LA-UR- 94-3121

Title: DECISION SUPPORT SYSTEM TO SELECT COVER SYSTEMS

Author(s): Kenneth V. Bostick

Submitted to: Milestone submission to US DOE

Los Alamos
NATIONAL LABORATORY

Form No. 836 R5
ST 2629 10/91

DISCLAIMER

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

Technology Information Profile (rev. 2) for ProTech
Information Last Revised: 2 August 1993
TTP Reference Number: AL131001

1. Technical Name of Technology: Decision Support System to Select Cover Systems

2. Common Name of Technology: Decision Support System

3. PI and Telephone No: Tom Hakonson, 505-665-5281, Fax: 505-665-3866

4. Affiliation: Group EES-15, Los Alamos National Laboratory

5. Technology Category: Containment / Disposal

6. Developers: US Department of Agriculture-ARS, Colorado State University, Sandia National Laboratories, Los Alamos National Laboratory

7. Application

7.1. Where: In Situ Containment
7.2. Media: Arid and/or Humid Soils
7.3. Targeted Contaminants: Radioactive and Mixed Waste

8. Scope of project:
Pilot Study

9. Integrated Demonstration (ID) Need/Requirements:
Containment technologies, including surface caps, are sought to reduce the potential for contaminant migration from the landfill by an alteration of the surface and/or subsurface soils. The process of selecting containment cover technologies for mixed waste landfills requires consideration of many complex and interrelated technical, regulatory, and economic issues. A Decision Support System (DSS) is needed to integrate the knowledge of experts from scientific, engineering, and management disciplines to help in selecting the "best capping practice" for the site.

10. Objective

10.1. Objective of technology (e.g., This technology will destroy VOCs in groundwater.):
The objective of this technology is to provide risk managers with a defensible, objective way to select capping alternatives for remediating radioactive and mixed waste landfills.The objective will be achieved through a joint project between LANL and USDA-ARS by developing a multi-objective decision making software system, with embedded simulation models, to design and/or evaluate engineered surface barriers for mixed waste landfills. The data collected from the Migration Barrier Covers for Mixed Waste Landfills (TTP AL-1212-11) project will be used to evaluate the DSS. We are proposing to adapt and test the prototype DSS for remediation of waste disposal sites with migration barrier cover technology, using the designs and data base from the existing cover barrier field demonstration at Hill AFB in Utah. The objectives of the work described below includes: (1), assembling the technical data base to develop site specific parameters for the KBS, (2), incorporate the multi-objective analysis tools of Yakowitz and Lane(1992) into the existing DSS, (3), assemble the heuristic data base and scoring functions for the DSS, (4), evaluate the DSS with monitoring data from Hill AFB, and select the "best" barrier cover design for meeting the regulatory requirements at a minimum of cost, (5), use the DSS to design and evaluate migration barrier cover alternatives for MWLs, and (6), compare DSS predicted performance with monitoring data from the planned MWLID barrier technology demonstrations at Hanford and SNL.

10.2. Baseline:

11. Process Description:
Applications of a DSS to natural resource management and to landfill cover remediation have been explored by Lane et. al. 1991 and a prototype DSS partially developed by the USDA-Agricultural Research Service for water quality management (Yakowitz et al., 1992). The DSS will use a computer model (a new version of the EPA's HELP model) to calculate water balance. The technical criteria include runoff erosion, percolation, interflow and evapotranspiration, given the climate of the area. Other criteria are pertinent regulations and cost, which all go towards an overall score which is used to compare which cap is best for the site.

A PC based, prototype DSS software package, running under Windows 3.1, is under development. It will be a user-friendly coupling between symbolic processing and numerical near surface hydrologic modeling. The embedded KBS will integrate confidence limits and exceedence probabilities from stochastic conjectural analyses of hydrologic variables in space and time, and the symbolic objects that influence landfill technology. The integration will result in a DSS that should improve long-range predictability of migration barrier performance by incorporating complex environmental processes, along with the management issues, into the decision making process.

To interpret the output of the KBS applied to landfill design and remediation problems, particularly when multiple, and sometimes conflicting objectives exist, requires the aid of decision analysis tools to simplify the decision making process. For example, the hydrologic analysis from the KBS might identify a particular barrier design as "better" in controlling runoff (and erosion) from the site but at the expense of increasing water infiltration into the landfill. A method is needed to decide whether the increased infiltration will significantly enhance the potential of deep percolation and concomitant migration of solutes toward groundwater and whether this the enhanced migration has relevance in light of other factors, such as, thickness of the unsaturated zone, potential use of the water, climate, and etc.

The DSS will use dimensionless scoring or utility functions parameterized from the quantitative KBS output and expert judgment to convert the range of the decision variables to a unitless common range. This process allows one to combine the decision variables and rank the alternative designs. A major task of this project is to integrate a new decision making methodology into the existing DSS in order to eliminate much of the subjectivity in existing multi-objective methods (Yakowitz and Lane, 1992).

11.1. Input:
Site-specific initializing data and parameters for cap design alternatives to use in the hydrologic models of the DSS (which acts as our best science) and the heuristic data and scoring functions to value (which act as the equivalent of our best judgment).

11.2. Output:
Total scores for each cap design that can be used to objectively select the best capping alternative for remediating the waste site.

12. Summary of Technology Advantages :
The DSS ensures that the risk manager uses the best scientific information on cap barrier design and performance along with other criteria to select the best remediation practice within the constraints of technical performance, regulatory requirements, and cost. The use of a DSS to design and evaluate barrier cover remediation technology will reduce the likelihood of selecting a barrier cover technology that doesn't meet performance objectives and the attendant costs of fixing mistakes. Candidate remediation technologies can be evaluated with the DSS, before-hand, to identify technical and regulatory problems inherent in the technologies, evaluate projected long term performance, and the practicality of the designs from a construction and economic viewpoint. The unique circumstance that reduces time and costs to demonstrate the prototype DSS for the MWLID is the existence of the Hill AFB landfill cover demonstration ($700K

already invested in the demonstration by the U.S. Air Force) and the extensive monitoring and characterization data bases. These data bases, with a minimum of effort, can be used to parameterize the DSS and to compare with decision variable output from the expert system embedded in the DSS. The DSS provides a technically sound, objective way of choosing a cap design which improves the quality and cost effectiveness of decisions made by the risk manager.

13. Limitations of Technology :
The DSS will require data to initialize and parameterize the embedded simulation models and the consensus of technical experts in developing the heuristic and scoring function information.

14. Major Technical Challenges:
(1) To illustrate the concept of a DSS within the context of the barrier cover demonstration at Hill AFB and (2) demonstrate multi-objective decision making software incorporating a Knowledge Based (or expert) System with embedded simulation models, using Hill AFB monitoring data to evaluate the KBS.

15. Technical Effectiveness:

15.1. Performance:

15.1.1. Remaining Contamination:
Summary (20 words or less): The DSS technology applies to containment of buried wastes in-situ. Therefore all the waste remains in place.
Further Description (unlimited length): However, a properly designed waste site cap can effectively reduce or eliminate transport of waste contaminants by hydrologic processes, including erosion and deep percolation.

15.1.2. Process Waste:

15.1.2.1. Status of waste (mobility, volume, hazard, recyclability)
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.2.2. Treatment (needed, available)
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.2.3. Decontamination / Decommissioning
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.2.4. Disposal (needed, available)
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.3. Practicality

15.1.3.1. Foreclose Future Options
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.3.2. Reliability
Summary (20 words or less): The DSS will provide an objective, repeatable method of selecting capping

alternatives that are tailored to the need for hydrologic control at the waste site.
Further Description (unlimited length):

15.1.3.3. Failure Control
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.3.4. Ease of Use:
Summary (20 words or less): A PC based, prototype DSS software package, running under Windows 3.1, is under development.
Further Description (unlimited length): It is a user-friendly coupling between symbolic processing numerical near surface hydrologic modeling.

15.1.3.5. Infrastructure:
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.3.6. Versatility:
Summary (20 words or less): The DSS can be used to design and/or evaluate many different capping alternatives
Further Description (unlimited length):

15.1.3.7. System Compatibility:
Summary (20 words or less): The software is Unix workstation based, compatible with most.
Further Description (unlimited length):

15.1.3.8. Off-the-Shelf:
Summary (20 words or less): On completion of the technology, software and documentation will be made available to user groups.
Further Description (unlimited length):

15.1.3.9. Maintainability:
Summary (20 words or less): Upgrades will have to be done by a regular staff designed to support the DSS.
Further Description (unlimited length):

15.1.3.10. Safety Measures:
Summary (20 words or less): Not applicable
Further Description (unlimited length):

15.1.4. "Works":
Summary (20 words or less): It has been applied to the Hill AFB in Utah and works beautifully.
Further Description (unlimited length):

15.2. Cost

15.2.1. Start-Up Cost:
Summary (20 words or less): Software will likely be available freely. Only startup costs are computer hardware and a person to operate it.
Further Description (unlimited length):

15.2.2. Operations and Maintenance Cost::
Summary (20 words or less): Minimal (<$1000 to maintain software and update as improvements are made)
Further Description (unlimited length):

15.2.3. Life-cycle cost:
Summary (20 words or less): Will depend on the number of times it is used to select landfill cap designs.
Further Description (unlimited length):

15.3. Time

15.3.1. Years Until Available
Summary (20 words or less): A prototype DSS will be available in FY94.
Further Description (unlimited length): We envision the completed DSS to be easily implemented and used in selecting capping alternatives by environmental restoration personnel at a particular site in about 2 man-months.

15.3.2. Speed/Rate:
Summary (20 words or less): Extremely fast.
Further Description (unlimited length):

15.3.3. Years to Finish:
Summary (20 words or less): It can paramaterize and score a site in five minutes.
Further Description (unlimited length):

16. Environmental Safety and Health:

16.1. Worker Safety:

16.1.1. Exposure to Hazardous Materials/Hazards
Summary (20 words or less):
Further Description (unlimited length):

16.1.2. Physical Requirements
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.1.3. Number of People Required
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.2. Public Health and Safety:

16.2.1. Accidents
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.2.2. Routine Releases
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.2.3. Transportation
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.3. Environmental Impacts:

16.3.1. Ecological Impacts
Summary (20 words or less): Not applicable

Further Description (unlimited length):

16.3.2. Aesthetics
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.3.3. Natural Resources
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.3.4. Energy Demands
Summary (20 words or less): Only energy demands of the workstation.
Further Description (unlimited length):

17. Socio-Political Interests:

17.1. Public Perception

17.1.1. Proponent Reputation:
Summary (20 words or less): LANL has essentially written the book on capping systems, with PNL as its only peer.
Further Description (unlimited length): Field demonstrations have been LANL scientists' focus, and they are recognized as the country's experts on capping technology.

17.1.2. Familiarity / Understandability:
Summary (20 words or less): The use of decision aids in the medical profession are well known and accepted by much of the public at large.
Further Description (unlimited length): Though DSS technologies are probably not familiar to the general public, the DSS is simply another application of decision support tools, which, for instance, have been used in the medical profession for years.

17.2. Tribal Rights / Future Land Use

17.2.1. Capacity for Unrestricted Use:
Summary (20 words or less): Not applicable
Further Description (unlimited length):

17.3. Socio-Economic Interests

17.3.1. Economic Impacts:
Summary (20 words or less): This technology could save $10's - 100's of millions by ensuring that the cap is not over-designed yet meets performance requirements.
Further Description (unlimited length): These performance requirement are dictated by the level of risk to humans and ecosystems from the contaminants at the site.

17.3.2. Labor Force Demands:
Summary (20 words or less): None
Further Description (unlimited length):

18. Regulatory Objectives

18.1. Compatibility with Cleanup Milestones:
Summary (20 words or less): The FY95 delivery of this technology will be compatible with the corrective

measures studies which will begin at many DOE sites around this time.
Further Description (unlimited length): This estimate is based on the current pace of the site characterization and assessment activities associated with the environmental restoration program

18.2. Regulatory Infrastructure / Track Record:
Summary (20 words or less): Current EPA regulations on cap designs focus on the use of the EPA RCRA cap but provide options for the use of alternative designs if equivalency can be shown.
Further Description (unlimited length): There currently is no objective way to develop and evaluate alternative designs, hence the need for tools such as the DSS.

18.3. Regulatory Compliance:
Summary (20 words or less): From a technical point of view, the DSS is particularly valuable in supporting a selected design that meets performance criteria.
Further Description (unlimited length):

19. Industrial Partnerships

19.1. Company Names:
US Department of Agriculture-ARS, Colorado State University, Sandia National Laboratories

19.2. Rationale:
USDA-ARS has pioneered in the use of DSS in natural resource management problems. A graduate student at CSU is using portions of this project for a Masters thesis. Sandia National Laboratories are collaborators in a joint migration barrier cover demonstration to be conducted beginning in FY94. The DSS will be used to design and evaluate barrier cover design alternatives for the demonstration.

19.3. Contract Mechanism:
A inter-agency contract between Los Alamos National Laboratory and USDA-ARS has been completed to conduct this joint project.

19.4. Other Potential Companies:

19.5. International:

20. Intellectual Property:

20.1. Patent Ownership:

20.2. Other Owners:

20.3. Patent Number:

21. Cost Sharing:

22. Background on this technology:
Applications of a DSS to natural resource management has been explored by Lane et. al. 1991 and a prototype DSS partially developed by the USDA-Agricultural Research Service for water quality management (Yakowitz et al., 1992). The application of DSS technology was recognized by LANL leading to the development of a PC based, prototype DSS software package, running under Windows 3.1, through a collaboration with USDA-ARS and Purdue University using program development funds at LANL. The results were encouraging enough that this proposal was written to complete development and testing of the DSS. At present we have no competitors.

23. Reference Documents:

Andriole, S.J. Handbook of Decision Support Systems.. Blue Ridge Summit, PA: Tab, 1989.

Ascough, J.C. 1992. A knowledge-based/numerical modeling approach for design and evaluation of shallow landfill burial systems. PhD Diss., Dept. of Agricultural Engineering, Purdue University, West Lafayette, IN.

Beasley, D.B., L.F. Huggins, and E.J. Monke. 1980. ANSWERS: A model for watershed planning. TRANS. of the ASCE (American Society of Civil Engineers). 23: 938-944.

Gershey, E.L., R.C. Klein, E. Party, and A. Wilkerson. 1990. Low level radioactive waste: From cradle to grave. Van Norstrand Reinhold Co., New York, 212 pp.

Hakonson, T. E., L. J. Lane, J. G. Steger, and G. L. DePoorter. 1982. Some interactive factors affecting trench cover integrity on low-level waste sites, IN: Proc. Low Level Waste Disposal: Site Characterization and Monitoring, Arlington, VA, NUREG/CP-0028, CONF-820674, Vol. 2.

Hakonson, T. E., J. L. Martinez, and G. C. White. 1982. Disturbance of a low-level waste burial site cover by pocket gophers. Health Phys. 42(6):868-871.

Hakonson, T. E. 1986. Evaluation of geological materials to
limit biological intrusion into low-level radioactive waste disposal sites. Los Alamos National Laboratory report, LA-10286-MS.

Hakonson, T. E., L. J. Lane, G. R. Foster,, and J. W. Nyhan. 1986. An overview of Los Alamos research on soil and water processes in arid and semi-arid ecosystems. L. J. Lane (ed.), pp. 7-10, IN: Erosion on Rangelands: Emerging Technology and Data Base, Proc. of the Rainfall Simulator workshop, Jan 14-15, 1985, Tucson, Arizona, Soc. for Range Management, Denver, CO. ISBN:0-960369264-4.

Hakonson, T. E., L. J. Lane, J. W. Nyhan, F. J. Barnes, and G. L. DePoorter. 1989. Trench cover systems for manipulating water balance on low-level radioactive waste sites. M. S. Bedinger and P. R. Stevens, (eds.), PP. 73-80, IN: Safe Disposal of Radionuclides in Low-Level Radioactive Waste Repository Sites: Low Level Radioactive Waste Disposal Workshop, USGS Circ.- 1036.

Hakonson, T. E., E. S. Springer, and L. J. Lane. 1992. Abiotic and biotic processes in deserts, C.C. Reith and B.M. Thomson, eds., IN: DESERTS AS DUMPS, University of New Mexico Press. ISBN 0-8263-1297-7

Harmon, P., R. Maus, and W. Morrissey. 1988. Expert systems tools and applications. John Wiley and Sons, Inc., New York, 289 pp.

Knisel, W.G. 1980. CREAMS: A Field-Scale Model for Chemicals, Runoff, and Erosion in Agricultural Management Systems. USDA Conservation Research Report No. 26.

Lane, L. J., J. C. Ascough, and T. E. Hakonson. 1991. Multi-objective decision theory- decision support systems with embedded simulation models. IN: Proc. Irrigation and Drainage, IR Div/ASCE (American Society of Civil Engineers), Honolulu, HI, (July 22-26, 1991) 445-451.

Leonard, R.A., W.G. Knisel, and D.A. Still. 1987. GLEAMS: Groundwater Loading Effects of Agricultural Management Systems. Trans. ASCE 30(5): 1403-1418.

Nyhan, J.W. and L.J. Lane. 1982. Use of a state of the art model in generic designs of shallow land repositories for low-level wastes. Proc. Symp. on Waste Management, Tucson, AZ. Mar. 8-11, 1982, pp. 235-244.

Nyhan J. W., T. E. Hakonson, and B. J. Drennon. 1990. A water balance study of two landfill cover designs

for semiarid regions. J. Environ. Qual. 19:281-288.

Schroeder, P.R., J.M. Morgan, T.M. Walski, and A.C. Gibson. 1984. The hydrologic evaluation of landfill performance (HELP) model. Vol.I and II. EPA/530-SW-84-010, US Environmental Protection Agency, Office of Solid Waste and Emergency Response, Wash., DC.

Stone, J.J., L.J. Lane, D. Yakowitz, and P. Heilman. 1992. Prototype decision support system for the water quality initiative. USDA-ARS Southwest Watershed Research Center, Tucson, AZ.(1992)

Williams, J.R., K.G. Renard, and P.T. Dyke. 1983. A new method for assessing the effect of erosion on productivity-- The EPIC model. J. Soil Water Conservation 38:381-383.

Williams, J.R., C.A. Jones, and C.A. Dyke. 1984. A modeling approach to determining the relationship between erosion and soil productivity. TANS. of the ASCE 27(1):129-144.

Wymore, A.W. 1988. Structuring system design intentional? p.704-709. In: Systems Science and Engineering (C. Weimin, ed.), Proc. Intrl. Conf. on Systems Science and Engineering (ICSSE '88), July 25-28, 1988, Beijing, China. International Academic Publishers, Beijing, China. pp. 704-709.

Yakowitz, D.S., L.J. Lane, J.J. Stone, P. Heilman, R.K. Reddy, B. Imam, 1992. Evaluating land management effects on water quality using multi-objective analysis within a decision support system, Proc. American Water Resources Association, 1st International Conference on Ground Water Ecology. Tampa, FL: April, 1992.

Yakowitz, D.S. and L.J. Lane, 1992. A multi-attribute decision tool for ranking a finite number of alternatives, Working Paper #891, USDA/ARS Southwest Watershed Research Center, 2000 E. Allen Rd., Tucson, AZ. 85719.

Information reviewed for accuracy (Principal Investigator's initials): KVB