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MINISTRY OF WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER MASTER PLAN

SECTORAL REPORT
(Q)

DATABASE

JULY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

Administrative Division of Districts

In this Study, the original 41 districts were considered and various statistical data, particularly socio-economic information, were collected for these districts. During the progress of the Study, six districts were detached from the original ones and established as new districts. In the report, the data on these new districts are grouped together with the corresponding original districts as shown below.

	Original Districts	New Districts	Data included in:
1.	Machakos	Makueni	Machakos/Makueni
2.	Kisii	Nyamira	Kisii/Nyamira
3.	Kakamega	Vihiga	Kakamega/Vihiga
4.	Meru	Tharaka-Nithi	Meru/Tharaka-Nithi
5.	Kericho	Bomet	Kericho/Bomet
6.	South Nyanza	Migori	South Nyanza/Migori

(Note: The last three Districts were established very recently.
The report refers only to the names of the original 41 districts.)

The administrative boundary map used in this Study is the latest complete map set covering the whole country (41 Districts, 233 Divisions and 976 Locations), prepared in 1986 by the Survey of Kenya, Ministry of Land, Housing and Physical Planning.

Data and Information

The data and information contained in the report represent those collected in the 1990-1991 period from various documents and reports made available mostly from central government offices in Nairobi and/or those analyzed in this Study based on the collected data. Some of them may be different from those kept in files at some agencies and regional offices. Such discrepancies if any should be collated and adjusted as required in further detailed studies of the relevant development projects.

THE STUDY ON THE NATIONAL WATER MASTER PLAN

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Q1. INTRODUCTION

The NWMP study renovated the computerized hydrological database system of MOWD (Ministry of Water Development) in the course of the study. This **Sectoral Report Q** describes the process of renovation that include details on (1) the existing database system and needs for change, (2) concepts of the new database system and its system configuration, (3) system hardware and application software developed, (4) logical structure of data tables (5) description of data stored in the System and (6) system installation procedure and training programme. A user manual was prepared as a separate volume and the chapter "Operation Of Database" is replicated in this report as an appendix for perusal.

Q2. EXISTING DATABASE SYSTEMS

2.1 Database Systems Related to the Study

A computerized database is effective and helpful for handling a large number of data and has been established in the various departments and offices in Kenya. In the field of water resources planning and development, database systems are being operated by MOWD, KMD (Kenya Meteorological Department) and LBDA (Lake Basin Development Authorities).

(1) MOWD

MOWD installed a computerized hydrological database system at their headquarters in Nairobi in 1984 with the assistance of SIDA. The database system consisting of 10 applications is built on the mini-computer WANG VS-15, and is operated by CSS (the Computer Services Section) of MOWD.

At present, this database system is comprised of the following three subsystems.

1) Surface water subsystem
   - information stored
     description of water level gauging station
     daily water level
     rating curve equation
   - quality of data maintenance
     well maintained
   - main users
     Hydrological section
     frequently utilized
   - reliability of data
     good

2) Ground water subsystem
   - information stored
     description of borehole
   - quality of data maintenance
     has not been updated. This subsystem has been scarcely used since another database system exists in the Ground Water section operating on PC where all new data are stored.
   - main users
     GA(Ground Water section)

3) Water permit information
   - information stored
     water permit

river numbering
- quality of data maintenance
update in progress
- main users
WAB (Water Apportionment Board)
occasionally used
- reliability of data
poor

Users can access these systems through a character terminal and/or a PC-based terminal connected to the mini-computer by a serial line. The database system stores data using ISAM (Indexed Sequential Access Method) File System of WANG.

The following data are collected but has not been stored in the database system.
- Some data on rating curve which have not been compiled yet
- Suspended load
- Water quality

(2) KMD

Meteorological data in Kenya have been collected by KMD. Climatological data are measured at 84 stations, while rainfall data are collected at about 2,800 meteorological stations of KMD and through the water related government agencies, such as MOWD and MOA, and private sectors.

The computer services section of KMD established a computerized database system in 1984 at their headquarters and has stored the following data.

1) Climatological data
- information stored
monthly and annual means of temperature,
relative humidity, sunshine,
wind run and evaporation
- quality of data maintenance
update in progress

2) Rainfall data
- information stored
station description
monthly rainfall
daily rainfall
- quality of data maintenance
update in progress

(3) LBDA

LBDA established their own database system for the various data related to water resources in the drainage area one (1) (Lake basin: the country is divided into five drainage areas). They collect or transfer data from MOWD, KMD, and other agencies and built a database system on their PC using dBASE; (an application of database management system).

2.2 Problems of the Existing Systems

Although the present database systems related to water resources development are powerful tools and used practically for planning and management of water resources, they suffer from the following shortcomings which inhibit using them directly in the NWMP study, where large number and different kinds of data from all over the country need to be handled within a limited study period.

(1) Water related data are managed by more than one agency and some data are duplicated by separate agencies or even within an agency. Maintenance of original data is essentially required.

(2) WANG system of MOWD has a limited storage capacity and is not large enough to store all the data over the country at once. Hence, they are now stored in five (5) removable disk packs by dividing the data area into five (5) drainage areas over the country.

(3) The MOWD computer system is a conventional centralized system consisting of a main computer with character terminals and has a limited capability to communicate with other computers like PC.

(4) Database functions of the MOWD system are limited to practical uses only, especially because of slow speed of data retrieval and processing, poor retrieval functions and poor user interfaces. Also, since the program is written in COBOL, using a file system peculiar to WANG, it is difficult to improve or rewrite the program.

(5) Data stored in Water permit subsystem are not reliable. They should be checked against the original data recorded on paper.

Q3. PROPOSED SYSTEM

3.1 Needs for Renovation

The NWMP study should handle a large number and many kinds of data over the country within a limited time span. A well organized database system is indispensable for conducting the study as well as for effectively utilizing the study results in each stage of the study. The system will also be helpful for utilizing the data in future studies and projects.

A database system to operate satisfactorily should conform to the following requirements.

1) Centralized Management of Data
2) Effective Retrieval Functions
3) Easy Operation and Maintenance
4) Continuity of data from the existing systems
5) Easy Expansion and Improvement

After a detailed study of the existing system, the study team concluded that the above requirements could not be fulfilled by any improvement of the existing system for the reasons discussed in the previous section and a completely new system should be developed to replace the existing system of MOWD.

3.2 Policy of Renovation

3.2.1 Scope of the new database system

The proposed new system shall be installed in MOWD and shall handle and process the following information.

1) Information on observation station including location maps and description tables
2) Meteorological data
3) Rainfall data
4) Surface water data
5) Suspended load data
6) Water quality data of surface and ground water
7) Ground water data
8) Water permit data

3.2.2 Basic requirements of database functions

The design requirement of the new system are:

1) to make it possible to handle a large number of data required in this Study and future studies.

2) to maintain the present procedures of CSS from data entry to output services as much as possible.

3) to use an application built using standardized relational database management system (SQL based RDBMS) which is widely used in the world.

4) to introduce a networked Client-server system consisting of a low-cost multi-task workstation as a server and user-friendly personal computers as clients,

5) to select appropriate combination of hardware and software

6) to build user-friendly interfaces including a graphical interface which enables retrieval of the required observation station from maps displayed on the client PC as well as table type interfaces.

3.2.3 Network in MOWD

The new database system shall be used in separate offices in the MOWD building through the local area network system. The server with RDBMS is installed at CSS (4th Floor) and client PCs are to be installed at CSS (4th Floor), PL and RE (5th Floor), SW and DE (3rd Floor) and GW and WQ (2nd Floor), respectively. Figure Q3.1 shows the network layout in the MOWD building.

3.2.4 Basic specifications of the hardware and software

Basic specifications of the hardware and software to fulfill the above requirements are as follows.

1) Server Workstation
   - 32bit CPU (5MIPS or higher)
   - 16MB Memory or higher
   - Color Monitor, Keyboard and Mouse
   - Disk Storage for Operating System (approximately 200MB)
   - Disk Storage for RDBMS (approximately 1GB)
   - Tape Drive for Data Exchange and Backup
   - Multi-task Operating System with Network Window System
   - High-speed Network Hardware (4Mbps or higher)
   - Standard Network Protocol Support
   - FORTRAN and C Language Support
   - Application Support like ARC/INFO
   - Initial Hardware and Software Installation
   - Reliable Hardware and Software Maintenance

2) RDBMS
- SQL Support
- High-level Language Support
- Multiple Network Support
- Reliable Software Maintenance

3) User Interface Subsystem
- 32bit CPU (1MIPS or higher)
- 4MB Memory or higher
- Color Monitor, Keyboard and Mouse
- Disk Storage for Local Operation (approximately 100MB)
- Operating System with Graphical User Interface
- High-speed Network Support
- Standard Network Protocol Support
- Development Tool for Graphical User Interface
- Reliable Hardware Maintenance

3.3 System Configuration

In accordance with the basic specifications, the study team determined the system configuration required for the new database system with due consideration to the situation of computer business in Kenya. The system comprises of a server workstation, four (4) units of client personal computers, two (2) printers, a local area network system, Relational Database Management System (RDBMS) and hydrological database applications developed by the study team.

The major considerations in selecting hardware and software products to be procured are given as follows.

(1) Server

Engineering workstation type of computer is best suited for the server. DEC product VAXstation3100 was selected as the server because of its high reliability as well as after care service, DEC has many users in Kenya such as Nairobi University and many public offices in Nairobi.

(2) Operating system of server

VMS peculiar to DEC products is selected as operating system of the server because of its popularity in Kenya, especially with graduates of Nairobi university and wide training and support service available in Kenya.

(3) Relational Database Management System (RDBMS)

ORACLE was selected as RDBMS. It is the best sold RDBMS in the world and supports many platform from mainframe to PC. It is also good for connectivity in

a network and is easy to expand. Support service for ORACLE in Kenya is well organized.

(4) Client PC

Macintosh II was selected as the client PC. It is one of the most user-friendly personal computers and therefore it is easy to operate for the staff of the database section as well as users such as experts or engineers in various fields. Macintosh is also well supported in Kenya.

(5) Network Media

Thinwire Ethernet was adopted for network media. It is the standard network media of DEC products and is the most popular for local area network.

(6) Network Protocol

DECnet and AppleTalk are adopted as network protocol in conjunction with hardware and software selection .

Figure Q3.2 shows the system configuration of the new database system. Final Specifications are listed in Table Q3.1.

3.4 Structure of Database Applications

3.4.1 Overview

The hydrological database system consists of a server and client PCs in the background. The system is built by customizing the following general purpose software.

1) Server (VAXstation3100)
   ORACLE for VAX
   LanWORKS
   VAX FORTRAN
   VAX C

2) Client PC (Macintosh)
   SuperCard
   ORACLE for Macintosh

The hydrological database applications are developed on the Macintosh and all the process of the database system are managed by the applications. Advanced users and system managers have added provision for operating the database directly by using the ORACLE software tools.

3.4.2 General structure

All the interfaces of the hydrological database applications appear on the client PC (Macintosh). Users will operate the system using the PC and normal users need not know how the server is working

The database application manages map and table information. The map retrieving system is developed on Macintosh by using software named SuperCard. It holds a general map covering the country and detailed maps of 1 to 500,000. The general map is an index map of the detailed maps. The detailed map indicates the locations of all the registered observation station specified by longitude and latitude by symbol marks. The general map appears first on the monitor of PC, and a user can access any detailed map by selecting the corresponding index area shown on the general map. Then the user would find the objective station on the detailed map and can access the selected station description table stored on the server. The necessary table information appears on the display monitor.

Data entered from PC are stored in the sever (VAXstation3100) in the form of a table managed by ORACLE (RDBMS) which is a software of general purpose relational database management system and has been specially customized for the hydrological database by the study team.

Table information contains a set of data of a certain category, for instance the rainfall station information table contains station ID, station name, longitude, latitude, province code, district code, drainage area code, station type, opening year, closing year, monthly mean rainfall, while the daily rainfall table contains station ID, date and daily rainfall depth. The map information, the rainfall station information table, and the daily rainfall table are linked each other by station ID as a key.

All the data tables stored in the hydrological database are listed in the following section.

Figure Q3.3 shows the general structure of the database applications.

3.4.3 Advanced operation

The hydrological database applications are powerful and user-friendly system for general users but the users are restricted to operate the system within the given interface circumstances to impose strict integrity measures.

However, there are many methods to access to the data stored in ORACLE and users can develop other interface tables than those already registered. The advanced uses of the system would include

1) use ORACLE tools by directly accessing to ORACLE from PC or the server console
2) use HyperCard Stacks attached to ORACLE for Macintosh
3) call the ORACLE from other program by using C language

For such advanced operation of the database, the user should be familiar with ORACLE tools and SQL. For further information, please refer to the user manuals of the system and the software.

3.5 Security

For protecting the database system from illegal users, user must type in the registered username and password when starting the sever. Starting ORACLE also requires the registered username and password.

In addition, for each table or column of the database, the system manager can set access privilege for each user. Two levels of access privilege can be set, a user can only retrieve data from table or column but not update or a user can both retrieve as well as update the table or column.

Q4. DATA STRUCTURE AND INTERFACES

4.1 List of Data Tables

The database handles the following information.

1) Observation Station information

1-1) Location maps (Table Q4.1)

1-2) Station description table including
Meteorological station (Table Q4.2)
Water level gauging station (Table Q4.6)
Borehole (Table Q4.13) and
Water permit location (Table Q4.15)

2) Data information

2-1) Meteorology
Meteorological data table (Table Q4.3) including
temperature
relative humidity
evaporation
sunshine hours and
rainy days

2-2) Rainfall
Daily rainfall data table (Table Q4.4)
Monthly rainfall data table (Table Q4.5)

2-3) Surface water
Daily water level data table (Table Q4.7)
Discharge measurement data table (Table Q4.8)
Rating curve equation at rated station (Table Q4.9)
Daily discharge data table (Table Q4.10)

2-4) Suspended load
Suspended load monitoring data table (Table Q4.11)

2-5) Surface water quality
Surface water quality monitoring data table (Table Q4.12)

2-6) Ground water
Borehole description and data table (Table Q4.13)

2-7) Ground water quality
Ground water quality monitoring data table (Table Q4.14)

2-8) Water permit
Water abstraction data (Table Q4.16)

4.2 List of User Interface Views

The hydrological database applications prepare the following views to be displayed on the monitor of client PC.

1) Setup Screen (Figure Q4.1)
It is the start up screen which appears when the server has not been connected to the client PC.

2) Connect menu in Setup Screen (Figure Q4.2)
Connect menu appears on the top left corner of the screen. One can start the database system or set Preferences from the connect menu, by selecting either "Login" or "Preferences".

3) Preferences window (Figure Q4.3)
When "Preferences" is selected from the previous view (Figure Q4.2) the preferences window appears. Users can set a default hostname and date formats of input and output.

4) Login window (Figure Q4.4)
When "Login" is selected from the view (Figure Q4.2), the Login window appears. Type in username and password to connect to the server system.

5) Summary menu in Setup Screen (Figure Q4.5)
When the server is successfully connected, the screen comes back to the start up screen. At this time, summary and map menus also appear on the upper side of the screen. The summary menu contains daily rainfall, daily water level, daily discharge. You can select one of the items to proceed to a summary table.

6) Daily rainfall summary (Figure Q4.6)
If the item of daily rainfall is selected in the previous screen, the Daily rainfall summary table appears. It shows the availability of daily rainfall data on annual basis for all the registered rainfall stations.

7) Map menu in Setup Screen (Figure Q4.7)
If the map menu is open in the setup screen, items of rainfall, surface water, ground water and water permit are shown. You can select one of the items to proceed to a location map screen in Figure Q4.7. For example, the location map of rainfall stations is selected in the figure.

8) Map screen and query menu (Figure Q4.8)
The map shows the location of rainfall stations. An index map is shown at lower left corner of the screen. You can scroll the location map to the appropriate location and select the objective station. Then you can gain access to the data table by selecting the item "view data" from the Query menu.

9) Table access window (Figure Q4.9)
This is a station description table. All the necessary data of a station are shown on a row. Retrieving of data can be carried out on this table by using a control panel which appears on the right half of the screen.

10) Table description window (Figure Q4.10)
As an example, if you select describe command from the control panel, the table description window appears. This table shows a list of all the column name contained in the station description table and their data type, etc.

11) Example of limited information table (Figure Q4.11)
If you want to get information only for selected items from the description table, you can select the necessary columns on the control panel, and create a table containing only the selected columns. In Figure Q4.11, those columns ID, name, longitude, latitude, open and dailymax are selected.

For further information on using the new system, please refer to the operation manual of the hydrological database system prepared as a separate volume.

Q5. DATA ENTRY AND REPORTING PROCEDURE

5.1 Data Conversion from Existing System to New System

The data stored in the existing database were transferred to the new system in the following manner.

(1) MOWD

Data files stored in the removable disk pack of the WANG system was copied on a 1/4-inch QIC tape and it was converted to a 1/2-inch 9-track Standard tape which is readable by the tape utility of the VAX system.

The discharge records expressed by BCD (Binary Coded Decimal) format was converted to readable TEXT format and then read into the new system.

(2) KMD

All the data stored in the system were converted to IBM-PC TEXT format and copied on 3.5 inch High Density Floppy Diskettes. Then they were transferred to Macintosh PC and reorganized into appropriate forms to store the new database system.

(3) LBDA

The data stored in IBM-PC were recorded in various formats such as TEXT file of IBM-PC, Lotus WK1 and dBASE. They were all converted into TEXT file format and stored in the new database system.

5.2 Entry of New Data

5.2.1 Data type

The new system has three data types. If a data row lacks a data value for a particular column, that value is assumed to be null. Columns of any data type may contain null values. The three data types are

1) Character type (Variable length character data, maximum length is 255)

2) Number type (integers or real numbers, maximum precision is 38)

3) Date type (dates are allowed from January 1, 4712 BC to December 31, 4712 AD)

5.2.2 Measurement system

1) All measurement data shall be expressed by SI (Standard International) system instead of Foot-pound system,

2) For the location of station, east longitude and north latitude are expressed by positive degrees.

3) The latest map numbering system used by Survey of Kenya is applied for classification of the location maps. Grid system is based on UTM (Universal Transverse Mercator).

5.2.3 Data entry procedure

There are two choices for entering data into the database. One is to type in directly from the console of Macintosh PC and the other is to import a data file from a diskette or tape or from a file created in the internal disk of PC.

The procedure for New data entry, Update and importing are as follows

New Data entry from console

1) Call the Table Access Window of the objective table from the database
2) Type in data in an appropriate field in the table
3) Proceed to Insert operation
4) Commit if it is correctly typed or Cancel (rollback) if any error is found in type-in operation
5) Then, register the data

Update operation

1) Select the Table Access Window of the objective table
2) Edit the data rows
3) Update operation
4) Commit or cancel (rollback)

Import operation

1) Select the Table Access Window of the objective table
2) Click Import button
3) Select the appropriate device and the file name to be imported
4) Click OK
5) Commit or cancel (rollback)

The meteorological data and rainfall data to be prepared by KMD will be imported to the Macintosh PC by means of 3.5 inch High Density Floppy Diskettes

5.3 Reporting

Two alternatives are provided for reporting. One is to print out on papers and the other is to export data on to a Diskette or a tape.

Q.6 DATA COLLECTION

6.1 General

The data stored in the new Database were those collected during the study period of the National Water Master Plan as well as those transferred from the existing database in MOWD and other agencies. This Chapter gives a brief description of the data collected and stored in the database and a proposal for data collection and preparation in future.

6.2 Meteorological Data

"Summary of Climatological Data in Kenya" have been published in 1953, 1964, 1975 and 1984. The first 3 publications were printed by the East African Meteorological Department (EAMD) and the latest by the Kenya Meteorological Department (KMD). The latest edition contains the climatological data collected at 84 meteorological stations covering a period of nearly 60 years.

Annual and monthly mean meteorological data for 84 stations were stored in the System. All the data are based on the latest publication.

6.3 Rainfall Data

6.3.1 Station description

In Kenya, rainfall has been measured for a few years to about 90 years at various stations since the rainfall station at Mombasa was first established in 1891. The rainfall data have been collected at meteorological stations of KMD and through the water related government agencies such as MOWD and MOA. Currently, data is collected at 2,857 stations on daily basis and stored in a computerized data bank at the headquarters of KMD.

Registration code of the stations are organized into 7 figures; the first 2 figures indicate the North Polar Distance of the latitude circle forming the northern edge of the degree square in which the station is located, the subsequent 2 figures indicate the meridian of longitude forming the western edge of the degree square, and the last 3 figures are set in ascending order corresponding to the date when the station was established.

6.3.2 Monthly rainfall data

From all the registered stations, 212 stations were selected, where records was available for more than 20 years. The monthly rainfall data for these stations was transferred from database of KMD to the new System.

6.3.3 Daily rainfall data

Daily rainfall records for these 212 stations were collected from the database of KMD. The data, however, does not cover the whole period in which monthly rainfall was recorded. The reasons are:

(i) daily rainfall records for the limited period of 1958 to 1988 have been stored in the database.

(ii) in case the monthly rainfall less than about 5.0 mm, daily rainfall data were never stored and

(iii) the old rainfall recording forms before 1957 have been abandoned and summarized monthly rainfall recording papers have been stored in KMD.

6.4 Water Level Data

6.4.1 Basin boundary map

The drainage system in Kenya is organized into 5 drainage areas. Although their basin boundaries which were divided into 158 sub-drainage areas were verified by remote sensing method on the scale of 1:1,000,000 the area which was covered by the cloud could not be confirmed exactly, which is about 150 km long at lower reach of the Tana River. Those boundaries were delineated by referring to topographic maps on the scales of 1:50,000 and 1:100,000 basin boundary maps which were prepared by MOWD and those of NMWP-I. These in-depth basin boundary maps are useful for low flow analysis, flood control schemes and dam planning.

The present basin boundary map was prepared under the colonial days in 1930's. This basin boundary has been used in Kenya. The station code of existing water level gauge has also been named after sub-drainage area code in basin boundary map.

The existing basin boundary map consisting of 158 sub-drainage areas, however, contains some errors in their boundaries since they were delineated on the basis of a topographical map without contour lines on a scale of 1:50,000. Part of these boundaries were elaborated referring to the latest topographical maps with contour lines on a scale of 1:50,000 to reset errors. Some relatively large sub-drainage areas were sub-divided further during this Study for convenience of handling. 197 sub-drainage areas were verified under this Study.

6.4.2 Description of hydrological station

Hydrological data concerning the surface water were collected from the Hydrology Section of MOWD which is responsible for collecting and evaluating data on rivers in Kenya. Their hydrological database system in headquarters of MOWD was established in 1983 and was mainly organized into 3 items namely (i) Surface water database, (ii) Groundwater database and (iii) Water permit database.

Data contained in the Surface water database are

(1) Basic information of water level gauging station,
(2) Daily water level (including lake water level), and
(3) Rating curve equation

Daily discharge was computed every time upon user's request. The data are interpolated linearly in case of the missing data.

Data on station history at registered 923 water level gauging stations were transferred into the New System from the previous database system.

6.4.3 Daily water level data

Daily water level data at 923 stations are registered in the database of MOWD. Most of the existing water level gauges have been installed at the river bank of perennial rivers and at Lake shores.

The first 8 gauging stations started their operation in 1921 on the highland streams namely at Kiambu and Nairobi districts (Sub-drainage area: 3B) and Thika River (Sub-drainage area: 4C). Lake water level observation started much earlier in 1908 on Lake Naivasha.

In the early 1930's the low flow observation network was enlarged in highland where the farms were concentrated and the drainage area was firstly divided into 5 main drainage areas. In the later 1940's and 1950's the observation network was extended to cover not only highland but low potential areas.

The distribution of water level gauging stations by drainage area are summarized below.

	Drainage Area	Nos. of Gauges					
		AS	ASW	S	SW	W	Total
1.	Lake Victoria	18	4	169	38	-	229
2.	Rift Valley	15	3	95	38	2	153
3.	Athi River/Coast	15	5	118	49	36	223
4.	Tana River	19	7	152	18	9	205
5.	E. N'giro River/North	7	6	58	30	12	113
	Total	74	25	592	173	59	923

Note: AS : Automatic recorder + Staff gauge
ASW : Automatic recorder + Staff gauge + Weir
S : Staff gauge
SW : Staff gauge + Weir
W : Weir

Of the above station, 399 stations are now under operation as enumerated below:

Drainage Area	Registered Station (nos.)		
	Operation	Abandoned	Total
1	114	115	229
2	50	103	153
3	74	149	223
4	116	89	205
5	45	68	113
Total	399	524	923

6.4.4 Rating equation

Of the registered stations, rating curves at 115 stations were stored in the former database at MOWD. In the Study, all the discharge measurement data in the Surface Water Section at MOWD were verified to confirm the accuracy of their rating curves. Rating curves for 331 stations were finally incorporated into the New System.

The Lake Basin Development Authorities (LBDA) also have their own database system in Kisumu. All the surface water data of MOWD concerning the Drainage Area 1 was backed-up when LBDA established their own database system. LBDA then carried out verification of the then existing 132 rating curves and reestablished more accurate ones. The 132 rating curves in Drainage Area 1 were compared with LBDA's data before incorporation into New System.

The rating equation is defined by the following power equation

$$Q = K (H + DH)^P$$

where, Q : Daily discharge (m3/sec)
H : Daily water level (m),
DH : Datum on rating curve (m), and
K and P : constant

6.4.5 Discharge measurement data

Discharge measurement data at rated stations were also incorporated into new system. One can verify the reliability of rating curves directly on the screen.

The discharge measurement data in drainage area 1 were transferred from the database of LBDA.

6.4.6 Daily discharge data

By using the rating equations, the daily water level data were converted into daily discharge data at 331 rated stations.

In cases where daily water level data is obviously beyond the applicable range of rating equation, the daily discharge was treated as a missing data.

6.5 Suspended Load Monitoring Data

None of suspended load measurement data had been stored in the database of MOWD. Under this Study, all the existing data were stored in the System. The numbers of suspended load monitoring stations are enumerated below.

Drainage Area	Station (nos)	River (nos)	Sample (nos)
1	67	58	554
2	52	36	907
3	50	32	1,304
4	90	58	2,447
5	18	13	271
Total	277	195	5,843

However, among the stations, 36 stations have more than 30 monitoring data.

6.6 Water Quality Monitoring Data

MOWD is maintaining a nationwide water quality monitoring programme. The programme itself is a well prepared system. However, the actual achievement to date was far less than the originally intended due to significant financial constraints.

Although it is a fact that water quality monitoring programmes are relatively expensive to run in terms of both capital and recurrent costs, the benefit derived from protection of the nations water resources outweigh these costs. The programme must be operated on a continuous basis.

In the New System, the water quality data of 120 stations (599 samples) were stored. Although some monitoring stations are located at existing water level gauging stations, locations of most are not mentioned. Such stations were grouped into lower, middle and upper reaches of the river. Thus the 599 samples was classified into 20 stations (183 samples) at existing water level gauging stations and 41 groups (416 samples) without exact locations.

6.7 Groundwater Data

6.7.1 Borehole data

Boreholes have been drilled by the Government as well as by individuals and corporate bodies. When a borehole has been drilled, it is assigned a serial number. Therefore all boreholes, that have been drilled in Kenya, are listed and plotted on a base map and the records of boreholes are filed at the Groundwater Section of the Ministry of Water Development. Registered completion records account to 9462 by March 1991. The Water Act provides that certain data should be submitted within one month of the completion of a borehole. The standard form (WAB. 28) demands information on location, ownership, purpose of use, date of construction, well dimension, property of aquifer, pumping test data, water potability, monitoring of water level, etc.

The relevant data concerning the Borehole are stored on the computer. The chemical properties are indicated only as a potability code. The logging data are expressed as a rock type code. The borehole completion record demands information on initial yield and water levels for all boreholes, but monitoring of groundwater abstraction and water levels have seldom been carried out and data on groundwater abstraction and water levels are not stored on the computer.

The major uses of boreholes are public water supply, agricultural, domestic and industrial, and livestock in order as shown in the following table. Observation and exploratory boreholes are included in spite of their small portion. About half of the boreholes have no information available.

Number of boreholes by use

Borehole use	No. of boreholes	Percentage (%)
Public water supply	2,137	22.6
Agricultural	948	10.0
Domestic	434	4.6
Industrial and commercial	224	2.4
Livestock	177	1.9
Observation	62	0.6
Exploratory	52	0.5
Other	973	10.3
Unknown	2,496	26.4
Undescribed	1,959	20.7
Total	9,462	100.0

Rock type remarkably affects aquifer characteristics. The country is considered to consist of three major rock types namely volcanic, metamorphic basement, and sediment rocks. The number of boreholes in each rock type are shown in the following table.

Number of boreholes by rock type

Rock type	No. of boreholes	Percentage (%)
Volcanics	3,883	41.0
Basements	1,592	16.8
Sediments	878	9.3
Volcanics over basements	162	1.7
Sediments over basements	67	0.7
Sediments over volcanics	72	0.8
Volcanics over sediments	52	0.6
Other	20	0.2
Unknown	255	2.7
Undescribed	2,482	26.2
Total	9,462	100.0

Groundwater abstractions have seldom been investigated in Kenya except in two studies (Chilton, 1970; Swarzenki & Mundorff, 1977) regarding a rather small part of the country for one or two years. The borehole completion record demands information on initial yield for all boreholes, but annual or seasonal values of actual groundwater abstraction have not been investigated nationwide.

6.7.2 Groundwater quality data

Database on water quality was newly established under this study and stored on the VAX station and Macintosh computer for data management.

Water quality analyses have been conducted for classification of potability and geochemical interpretation. The classification of potability and geochemical interpretation demand water temperature, electric conductivity, pH, total dissolved solid (TDS), total hardness, color, turbidity, permanganate number, chloride (Cl), nitrite (NO_2), Nitrate (NO_3), iron (Fe), manganese (Mn), fluoride (F), sodium (Na), potassium (K), calcium (Ca), Magnesium (Mg), bicarbonate (HCO_3), sulphate (SO_4), silica (SiO_2), carbonate (CO3) and etc. The water quality data of groundwater are available only for about 11 % (1,435 nos.) of the boreholes in the country.

6.8 Water Abstraction Permit Data

(1) Source of data

The original data source of water abstraction permits is in the form of Application Form. Obligation exist for the applicant to fill this form in order to get permits. When an application reaches the Water Apportionment Board, the application is registered in Ledger with a serial number and a file for the application is opened. File number is given like W/10001/5 where the first digit indicate number of the catchment area, next four digits mean river number and last digit(s) means a serial number of application in same river course.

After processing the application (inspection by water bailiff, advertisement, etc.), the application is brought to the Water Apportionment Board Meeting which is held on the first

Friday of every month. For examination of the application at the Board, the application is summarized in the form of agenda. After a decision by the Board minutes are prepared. The serial number given at receipt of the application then becomes the permit number. The MOWD database is prepared based on the minutes mentioned above. The surface water abstraction permit data of more than 15,000 were stored in the database.

(2) Reliability of data

Data in the MOWD database was checked from various aspects, and the following are findings:

(a) Incompleteness of Original Data

The application form are not always filled completely.

(b) Mistakes during Processing of application and permit

During the application processing of Surface Water abstraction permit, drafting and typing are made twice during the entire process. Even though checking is made, human errors are unavoidable. Obvious mistakes like Permit number of 30,000 belong to this category.

(c) Data Entry Errors.

Input of data into computer is made by reading the minutes which are not organized well and many errors are possible.

(d) Unit of Amount of Abstraction

The amount of abstraction is expressed in m^3/day or g.p.d in the minutes while entering into the computer, the unit is converted into ft^3/sec. Conversion mistakes were found.

(e) River Name, River Code, Basin Code

Under a same river code such as 10201, there are several river names. Spelling of river name is not unified. Treatment of tributaries are various, sometimes mentions " xxxx stream, tributary of yyyy river " but others only " xxxx stream ". One river name having many river code is acceptable specially in case of big river where the upstream and downstream have different codes, but reverse is not acceptable. Many records was found with one code having many river names.

(f) Name of Permit Holders

Name of permit holders are often abbreviated arbitrarily. For example,

- Chief of Conservator of Forest
- Conservator of Forest

- Forest Conservator
- Conservator, Forest

(g) Map No. and Coordinates

Many data lack information on map number and coordinates.

(h) Percentage of Water Use

Sum of percentages of water usage sometimes exceeded 100 %.

(3) Data scrutiny

Upon finding several deficiencies in the MOWD database, the Study Team tried to fill the following data gaps.

(a) Ledger of Application

The Water Apportionment Board keeps Ledger Books which register from Permit No. 1 until the latest one. Ledger keeps records of registration No. applicant name and address, river name, etc. but no records of amount of water and purpose of abstraction. Although there are many blanks and several missing pages, it was considered that Ledger would be a prime source of information. Data so far available was entered in PC system.

(b) Minutes of Water Apportionment Board

The minutes of the Water Apportionment Board Meeting are kept intermittently by the Board. Considering that the minutes in recent 10 years or so would be able to cover a substantial part of the currently effective permits, data since 1978 was also entered into PC system.

In case of abstraction for irrigation water use: minor irrigation or general irrigation, acreage and crop information which are excluded from the MOWD data base was added.

(c) Cross-checking among three Data

Although the original source of information is single, there are three package of information : MOWD, Ledger and Minutes. By cross-checking one with the other data gaps were filled wherever judged to be appropriate. Some checking are as follows:

(a) Check of dates like day :35, month : 16, year : 1081.There are lots of Feb. 30, 31 April 31 and the like.
(b) Check of consistency between river name and river code

(c) Check of consistency between river code and basin code
(d) Check of consistency between coordinates and map no
(e) Check of abnormally big abstraction amount

Since the above checking remained as relative checking, improvement to the accuracy of the database was quite limited.

6.9 Further Consideration of Data Collection and Preparation

6.9.1 Meteorological data

Because of the limitation of man-power for data input, the annual and monthly mean meteorological data for the period from several years to some 60 years was unable to be stored in the New System even though the annual and monthly variations data may take an important role for water-related schemes in their feasibility study stages. At least, the monthly values at 83 meteorological stations should be collected from the KMD and be stored in the System.

6.9.2 Rainfall data

Daily and monthly rainfall data as of the end of 1988 at the selected 212 stations were stored into the New System. All the data were collected from the database of KMD, while a number of rainfall data was compiled from rainfall data book of MOWD. The data in MOWD should be stored in the System.

6.9.3 Water level data

(1) Source of Data

Punching errors are evident in water level data when MOWD established the former database system in 1963 while transferring from HERUFI HOUSE. These errors was not corrected in 1990. The data should be corrected comparing with the original log book of water level records.

(2) Rating Equation

Rating equations at 331 rated water level gauging sites were stored in the System. The applicable range of the equation, however, does not cover the range from medium to high water levels. In the System, the minimum water level for applicable range was stored, while the maximum water level was not stored. The maximum water level should be stored on the basis of the cross section of water level gauging station and discharge measurement data.

Furthermore, frequent discharge measurement should be carried out at rated water level gauging stations.

6.9.4 Suspended load monitoring data

Suspended load measurement has been carried out at 277 water level gauging stations. Among the stations, 36 stations have more than 10 data. Although the suspended load discharge curves at 36 stations were established in the Study, such curves may not have enough accuracy.

Suspended load data, in general, contributes well for the estimation of soil erosion rate and the sediment deposit volume into a reservoir. More frequent monitoring of suspended load should be required at principal stations.

6.9.5 Water quality monitoring data

(1) Among a monitoring stations, 20 stations are located at existing water level gauging stations. However, the remaining stations could not find out the point of sampling. At present, such stations are classified into 30 groups in the System.

(2) In case that the water sampling is carried out at different location of existing water level gauging station, the point of sampling should be mentioned in log book.

(3) At least, water sampling should be carried out 4 times a year at principal monitoring stations.

6.9.6 Groundwater Data

(1) Borehole Data

The borehole database stored data of boreholes registered by March 1991. Data of boreholes, which were registered after that time and will be registered, should be stored in the database. At the same time, renewal of the data should be necessary, specially regarding location data and monitoring data of water levels.

(2) Groundwater Quality Data

The groundwater quality database stored chemical data of boreholes reported by March 1991. Data of boreholes, which were reported after that time and will be reported, should be stored in the database. At the same time, renewal of the data should be necessary.

6.9.7 Water abstraction permit data

(1) General

The surface water abstraction permits currently effective is more than 15,000, and is beyond human capacity to sort manually. Thus, the water abstraction permit data is suitable for computerized database system. In administration of the water abstraction permits, the following operation will be required:

(a) Sorting out of expired permits and their renewal.
(b) Judgment of new applications whether permissible or not, in terms of available flow and the already existing permits in a river in question.

A database system should be accurate as far as possible and must be updated from time to time. Inaccurate and old database is meaningless in all respects. Therefore, continuous effort to maintain the database is needed. In order to secure such efforts, a Database Manager should be appointed and necessary fund should be secured. Otherwise, a database once accurate and updated will soon become out-dated.

Expected users of the water abstraction permit database would be;

(a) Staff of the Water Apportionment Board,
(b) Provincial and District water engineers,
(c) Water bailiff,
(d) Planning and design peoples of Ministries and Corporations, and
(e) Consultants who are engaged in planning and design

All of them are considered to have some knowledge on the water abstraction permit. Its legal basis shall be referred to the Water Act.

The water abstraction permit data is a prime source of information on surface water use in Kenya. For the proper management of the water resources in Kenya, proper management of the water abstraction permits is of vital importance, and such management can be achieved only based on accurate and complete information and data. In this context, several recommendations are presented for the future improvement of the water abstraction permit database system.

(2) River Order

Present river number seems to be attached rather abruptly. Big rivers and small streams are dealt with similarly. One river number has several names located in far different place. Rivers where no water abstraction has been made has no river number.

This situation decreases the capability of the database system and makes it difficult to know amount of water abstraction permitted in one river accurately. Systematic numbering and unified spelling of river names are recommended.

One of methods of systematic river numbering is " river order system " where river order is given as:

Order 1 : main streams having river mouths in sea, lakes or international border, independently from river size

Order 2 : primary tributaries flowing into Order 1 rivers

Order 3 : secondary tributaries flowing into Order 2 rivers

so on

(3) Positioning of Intake Site

The current positioning of an intake site is depending on 1 to 50,000 topographic maps and reading out of UTM coordinates shown in maps. However, fulfillment of these data in the MOWD database is far from satisfactory, since 1 to 50,000 topographic maps is not always available to applicants and water bailiff and further exact positioning of the intake site of 1 to 50,000 map, even if available, needs some sort of skills.

To solve this situation, one of cost-effective methods with relative accuracy would be to use marketed " Global Positioning System " which uses satellites and has positioning accuracy of about 100 meters. If this system is used, it will not be difficult to determine the coordinate of each intake point. Accurate positioning of intake points will much improve the quality of the water abstraction permit data.

GSP equipment now costs about Japanese Yen 150,000 or Ksh30,000. Even if all the provincial and district water engineers are equipped with, the benefit will far exceed the cost.

(4) Use of Data Coding Sheet

Current practice of data collection - writing, re-writing and typing are one major source of error in the database. Therefore, it is recommended to use " Data Coding Sheet " along with the application form. The coding sheet will be firstly filled with applicants : applicant name and address, usage and required amount, intended methods, etc.. Water bailiff will supplement information such as river name and number and basin code. The Water Apportionment Board will provide permit number, file number, and water amount finally permitted. Then, the coding sheet will be forwarded for processing in to computer. In this way rewriting and typing can be eliminated providing more reliability. Care must be taken to carefully design the data coding sheet which can be used for several years.

A sample of data coding sheet is shown in Table Q.6.1. Some addition to data coding sheet is recommended as follows:

1) Classification of Permit Holders

Section 39 of the Water Act stipulates the following classification for use of water or drainage of land:

private project
community project
public project
urban project

It is considered that classification mentioned above will help management of water abstraction permits, hence it is recommended to include the classification.

2) Water Supply System Name

The present application form requests applicant's name and address and does not request name of water supply system specifically. Then, in case of MOWD water supply schemes, the Director of Water Development becomes applicant. If water supply system name is not mentioned in the application, it is not easy to identify water supply system name afterward. So, it is recommended to put request for system name in Data sheet.

3) Number of Human and Livestock Population

Since unit consumption rates of human and livestock are within a certain ranges, abnormal amount for domestic use can be easily detected.

4) Use for Groundwater Abstraction Permits

The present water abstraction permit database deals only surface water abstraction permits. However, if there is need to include groundwater abstraction permits, it will be possible to use same Coding Sheet with slight modification. Major differences between surface and ground water are File No. : W/xxxxxx/xx for surface water and C-yyyy for groundwater, and no expire date for groundwater.

Q7. INSTALLATION AND TRAINING

7.1 Procedure of Installation

The procedure of installation of the system is chronologically described below.

(1) September, 1990

JICA gave an order for a set of hardware and software including a Server (VAXstation 3100), a ORACLE RDBMS, a Client PC (Macintosh IIfx), a Laser Printer, and other software.

(2) June, 1991

JICA additionally gave another order including three units of client PC (Macintosh IIfx), a Laser Printer, and UPSs (Uninterruptable Power Supply).

(3) August, 1991

The following hardware and software were installed in CSS in the MOWD building.

1) Server
   VAXstation3100 and VMS operating system
   ORACLE
   LanWORKS
   Thinwire Ethernet for network media
   UPS for VAXstation

2) Client PC
   Four (4) units of Macintosh II
   Two (2) units of Laser printer
   UPSs for Macintosh

(4) September, 1991

Hydrological Database Applications were setup on the above hardware and software.

1) Server setup including database table creation and data loading, and

2) Client PC setup including installation of ORACLE tools, the database applications and the network communication software

(5) May,1992

1) Installation of a client PC in each office in the MOWD building.

2) Final check was carried out and then the system was transferred to MOWD.

Maintenance contracts are effective for 2 years for hardware and software products.

7.2 Training Programme

(1) Training to system engineers

The study team carried out a training programme for the system manager and system engineers of the Computer Service Section of MOWD for 2 months in 1991 and 1 month in 1992 including

- On-site training of network environment,
- Basic operation of Macintosh,
- Basic communication method between Macintosh and VAXstation
- RDBMS internal Data Backup,
- ORACLE SQL*Loader, SQL*Form tools
- Hydrological Database User Interface System
- Data exchange between Macintosh and IBM-PC.

They also studied VAX/VMS system management course for one month in 1991.

(2) Training to general users

The study team also carried out a training programme for general users for 2 weeks in May and June in 1992. The number of trainee was some 16 persons from the hydrological section, ground water section, water planning section, etc., of MOWD.

The programme contained the detailed explanation and practice of all the operation of the database system.

TABLES

Table Q3.1 Database System Hardware and Software (1/6)

Component	Item	Description	Category
Server Workstation	VAXstation 3100 model 38 System	32bit CPU/16MB Memory/SCSI/Ethernet/Serial/Mouse	Hardware
	VR299 19" Color Monitor	1024 x 864 pixel	Hardware
	2 x RZ23 104MB Hard Disk Drive		Hardware
	TZ30 95MB Tape Drive		Hardware
	2 x RZ56 655MB Hard Disk Drive		Hardware
	BA42 Storage Expansion Box		Hardware
	TLZ04 1.2GB Cassette Tape Drive		Hardware
	30ft Thinwire Ethernet Cable		Hardware Accessory
	2 x Thinwire Ethernet Terminator		Hardware Accessory
	Power Cords		Hardware Accessory
	Cleaning Cassete		Hardware Accessory
	10 x 60m Data Cassetes		Hardware Accessory
	VMS Operating System	VMS V5.4 BIN TK50 1/2	Software Media
		VMS V5.4 BIN TK50 2/2	Software Media
		VMS V5.4 BIN TK50 MANDATORY UPDATE	Software Media
		VMS V5.4-1 BIN TK50	Software Media
	VAX FORTRAN	VMS FORTRAN V5.5 BIN TK50	Software Media
	VAX C	VAX C V3.1 BIN TK50	Software Media
	DEC LanWORKS for Macintosh	DEC LanWORKS/MAC V1.0 TK50	Software Media
		DEC LanWORKS/MAC V1.0 DD	Software Media
	Software License Certificate	VAX VMS SINGLE USER LICENSE	Software License
		VMS WORKSTATION SOFTWARE	Software License
		DESKTOP-VMS	Software License
		DECWINDOWS DEVELOPER KIT VMS FOR OSF/MOTIF	Software License
		VAXCLUSTER SOFTWARE	Software License
		DEC END NODE	Software License
		DECNET FULL FUNCTION	Software License
		VAX FORTRAN	Software License
		VAX C	Software License
		DEC LANWORKS MAC CLNT LIC W/W	Software License
	VAXstation 3100 Model 38 Customer Hardware Information	VAXstation 3100 Planning and Preparation	Manual
		VAXstation 3100 Model 38 Owner's Manual	Manual

Table Q3.1 Database System Hardware and Software (2/6)

Component	Item	Description	Category
		Network Guide	Manual
		Installing and Using The VR299 Color Monitor	Manual
		BA42 Storage Expansion Box Installation Guide	Manual
		TLZ04 Cassette Tape Drive Owner's Manual	Manual
		VAX FORTRAN Installation Guide	Manual
		VAX C Installation Guide	Manual
	VMS Release Notes Volume 1	Software Product Description	Manual
		Overview of Documentation	Manual
		New Features	Manual
	VMS Release Notes Volume 2	Installation and Operations: VAXstation 3100	Manual
		Upgrade and Installation Manual	Manual
		Release Notes	Manual
	VMS System Manager's Manual		Manual
	VMS License Management Utility Manual		Manual
	VMS User's Manual		Manual
	VMS Using DECwindows	VMS DECwindows User's Guide	Manual
		VMS DECwindows Desktop Applications Guide	Manual
	VAX FORTRAN User Manual		Manual
	VAX FORTRAN Language Reference Manual		Manual
	VAX C Guide to VAX C		Manual
	VAX C Run-Time Library Reference Manual		Manual
	DEC LanWORKS for Macintosh System Administrator	Planning and Installation Guide	Manual
		Introduction to the AppleTalk Network System	Manual
		System Administrator's Guide	Manual
		System Administrator's Reference Manual	Manual
		MacTCP Administrator's Guide	Manual
		DECnet for Macintosh User's Guide	Manual
	DEC LanWORKS for Macintosh Network Services User's Guide		Manual
	DEC LanWORKS for Macintosh MacX User's Guide		Manual
	DEC LanWORKS for Macintosh MacTerminal User's Guide		Manual

Table G3.1 Database System Hardware and Software (3/6)

Component	Item	Description	Category
Client PC	Macintosh IIfx Personal Computer	40MHz MC68030 CPU/MC68882 Floating-Point Unit/8MB Memory	Hardware
	Apple Desktop Bus Mouse		Hardware
	Power Cord		Hardware Accessory
	System Tools	Version 6.0.5	Software Media
	Utilities 1	Version 6.0.5	Software Media
	Utilities 2	Version 6.0.5	Software Media
	Printing Tools	Version 6.0.5	Software Media
	Apple Network Products Installer	Version 6.0.5	Software Media
	Welcome		Software Media
	Looking Inside Macintosh IIfx		Software Media
	HyperCard 1	Version 1.2.5	Software Media
	HyperCard 2	Version 1.2.5	Software Media
	HyperCard 3	Version 1.2.5	Software Media
	Setting Up Your Macintosh IIfx		Manual
	Macintosh IIfx Special Options and Technical Information		Manual
	Getting Started with Your Macintosh		Manual
	Macintosh Reference		Manual
	Network Products Installer Guide		Manual
	HyperCard User's Guide		Manual
	HyperTalk Beginner's Guide: An Introduction to Scripting		Manual
	Apple EtherTalk NB Card		Hardware
	Accessory Pack		Hardware Accessory
	EtherTalk Installer disk	Version 2.0.1	Software Media
	Apple EtherTalk NB *User's Guide*		Manual
	Apple Extended Keyboard II		Hardware
	Template		Hardware Accessory
	Keyboard Cable		Hardware Accessory
	Apple Extended Keyboard II Owner's Guide		Manual
	Apple High-Resolution RGB Monitor	640 x 480 pixel	Hardware
	Video Cable		Hardware Accessory
	Power Coard		Hardware Accessory
	Apple High-Resolution RGB Monitor		Manual
	3 x *Macintosh IIsi Personal Computer*	20MHz MC68030 CPU/9MB Memory	Hardware

Table Q3.1 Database System Hardware and Software (4/6)

Component	Item	Description	Category
	Microphone		Hardware
	Apple Desktop Bus Mouse		Hardware
	Power Cord		Hardware Accessory
	System Startup	Version 6.0.7	Software Media
	System Additions	Version 6.0.7	Software Media
	Apple Network Products Installer	Version 6.0.7	Software Media
	Macintosh Basics		Software Media
	HyperCard Program	Version 2.0v2 Lite	Software Media
	Setting Up Your Macintosh IIsi		Manual
	Macintosh IIsi Special Options and Technical Information		Manual
	Getting Started with Your Macintosh		Manual
	Macintosh Reference		Manual
	Network Products Installer Guide		Manual
	HyperCard Basics		Manual
	NuBUS Adapter Card with M68882 Floating-Point Unit		Hardware
	Apple Ethernet NB Card		Hardware
	Apple EtherTalk Installer disk	Version 2.5.1	Software Media
	Apple Ethernet NB Card User's Guide		Manual
	Thin Coax Transceiver		Hardware
	2-Meter Cable		Hardware Accessory
	Ethernet Thin Coax Transceiver Owner's Guide		Manual
	Apple Keyboard		Hardware
	Keyboard Cable		Hardware Accessory
	Macintosh 12" Monochrome Display	640 x 480 pixel	Hardware
	Power Cord		Hardware Accessory
	Macintosh 12" Monochrome Display		Manual
Laser Printer	2 x LaserWriter II NTX		Hardware
	Power Cord		Hardware Accessory
	LaserWriter II Installation Disk		Software Media
	LaserWriter II NT/NTX Fonts		Software Media
	LaserWriter II NT/NTX Owner's Guide		Hardware Accessory
	3 x LocalTalk Connector Kit		Hardware Accessory

Table Q3.1 Database System Hardware and Software (5/6)

Component	Item	Description	Category
ORACLE RDBMS	ORACLE for VAX/VMS	Version 6.0.31.2 (2 x TK50)	Software License and Media
	Installation and Release Notes		Manual
	Installation and User's Guide		Manual
	Database Administrator's Guide		Manual
	Performance Tuning Guide		Manual
	Utilities User's Guide		Manual
	Error Messages and Codes Manual		Manual
	SQL*Net DECnet User's Guide		Manual
	PRO*C User's Guide		Manual
	SQL Language Reference Manual		Manual
	SQL Language Quick Reference		Manual
	SQL*Plus User's Guide and Reference		Manual
	SQL*Forms Designer's Tutorial		Manual
	SQL*Forms Designer's Reference		Manual
	SQL*Forms Designer's Quick Reference		Manual
	SQL*Forms Operator's Guide		Manual
	SQL*Forms Operator's Quick Reference		Manual
	SQL*Forms Documentation Addendum		Manual
	ORACLE for Macintosh Database Version	Version 1.2 Software Diskette (8 x 2DD)	Software License and Media
	ORACLE for Macintosh References		Manual
	ORACLE for Macintosh Getting Started		Manual
	ORACLE for Macintosh System Release Bulletin		Manual
	ORACLE for Macintosh Error Codes		Manual
	ORACLE for Macintosh Customer Info		Manual
	ORACLE for Macintosh User's Guide		Manual
	SQL*Net for Macintosh	Version 1.2 Software Diskette (3 x 2DD)	Software License and Media
	SQL*Net for Macintosh User's Guide		Manual
	SQL*Net for Macintosh Getting Started		Manual
	SQL*Net for Macintosh Error Codes		Manual
	SQL*Net for Macintosh Customer Info		Manual
	Farallon PhoneNET Liaison Software Router	Version 3.0.2	Software License and Media
	PhoneNET Liaison User's Guide		Manual
	User's Guide Supplement		Manual

Table C3.1 Database System Hardware and Software (6/6)

Component	Item	Description	Category
Other Software	Symantec THINK C	Version 4.0 (4 x 2DD)	Software License and Media
	THINK C User's Manual		Manual
	THINK C Standard Libraries Reference		Manual
	Silicon Beach SuperCard	Version 1.5 (3 x 2DD)	Software License and Media
	SuperCard User Manual		Manual
	SuperCard Language Guide		Manual
	SuperCard Quick Reference Card		Manual
	Symantec GreateWorks	Version 1.0 (4 x 2DD)	Software License and Media
	GreateWorks Installation Guide		Manual
	GreateWorks User's Guide		Manual
Network Equipment	DECrepeater 90C		Hardware
	2 x 185m Thinwire Ethernet		Hardware Accessory
	10 x BNC Connector		Hardware Accessory
	1 x T-Connecter		Hardware Accessory
	4 x Terminator		Hardware Accessory
Power Supply Equipment	3.3 KVA UPS		Hardware
	5 x 0.5 KVA UPS		Hardware

Table Q4.1 Database Table Description (Map Information)

Table Name	Column Name	Datatype	Null?	Description
MAP	MAPNO	CHAR(11)	NOT NULL	Map number
	NAME	CHAR(24)		Map name
	SCALE	NUMBER(8)		Map scale
	LEFT	NUMBER(6,2)		Left edge longitude (degree)
	BOTTOM	NUMBER(6,2)		Bottom edge latitude (degree)
	RIGHT	NUMBER(6,2)		Right edge longitude (degree)
	TOP	NUMBER(6,2)		Top edge latitude (degree)
	GRIDLEFT	NUMBER(6)		Left edge UTM grid (m)
	GRIDBOTTOM	NUMBER(6)		Bottom edge UTM grid (m)
	GRIDRIGHT	NUMBER(6)		Right edge UTM grid (m)
	GRIDTOP	NUMBER(6)		Top edge UTM grid (m)

Table Q-1.2 Database Table Description (Meteorological and Rainfall Stations)

Table Name	Column Name	Datatype	Null?	Description
RF_ST	ID	NUMBER(8)	NOT NULL	Station ID
	NAME	CHAR(32)	NOT NULL	Station name
	LONGITUDE	NUMBER(10,6)		longitude (degree)
	LATITUDE	NUMBER(10,6)		latitude (degree)
	ALTITUDE	NUMBER(4)		altitude (m)
	PROVINCE	NUMBER(1)		Provincial code
	DISTRICT	NUMBER(2)		District code
	DRNGAREA	NUMBER(4)		Drainage area code
	STTYPE	NUMBER(1)		Type of station
	OPEN	NUMBER(4)		Opened year
	CLOSE	NUMBER(4)		Closed year
	CALYEARS	NUMBER(3)		Available period (years)
	JAN	NUMBER(5)		Monthly mean of January (1/10mm)
	FEB	NUMBER(5)		Monthly mean of February (1/10mm)
	MAR	NUMBER(5)		Monthly mean of March (1/10mm)
	APR	NUMBER(5)		Monthly mean of April (1/10mm)
	MAY	NUMBER(5)		Monthly mean of May (1/10mm)
	JUN	NUMBER(5)		Monthly mean of June (1/10mm)
	JUL	NUMBER(5)		Monthly mean of July (1/10mm)
	AUG	NUMBER(5)		Monthly mean of August (1/10mm)
	SEP	NUMBER(5)		Monthly mean of September (1/10mm)
	OCT	NUMBER(5)		Monthly mean of October (1/10mm)
	NOV	NUMBER(5)		Monthly mean of November (1/10mm)
	DEC	NUMBER(5)		Monthly mean of December (1/10mm)
	DMAXDATE	DATE		Date of daily maximum occured
	DAILYMAX	NUMBER(4)		Recorded daily max. (1/10mm)

Table Q4.3 Database Table Description (Meteorological data)

Table Name	Column Name	Datatype	Null?	Description
RF_MT	ID	NUMBER(8)	NOT NULL	Station ID
	YEARSTART	NUMBER(4)		Beginning year of records
	YEAREND	NUMBER(4)		End year of records
	MONTH	NUMBER(2)	NOT NULL	Month
	TEMPMAX	NUMBER(4,1)		Daily maximum temperature (degree)
	TEMPMIN	NUMBER(4,1)		Daily maximum temperature (degree)
	TEMPEXHIGH	NUMBER(4,1)		Extreme high temperature (degree)
	TEMPEXLOW	NUMBER(4,1)		Extreme low temperature (degree)
	HUMIDITYMAX	NUMBER(2)		Daily maximum relative humidity (%)
	HUMIDITYMIN	NUMBER(2)		Daily minimum relative humidity (%)
	SUNSHINE	NUMBER(4,1)		Daily sunshine hours (hours)
	WINDRUN	NUMBER(5,1)		Daily wind run (km/day)
	EVAPORATION	NUMBER(4)		Daily evaporation (mm)
	MEANRAIN	NUMBER(4)		Mean rainfall (mm)
	RAINDAYS	NUMBER(2)		Mean raindays (days)

Table Q4.4 Database Table Description (Daily Rainfall Data)

Table Name	Column Name	Datatype	Null?	Description
RF_DATA	ID	NUMBER(8)	NOT NULL	Station ID
	YEAR	NUMBER(4)	NOT NULL	Observed year
	DAY	NUMBER(2)	NOT NULL	Observed day
	JAN	NUMBER(4)		January (1/10mm)
	FEB	NUMBER(4)		February (1/10mm)
	MAR	NUMBER(4)		March (1/10mm)
	APR	NUMBER(4)		April (1/10mm)
	MAY	NUMBER(4)		May (1/10mm)
	JUN	NUMBER(4)		June (1/10mm)
	JUL	NUMBER(4)		July (1/10mm)
	AUG	NUMBER(4)		August (1/10mm)
	SEP	NUMBER(4)		September (1/10mm)
	OCT	NUMBER(4)		October (1/10mm)
	NOV	NUMBER(4)		November (1/10mm)
	DEC	NUMBER(4)		December (1/10mm)

Table Q4.5 Database Table Description (Monthly Rainfall Data)

Table Name	Column Name	Datatype	Null?	Description
RF_MDATA	ID	NUMBER(8)	NOT NULL	Station ID
	YEAR	NUMBER(4)	NOT NULL	Observed year
	JAN	NUMBER(5)		Monthly mean on January (1/10mm)
	FEB	NUMBER(5)		Monthly mean on February (1/10mm)
	MAR	NUMBER(5)		Monthly mean on March (1/10mm)
	APR	NUMBER(5)		Monthly mean on April (1/10mm)
	MAY	NUMBER(5)		Monthly mean on May (1/10mm)
	JUN	NUMBER(5)		Monthly mean on June (1/10mm)
	JUL	NUMBER(5)		Monthly mean on July (1/10mm)
	AUG	NUMBER(5)		Monthly mean on August (1/10mm)
	SEP	NUMBER(5)		Monthly mean on September (1/10mm)
	OCT	NUMBER(5)		Monthly mean on October (1/10mm)
	NOV	NUMBER(5)		Monthly mean on November (1/10mm)
	DEC	NUMBER(5)		Monthly mean on December (1/10mm)
	TOTAL	NUMBER(5)		Anual mean (1/10mm)

Table Q4.6 Database Table Description (Water Level Gauging Station Description)

Table Name	Column Name	Datatype	Null?	Description
SW_ST	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	RATED	CHAR(1)		Rated or not
	SEDIMENT	CHAR(1)		Sediment sampling or not
	LONGITUDE	NUMBER(10,6)		Longitude (degree)
	LATITUDE	NUMBER(10,6)		Latitude (degree)
	ALTITUDE	NUMBER(4)		Altitude (m)
	AREA	NUMBER(5)		Catchment area (km2)
	RIVERNO	NUMBER(8)		River code
	DISTRICT	NUMBER(2)		District code
	GRIDX	NUMBER(3)		UTM X grid reference
	GRIDY	NUMBER(3)		UTM Y grid reference
	LOGAUGE	NUMBER(4)		Lower gauge height (m)
	UPGAUGE	NUMBER(4)		Upper gauge height (m)
	UNIT	CHAR(1)		Gauge unit
	TYPE	CHAR(3)		Station type
	INSTALL	DATE		Installation date
	OPEN1	DATE		Opening date
	CLOSE1	DATE		Closing date
	OPEN2	DATE		Opening date
	CLOSE2	DATE		Closing date
	OPEN3	DATE		Opening date
	CLOSE3	DATE		Closing date
	BMDIR	CHAR(10)		Benchmark direction
	BMDIST	NUMBER(2)		Benchmark distance (m)
	BMAL	NUMBER(4)		Benchmark assumed level (m)
	GAUGERL	NUMBER(4)		Gauge reduced level (m)
	RELST	CHAR(8)		Related station
	LOCDESC	CHAR(120)		Location description
	ACSSDESC	CHAR(60)		Access description
	CTRLDESC	CHAR(60)		Control description
	CTCHDESC	CHAR(120)		Catchment description
	REMARKS	CHAR(120)		Remarks

Table Q4.7 Database Table Description (Daily Water Level Data)

Table Name	Column Name	Datatype	Null?	Description
SW_DATA	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	YEAR	NUMBER(4)	NOT NULL	Observed year
	DAY	NUMBER(2)	NOT NULL	Observed day
	JAN	NUMBER(4)		January (cm)
	FEB	NUMBER(4)		February (cm)
	MAR	NUMBER(4)		March (cm)
	APR	NUMBER(4)		April (cm)
	MAY	NUMBER(4)		May (cm)
	JUN	NUMBER(4)		June (cm)
	JUL	NUMBER(4)		July (cm)
	AUG	NUMBER(4)		August (cm)
	SEP	NUMBER(4)		September (cm)
	OCT	NUMBER(4)		October (cm)
	NOV	NUMBER(4)		November (cm)
	DEC	NUMBER(4)		December (cm)

Table Q4.8 Database Table Description (Discharge Measurement Data)

Table Name	Column Name	Datatype	Null?	Description
SW_HQ	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	SDATE	DATE	NOT NULL	Sampling date
	GH	NUMBER(4)	NOT NULL	Water level (cm)
	Q	NUMBER(8,3)	NOT NULL	Discharge (m3/s)

Table Q4.9 Database Table Description (Raiting Equation)

Table Name	Column Name	Datatype	Null?	Description
SW_RC	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	SDATE	DATE	NOT NULL	Sampling date
	LWL	NUMBER(6,2)	NOT NULL	Applicable minimum water level (m)
	K	NUMBER(12,4)		K coefficient
	P	NUMBER(12,4)		P coefficient
	DH	NUMBER(6,2)		DH coefficient (m)
	SOURCE	CHAR(4)		Data source (agency)

Table Q4.10 Database Table Description (Daily Discharge Data)

Table Name	Column Name	Datatype	Null?	Description
SW_Q	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	YEAR	NUMBER(4)	NOT NULL	Observed year
	DAY	NUMBER(2)	NOT NULL	Observed day
	JAN	NUMBER(5)		January (m3/s)
	FEB	NUMBER(5)		February (m3/s)
	MAR	NUMBER(5)		March (m3/s)
	APR	NUMBER(5)		April (m3/s)
	MAY	NUMBER(5)		May (m3/s)
	JUN	NUMBER(5)		June (m3/s)
	JUL	NUMBER(5)		July (m3/s)
	AUG	NUMBER(5)		August (m3/s)
	SEP	NUMBER(5)		September (m3/s)
	OCT	NUMBER(5)		October (m3/s)
	NOV	NUMBER(5)		November (m3/s)
	DEC	NUMBER(5)		December (m3/s)

Table Q4.11 Database Table Description (Suspended Load Monitoring Data)

Table Name	Column Name	Datatype	Null?	Description
SW_SL	ID	CHAR(8)	NOT NULL	Water level gauging station ID
	RIVER	CHAR(24)	NOT NULL	River name
	SDATE	DATE	NOT NULL	Sampling date
	GH	NUMBER(4)		Water level (cm)
	Q	NUMBER(8,1)		Discharge (m3/s)
	SLOAD	NUMBER(8,2)	NOT NULL	Suspended load (ppm)

Table Q4.12 Database Table Description (Surface Water Quality Monitoring Data)

Table Name	Column Name	Datatype	Null?	Description
SW_WQ	ID	CHAR(6)		Water level gauging station ID
	NAME	CHAR(40)		Lake of River Name
	SDATE	DATE		Sample Date
	RDATE	DATE		Report Date
	TMP	NUMBER(6)		Temperature (degree)
	CLR	NUMBER(6)		Colour
	EC	NUMBER(6)		Electric Conductivity
	TB	NUMBER(6)		Turbidity
	PH	NUMBER(6)		Potential of Hydrogen
	BOD	NUMBER(6)		Biochemical Oxygen Demand (ppm)
	COD	NUMBER(6)		Chemical Oxygen Demand (ppm)
	TDS	NUMBER(6)		Total Dissolved Solid (ppm)
	TSS	NUMBER(6)		Total Suspended Solid (ppm)
	PNO	NUMBER(6)		Permanganate No. (ppm)
	CH	NUMBER(6)		Carbonate Hardness (ppm)
	NCH	NUMBER(6)		Non Carbonate Hardness (ppm)
	TH	NUMBER(6)		Total Hardness (ppm)
	TA	NUMBER(6)		Total Alkalinity (ppm)
	TN	NUMBER(6)		Total Nitorogen (ppm)
	CO2	NUMBER(6)		Free Carbon Dioxide (ppm)
	CO3	NUMBER(6)		Carbonate (ppm)
	HCO3	NUMBER(6)		Bicarbonate (ppm)
	NH4	NUMBER(6)		Ammonia (ppm)
	FSNH4	NUMBER(6)		Ammonia (ppm)
	ANH4	NUMBER(6)		Ammonia (ppm)
	NO2	NUMBER(6)		Nitrate (ppm)
	NO3	NUMBER(6)		Nitrite (ppm)
	O2	NUMBER(6)		Dissolved Oxygen (ppm)
	PO4	NUMBER(6)		Phosphate (ppm)
	SO4	NUMBER(6)		Sulphate (ppm)
	SIO2	NUMBER(6)		Silica (ppm)
	AL	NUMBER(6)		Aluminum (ppm)
	ASX	NUMBER(6)		Arsenic (ppm)
	B	NUMBER(6)		Boron (ppm)
	BA	NUMBER(6)		Barium (ppm)
	CA	NUMBER(6)		Calcium (ppm)
	CD	NUMBER(6)		Cadmium (ppm)
	CL	NUMBER(6)		Chloride (ppm)
	CU	NUMBER(6)		Copper (ppm)
	CR	NUMBER(6)		Chromium (ppm)
	F	NUMBER(6)		Fluoride (ppm)
	FE	NUMBER(6)		Iron (ppm)
	HG	NUMBER(6)		Mercury (ppm)
	K	NUMBER(6)		Potassium (ppm)
	MG	NUMBER(6)		Magnesium (ppm)
	MN	NUMBER(6)		Manganese (ppm)
	NA	NUMBER(6)		Sodium (ppm)
	PB	NUMBER(6)		Lead (ppm)
	SE	NUMBER(6)		Selenium (ppm)
	Z	NUMBER(6)		Zinc (ppm)

Table Q4.13 Database Table Description (Borehole Data)

Table Name	Column Name	Datatype	Null?	Description
GW_ST	ID	NUMBER(5)	NOT NULL	Borehole number
	COMPLETION	DATE		Completion date
	STATUS	CHAR(1)		Status
	USE	CHAR(2)		Use
	OWNER	CHAR(1)		Owner
	MONITORING	CHAR(1)		Monitoring frequency
	POTABILITY	CHAR(1)		Potability of water
	LONGITUDE	NUMBER(8,4)		Longitude (degree)
	LATITUDE	NUMBER(8,4)		Latitude (degree)
	ALTITUDE	NUMBER(4)		Altitude or Elevation (m)
	MAPNO	CHAR(11)		Map sheet number
	GRIDX	NUMBER(6)		UTM X grid reference
	GRIDY	NUMBER(6)		UTM Y grid reference
	BASIN	CHAR(3)		Drainage basin
	DISTRICT	NUMBER(2)		District code
	TOTALDEPTH	NUMBER(3)		Total depth (m)
	HORIZONS	NUMBER(1)		Number of producing horizons
	ROCK	NUMBER(2)		Rock type
	STRUCKDEPTH	NUMBER(3)		Struck water level (m)
	RESTWL	NUMBER(3)		Rest water level (m)
	DIAMETER	NUMBER(3)		Diameter at base (cm)
	CASING	CHAR(1)		Type of openings
	BASE	NUMBER(3)		Base blank (m)
	LENGTHOPEN	NUMBER(3)		Length of openings (m)
	TESTNO	NUMBER(1)		Number of pumping tests
	DISCHARGE	NUMBER(4)		Discharge (l/min)
	DRAWDOWN	NUMBER(5,1)		Drawdown during pumping test (m)
	HOURS	NUMBER(2)		Length of pumping (hour)
	RECOVERY	NUMBER(2)		Length of recovery (hour)
	TVALUE	NUMBER(8,6)		Transmissivity (m2/min)
	SVALUE	NUMBER(8,6)		Storage coefficient
	Z	NUMBER(6)		Zinc (ppm)

Table Q4.14 Database Table Description (Grandwater Quality Data)

Table Name	Column Name	Datatype	Null?	Description
GW_WQ	ID	NUMBER(5)	NOT NULL	Sample No.
	SDATE	DATE		Sample Date
	RDATE	DATE		Report Date
	TMP	NUMBER(6)		Temperature (degree)
	CLR	NUMBER(6)		Colour (TCU)
	EC	NUMBER(6)		Electric Conductivity (micro S/cm)
	TB	NUMBER(6)		Turbidity (NTU)
	PH	NUMBER(6)		Potential of Hydrogen
	BOD	NUMBER(6)		Biochemical Oxygen Demand (mg/l)
	COD	NUMBER(6)		Chemical Oxygen Demand (mg/l)
	TDS	NUMBER(6)		Total Dissolved Solid (mg/l)
	TSS	NUMBER(6)		Total Suspended Solid (mg/l)
	PNO	NUMBER(6)		Permanganate No. (mg/l)
	CH	NUMBER(6)		Carbonate Hardness (mg/l)
	NCH	NUMBER(6)		Non Carbonate Hardness (mg/l)
	TH	NUMBER(6)		Total Hardness (mg/l)
	TA	NUMBER(6)		Total Alkalinity (mg/l)
	TN	NUMBER(6)		Total Nitorogen (mg/l)
	CO2	NUMBER(6)		Free Carbon Dioxide (mg/l)
	CO3	NUMBER(6)		Carbonate (mg/l)
	HCO3	NUMBER(6)		Bicarbonate (mg/l)
	NH4	NUMBER(6)		Ammonia (mg/l)
	FSNH4	NUMBER(6)		Ammonia (mg/l)
	ANH4	NUMBER(6)		Ammonia (mg/l)
	NO2	NUMBER(6)		Nitrate (mg/l)
	NO3	NUMBER(6)		Nitrite (mg/l)
	O2	NUMBER(6)		Dissolved Oxygen (mg/l)
	PO4	NUMBER(6)		Phosphate (mg/l)
	SO4	NUMBER(6)		Sulphate (mg/l)
	SIO2	NUMBER(6)		Silica (mg/l)
	AL	NUMBER(6)		Aluminum (mg/l)
	ASX	NUMBER(6)		Arsenic (mg/l)
	B	NUMBER(6)		Boron (mg/l)
	BA	NUMBER(6)		Barium (mg/l)
	CA	NUMBER(6)		Calcium (mg/l)
	CD	NUMBER(6)		Cadmium (mg/l)
	CL	NUMBER(6)		Chloride (mg/l)
	CU	NUMBER(6)		Copper (mg/l)
	CR	NUMBER(6)		Chromium (mg/l)
	F	NUMBER(6)		Fluoride (mg/l)
	FE	NUMBER(6)		Iron (mg/l)
	HG	NUMBER(6)		Mercury (mg/l)
	K	NUMBER(6)		Potassium (mg/l)
	MG	NUMBER(6)		Magnesium (mg/l)
	MN	NUMBER(6)		Manganese (mg/l)
	NA	NUMBER(6)		Sodium (mg/l)
	PB	NUMBER(6)		Lead (mg/l)
	SE	NUMBER(6)		Selenium (mg/l)
	Z	NUMBER(6)		Zinc (mg/l)

Table Q4.15 Database Table Description (Water Abstraction Permit Data)

Table Name	Column Name	Datatype	Null?	Description
WP_ST	PERMITNO	NUMBER(6)	NOT NULL	Water permit number
	SUPPLNO	NUMBER(2)		Supplement number
	FILENO	CHAR(16)		File number
	ISSUE	DATE		Date of issue
	EXPIRE	DATE		Date of expire
	CANCEL	DATE		Date of cancel
	RENEW	CHAR(1)		Renewal flag
	DISTRICTNO	NUMBER(3)		District code
	LOCATIONNO	NUMBER(5)		Location code
	BASIN	CHAR(3)		Basin name
	RIVERNO	NUMBER(5)		River code
	NEARSTATION	CHAR(6)		Name of nearest station
	UPDOWN	CHAR(1)		Upstream or downstream
	CLASS	NUMBER(1)		
	NAME	CHAR(40)		Name of permit holder
	ADDRESS	CHAR(40)		Address of permit holder
	LRNO	CHAR(11)		Ledger number
	LOCATION	CHAR(20)		Location name
	TRIBUTARY	CHAR(1)		Type of water source
	RIVERNAME	CHAR(20)		River name for water source
	BOREHOLENO	NUMBER(6)		borehole number for water source
	MAPNO	CHAR(5)		Map number of abstraction point
	GRIDEAST	NUMBER(6)		UTM grid east (m)
	GRIDNORTH	NUMBER(6)		UTM grid north (m)
	LONGITUDE	NUMBER(6,4)		Longitude (degree)
	LATITUDE	NUMBER(6,4)		Latitude (degree)
	ABSTWORK	NUMBER(1)		Type of abstraction
	INTAKE	NUMBER(1)		Type of intake structure
	LIFTING	NUMBER(1)		Type of lifting mechanism
	DELIVERY	NUMBER(1)		Type of delivery mechanism
	MINUTESNO	NUMBER(10)		Minutes number
	VALIDITY	NUMBER(1)		Validity of water permit

Table Q4.16 Database Table Description (Water Abstraction Rate)

Table Name	Column Name	Datatype	Null?	Description
WP_ABST	PERMITNO	NUMBER(6)	NOT NULL	Water permit number
	SUPPLNO	NUMBER(2)		Supplement number
	NORMAL_FLOOD	CHAR(1)	NOT NULL	Normal or flood
	AMOUNT	NUMBER(8)	NOT NULL	Water abstraction rate
	RETURN	NUMBER(8)		Return flow
	AMOUNT_UNIT	CHAR(3)	NOT NULL	Unit of the above
	PURPOSE	NUMBER(2)	NOT NULL	Purpose of water abstraction
	POPULATION	NUMBER(8)		Numbers of beneficiaries
	LIVESTOCK	NUMBER(6)		Numbers of livestock
	IRRIGATION_AREA	NUMBER(7)		Irrigation area
	AREA_UNIT	CHAR(3)		Unit of the above
	MAINCROP	NUMBER(2)		Main crop for the above irrigation

Application Form for Water Abstraction Permit

Official Use ☐ Renew Permit No. Supplement No. Issue Date day / month / 19 9
File No. Expire Date / /
☐ Rejected Minutes No. Cancel Date / /

Applicant
Name
Name of Project
Address P. O. Box
LR No. / Location

Source
☐ Tributary ☐ Canal Furrow ☐ Water Course Gully Creek Valley Swamp Depression ☐ Dam
of ☐ River Stream ☐ Spring ☐ Lake Pond ☐ Flood Course ☐ Well Borehole
at (if applicable) Well/Borehole No.
Map No. / Grid East Grid North (* unit: meter)
or Longitude . Latitude . (* unit: degree in decimal)

Works
Abstraction Work ☐ 0 None ☐ 1 Partial Weir ☐ 2 Full Weir ☐ 3 Dam ☐ 4 Bank (water hole, well) ☐ 9 Others
Intake Structure ☐ 1 Canal ☐ 2 Pipe ☐ 3 Sump/Box ☐ 4 Gravity (controlled) ☐ 5 Gravity (uncontrolled) ☐ 9 Others
Lifting Mechanism ☐ 0 None ☐ 1 Hydraulic Ram ☐ 2 Pump (motor) ☐ 3 Pump (engine) ☐ 4 Turbine ☐ 9 Others
Delivery Mechanism ☐ 1 Furrow ☐ 2 Canal ☐ 3 Pipeline (gravity) ☐ 4 Pipeline (pressure) ☐ 9 Others

Amount I ☐ Normal ☐ Flood Amount Return Flow ☐ gpd ☐ m³d
if source is borehole, omit Normal/Flood and Return Flow.

Purpose
☐ 11 Public ☐ 12 Domestic No. of Population No. of Livestock
or ☐ 21 Industry ☐ 22 Power ☐ 23 River Works ☐ 24 Construction ☐ 25 Fishery ☐ 99 Others
☐ 31 General Irrigation ☐ 32 Minor Irrigation Irrigation Area ☐ acre ☐ ha
or Main Crop (only one) ☐ 1 Maize ☐ 2 Wheat ☐ 3 Rice ☐ 4 Sorgum/Millet ☐ 5 Beans ☐ 6 Coffee ☐ 7 Tea ☐ 8 Cotton ☐ 9 Sugar cane ☐ 10 Pyrethrum ☐ 11 Sisal ☐ 12 Horticultural crops ☐ 13 Fodder crops ☐ 99 Others

II ☐ Normal ☐ Flood Amount Return Flow ☐ gpd ☐ m³d

Purpose
☐ 11 Public ☐ 12 Domestic No. of Population No. of Livestock
or ☐ 21 Industry ☐ 22 Power ☐ 23 River Works ☐ 24 Construction ☐ 25 Fishery ☐ 99 Others
☐ 31 General Irrigation ☐ 32 Minor Irrigation Irrigation Area ☐ acre ☐ ha
or Main Crop (only one) ☐ 1 Maize ☐ 2 Wheat ☐ 3 Rice ☐ 4 Sorgum/Millet ☐ 5 Beans ☐ 6 Coffee ☐ 7 Tea ☐ 8 Cotton ☐ 9 Sugar cane ☐ 10 Pyrethrum ☐ 11 Sisal ☐ 12 Horticultural crops ☐ 13 Fodder crops ☐ 99 Others

III ☐ Normal ☐ Flood Amount Return Flow ☐ gpd ☐ m³d

Purpose
☐ 11 Public ☐ 12 Domestic No. of Population No. of Livestock
or ☐ 21 Industry ☐ 22 Power ☐ 23 River Works ☐ 24 Construction ☐ 25 Fishery ☐ 99 Others
☐ 31 General Irrigation ☐ 32 Minor Irrigation Irrigation Area ☐ acre ☐ ha
or Main Crop (only one) ☐ 1 Maize ☐ 2 Wheat ☐ 3 Rice ☐ 4 Sorgum/Millet ☐ 5 Beans ☐ 6 Coffee ☐ 7 Tea ☐ 8 Cotton ☐ 9 Sugar cane ☐ 10 Pyrethrum ☐ 11 Sisal ☐ 12 Horticultural crops ☐ 13 Fodder crops ☐ 99 Others

Applicant : _____ *Date:* _____

Official Use
District Code / Location Code . Basin Code / River Code / Gauging Station ☐ Up ☐ Downstream
Class ☐ 1 Private ☐ 2 Community ☐ 3 Public ☐ 4 Urban
Gross Normal Amount Return ☐ gpd ☐ m³d
Gross Flood Amount Return ☐ gpd ☐ m³d
Date of Inspection by Water Bailiff / /
Flow Recorded or Mean River Flow ☐ gpd ☐ m³d
Total Allocation so far Normal Flood ☐ gpd ☐ m³d

Water Bailiff Date: _____
Hydrologist/Hydrogeologist Date: _____
Water Apportionment Board Date: _____

Table Q6.1 Application Form for Water Abstraction Permit

FIGURES

Ministry of Water Development

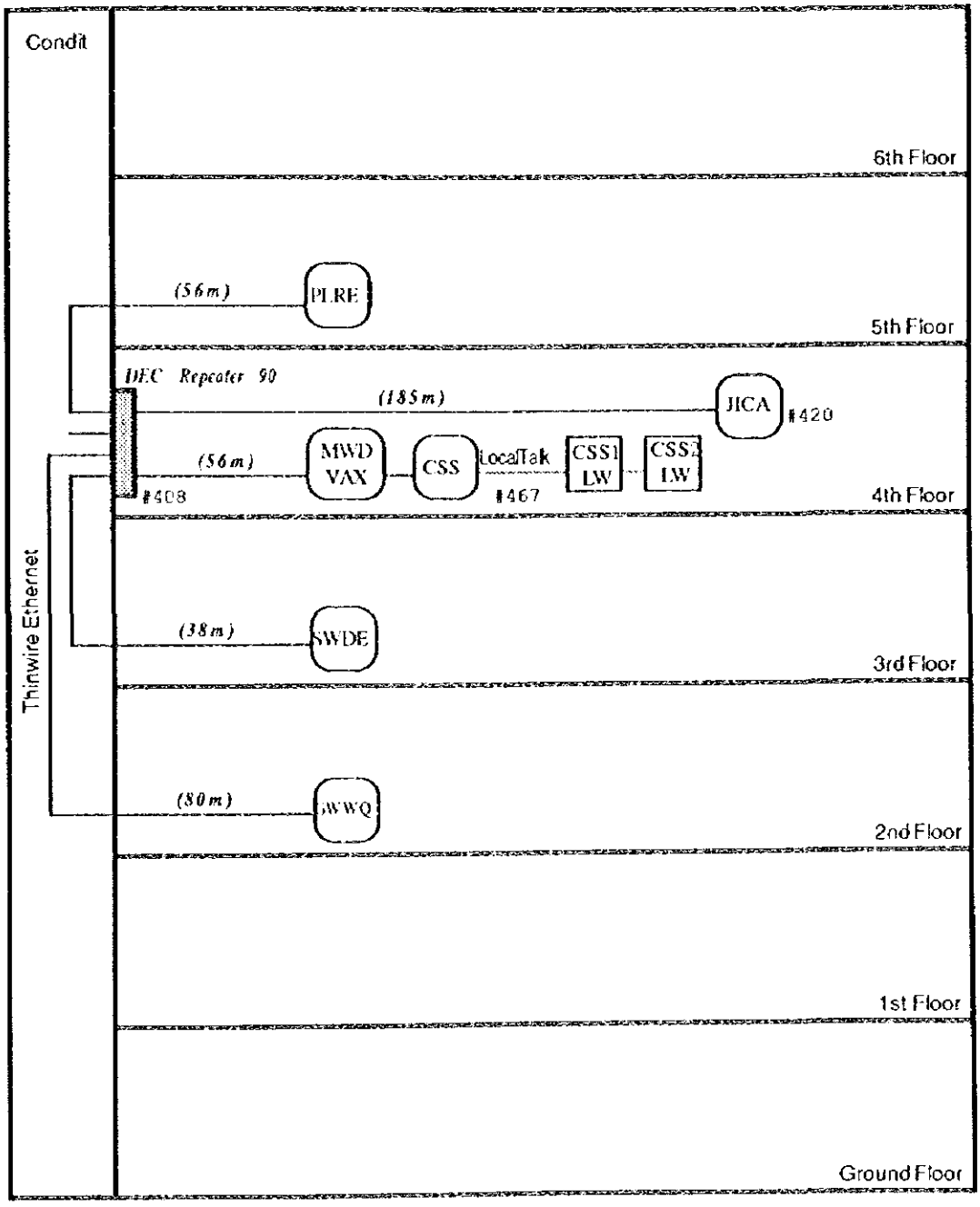

Figure Q3.1 MOWD Network Layout

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. Q3.2

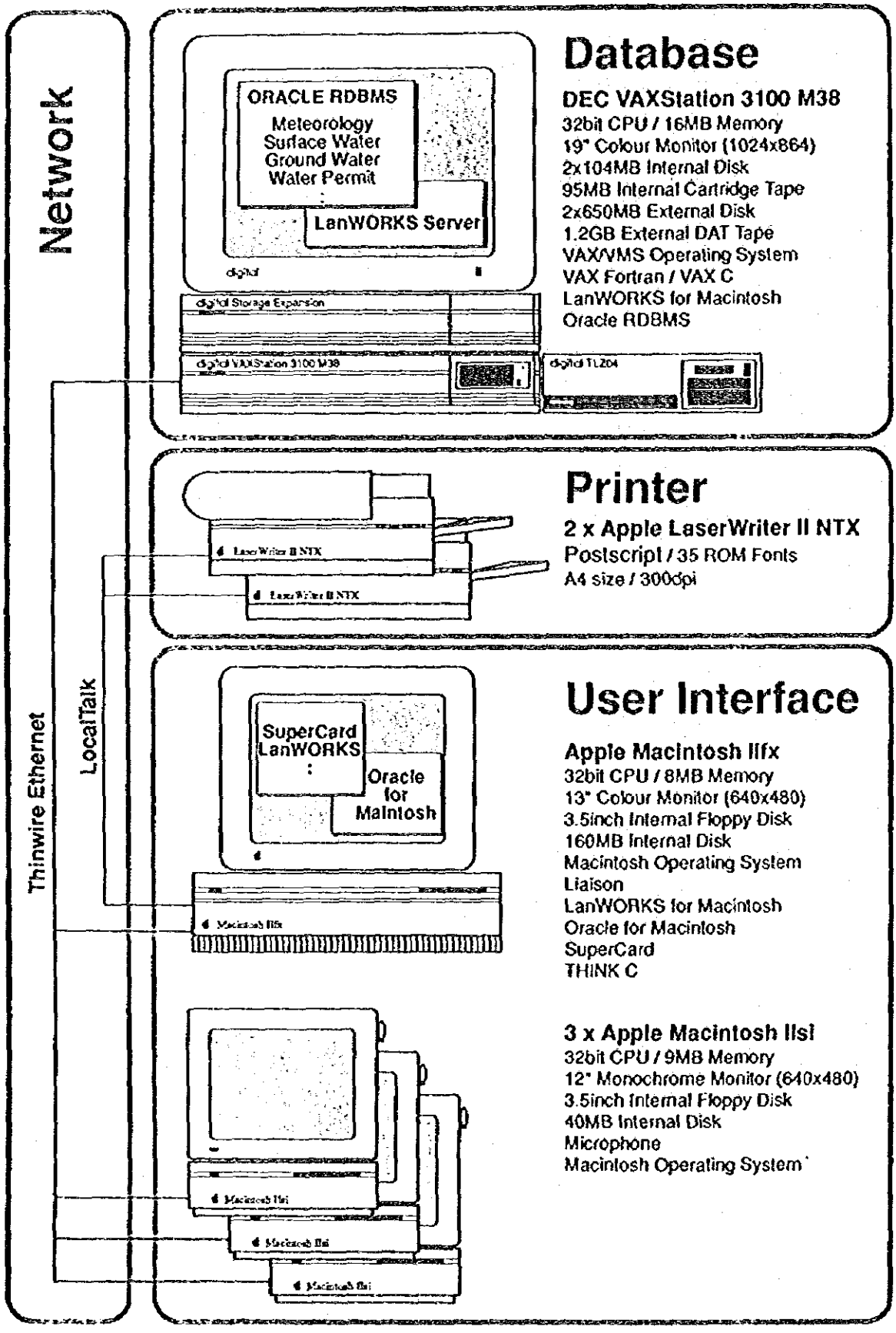

Figure Q3.2 Database System Configuration

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

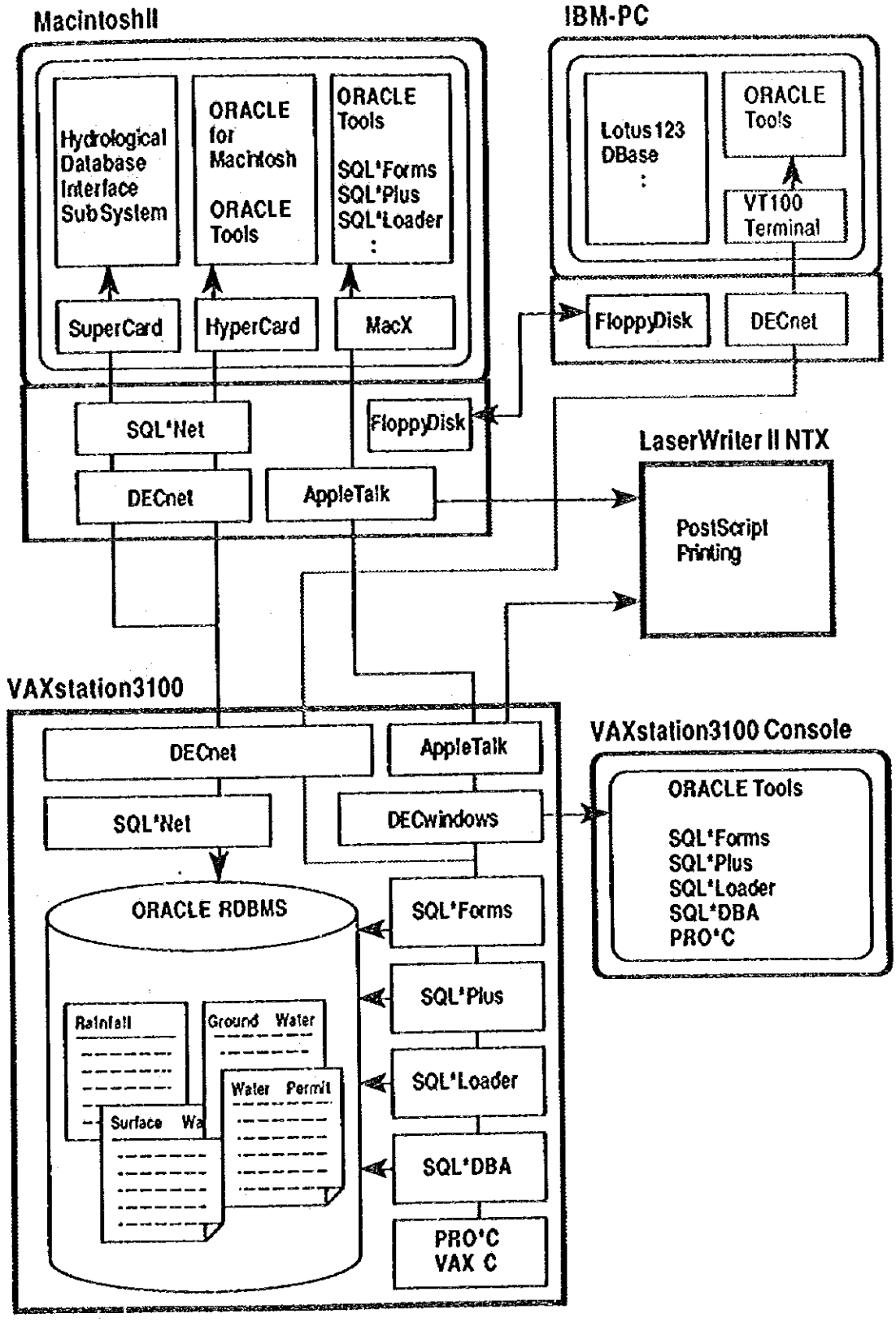

Figure Q3.3 General Database System Structure

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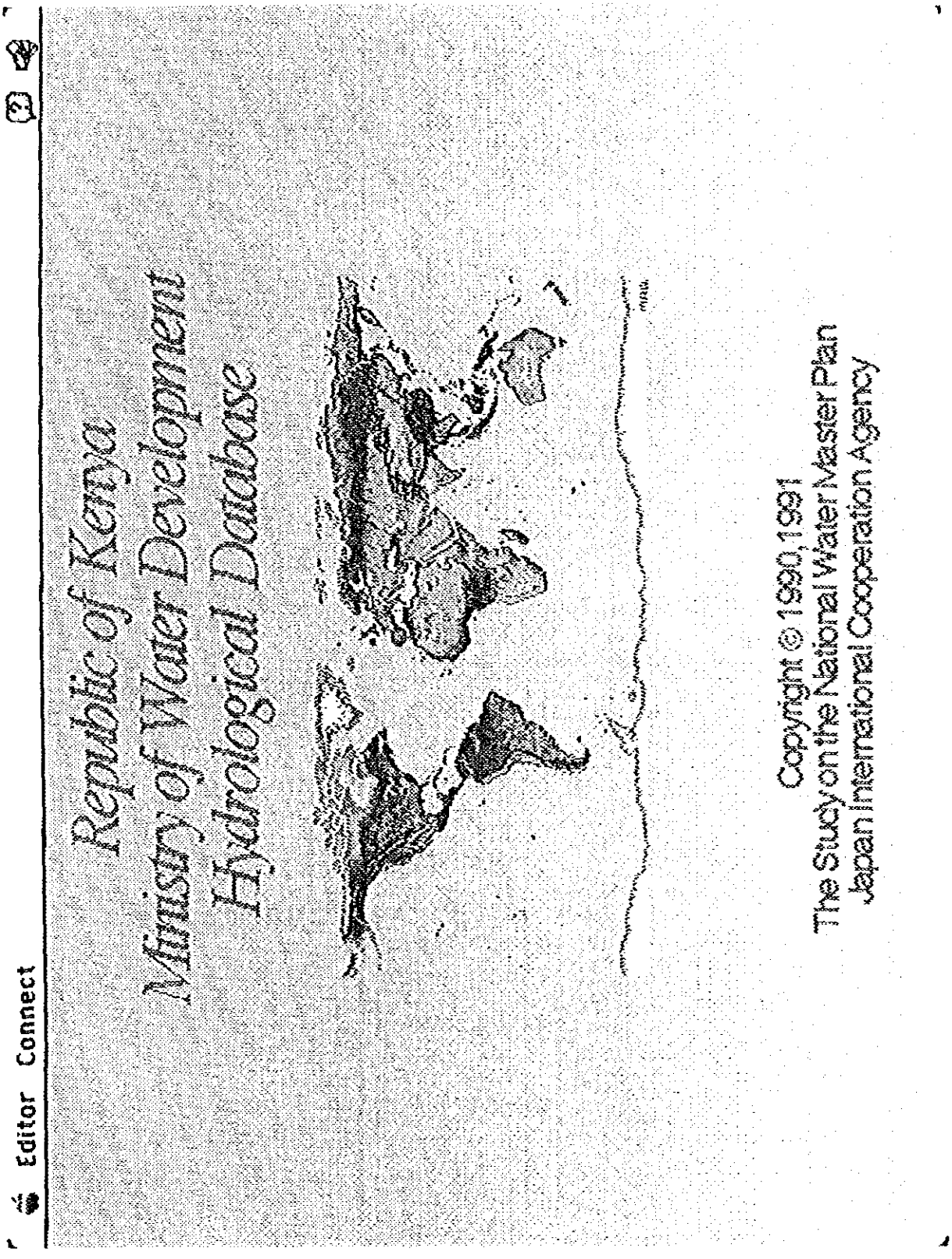

Figure Q4.1 User Interface View (Startup Screen)

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