Environmental management with VULCAN

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Abstract

Effective environmental management can be a very demanding task. Understanding the environmental impact of any engineering project is an integral aspect of its assessment. Large amounts of information must be evaluated and incorporated into an acceptable model, understandable by all participants in the decision making process. Maptek's interactive 3D system – VULCAN – translates complex data from different sources into visual information. It's interactive modelling and visualization capabilities allow the effect of pollutants to be assessed, providing successful environmental solutions. The system provides efficient tools for data integration, analysis and communication, supporting an interactive, intuitive approach to meeting planning requirements and raising community awareness. VULCAN assimilates site assessment data in order to develop and visualize restoration strategies using 3D interactive graphics. The ability to evaluate and present all possible scenarios during planning and remediation exercises facilitates communication, ensuring optimum decision-making.

1 Introduction

Environmental management and planning requires the integration of large volumes of disparate information from many sources and the analysis of this information with efficient tools for assessment and evaluation. Effective methods of communication that allow interactive participation in the planning, assessment and decision-making processes are also very important.

The VULCAN software package from Maptek (Pty) Ltd comprises a large number of 3D graphical tools within an interactive 3D interface called

ENVISAGE. These tools are designed and developed to help engineers and scientists to identify and solve environmental problems. This paper presents the capabilities of this integrated system per application area for environmental management.

2 Site investigation and monitoring

Monitoring of water table levels, contamination, ventilation, bench movement, temperature and air pressure is necessary for effective site management. Time-varying point data collected automatically from site monitors or entered manually can be stored in a customised time series database for 3D viewing and validation (Fig. 1). The information can be displayed in 3D, either for a specific time or for a range of time periods. Information between recording periods can be interpolated using linear, least squares or spline interpolation techniques. VULCAN provides a monitoring history for both static and moving monitors.

Links to various statistics packages enable time series analysis to be performed. Surface and contour maps of different periods can be produced. Results are animated to highlight changes at the stations through time.
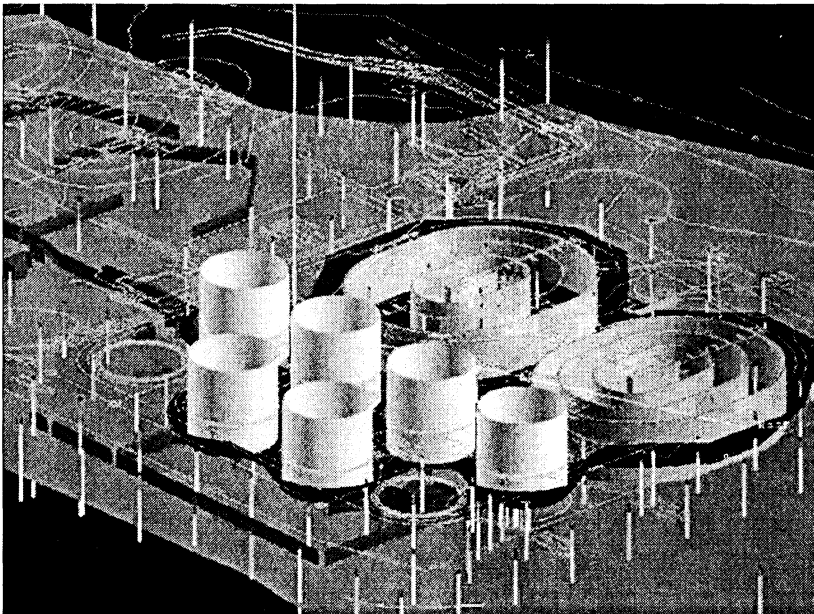

Figure 1: Site investigation data used to design in 3D for civil engineering work.

3 Pollution modelling and volumetrics

Resource assessment, hydrogeological studies, waste disposal and civil engineering projects benefit from accurate 3D interpretation. VULCAN's interactive modelling and visualisation capabilities allow the effect of the pollutants to be assessed, providing successful environmental solutions.

3D pollution models can be created using a number of methods such as trend analysis, kriging, 2D and 3D triangulations, and block models. VULCAN is able to analyse models and rapidly determine volumes, averages and totals of attributes associated with the models. Grid, triangulation, and block modelling techniques give the flexibility to solve different problems with the appropriate modelling method.

4 Rehabilitation and contamination control

Rehabilitation design involves a complex interplay of environmental, local and economic constraints. Remediation of contaminated sites makes an essential, positive contribution towards renewing the environment. Accurate rehabilitation design involves superimposing the re-graded working surface on the disturbed landscape to calculate the cut and fill required, and to produce the final topography.

VULCAN assimilates site assessment data in order to develop and visualise restoration strategies using 3D interactive graphics. VULCAN enables the engineer to:

- Display polygons and cut and fill between current and post-working surfaces, showing slope, aspect and drainage.
- Edit the view to smooth the surface, specify slope and aspect, adjusting the gradient to remove drainage pockets.

The tools provided with VULCAN can help optimise rehabilitation strategies to give the greatest benefit for the least cost.

5 Nuclear waste management

Safe disposal of nuclear waste material requires an accurate understanding of geological barriers surrounding a potential repository. Conceptual geological, geophysical and hydrogeological models are validated by analysing site investigation data in three-dimensional space and through time.

5.1 Data Integration

VULCAN permits the integration of data from a variety of sources: site characterisation data; formation and geological data; mapping, core logging and seismic data; and specialist radionuclide transport modelling codes. Flexible

design tools allow an underground waste repository to be modelled interactively, then validated against the geological, geophysical and hydrogeological data in 3D space and time (Fig. 2).
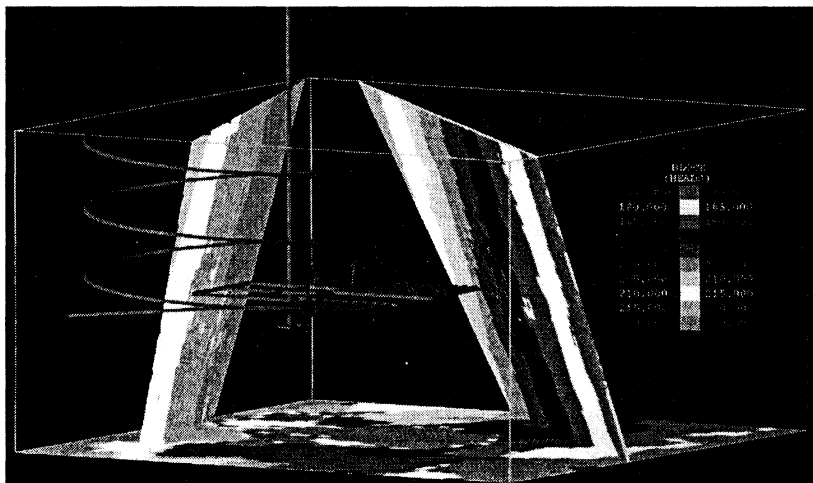

Figure 2: Groundwater head variation across a potential repository.

5.2 Interface to the modelling code

Hydro-test information can be incorporated to complete the site characterisation data set. Powerful block modelling and 3D surface mesh building capabilities combine to model complex geotechnical, geological and host-rock geometries (Fig. 3). Customised interfaces allow access to appropriate flow and transport modelling codes. For example, the Golder Associates' FracMan code enables fracture network meshes to be displayed and draped with head and transmissivity values [1]. Transport pathways can be viewed in relation to the fracture network and repository design, using animated time sequences.

5.3 Shaft Mapping

Shaft mapping data from demonstration rock laboratories can be captured in a shaft view and easily projected into the rock-volume space (Fig. 4). The shaft mapping facility allows the cylindrical view of the shaft to be unwrapped and presented on the computer screen. Features can be digitised and transformed to their true position in 3D space. This useful technique can be applied to both horizontal and vertical openings.
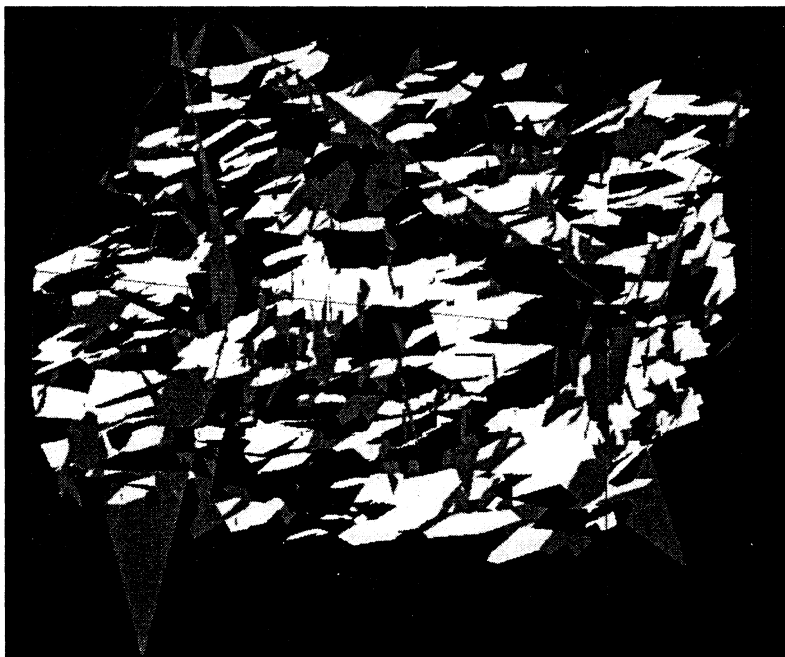
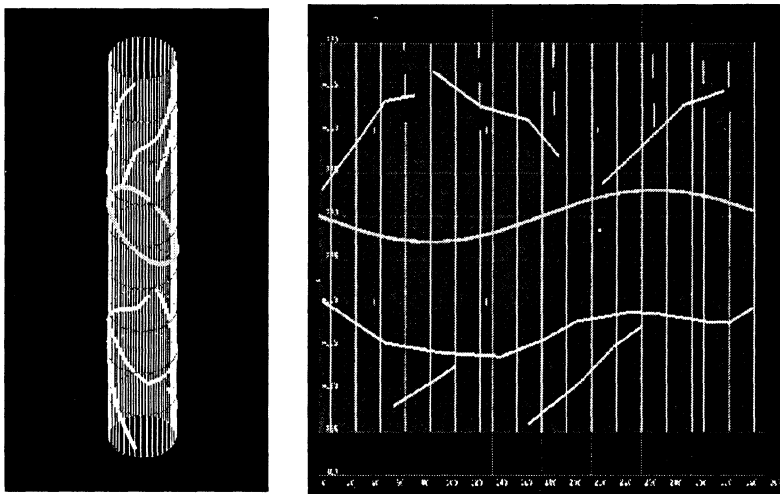Figure 3: Display and analysis of discrete fracture networks and faults.

Figure 4: Shaft view of shaft mapping data in ENVISAGE.

6 Groundwater analysis

The understanding of groundwater systems is a vital step in most environmental engineering projects, where this can be used to model contaminant pathways and to identify potential water resources. The development of conceptual hydrogeological models is usually based on the same geological information as used for geotechnical evaluation, site investigation and delineation of geological features.

VULCAN can incorporate observed hydrogeological data to interface to Modflow [2] and Aquifem-N flow codes, improving the accuracy and confidence of the groundwater evaluation process. The tools provided enable a number of modelling processes incorporated in the groundwater analysis. Specifically, VULCAN can perform the following tasks:

- Create graphical representations of conceptual hydrogeological models
- Display the extent and flow of aquifers in 2D and 3D (Fig. 5)
- Allow advective transport modelling of potentially hazardous pathways
- Integrate topographic, geological and survey information with hydrogeological data (Fig. 6)
- Support 3D finite difference and quasi 3D finite element codes
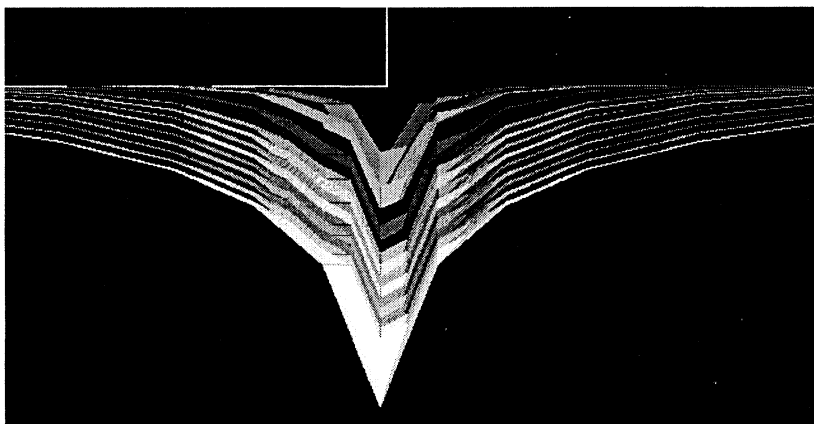

Figure 5: Section view of hydrogeological models from Modlow in ENVISAGE.

Presentation of groundwater modelling results within VULCAN allows easy comparisons of piezometric pressures and hydrographs (Fig. 7). Observed data can be recalled within predefined windows to simply evaluate model transient performance. Difference plots of water level data can assist with model calibration.
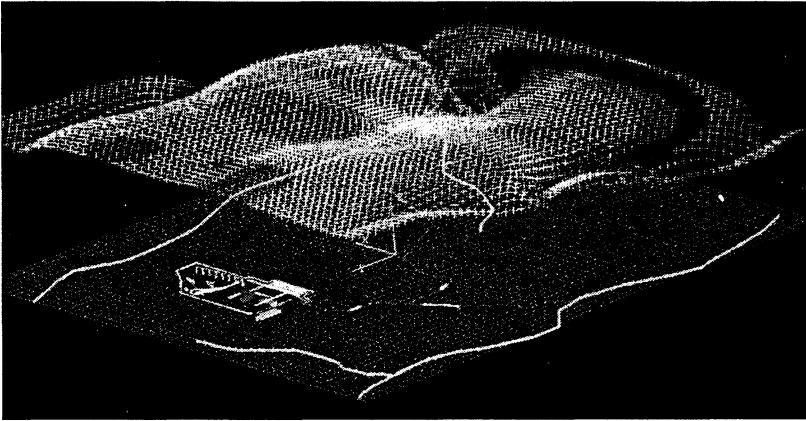
Figure 6: Finite difference mesh including surface mine design and cadastral
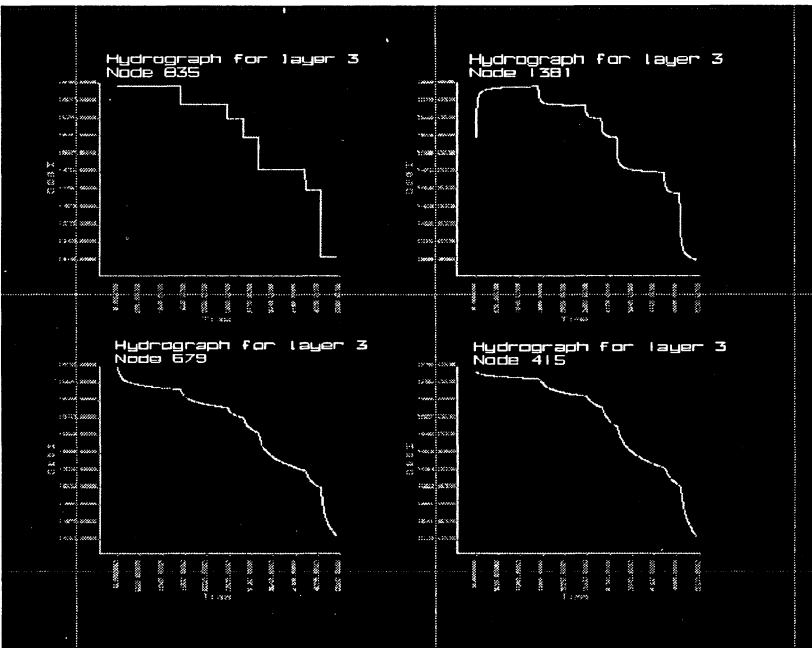information created from 3D aquifer model.

Figure 7: Multiple hydrographs produced and displayed in ENVISAGE.

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7 Visual impact studies

Visual impact assessment is another information-intensive task. Traditionally, computerised visualisation systems have had a terrain or an urban land-use focus. VULCAN can handle both surfaces and solids with accuracy. The visualisation module incorporates an advanced 3D mapping and animation environment with functions such as:

- Import and edit surface topography;
- Create and edit land-use features;
- Drape photographs over natural or rehabilitated terrain (Fig. 8);
- Change views with time as the project progresses;
- View and edit the development interactively from any location (Fig. 9).

The system allows the calculation of a 'zone of visual influence' as a series of radii from a point on a grid that can be contoured. The virtual reality features of the software enable walk throughs and flybys or animation sequences to be stored or saved to video.
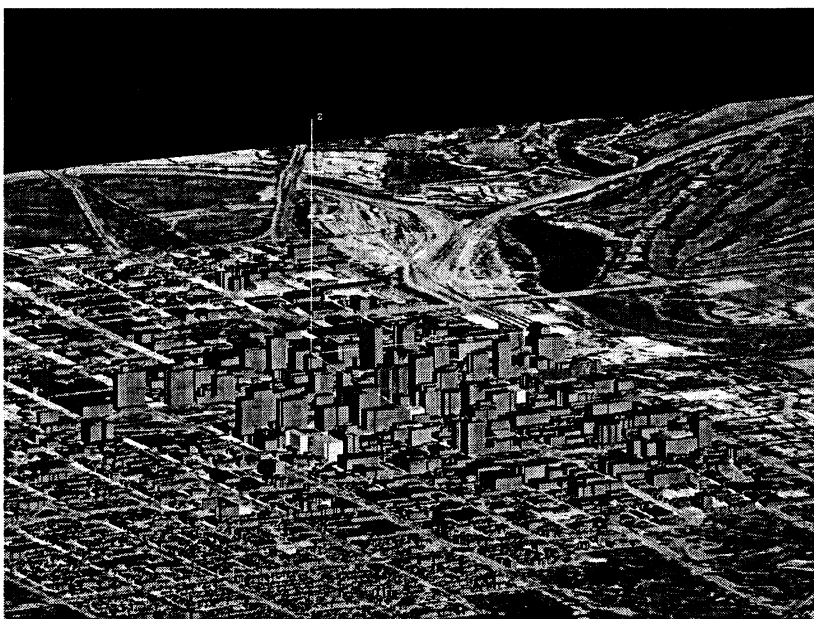

Figure 8: Aerial photographed draped on landscape triangulation and combined with 3D solid models of buildings from a city.

Figure 9: Road design combined with surface triangulation model of surrounding topography.

8 Conlcusions

This paper has shown some of the main areas of application of VULCAN software in the field of environmental management. The benefits of using the functionality and graphical capabilities of VULCAN have been demonstrated through various examples of its application in key areas of environmental analysis. The integration of different types of graphical and numerical information in the ENVISAGE graphical environment enables the engineer to gain better understanding of the particular problem and reach the best solution. VULCAN is a software package that is characterised by ease of use, powerful data manipulation, multi-dimensional modelling, high performance graphics and dynamic, virtual reality capabilities that is suitable for the handling and modelling of complex and large amounts of data from any environmental study.

References

[1] Golder Associates, *FracMan Home Page,* URL: www.golder.com/fracman/
[2] McDonald, M.G. & Harbaugh, A.W. *A modular three-dimensional finite-difference groundwater flow model*, U.S. Geological Survey Techniques of Water Resource Investigations, Book 6, Chapter A1, 1988.