Management, Visualization, and Analysis of Environmental and Geotechnical Data

Topical Report

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

September 1994

Work Performed Under Cooperative Agreement No.: DE-FC21-92MC29467

U.S. Department of Energy
Office of Environmental Management
Office of Technology Development
Washington, DC

For

U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
West Virginia University Research Corporation
Morgantown, West Virginia

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Management, Visualization, and Analysis of Environmental and Geotechnical Data

Topical Report

Work Performed Under Cooperative Agreement No.: DE-FC21-92MC29467

U.S. Department of Energy
Office of Environmental Management
Office of Technology Development
1000 Independence Avenue
Washington, DC 20585

For

U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-
0880

By

West Virginia University Research Corporation
P. O. Box 6064
Morgantown, West Virginia 26506

September 1994

Table of Contents

SECTION	PAGE No.
1. Introduction	1
1.1 Scope	1
1.2 Schedule	1
1.3 Report Overview	2
2. ICASE/GRACE	3
2.1 Brief Description	3
2.2 Desirable Features	5
2.3 General Comments	6
3. Evaluation of Current Technology	9
3.1 Geographic Information Systems (GISs)	9
3.1.1 Intergraph's MGE	9
3.1.2 ESRI's ARC/INFO	11
3.1.3 MapInfo	11
3.2 Environmental Technology'94 Conference	13
3.3 National Conference on Environmental Problem Solving with GISs ..	14
4. Conclusions and Recommendations	16
4.1 Conclusions	16
4.1.1 ICASE/GRACE	16
4.1.2 Evaluation of Current Technology	17
4.1.2.1 Geographic Information Systems (GISs)	17
4.1.2.2 Environmental Technology '94 Conference	17
4.1.2.3 National Conference on Environmental Problem Solving with GISs	18
4.2 Recommendations	18

Appendices

- Appendix 1.** *General technical comments about ICASE/GRACE*
- Appendix 2.** *Comments about specific ICASE/GRACE components*
- Appendix 3.** *Comments about ICASE/GRACE manual*
- Appendix 4.** *Email messages of relevant communication*
- Appendix 5.** *Example section of Fast Simulator Code*
- * **Appendix 6.** *Copy of a brochure on Intergraph's ERMA*
- * **Appendix 7.** *Summary of Environmental Technology '94 Conference materials*
- Appendix 8.** *Summary of materials presented at the National Conference on
Environmental Problem Solving with GISs*

* Copyright material was removed.

1. Introduction

1.1 Scope

The tasks for this subcontract, entitled MANAGEMENT, VISUALIZATION, AND ANALYSIS OF ENVIRONMENTAL AND GEOTECHNICAL DATA, were as follows:

- *analyze USACE operational needs and constraints (including assumptions about GIS, database, and platform use)*
- *determine specific needs for data interchange across hardware platforms and software systems*
- *specify data translation as necessary to achieve interchange*
- *obtain information on selected current data-related technology, and user experiences with the technology by participation in a timely conference and exhibit*
- *obtain 3-D visualization software from the University of Cincinnati, become familiar with it, and make a preliminary assessment of it relative to USACE needs*
- *document and present all findings relative to needs and assessments*
- *make specific recommendations concerning Phase II activities*
- *in carrying out these activities, interact as required with METC, USACE Huntington District, USACE Nashville District, University of Cincinnati Center for Geo-Environmental Science and Technology, and WVU National Research Center for Coal and Energy.*

This report documents the results obtained in carrying out these tasks.

1.2 Schedule

The original schedule was from June 1, 1994 to August 31,

1994. A 30-day no cost extension was granted, through September 30, 1994.

1.3 Report Overview

This report documents the work performed in response to the tasks listed above, with relative emphasis on individual tasks determined by interactions with METC and USACE.

The remainder of this report is organized as follows: Section 2 gives an overview and assessment of the ICASE/GRACE system. Section 3 gives an overview of the current status of commercial GIS software. It also includes brief descriptions of the *Environmental Technology '94: Computing and Information* conference and the *National Conference on Environmental Problem Solving with GIS*. Section 4 presents some concluding remarks. Detailed supporting materials can be found in the Appendices.

2. ICASE/GRACE

On June 15, 1994 a meeting was arranged at the University of Cincinnati Center for Geo-Environmental Science and Technology (CGEST) to familiarize participants with ICASE/GRACE. Key participants at that meeting were representatives from Marshall University (Jim Hooper and Akhtar Lodgher), WVU National Research Center for Coal and Energy (Ray Lovett), USACE Huntington District (Dave Meadows), CGEST (Gerard Roberto, John Franco, Kevin Savage, and a student).

A detailed presentation of ICASE/GRACE was made, and Marshall University obtained an "executable only" copy of the system, along with four data sets and a simulation library on one data set.

2.1 Brief Description

ICASE/GRACE (ICASE is derived from "Integrated Computer Assisted Site Evaluation", and GRACE is derived from "Graphical Remedial Assessment and Cost Evaluation") is a system which allows the user to graphically visualize (in two and three dimensions) contaminant concentrations at a site and assist in the assessment of remediation plans. The remediation plans are based on cost and specified performance objectives. Components of ICASE/GRACE include a cost database, site characterization files, a basemap, site data, groundwater simulators and a graphical user interface (GUI). The interactions between the components are illustrated in Figure 1.

Figure 1: ICASE/GRACE Components Interaction Diagram

ICASE is the graphical user interface (GUI) to GRACE through which images of various data are displayed. Values used to construct these images are obtained by interpolating input data over two and three dimensional uniform grids. Custom menus allow the user to access information at data points. Site stratigraphy can be seen through user defined cross sections. A *theme* specifying parameters such as time, depth, contaminant, etc., can be set and the concentration presented as a color coded visual image.

GRACE is the remediation component and develops a remediation scenario (for a particular theme) based on cost and performance, through a set of groundwater simulators. Currently, contaminant plume migration in groundwater and the effect of remediation mechanisms (such as pump-and-treat) can be visualized.

2.2 Desirable Features

ICASE/GRACE runs under DOS on a 386DX or 486DX machine with 4MB of RAM, a math co-processor, a VGA card, and a 40MB hard drive. It does not run under a DOS window in MS Windows 3.1.

In terms of input data, it can read site characterization files (such as roads, buildings) generated from popular packages such as AUTOCAD. Data such as constant head boundaries, leakance, etc can be easily edited. The cost data is maintained as an ASCII database, making it easy to edit using popular editors.

The output information is available in the form of image, graphs and tables. Various zoom levels (up to a max of 8X) are available to look at image information in detail. Information on site stratigraphy, details of a test or remediation well, and similar information can also be viewed.

A manual explaining the installation and use of ICASE/GRACE is available. Comments about the manual are included in Appendix 3.

The unique feature of ICASE/GRACE is the capability of viewing the effect of remediation scenarios of a contaminated site. Since it can be installed on a small-scale laptop computer, it has the potential of being used at remote field sites, as well as serving in a management-support role in public demonstrations for site visualization and examination of "what if" scenarios.

2.3 General Comments

In this section, general "global" comments about the overall system are presented. Detailed technical comments about the system are presented in Appendix 1 and detailed comments about specific system components are presented in Appendix 2.

To date, the development of this system has been primarily a research-oriented effort, and as such the resulting software lacks some of the consistency and stability desirable in a software "product". This is a natural and inevitable occurrence. Our comments thus should not be taken as critical of the effort so far, but rather suggestive of how the software can be improved as time and resources permit.

The system is quite large and has many interacting components which make it quite complex. A top level diagram showing the interactions of the various components is given in Figure 1. (This diagram was sketched by John Franco at the June 15, 1994 meeting with CGEST in Cincinnati). As the system grows larger, a well documented "systems approach" (such as preparation of analysis and design documents) to software development becomes necessary. It is well documented in literature that effort spent early on systematic

analysis and design will lower development and maintenance costs. This is especially true in a situation where many sections of the system are implemented by students. An incoming student may "inherit" vast amounts of code written by outgoing students, placing a large burden on him or her to "unravel" secrets of the system from the code.

From the user's perspective of using a large system, a user interacts with the system through the interface of the various components. The transition from one component to another should be "smooth" so that it is as transparent as possible. This smoothness can be achieved by providing identical or very similar interfaces among components. The interfaces should provide similar mechanisms of data entry, data output, moving to subcomponents, etc.,

Another feature of a well developed system is testing. Testing should be done not only after a major subsystem of the component is built, but at various stages of its development. Testing should be incorporated in the analysis, in the design and implementation of the subcomponents. Essentially, testing should be well documented and be a part of the process. A proper test plan should indicate how the system will be tested, even before it is built. If a system grows too large before its components are thoroughly tested, many errors will remain hidden (especially if the code is written in C). Appendix 4 indicates some of the comments of John Franco about how the system has been tested.

Also, the actual code of the system should be well documented. If pieces of code are obtained from other sources, appropriate header information which explains the functions of the major sections should be provided.

Finally, the grid size of the system is 40x40. It is not known in detail what the implications are of increasing the grid size, from a software perspective. However, for a large area, the 40x40 grid may be a little too coarse, and the interpolations may not be accurate. John Franco addresses the issue of grid size, as presented in Appendix 4.

3. Evaluation of Current Technology

3.1 Geographic Information Systems (GISs)

In this subsection we present salient features of the following commercial GIS systems:

1. MGE (Modular GIS Environment) from Intergraph Corporation
2. ARC/INFO from Environmental Systems Research Institute (ESRI), Inc.
3. MapInfo from MapInfo Corporation

3.1.1 Intergraph's MGE (Modular GIS Environment)

Contact Person:

Tamara Brukard
Intergraph Corporation
Huntsville, AL 35894-0001
(205) 730-1751

Intergraph's MGE is a comprehensive systems which can create, maintain and analyze GIS and mapping databases. It also provides a set of tools for both production and planning environments. MGE is available for workstations running under Unix and Windows NT. A smaller version (called MGE PC-1) for PC's is also available.

MGE uses a relational database engine and can import files from popular formats such as Informix, Oracle, Ingres, SYBASE and DB2.

MGE consists of a suite of separate modules which can be custom fit based on user needs. For the Windows NT environment, a basic setup would consist of MicroStation 32, MGE Basic Nucleus, MGE Projection Manager and MGE

Basic Administrator. Other modules include MGE Base Mapper, MGE TIGER Translator, MGE Modeler, MGE Segment Manager, MGE Map Finisher, MGE Vista Map, ASCII Loader, I/RASC, and I/Geovec.

Another MGE product scheduled for release at the end of August 1994 for the Windows NT platform is ERMA (Environmental Resource Management Application). It consists of a suite of modules including ERMA Groundwater, ERMA Site Geologist, ERMA Data Manager and ERMA Site Restoration Solution (SRS). The ERMA SRS module allows the user to manage site data, assess risk for contaminated sites, model groundwater and contaminant transport, develop remedial designs and cleanup activities and monitor site after remediation is complete. A copy of the brochure on ERMA, which provides a description of its modules, is included as Appendix 6.

MGE Voxel, a three-dimensional visualization module is available for the Unix platforms.

We have established contact with Doug McKenzie of McKenzie Engineering, Summersville, WV who is the local representative of Intergraph MGE software. We are in the process of viewing a thorough demonstration of MGE. As listed above, MGE has many modules, and it necessary to find out the exact functionality of each module. Also, Intergraph is in the process of converting their Unix based modules (which worked on proprietary Intergraph hardware) to Windows NT based modules for Intel's pentium architecture. The modules, many of them incorporating new features, are in various stages of completion (and testing). Thus, it is our recommendation to undertake a thorough study of MGE Windows NT software, documentation, training materials, support services and near-future product releases.

3.1.2 ESRI's ARC/INFO

Contact Person:

Ms. Lee Ross
Marketing Division
Environmental Systems Research Division, Inc.,
8000 Corporate center Dr., Suite 111
Charlotte, NC 28226.
(704) 541-9810

ARC/INFO is the oldest GIS product in the market and is widely used by many organizations around the world. ARC/INFO uses a proprietary database system for all its internal data manipulations forcing users to custom build links from popular database formats. The system runs on Unix based workstation environments.

PC ARC/INFO, a PC based product has recently been updated to run under Windows. It consists of a suite of six modules: STARTER Kit, ARCPLOT, ARCDIT, DATA CONVERSION, OVERLAY and NETWORK. A basic macro language called SML allows users to build and automate GIS procedures and create customized interfaces.

3.1.3 MapInfo

Contact person:

Randy Drawas
Vice President, Marketing
MapInfo Corporation
One Global View, Troy, NY 12180-8399.
(518) 285-6000
Sales: (800) 327-8627, Federal Sales: (800) 619-2333

MapInfo is a desktop mapping software which allows the user

to visualize and manipulate geographic information by using two dimensional maps. Some of its features are:

- *Attaching data to any object* - any object on the map can have data attached to it. This enables the user to perform a variety of analyses by simply clicking on the object.
- *Layering* - a single map can be composed from hundreds of layers. Each layer can be derived from a different file format. For example, one layer may derive data from a Lotus spreadsheet, whereas another can use a dBASE format. Most popular bitmap file formats are also supported. Maps and data from other popular GIS systems, such as MGE and ARC/INFO can also be imported using appropriate tools.
- *Multiple dynamically linked views of data* - information is presented in three distinct ways: as maps, in rows and columns, and as graphs and charts. making changes to data in one view automatically updates all other views.
- *Relational database* - an underlying relational database engine maintains all data.
- *Thematic mapping* - allows user to custom shade maps based on user-defined criteria.
- *Geographic analysis* - allows user to manipulate geographic data on maps so that they can be quickly analyzed.

System details:

MapInfo is available for MS Windows, Macintosh, Sun and Hewlett-Packard platforms. For the Windows platform, it requires a 80386 or higher processor with 4 MB of memory running Windows 3.1 or higher. The current price for a single seat of MapInfo for Windows and Macintoshes is \$1295, whereas for the Sun and HP it is \$2495. Site licenses for networks are also available.

3.2 Environmental Technology '94: Computing and Information Conference

The activities of the conference, which consisted of pre-conference tutorials, technical sessions and vendor exhibits, were held June 7 - 10, 1994 in Crystal City, Washington DC. Jim Hooper and Akhtar Lodgher attended the conference and participated in the activities. This section briefly describes the activities at that conference. Appendix 7 has more details on information gathered on each of these activities.

There were three pre-conference tutorials:

1. *Visualization Technology and its Application to Environmental Management and Advances in Scientific Visualization*
2. *Environmental Audits and Site Assessments*
3. *Environmental Information Sources: What's Available, Who Can Use It, and How to Access It.*

The technical session consisted of talks based on the following six major themes: (i) Environmental Policy in Transition: From Control to Prevention, (ii) Environmental Risk Assessment, Risk Communication and Risk Management, (iii) Environmental Technologies, (iv) Information Visualization Systems (v) Natural resources and Ecosystems: Assessment, management, and Policy, and (vi) International Environmental Issues.

The vendor exhibition consisted of about 35 exhibitors representing organizations from state, federal and private sectors. Most organizations presented materials related to environmental technology. Vendors such as Intergraph and ESRI had limited demonstrations of their GIS products. Some of the federal organizations represented at the exhibition were USACE, USDOE, USEPA, and US Geological Survey.

3.3 National Conference on Environmental Problem Solving With Geographic Information Systems

The National Conference on Environmental Problem Solving with Geographic Information Systems was held in Cincinnati from September 21-23, 1994. Akhtar Lodgher attended the conference. This conference was sponsored by the U.S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, OH.

The goal of the conference was to exchange information about using GIS for environmental applications, rather than to discuss the programming of specific GIS systems. The papers presented in the technical session of this conference examined the components of the framework for applying GIS to environmental problems. More specifically, the objectives of the conference were to:

- identify the spectrum of environmental situations to which GIS could be applied, especially problems related to watershed and ground-water protection, nonpoint source water pollution assessment and control, and crossmedia contamination and management.
- define the process to be followed when applying GIS to environmental solutions by presenting a wide range of applications, describing actual experiences and lessons learned, and facilitating effective technology transfer.

The agenda of the conference, which includes the title and authors of the papers, is included in Appendix 8.

An observation made by many presenters was that it was important to have a GIS specialist for their respective projects. It took a considerable amount of time for geo-scientists and

engineers to learn the details of working with a GIS. This is because a GIS system has many components, and data for the system is gathered from different sources and is in different formats. A GIS specialist could do the transformation of data and present the results in various forms much faster, resulting in a shorter turnaround time.

4. Conclusions and Recommendations

In this section we draw conclusions from the work performed, and offer some recommendations for consideration.

4.1 Conclusions

4.1.1 ICASE/GRACE

After reviewing the University of Cincinnati's ICASE/GRACE system, we conclude that there are numerous desirable characteristics, including the following:

- The DOS basis, and the limited memory requirement, makes the system portable, e.g., to field sites, by means of a laptop computer
- The system can receive data from popular related packages (AutoCAD), and can interact with ASCII files
- The system has very attractive capabilities to view the effects of remediation scenarios of a contaminated site, in two or three dimensions
- Cost and specified performance objectives are evaluated relative to remediation scenarios

Some issues have been identified concerning ICASE/GRACE, including those listed below, needing eventual resolution.

- The system resulted from a research effort, resulting (inevitably) in a software system that needs some improvements in order to become a reliable "product"
- Effort is needed to improve user interface consistency, and further testing is needed in order to increase usage stability

- More complete documentation is needed, targeted to specific audiences (software maintainers, novice users, experienced users)
- More control is needed by the user in selecting appropriate grid sizes

4.1.2 Evaluation of Current Technology

4.1.2.1 Geographic Information Systems (GISs)

We obtained information on a number of geographic information systems during this contract, including Intergraph's MGE (for Modular GIS Environment), ARC/INFO, and MapInfo. These and many other GISs (including the public-domain GRASS system) have their adherents, based on area of application, experience, and cost, among other criteria. Given the focus on applications involving the Huntington District Office of the U.S. Army Corps of Engineers (USACE), it is significant that the Nashville District, with whom the Huntington District has collaborative remediation efforts, has chosen MGE as their primary GIS. In view of this, it becomes important for the Huntington District to have MGE available in order to easily exchange data, and permit each district to benefit from the work of the other.

It will also be important to consider the role of support tools that are in current use relative to MGE (or relative to any other GIS chosen, for that matter). For example, cost modeling tools in current use may need to interface with a GIS. This is also true of other packages such as MODFLOW, and perhaps with the ICASE/GRACE tool.

4.1.2.2 Environmental Technology '94 Conference

This conference provided valuable insight into the current state-of-the-art in environmental computing technology, and

provided important sources for necessary future contacts. A brief summary is provided of the conference, and extensive additional materials are available which were obtained at, or after, the conference.

4.1.2.3 National Conference on Environmental Problem Solving with GISs

At this conference, the presenters shared their experiences in using GISs for developing solutions for environmental problems. The titles of the papers presented, along with the names of the authors and their affiliations are provided. The abstracts of the papers are available.

4.2 Recommendations

We offer the following recommendations for follow-on activities:

- Obtain Intergraph MGE Windows NT version, evaluate against specific needs of METC and USACE
- Use WV Ordnance data from Nashville USACE District for experimentation
- Determine the need for interchange of data between MGE and other tools (including ICASE/GRACE, other database systems, modeling and analysis tools--including cost modeling)
- Make improvements as needed to ICASE/GRACE
- Determine and propose approaches for developing an integrated system which includes a GIS and needed auxiliary software and data, and which offers a "standard look and feel" to the user

- Devise and recommend operational procedures to make effective use of technical capabilities
- Prepare educational/training tutorial material to enable technology transfer for technical capabilities and operating procedures
- In all these activities, work closely with METC and USACE personnel to ensure the validity and effectiveness of concepts as they are formulated

APPENDICES

APPENDIX 1

General Technical comments about ICASE/GRACE

GENERAL TECHNICAL COMMENTS ABOUT ICASE/GRACE

1. Consistency of pull down menus: All the options in the title menu should be pull down, rather than have exceptions for two (Query and Theme).
2. For the title menu and the options under each of these menus, only those options should be highlighted which can be operated upon at that particular time. Clicking on some of the options (which actually cannot be triggered at that time) "hangs" the system. For example: currently the system allows one to register a site when it is not loaded. It attempts to register a site (creating a .REG file) even when there is no data. When the user next attempts to SET SITE CENTER, it says it is not possible because the site is registered.
3. There is not enough distinction between menu options with dots (...) and options without dots. Generally, options with dots should trigger an options box where the user can make a choice, and options without dots should trigger an action directly when clicked. There are some options without dots that trigger an options box, whereas some are action options.
4. Mouse clicks are not consistent. Generally, one click should select an option from a drop down list, and leave the selection highlighted. If the user double clicks on a selection from a drop down list, then the selection is made and the action associated should be executed. Or else, if a user selects an option from a drop down list, (and then selects a few other options from other drop down lists in the box) and then clicks on the OK button, the action should execute with all the selections made. Also, the next time the box (or window) shows up, the previous selections should be highlighted. The problem of mouse clicks is quite apparent in the

THEME box.

5. The design of options that have sub-options (or sub-menus) is questionable. By physically moving the cursor on or very near the little dark right arrow, the submenu appears. However, by clicking on the parent menu option, the submenu does not appear. In fact, the entire parent menu "closes", which is quite irritating.
6. The menus should be designed such that it could still be used without a mouse (though inconveniently). That is, menu options should have a highlighted character which could be used for triggering the option. This is also necessary for "experts" who know the sequence of steps they have to execute and can use keyboard keys quite effectively.
7. A corollary of the above is that for a highlighted menu option, one should be able to press the ENTER key on the keyboard to trigger it, in addition to the left mouse click.
8. The QUIT option on FILE menu should ask if the user really wants to quit. It is possible that one could have clicked on it accidentally.
9. If possible, have some kind of tracking mechanism as to the files that need to be saved when a user wants to QUIT.
10. It should be possible to accomplish all operations involving the use of mouse by using only the LMB (left mouse button). For some operations, a double click or a slight change in the interface design may be necessary to accomplish this. The use of the RMB (right mouse button) should only be an alternative to an

extended operation of the LMB (say, an operation requiring two clicks of the LMB).

11. For situations where the user has to enter a number from the keyboard, the mouse (or cursor) is lost. The user really does not know what to do at that point because the mouse arrow is lost, there is no blinking cursor, and there are no instructions on what needs to be done.
12. The little magenta button at the top left corner of a box, closes the box, and accepts any data that has been entered in that box (example SITE\SET SITE CENTER). This is quite contrary to every windows based system I have seen. A button on the top left corner of a window or box exits (and closes) the box, without changing any info in that box.
13. For any window or box in which the user either selects from a set of choices or enters any data, there should be an "ACCEPT" or "OK" button and a "CANCEL" button. The "ACCEPT" button should accept all the data the user entered, close the box, and act on that data. The "CANCEL" button should restore all values in the fields prior to any changes made, and close the box. Any button provided on the top left corner should function only as the "CANCEL" button. This is the defacto standard for all windows based systems, irrespective of the platform (unix, dos, etc).
14. For boxes where only one item should be entered, then the typing of the new data and pressing the ENTER key should be equivalent of ACCEPT.
15. When multiple boxes are displayed on the screen, the box which has the focus (which is currently active) should have some kind of an indicator (say, change in

color). It is quite possible to miss which box is active when two full boxes are seen on the screen and the mouse arrow is lost (when data is to be entered).

16. Currently, it is possible to change the focus of a box by moving the mouse arrow in it, even when the box is only partly visible. This makes it possible to click and execute an action from a partly hidden box by just one click. However, when the screen is cluttered, it is possible for a user to click once on an action button accidentally while moving between boxes. This can be prevented by using the first mouse click to change the focus of the box, and then use subsequent mouse clicks for action.
17. For actions where an operation on the base map is required (say THEME) the base map should become the focus, that is, it should be seen in its entirety and not be hidden by boxes. This can be accomplished by either closing all the other boxes, or by treating the base map as a box (or window) and putting all the other open boxes in the background.
18. The system does not allow the user to choose multiple parameters for the theme. I think it would be nice to see the effect of two or more parameters, than getting each separately and doing an overlay.
19. For boxes that have a scroll bar attached, the scroll arrows (the little up arrow and down arrow next to the box) should become "active" (by changing color) only when there are more items in the list than displayed in the box.
20. In a selection box, there is no physical difference between buttons from which only one item can be chosen and buttons from which multiple options can be

chosen. The problem is quite prominent in the DISPLAY OPTIONS box.

APPENDIX 2

Comments about specific ICASE/GRACE components

COMMENTS ABOUT SPECIFIC ICASE/GRACE COMPONENTS

1. For the Title Menu, only the LMB triggers action, whereas for submenus, either LMB or RMB triggers the action.
2. Selecting FILE\EXPORT throws a bunch of numbers on the screen when there is nothing to export.
3. For FILE\LOAD MAP, the functionality of the OK button on the box that comes up is not understood. Single click on the file name selects the file or directory, hence the user is given no chance to move to the OK button.
4. For FILE\LOAD SITE, again the functionality of the OK button is not understood. For the example studied (where the case is stored in \MUNI), when the box opens, none of the files are highlighted. The instruction of clicking on the OK button to load the site is quite confusing, because the user does not know whether a file is to be selected or a directory is being selected. In fact, clicking on any file (.DBF) in the lower drop down list triggers the action. So, is that DBF file only loaded? Basically, if the lower box is just an information box (to show the DBF files) then there should be a difference between a drop down box from where a selection can be made, and a scrollable information box.
5. For SITE\SET SITE CENTER, the instructions in the message window are incorrect. When user presses the RMB to escape (as per instructions) another box comes up.
6. For SITE\SET SITE CENTER, there is no mechanism for the user to "escape" out after the user makes the first click, and before he enters (or changes) the x and

y values. Neither the RMB nor the ESC key works at that point. It is very possible that the user may want to escape out at this point. The magenta button on top left adds to the confusion because clicking on it without changing the values accepts the existing values for the new center.

7. For SITE\SET SITE SCALE, after the first two instructions, when the message to enter the length appears, the mouse arrow is lost and there is no blinking cursor, and the user does not know what to do. (See general comment in the previous section).
8. For SITE\REGISTER SITE, if files are not found, the messages come up twice. Only one message should appear and the others should be suppressed.
9. For facility info, (SITE\FACILITY INFO), information box should not come up if site is not loaded.
10. THEME box has no magenta box to close (inconsistency) on top left corner. Again, it should not display if site is not loaded.
11. For X-sections, message is incorrect. It instructs to release mouse button after it has been released. Also, it allows you to go through the steps of performing an xsection before a site map or site info is loaded. Only after all steps are performed the message indicates that the site is not loaded. The message should be displayed earlier.
12. Query builder should have a close button (magenta button) on top left corner.
13. For LOCATE, objects blink when clicked on. For the test file (MUNI), some objects are under the Main (title)

menu and are permanently hidden (example: MP3, MP4). The question is: Does the scale (resolution) of the base map include the title menu?

14. The Cross-section box displayed through VIEWXSECTION grabs all focus (that is, no other boxes can be made active when it is active), whereas that is not the case with other boxes.
15. The THEME box closes (and the other boxes which may be open at that time do not close) when a theme is triggered. Since one would like to see different iterations by setting different themes, it would be convenient to toggle back and forth between the base map and the theme box, without the theme box closing every time a different theme is chosen.
16. After the color scale is changed a few times, the lines in the base map appear to be broken, and are not quite clear.
17. Setting a button in the color scale box changes only the color of the type and not the shape. This is inconsistent with clicking on a button in the DISPLAY OPTIONS box.
18. The color scale box should allow the setting of numbers manually for quick and precise setting.
19. In the color scale box, the use of LMB and RMB to respectively decrease and increase the values should be disallowed. Instead, little scroll arrows should be used for the same functionality. As mentioned in the general comments, the use of RMB should only be as an alternative to an extended LMB operation.
20. In the color scale box, the AUTO and MAN buttons

should be a collapsed into a single toggle button.

21. In the color scale box, the Manual mode should retain the last manual setting when toggling back from the auto setting.
22. In the 3D viewer, slicing does not seem to be working correctly. I could not draw a line to slice properly.
23. Colors in 3D viewer have a different meaning than in 2D. This could be quite confusing.
24. It should be possible to switch back and forth from 2D view to the 3D view by using a toggle key, to see the relationship between the views.
25. Instead of the words HRotation and VRotation for rotating the 3D object, icons which graphically show the axis of rotation should be used.
26. In 3D viewer, for vertical rotation, when mouse moves up, image should move up. Currently, image moves down.
27. In 3D viewer, when rotate button is clicked, the mouse arrow is lost, and user does not know how to get it back. By moving the mouse, the picture rotates, which adds to the confusion. One solution is to fix the mouse arrow on the screen, and display a message saying that moving the mouse rotates the image and rotation can be stopped by clicking on LMB. A better solution is not to "lose" or "fix" the mouse arrow. This can be accomplished by using scroll arrows for horizontal and vertical rotations.
28. In 3D viewer, if Site Top and Site Bottom cannot be changed, they should be displayed using a different

box pattern than using a pattern where entries can be changed.

29. For viewing Xsections, the use of the second line for Single and Multiple sections is unclear.
30. For multiple xsections, the program "hangs" when the two lines to be drawn are parallel.
31. For sizing of xsection display boxes, it is hard to "catch" the lower right corner of the box. Providing a small box on the corner for this purpose would be helpful.
32. When the xsection is displayed, the default width of the xsection should be the length of the crossection.
33. Panning should be allowed directly in the zoom mode. That is, an icon with four directional arrows should be provided in the zoom view, and one should be able to pan directly in the zoom mode by clicking on the arrows.
34. The menu option MAP\REDRAW should be named something else (such as NO MAGNIFICATION) because the basemap is displayed with no magnification.
35. For the Query, for the Samples and Area modes, the depth has to be set from the Theme menu. Since the process of asking a query is independent of the process of displaying a theme, the query process should allow the user to enter the depth, and other details.
36. The system "hangs" when the OPTIONS\TECHNOLOGY\BIOREMEDIATION\GOOD or LOW

option is chosen.

37. In the SITE EDITOR, for the boxes displaying the values, a different color should be used. It is quite difficult to see the values in the current color scheme because the background color is very similar to the foreground color.
38. It is not clearly understood as to how the RESTORE VALUES button on the Site Editor works. What does the values restore to? How many levels can be restored?
39. The mouse clicks for entering the values in the Site Editor are different than the main system. After the grid cells are selected, one has to enter values directly in the NEW VALUE box, without clicking on the mouse.
40. It is not clearly understood how the selected cells in the Site Editor are displayed. When cells are selected the first time, their color turns magenta. However, if the values for the selected cells are changed, and one exits the Site Editor, and reenters it, the selected cells of the previous operations are still highlighted, though in a yellow color.
41. For inserting remediation objects onto the base maps, the use of the RMB should be minimized or eliminated. Most operations should be accomplished with the LMB and single or double mouse clicks.
42. For entering data for remediation objects, the use of RMB should be minimized or eliminated. At many places, the way data is entered is not consistent with the general scheme used for entering data.

APPENDIX 3

Comments about ICASE/GRACE manual

COMMENTS ABOUT ICASE/GRACE MANUAL

General comments about the manual:

1. The manual does have a lot of information, but it is not organized very well. Some sections are in too much detail, whereas others are skimpy. This is because of a lack of focus of who the audience is.

Suggestion: For this system, at least three manuals seem to be necessary:

i) Users manual:

This manual should focus only on what a user needs to know about the system from the perspective of just using the system. Details about the functionality of the various options and step by step instructions on how to use them should be addressed.

ii) Systems manual:

This manual is for personnel who are responsible for "maintaining" the system, and setting up the default parameters, system files, and other system details. The "guts" of the system should be explained here.

iii) Training or Tutorial Manual:

This manual, designed for beginning users, should guide the user through an example, and provide step by step instructions on executing the various options of the system.

Specific comments about the manual:

1. At the present moment, the manual is marked up with comments.
2. The section dealing with remediation objects and their use should be elaborated with detailed examples.

APPENDIX 4

Email messages of relevant communication

**QUESTIONS (AND THEIR ANSWERS) ABOUT THE SYSTEM
ASKED OF CGEST, Univ. of Cincinnati.**

Humberto:

On the 2-D view screen, I would like to know (in detail) what is actually happening (the processes) to the data (all the way from input) to the point when the colors are seen on the screen. I am trying to understand the models that come into play (interpolation, groundwater, etc), what data is acted upon by which model, and what is the output of one that feeds into the other.

The grid size is 40x40. Can it be changed to other numbers? If so, what are the limits?

For each of the models being used, how was their representation (accuracy, correctness, etc) on the computer (and what you see on the screen) tested? Was it done manually on a test data? if so, what was the nature of the test data (size, # of wells, ground layers, etc)?

Will have more questions later.

Akhtar.

Date: Tue, 28 Jun 1994 11:47:09 -0400 (EDT)
From: John Franco <franco@franco.csm.uc.edu>
Subject: questions
Resent-to: LODGHER@MUVMS6.MU.WVNET.EDU

Hello,

Here are some answers to your questions:

1. What is happening to the data from input to the point when the colors are seen on the screen?

a. Stratigraphy -

The data is at points on the site. For each point, a stratigraphic layer and depth are given and ground elevation is given. Thus we might have, for a point, SAND 30 GRAVEL 22 REFUSE 16 and ELEVATION 500 X_POS 349004 Y_POS 55432 which means that at x,y point (349004, 55432), surface elevation is 500 feet, the layer of sand is from elevation 500 to 470 feet, gravel from 470 feet to 448 feet and so on. This data is interpolated over the site using inverse square and krigging methods. Interpolation is on ground elevation first, then the bottom of the first layer and so on. If a layer is defined in STRATA.ORD but that layer is skipped over at the data point (that is, there are defined layers above and below the skipped layer) then the depth of that layer at that point is assumed to be 0. If the layer is not present at the data point and no layer is given below the layer at the data point then that point is not used for interpolating that layer's boundary. If during interpolation some grid values of a layer boundary go above the boundary of the previous layer, then the boundary of the currently interpolated layer is set to the same value as at the boundary of the previous layer for all grid points where this happens.

Stratagraphic interpolation is performed once: when the site is registered (or when the associated site files are modified). The results of stratagraphic interpolation are saved in BOREGRID.DAT (inverse-square) and KRIGGRID.DAT (krigging). Each time a well or boring log is requested, both the real data at that well or boring is consulted and displayed as well as the .DAT file. In the later case a simple linear interpolation from the nearest four grid points gives the layer boundaries. Each time a Xsection is displayed, for each linear piece of the Xsection, layer boundaries at 20 equally spaced points along the piece are computed from the appropriate .DAT file. Filled polygons are constructed to show the areas bounded by the layer boundaries. Since linear interpolation on the *.DAT file data, there is a possibility that fence polygons are slightly out of match at the posts. This is not now considered a problem since no mismatch has yet to be found to be significant.

b. Parameters

Parameter values are visualized using the THEME box. The user filters data points by date (down to the day), depth or stratagraphic layer, medium, and parameter. For each data point (<x,y> coordinates are alike) where there several samples matching the theme, the average of these samples is taken. Then all matching samples (including averaged samples taken as one sample) are interpolated. If the inverse-square switch on the interpolation box is set, then inverse square interpolation is used. If the Krigging switch is set then Krigging is used. In the case of inverse square interpolation, the number of nearest neighbors considered is a parameter that may be set by the user. The interpolation results in a grid of points with various values. The Color Box contains six breakpoints (seven colors including black). A color is given to a cell on the screen

corresponding to a grid point by determining which pair of breakpoints the value of the grid points falls between (or which extreme does it fall into). If the user wishes, contouring may be selected to smooth out the image. The contouring algorithm finds breakpoint values along edges of each cell (assuming linear interpolation or extrapolation) and fills polygons between these breakpoints. In 3D, interpolation is as above except that the depth is considered as a distinct dimension. Thus, data points are averaged in inverse square interpolation only if they have the same x,y,z coordinates. Construction of polygons through 3D cells is similar to that for 2D except we are looking for only one breakpoint since we are trying to develop a locus at a particular parameter value. Polygons are shaded by computing the dot product of the angle of viewing and the direction of the polygon. With the "Scaling" mode turned on, the vertical distance in the viewing cube is the same as the horizontal distance and all distance calculations are true. With the "Scaling" mode turned off and the "Enhance" mode turned off, all distance calculations are true but the vertical distance is set by the zone given in the theme box. Thus, there is some exaggeration of the figure in the vertical direction in this case. However, the locus of points is true (to x,y,z points it passes through). With the "Enhance" mode turned on and Scaling mode off, distances are calculated as though $dx=dy=dz$. Thus, if the absolute distances are different along all perpendicular edges of the viewing cube, exaggeration in all directions occurs and the resulting figure is NOT a locus. This feature is used to better visualize relative effects from groups of data points. Note that the figure in Enhance mode may not be the same as the figure in Scaling mode when the elevation ranges are the same.

c. Simulation

Only 2D simulators are currently installed. The user sets a theme and visualizes a parameter concentration on the screen (in colors). Usually, one or two of the layers represents an aquifer and the user will set the zone to include only those layers. Thus the colors should represent the concentration in the aquifer. This grid (the values) is input to the simulator along with grids representing transmissivity, head, constant head boundaries, recharge, storage coefficients, and other site properties. Currently, the property grids are manually entered in row major order into files that are read by the simulator. By the end of the summer we should have easier editing of such files. Constant Head boundaries are edited by the Site Editor. The French simulator computes simulation frames very quickly because it constructs a library of scenarios for well placement when the site is being set up. This library is a file called site.lib. When a user puts wells on the site, a superposition of scenarios gives the head used by the simulator. The simulator then solves the transport equation (assuming steady state) and produces concentration grids for each frame of the simulation. These are immediately displayed (the user sees a real time animation of these). The equations solved by the French simulator are the same as those solved by the MOC89 simulator except the method for solving transport is not the method of characteristics. Instead, French uses a straightforward numerical solution. See the accompanying code for details.

2. The grid size is 40x40. Can it be changed?

Actually, the grid size is governed by two variables: H_SIZE and V_SIZE. Currently, these variables are not accessible to the user - this is largely because we are still prototyping. Eventually we will open these vari-

ables and allow user access. However, before we do this we must solve problems such as What if a user makes a simulation in 40x40 and then wants to suddenly change to another grid size? Should the user be forced to start all over or would another interpolation be acceptable? Should such an interpolation be automatic? In any event, there will have to be some upper limit on dimensions for practical reasons: probably 80x120 which gives a cell of about 5x5 pixels (pretty small).

3. How has the output been tested.

So far, we have only checked the code carefully by hand (and not all of it, either). The Krigging code is brand new and I have not checked it at all yet. We have real data from four different sites and have spot checked the results for inconsistencies. Thus far, anything significant that we have noticed has been fixed. There are undoubtedly still errors to be found and the process of finding them will be one of gradual--improvement. Since we have been concentrating on proof-of- concept, there has not been an urgent need to validate all the output. This, of course will change soon.

John:

I want to clarify some of the responses you had given to some earlier questions. I have included sections of your reply, for quick reference:

My earlier question:

1. What is happening to the data from input to the point when the colors are seen on the screen?

Your reply:

a. Stratigraphy -

The data is at points on the site. For each point, a stratigraphic layer and depth are given and ground elevation is given. Thus we might have, for a point, SAND 30 GRAVEL 22 REFUSE 16 and ELEVATION 500 X_POS 349004 Y_POS 55432 which means that at x,y point (349004, 55432), surface elevation is 500 feet, the layer of sand is from elevation 500 to 470 feet, gravel from 470 feet to 448 feet and so on. This data is interpolated over the site using inverse square and krigging methods.

Clarification:

I guess that "interpolated over the site" means that the values are interpolated for the 40x40 grid. What would be the implications of this when the grid size is increased (in terms of time)? Are there any other assumptions (than the ones you mentioned) that you are making in these methods in terms of boundary conditions?

Your earlier reply continues:

Each time a Xsection is displayed, for each linear piece of the

Xsection, layer boundaries at 20 equally spaced points along the piece are computed from the appropriate .DAT file.

Clarification:

Could you elaborate a little bit more on this process? I tried to look at the contents of these files, but they are in a coded form. How is the interpolation done? What happens if xsection line does not "cut" through any of the grid corners?

Your earlier reply continues:

b. Parameters

Parameter values are visualized using the THEME box. The user filters data points by date (down to the day), depth or stratigraphic layer, medium, and parameter. For each data point (<x,y> coordinates are alike) where there several samples matching the theme, the average of these samples is taken. Then all matching samples (including averaged samples taken as one sample) are interpolated.

Clarification:

For example, say benzene, if the amount of benzene is X11 on day 1 in layer 1, and X12 on day 1 and layer 2, and X13 on day 1 and layer 3, and so on, to X59 on day 5 and layer 9, then the amount of benzene is averaged over the 45 values (for 5 days and nine layers)? This would be at a data site, say a well or a boring. Then this value of benzene is used to interpolate for other grid cells (in conjunction with amounts of benzene detected in other wells). Is my assumption of the process correct?

Your earlier reply continues:

c. Simulation

The French simulator computes simulation frames very quickly because it constructs a library of scenarios for well placement when the site is being set up. This library is a file called site.lib. When a user puts wells on the site, a superposition of scenarios gives the head used by the simulator. The simulator then solves the transport equation (assuming steady state) and produces concentration grids for each frame of the simulation. These are immediately displayed (the user sees a real time animation of these).

Clarification:

When the library is constructed, does it assume all possible combinations of wells, depth, rate of pumping, etc? How many such combinations are there, and what are those? What happens when a user puts multiple wells, trenches, and other remediation objects?

I tried to run the MOC89 Simulation. But when I triggered it, a box came up apparently asking me to make a file selection. Since no mention of such a box is there in the manual, is there something that I need to know which I may have missed in our trip there?

Akhtar.

Date: Fri, 08 Jul 1994 13:54:09 -0400 (EDT)
From: John Franco <franco@franco.csm.uc.edu>
Subject: RE: questions
To: LODGHER@MUVMS6.MU.WVNET.EDU

>

> John:

>

> I want to clarify some of the responses you had given to some earlier questions. I have included sections of your reply, for quick reference:

>

>

> My earlier question:

>

> 1. What is happening to the data from input to the point when the colors are seen on the screen?

>

> Clarification:

>

> I guess that "interpolated over the site" means that the values are interpolated for the 40x40 grid. What would be the implications of this when the grid size is increased (in terms of time)? Are there any other assumptions (than the ones you mentioned) that you are making in these methods in terms of boundary conditions?

>

a. Time should increase linearly for each dimension (x4 for 80x80)

b. No assumptions that I remember for interpolation. For simulation, assumptions are the same as for the MOC simulator (USGS) - Please refer to docs for MOC (readily available- probably a colleague has them) for more info - if I tried to dredge it from memory, I would not give the right answer (the fast simulator is the domain of Dr. Don French in the Math Dept. at UC).

> Clarification:

>

> Could you elaborate a little bit more on this process? I tried to look at the contents of these files, but they are in a coded form.

a. We choose 20 points along the site. Each has an x,y coordinate. For each point we enter the stratigraphy file (well documented in an appendix of the manual) and choose the cell containing the point. Then we perform a linear interpolation from the corners (first along edges, to locate two intermediate points, then along the line connecting the intermediate points).

> How is the interpolation done? What happens if xsection line does not "cut" through any of the grid corners?

b. Each point on the line should cut through a cell. If not, I have a bug to fix.

>

>

> Your earlier reply continues:

>

> b. Parameters

> Parameter values are visualized using the THEME box. The user filters data points by date (down to the day), depth or stratigraphic layer, medium, and parameter. For each data point (<x,y> coordinates are alike) where there several samples matching the theme, the average of these samples is taken. Then all matching samples (including averaged samples taken as one sample) are interpolated.

> Clarification:

>

> For example, say benzene, if the amount of benzene is X11 on day 1 in layer 1, and X12 on day 1 and layer 2, and X13 on day 1 and layer 3, and so on, to X59 on day 5 and layer 9, then the amount of benzene is averaged over the 45 values (for 5 days and nine layers)?

A. Yes, if the theme allows those dates and those depths.

> This would be at a data site, say a well or a boring. Then this value of benzene is used to interpolate for other grid cells

(in conjunction with amounts of benzene detected in other wells). Is my assumption of the process correct?

- b. I did not understand the above completely so I will guess: the average number is used as the only number at the data point when interpolating. This number has no affect on numbers produced at other data points, only on numbers produced at grid points.

>

> Clarification:

>

> When the library is constructed, does it assume all possible combinations of wells, depth, rate of pumping, etc?

- a. No. It puts one well of unit draw in each cell and computes the head difference (that is actually what is stored in the library). When consulted during a simulation, head frames are taken from the library for all cells containing wells and the total head is the sum of the head differences of each frame, multiplied by a factor that takes account of the actual flow in or out of the cell (due to wells). The result is added to the head computed for no wells on the site (found in the library as well).

> How many such combinations are there, and what are those? What happens when a user puts multiple wells, trenches, and other remediation objects?

- b. For a 40x40 site library, there are 1601 frames (the first one is the head with no wells, and the rest are the head differences). Multiple well question is answered in a.

>

>

> I tried to run the MOC89 Simulation. But when I triggered it, a box came up apparently asking me to make a file selec-

tion. Since no mention of such a box is there in the manual, is there something that I need to know which I may have missed in out trip there?

The box should be asking for the name of a file. MOC89, out of the box, requires a file as input (unless one is willing to spend a lot of time pumping the data in by hand). Our code creates such a file. We ask the user to name it because the user might want to record all simulations requested of MOC. Simply type in a name like TEST - this creates the file TEST.IN which will be input to MOC89.

APPENDIX 5

Example section of Fast Simulator Code

Fast simulator Code:

Date: Tue, 28 Jun 1994 12:00:59 -0400 (EDT)
From: John Franco <franco@franco.csm.uc.edu>
Subject: fast simulator code
Resent-to: LODGHER@MUMS6.MU.WVNET.EDU

```
#include <graphics.h>
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <conio.h>
#include <dir.h>
#include "mouse.h"
#include "constant.h"
#include "mytypes.h"
#include "prototyp.h"

extern DIALOGBOX *PositionBox;
extern DIALOGBOX *ScaleTemplate;
extern DIALOGBOX *ControlBox;
extern DIALOGBOX *GraphsBox;
extern ICON *HeadPtr;
extern MESH mesh;
extern FILE *hist_fd[NUMBER_ATTR+1][GRAPH_HIST_LIMIT];
extern char hist_file[GRAPH_HIST_LIMIT][13];
extern char hist_lim[GRAPH_HIST_LIMIT];
extern int cur_hist_ptr;
extern char save_file[];
extern double SiteScale;
extern int framenum;
extern char conc_file[];

float *trans;
float *rech;
float *hn;
float *b;
float *un;
float *unp1;
float *htau;
int *nodeid;
float *h0;
float *c0;

char ixobs, iyobs;

int h_size, v_size;
int ntim, npmp, nx, ny, npmax, npnt, nitp, numobs, itmax, nrec,
  npntpd, ncodes, npntmv, loc_npntvl, loc_npntd, loc_npdelc, loc_npnchv;
int nwells, input;
float eps, beta, alphaT, alphaL, dx, dy, fctr;
float pint, tol, poros, s, timx, tinit, xdel, ydel,
  dltrat, celdis, andctr;
long wells_start, site_matrix_start, head_matrix_start;

int SlideFrame(VIEWPORT *, int, int);
void ChangeGraceEnv(void);

void move(float *a1, float *a2)
{
    int i;
    for (i=0; i < v_size*h_size; i++) a1[i] = a2[i];
}

void subt(float *a1, float *a2)
{
    int i;
    for (i=0; i < h_size*v_size; i++) a1[i] -= a2[i];
}

void zero(float *a1)
{
    int i;
```

```

    for (i=0; i < h_size*v_size; i++) a1[i] = 0;
}

void fe(float *unp1, float *un, float *d, float *b, float *v, float *f, float dx
, float dy, float dt)
{
    int i, k, j, X, Y;
    float s, une, unn, dx, dy, flow;
    float s1, s2, s3, s4, dbx1, dbx2, dby1, dby2, ddX, ddY;
    locrec mouse, m;

    m.column = -1; m.row = -1;

    dx = dt/dx;
    dy = dt/dy;

    for (i=h_size; i<h_size*(v_size-1); i++)
    {
        if (i%h_size == 0)
        {
            mouse = *mpos();
            if (mouse.row != m.row || mouse.column != m.column)
            {
                UpdatePositionBox
                (PositionBox->left, PositionBox->top,
                 mouse.column, mouse.row,
                 ((double)NewValueAtPositionFILE(NULL, 0, mouse.column, mouse.row)
                ));
                m.column = mouse.column; m.row = mouse.row;
            }
            continue;
        }
        if (i%h_size == h_size-1) continue;

        k = 3*i;
        j = 3*h_size;
        s = un[i];
        dbx1 = b[i+1]+b[i];
        dbx2 = b[i]+b[i-1];
        dby1 = b[i+h_size]+b[i];
        dby2 = b[i]+b[i-h_size];
        ddX = dx/b[i];
        ddY = dy/b[i];
        X = 2*i;
        Y = X+1;

        s1 = (d[k]+d[k+3])*(un[i+1]-un[i])/dx;
        s2 = (d[k+2]+d[k+5])*(un[i+h_size+1] - un[i-h_size+1] + un[i+h_size] - un[
i-h_size])/(2.0*dy);
        s3 = (d[k]+d[k-3])*(un[i]-un[i-1])/dx;
        s4 = (d[k+2]+d[k-1])*(un[i+h_size] - un[i-h_size] + un[i+h_size-1] - un[i-
h_size-1])/(2.0*dy);
        s += ddX*(dbx1*(s1+s2) - dbx2*(s3+s4))/4.0;

        s1 = (d[k+j+2]+d[k+2])*(un[i+h_size+1]-un[i+h_size-1]+un[i+1]-un[i-1])/(2.
0*dx);
        s2 = (d[k+j+1]+d[k+1])*(un[i+h_size] - un[i])/dy;
        s3 = (d[k+2]+d[k-j+2])*(un[i+1]-un[i-1]+un[i-h_size+1]-un[i-h_size-1])/(2.
0*dx);
        s4 = (d[k+1]+d[k-j+1])*(un[i] - un[i-h_size])/dy;
        s += ddY*(dby1*(s1+s2) - dby2*(s3+s4))/4.0;

        if (v[X] > 0)
        { une = (b[i]+b[i-1])*(un[i] - un[i-1])/2.; }
        else
        { une = (b[i+1] + b[i])*(un[i+1] - un[i])/2.; }

        if (v[Y] > 0)
        { unn = (b[i] + b[i-h_size])*(un[i] - un[i-h_size])/2.; }
        else
        { unn = (b[i+h_size] + b[i])*(un[i+h_size] - un[i])/2.; }

        if (f[i] <= 0) flow = 0; else flow = f[i]*dt*un[i];
        s += -flow/b[i] - v[X]*ddX*une - v[Y]*ddY*unn;
        if (s < 0) s = 0;

        unp1[i] = s;
    }
}

```

```

for (i=1; i<h_size; i++)
{
    un[i] = un[i+h_size];
    un[h_size*(v_size-1)+i] = un[h_size*(v_size-2)+i];
}

for (i=1; i<v_size; i++)
{
    un[i*h_size] = un[i*h_size+1];
    un[(i+1)*h_size-1] = un[(i+1)*h_size-2];
}
un[h_size*v_size-1] = un[h_size*(v_size-1)-2];
un[0] = un[h_size+1];
un[h_size-1] = un[2*h_size-2];
un[h_size*(v_size-1)] = un[h_size*(v_size-2)+1];
}

```

APPENDIX 6

A copy of the brochure on Intergraph's ERMA

Material removed due to copyright law.

APPENDIX 7

Summary of Environmental Technology'94 Conference materials

**Summary of *Environmental Technology '94 Computing and Information*
Conference materials**

Pre-Conference Tutorials:

There were three tutorials:

1. *Visualization Technology and its Application to Environmental Management and Advances in Scientific Visualization*
2. *Environmental Audits and Site Assessments*
3. *Environmental Information Sources: What's Available, Who Can Use It, and How to Access It.*

Tutorial 1:

Visualization Technology and its Application to Environmental Management and Advances in Scientific Visualization

Contact persons:

Mr. Eric Bayer

Senior Systems Consultant, Intergraph Corp.,
Huntsville, AL 35894.

Ms. Dana Roberson

Senior Systems Analyst, Argonne National Laboratory
One Bank St., Suite 250, Gaithersburg, MD 20878.
(301) 948-0698 # 27

Mr. Bruce Hastings

Environmental Division, Argonne National

Laboratory
9700 S. Cass St., Argonne, IL 60439.
(708) 252-3253

Mr. Jim Brown

Pacific Northwest Laboratory
Batelle Blvd., Richland, WA 99352.
(509) 375-3626

This tutorial presented some of the complexities of environmental analyses due to the large volumes of numerical data, technical information, maps and regulations. Data visualizations systems are critical for gathering and presenting the information in a comprehensible fashion. Each speaker presented their experiences in this area.

The group from Argonne presented an application they had developed using MapInfo, a 2-D visualization system. Issues for "in-field" visualization, such as simplicity, and flexibility, were discussed.

Mr. Jim Brown of Pacific Northwest Laboratory discussed some issues regarding the access of information in a distributed environment. An overall systems approach was presented. An overview of the Tank Waste Information Network System (TWINS) was presented.

Mr. Eric Bayer discussed the current status of volume visualization and the effort of his organization, Intergraph, in developing a volume visualization tool called Voxel. An overview of volume visualization techniques was presented. A short demonstration of the visualization tool was given.

Tutorial 2:

Environmental Audits and Site Assessments

Contact persons:

Dr. Jay Turim, Mr. John Haines, Mr. John Kolojeski

Enviro-Tech Sciences Group, Inc.,
1801 Robert Fulton Dr., Suite 400,
Reston, VA 22091.
(703) 758-6727

Mr. Mark J. Bennett

President, Environmental Data
Resources
187 S. Woodward Ave., Suite 204,
Birmingham, MI 48009.
(800) 352-0050 Ext 200

This tutorial presented the regulatory and technical aspects of environmental audits and site assessments. Topics discussed included: the need for environmental audits, objectives of the audits, how they are accomplished, cost ranges, limitations and contractor liabilities. The three phases of environmental site assessment were discussed. An overview of environmental risk assessment was presented.

Mr. Mark Bennett presented the services offered by his organization to client companies performing site assessments. Freedom of Information Act (FOIA) generally has a very large turn-around time (of the order of 6-months to a year) for inquiries about sites which may have contamination. Service companies, such as Mr. Bennett's Environmental Data Resources, maintain their own databases and provide information to their clients about the "history" of a site in terms of

its ownership and contaminations.

Tutorial 3:

*Environmental Information Sources: What's Available,
Who Can Use It, and How to Access It.*

Contact Persons:

Mr. Andrew Waldo,
President, Ariel Research Corporation
7910 Woodmont Ave., Suite 902,
Bethesda, MD 20814.
(800) 982-0064

Mr. Bruno M. Vasta,
TOXNET Administrator, National Library
of Medicine

This tutorial presented various sources of environmental information, both federal and private. Usefulness of data sources, from the standpoint of locating particular types of information, identifying quality sources, and ease of use were covered. Locations of various electronic databases and their accessibility were presented.

Companies in the Private Sector offering related products and services

This section briefly describes the products and services of companies in the private sector involved with environmental work. Summaries of the following companies is provided:

1. Envirotech Online
2. Environmental Information Networks, Inc.
3. Nuclear Remediation Technologies
4. Enviro-Tech Sciences Group
5. Environmental Data Resources

Material removed due to copyright law.

APPENDIX 8

*Summary of materials presented at the National
Conference on Environmental Problem Solving with
Geographic Information Systems*

United States
Environmental Protection Agency
Office of Research and Development

National Conference on Environmental Problem Solving With Geographic Information Systems

Cincinnati, OH
September 21-23, 1994

Agenda

WEDNESDAY SEPTEMBER 21, 1994

- 8:30AM **Registration**
- 10:00AM **Welcome Speakers**
Daniel Murray and Susan Schock, Center for Environmental Research Information (CERI), U.S. Environmental Protection Agency (EPA), Cincinnati, OH
Thomas Davenport, Region V, EPA, Chicago, IL
Donald Schregardus, Ohio Environmental Protection Agency, Columbus, OH
Javier Ruis, Soil Conservation Service (SCS), U.S. Department of Agriculture (USDA), Fort Worth, TX
- 11:00AM **Keynote Address**
Dynamic GIS: Tools, Weapons, and Video Games for the 21st Century
Mark Monmonier, Department of Geography, Maxwell School of Citizenship & Public Affairs, Syracuse University, Syracuse, NY
- 12:00PM **LUNCH**

Concurrent Sessions

1:00-2:30PM	SESSION A: Concepts and Philosophy of GIS Use for Environmental Problem Solving
<i>Moderator: Susan Schock, CERI, EPA, Cincinnati, OH</i>	SESSION B: Wetlands and Riparian Zone Assessment and Management Using GIS
<i>Moderator: Daniel Murray, CERI, EPA, Cincinnati, OH</i>
1:00PM	A-1: GIS Uncertainty and Policy: Where Do We Draw the Twenty-Five Inch Line?
<i>James E. Mitchell, Kansas Geological Survey, Lawrence, KS</i>	B-1: Wetlands Mapping and Assessment in Coastal North Carolina: A GIS-Based Approach
<i>Lori A. Sutter, Division of Coastal Management, State of North Carolina, Raleigh, NC</i>

WEDNESDAY **SEPTEMBER 21, 1994 (continued)**

1:30PM	A-2: Developing and Using Interpretive Hydrogeologic Maps
<i>Donald A. Keefer, Illinois State Geological Survey, Champaign, IL</i>	B-2: The Watershed Assessment Project: Tools for Regional Problem Area Identification
<i>Christine L. Adamus, St. Johns River Water Management District, Palatka, FL</i>
2:00PM	A-3: "You Can't Do That With This Data" or Uses and Abuses of Tap Water Monitoring Analyses
<i>Michael R. Schock, Risk Reduction Engineering Laboratory, EPA, Cincinnati, OH</i>	B-3: Riparian/Wetland Corridor Planning With GIS
<i>Margaret A. Fast, Kansas Water Office, Topeka, KS</i>
2:30PM	BREAK	
3:00-4:30PM	SESSION C: Experiences in Using GIS for Environmental Problem Solving
<i>Moderator: George Cummings, SCS, USDA, Cincinnati, OH</i>	SESSION D: Environmental Applications Using GIS and Remote Sensing
<i>Moderator: John Lyon, Ohio State University, Columbus, OH</i>
3:00PM	C-1: Small Is Beautiful: GIS and Small Native American Reservations—Approach, Problems, Pitfalls and Advantages
<i>Jeff Besougloff, Upper Sioux & Lower Sioux Indian Communities, Redwood Falls, MN</i>	D-1: Development of Landscape Level Habitat Units Using Multi-Temporal/Multi-Scale Remote Sensing and Ancillary Landscape Data for a Biodiversity Assessment for the Central Appalachians
<i>Ree Brannon, West Virginia University, Morgantown, WV</i>
3:30PM	C-2: Facilitation of Water-Surface-Profile Computations by Use of a GIS
<i>Ralph J. Haefner, U.S. Geological Survey, Columbus, OH</i>	D-2: An Investigation Using GIS To Assist in Aquatic Macrophyte Management for Legend Lake, Menominee County, Wisconsin
<i>Michael F. Troge, University of Wisconsin at Stevens Point, Stevens Point, WI</i>
4:00PM	C-3: Data Quality Issues Affecting GIS Use for Environmental Problem Solving
<i>Carol B. Griffin, EPA Research Fellow, Idaho Falls, ID</i>	D-3: GIS-Assisted Riparian Characterization and Temperature Modeling of the Upper Grande Ronde River Basin in Northeast Oregon
<i>Douglas J. Norton, Office of Water, EPA, Washington, DC</i>
4:30PM	ADJOURN	
4:30-6:00PM	Exhibits/Poster Session	

8:30-10:00AM	SESSION E: Groundwater Assessment and Management Using GIS - I <i>Moderator: John Shafer, Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC</i>	SESSION F: Watershed-Based GIS Applications - I <i>Moderator: Robin Corathers, Rivers Unlimited Mill Creek Restoration Project, Cincinnati, OH</i>
8:30AM	E-1: Verification of Contaminant Flow Estimation With GIS and Aerial Photography <i>Thomas M. Williams, Clemson University, Georgetown, SC</i>	F-1: A Watershed-Oriented Database for Regional Cumulative Impact Assessment and Land Use Planning <i>Steven J. Stichter, Division of Coastal Management, State of North Carolina, Raleigh, NC</i>
9:00AM	E-2: Taking a GIS Into the 3rd and 4th Dimensions To Solve Ground-Water Remediation Problems <i>Dennis R. Smith, Dynamic Graphics, Inc., Bethesda, MD</i>	F-2: Watershed Stressors and EMAP Estuarine Indicators for South Shore Rhode Island <i>John F. Paul, Environmental Research Laboratory, EPA, Narragansett, RI</i>
9:30AM	E-3: Use of a GIS To Estimate Ground-Water Availability in West Central Georgia <i>William H. McLemore, Georgia Geologic Survey, Atlanta, GA</i>	F-3: Design of GIS To Compare Wetland Impacts on Runoff in Upstream Basins of the Mississippi and the Volga <i>Tatiana B. Nawrocki, University of Minnesota at Duluth, Duluth, MN</i>
10:00AM	BREAK	
10:30AM-12:00PM	SESSION G: Groundwater Assessment and Management Using GIS - 2 <i>Moderator: Randy Revetta, CERL, EPA, Cincinnati, OH</i>	SESSION H: Watershed-Based GIS Applications - 2 <i>Moderator: Steve Crabtree, SCS, USDA, Burlington, KY</i>
10:30AM	G-1: GIS Techniques Applied to the Hydrogeological Characterization of a U.S. Department of Energy Facility in Northeastern Illinois <i>Glenn H. Wittman, U.S. Department of Energy, Argonne, IL</i>	H-1: The Design and Application of a GIS Data Base for the Analysis of Nonpoint Source Pollution in a Watershed <i>Thomas H. Cahill, Cahill Associates, West Chester, PA</i>
11:00AM	G-2: Geologic and Ground-Water Resource Evaluation of Will and Southern Cook Counties, Illinois, Using a GIS <i>Edward C. Smith, Illinois State Geological Survey, Champaign, IL</i>	H-2: A GIS for Aquatic Resource Management and Protection for the Upper Ohio River Basin in Pennsylvania <i>Jerry G. Schulte, Ohio River Valley Water Sanitation Commission (ORSANCO), Cincinnati, OH</i>

THURSDAY **SEPTEMBER 22, 1994 (continued)**

11:30AM	G-3: Using GIS/GPS in the Design and Operation of Minnesota's Ground-Water Monitoring and Assessment Program (GWMAP) <i>Tom Clark, Minnesota Pollution Control Agency, St. Paul, MN</i>	H-3: Examining the Influence of Watershed Characteristics on Stream Water Quality, Physical Habitat, and Biota <i>Carl Richards, University of Minnesota at Duluth, Duluth, MN</i>
12:00PM	LUNCH	
1:30-3:00PM	SESSION I: Groundwater Assessment and Management Using GIS - 3 <i>Moderator: Jim Kreissl, CERL, EPA, Cincinnati, OH</i>	SESSION J: Urban Nonpoint Source Applications Using GIS <i>Moderator: John Kosco, Office of Water, EPA, Washington, DC</i>
1:30PM	I-1: Application of GIS and Modeling in Remediation of Ground-Water Contamination <i>Randall R. Ross, Robert S. Kerr Environmental Research Laboratory, EPA, Ada, OK</i>	J-1: A GIS Toolbox for Targeting Nonpoint Source Pollution in Urban Areas <i>Michael L. Ketcham, Purdue University, West Lafayette, IN</i>
2:00PM	I-2: Use of GIS in Modeling Ground-Water Flow in the Memphis, Tennessee, Area <i>James E. Outlaw, The University of Memphis, Memphis, TN</i>	J-2: Using GIS To Create Awareness of Nonpoint Source Water Quality Impacts in an Urbanizing Watershed <i>Peter Coffin, University of Massachusetts, Worcester, MA</i>
2:30PM	I-3: GIS in Statewide Ground-Water Vulnerability Evaluation to Pollution Potential <i>Kumar C.S. Navalar, Purdue University, West Lafayette, IN</i>	J-3: Linking GIS With Watershed Models and Management Assessment Techniques <i>John Lovell, Tetra Tech, Inc., Fairfax, VA</i>
3:00PM	BREAK	
3:30-5:00PM	SESSION K: Chemical Contamination Assessment of Water Resources Using GIS <i>Moderator: Samuel Noe, Joint Center for GIS and Spatial Analysis, University of Cincinnati, Cincinnati, OH</i>	SESSION L: River Basin Assessment and Modeling Using GIS <i>Moderator: Pat Burke, CERL, EPA, Cincinnati, OH</i>
3:30PM	K-1: Vulnerability of Missouri Drinking Water to Chemical Contamination <i>Christopher J. Barnett and Steven J. Vance, University of Missouri at Columbia, Columbia, MO</i>	L-1: Spatial Modeling of Biocriteria and Upstream Basin Characteristics for the Black River, Ohio <i>Dale A. White, Ohio Environmental Protection Agency, Columbus, OH</i>

THURSDAY **SEPTEMBER 22, 1994 (continued)**

4:00PM	K-2: Determining the Extent of Agricultural Chemical Contamination in Water Resources in the Midwestern United States
<i>William A. Battaglin, U.S. Geological Survey, Lakewood, CO</i>	L-2: GIS for Water Quality Management and Modeling in the Ohio River Basin
<i>Jason P. Heath, Ohio River Valley Water Sanitation Commission (ORSANCO), Cincinnati, OH</i>
4:30PM	K-3: A GIS-Based Approach in Characterizing Chemical Compounds in Soil and Modeling of Remedial System Design
<i>Leslie L. Chau, ICF Kaiser Engineers, Inc., Oakland, CA</i>	L-3: Reach File 3 and the Development of GIS Water Quality Tools
<i>Stephen R. Bevington, North Carolina Department of Health, Environment, & Natural Resources, Raleigh, NC</i>
5:00PM	ADJOURN	

FRIDAY **SEPTEMBER 23, 1994**

-
8:30-10:00AM	SESSION M: Agricultural Nonpoint Source Applications Using GIS - I
<i>Moderator: Lyn Kirschner, Conservation Technology Information Center, West Lafayette, IN</i>	SESSION N: Urban Environmental Analysis Using GIS
<i>Moderator: Justice Manning, CERL, EPA, Cincinnati, OH</i>
8:30AM	M-1: Nonpoint Source Pesticide Pollution of the Pequa Creek Watershed, Lancaster County, Pennsylvania: An Approach Linking Probabilistic Transport Modeling and GIS
<i>Robert T. Paulsen, The Paulsen Group, Bowie, MD</i>	N-1: GIS Model for Land Use Suitability of Greenbelt Area
<i>Joanna J. Becker, Environmental Planning Services, Santa Rosa, CA</i>
9:00AM	M-2: Integration of GIS With the Agricultural Nonpoint Source Pollution Model (AGNPS) To Evaluate Model Output at High Resolutions
<i>Suzanne R. Perlitch, State University of New York, Syracuse, NY</i>	N-2: Application of GIS for Environmental Impact Analysis in a Traffic Relief Study
<i>Bruce E. Stauffer, Advanced Technology Solutions, Inc., Lancaster, PA</i>
9:30AM	M-3: Integration of GIS and Hydrologic Models for Nutrient Management Planning
<i>Clyde W. Fraisse, University of Florida, Gainesville, FL</i>	N-3: GIS as a Tool for Predicting Urban Growth Patterns and Risks From Accidental Release of Industrial Toxins
<i>Samuel V. Noe, Joint Center for GIS & Spatial Analysis, University of Cincinnati, Cincinnati, OH</i>
10:00AM	BREAK	

FRIDAY **SEPTEMBER 23, 1994 (continued)**

10:30AM-12:00PM

SESSION O: Agricultural Nonpoint Source Applications Using GIS - 2

Moderator: Daniel Murray, CERL, EPA, Cincinnati, OH

SESSION P: Diverse Environmental Applications Using GIS

Moderator: Susan Schock, CERL, EPA, Cincinnati, OH

10:30AM

O-1: XGRCWP, a Knowledge and GIS Based System for Selection, Evaluation, and Design of Water Quality Control Practices in Agricultural Watersheds

Michael A. Foster, Pennsylvania State University, University Park, PA

P-1: Comparing Experiences in the British and U.S. Virgin Islands in Implementing GIS for Environmental Problem Solving

Bruce Potter, Island Resources Foundation, Washington, DC

11:00AM

O-2: EPA's Reach Indexing Project: Using GIS To Improve Water Quality Assessment

John J. Clifford, Office of Wetlands, Oceans & Watersheds, EPA, Washington, DC

P-2: Integration of EPA Mainframe Graphics and GIS in a UNIX Workstation Environment To Solve Environmental Problems

William B. Samuels, Science Applications International Corporation, McLean, VA

11:30AM

O-3: Application of GIS Techniques to the Results of Probabilistic Modeling for Herbicide Runoff in Corn Growing Soils in Illinois, Indiana, Missouri, and Nebraska

Robert T. Paulsen, The Paulsen Group, Bowie, MD

P-3: Development of a GIS for Former Industrial Properties in the Mahoning River Corridor

Scott C. Martin, Youngstown State University, Youngstown, OH

12:00PM

O-4: Linking Environmental Models and GIS Through Inter-Application Communication

Carl A. Horton, Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC

P-4: Polygon Development Improvement Techniques for Hazardous Waste Environmental Impact Analysis

David A. Padgett, Austin Peay State University, Clarksville, TN

12:30PM

ADJOURN