A DATABASE FOR GROUND-WATER ASSESSMENT IN ETHIOPIA

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ABSTRACT

In 2003, an estimated 13 million Ethiopians needed food assistance as a result of drought, and the problem continues in parts of the country in 2004. To provide sustainable water supply and food self-sufficiency, and to provide for improved living conditions for its people, Ethiopia needs to assess and manage the water resources of the country.

Critical to the success of the proposed National Ground-Water Assessment Program for Ethiopia are use of standardized field forms and a National ground-water database for storing, processing, and analyzing ground-water data. The Ethiopian National Ground-Water Database (ENGDA) and several standardized field forms have been developed by the U.S. Geological Survey, in conjunction with the International Atomic Energy Agency, the Geological Survey of Ethiopia, and the Ministry of Water Resources. The database has been designed to be easy to use and to include the data and functionality necessary for detailed ground-water investigations.

ENGDA uses Microsoft Access© 2000, and functions through a series of menus. The graphical-user-interface has five principal functions: (1)

input and editing of data, (2) creation of reports and water-level graphs, (3) retrieval of data, (4) export of data tables in digital format, and (5) administration of the database. Ground-water information to be stored in ENGDA includes borehole and spring site information, water levels, and water-quality data. Documentation for ENGDA is contained in a user reference manual that includes a database dictionary that defines data fields to be used in the database and field forms.

ENGDA initially will be installed on computers at the Addis Ababa offices of the Ministry of Water Resources, the Geological Survey of Ethiopia, and Addis Ababa University, and available data will be loaded into the database. Later, local data will be loaded into ENGDA in other parts of the country using standardized field forms, and then loaded into the central ENGDA database at government offices in Addis Ababa.

INTRODUCTION

Ethiopia has abundant water resources, with an estimated mean annual runoff of about 111 billion m^3 from its 12 major river basins (Ethiopia Ministry of Water Resources, written commun., 2001); however, the Nation's water resources are not uniformly distributed, either areally or temporally, and droughts are a recurrent problem. In 2003, an estimated 13 million Ethiopians needed food assistance as a result of drought (FEWSNET, 2003), and the problem continues in parts of the country in 2004. Ground water can provide a sustainable source of water during times of drought; however, the amount of ground-water contribution to the base flow of Ethiopia's rivers and the amount of ground water stored in aquifers has not been quantified.

To provide sustainable water supply and food self-sufficiency, and to provide for improved living conditions for its people, Ethiopia needs to assess and manage the water resources of the country. Effective management of the country's water resources, including development of sustainable supplies, depends on sufficient and accurate information on which to build a scientifically sound management strategy.

A National Ground-Water Assessment Program was proposed at a workshop in 2000 (Amha and others, 2001). This proposed Assessment Program would address National ground-water issues, including ground-water/surface-water interaction, and provide information needed to manage the Nation's ground-water resources. One critical component of the proposed National Ground-Water Assessment Program is the implementation of a National database for ground-water information. This paper describes the database that has been developed for Ethiopia by the U.S. Geological Survey (USGS), in conjunction with the International Atomic Energy Agency (IAEA), the Geological Survey of Ethiopia (GSE), and the Ethiopia Ministry of Water Resources (MoWR).

PROBLEM

Critical to the success of the proposed National Ground-Water Assessment Program are use of standardized data collection forms, and a

National ground-water database for storing, processing, and analyzing ground-water data. Several databases that include ground-water information currently are used in Ethiopia; however, they were designed specifically for individual agencies. The databases store different information in a variety of formats, so that the databases are not always compatible. Because the databases were designed with proprietary software, they cannot be readily modified to promote compatibility with other databases. Additionally, existing databases are generally sparsely populated, and critical data for existing sites, such as well location or well construction, are often missing. Because of these shortcomings, the existing databases cannot be used for the comprehensive analysis needed for National ground-water assessment and management.

In response to the latest drought crisis, many wells have been drilled, springs have been developed, and water-quality samples have been obtained and analyzed, by both Ethiopian government agencies and non-governmental agencies. Because of a lack of standardized field forms and a centralized database, critical information from these activities could fail to be collected or archived.

NATIONAL GROUND-WATER DATABASE

A database workgroup was formed at the 2000 workshop to begin work on the initial database design requirements, as well as on early drafts of several standardized field forms and a database dictionary. Since that workshop, USGS has continued work on database construction, as well as updates to the field forms and database dictionary, with input from members of the workgroup.

The Ethiopian database was modified from the Environmental Information System (ENVIS) database developed by the USGS for Cyprus (U.S. Geological Survey, 2003). The Ethiopian version of the database has been designated as the "Ethiopian National Ground-Water Database" (ENGDA). The database uses Microsoft Access© 2000[1], and it will be

[1] Use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

installed on personal computers at various government and university offices. ENGDA is designed to input, store, and report ground-water information needed to assess and manage Ethiopia's ground-water resources.

The ENGDA menu-based graphical-user-interface has five principal functions: (1) input and editing of data, (2) creation of reports and water-level graphs, (3) retrieval of data, (4) export of data tables in a digital format, and (5) administration of the database (fig. 1). An example of a data-entry form for borehole site information is shown in figure 2. Error messages are displayed as "pop-up" boxes on the entry screen when data-entry or other errors are detected.

The database has been designed to be easy to use and to include the data and functionality necessary for detailed ground-water investigations. ENGDA is adaptable to changing needs because it is not proprietary software. Modifications to the database design, such as inclusion of new parameters and tables, are relatively easy to implement by users who are knowledgeable in Microsoft Access© programming.

Ground-Water Information

Ground-water information to be stored in ENGDA includes borehole and spring site information, water levels, and water-quality data (fig. 1). Documents, such as maps or directions to a site, and photographs also can be stored in ENGDA. The primary identification information for a site in the database is a unique name that is assigned to each site, consisting of a "site code" and the name of the closest village to the site. Borehole and spring site geographic information, such as physical location and ownership, is entered into the database using the geography menu (fig. 2).

Borehole information includes borehole construction, drilling details, hole description, water encountered during drilling, casing, packing in the well bore, well development, lithology, aquifer-test details and hydraulic properties, well yield, water levels, and pump information. Data for each of these types of information are viewed, entered, and edited in separate menus. Spring information includes spring type, spring permanence, discharge, pool elevation, and use of the spring.

Water-level data stored in ENGDA includes measurement date, depth to water below land surface, measuring point height, method of measurement, and the information source. Spring-pool elevation data also can be entered using the water-level input menu.

Water-quality data stored in the database includes information about the sample-collection history as well as the analytical results for both wells and springs. Results can be stored for physical, organic, inorganic, isotopic, biologic, and minor-elements analyses, as well as other water-quality characteristics such as toxicity. New parameters can be added easily to the database dictionary as needed.

Reports, Data Retrievals, Data Export

ENGDA contains options for generating several types of reports of data available for a site or for a group of sites. Reports include site inventory, summary of site information, site details, summary of ground-water levels, and summary of water-quality analyses. Other reports can be designed as needed.

Retrievals of data from ENGDA for each site or group of sites include water-level data (including graphs) and water-quality data. Retrieved data can be exported in a digital format to a document, a data table, or a spreadsheet. Other data-retrieval options can be designed as needed.

ENGDA also contains options for exporting data tables from the database in digital format directly to an external application, such as a spreadsheet or ground-water model. The user must be familiar with the database dictionary to be able to use exported tables, because the data field names that appear in the tables are the names used internally in ENGDA. Data for many fields are in the form of codes; for example, single-letter codes are used to store data about the topographic setting of sites (hilltop: H, floodplain: G).

Database Administration

The "Administration" function of the main ENGDA menu (fig. 1) is accessible only to database administrators, and contains options for maintaining or changing data tables and for accomplishing several administration tasks such as assigning user rights. Many of the administrative functions of the database are completed using ENGDA administration menus. Some administrative tasks, however, require functionality built into Microsoft Access© or require modifying internal ENGDA data tables, so that the administrator must have knowledge of Microsoft Access© functions and programming to perform the task.

The database contains a variety of security safeguards including password protection and user restrictions on data entry and editing. The username and date of all changes are recorded automatically by ENGDA. All users can create reports and retrieve data using built-in menus or Microsoft Access© functions, but database administrators control user access to create and update information.

Documentation

Documentation for ENGDA is contained in a user reference manual. The manual includes instructions for opening the database, data input, editing data, creating reports, retrieving data, creating water-level graphs, and exporting data. A database dictionary, which defines data fields used in the database and field forms, is a large part of the user reference manual. The manual also includes sections on database installation, troubleshooting, and procedures for bulk loading of existing data.

DATABASE IMPLEMENTATION

The ENGDA database software will be installed on personal computers in the Addis Ababa offices of GSE, MoWR, and Addis Ababa University (AAU) during 2004. Key individuals will be trained in database installation, administration, maintenance, and use, and existing data in those offices will be loaded into ENGDA. One of these offices will be selected as the location for the central database, and data from the other offices will be loaded into ENGDA in that office. Later, the database software will be installed on computers at MoWR Regional Bureau offices, where local data will be loaded and stored in ENGDA. The local data will be copied periodically to compact disks and loaded into the central database in Addis Ababa.

FIELD FORMS

In addition to the database, standardized field forms for data collection are critical to the successful implementation of the database, analysis of ground-water data, and management of the resource. Such forms help to ensure that all critical information is recorded in the field and available for input to the database, and that the data are in a consistent format. A variety of field forms, including forms for well inventory, spring inventory, water-level measurement (fig. 3), well construction, aquifer test information, water use, and borehole lithology, have been designed for

ground-water data collection in Ethiopia. Data fields on the forms are defined in the database dictionary, often through the use of letter or numeric code values.

ACKNOWLEDGEMENTS

Funding for the database development was provided by the IAEA and USGS. Support for the database, including logistical support in Ethiopia, access to existing databases, and advice on information needed in the National database, has been provided by the Ethiopian Science and Technology Commission (ESTC), MoWR, GSE, and AAU. Initial input to the development of the database and field forms was provided by members of the database workgroup, including Atakelt Teferie (MoWR), Yohannes Belete (GSE), Shiferaw Ayele (GSE), and Yirga Tadesse (Addis Ababa Water and Sewerage Authority). Eyilachew Yitayew (MoWR), Bisrat Lemma (GSE), and Dr. Tenalem Ayenew (AAU) suggested additions and modifications to ENGDA. Fanta Demisse (ESTC) provided critical logistical support and coordination for early meetings on database development. James Bisese (formerly of USGS) provided much of the work in the early development of the database.

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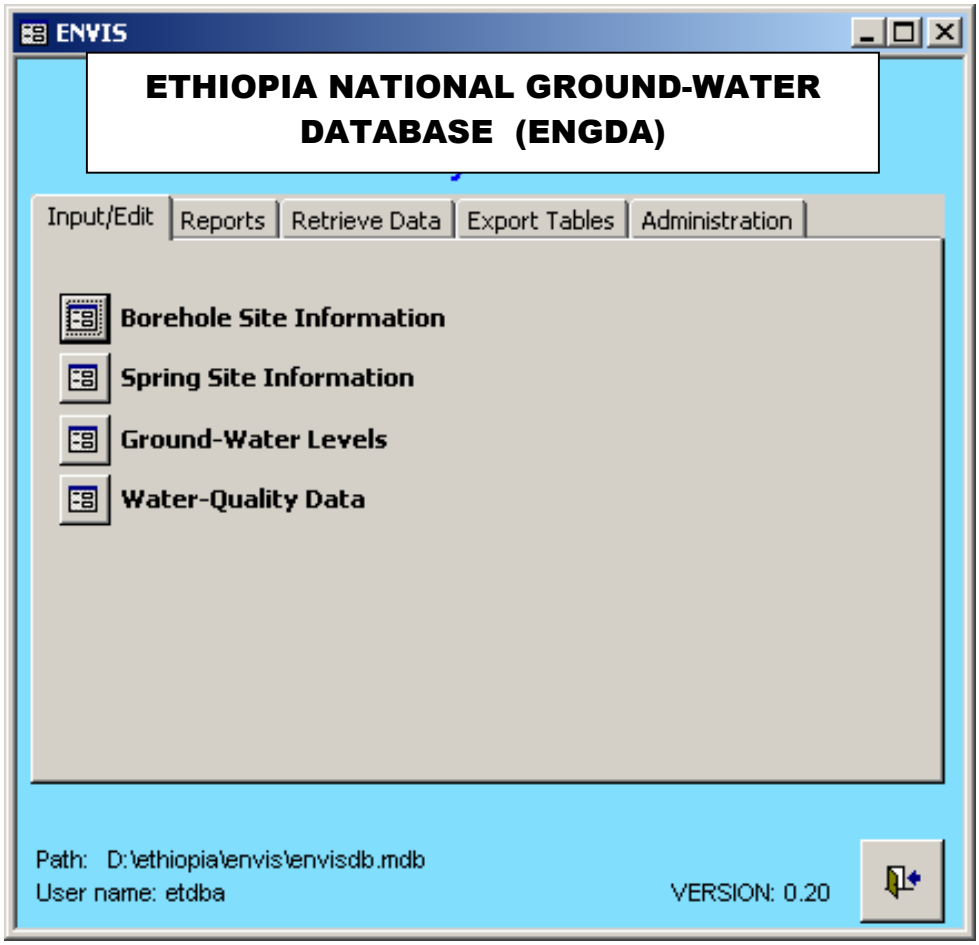

Figure 1. – Main ENGDA menu, showing the five principal functions of the database.

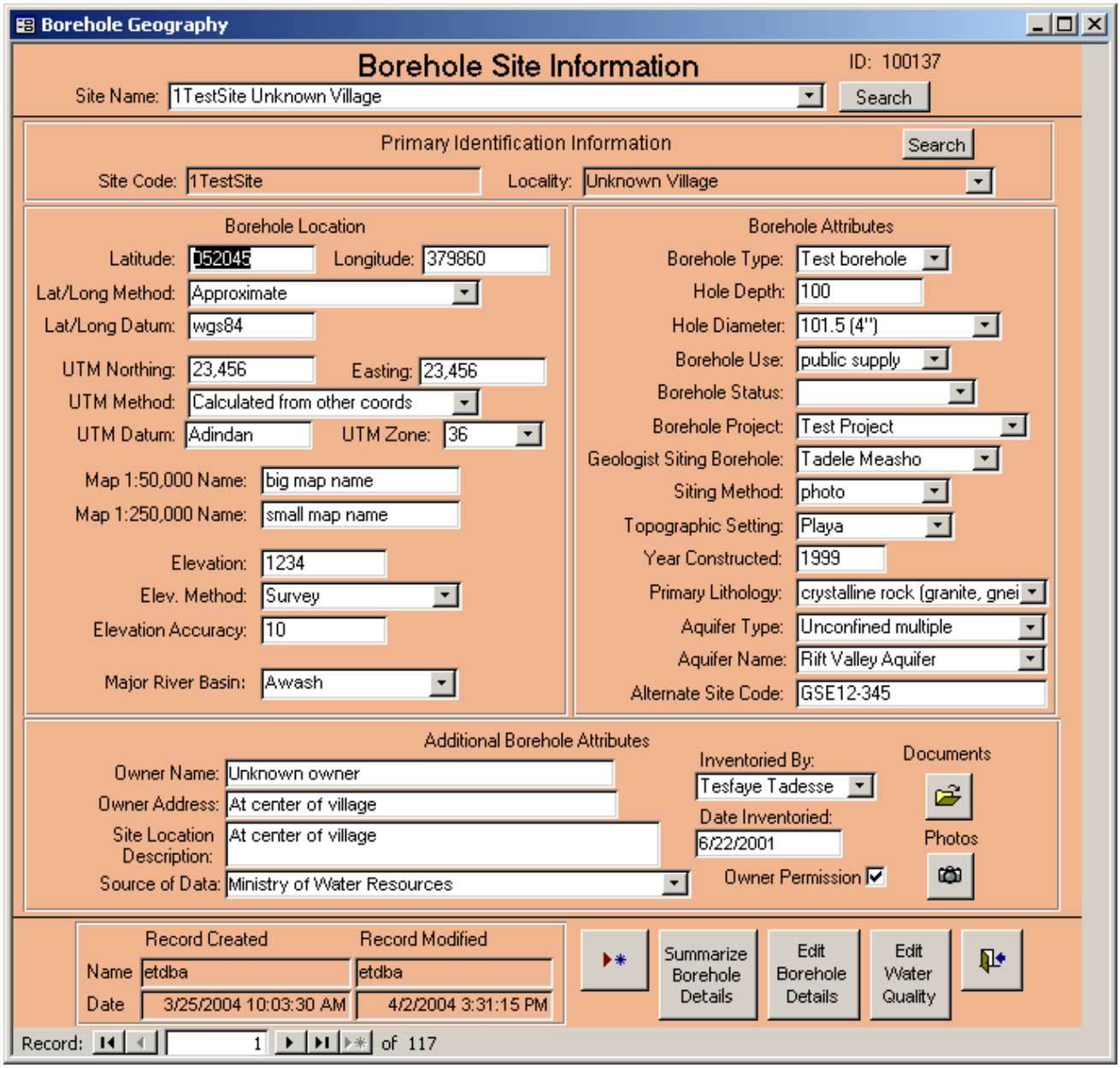

Figure 2. – Example of the borehole site information data-input form.

WATER-LEVEL MEASUREMENT FIELD FORM

SITE CODE: _____ LOCALITY (Village-Zone):

_____

MEASURING POINT (MP) DESCRIPTION:

_____

MP HEIGHT: _____ meters above/below land surface (negative if below land surface)
LAND SURFACE ELEVATION: _____ meters **ELEVATION METHOD (GPS Topo Map Survey Estimate)**
Measurement Method: Unknown (0), Steel Tape (1), Electric Tape (2), Pressure Gage (3), Timing the sound from dropping a stone (4), Reported (5),
Estimated from the length of a string (6), Use of a sounder on the end of a string (7), Transducer (8), Other (9)
Well Status: Unknown (0), Static (1), Pumping (3), Pumped Recently (4), Nearby Well Pumping (5), Dry (6), Obstructed (7)

Measurement Date/Time	Held	Cut	Depth to Water	+/- MP	Depth to Water Below Land Surface	Measure-ment Method	Equip-ment ID	Well Status	Person Measuring Well

RECORD ADDITIONAL MEASUREMENTS ON BACK OF FORM									

COMMENTS:

Figure 3. – Example of a standardized field form for data collection.