



SITE Technology Capsule

GIS\Key™ Environmental Data Management System

Introduction

In 1980, the U.S. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), known as Superfund, which is committed to protecting human health and the environment from uncontrolled hazardous waste sites. CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) in 1987 —amendments that emphasize the achievement of long-term effectiveness and permanence of remedies at Superfund sites. SARA mandates implementing permanent solutions and using alternative treatment technologies or resource recovery technologies, to the maximum extent possible, to clean up hazardous waste sites.

State and federal agencies, as well as private parties, are now exploring a growing number of innovative technologies for treating hazardous wastes. The sites on the National Priorities List total over 1,200 and comprise a broad spectrum of physical, chemical, and environmental conditions requiring varying types of remediation. The U.S. Environmental Protection Agency (EPA) has focused on policy, technical, and informational issues related to exploring and applying new technologies applicable to Superfund sites. One such initiative is EPA's Superfund Innovative Technology Evaluation (SITE) program, which was established to accelerate development, demonstration, and use of innovative technologies used to perform or support site remediations and related issues. The GIS\Key™ Environmental Data Management System was selected for SITE testing to assess its ability to provide useful and effective information to aid in site investigations and remedial activities. The evaluation occurred between April and December 1993. The specific objectives of the evaluation were to:

- Determine if the software performs the functions that are claimed by the developer

- Assess the accuracy of the GIS\Key™ output and review GIS\Key™ procedures used to ensure data integrity
- Review the general usability of GIS\Key™
- Compare GIS\Key™ features to user requirements

These capsules are designed to help EPA remedial project managers, EPA on-scene coordinators, contractors, and other site cleanup managers understand the types of data and site characteristics needed to evaluate whether a technology can be effectively employed at Superfund sites.

Abstract

GIS\Key™ is a custom-developed software system for the management of site-specific chemical, geologic, and hydrologic data. This software system, which is being used at a number of hazardous waste and Superfund sites, was selected for SITE testing to assess whether it truly facilitates the collection, reporting, and analysis of large volumes of site-specific environmental data. During the SITE evaluation, operators used GIS\Key™ to assess the production of a variety of contour maps, tabular chemistry reports, geology tables, hydrogeologic tables, geologic logs, and chemistry and hydrogeology graphs. The system's user-friendly design, compatibility with 386 and 486 personal computers using Disk Operating System (DOS), one-time data entry requirements, and built-in data quality checks contributed to the positive assessment of the software's performance.

Software Description

GIS\Key™ is an integrated system for the management of chemical, geologic, and hydrologic data developed by GIS\Solutions, Inc. of Concord, California. The software is designed to meet the needs of industry and to satisfy RCRA and CERCLA reporting requirements. GIS\Key™ integrates several commercial off-the-shelf



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products (e.g., AutoCAD®, FoxBASE™, and QuickSurf™) to produce a variety of site-specific tables, graphs, and maps, thereby facilitating the collection, reporting, and analysis of site management data. GIS\Key™ can be installed and used on 386 and 486 personal computers running DOS. The optimum hardware configuration for running GIS\Key™ is listed in Table 1.

Table 1. Optimum Hardware Configuration for GIS\Key™ Release 1.1.2

Optimum Hardware Configuration

- 486-66 Motherboard with 256K Cache
- 16 Mb RAM
- 1.2 Gb SCSI Hard Drive
- 3.5" and 5.25" Floppy Drives
- 20" Monitor
- 101 Keyboard and Mouse/Digitizer
- SCSI Controller
- 250 Mb Tape Backup

Environmental data for a project — chemical, geological, and hydrological — is stored in the GIS\Key™ Database, which is a relational data management application implemented in FoxBASE™. The database is tied to the graphical component, GIS\Key™ Graphics, which is built using AutoCAD®. The GIS\Key™ graphical interface depicts wells and bore-holes on a map of the site. The user chooses a report from a menu, picks a location from the map, and then follows the prompts to create a variety of output. GIS\Key™ can prepare geologic cross sections, boring logs, potentiometric maps, isopleth maps, structure maps, summary tables, hydrographs, chemical time series graphs, and numerous other maps and line graphs. QuickSurf™ (Version 2.91), a third-party contouring program developed by Schrieber Instruments, is used to contour geology, hydrology, and chemistry data stored in GIS\Key™ Database.

Any AutoCAD® compatible digital basemaps can be imported into GIS\Key™. There are a number of vendors

who can provide general basemap data, usually based on the U.S. Geologic Survey (USGS) 7.5 minute quadrangle maps. Additionally, users usually import specific project map data (i.e., RCRA facility and CERCLA sites) which provide greater detail and resolution necessary for comprehensive studies. With GIS\Key™, users add graphic points representing wells, borings, and sampling locations onto this basemap. GIS\Key™ provides the ability to verify the entered chemical, geologic or hydrologic information and "tie" this information to specific graphic points placed on the basemap.

Data can be entered into the GIS\Key™ Database either manually or electronically. Existing databases can be converted into GIS\Key™ format and laboratory reports on magnetic media can be directly imported. Pull-down menus, data entry forms, and look-up lists for frequently used values aid manual data entry. The lists store such information as EPA test methods, practical quantification limits, Chemical Abstract Service (CAS) numbers, chemical aliases, and regulatory threshold values for over 3,500 chemicals.

GIS\Key™ includes features that help the user identify erroneous or questionable data. Data validation routines include graphical display of summary statistics and user alerts when QA/QC results fall outside data quality objectives, sample results fall outside historical ranges, sample results exceed applicable regulatory standards, and ionic balances fall outside data quality objectives.

A list of GIS\Key™ chemical, geologic, and hydrologic products that GIS\Key™ provides is shown in Table 2. A brief description of the types of tables, contour maps, and graphs provided by GIS\Key™ are shown in Table 3.

Software Applicability

GIS\Key™ is designed to facilitate the collection and analysis of site management data at Superfund and other hazardous wastes sites. Based on its performance during the evaluation, GIS\Key™ can be used to characterize a

Table 2. GIS\Key™ Products

<i>Chemistry</i>	<i>Geology</i>	<i>Hydrology</i>
• Isopleth maps of soil or water quality-plan section view	• Boring logs with company logos	• Density-corrected water level contour maps
• Chemical concentration time series graphs	• Geologic cross-section maps	• Floating product contour maps
• Chemical versus chemical graphs, inter- and intra-well	• Isopach maps	• Hydraulic conductivity contour maps
• Trilinear Piper diagrams	• Structure maps	• Water elevation versus time graphs
• Chemical concentration versus distance graphs	• Presentation-quality data tables	• Floating product thickness versus time graphs
• Presentation-quality data tables		• Extraction well graphs -flow versus time -concentration versus time -chemical flux versus time
		• Presentation-quality data tables

Table 3. Types of GIS\Key™ Tables, Contour Maps, and Graphs

<i>Tables</i>	<i>Contour Maps</i>	<i>Graphs</i>
<i>Chemistry</i>	<i>Hydrogeologic:</i>	<i>Chemistry:</i>
<i>Geology - well construction and borehole summary tables</i>	- fluid level elevation (water table contour maps)	- concentration vs. time
<i>Hydrogeologic - flow data and fluid level</i>	- fluid level elevation (potentiometric surface maps)	- chemical vs. chemical
<i>Geologic Logs - well and borehole logs</i>	- equivalent freshwater head	- site vs. site
	- hydraulic conductivity	- distance concentration
	- specific storage	- statistics
	- specific yield	- depth vs constituent
	<i>Chemical Concentration Isopleths:</i>	- trilinear pipers
	- plan view isopleths	<i>Hydrology:</i>
	- section view isopleths	- hydrograph
	<i>Geologic Structure Elevation:</i>	- flow rate
	- geologic formations	- cumulative flow
	- blow counts	- flux rate
	- soil units	- cumulative flux
	- other units	- floater thickness
	<i>Geologic Structure Thickness Isopach</i>	- sinker thickness

variety of sites containing soil and/or groundwater contamination. Since GIS\Key™ is capable of efficiently and accurately processing a large volume of data, it is particularly useful during site investigations and remedial activities at larger sites. The various tables, graphs, and maps generated by GIS\Key™ can be used to produce reports meeting CERCLA and RCRA reporting requirements. These products can also be used to develop and maintain groundwater monitoring programs, to help determine the location of future monitoring wells, and to evaluate contaminated groundwater movement during the design of any landfill, holding or disposal pond, or reclamation project. Depending on site- and project-specific data requirements and availability, GIS\Key™ can be used to process both current and historical data. The system does not provide a means for managing ecological assessments or air pollutant data.

Software Benefits and Limitations

During the SITE evaluation of GIS\Key™, a number of software benefits and limitations were identified. A brief list of these benefits and limitations is presented in Table 4.

Performance Data

During the evaluation, emphasis was placed on evaluating the system's performance with respect to ease of use, system requirements, personnel requirements, data entry and database creating procedures, data integrity procedures, and electronic data exchange capabilities. The steps used to evaluate GIS\Key™ mirrored, in some respects, the guidance developed by the USGS for evaluating geographic information system (GIS) products. Emphasis was placed on analyzing several procedures and capabilities common to GIS\Key™ chemistry, geology, and hydrology modules. Ultimately, the evaluation sought

to determine how well the various procedures and capabilities associated with GIS\Key™ performed during collection, reporting, and analysis of a set of site management data. Two analysts, experienced in GIS and environmental database management performed the evaluation.

The evaluation found that GIS\Key™ is an effective way to prepare the wide variety of contour maps, graphs, tables, and site maps required at a typical hazardous waste site. These products were generated without encountering any major problems. GIS\Key™ uses commercial off-the-shelf components (i.e., AutoCAD® graphics and FoxBASE™ database), so numerous third-party database tools are available to create queries and report formats not included with GIS\Key™. The system can be a cost-effective, time-saving method for managing large volumes of environmental data. A number of issues relating to the general useability of GIS\Key™ were addressed during the generation of the various GIS\Key™ products. The following subsections address the various functions and capabilities which were assessed. This information is also summarized in Table 5.

New Project Setup

It was relatively easy to set up a new project, a project directory structure, and a project basemap during the evaluation. However, since all the project directories must be on the same drive as the GIS\Key™ directory, mass storage difficulties can arise as project files grow.

Map Management

Standard AutoCAD® drawing files are used for all GIS\Key™ basemaps. The utilities provided for the addition and editing of map symbols were tested and no problems were encountered. During the generation of the project basemap, the basemap and symbols were

Table 4. Benefits and Limitations

Benefits	Limitations
<ul style="list-style-type: none">• GIS\Key™ is a turnkey data management system, with chemistry, geology, and hydrology capabilities• GIS\Key™ produces presentation quality graphics, in a wide variety of output formats• Specialized or advanced computer skills are not needed to routinely use GIS\Key™• GIS\Key™ reviews chemical laboratory QC data, generates exception reports, and marks sample locations on the project basemap which contain data outside of the QC objectives• GIS\Key™ uses industry standard file formats for data storage, facilitating the exchange of GIS\Key™ data with other applications (i.e., third-party software)• GIS\Key™ stores data in a unified database that provides several validity and consistency checks• GIS\Key™ relates data across data categories, improving report and map consistency• Data can be analyzed interactively; users can modify their assumptions, views, and queries• GIS\Key™ provides graphic editing capabilities through AutoCAD®, a well-known design application• Duplication of effort is minimized due to one-time data entry and a variety of predefined routines and queries; easy, menu-driven routines simplify complex tasks (i.e., generating contours)• GIS\Key™ runs on standard DOS PCs and on local area networks• GIS\Key™ stand-alone data entry modules can be purchased separately at a reduced cost• Reference lists are provided (i.e., regulatory thresholds and chemical names, aliases, and registry nos.)• GIS\Solutions operates a bulletin board (e.g., to exchange files) and provides personnel for call-in support routines	<ul style="list-style-type: none">• GIS\Key™ does not manage ecological assessment or air emission data• Specialized AutoCAD® and database management system skills are required to make full use of GIS\Key™• Printed report formats are relatively inflexible; general report-writing powers are not provided• Basemap integrity is vulnerable; improperly used AutoCAD® commands can delete sample locations and destroy map and database links, causing map and database inconsistencies• Database integrity is vulnerable; invalid or inconsistent data can be entered into the database (water data for a borehole), causing query anomalies• GIS\Key™ performs predefined database queries; third-party tools are needed for ad hoc queries• GIS\Key™ is limited to post-project data analysis only; no planning capabilities are provided• Data storage limitations constrain the entry of location data, well construction and log information, and QA/QC data• GIS\Key™ does not include audit or transaction logging capabilities• Circles, irregular shapes, and spatial operators cannot be used to select sample locations; polygon operations are not supported• Database structure documentation is incomplete, limiting the usefulness of electronic data transfer operations

Table 5. Performance Summary

Element/Function Evaluated	Performance
New project setup	<ul style="list-style-type: none"> • it was relatively easy to set up a new project, a project directory tree structure, and a project basemap
Map management	<ul style="list-style-type: none"> • mass storage difficulties may arise as project files grow • no problems were encountered during the addition or editing of map symbols using the utilities • during the set up of a new project basemap, the basemap and map symbols were digitized with satisfactory accuracy using two methods
Data entry screens - geological, chemical, and hydrogeological	<ul style="list-style-type: none"> • provide several time saving features, including dynamic look-up lists and quick return to the most recent item accessed • defaults are provided by GIS\Key™ for several fields
Data import routines	<ul style="list-style-type: none"> • on-line help is not available during data entry • can input data in a wide array of formats • allows for downloading of laboratory data
Data integrity checks	<ul style="list-style-type: none"> • instructions are available to help the laboratory prepare a import file • performs some data quality checks on key fields for consistency and reasonableness as part of the data entry screens
Data validation	<ul style="list-style-type: none"> • third-party data management tools are needed to prepare data files for GIS\Key™ import routines and for data quality checks beyond those included with GIS\Key™ • tracks significant figures • compares QA/QC laboratory results to user-defined QC objectives for method and field blanks, duplicates, splits, matrix spikes, control samples, surrogates, and holding times, • checks ionic balances, and checks for concentrations outside of historical ranges or in excess of action levels • reports automatically generated outlining exceptions to project data quality objectives
Data queries	<ul style="list-style-type: none"> • seven data validation fields are available • one of the most powerful and often used tools available to the user • can perform both spatial and non-spatial queries <ul style="list-style-type: none"> - spatial data retrieval capabilities use standard AutoCAD® commands - GIS\Key™ symbol lists (i.e., user-defined subsets of frequently used sample locations) are used to simplify AutoCAD® spatial data selection
Contouring - geology, hydrology, and chemistry data	<ul style="list-style-type: none"> • carried out by QuickSurf™ (version 2.91), a third-party software application integrated with GIS\Key™ • the QuickSurf™ algorithm works well for surfaces which are continuous with respect to slope and curvature (first and second derivatives) — but may not truly represent surfaces which contain breaks or faults
Calculations	<ul style="list-style-type: none"> • performed well during the editing of posted values and the adding of control points • during the entry of flow rate, fluid level, and QC data, GIS\Key™ automatically performs specific calculations (average flow rate, cumulative flow, spike percent recoveries, and matrix spike duplicate relative percent differences) • calculates areas, perimeters, and lengths using standard AutoCAD® commands; volume calculations are supported through Quicksurf™
Products	<ul style="list-style-type: none"> • can export to EPA GRITS/STAT to perform advanced statistical functions • can effectively produce a variety of high quality products (i.e., contour maps, tabular chemistry reports, geology tables, hydrogeologic tables, geologic logs, and chemistry and hydrology graphs) • standard product formats are available; however, they can be custom tailored by GIS\Solutions or by the user using third-party software
Hardware configurations	<ul style="list-style-type: none"> • performed all its functions on PC class systems in the DOS environment • works quickly and presents few hardware problems using the optimum system configuration; based on timing results the optimum hardware configuration should be used to achieve worker efficiency
Project planning	<ul style="list-style-type: none"> • determining how to manage the data being generated is a major challenge • codes and lists must be defined to categorize project data (sampling events, preparation fractions, program types) for storage and retrieval • list and code, organize or group related data and simplify data entry • update and query anomalies can be avoided by using a data management perspective and third-party software to manage codes
Training	<ul style="list-style-type: none"> • basic and advanced training is available covering AutoCAD® and a detailed walk-through of GIS\Key™ capabilities • users are guided through the creation of GIS\Key™ outputs
Documentation and support services	<ul style="list-style-type: none"> • well presented but needs additional emphasis on project planning and setup • the user guide is well prepared and adequately covers the system's modules and activities • does not represent some changes that have occurred with new software versions
User requirements	<ul style="list-style-type: none"> • helpful and readily available call-in support is offered • general users do not need specialized computer skills or advanced GIS\Key™ training to operate the software • project administrators need advanced database/data management skills and computer skills to be able to perform some of the more advanced project setup and maintenance tasks
Software operability or "user friendliness"	<ul style="list-style-type: none"> • in general, GIS\Key™'s user interface is well organized and easy to operate • User friendliness is due in part to functions that can usually be selected from pull-down or pop-up menus; prompts displaying default answers are usually available • the menu guide the user through complex data manipulation and display steps

digitized using two methods. Satisfactory accuracy of the coordinates of map symbols was obtained.

Data Entry Screens

Data entry screens are available for geological, chemical, and hydrogeological data processed by GIS\Key™. These screens provide several time-saving features, including dynamic look-up lists and quick return to the most recent item accessed. Defaults are provided by GIS\Key™ for several fields, simplifying the entry of sequential data. On-line help is not available during data entry.

Data Import Routines

Electronic import routines allow the import of data from several standard formats. A separate program is available to facilitate import of electronic laboratory data. Staff with database management expertise is needed for data import; laboratory data requires pre-processing following instructions from GIS\Solutions and the user is responsible for data integrity and consistency when other types of data are imported.

Data Integrity Checks

GIS\Key™ performs some data quality checks for consistency and reasonableness as part of the data entry screens and data import routines on key fields and selected attribute fields. Third-party data management tools are needed to prepare data files for GIS\Key™ import routines and for data integrity checks beyond those included with GIS\Key™. The system tracks the significant figures of all chemical concentrations and reporting limits.

Data Validation

GIS\Key™ can be used to compare QA/QC laboratory results to user-defined QC objectives. Reports are automatically generated outlining exceptions to project data quality objectives. Built-in routines are available to: identify chemical concentrations that fall outside historical ranges; identify concentrations in excess of action levels; check ionic balances; and compare QC results against QC objectives for method and field blanks, duplicates, splits, matrix spikes, control samples, surrogates, and holding times. Seven data validation fields are available to store data qualifiers reported by the lab or assigned by the user.

Data Queries

The ability of GIS\Key™ to query data is one of the most powerful and often-used tools available to the user. Data queries are prompt driven; therefore, knowledge of a data query language is not required. GIS\Key™ spatial data retrieval capabilities are limited to those provided by AutoCAD® (individual entity selection and rectangular selection windows). GIS\Key™ allows the user to save AutoCAD® selection sets by storing them in "symbol lists." These user-named "symbol lists" allow relevant entities to be quickly re-selected. "Symbol lists" must be created in advance and then manually maintained. An attribute of the system is the speed at which queries and postings can be made.

Contouring

Contouring geology, hydrology, and chemistry data is carried out by QuickSurf™ (Version 2.91), a third-party software package that is integrated with GIS\Key™. The

QuickSurf™ algorithm works well for surfaces that are continuous with respect to slope and curvature (first and second derivatives), but may not truly represent surfaces which contain breaks or faults. A number of structure maps were successfully constructed to test the effect of editing posted values and adding contour control points.

Calculations

During the entry of flow rate, fluid level, and QC data, GIS\Key™ automatically performs specific calculations (average flow rate, cumulative flow, spike percent recoveries, and matrix spike duplicate relative percent differences). GIS\Key™ calculates areas, perimeters, and lengths using standard AutoCAD® commands. Volume calculations are supported through Quicksurf™. GIS\Key™ can export data to the EPA Groundwater Information Tracking System/Statistics (GRITS/STAT) program for advanced statistical functions.

Products

GIS\Key™ provides an effective way to produce contour maps, tabular chemistry reports, geology tables, hydrogeologic tables, geologic logs, and chemistry and hydrogeology graphs. Standard formats are available from the software; however, it can be custom tailored by GIS\Solutions staff or by the user through third-party software. The products produced by the system are of high quality.

Hardware Configurations

GIS\Key™ performs its functions on standard PC class systems in the DOS environment. When using the optimum system proposed by GIS\Solutions, the system works quickly and presents few hardware problems.

Table 6 presents timing results for several processes on three different platform configurations. Although GIS\Key™ was able to perform all of its functions on a 386 class PC (4 Mb RAM), the timing results shown in Table 6 indicate that a more powerful processor and memory hardware configuration can be used to obtain higher efficiency.

Project Planning

One real challenge at any site is associated with determining how to manage the data being generated. Through proper project planning, GIS\Key™ can be used to define codes and lists to categorize project data (sampling events, preparation fractions, program types) for storage and retrieval. GIS\Key™ uses this information to organize or group related data and to simplify data entry. With a good data management perspective and the use of third-party software, these codes can be managed to avoid update and query anomalies.

Training

Users can obtain basic and advanced training. Training covers AutoCAD® and a detailed walk-through of GIS\Key™ capabilities. Users are guided through the creation of GIS\Key™ outputs. The training is well presented but needs additional emphasis on project planning and setup.

Documentation and Support Services

The User Guide is well-prepared and covers the system's modules and activities. It does not represent in all cases the changes that occurred as new versions of software were incorporated into GIS\Key™. The call-in

support offered was readily available and of great help in understanding issues.

User Requirements

GIS\Key™ users fall within two categories: general users and system administrators. General users are responsible for the day-to-day operation of the GIS\Key™ system (i.e., information retrieval) and do not need specialized computer skills to use the software. Project administrators, however, need advanced computer and database management skills to perform advanced project setup and maintenance tasks.

Software Operability or "User Friendliness"

In general, GIS\Key™'s user interface is well organized and easy to operate. This is due in part to the various menus, both graphical and text-based, employed by GIS\Key™. When working within GIS\Key™, functions can usually be selected from pull-down or pop-up menus. Prompts displaying default answers are usually available. GIS\Key™'s menu guide the user through complex data manipulation and display steps, making it possible for users without AutoCAD® experience to be able to prepare a site map, complete with a title block and border.

Software Status

GIS\Solutions, Inc. was organized in July 1990. GIS\Key™ was generated as part of a company wide effort to develop user-friendly software products which offer significant reductions in environmental compliance costs while improving the accuracy and quality of environmental data. The various chemical, geologic, and hydrogeologic modules which make up GIS\Key™ are sold to industry, environmental consultants, government, owners/operators, and regulatory agencies, directly and through distributors.

Technical services, such as software customization, can be obtained at the client's request. Technical support packages, such as annual software maintenance and GIS\Key™ training, are included in each software sale. Professional scientists, geologists, and engineers employed by GIS\Solutions are responsible for providing technical training and client support services.

Notice

This document has been subjected to EPA's peer and administrative reviews and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

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Table 6. Selected Processing Times

Process	Time		
	386-33/4MbRAM	486-33/8MbRAM	486-33/16MbRAM
load GIS\Key™	40 seconds	23 seconds	13 seconds
open a 1.9 Mb drawing	3 minutes 45 seconds	1 minute, 50 seconds	1 minute, 21 seconds
open a 322 Kb drawing	40 seconds	18 seconds	14 seconds
swap out to database	35 seconds	22 seconds	2 seconds
plot 1.9 Mb drawing	14 minutes	NA	1 minute, 28 seconds
plot 322 Kb drawing	5 minutes	NA	1 minute, 22 seconds

NA - Not available

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