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US Army Corps of Engineers®
Engineer Research and Development Center

Data Management of Watershed Information and Data Enterprise Repository Implementation at Fort Hood, Texas

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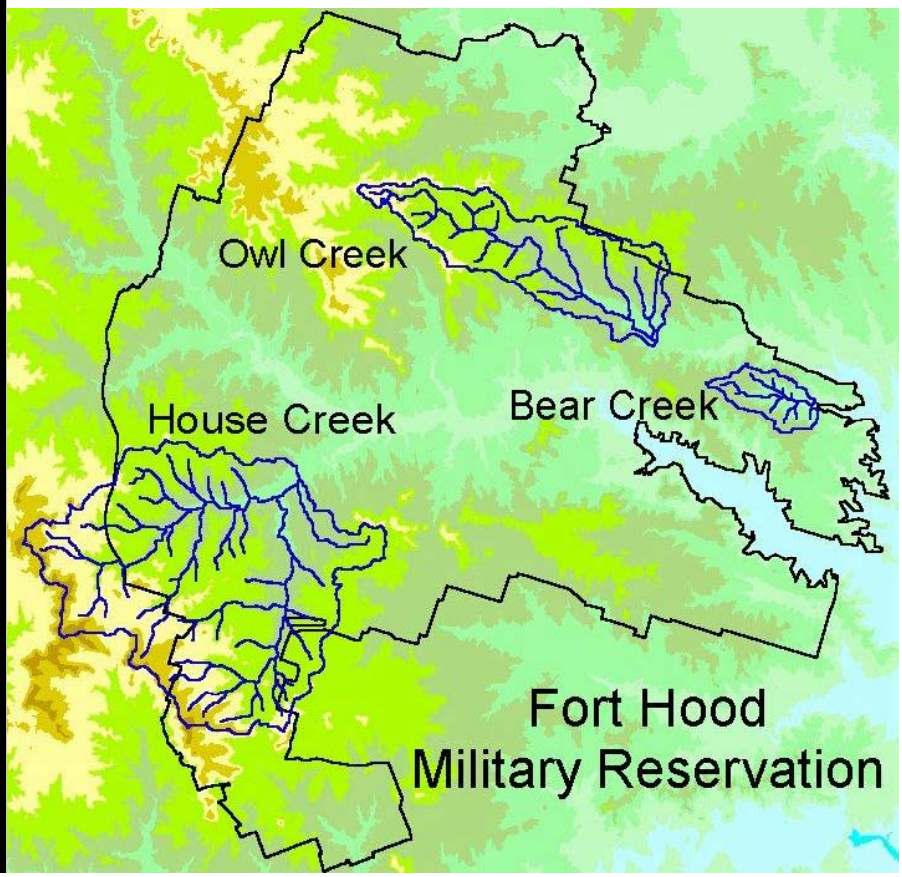
March 2003



Construction Engineering Research Laboratory

Foreword

This study was conducted for the Department of Public Works (DPW), Natural Resources Branch, Fort Hood, TX. The technical monitor was Mr. Dennis M. Herbert.

The work was performed by the Ecological Processes Branch (CN-N) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL) for a jointly funded research proposal entitled "On-Site Data Management of Watershed Information at Fort Hood, Texas, and Data Management Plan and User Documentation to Support LMS." The CERL Principal Investigator was Mr. William D. Meyer. Work for the Data Management Plan and User Documentation to Support LMS was completed by Dr. Marilyn O. Ruiz of the University of Illinois, Urbana, Illinois. Work onsite at Fort Hood involving the Date Enterprise Repository implementation was completed by Mr. David Hoffpauir and Dr. Gary Smith of the Texas Research Institute for Environmental Studies (TRIES) of Sam Houston State University, Huntsville, Texas. The technical editor was Gloria J. Wienke, Information Technology Laboratory. Steve Hodapp is Chief, CEERD-CN-N, and Dr. John T. Bandy is Chief, CEERD-CN. The associated Technical Director was William D. Goran, CEERD-CV-T. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN and the Director of ERDC is Dr. James R. Houston.

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Background

The Data Enterprise Repository (DER)

In 1998, the Engineer Research and Development Center's Construction Engineering Research Laboratory (ERDC/CERL) was tasked with evaluating options for an enterprise Geographic Information System (GIS) solution at a military installation. The goals of the evaluation were to determine a technical solution that would use commercial software to support both the daily GIS requirements of the installation as well as spatial modeling efforts. Fort Hood, Texas, was selected as a field site due to the mature GIS usage at the installation and the willingness of key personnel to cooperate in the project.

GIS was being used at Fort Hood in numerous applications, such as mapping the habitation of black capped vireo and golden cheeked warbler populations, managing cultural resource sites, and planning of military training activities. GIS activities were being pursued at several different offices on the installation, including the Environmental Division office, the Cultural Resources Management Team, the Natural Resources Branch, and the Integrated Training Area Management office. Many employees in these offices were concerned about the lack of a well-documented, centralized database for GIS data. By meeting the following objectives, the DER sought to address this concern.

- Provide a centralized repository accessible by the Fort Hood Intranet to archive, access, and manage data at the local level.
- Improve data quality and reusability through standardization, consistent management practices, and creation of metadata.
- Make data available to enterprise applications through a documented framework from which to access the data.

The DER also sought to benefit those who need to view maps from the system, but do not use a GIS, and to enable people offsite, who are performing work at Fort Hood, to get better access to the data they require for their work (Ruiz et al. 2001).

Fort Hood, Texas (Figure 1) is a 340-square mile installation (217,337 acres [7004 ha]); it is the only post in the United States capable of stationing and training two Armored Divisions. The rolling, semi-arid terrain is ideal for training and testing military units and individual soldiers. Fort Hood is the home and headquarters of the Command III Corps.

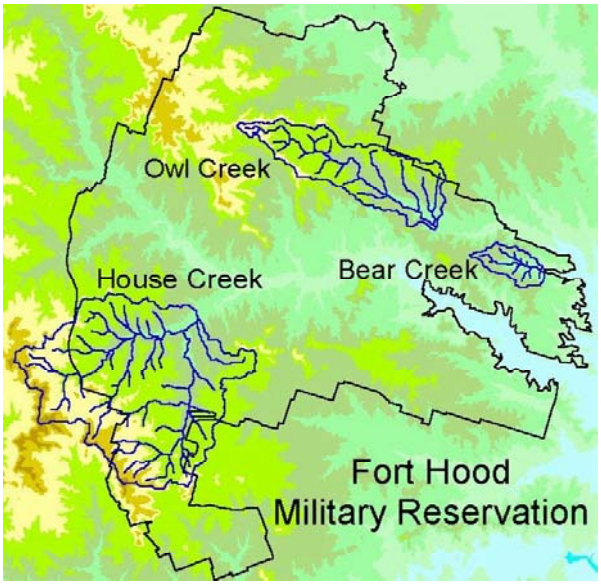

Figure 1. The Fort Hood military field application site.

For many years, the primary focus of III Corps was to support NATO. As the world and the U.S. Army have changed, the III Corps has also changed, and expanded its focus to be ready to deploy at a moment's notice to any location, and win. The mission of the III Corps is to deploy to a theater of operations, conduct military operations across the spectrum of conflict, and redeploy.

In recent years, III Corps forces have fought in and supported operations worldwide, to include Grenada, Panama, Honduras, Saudi Arabia, Kuwait, and Iraq and have provided humanitarian support for Operation Restore Hope in Somalia. III Corps elements also provided support for Operation Joint Endeavor in Bosnia. III Corps major units are the 1st Cavalry Division and the 4th Infantry Division; the 3rd Armored Cavalry Regiment, the III Corps Artillery; and the 13th Corps Support Command.

Resource management challenges at Fort Hood

Some of the enduring land and resource management issues that Fort Hood faces include monitoring the impacts of training on Threatened and Endangered Species (TES) and testing TES population viability under alternative land management strategies. Land managers at Fort Hood are additionally responsible

for ensuring that training areas maintain their usefulness for training activities by minimizing erosion and other land degrading activities. Land managers need to have estimates of erosion potential, trafficability problems, and flooding hazards to ensure safe and excellent training today while making sure that future training can be accommodated on the same landscape. Geographic Information Systems are essential to meeting these needs.

Objective

In late September of 2001 the Natural Resources Branch at Fort Hood, Texas, funded the operational implementation of the Data Enterprise Repository (DER). The DER was an Enterprise Geographic Information System designed to house GIS data collections at Fort Hood and to provide intranet access to that data for authorized users. The DER was also intended to provide a storage location for remotely sensed data gathered from weather station platforms located in Fort Hood's training areas. The implementation of the DER system involved the efforts of ERDC/CERL and the Texas Research Institute for Environmental Studies (TRIES). The objective of this report is to document those efforts and explain the lessons learned throughout the process. The report concludes with a summary of the current status of the implementation, and provides recommendations on future directions.

Approach

At the request of Fort Hood Natural Resources Branch, ERDC/CERL and TRIES undertook the steps to implement the DER. To accomplish the implementation three tasks had to be addressed: (1) the DER had to be installed and populated with installation GIS data, (2) a web site had to be developed to retrieve and link to the DER downloaded data collected from the remote instrument platforms located in the House Creek and Owl Creek watersheds, and (3) documentation on DER administration needed to be completed as an online user manual that could be provided to installation personnel. The tasks were assigned as follows: ERDC/CERL was responsible for Tasks 1 and 3; TRIES was responsible for Task 2 with on-site technical responsibilities for Task 1.

Mode of Technology Transfer

Researchers installed the DER and populated it with Fort Hood GIS data. They created a web site to retrieve data from remote instrument platforms and

download the data to the DER. They also developed an online user manual for installation personnel. Following the successful completion of these tasks, researchers gave a training presentation on the system and provided an online user's manual to the Fort Hood personnel who have the responsibility for the ongoing administration of the system. See the Appendix for a presentation on DER and Environmental Monitoring

This report will be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 Data Enterprise Repository (DER) Implementation

Task 1: Install DER and upload with installation GIS data

From October of 2001 through August of 2002 Mr. David Hoffpauir and Dr. Gary Smith of TRIES worked on the on-site technical requirements of Task 1. Mr. Hoffpauir was charged with installing the software and hardware necessary to operate the DER. Dr. Smith's role was to provide documentation for using the DER interface. The software and hardware necessary for DER implementation included the following components.

Software

Geographic Information System
- Environmental Systems Research Institute (ESRI) ArcGIS

Database
- ESRI ArcSDE
- Oracle

Web Mapping and the DER Custom Interface
- ESRI ArcIMS
- Microsoft Internet Information Server
- Java Runtime Environment
- MS Access

Hardware

Hardware for the server component of the system at Fort Hood included three different computers. The three machines are identified below by name. Following each computer name is the software and data present on that computer. The operating system for all of these machines is MS Windows 2000.

DPW-ENV
- ESRI License Manager
- ESRI GIS Product Install (Workstation)
- Image data
- Backup files

DPW-GIS
- Oracle 9i database
- GIS datasets in ArcGIS Geodatabase
- CADD data
- Metadata
- ESRI GIS Product Install (Desktop)
- ArcSDE

DPW-WEB
- MS Internet Information Server (IIS)
- ArcIMS (map server)
- ArcIMS Administration Tools
- ArcIMS Metadata Server
- DER (Data Enterprise Repository) component

Installation of the software and hardware components proceeded with few problems. Sample GIS data was loaded from the Environmental Division office, the Cultural Resources Management Team, the Natural Resources Branch, and the Integrated Training Area Management office.

Task 2: Develop a website to retrieve and link to the DER the downloaded data from the remote instrument platforms in the House Creek and Owl Creek watersheds

Instrument Platform Description

The instrument platforms located on House Creek and Owl Creek at Fort Hood were installed in 1998. These two platforms collect weather and stream data to be used in watershed modeling intended to analyze the impact of training activity on erosion, soil moisture, flood control and other factors relating to watershed management (Smith and Leipnik 2001). The platforms consist of Forest Technology Systems remote telemeter weather stations that have been further modified to accept stream level, turbidity, and soil moisture sensors (Leipnik 2001). The weather station instruments include an anemometer, wind direction sensor, humidity and temperature sensor, a tipping bucket rain gauge, and a ponderosa

pine fuel stick. The weather station instruments are mounted on a 4-ft by 4-ft by 5-ft (1.22-m by 1.22-m by 1.52-m) steel enclosure with a watertight door. The enclosure was designed to be bullet proof and is set in concrete for added support. Also attached to the enclosure is a 20-ft (6.1-m) mast supporting a cell phone antenna and a solar panel. Contained with in the enclosure is a Forest Technology Systems data logger, a deep cycle battery, a voltage regulator, a cell phone modem, and a Motorola cell phone. The stream level, turbidity, and soil moisture sensors consist of a bubbler-based water level sensor manufactured by Hydrologic Services of Australia, a laser backscattering-based turbidity sensor from McVan industries of Australia, and Gro-point dielectric constant soil moisture sensors. The sensors record data at 10-minute intervals; the data are stored in the data logger.

Collected data

The data collected by the instrument platform includes soil moisture in volumetric content over a range of 8 to 48 percent, stream level, turbidity, rainfall, temperature, relative humidity, fuel stick temperature, fuel stick relative humidity, wind speed, and wind direction (Leipnik 2001). Derived indices include hourly precipitation and 24-hour precipitation, as well as maximum and minimum 24-hour figures for all meteorological parameters (Leipnik 2001).

Data retrieval and DER website link

Due to Department of Information Management (DOIM) Security Protocols at Fort Hood, computers connected to the Fort Hood network cannot utilize cell phone communication to retrieve the data collected by the instrument platforms.

Since only a cell phone could be used to contact the stations, this activity was carried out by TRIES. The data was retrieved daily from the instrument platforms via a cell phone call from TRIES at Sam Houston State University. Once retrieved, the data were manually exported to a Microsoft Access database file format, which was then posted to a web site at Sam Houston State University. Fort Hood personnel could then access the web site and download the data to the DER.

Problems encountered

The development of the procedure to retrieve the data and website to display the data was completed successfully, but there were two persistent problems that plagued this activity. The first problem was that the instrument platforms were frequently breaking down and couldn't be repaired in a timely manner. This

caused an interruption in data collection. Just as frequently the TRIES website was non-functional due to system administration problems at Sam Houston State University. Since both the maintenance of the instrument platforms and administration of the website were beyond the control of this project a solution to these problems could not be effected.

Figures 2 through 5 show some of the instrumentation on the instrument platform at House Creek. An identical instrument platform is in operation at Owl Creek.

Figure 2. Enclosure and weather station instrumentation at House Creek.

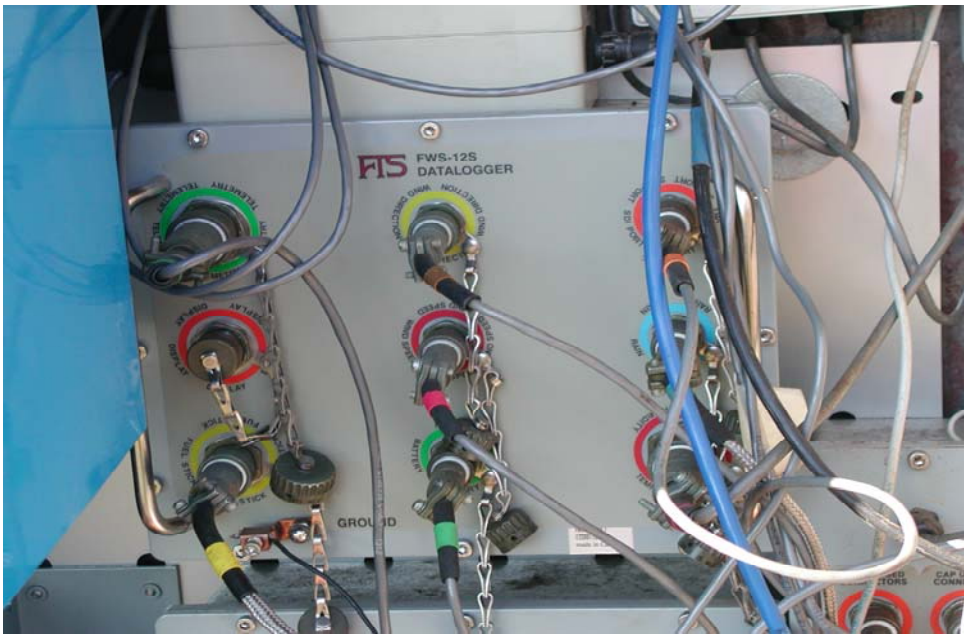

Figure 3. The FTS FWS-12S datalogger.

Figure 4. A soil tensiometer.

Figure 5. Enclosure for stream sensors.

Task 3: Develop a User's Manual for management and administration of DER

Task 3 required linking of documentation developed by Dr. Gary Smith at TRIES and Dr. Marilyn Ruiz of the University of Illinois. Dr. Ruiz was retained for this purpose because she had extensive experience in the implementation of GIS enterprise systems. The resulting document entitled "Data Management Plan & User Documentation for the Data Enterprise Repository" was developed in a web page format so it could be posted on the Fort Hood Intranet making it easily accessible to users and the DER administrator.

3 Recommendations and Conclusion

Instrument Platform Maintenance and Data Upload Problems

To keep the instruments operating and reporting in a continuous manner it is recommended that ongoing maintenance of the platforms be transferred to Fort Hood personnel or an onsite contractor that can respond and fix a malfunctioning instrument with in a 24-hour period. To accomplish this it is suggested that an automatic notification system be incorporated into the instrument platform that will notify Fort Hood personnel or an independent contractor of instrument failure. The maintenance team could then respond to the problem immediately. Additionally, an automatic notification system should be incorporated into the download and checking of daily data retrieval to ensure that the data being collected is within specified parameters. This system will notify maintenance personnel if the instruments are out of calibration and need recalibration. Modeling efforts that rely on this data require that it be collected in a continuous and uninterrupted fashion with a minimum of down time.

It is further recommended that the cell phone connection to the House Creek and Owl Creek instrument platforms be replaced with C-lines (standard land-based phone lines). This will comply with DOIM security protocols for a Fort Hood network computer to communicate directly with the instrument platforms, since a cell phone will not be used. Data could then be uploaded from the Fort Hood network computer eliminating the need for reliance on the TRIES website.

Continuing the Administration of the DER

At the completion of this project, the DER was implemented with a GIS sample data set from four Fort Hood Offices. The data set was accompanied by an online data management plan with user documentation. However, obstacles remained that needed to be addressed before the DER could be effectively used. There was a question of whether or not to convert all the engineering data, which was in CADD format, to ESRI's GIS format. The ESRI GIS format can accomplish the majority of data manipulation requirements that CADD systems offer. The DER was developed using the ESRI GIS data format rather than the CADD format because it offered the greatest level of cross platform use compati-

bility. Trying to accommodate both data formats was problem prone. Therefore it is suggested that all data in CADD format be converted to ESRI GIS format.

Also, of issue was the ongoing administration and maintenance of the DER software and hardware and the coordination of data quality control and uploading data into the DER. It is recommended that Fort Hood hire a full-time GIS database administrator to centralize the control of these activities. Having the GIS stakeholders from each of Fort Hood's offices responsible for these activities in a piecemeal fashion could lead to a lapse in system maintenance, especially during times when employees leave positions of responsibility. In addition, the level of understanding and oversight required would be more efficiently handled by a single individual.

Conclusion

Fort Hood is in an excellent position to move forward with Enterprise GIS, but administrative/management issues need to be resolved. In the short term, to keep the DER functioning properly, software support should not be allowed to lapse. This requires that funding be maintained for this purpose. At the conclusion of this project no funding had been identified for this purpose. In the longer term, the recently established GIS Process Action Team (PAT) is positioned to help to overcome current institutional issues that confront the introduction of any new technology and approach to daily work. From a technology perspective, the options are available today. Fort Hood needs to continue to build on its existing data, technology, and personnel structure to fully achieve an enterprise GIS solution.

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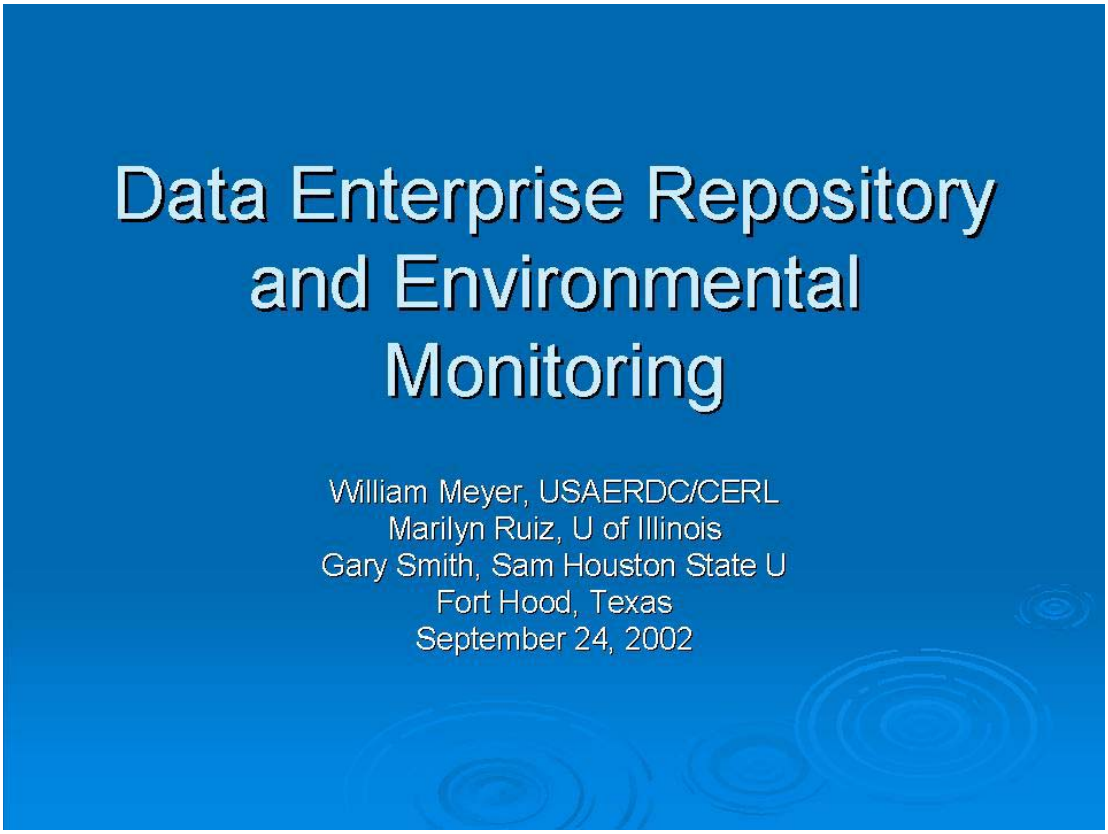
Appendix: DER Final Presentation



Overview of the Presentation

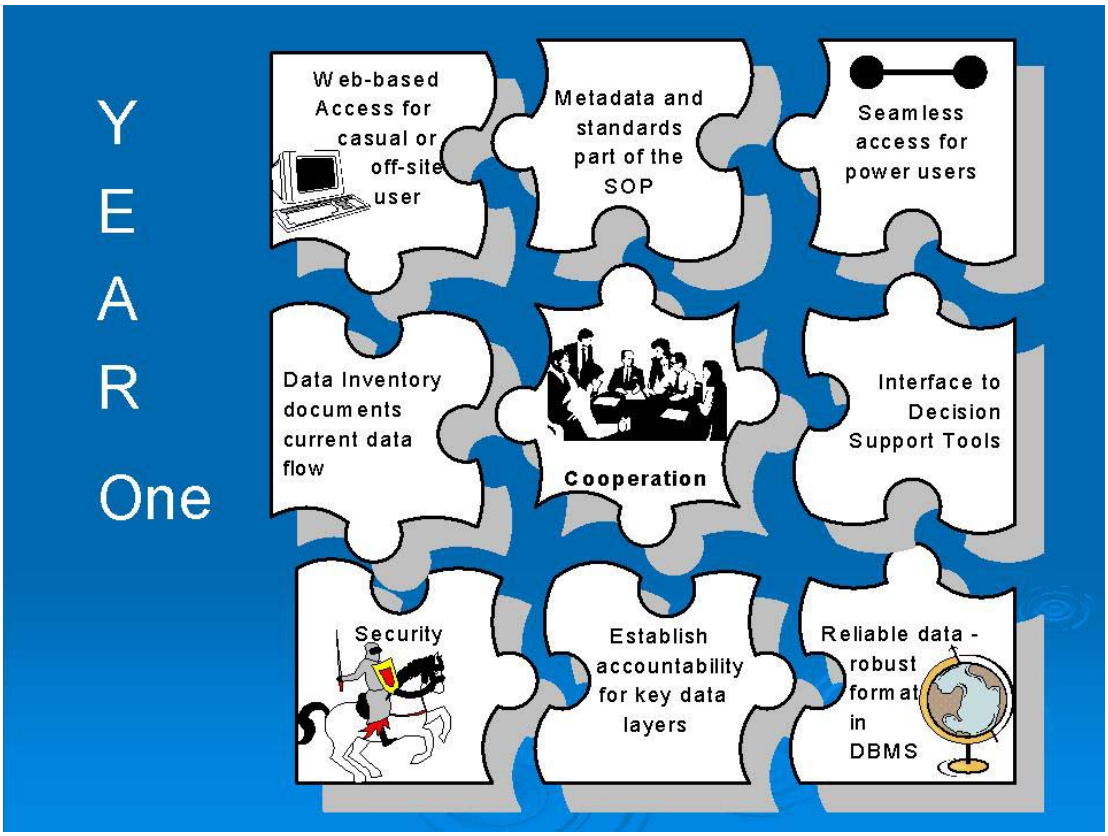
- Background – some history of the Data Enterprise Repository (DER), the Land Management System and environmental monitoring at Fort Hood
- State of things today
- Some thoughts about the future

Research Context for the Data Enterprise Repository

- Information technology was moving toward web-based applications with more centralized databases.
- In GIS → Enterprise GIS and tighter integration of GIS with IT, in general
- Options for application development and GIS implementation needed to be examined and assessed
- How might these things be realized in a "real life" application?

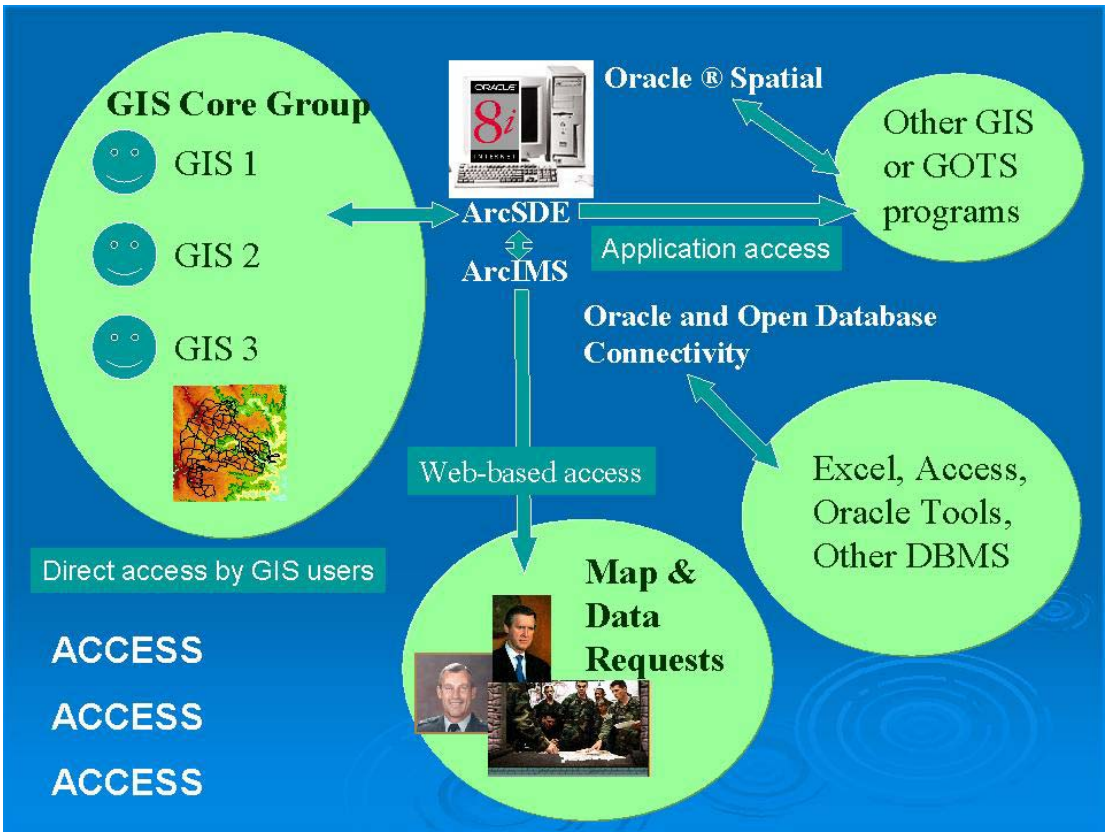
DER Objectives

- Deposit, archive, access and resource management data at local level
- Improve data quality and reusability through standardization, consistent management practices and creation of metadata
- Make data available to enterprise applications through a documented framework from which to access the data
- Emphasis on natural and cultural resource data, rather then CAD engineering and facilities data



Accountable Parties – Groups that Create, Contract or Otherwise Obtain Spatial Data for Fort Hood

- ENV – The Environmental Division of the DPW.
- NRB – The Natural Resource Branch of the Environmental Division, including The Nature Conservancy, which is under contract to the NRB
- CR – Cultural Resources Team in the Environmental Division
- ENG – The Engineering Division of the DPW
- ITAM – The office of the Integrated Training Area Management program
- G-3 – Range Safety Office/Range Engineering Office



More Recent History

- Congressional funding requirements bogged down the delivery and use of funds for the DER
- LMS field application progressed without the full DER implementation (timing of funding) using a prototype system at TRIES and CHL
- Field equipment installation and data collection plagued by problems: drought, rodents, vandals, you name it

Current Status - DER

- GIS data inventory was performed and summarized
- Documentation of DER prototype
- Data Enterprise Repository hardware and software framework are in place
- An initial set of data are available using the framework
- A web-based interface for map viewing is installed at Fort Hood
- The DER group has been involved with the GIS Process Action Team, which was set up to plan a solution to the ongoing issue of the institutional/management side of enterprise GIS

Current Status - Environmental Monitoring and Modeling

- Demonstration of soil moisture mapping from field and GIS data
- Field equipment simplified (one less watershed) and data stream starting, with website for data posting
- Soil moisture model has been calibrated for Fort Hood and is available at Coastal and Hydraulics Lab in Vicksburg

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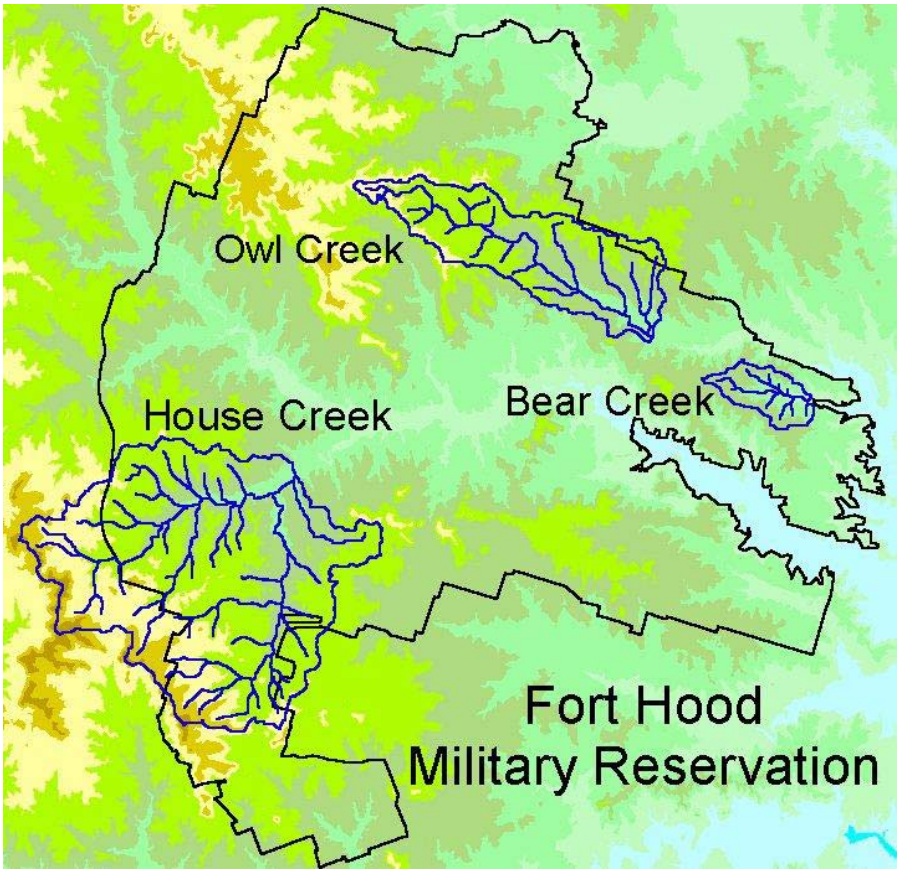


Software Investment
$74,102

- Enterprise GIS $27,582
  - ArcGIS $6582
  - ArcSDE 5 connects $15,000
  - ArcIMS $6000
- Oracle $45,400
- RemSoft $1120
  - BEHAVE
  - Weather Pro 3

Equipment/Hardware
$115,000

- Approximately 20 pieces of equipment to monitor soil moisture, water characteristics, and weather at Owl and House Creek
- Replacement cost about $105,000
- Computers on-site $10,000

Planning and Implementation Costs $118,000

- Install and tune Oracle, SDE, IMS, and ArcGIS - $15,000
- Field equipment planning and set up - $78,000
- Data inventory, needs assessment, consulting – approx. $25,000

Today's Status Overview

- Over $300,000 investment (conservative estimate, not including research costs) in the existing framework
- Impetus from the PAT for enterprise GIS amidst on-going need for consolidation of GIS effort
- Weather, soil and water sensors require on-going maintenance
- Cell phone bill for stations paid through September 2003
- Software requires maintenance and system administration
- CERL is consolidating detailed information about the DER and monitoring stations for Fort Hood

Increased Headquarters Guidance on Enterprise GIS

- For installations, HQDA has provided guidance for GIS implementation.
  - "Army GIS programs and offices must take steps to establish integrated GIS data and systems on installations to allow for sharing across functional areas..."
  - Federal Geographic Data Committee Content Standards for metadata
  - Avoid wasteful duplication
  - Use Spatial Data Standards for Facilities, Infrastructure and Environment

Recommendations Enterprise GIS

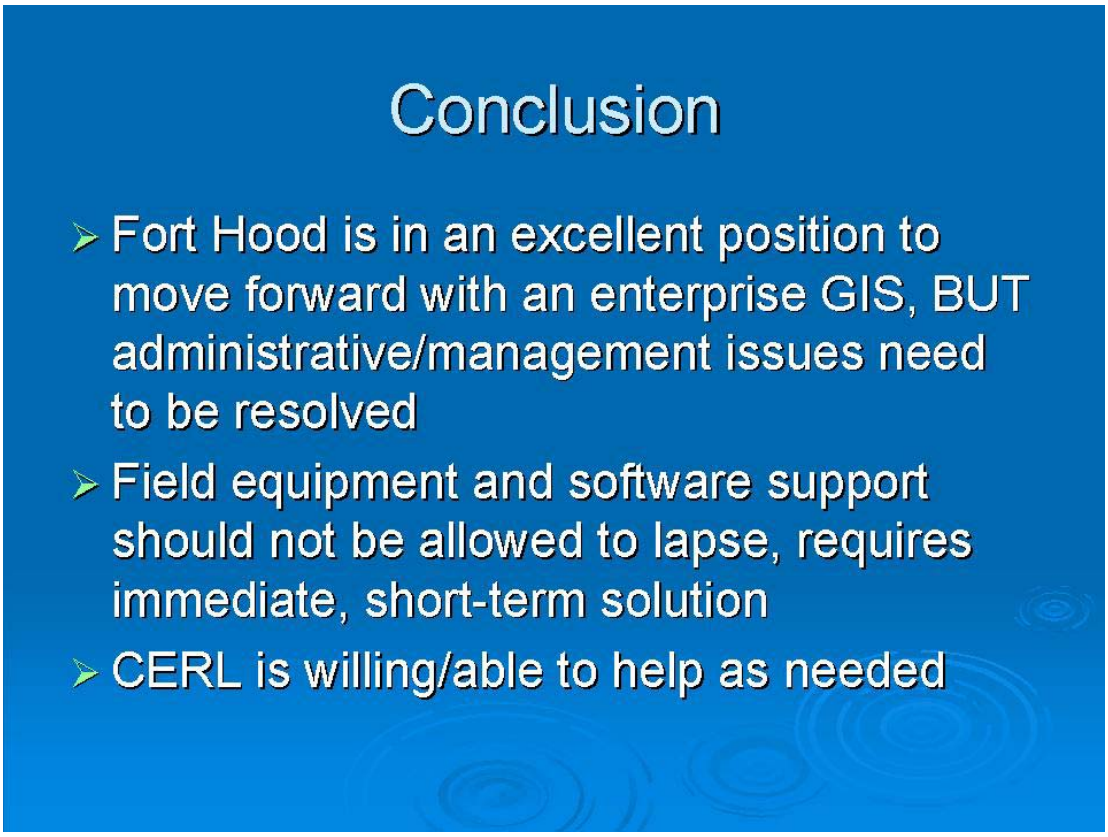
- Choose a single software platform for all CAD/GIS functions. Recommend ESRI.
  - in line with other DoD installations
  - capitalize on existing investment
  - better focus for maintenance, training and establishment of expertise on-post
- Need a full-time on-post GIS coordinator
  - Approximate salary $45-$55,000
  - Duties must focus on management, training, coordination. NOT responsible to "making maps"
- Exact requirements for additional geo-spatial personnel needs to be evaluated, but might include an additional 3 to 5 people

Recommendations Enterprise GIS

- Higher level support to bridge gaps among divisions, e.g. Garrison Commander
- Contract to
  - Get CAD files into ESRI format
  - Make files compliant with Spatial Data Standards
- Need annual maintenance on ArcSDE and ArcIMS immediately, approx $3000. Oracle annual maintenance due in April 2003, approx $6000
- CERL/TRIES support is ended. No system administration currently ongoing

Recommendations Monitoring

- TRIES support ends at end of September
- Equipment requires maintenance and periodic site visits
- Possible linkage with Coastal Hydraulics Laboratory for continued support for soil moisture modeling


Conclusion
Fort Hood is in an excellent position to move forward with an enterprise GIS, BUT administrative/management issues need to be resolved
Field equipment and software support should not be allowed to lapse, requires immediate, short-term solution
CERL is willing/able to help as needed

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14. ABSTRACT

In 1998, the Engineer Research and Development Center's Construction Engineering Research Laboratory (ERDC/CERL) was tasked with evaluating options for an enterprise Geographic Information System (GIS) solution at a military installation. The goals of the evaluation were to determine a technical solution that would use commercial software to support both the daily GIS requirements of the installation as well as spatial modeling efforts. Fort Hood, Texas, was selected as a field site due to the mature GIS usage at the installation and the willingness of key personnel to cooperate in the project.

In late September of 2001 the Natural Resources Branch at Fort Hood, Texas, funded the operational implementation of the Data Enterprise Repository (DER). This report documents the implementation efforts and the lessons learned throughout the process. The report concludes with a summary of the current status of the implementation, and provides recommendations on future directions.

15. SUBJECT TERMS
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