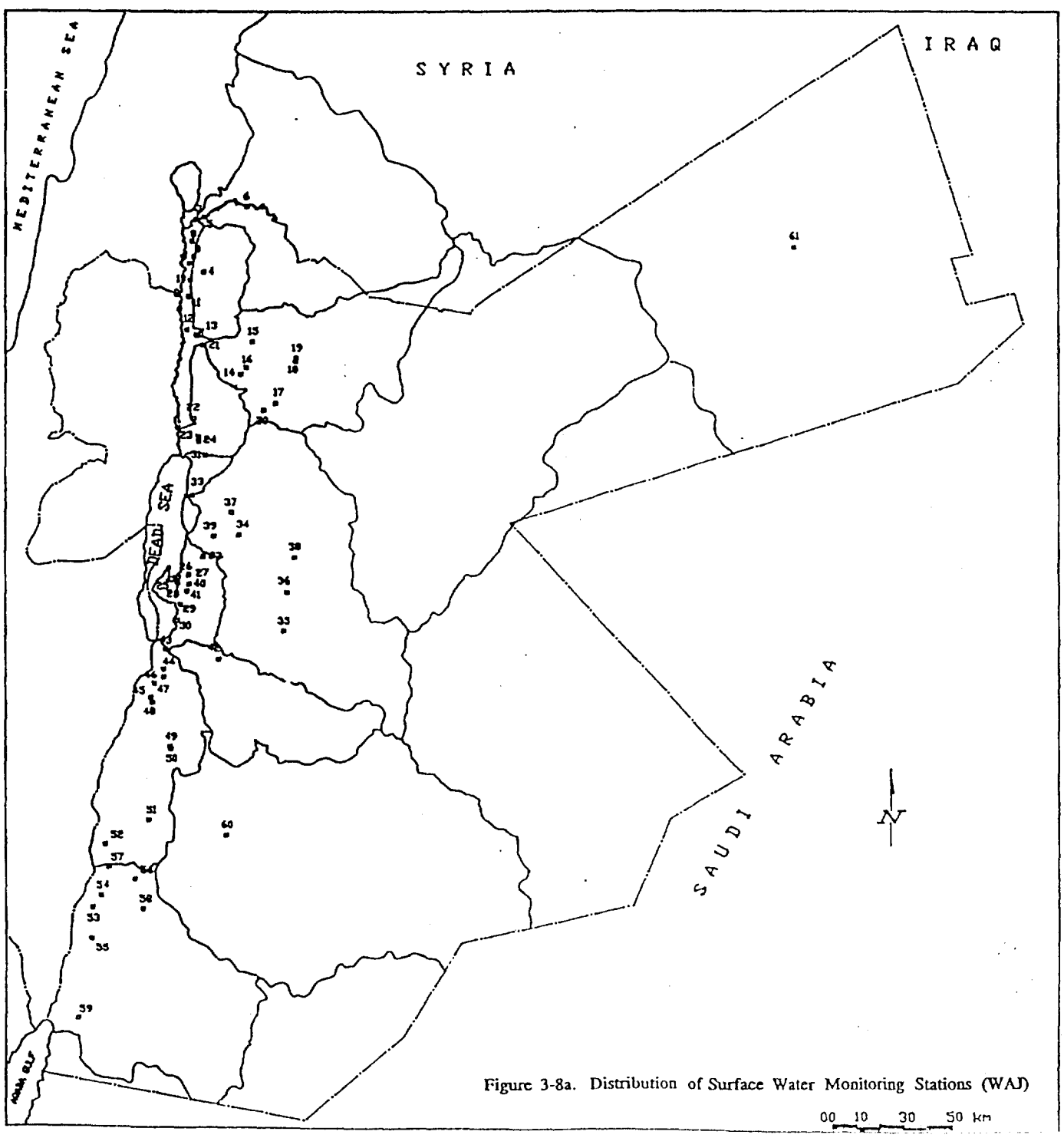


Figure 3-8a. Distribution of Surface Water Monitoring Stations (WAJ)

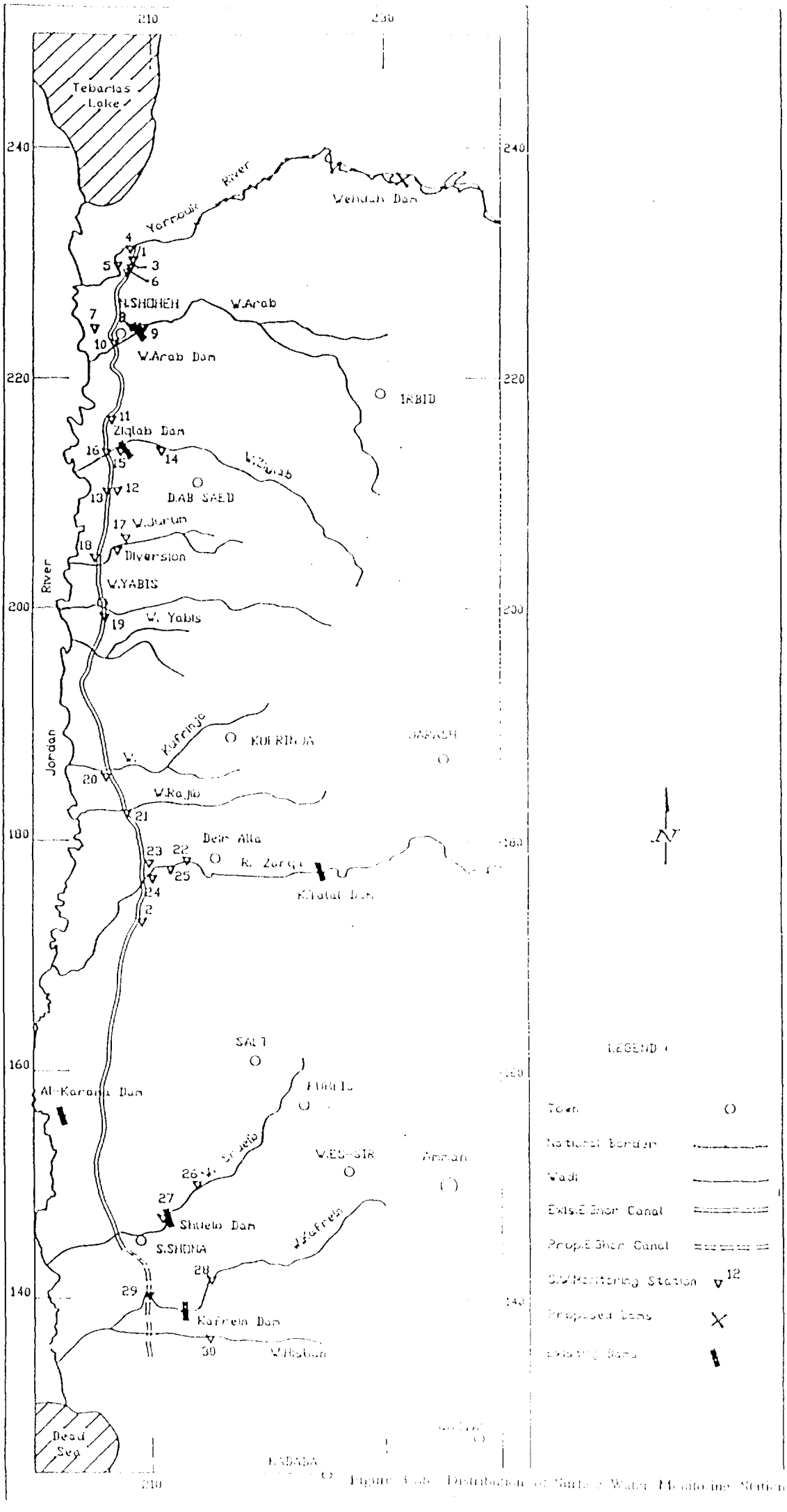


Figure 5.6: Distribution of Surface Water Monitoring Stations (D.S.)

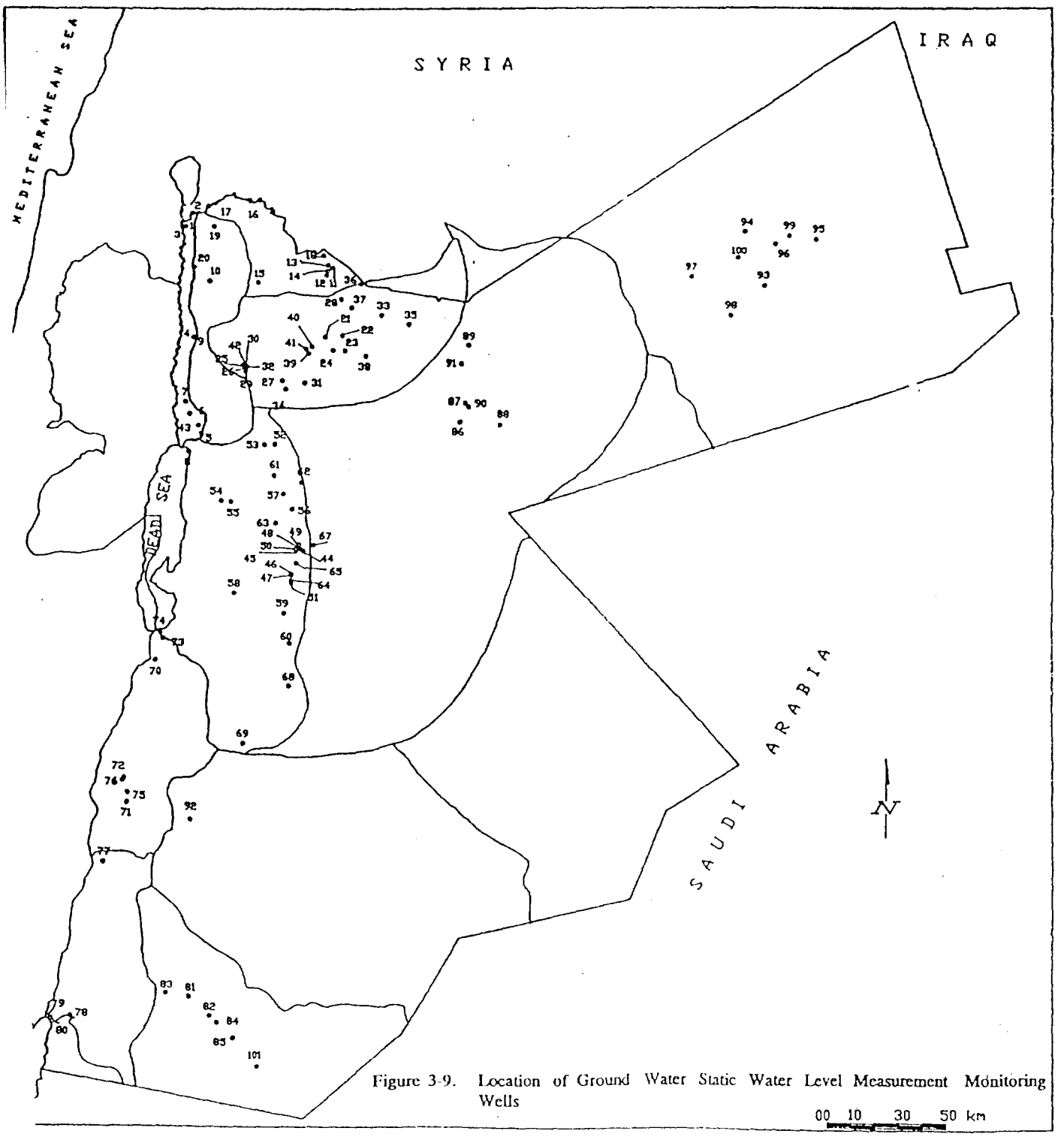


Figure 3-9. Location of Ground Water Static Water Level Measurement Monitoring Wells

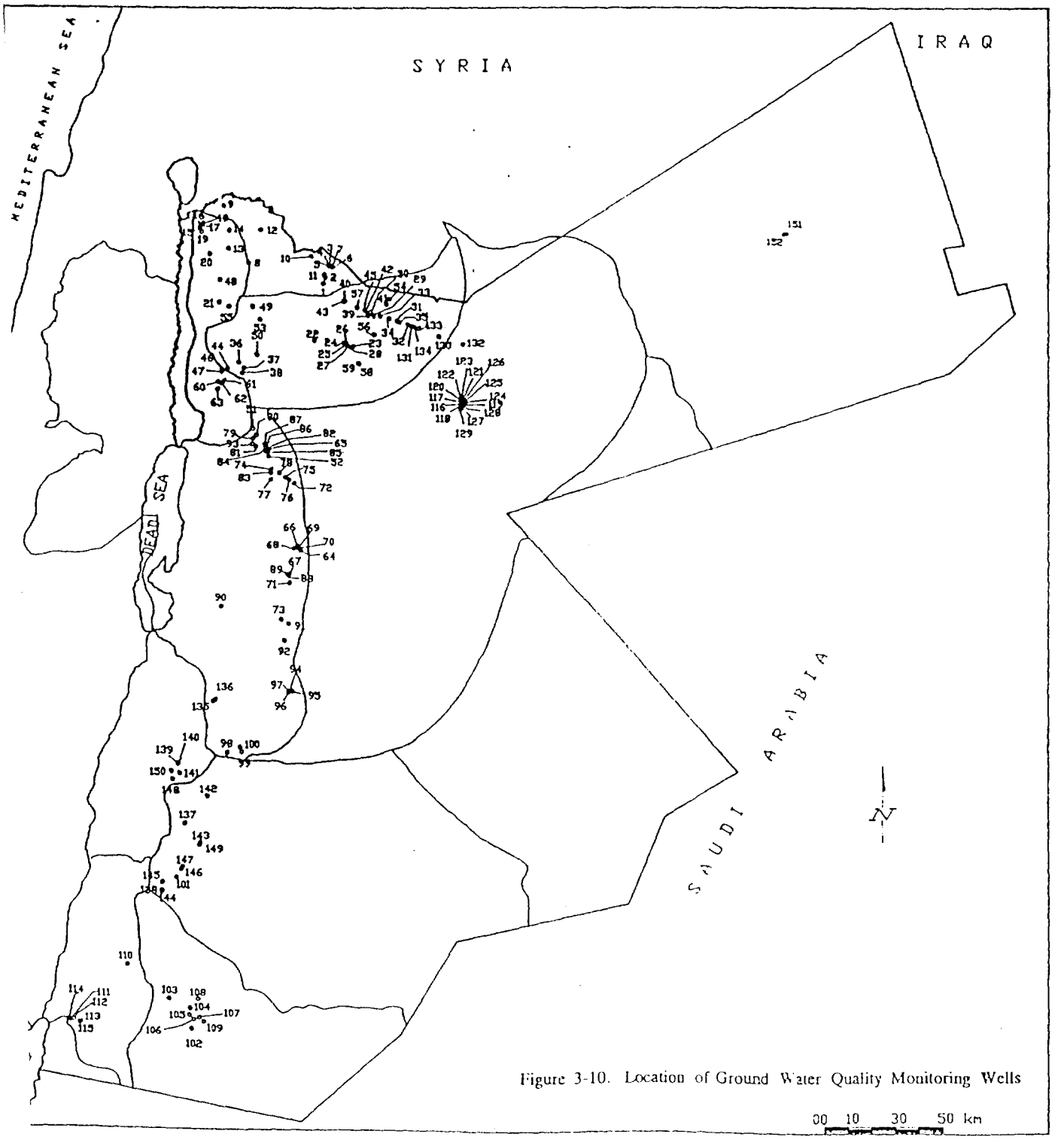


Figure 3-10. Location of Ground Water Quality Monitoring Wells

Figure 3-11. Generalized Stratigraphic Column of Jordan and Aquifer Potential

AGE (MM YEAR)	ERA	SYSTEM		EPOCH	GROUP	FORMATION	SYMBOL	ROCK TYPE	THICKNESS RANGE (m)	AQUIFER POTENTIAL
1.5	CENOZOIC	QUARTER-NARY		HOLOCENE	JORDAN VALLEY	Alluvium	Qal	soil, sand, gravel	?	Good to Excellent
				PLEISTOCENE		Lisan	JV3	marl, clay, evaporites	300+	Poor
70		TERTIARY		PLIOCENE		Samra Neogene	JV1-2	conglomerate with silicious cement, sand, and gravel	100 - 350	Fair
				MIOCENE						
				OLIGOCENE						
				EOCENE	BELQA	W. Shalia	B5	limestone, chalky and marly with glauconite	350+	Poor
				PALEOCENE		Falij	B4	chert and limestone	30 -50	Good
140	MESOZOIC	CRETACEOUS	UPPER	MAESTERICHTIAN		Muwaqqar	B3	chalk, marly chalk and marl	300+	Poor
				CAMPANIAN		Amman	B2	chalk, limestone with phosphate	30 - 120	Excellent
				SANTONIAN		Ruseifa	B1	chalk, marl, marly limestone	0 - 75	Poor
			MIDDLE	TURONIAN	AJLUN	Wadi Sir	A7	limestone, dolomitic, some chert	65 - 100	Excellent
						Shueib	A5/6	limestone, marly limestone	70	Fair to Poor
				CENOMANIAN		Hummar	A4	dolomite, dolomitic limestone	60 - 120	Good to Fair
						Fuheis	A3	marl, marly limestone	80 - 120	Poor
						Naur	A1/2	limestone, dolomitic limestone, marly limestone	250 - 350	Good
			LOWER	ALBIAN	KURNUB	Subeihi	K2	sand, shale, clay, and sandy limestone	230 - 270	Poor
				ABTIAN						
				NEOCOMIAN		Aarda	K1	sandstone, marl, and shale		
200		JURASSIC		PORTLANDIAN	ZARQA	Huni	Z2	limestone, marlstone, sandstone, and shale	200 - 250	
				OXFORDIAN						
				COLLOVIAN						
				BATHONIAN						
				BAJOCIAN						
				LIASSIC						
230		TRIASSIC		KEUPER		Main	Z1	limestones,shale, sandstones, and evaporites	?	Poor
				MUSCHELKALK						
				BUNTSANDSTEIN						

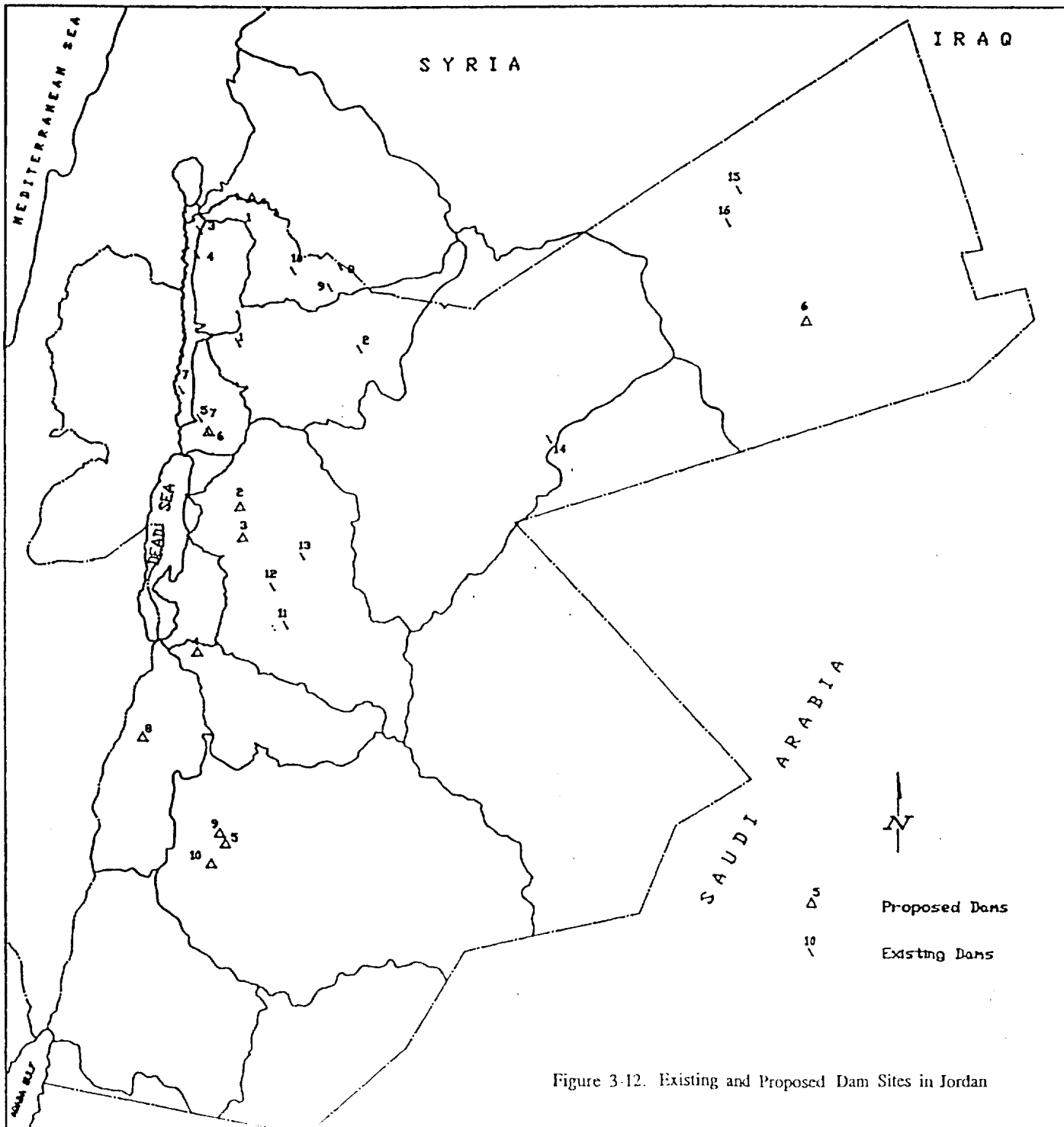


Figure 3-12. Existing and Proposed Dam Sites in Jordan