Final Report 2001-2002: Subsurface Database for the Shelby County Hazard Mapping Project

The Creation, Expansion, Maintenance, and Application of a Subsurface Database for Shelby County, Tennessee – A Cooperative Agreement Between the Center for Earthquake Research and Information and the Ground Water Institute at The University of Memphis

Ground Water Institute
THE UNIVERSITY OF MEMPHIS

Brian Waldron, Ph.D. PE

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Introduction

The Memphis, Shelby County Seismic Hazard Mapping Project has provided a unique opportunity for collaborative research between Center for Earthquake Research and Information (CERI), the United States Geological Survey (USGS), and the Ground Water Institute (GWI) at The University of Memphis. This research effort is leading to better understand of the geologic, hydrologic, and geotechnical features in Shelby County. This understanding has been a crucial component in development of the proposed subsurface database. The development of the database and access to it by geological and geotechnical professionals should enhance a better understanding of those features which make the geology in the area unique. Interest from various parties has transformed this project into a multi-use application of the database within the fields of earthquake research, geology, and engineering. The ever-growing database is the most extensive source of subsurface information within this area.

Project Status

To serve data using the Internet and via GIS software, two database structures have been put in place. The first database structure is Oracle. Originally, all spatial data was to be placed into Oracle for dissemination and local use. ArcIMS software developed by ESRI (Environmental Systems Research and Information) would serve spatial files located in Oracle over the Internet. However a problem became apparent as the hazard mapping project continued.

Two server types are available in ArcIMS. One is an image server and the second a feature server. With an image server, a request to view a map is made by the user, that request is sent to the host computer running ArcIMS, the necessary data is formed into a map, saved as an image, and sent back to the user's machine. An Image server is the most basic server. A feature server requires a one time download of JAVA software to be installed on the user's machine and spatial data is sent to the user's computer and assembled there. There is more functionality available with a feature server, yet we found that this service is very sensitive to the type and version of browser used.. We chose to use an image server to alleviate problems.

Though we are using an image server, ArcIMS is sensitive as a whole to Oracle. ArcIMS would not work properly if Oracle was down, files were changed or updated. Therefore, all of the spatial files used in ArcIMS were copied onto a local hard drive (flatfile) and served from the hard drive. This has virtually eliminated all problems. The flatfiles are considered to be a second database type.

The expected tasks to be completed for this grant are indicated in Table 1 by having color-filled cells. This is similar to the table as listed in the previous final report (2000), yet those tasks that were labeled as "in process" are now completed or obsolete. The specified Target Completion Dates were determined at the completion of the previous contract. Each task has been grouped into Items 1-6. The status of these tasks are described in detail following the Table.

Table 1. Task schedule table for 2001 with tasks divided into Items.

Task	Status	Target Completion Date	
Establishment of RDBMS and spatial servers	Complete	----	
Importation of GWI well information and Hwang's geotechnical data into the subsurface database	Complete	----	
Identification and formal establishment of named formations	Complete	----	
Draft implementation of 2D index map for viewing and querying geophysical information on the Internet including database description documentation and user manual	Complete	1-Oct-00	Item 1
Add hydrologic and well construction data contained within the USGS GWSI database to the subsurface database	Obsolete	1-Dec-00	Item 2
Final development of 2D index map for viewing and querying of geophysical information on the Internet	Complete	1-Feb-01	Item 1
Lithology interpretation of well and boring logs within the six quadrangles that constitute the study area and inclusion of these interpretations into the database	Complete	1-Mar-01	Item 3
Generation of subsurface lithology for each of the six quads	Continuing	1-Apr-01	Item 4
Scanning of geophysical logs and addition to the database	Pending	1-Jul-01	Item 5
Establishment of 3D surfaces and query capability of lithology characteristics	Pending	1-Sep-01	Item 6
Expansion of the database.	(Indefinite)	----	

Item 1: *Draft implementation of 2D index map for viewing and querying geophysical information on the Internet including database description documentation and user manual* **and** *Final development of 2D index map for viewing and querying of geophysical information on the Internet.*

The geotechnical and geophysical well locations for the six-quadrangle study area and surrounding region are now available for viewing using an Internet browser. The URL link is http://gwidc.gwi.memphis.edu/website/introduction. Data being served by this site is stored on a local computer drive, not from the Oracle database as originally planned. The software package being used is ArcIMS (Internet Map Server). Problems with the Oracle service resulted in numerous downtime periods. No downtime periods have been encountered since serving the spatial data from the local drive. Documentation on how to use the ArcIMS internet tools is supplied in PDF format at the above URL.

Item 2: *Add hydrologic and well construction data contained within the USGS GWSI database to the subsurface database*

It was determined that well construction data contained within the USGS GWSI database was not a necessary component in developing hazard maps. Any geologic information used from USGS geophysical borings came directly from the paper logs and not from GWSI (see Item 3). Hydrologic and faulting data was digitized from USGS paper maps and imported into the Oracle database. This data is made available to authorized persons via ESRI software or other RDBMS (relational database management systems). Documentation on how to use the import this spatial data from Oracle is supplied in PDF format at http://gwidc.gwi.memphis.edu/website/introduction.

Item 3: *Lithology interpretation of well and boring logs within the six quadrangles that constitute the study area and inclusion of these interpretations into the database*

Interpretation of the geotechnical borings (< 50m) was conducted under the supervision of Dr. Roy Van Arsdale at the University of Memphis in the Department of Earth Sciences. In the previously determined stratigraphic classifications, only four alluvial classification were specified. A single alluvial classification for deposits along the Wolf River was given, Qal4. Dr. Van Arsdale determined that the alluvium along the Wolf River could be divided into an upper unit (overburden, silty-clay) and a lower unit (more sandy). To allow for this distinction, an alluvial classification addition, Qal5, was added thus splitting the Wolf River alluvium. This change is reflected in the database by the addition of a Qal5 column. The ground surface elevations for each geotechnical boring was calculated from the USGS National Elevation Dataset or NEDs. All blanks in Dr. Van Arsdale's dataset were set to a "nodata" value of –999. A total of 887 records were entered into the database as "strat_uofm".

A separate file of geophysical log interpretations was constructed do to the differences in source data detail. Interpretation of the geophysical logs (< 1500m) was conducted by personnel at the USGS Nashville, TN office. Before correcting ground surface elevations using NEDs, the locations of a majority of the wells (primarily MLG&W water wells) were matched with GPS coordinates. The remaining locations remained unchanged. Because of the general nature of geophysical logs, alluvium could not be subdivided into upper and lower units where applicable. Therefore, an single alluvium designation was provided (Qal). Alluvium was not broken out by river system. A total of 402 records were entered into the database as “strat_usgs”.

Item 4: *Generation of subsurface lithology for each of the six quads*

Completed datasets were not supplied in time for stratigraphy surfaces to be constructed. However, a partial dataset was used to experiment on interpolation schemes. The interpolation routines in the software package GMS (Groundwater Modeling System) by Boss International was used to compare interpolation results. In short, this research is still ongoing. New software by ESRI (Environmental Systems Research and Information) is currently available, provides more functionality than GMS, and is being used to compare interpolation schemes. Joan Gomberg with CERI (Center for Earthquake Research and Information) at the University of Memphis is conducting work on surface fitting. This work will continue.

Item 5: *Scanning of geophysical logs and addition to the database*

The goal was to scan the geophysical well logs and provide them to the user as custom format Adobe Acrobat files (PDF). However, purchase of a roll scanner proved to be expensive. Also, scanning of the logs was deemed not a priority compared to lithologic interpretation, interpolation, and input into the earthquake simulation model. An option other than scanning is to have the logs put to microfilm. This preserves the information and allows another, more inexpensive avenue to a digital format.

Item 6: *Establishment of 3D surfaces and query capability of lithology characteristics*

Very few software packages exist that can display, much less construct three-dimensional volumes of lithology. GMS is very inexpensive (~$200 educational seat), yet 3D volumes are derived from surface created using a linear TIN interpolation. A linear TIN interpolation scheme is very basic and does not produce reasonable results, especially with clustered or sparse data. The other extreme is EarthVision which the USGS has two licenses. It is a difficult piece of software for a new user to learn and costs approximately $70,000 (educational). Again due to time constraints, construction of a three-dimensional subsurface volume was not critical to the hazard mapping. In the future it is planned for a 3D volume to be placed on the web for interactive manipulation by users, however reasonably-priced technology is not to this point. It is hoped that in the future a 3D volume can be constructed and cross-sectional slices made. These slices would be available on the internet to users as images. User can download the subsurface data via the link above and create 3D surfaces using their own software packages.

Project Continuation Description

1. Newer versions of ESRI products do not work with the current version of Oracle (8.1.5). Oracle will be upgraded to 8.1.7.
2. User requests to be able to download tables and spatial files from the Internet via FTP (file transfer protocol) will need to be incorporated into the current website.
3. Two-dimensional surfaces of the different stratigraphic units including estimates of error will need to be conducted.
4. Data errors such as with NED elevations need to be addressed as the accuracy of the stratigraphic unit elevations depend solely on those ground surface elevations. NEDs have a Level 1 accuracy which means ± 30 ft. elevation differences. This error margin has a greater significance in the shallower units because their thickness is not large.
5. As stated in Table 1, database maintenance will be indefinite. At the end of the project, the Ground Water Institute will continue with the maintenance of the database.

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