GEOGRAPHIC INFORMATION SYSTEM

FOR SITE SELECTION

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ABSTRACT

Geographic Information Systems (GIS) first became popular among municipalities, government agencies and utilities as a means to efficiently handle and display large volumes of data--for example, demographic, land-use, or utility records. More recently, however, the increasing sophistication and analytical capabilities of these systems have made engineering applications possible, so that Geographic Information Systems are now becoming an important extension of the whole Computer Assisted Engineering (CAE) technology.

INTRODUCTION

This paper describes Bechtel's Geographic Information System (BGIS) and its application to the site selection process. A Geographic Information System (GIS) is a computerized system for data base management of graphical and non-graphical information. As developed over the past several years, Bechtel's GIS also inlcudes the capability to perform various kinds of analyses using this information. The GIS can efficiently handle and display large volumes of data, which typically vary widely as to content, scale, resolution, and accuracy. For example, the data base relevant to a particular project might include data purchased or acquired in digital form, geographic data digitized from original maps, digitized drawings from published reports or papers, data keyed in from data entry terminals, as well as raster data (as opposed to vector data) recorded by scanners.

There are three important features of the GIS. One is the ability to register onto a common base data that are originally in different formats and scales. This feature makes the system particularly useful for engineering geology and other earth sciences because of the diversity of information that needs, to be processed, including geologic, hydrologic, chemical, geophysical, and seismological data. These data are often presented in different forms and scales and must be converted into compatible formats before they can be used in an analysis. The second important feature is the ability to store the data with very high precision. The BGIS graphical data file, for example, has over 4 billion points of resolution, providing the capability to map the entire world with an accuracy of a few centimeters. As the areal extent of a study decreases, the accuracy or data resolution increases. The third, and possibly most important feature of a GIS is its ability to link interactively graphical and non-graphical information.

The types of studies that have involved Bechtel is GIS and their associated information bases are shown in Fig. 1. Our emphasis so far has been on site selection and waste disposal studies, but the GIS could also be applied to any mapping and/or data base applications. The two generic examples reviewed herein deal with seismic design analysis and subsurface contaminant migration.

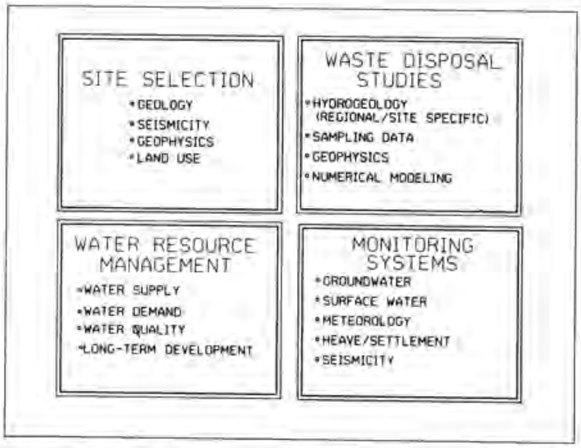

Fig. 1. BGIS Analyses and Associated Data Bases.

SEISMIC SITING ANALYSIS APPLICATION

A seismic hazard analysis is typically undertaken to find the best location for a proposed structure or to evaluate an existing site. To calculate the seismic hazard at a site or several potential sites, one starts by assembling a large data base that includes information on geologic, seismologic, and geophysical data, as well as the results of previous analyses. This usually entails massive compilation and entry of graphical data (maps, curves, etc.) and non-graphical data (catalogs, tables, etc.), most of which come in different scales and projections.

Shown in Fig. 2 are the maximum horizontal principal stress vectors that were assembled in the context of a probabilistic analysis of seismic hazard in the Eastern United States. Attached to each graphical stress vector is a non-graphical data base entry. The analyst can retrieve the data base information from a dual-screen workstation. Using a cursor, the analyst selects a specific graphic element displayed on the right screen and all the information about that element appears automatically on the left screen. In addition to single element interrogation, reports can be created by retrieving from the data base

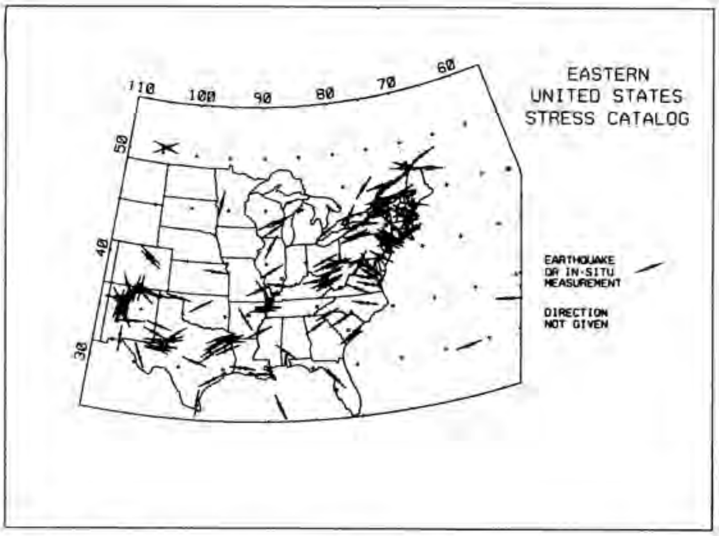

Fig. 2. Maximum Horizontal Stress Direction in the Eastern United States.

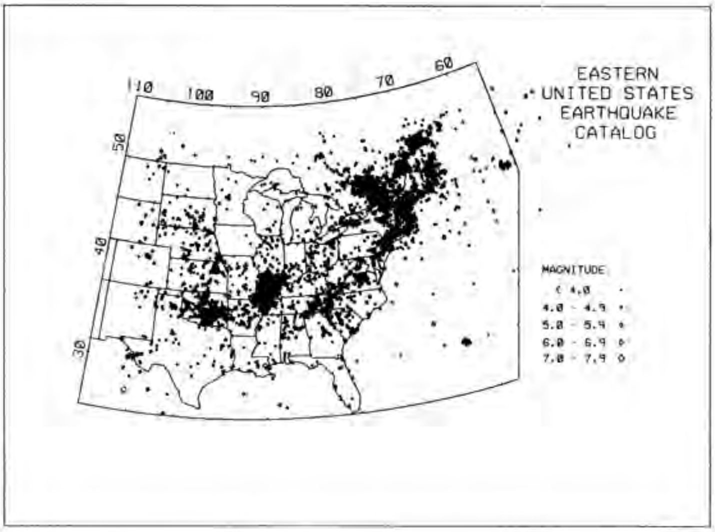

Fig. 3. All Catalog Eastern United States Earthquakes.

all data pertaining to a region defined within any arbitrary polygon. This type of graphics-to-data-base linkage is applicable to many other types of information including data attached to ground water wells, earthquakes, and chemical samples.

The integrated earthquake data base used for the seismic hazard analysis is shown in Fig. 3 (all events) and Fig. 4 (large magnitude events). Based on the stress, earthquake, geologic, and geophysical information, tectonic features and seismotectonic source zones can be interactively defined. A set of tectonic features created in this way is shown in Fig. 5., and the resulting source zones are displayed in Fig. 6. From these source zones and the earthquake catalog, statistical analyses were performed and the seismic hazard at several sites was calculated. The resulting probabilistic hazard curve can then be used for design and licensing.

HAZARDOUS WASTE SITE ANALYSIS APPLICATION

Similar to the seismic hazard application - with respect to the GIS methodology - is the contaminant waste study. The data base for such analyses usually includes geohydrologic properties of the site, and chemical data (from laboratory or field tests). In BGIS, these data are also interfaced with analysis software for contaminant modeling. The graphics-to-data-base linkage discussed in the context of seismic-hazard analysis is similarly applicable to information retrieval from ground-water wells, boring logs, or chemical sampling points. In addition, hazardous-waste disposal studies commonly involve three-dimensional graphics, to evaluate, for example, the three-dimensional extent of contamination. Traditionally, this type of evaluation was performed using only a series of two-dimensional contours. It was then left to the

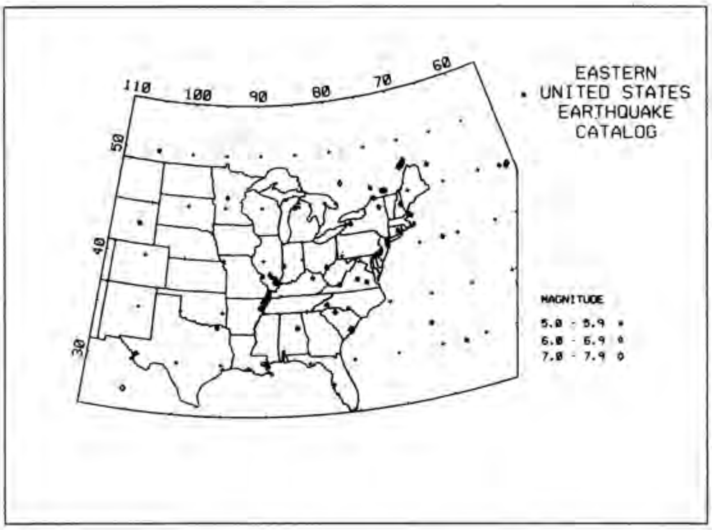

Fig. 4. All Magnitude 5 and Greater Earthquakes in the Eastern United States.

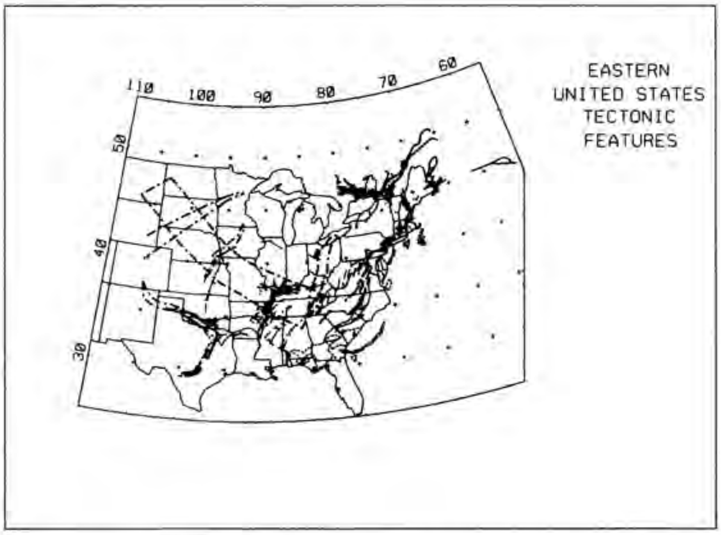

Fig. 5. Tectonic Features in the Eastern United States.

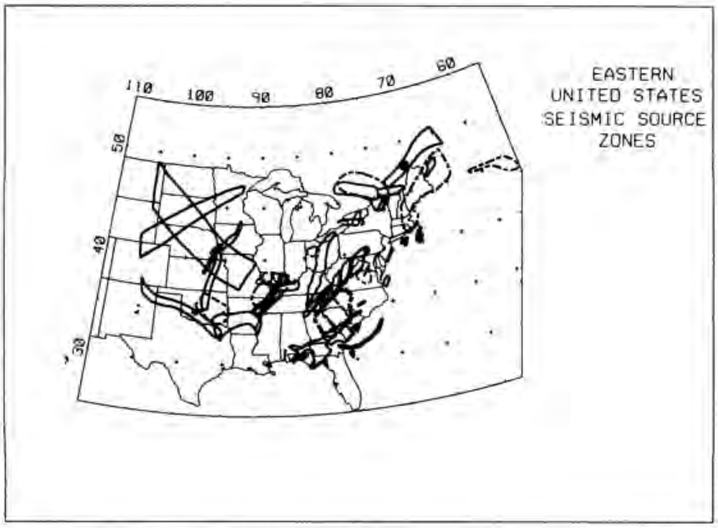

Fig. 6. Seismic Source Zones in the Eastern United States Interpreted from Tectonic Features.

engineer to form a mental three dimensional model of the contamination, based on superposition of several contour slices. Three-dimensional displays greatly facilitate such analysis.

A hazardous-waste study site is shown in Fig. 7. Included in this map are the disposal pits, sampling points and various local features. Given a particular contaminant (in this case, methylene chloride) and a specific cutoff value (e.g. 150 ppm), a wire frame three-dimensional model can be created based on the test results obtained from field samples. The distribution of methylene chloride that exceeds the 150-ppm, cutoff value can be viewed in two dimensions (Fig. 8) or three dimensions (Fig. 9). This process can be repeated for any chemical species or cutoff value.

CONCLUSIONS

This paper has illustrated two applications of Bechtel's Geographic Information System BGIS; namely, project siting and waste-disposal site evaluation. The BGIS software was developed in-house over several years, and is currently applied to a wide variety of projects, large and small. This methodology has been shown to provide systematic and cost-effective solutions to engineering and design anaysis problems.

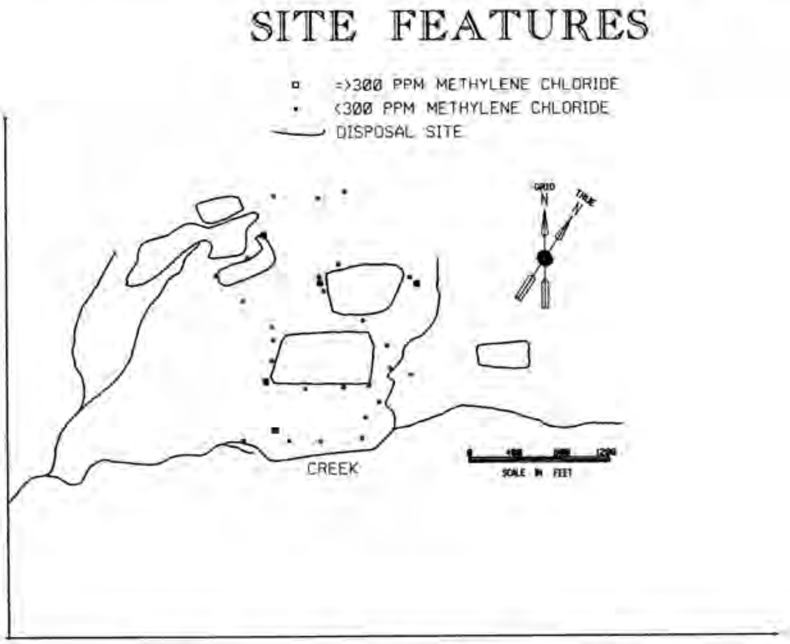

Fig. 7. Hazardous Waste Site and Local Features.

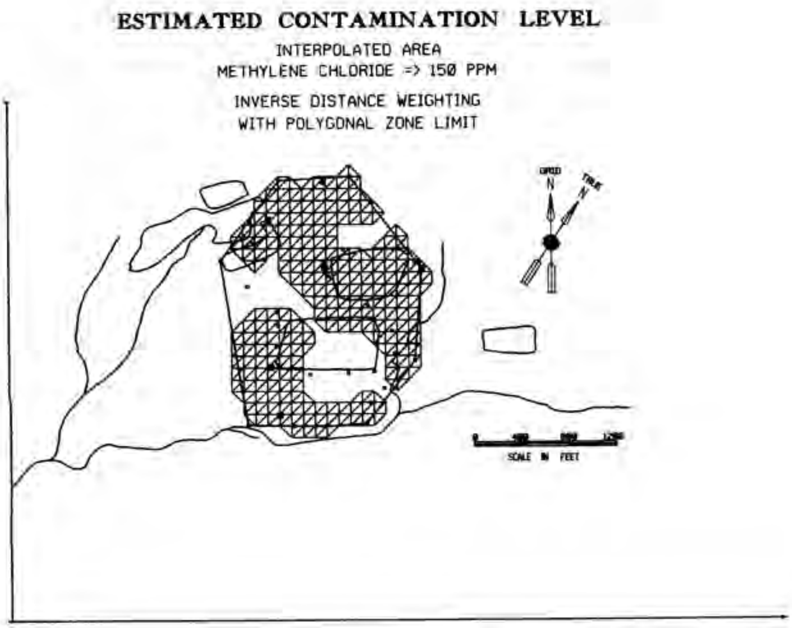

Fig. 8. Distribution of Methylene Chloride Contamination Exceeding 150 ppm.

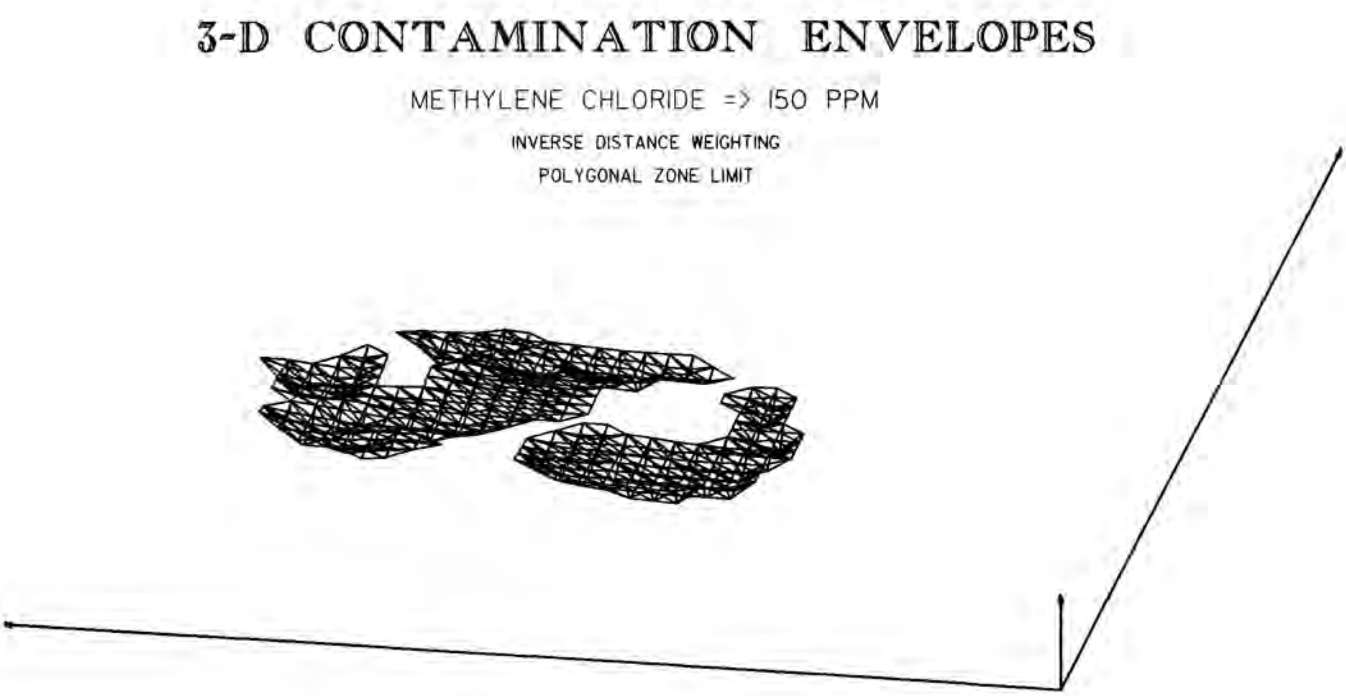

Fig. 9. Three Dimensional Distribution of Methylene Chloride Contamination Exceeding 150 ppm.