EVALUATION OF SELECTED ENVIRONMENTAL

DECISION SUPPORT SOFTWARE*

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1.0 INTRODUCTION

Decision Support Software (DSS) continues to be developed to support analysis of decisions pertaining to environmental management. Decision support systems are computer-based systems that facilitate the use of data, models, and structured decision processes in decision making. The optimal DSS should attempt to integrate, analyze, and present environmental information to remediation project managers in order to select cost-effective cleanup strategies. The optimal system should have a balance between the sophistication needed to address the wide range of complicated sites and site conditions present at DOE facilities, and ease of use (e.g., the system should not require data that is typically unknown and should have robust error checking of problem definition through input, etc.).

In the first phase of this study [Sullivan, et. al., 1997], an extensive review of the literature, the Internet, and discussions with sponsors and developers of DSS led to identification of approximately fifty software packages that met the preceding definition. These software packages were classified according to six major areas of decision support:

- Site characterization data analysis including visualization of site characterization data and integration of data
- Nature and extent of contamination analysis
- Data worth analysis
- Remedial action analysis which includes optimization of design as well as comparison between different alternatives
- Human health risk (dose) analysis (compliance with regulatory limits)
- Economic cost/benefit analysis.

A DSS code can evaluate one or several of the categories listed above. For example, DSS exists for optimal design of landfill cover systems. This software has a specific application and does not address other remedial alternatives. As a more complex example, DSS exist that can simulate several remedial action alternatives for multiple contaminants, and provide a risk assessment and cost/benefit analysis of each. The variety of waste management problems and environmental conditions is so vast that, currently, no DSS system covers all aspects relevant to environmental remediation problems. Care must be taken by the analyst to match the capabilities of the DSS with the problem requiring a decision.

The objective of this project is to evaluate different DSS in terms of their capabilities and limitations. The first phase of this project was the subject of a previous report [Sullivan, et. al., 1997]. It identified existing DSS developed by DOE, other government agencies, and private industry, collected information on their capabilities, identified issues in the implementation of DSS packages, and recommended more detailed evaluation of DSS code packages that might be useful to the DOE.

The criteria used to select a DSS package for further evaluation included:

- Codes that have the flexibility to address a wide range of situations applicable to DOE sites (therefore, code packages designed to address a single remediation technology were removed from further consideration)
- Codes that have gained wide spread recognition throughout the United States
- Codes that have had successful field scale applications.

Based on these criteria, nineteen codes were reviewed. Due to the nature of the problems addressed, two major categories were identified for DSS software. The first includes remedy selection, remedial design optimization, and cost/benefit analysis. The second contains site characterization, plume characterization, and risk assessment issues. For the most part, these categories were mutually exclusive. However, three software packages, RAAS, SELECT, and MARS, spanned both categories.

The objective of the review was to evaluate the DSS on a screening level in order to provide information to decision makers on the utility of a particular DSS package to a site-specific application. It is not meant as a detailed technical review of the various aspects of the DSS package which is beyond the scope of this report. This review is meant to provide a method to acquire information rapidly on the general capabilities of the codes. Further information can be obtained from the contacts listed in the review tables, if necessary.

This review is not meant as an endorsement of any particular code. The level of detail in the screening evaluation does not permit such judgements. Selection of a particular code for a site-specific application depends on many technical (site and contaminant characteristics), regulatory (compliance agreements schedules and acceptance of a particular choice of software), and economic (cost of software and training) factors. These factors and the technical capabilities of the software will influence the selection of a particular software package as a tool for use in the decision making process.

The rating system used in this report favors software that simulates a wide range of environmental problems. It is emphasized that the ratings are on a screening level and not meant to evaluate the technical adequacy of any of these packages. It would be prudent, before using any packages, to obtain documentation on the application of the code to problems similar to those under consideration.

Chapter 2 provides a glossary of terms, as well as the rationale for rating various aspects of DSS performance, and is an important key for understanding the contents of the summary tables that review the DSS.

The following remedial action Decision Support Software listed in Table 1 have been reviewed in more detail. The results of the analyses are found in the table in Chapter 3. Chapter 3 provides a brief narrative description of each of these software packages and the evaluation table.

Table 1: List of Remedial Action DSS Packages Reviewed

BIOSVE (Biodegradation, Soil Vapor Extraction and Vacuum Enhanced Recovery)	RAAS (Remedial Action Assessment System)
CURE (Cost Uncertainty in Remediation Engineering)	RACER (Remedial Action Cost Estimation)
MARS (Multi-phase Area Remedy Selection)	SELECT (Remedy Selection)

The following site characterization/risk assessment software have been reviewed in more detail and the results of the analysis are found in the table in Chapter 4. The DSS are listed in Table 2. Chapter 4 provides a brief narrative description of each of these software packages and the evaluation table.

Table 2: List of Site Characterization/Risk Assessment DSS Reviewed

API-DSS (American Petroleum Institute Decision Support Software)	PRECIS (Probabilistic Risk Evaluation and Characterization Investigation System)
GANDT (Ground Water Analysis and Network Design Tool)	RAAS (Remedial Action Assessment System)
GMS (Ground Water Modeling System)	SADA (Spatial Analysis and Decision Assistance)
MAPER (Multi-Sensor Analysis Program for Environmental Remediation)	SEDSS (Sandia Environmental Decision Support Software)
MARS (Multi-Phase Areal Flow Remedy Selection)	SELECT (air and water quality remedy selection tool)
OPTMAS (Optimization Program to Minimize Analytical Sampling)	SitePlanner (site characterization and plume definition tool)
PLANET (Pump Layout Evaluation Tool)	SmartSampling (economic and risk based decision analysis)
PLUME (Plume contamination levels and extent)	

2.0 DSS GLOSSARY

The following glossary defines the rationale for ranking the DSS Software in Chapters 3 and 4. The Glossary begins with terms which are common to the chapter 3 table, Remedial Action DSS, and the Chapter 4 table, Site Characterization and Risk Assessment DSS. Definition of all terms in the table and the ranking system are explained. The Glossary continues with terms unique to the Remedial Action table, Chapter 3. The Glossary concludes with a section on terms unique to the Site Characterization and Risk Assessment table, Chapter 4.

DSS Glossary

Legend The following symbols are used for all ratings:

● Highest level of model robustness
⊙ Intermediate level of model robustness
□ Lowest-level of model robustness
I Insufficient information to make an evaluation.

A blank field indicates that the code does not have the capability to model the parameter associated with the field.

Terms Common to Both Remedial Action DSS Table and Site Characterization and Risk Assessment Table

Developer/Vendor: Name of primary developer and supplier of DSS.

Point of Contact: Person/location identified by the developer/vendor as the contact point for DOE or DOE contractors to obtain additional information.

Platform: Operating system(s) that DSS utilizes.

Contaminant Characteristics: Assess the ability for software to provide decision support for each of the listed classification of contaminants. The contaminant categories are:

Organic: VOC, semi-volatiles, PAH, etc.
Inorganic: Non-radioactive metals.
Mixed Organic/Inorganic: Mixture of any combination of organics and inorganics.
Radioactive: All Types of radioactive waste excluding tritium. If a DSS can address tritium, it is noted in the comments section of the table.
Mixed LLW: Mixture of low level radioactive waste and organic and/or inorganic hazardous waste.
Mixed TRU: Mixture of transuranic waste and organic and/or inorganic hazardous waste. TRU contains greater than 10 nCi of transuranic isotopes/gram of waste. Transuranics are isotopes having an atomic number greater than 92.
Sanitary: Sewage waste that is not classified as hazardous.

Energetics: Explosives, propellants, and pyrotechnics (PEP), and undetonated ordnance.

The evaluation criteria are:

- ● DSS specifically designed to address this classification of contaminants and can handle a wide range of contaminant types within this class. For example, specific volatile and semi-volatile compounds within the organic classification.
- ⊙ DSS specifically designed to address this classification of contaminants and can handle only a portion of the range of contaminants within this classification. For example, only semi-volatile compounds within the organic classification.
- □ DSS can handle this classification of contaminants but does not take into consideration how various sub-classifications within this group may behave differently.

Phase: Ability for the software to address each phase that a contaminant may exhibit. The phase will impact the contaminant's transport through media; therefore, a DSS must be selected that can model the appropriate transport mechanism. The phases considered are:

Gas: Contaminant exists as vapor and/or gas that can move through the media.
Liquid: Contaminant is present in an aqueous phase (dissolved in water).
Non-Aqueous Phase: The separate phase portion of a contaminant that exists after its dissolved concentration in water reaches the saturation limit for that contaminant, commonly referred to as a non-aqueous phase liquid (NAPL). Often, NAPLs are grouped based on specific gravity. NAPLs with a specific gravity greater than water are known as Dense NAPLs (DNAPL). Those with a specific gravity less than water are known as Light NAPLs (LNAPL). DSS that can address all types of NAPLs are rated the highest.

The evaluation criteria are:

- ● DSS designed to model this phase and utilize site and chemical specific parameters to tailor the analysis to site conditions. The model can address a variety of contaminant stages within one phase (e.g. - DNAPL and LNAPL). The model can address the transfer of the contaminant from one phase to another.
- ⊙ DSS designed to model this phase and utilize site and chemical specific parameters to tailor the analysis to site conditions. The model does not address transfer between phases.
- □ DSS designed to model this phase based on generalized site and chemical parameters.

Site Environmental Characteristics: Ability of DSS to address a variety of unique site characteristics.

Vadose Zone: The zone above the water table where the pore space is filled with a mixture of gas and liquid.

- ● DSS can simulate vadose zone properties relevant to flow and transport, and may use site and chemical specific parameters to tailor the analysis to site conditions. DSS can address transfer of contaminant from the vadose zone to the saturated zone.
- ⊙ DSS does not address transfer of contaminant from the vadose zone to the saturated zone. It is similar to above classification with this exception.
- □ DSS designed to model contaminants only in the vadose zone based on generalized site and chemical parameters.

Saturated: The zone beneath the water table where all available pore space is filled with liquid.

- ● DSS can simulate saturated zone properties relevant to flow and transport, and may use site and chemical specific parameters to tailor the analysis to site conditions. DSS can address transfer of contaminant from the vadose zone to the saturated zone.
- ⊙ DSS does not address transfer of contaminant from the vadose zone to the saturated zone. It is similar to the above classification with this exception.
- □ DSS designed to model contaminants only in the vadose zone based on generalized site and chemical parameters.

Extreme Environmental Conditions: Ability for the DSS to address unique site conditions. These include very low or high pH, the presence of fractured bedrock, sludges, arid climates, etc. The specific condition that the DSS is able to address will be noted in the table.

- ● DSS can address more than one extreme environmental condition using site and contaminant specific parameters to adjust the model to site conditions (for example, conditions of low pH and fractured flow regimes).
- ⊙ DSS can address one extreme environmental condition using site and contaminant specific parameters to adjust the model to site conditions.
- □ DSS can address one or more extreme environmental conditions based on generalized site and chemical parameters.

Class of Problem: Assess the ability of the DSS to address the issues and remedial approaches unique to each of the following regulatory programs:

RCRA: Resource Conservation and Recovery Act which pertains to active hazardous waste generation, transport, storage or disposal facilities.
CERCLA: Comprehensive Environmental Recovery and Comprehensive Liability Act which pertains to sites abandoned or never permitted under RCRA hazardous waste regulations.
UMTRA: Uranium Mill Tailing Remedial Action Program which pertains to mill tailings.
LLW: NRC, DOE, and EPA regulations which pertain to Low-Level Waste.

The evaluation criteria are: .

- ● DSS is specifically designed to address the requirements, issues, and remedial approaches of the regulatory program indicated. For example, regulatory

requirements are built into the code database and used as a basis for comparison.

- ⊙ DSS can address the specific requirements, issues, and remedial approaches of the regulatory program indicated in a limited manner.
- □ DSS can address the general requirements, issues, and remedial approaches of the regulatory program in a limited manner.

Complexity: An evaluation of the overall difficulty and level of skill and knowledge required to use the DSS. A rating was derived by assessing the overall rating of training requirements, documentation, error trapping, data importing, vendor support, and technical background required to use the DSS effectively. The evaluation gave a higher rating to those programs that required less training and were easiest to use. The more complicated and sophisticated models were given lower ratings. The evaluation criteria are:

- ● The DSS can be self taught. Printed documentation is available. It includes on-screen documentation/help. The DSS incorporates a high level of error trapping and assistance with inputting the correct type of data. Data can be readily imported from other software. Vendor support is available. Mid-level technical background is required for use.
- ⊙ One to two days of training is required. The DSS includes on-screen documentation/help. It incorporates some error trapping and assistance with inputting the correct type of data. The DSS has some capability to import data from other software. Vendor support is available. Mid-level technical background is required for use.
- □ More than two days of training is required. No or limited on-screen documentation/help is available. The DSS has limited error trapping. There is limited capability to import data from other software. Limited vendor support is available. High-level technical background is required for use.

Usage: Identify primary user group (DOE, EPA, industry, etc.), extent of use, and agency acceptance or peer review status.

Stage of Development: Indicate if DSS is available for wide spread use or is still in the developmental process. List agency acceptances and peer review information identified.

Cost Range: Cost range for obtaining DSS to operate on one work station. This will include Federal Agency/Public Sector price if possible. Comment section will indicate if training costs are included.

Comments: Unique features of DSS. These will include major benefit and deficiencies as compared to other DSS. Other issues such as plans for new versions and training cost information are included when available.

Terms Unique to the Remedial Action DSS Table

Remedial Alternatives: Ability for DSS to analyze and optimize remedial designs to address site specific conditions. Broad classes of similar remedial technologies are placed into Remedial Alternative Groupings (*i.e.* containment, in-situ treatment, ex-situ treatment). The groupings are:

Containment: Alternatives that address contamination by controlling routes of exposure and movement of contamination from the source area. This includes:

> *Cut-Off-Walls*: Includes slurry walls, steel sheet pile walls, freeze walls, and membrane walls.
> *Hydraulic:* Containment maintained by creating hydraulic control through pumping with or without reinjection, or a hydraulic barrier by using an interceptor drain, or using other hydraulic methods.
> *Caps:* Impermeable or low-permeability surface barrier used to control surface water infiltration and minimize direct human contact with contamination.
> *Other:* Additional remedial alternatives that contain the contamination including solidification, stabilization (fixation), and ground freezing.

In-Situ Treatment: Remedial Alternatives that reduce levels of contamination and/or destroy contamination without bringing the contaminated soil and/or ground water to the surface. This includes:

> *Natural Attenuation:* Natural subsurface processes (such as dilution, volatilization, biodegradation, adsorption, and natural chemical reactions) that reduce contaminant concentrations to acceptable levels.
> *Biological:* Processes that stimulate the activity of microbes to enhance the biological degradation of organic contaminants.
> *Physical/Chemical:* Processes that use physical and/or chemical actions to remove and/or destroy contaminants. These include Soil Vapor Extraction, surfactant flushing, vitrification, passive treatment walls, radio frequency, electro-kinetics, and air sparging.

Ex-Situ Treatment: Remedial Alternatives that reduce levels of contamination and/or destroy contamination after the contaminated soil and/or ground water is brought to the surface.

> *Biological:* See above. This includes land farming, biopiles, and bioreactors.
> *Physical/Chemical:* See above. This includes soil washing, stabilization, air stripping, carbon absorption, and UV oxidation.
> *Thermal:* Removal and or destruction of contaminants utilizing a thermal process which can be low or high temperature.

The evaluation criteria are:

- ● DSS can analyze a number of variations to this remedial alternative and select the most effective option. DSS can address both soil and ground water as applicable and can assist in optimizing remedial designs.
- ⊙ DSS can analyze a number of variations to this remedial alternative and select the most effective option or assist in optimizing remedial designs. DSS can address either soil or ground water contamination, but not both simultaneously.
- □ DSS can either analyze the effectiveness of a limited number of variations to this remedial alternative or can assist only in optimizing the remedial design or development of a cost-estimate based on the specific remedial alternative.

Remedy Selection: Ability to define potential site specific remedial alternatives.

- ● DSS defines a large range of remedial alternatives from each Remedial Alternatives grouping and can combine remedial alternatives into treatment trains.
- ⊙ DSS defines a large range of remedial alternatives from at least two Remedial Alternatives grouping, or a limited number of remedial alternatives from each remedial alternatives grouping.
- □ DSS defines remedial alternatives from only one Remedial Alternatives grouping.

Remedial Design Optimization: Ability to analyze and optimize remedial designs.

- ● DSS can both analyze and optimize remedial designs from each remedial alternatives grouping.
- ⊙ DSS can analyze or optimize remedial designs from each remedial alternatives grouping.
- □ DSS can analyze or optimize remedial designs from at least one remedial alternatives grouping.

Economic Analysis: Ability to define the costs associated with different remedial alternatives and perform a cost/benefit analysis. This aids in selecting optimal remedial action approach and/or design.

- ● DSS can develop costs associated with different remedial alternatives and perform a cost/benefit analysis. The cost database used by the system can be readily modified or updated.
- ⊙ DSS can develop costs associated with different remedial alternatives and perform a cost/benefit analysis.
- □ DSS can develop costs associated with different remedial alternatives.

Data Visualization: Assess the overall presentation, flexibility, and options associated with the DSS data visualization.

- ● Data are presented in three dimensions and full color with labeling and numerous options for viewing. This includes viewing from a variety of perspectives and ability to readily select data sets shown.
- ⊙ Data are presented in three dimensions with limited color and labeling or two dimensions with full color. The ability to view from different perspectives and the number of viewing options is more limited than the above category.
- □ Data are presented in two dimensions with limited color and labeling. Limited options for viewing.

Terms Unique to the Site Characterization DSS Table

Site Characterization: Assess ability for DSS to assist with characterizing the nature and extent of contamination, hydrogeological properties, and distribution of waste. Characterization can be made by incorporating a wide range of parameters. These include contaminant analytical data, hydrogeological properties, land use and site setting information, and waste disposal data.

- ● DSS incorporates a wide range of data from a large number of the parameters listed above and aids in developing a full characterization of a site.
- ⊙ DSS incorporates a limited combination of data from a reduced number of the parameters listed above and aids in developing a full characterization of the site as it relates to these limited parameters.
- □ DSS incorporates information relating to only one of the parameter groups listed above (for example, soil borings to develop a geological profile).

Plume Characterization: Assess ability for DSS to model flow and transport associated with ground water contamination plume.

- ● DSS can model a number of the contaminant plume's fate and transport properties under a variety of user defined conditions. DSS can account for processes that will vary chemical concentrations such as adsorption, hydrolysis, metabolic transformations, and reduction. DSS can simulate plume behavior under user varied conditions. DSS may use advanced geostatistical simulations to define the plume.
- ⊙ Same as above, with a limited ability to account for processes that will vary chemical concentrations and to simulate plume behavior under user varied conditions.
- □ DSS uses spatial extrapolation to define the plume and does not account for the physical and chemical processes that can lead to variations in chemical concentrations in soil or ground water.

Risk Assessment: Rating of the ability of the DSS to calculate the risk that site conditions pose to human health and the environment.

- ● DSS can estimate the human health impacts from multiple exposure routes (inhalation, ingestion, dermal contact, and external dose). DSS can estimate impact

to environmental receptors.

- ⦿ Same as above, with no ability to estimate impact to environmental receptors.
- ☐ DSS estimate the human health impacts from a limited number of exposures routes. For example, the DSS may be capable of estimating only health effects associated with drinking of contaminated water.

Data Fusion: Assess the ability of the DSS to analyze multiple data types and develop an optimal estimate of site conditions by identifying synergies and conflicts in data from various sources.

- ● DSS can integrate and optimize a wide variety of data types from various sources. DSS can identify synergies and conflicts and select the most appropriate data to integrate.
- ⦿ DSS can integrate a limited number of specific data types from specific sources. DSS can identify synergies and conflicts and select the most appropriate data to integrate.
- ☐ DSS can integrate a limited number of specific data types from specific sources. DSS integrates all data and does not identify synergies and conflicts among the data.

Interface With Flow Codes: Assess the ease associated with the operator modifying the distribution of data/calculation points. This may allow user to input empirical data from on-site experience (knowledge of local anomalies in site conditions, unique localized site features, etc.).

- ● Operator can readily modify distribution on a localized level.
- ⦿ Operator can readily modify distribution on a global level.
- ☐ Operator can modify the distribution on a localized or global level with significant effort and/or knowledge of the flow code used by the DSS.

Sampling Guidance: Ability of the DSS to assist in the selection of field sampling locations and parameters.

- ● DSS can generate sampling locations and suggest sampling parameters. DSS provides a probabilistic assessment of the anticipated results from this location. The DSS suggests where to sample, which chemicals to sample for, and predicts what will be found at this location.
- ⦿ DSS can generate sampling locations or suggest sampling parameters.
- ☐ DSS provides a limited assessment of the anticipated results from this location. For example, spatial extrapolation may be used to estimate sampling locations.

Data Plausibility: The ability of the DSS to determine if data entered is a plausible value for the associated parameter.

- ● DSS determines if the data entered is a plausible value for the associated parameter. If the value is not plausible, guidance and default values are provided.

- ⦿ DSS determines if the data entered is a plausible value for the associated parameter. If the value is not plausible, limited guidance is provided.
- ☐ DSS does not check for data plausibility and will run, possibly generating meaningless results.

Data Worth: The ability to assess the significance of collecting more data as a means of reducing uncertainties in the decision making process. Aids in the development and implementation of sampling strategies.

- ● DSS uses probabilistic and statistical models to determine the benefit of collecting additional samples on the development of a complete site characterization or risk assessment. Models assess the significance of additional data points relative to the overall results of the model and take into account the cost/benefit of collecting more data. DSS incorporates a sensitivity analysis.
- ⦿ Same as above, except a cost/benefit analysis is not performed.
- ☐ Same as highest ranking, except cost/benefit and sensitivity analyses are not performed.

Surface Structures: Assess ability of the DSS to incorporate surface structures into the model and show the structure accurately on the screen or hard copy print out.

- ● DSS takes into consideration surface structures (caps, buildings, etc.). DSS shows structures on visual displays accurately and clearly and is capable of providing a hard copy print out.
- ⦿ DSS takes into consideration surface structures in a limited manner. DSS shows structures on visual displays accurately and clearly and is capable of providing a hard copy print out.
- ☐ DSS can show structures and has more limited viewing or output. For example, the DSS can not produce hard copy output.

Hydrologic Structure: Same as Surface Structures, except as it relates to variations in hydrologic structures.

Buried Objects: Same as Surface Structures, except as it relates to the presence of buried objects.

Plume Visualization: Assess the overall presentation, flexibility, and options associated with the plume visualization of the DSS.

- ● The plume presented in three dimensions and full color with labeling and numerous options for viewing. This includes viewing from a variety of perspectives and ability to select different output format and contents readily (e.g. switch from hydraulic head data to contamination data).
- ⦿ The plume presented in three dimensions with limited color and labeling or two dimensions with full color. Viewing data from different perspectives is cumbersome

or not possible.

- ☐ The plume presented in two dimensions with limited color and labeling. There are limited options for viewing.

Exposed Group Assess capability for DSS to take into consideration the following exposed groups:

Public: General population surrounding a site.
Worker: Population that is present at the site during normal work hours.

- ● DSS can separately assess the risk posed to each exposed group and generate a group specific risk assessment.
- ☐ DSS can assess the risk posed to one group and generate a group specific risk assessment.

3.0 REMEDIAL ACTION DECISION SUPPORT SOFTWARE

The screening level review covers the following major areas for remedial action decision support software:

- DSS developer and contact
- Contaminants addressed
- Site environmental characteristics considered
- Remedial alternatives
- Class of problems (regulatory criteria addressed)
- Other miscellaneous technical criteria (visualization tools, stage of development, usage, etc.).

The detailed criteria used to rate each of the above areas are provided in the Glossary in Chapter 2. In general, software that could handle a wide range of problems was rated higher than those that could not. This review does not evaluate technical limitations, nor does it imply that there are technical limitations in the software.

The information provided was obtained from vendor supplied literature, review of related web sites and, in some cases, telephone interviews with code developers. Telephone interviews were found to provide both the most and the best information about the different packages. Vendor literature was often not detailed enough to make a clear evaluation of all aspects found in the table. Interviews were conducted with the vendors and/or developers of the DSS packages CURE, RAAS, and RACER. A table evaluating the software listed below is located immediately after the list.

BIOSVE — This DSS simulates soil vapor extraction, vacuum enhanced recovery and biodegradation into one model. The code can be used to examine alternative remediation strategies to optimize system design. This code is limited to the three technologies listed above and would need to be expanded to address other remedial technologies.

CURE — Cost Uncertainty in Remediation Engineering (CURE) software is a modification of the RACER code developed for Air Force remediation problems. Monte Carlo type analysis is incorporated to estimate the uncertainties in cost estimates and, therefore, help plan contingencies for remediation activities. This software was developed, in part, to address UMTRA problems.

MARS — Multi-phase areal flow ground water modeling system simulates recovery and migration of LNAPL and ground water. This software assists in remedy selection for LNAPL problems.

RAAS — Remedial Action Assessment System was developed at Pacific

Northwest Laboratory. RAAS consists of two codes: ReOpt and MEPAS. ReOpt contains an extensive data base on remediation technologies and regulatory information. It has an expert system which can be used to develop a short list of remedial alternatives applicable for a given site. MEPAS contains models to estimate risk due to exposure from air, ground water, surface water, or soil. The program was designed to be used in Remedial Investigation/Feasibility Studies.

RACER — This software package by EarthSoft combines cost estimation expert system with an environmental data management system to aid in the development of multiple cost estimates utilizing "what if" scenarios. The output can be connected with a data visualization system.

SELECT — This Decision support tool is directed to evaluation of air and water quality. It has the capabilities to perform site characterization and visualization, subsurface and atmospheric fate and transport, risk assessment, and cost evaluation of different remedial options.

SitePlanner — SitePlanner assists in the development of data collection plans. It contains a 3-d visualization system to map contaminant plumes, as well as interpolation procedures to estimate contaminated volume.

Remedial Action Decision Support Software

A blank field indicates that the code does not have the capability to model that field.

	RAAS	RACER	CURE
Developer/Vendor	DOE contact: Pacific Northwest National Laboratory 3320 Q Ave. Richland, WA 99352 http://mepas.pnl.gov:280/raas All others: Battelle Press 505 King Avenue Columbus, OH	Delta Research Corp. 1501 Merchants Way Niceville, FL 32578	Sandia National Laboratories Environmental Risk Assessment and Regulatory Analysis Dept. PO Box 5800, MS0720 Albuquerque, NM 87185-0720
Point of Contact	Janet Bryant PNNL 509-375-3765	Les Rose 904-897-5380 www.deltabtg.com	Robert Knowlton 505-844-8533 Ken Sorenson 505-844-0074
Platform	Windows	Windows	Windows ’95, NT
DSS Function			
Remedy Selection	●	⊙	
Remedial Design	⊙		
Economic Analysis	⊙	●	●
Contaminants			
Organic	●	⊙	⊙
Inorganic	●	⊙	⊙
Mixed Organic/Inorganic	●	⊙	⊙
Radioactive	●	⊙	⊙
Mixed LLW	●	⊙	⊙
Mixed TRU	●	⊙	⊙
Sanitary			
Energetics	□	⊙	⊙
Phase*			
Gas	●	□	
Liquid	●	□	
Non-Aqueous Phase	⊙	□	
Site Environmental			
Vadose	●		
Saturated	●		
Extreme environmental conditions (pH, fracture flow, etc.)	⊙		

Remedial Action Decision Support Software

A blank field indicates that the code does not have the capability to model that field.

	RAAS	RACER	CURE
Remedial Alternatives:			
Containment			
Cut-off Walls	●	⊙	⊙
Hydraulic	●	⊙	⊙
Caps	●	⊙	⊙
Other	●	⊙	⊙
In-situ treatment			
Natural attenuation	●	⊙	⊙
Biological	●	⊙	⊙
Physical/chemical	●	⊙	⊙
Ex-situ treatment			
Biological	●	⊙	
Physical/Chemical	●	⊙	
Thermal	●	⊙	
Class of Problems			
RCRA	●	●	⊙
CERCLA	●	●	⊙
UMTRA	I	●	●
LLW	⊙	●	⊙
Other Technical Criteria:			
Data Visualization	□	□	□
Complexity	□	⊙	⊙
Usage	> 125 DOE, EPA, DOD and industry users	> 1500 users. DOD, DOE EPA accepted. Developed by Air Force.	Used at SNL and various UMTRA sites. Developed in part to support UMTRA type problem solving.
Stage of Development	Final Version 1.1 Annual updates. Peer reviewed by independent panel.	Version 3.2. Upgrade cost database every 2 year. Numerous adds on available and under development.	Beta Version. Draft user manual available. Version 1.0 in ’97.
Cost Range	DOE = $0 full support. Other Public Sector $250 no support. Private = $1,950 full support.	$750 for DOE, $1300 for non-DOE contractors. Cover software, 2 day training session and upgrades. Individual becomes the license holder.	Free to Public Sector.

Remedial Action Decision Support Software

A blank field indicates that the code does not have the capability to model that field.

	RAAS	RACER	CURE
Comments	2-3day training session recommended. Utilizes ReOpt and MEPAS. Designed to support RI/FS efforts.	Primarily a parametric cost estimating tool but can easily be bundled with CADD or other DSS to add risk assessment, visual displays, and sampling. Can generate simple default sampling field programs. Can develop costs associated with sampling tritium.	A modification of RACER. A sensitivity analysis is used to assess the importance of RACER unit operation primary variables, relative to impact on overall project cost. Utilizes a Monte Carlo/Latin Hypercube sampling method to quantify uncertainty. Currently focuses on ground water.

Remedial Action Decision Support Software

A blank field indicates that the code does not have the capability to model that field.

	Bio-SVE	**MARS**	**SELECT**
Developer/Vendor	Vendor: Scientific Software Group P.O. Box 23041 Washington, DC 20026-3041	Developer DAEM Vendor P.O. Box 23041 Washington, DC 20026-3041	Ernest Orlando Lawrence Berkeley National Laboratory 1 Cyclotron Rd. Berkeley, CA 94720
Point of Contact	http://www.scisoftware.com	703-620-9214 http://www.scisoftware.com	http://omega.lbl.gov:80/select/I
Platform	windows	windows	Windows or Unix
DSS Function			
Remedy Selection	☐	☐	⊙
Remedial Design	☐	☐	
Economic Analysis			●
Contaminants			
Organic	●	●	●
Inorganic		I	●
Mixed Organic/Inorganic		I	●
Radioactive		I	●
Mixed LLW		I	●
Mixed TRU		I	I
Sanitary		I	I
Energetics		I	I
Phase*			
Gas	●		●
Liquid	●	●	●
Non-Aqueous Phase	⊙	●	I
Site Environmental			
Vadose	●		●
Saturated	●	●	●
Extreme environmental	I	⊙	I
Remedial Alternatives:			
Containment			
Cut-off Walls			
Hydraulic	☐	⊙	
Caps			

Remedial Action Decision Support Software

A blank field indicates that the code does not have the capability to model that field.

Other			
	Bio-SVE	**MARS**	**SELECT**
In-situ treatment			
Natural attenuation	●	⊡	●
Biological	⊡	⊡	●
Physical/chemical	⊡		⊡
Ex-situ treatment			
Biological			
Physical/Chemical			
Thermal			
Class of Problems			
RCRA	●	I	I
CERCLA	●	I	I
UMTRA		I	I
LLW		I	I
Other Technical Criteria:			
Data Visualization	□	●	⊡
Complexity	●	●	⊡
Usage	Commercially available. Manual and support from Scientific Software.	Commercially available.	Insufficient Information to determine.
Stage of Development	Commercially available.	Commercially available. Utilizes finite element model BIOF&T-3D.	Prototype with partial capabilities is available. Uses EPA and CAL EPA RA databases.
Cost Range	Available for a fee.		? Assumed to be public domain.
Comments	Designed to address a release of hydrocarbons. Can model free product recovery, SVE, and natural or engineered bioremediation. Typical physicochemical properties data files for gasoline are provided. Utilizes Johnson, et al., equilibrium model.	Models areal coupled flow of LNAPL and aqueous transport of up to 5 species in ground water. Can simulate recovery and migration of LNAPL and ground water in heterogeneous and/or anisotropic fractured or porous media. Geared primarily towards hydrocarbons.	Allows for easy updating/modification of database information. Has a limited number of pre-set treatment trains. Plan to link to RACER/ENVEST. Goal is to focus on selecting cost-effective environmental remediation that maximizes health risk reduction.

● Highest level of model robustness

⦿ Intermediate level of model robustness

☐ Lowest-level of model robustness

I Insufficient information available to make an evaluation.

A blank field indicates that the code does not have the capability to model that field.

* Contaminants have been divided into different phases for transport since this may effect model selection. For example, organic contaminants may exist in the gas phase, liquid phase (i.e. dissolved substance), or as a separate non-aqueous phase. The selection of an appropriate DSS code would depend on the phase in which the contaminant exists, not the fact that it is an organic contaminant.

4.0 SITE CHARACTERIZATION/ RISK ASSESSMENT DECISION SUPPORT SOFTWARE

The screening level review covers the following major areas:

- DSS developer and contact
- Contaminants addressed
- Site environmental characteristics considered
- Plume characteristics
- Risk assessment characteristics
- Class of problems (regulatory criteria addressed)
- Other miscellaneous technical criteria (visualization tools, stage of development, usage, etc.)

The detailed criteria used to rate each of the above areas are provided in the Glossary in Chapter 2. In general, software that could handle a wide range of problems was rated higher than those that could not. This review does not evaluate technical limitations, nor does it imply that there are technical limitations in the software.

The information provided was obtained from vendor supplied literature, review of related web sites and, in some cases, telephone interviews with code developers. Telephone interviews were found to provide the most and the best information about the different packages. Vendor literature was often not detailed enough to make a clear evaluation of all aspects found in the table. Interviews were conducted with the vendors and/or developers of the DSS packages GANDT, GMS, OPTMAS, PLUME, PRECIS, RAAS, SADA, SEDSS, SitePlanner, and SmartSampling. A table evaluating the software listed below is located immediately after the list.

API-DSS American Petroleum Institute-Decision Support System for Exposure and Risk Assessment, V 1

Software evaluates site-specific risks, identifies needs for site remediation, assists with development of site cleanup levels, and evaluates uncertainty in risks due to uncertainties in the data using a Monte Carlo type analysis. At present, it is limited to simulating only five chemicals at a time and the chemicals are all associated with the petroleum industry (e.g. the list contains sixteen hydrocarbons, six petroleum additives, and three metals). In addition, it performs probabilistic risk calculations, but is not automated to compare alternative scenarios.

GANDT Ground water analysis and network design tool (formerly, BOSS Borehole Optimization Support System) is software that will help determine the optimum number and location of boreholes and monitoring wells necessary to define the nature and extent of contamination. Monte Carlo uncertainty analysis of flow and

transport is used to simulate migration from the site and, thereby, optimize monitoring network design. Simulation of vapor phase transport in the vadose zone for VOCs and ground water flow are permitted. Spatial variability in transport properties (e.g. hydraulic conductivity) are modeled using geostatistical routines.

GMS — GMS is a graphical visualization tool for ground water modeling. It assists in mesh and grid generation, visualization of results, preparing input files for flow and transport codes, and geostatistical data analysis. Although developed for ground water modeling applications, it is general in structure, and may be useful for many two and three-dimensional models. GMS as a stand alone platform is not geared towards decision support. It could provide analysis for pump layout optimization similar to BOSS or PLANET, or geostatistical data analysis.

MAPER — Multi-sensor Analysis Program for Environmental Remediation is a tool that combines data from several geophysical techniques to optimize the definition of the subsurface. It can be used to better define subsurface features and, thereby, assist in estimating contaminant volume and sensor placement.

MARS — Multi-phase areal flow ground water modeling system simulates recovery and migration of LNAPL and ground water. Assists in remedy selection for LNAPL contamination problems.

MODLP — A linear optimization program for calculating capture zones to define well emplacement. This work is an extension of the MODFLOW computer code.

OPTMAS — Optimization Program to Minimize Analytical Sampling is a software tool that uses geostatistical simulations and optimization theory to predict the locations for obtaining soil samples required to estimate the nature and extent of surface soil contamination.

PLANET — Pump Layout and Evaluation Tool is designed for examining various pump and treat options. PLANET is connected MODFLOW, to perform water flow analysis, and to MT3D to perform transport analysis, with a Graphical User Interface to provide a simple procedure to move wells for different simulations and to visualize the data.

PLUME — This computer code evaluates current plume locations based on sparse

data. Geostatistical techniques are used to evaluate the probability of contamination levels exceeding certain values. The calculated concentration levels and uncertainties are used to guide sampling plans.

PRECIS — Probabilistic Risk Evaluation and Characterization Investigation Systems helps conduct a probabilistic assessment to quantify risk and uncertainty in the projection of risk to human receptors. The code is an extension of the RESRAD code which performs the evaluation of dose or risk and includes a Latin Hypercube sampling routine and other data handling routines to permit probabilistic simulation. Improvements to the RESRAD code include incorporation of over 150 hazardous chemicals in the data base, addition of a ground water transport model to simulate contaminant migration, improved sensitivity analysis, dermal exposure analysis, and automatic documentation of the assumptions used in the model. It was developed to support UMTRA type problems.

RAAS — Remedial Action Assessment System was developed at Pacific Northwest Laboratory. RAAS consists of two codes, ReOpt and MEPAS. ReOpt contains an extensive data base on remediation technologies and regulatory information. It has an expert system which can be used to develop a short list of remedial alternatives applicable for a given site. MEPAS contains models to estimate risk due to exposure from air, ground water, surface water, or soil. RAAS was developed to address Remedial Investigation/Feasibility Studies performed as part of CERCLA analysis.

SADA — Spatial Analysis and Decision Assistance is a Windows based software tool that combines geostatistical techniques, decision methods, and visualization tools to provide quantitative risk-based analysis to support decisions. SADA can estimate costs associated with various cleanup levels, estimate cleanup volumes, assist in sampling design, and perform human health risk assessment.

SEDSS — Sandia Environmental Decision Support Software is a platform to assist decision makers in determining if compliance objectives can be met. It contains a data base of compliance objectives for EPA superfund sites, NRC low-level waste sites, and uranium mill tailings sites. It uses a series of modules to assist in conceptual model development, data evaluation, fate and transport analysis, sensitivity analysis, data worth analysis, and decision making. SEDSS automatically documents assumptions used. Decision analysis is based

on probabilistic risk based criteria. Currently, it addresses only the ground water pathway in the analysis.

SELECT — A decision support tool directed to evaluation of air and water quality. It has the capabilities to perform site characterization and visualization, subsurface and atmospheric fate and transport, risk assessment, and cost evaluation of different remedial options.

SitePlanner — SitePlanner assists in the development of data collection plans. It contains a 3-d visualization system to map contaminant plumes, as well as interpolation procedures to estimate contaminated volume.

SmartSampling — This DSS performs economic risk-based decision analysis. The process uses visualization tools, geostatistical software, and data management systems. It can be used to guide site characterization. It can estimate the probability that contamination exceeds a certain value, and use this information to choose between design strategies, in order to minimize cost and maximize the probability of compliance. It includes data visualization and cost functions, and documents assumptions used in the analysis.

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Site Characterization and Risk Assessment Decision Support Software

	GANDT **Ground Water Analysis and Network Design Tool**	**GMS** **DOD Ground Water Modeling System**	**PLUME**
Developer/Vendor	Sandia National Laboratories Environmental Risk Assessment and Regulatory Analysis Dept. PO Box 5800, MS0720 Albuquerque, NM 87185-0720	*Developer*: Brigham Young University and U.S. Army Engineer Waterways Experiment Station *DOE/DOD/EPA Vendor:* U.S. Army Engineer Waterways Experiment Station, CHG, 3909 Halls Ferry Rd, Vicksburg, MS 39180 *Public Sector Vendor:* Scientific Software Group PO Box 23041 Washington, DC 20026	Public Sector: Argonne National Laboratory EAD/Bldg. 900 9700 S. Cass Ave. Argonne, IL 60439 Commercial: ConSolve, Inc. 297 Boston Post Rd Suite 203 Wayland, MA 01778 508-358-8061
Point of Contact	Robert Knowlton 505-844-8533 Ken Sorenson 505-844-0074	*DOE/DOD/EPA Vendor*: www.hlnet.wes.army.mil/software/interfaces/GMS *Public Sector Vendor*: Kim Barlay (703) 620-9214	Robert Johnson 708-252-7004 Jack Ditmars 708-252-5953
Platform	Windows or Mac	Windows or UNIX	Sun SparcStation PC compatible with SCO Unix
DSS Function			
Site Characterization	●	⊙	⊙
Plume Characterization	●	●	
Risk Assessment			
Contaminant Characteristics:			
Organic	●	□	□
Inorganic	●	□	□
Mixed Organic/Inorganic	●	□	□
Radioactive	●	□	□
Mixed LLW	●	□	□
Mixed TRU	●	□	□
Sanitary		□	□

Site Characterization and Risk Assessment Decision Support Software

	GANDT **Ground Water Analysis and Network Design Tool**	**GMS** **DOD Ground Water Modeling System**	**PLUME**
Energetics	●	□	□
	GANDT **Ground Water Analysis and Network Design Tool**	**GMS** **DOD Ground Water Modeling System**	**PLUME**
Phase*			
Gas	●	⊙	
Liquid	●	●	
Non-Aqueous Phase	⊙		
Site Environmental Characteristics			
Vadose	●	□	□
Saturated	●	⊙	□
Extreme Environmental Characteristics (e.g. pH, fracture flow etc.)			□
Site and Plume Characterization Issues			
Data Fusion	□	□	●
Interface with flow codes	●	●	●
Sampling Guidance	⊙		●
Data Plausibility	□		□
Data Worth	●		●
Data Visualization			
Surface Structures	●	●	□
Hydrologic structure	●	●	□
Buried Objects	●	●	□
Plume Visualization	●	●	□
Risk Assessment Issues			
Class of Problems			
RCRA	●	□	⊙
CERCLA	●	□	●
UMTRA	●	□	⊙

Site Characterization and Risk Assessment Decision Support Software

LLW	●	□	⊡
Exposed Group			
Public			
Worker			

Site Characterization and Risk Assessment Decision Support Software

	GANDT **Ground Water Analysis and Network Design Tool**	**GMS** **DOD Ground Water Modeling System**	**PLUME**
Other Technical Criteria:			
Complexity	☐	☐	☐
Usage	Used at SNL.	More than 700 users in public and private sector. Widely accepted. Models are peer reviewed.	6-12 users (DOE, EPA, Army). Has been used at a number of DOE facilities (ANL, SNL, BNL).
Stage of Development	Beta version available. Version 1.0 available in '97.	General release Version 2.1 due summer '97. DOE, DOD, EPA participated in the development.	Version 1.2 is available. Beta Windows version. Underlying methodologies have been peer reviewed.
Cost Range	Free to Public Sector.	Free to on-site DOE, DOD, EPA users.	Free to DOE.
Comments	Optimizes the number and placement of monitoring wells to delineate the nature and extent of contamination utilizing a probabilistic framework which incorporates a Monte Carlo analysis. Models static conditions. Utilizes GSLIB. Plan to add capabilities to evaluate ground water remediation alternatives as they pertain to UMTRA.	High performance data visualization package. Integrates 10 task oriented modules. Acts as interface to widely used models (MODFLOW, MT3D, MODPATH, FEMWATER). Additional models regularly added. V. 2.1 will include SEEP2D. Developers have engineering and science backgrounds.	Allows integration of secondary data. Uses a combination of Bayesian and spatial statistics. Can directly be integrated with data management and visualization tools such as Site Planner, Xess, Geo-EAS, XDataSlice.

Site Characterization and Risk Assessment Decision Support Software

	PRECIS **Probabilistic Risk Evaluation and Characterization Investigation System**	**RAAS** **Remedial Action Assessment System**	**SEDSS** **Sandia Environmental Decision Support System**	**Smart Sampling**
Developer/Vendor	Sandia National Laboratories Environmental Risk Assessment and Regulatory Analysis Dept. PO Box 5800, MS0720 Albuquerque, NM 87185-0720	DOE contact: Pacific Northwest National Laboratory 3320 Q Ave. Richland, WA 99352 http://mepas.pnl.gov:280/raas All others: Battelle Press 505 King Avenue Columbus, OH	Sandia National Laboratories Environmental Risk and Decision Analysis PO Box 5800, MS-1345 Albuquerque, NM 87185-1345 http://www.nwer.sandia.gov/sedss/sedss/html	Sandia National Laboratories PO Box 5800, MS-1345 Albuquerque, NM 87185-1345 http://www.nwer.sandia.gov/sample/index.html
Point of Contact	Robert Knowlton 505-844-8533 Ken Sorenson 508-844-0074 SNL	Janet Bryant 509-375-3765	David Gallegos, Technical Project Manager 505-848-0761 dpgalle@nwer.sandia.gov	Paul Kaplan 505-848-0684 pgkapla@nwer.sandia.gov
Platform	Windows and Mac	Windows	Unix (Sun Sparcstation)	Windows and/or Unix
DSS Function				
Site Characterization		●	●	□
Plume Characterization		●	●	□
Risk Assessment	⊙	⊙	□	
Contaminant Characteristics:				
Organic	●	●	●	□
Inorganic	●	●	●	□
Mixed Organic/Inorganic	●	●	●	□
Radioactive	●	●	●	□
Mixed LLW	●	●	●	□
Mixed TRU	●	●	●	□
Sanitary				□
Energetics	●	□		□
Phase*				
Gas	●	●		
Liquid	●	●	⊙	

Site Characterization and Risk Assessment Decision Support Software

Non-Aqueous Phase	⊙	⊙		
	PRECIS **Probabilistic Risk Evaluation and Characterization Investigation System**	**RAAS** **Remedial Action Assessment System**	**SEDSS** **Sandia Environmental Decision Support System**	**Smart Sampling**
Site Environmental Characteristics				
Vadose	●	●	●	□
Saturated	●	●	●	□
Extreme Environmental Characteristics (e.g. pH, fracture flow etc.)		⊙		□
Site and Plume Characterization Issues				
Data Fusion	□	□	⊙	●
Interface with flow codes		⊙	□	⊙
Sampling Guidance			●	●
Data Plausibility	□	⊙	⊙	□
Data Worth	●		●	●
Data Visualization				
Surface Structures	⊙	⊙	□	⊙
Hydrologic structure		⊙	□	⊙
Buried Objects		⊙	□	⊙
Plume Visualization	□		□	●
Risk Assessment Issues				
Class of Problems				
RCRA	●	●	●	●
CERCLA	●	●	●	●
UMTRA	●	I	●	●
LLW	●	⊙	●	●
Exposed Group				
Public	●	●	⊙	
Worker	●	⊙	□	
Other Technical Criteria:				
Complexity	⊙	□	⊙	□

Site Characterization and Risk Assessment Decision Support Software

Usage	Widely used at the SNL facility.	> 125 DOE, EPA, DOD and industry users.	Beta version in use by sponsors: EPA, NRC, DOE.	Process has been used at a number of DOE facilities by SNL and has strong interest from industry.
	PRECIS **Probabilistic Risk Evaluation and Characterization Investigation System**	**RAAS** **Remedial Action Assessment System**	**SEDSS** **Sandia Environmental Decision Support System**	**Smart Sampling**
Stage of Development	Beta version available. Version 1.0 should be available before the end of '97. Uses EPA guidance and RESRAD code.	Final Version 1.1. Annual updates. Peer reviewed by independent panel.	Currently under development. Beta Version 1.0 has partial capabilities of full system. Beta release can conduct probabilistic dose, concentration, risk and hazard assessment, sensitivity and data worth analysis. PC version and other upgrades are planned.	10 years in development. Uses DSS tools from Stanford Center for Reservoir Forecasting. Utilizes GSLIB, which is updated every 2 years. Has been used by OH EPA and at Mound Facility. A robust process for skilled analyst.
Cost Range	Free to Public Sector.	DOE = $0 full support. Other Public Sector $250 no support Private = $1,950 full support	Planned to be Public Domain.	2-4 day required training session ~$1,000.

Site Characterization and Risk Assessment Decision Support Software

	PRECIS **Probabilistic Risk Evaluation and Characterization Investigation System**	**RAAS** **Remedial Action Assessment System**	**SEDSS** **Sandia Environmental Decision Support System**	**Smart Sampling**
Comments	Includes sensitivity analysis method to prioritize the site characterization needs based on the relative importance of a parameter to the uncertainty in risk. Utilizes a Monte Carlo/ Latin Hypercube Sampling method to quantify uncertainties in risk and soil concentration thresholds. Can readily be converted to a Unix based program. Can address tritium. Models static conditions.	2-3day training session recommended. Utilizes ReOpt and MEPAS. Designed to support RI/FS efforts.	SEDSS is both a methodology/frame work and software tool. Provides a framework for making consistent, technically defensible and traceable decisions. Support and training directly from developers. Can support analysis of uncertainty and costs associated with remediation.	This is a process that utilizes various DSS, not a specific DSS itself. Provides methodology for real time analysis of data for field teams to adjust sampling program. Geostatistical simulation techniques are applied to existing site data to generate maps modeling probability of exceeding cleanup threshold. The maps can be used to determine optimal sampling locations.

Site Characterization and Risk Assessment Decision Support Software

	OPTMAS **Optimization Program to Minimize Analytical Sampling**	**SADA** **Spatial Analysis and Decision Assistance**	**SitePlanner**	**MAPER** **Multi-Sensor Analysis Program for Environmental Restoration**
Developer/Vendor	Sandia National Laboratories Environmental Risk Assessment and Regulatory Analysis Dept. PO Box 5800, MS0720 Albuquerque, NM 87185-0720	Oak Ridge National Laboratories 1060 Commerce Park Drive Oak Ridge, TN 37830 University of Tennessee will hold copyright	Public Sector: Argonne National Laboratory EAD/Bldg. 900 9700 S. Cass Ave. Argonne, IL 60439 Commercial: SiteView ConSolve, Inc. 297 Boston Post Rd. Suite 203 Wayland, MA 01778	New Mexico State University Las Cruces, NM 88003-0001 Physical Science Laboratory Las Cruces, NM 88003-002
Point of Contact	Robert Knowlton 505-844-8533 Ken Sorenson 508-844-0074 SNL	Robert Stewart Oak Ridge National Laboratories 423-241-5741 U74@ornl.gov	Robert Johnson 708-252-7004 Jack Ditmars 708-252-5953	R. Wayner McCorkie New Mexico State 505-646-5733 Greg Moran Physical Science Laboratory 505-522-9276 http://www.nmsu.edu/~ecl/
Platform	Windows and Mac	Windows ‘95	Sun SparcStation PC compatible with SCO Unix	I
DSS Function				
Site Characterization	●	●	□	●
Plume Characterization		□		□
Risk Assessment		⊡		
Contaminant Characteristics:				
Organic		●		I
Inorganic		●		I
Mixed Organic/Inorganic		●		I
Radioactive		●		I
Mixed LLW		⊡		I
Mixed TRU		I		I
Sanitary				I

Site Characterization and Risk Assessment Decision Support Software

	OPTMAS **Optimization Program to Minimize Analytical Sampling**	**SADA** **Spatial Analysis and Decision Assistance**	**SitePlanner**	**MAPER** **Multi-Sensor Analysis Program for Environmental Restoration**
Energetics		I		I
	OPTMAS **Optimization Program to Minimize Analytical Sampling**	**SADA** **Spatial Analysis and Decision Assistance**	**SitePlanner**	**MAPER** **Multi-Sensor Analysis Program for Environmental Restoration**
Phase*				
Gas				☐
Liquid				☐
Non-Aqueous Phase				I
Site Environmental Characteristics				
Vadose	⊙	☐		⊙
Saturated		☐		⊙
Extreme Environmental Characteristics (e.g. pH, fracture flow etc.)				I
Site and Plume Characterization Issues				
Data Fusion	☐	☐	☐	●
Interface with flow codes	●	●	●	I
Sampling Guidance	⊙	⊙		●
Data Plausibility	☐			I
Data Worth	●	●		●
Data Visualization				
Surface Structures	☐	☐	●	●
Hydrologic structure		☐	●	●
Buried Objects		☐	●	●
Plume Visualization	☐	☐	●	⊙
Risk Assessment Issues				
Class of Problems				
RCRA	●	●	●	I
CERCLA	●	●	●	I
UMTRA	●	☐	●	I
LLW	●	☐	●	I

Site Characterization and Risk Assessment Decision Support Software

Exposed Group				
Public		●		
Worker		●		
	OPTMAS **Optimization Program to Minimize Analytical Sampling**	**SADA** **Spatial Analysis and Decision Assistance**	**SitePlanner**	**MAPER** **Multi-Sensor Analysis Program for Environmental Restoration**
Other Technical Criteria:				
Complexity	⊙	□	●	●
Usage	Used at SNL.	ORNL is using SADA on a limited basis. Beta release scheduled for 10/97.	Has been used at a number of DOE facilities (ANL, SNL, BNL).	Designed for application in the field.
Stage of Development	Beta version available.	Beta release 10/97 primarily to DOE. Uses EPA risk assessment model and GSLIB.	Final. 100+ users. Most new users are utilizing the Windows based SiteView.	Insufficient information to evaluate.
Cost Range	Free to Public Sector	Free to DOE	Free to DOE	Public domain
Comments	Tool to optimize the placement of surface soil sampling locations to delineate nature and extent of contamination using geostatistical models in a probabilistic framework. Incorporates Monte Carlo simulations.	Modular design allows for easy expansion of capabilities. Working on expanding sampling optimization component and adding secondary information analysis. Can readily import and export data. Presents steady state conditions. Operator should be familiar with geostatistics.	Graphical object-oriented database. Can store and display any type of data that is discrete with spatial coordinates. Can import/export from spreadsheets, AutoCad, ArcInfo, and Plume. Can calculate quantities and coordinates. SiteView is more user friendly and has better graphics but cannot complete calculations as well.	Allows the analysis of multiple data types, and yields an optimal estimate of the distribution of subsurface materials. Achieves a hybrid inversion through a joint optimization algorithm.

Site Characterization and Risk Assessment Decision Support Software

	API-DSS **American Petroleum Institute Exposure and Risk Assessment DSS**	**MODLP**	**PLANET**	**SELECT**
Developer/Vendor	Developer: Dr. Atul Salhotra and Woodward-Clyde Consultants Vendor: Geraghty and Miller, Inc. Modeling Group 1131 Benfield Boulevard, Suite A Millersville, MD 21108	Research Center for Ground water Remediation Design 109 Votey Building University of VT Burlington, VT 05405-0156 http://www.rcgrd.uvm.edu	Ernest Orlando Lawrence Berkeley National Laboratory 1 Cyclotron Rd. Berkeley, CA 94720	Ernest Orlando Lawrence Berkeley National Laboratory 1 Cyclotron Rd. Berkeley, CA 94720
Point of Contact	Karen Crow 410-987-0032 www.gmgw.com	George Pinder 802-656-8697	I? www.erd.llnl.gov	http://omega.lbl.gov:80/select/I
Platform	Windows	I	Windows	Windows or Unix
DSS Function				
Site Characterization			⊙	⊙
Plume Characterization	⊙	⊙		●
Risk Assessment	⊙			⊙
Contaminant Characteristics:				
Organic	●	●	I	●
Inorganic	●	I	I	●
Mixed Organic/Inorganic	●	I	I	●
Radioactive		I	I	●
Mixed LLW		I	I	●
Mixed TRU		I	I	I
Sanitary		I	I	I
Energetics		I	I	I
Phase*				
Gas	●		I	●
Liquid	●	⊙	⊙	●
Non-Aqueous Phase	I	I	I	I
Site Environmental Characteristics				
Vadose	●	I		●
Saturated	●	⊙	⊙	●
Extreme Environmental Characteristics (e.g. pH, fracture flow etc.)	I	I	I	I

Site Characterization and Risk Assessment Decision Support Software

	API-DSS **American Petroleum Institute Exposure and Risk Assessment DSS**	**MODLP**	**PLANET**	**SELECT**
Site and Plume Characterization Issues				
Data Fusion	I	I	I	I
Interface with flow codes	I	●	⊙	●
Sampling Guidance			●	I
Data Plausibility	I	I	I	●
Data Worth		I	●	I
Data Visualization				
Surface Structures	I	I	I	⊙
Hydrologic structure	I	I	I	⊙
Buried Objects	I	I	I	⊙
Plume Visualization	□	⊙	●	●
Risk Assessment Issues				
Class of Problems				
RCRA	I	I	I	I
CERCLA	I	I	I	I
UMTRA	I	I	I	I
LLW	I	I	I	I
Exposed Group				
Public	●			●
Worker	●			●
Other Technical Criteria:				
Complexity	●	⊙	I	⊙
Usage	I	Used by LLNL	Used at LLNL.	I
Stage of Development	Commercially available with technical support from Geraghty and Miller.	Final version available. Sponsored by LLNL.	No support available.	Prototype with partial capabilities is available. Uses EPA and CAL EPA RA databases.
Cost Range	$600	? Assumed to be public domain	I	? Assumed to be public domain

Site Characterization and Risk Assessment Decision Support Software

	API-DSS **American Petroleum Institute Exposure and Risk Assessment DSS**	**MODLP**	**PLANET**	**SELECT**
Comments	Utilizes physical, chemical, and toxicological property data risk. Comes set up with petroleum related compounds. User can add up to 75 compounds. Can be implemented in a deterministic or Monte Carlo mode.	Uses the MODFLOW program with a linear programming wrapper. Helps with the design of capture zones for controlling the movement of contaminated water.	Designed to select optimal well placement for pump and treat. Utilizes MODFLOW and MT3D.	Allows for easy updating/modification of database information. Uses T2VOC to simulate transport. Goal is to focus on selecting cost-effective, environmental remediation that maximizes health risk reduction.

Site Characterization and Risk Assessment Decision Support Software

	MARS **Multi-phase Areal Remediation Simulator**
Developer/Vendor	Developer DAEM Vendor P.O. Box 23041 Washington, DC 20026-3041
Point of Contact	703-620-9214 http://www.scisoftware.com
Platform	windows
DSS Function	
Site Characterization	
Plume Characterization	●
Risk Assessment	
Contaminant Characteristics:	
Organic	●
Inorganic	
Mixed Organic/Inorganic	
Radioactive	
Mixed LLW	
Mixed TRU	
Sanitary	
Energetics	
Phase*	
Gas	
Liquid	●
Non-Aqueous Phase	●
Site Environmental Characteristics	
Vadose	
Saturated	●
Extreme Environmental Characteristics (e.g. pH, fracture flow etc.)	⊙
Site and Plume Characterization Issues	
Data Fusion	□
Interface with flow codes	●
Sampling Guidance	
Data Plausibility	⊙
Data Worth	
Data Visualization	
Surface Structures	I

Site Characterization and Risk Assessment Decision Support Software

	MARS Multi-phase Areal Remediation Simulator
Hydrologic structure	●
Buried Objects	I
Plume Visualization	●
Risk Assessment Issues	
Class of Problems	
RCRA	I
CERCLA	I
UMTRA	I
LLW	I
Exposed Group	
Public	
Worker	
Other Technical Criteria:	
Complexity	●
Usage	Commercially available
Stage of Development	Commercially available. Utilizes finite element model BIOF&T-3D
Cost Range	I
Comments	Models coupled flow of LNAPL and aqueous transport of up to 5 species in ground water. Can simulate recovery and migration of LNAPL and ground water in heterogeneous and/or anisotropic fractured or porous media. Geared primarily towards hydrocarbons.

● Highest level of model robustness
⊡ Intermediate level of model robustness
□ Lowest-level of model robustness
I Insufficient information available to make an evaluation.
A blank field indicates that the code does not have the capability to model that field.

* Contaminants have been divided into different phases for transport since this may effect model selection. For example, organic contaminants may exist in the gas phase, liquid phase (i.e. dissolved substance), or as a separate non-aqueous phase. The selection of an appropriate DSS code would depend on the phase in which the contaminant exists, not the fact that it is an organic contaminant.

REFERENCES

Sullivan, T.M., Moskowitz, P.D, Gitten, M., and Schaffer, S., “Environmental Decision Support Software Identification and Preliminary Review”, BNL-66384, November, 1996.