PNL-SA-18139

PNL-SA--18139

DE91 004650

BRIEFING PAPER -- REMEDIAL ACTION ASSESSMENT SYSTEM

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April 1990

Work Supported by
the U. S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

BRIEFING PAPER

Revision 1

REMEDIAL ACTION ASSESSMENT SYSTEM (RAAS)

A. NEED

Congress has mandated a more comprehensive management of hazardous wastes with the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund") and the Superfund Amendment and Reauthorization Act (SARA). This mandate includes restoration of disposal sites contaminated through past disposal practices. This mandate applies to facilities operated for and by the Department of Energy (DOE), just as it does to industrial and other institutions. To help implement the CERCLA/SARA remedial investigation and feasibility study (RI/FS) process in a consistent, timely, and cost-effective manner, a methodology needs to be developed that will allow definition, sorting, and screening of remediation technologies for each operable unit (waste site). This need is stated specifically in Section 2.2.2.1 of the October 1989 Applied Research, Development, Demonstration, Testing, and Evaluation (RDDT&E) Plan of the DOE. This Briefing Paper is prepared to respond to this need.

The first step in the feasibility study process is the initial identification of methods of treatment of the contaminants (Phase I of the feasibility study). These treatments may include technologies that reduce or destroy the toxic properties, significantly reduce the volume of contaminants, or by some means eliminate further transport of the contaminants. The various technologies are then screened and combined into "treatment trains," with each "train" being a remedial alternative. Each remedial alternative is then screened using a number of criteria such as effectiveness, implementability, and cost. The remedial alternatives remaining are further evaluated based on results from further site characterization, results of treatability testing, and further refinement of the other screening criteria. This final phase is Phase III of the feasibility study and leads to the Record of Decision (ROD).

In summary, a methodology for screening of remedial alternatives is needed to ensure that the appropriate environmental issues are addressed and that only the most appropriate remedial alternatives are highlighted for final consideration. Remedial action alternatives need to be investigated in a consistent and defensible methodology by 1) integrating unit processes into treatment trains, and 2) evaluating viability of each remedial alternative. For the latter, performance, reliability, implementability, short- and long-term effectiveness, clean-up standards (i.e., Applicable or Relevant and Appropriate Requirements - ARARs), reduction in contaminant risk and mobility, and cost need to be considered. Although it may take 3 years for the methodology to be fully developed, accepted, and deployed, it will be available for use on the vast majority of DOE operable units. For example, the schedule required for completing these activities at Hanford is 16 years (*Proposed Action Plan for Implementation of the Hanford Federal Facility*

Agreement and Consent Order, February 1989); therefore, the methodology will be available in time to support these activities.

B. TECHNICAL SOLUTION

The objective of this project is to develop a computer-based methodology that will accelerate the RI/FS process at DOE sites that are subject to control under CERCLA. It is also intended to accelerate the corrective measures studies for inactive sites under RCRA control. As part of the methodology, the identification of remediation schemes from established technologies for each operable unit will be traceable and consistent from unit to unit and site to site. Thus, a number of DOE offices will benefit from the development of such a technical tool for the implementation of the RI/FS process. These include those offices that are responsible for the management of CERCLA sites programs such as the Office of Environmental Restoration and Waste Management (DOE-EM), as well as those offices responsible for assistance and oversight such as the Office of Environmental Guidance and Compliance.

The initiative described in this briefing paper is the development of the Remedial Action Assessment System (RAAS). This methodology will screen the full spectrum of acceptable treatment technologies, link the technologies into remedial alternatives, and identify the most attractive remedial alternatives necessary to reduce the health risk to an acceptable level. RAAS will aid the user in performing the feasibility study under the most current guidance by the Environmental Protection Agency (EPA). In summary, the objective is to develop RAAS to identify and evaluate appropriate alternatives for the remediation of DOE waste units.

Development of the RAAS methodology is presently intended to be led by the Pacific Northwest Laboratory (PNL). However, PNL and Los Alamos National Laboratory (LANL) are currently developing a collaborative effort to integrate PNL's RAAS development with LANL's enhanced cost and scheduling modeling efforts. Since parallel cost and scheduling efforts are proposed to be incorporated into RAAS, a collaborative development activity between PNL and LANL has the potential of saving significant costs (i.e., $1.5M) in out-year activities (i.e., FY 1991 and FY 1992). These cost savings have been reflected in the requested budgets for FY 1991 and FY 1992.

RAAS is supported by DOE-EM as an advisory tool for operable unit managers at DOE field sites. RAAS is an integral part of the risk management system identified in DOE's *Applied Research, Development, Demonstration Testing, and Evaluation (RDDT&E) Plan* by helping to 1) identify remediation technology needs for DOE sites, 2) determine the type of technical data needed to evaluate a new or emerging technology, and 3) evaluate the value-added benefits of a newly developed technology against its established competitors. Furthermore, since the concept of RAAS is important within EPA and the Department of Defense (DOD), this tool will foster interagency communications and possibly even joint development and testing. Finally, RAAS might be used to analyze various mixes of established containment and treatment technologies at complex DOE sites where complete treatment is not practical. This could lend insight to future DOE-EM decisions and to ensure that an adequate balance among containment, separation, removal, pretreatment, treatment, and disposal technologies is available.

The intent of the RAAS is to mimic the feasibility study process in a computer-based methodology. Use of the RAAS methodology will result in a number of time- and cost-reduction benefits to DOE (and EPA). Several of these benefits are:

1. Consistency of documentation--RAAS provides a consistently applied methodology that forces documentation of assumptions and bases for decisions during the feasibility study. The methodology is being designed to be flexible to meet specific user and regulatory agency needs. The documentation is specific to a particular assessment and is automatically provided by the computer. The major advantage of this consistently documented approach is a quality assurance log of all decisions, whether they are made by the user or the computer based on its internal set of rules. This will allow a systematic backtracking of the feasibility study process.

2. Time compression for the RI/FS process and subsequent cost savings--RAAS would result in an acceleration of the RI/FS process. It has been conservatively estimated that the time associated with this process could be reduced by about 1 year. Streamlining the feasibility process by this methodology will also help streamline characterization and treatability test requirements as well as acceptance of the results of the feasibility study by regulatory agencies and the public. As such, it is conservatively estimated to reduce the cost of the RI/FS process by 10 to 20%. The time and cost savings are possible because the RAAS methodology would reduce the staff labor that is anticipated to be required for each operable unit to manually gather technical data on treatment remediation technologies; screen the technologies from an engineering and regulatory basis; link individual technologies into treatment trains (remedial alternatives); and evaluate the effectiveness, implementability, and cost of each remedial alternative. At an estimated cost of $2.5 to $3.5 billion to perform RI/FS at all DOE sites, RAAS could save between $250 and $700 million for an estimated payback of RAAS development costs of between 30 and 80 to 1.

3. Less duplication of effort--Technology data would be available as a starting point of the RI/FS process. RAAS, therefore, eliminates the technology data collection efforts that would be required if the methodology were not available.

4. Early EPA involvement--There would be direct EPA involvement with the intention of gaining that agency's insight, technical experiences, and acceptance. EPA plans to be involved with an oversight committee that provides review and guidance on the technical approach to developing the methodology. PNL intends to involve EPA in utilizing relevant aspects of EPA-developed systems such as the Cost of Remedial Actions (CORA) model in the development of RAAS. Those activities would result in interagency cooperation and support between DOE and EPA.

5. Support of Hanford Tri-Party Agreement Milestone M-15-00--Development of the RAAS methodology is driven by the RI/FS process required by CERCLA. Milestone M-15-00 in the Hanford Federal Facility Agreement and Consent Order (Hanford Tri-Party Agreement) requires that the RI/FS process be completed for all operable units by September 2005. The RAAS methodology would help ensure that the schedule and cost estimates can be met or even compressed, and provide a consistent evaluation from site to site.

In summary, the RAAS methodology is to be a fully integrated, user-friendly system providing a source to receptor analysis with remedial alternative assessment. It will save both time and money for completion of RI/FS processes at DOE facilities. The methodology will provide consistency in screening and selecting remedial actions, including data collection, results, protocol, and documentation. The methodology will also provide defensible and traceable results. The RAAS methodology is to be implemented in a manner to encourage interagency cooperation and support and to reduce duplication of effort.

C. APPROACH

RAAS is to be developed to reduce time and costs associated with conducting remedial action feasibility studies at inactive radioactive, hazardous, and mixed waste sites for the DOE. The approach for developing the methodology is described in this section. The activities described cover the entire development effort for FY 1990, FY 1991, and FY 1992. The technical and project management activities are divided into four main tasks, 1) Remedial Alternatives Data Base, 2) Methodology Development, Testing, and Documentation, 3) Technology Transfer and Training, and 4) Project Management.

TASK 1. REMEDIAL ALTERNATIVES DATA BASE

The objective of this task is to develop a data base of information about the various remedial action technology alternatives to be considered for application at DOE sites. The data will be collected for established technologies, as opposed to those technologies still requiring research, development, and demonstration. These data will be used 1) as the basis for a user-friendly personal computer-based methodology that can be used at each DOE site for identifying and qualitatively assessing appropriate remedial action processes (i.e., air stripping, capping), and 2) as a data source for developing rules for selection of remedial action processes in the methodology to be developed in Task 2.

The technology information data base will be derived primarily from EPA sources (technology reports, technology screening guidance, RI/FS guidance and reports, RODs, etc.) and DOE sources (technical reports, technology data bases, DOE site environmental documents, etc.). The contents of currently existing technology data bases will be evaluated, and to the extent practicable, adapted for the purposes of this task.

Development of the user-friendly personal computer program for accessing the technology data base will be conducted in parallel with the development of the data base. A computer system and software will be selected for this program taking into consideration the types of systems readily available to potential users (DOE sites) and compatibility with the methodology to be developed in Task 2.

A user manual for the personal computer program will be prepared. This documentation will assist the various DOE site users in applying the methodology for identifying and assessing appropriate remedial action technologies for their sites.

In FY 1990, a prototype data base and user-friendly computer system will be developed for external peer review. The prototype will include data for 15 to 20 processes and will demonstrate the primary features of the software developed for accessing the data base. Task 1 will be organized and conducted as three technical subtasks, plus task management activities. The three technical subtasks and their primary content are described in the following sections.

Identification of Processes

This subtask will identify initial processes for inclusion in the data base, review EPA and DOE technology data sources to develop a comprehensive list of processes to be considered for inclusion, prioritize processes for inclusion in the data base, and develop criteria for adding processes to the data base in the future. Conduct of this task may involve subcontracts with Utah State University and selected DOE site contractors.

Development of both the personal computer program for accessing the technology data and the technology selection rules for Task 2 require classifying the various remedial action processes based on a number of features. Each technology will be classified according to such characteristics as:

- contaminants addressed (e.g., volatile organics, heavy metals)
- waste matrix treated (e.g., soil, groundwater)
- treatment objective (e.g, containment, removal, separation)
- treatment type (e.g., physical, chemical, thermal, biological)
- treatment mode (e.g., in situ, at grade, off site).

Determining an appropriate list of classification categories for each of these application characteristics will be one of the initial subtask activities, since these categories will form the basis for developing and organizing the technology data base. These classification categories will be determined as part of developing the comprehensive list of technologies for the data base, since this structure is key to ensuring that a comprehensive list of technologies is developed. This activity will be closely coordinated with Task 2 to ensure that a consistent approach is adopted.

The technology data base will be developed in two phases. This subtask will identify an initial list of processes (perhaps 15 to 20) that includes familiar, commonly used processes (e.g., incineration, capping). To the extent possible, this list will include one or more processes from each treatment type (physical, thermal, etc.), each waste matrix, each treatment mode, and the most prevalent contaminant categories. The initial processes will be selected such that approximately half of them will be appropriate for mixed waste remedial actions. These initial processes will form the basis for the prototype data base and computer access system to be developed in FY 1990.

In parallel with the initial data acquisition activities in the next subtask, this subtask will perform an assessment of EPA RI/FS and Record of Decision reports and DOE data bases and environmental plans to identify a comprehensive list of processes currently deemed suitable for consideration for DOE environmental restoration activities. The processes not included in the first phase for the prototype data base will be prioritized based on technical maturity and likely acceptance for use. Processes from this comprehensive list will be added to the technology data base in the next subtask in a second phase of technology data base development.

Technology Data Base Development

This subtask will collect the detailed data for each process included in the data base and prepare it for access by the personal computer program and use as the basis for selecting and assessing technologies into the methodology developed in Task 2. This subtask may involve subcontracts with Utah State University and selected DOE site contractors.

In addition to containing the classification characteristics described above for each process, the technology data base will contain a variety of information that will assist users in assessing potential remedial action processes. It will also contribute to the selection and assessment of remedial technologies in the methodology developed in Task 2. Examples of the kind of data that will be included for each process are:

- process description
- flow sheet(s)
- waste characterization data requirements
- regulatory constraints
- limiting characteristics
- associated processes for pretreatment, residuals treatment, etc.
- sites where previously used or considered for use
- vendors
- references.

This type of data will be collected for the initial 15 to 20 processes identified by the previous subtask and prepared for inclusion in the prototype data base. A key activity for this subtask will be the review of the data developed for the various technologies to ensure consistency and appropriate technical content. This may involve both internal and external peer review of the material.

The magnitude of the effort required to complete data acquisition and review for this first phase will determine how many additional processes from the comprehensive list developed in the previous subtask can be included in the data base in FY 1990. Data will be developed for the remaining technical processes in FY 1991.

Information System Development

This subtask will select an appropriate hardware/software system for accessing the technology data base and develop a program that is user-friendly and will allow addition of technology data by modules as the technology data base evolves. It is envisioned that the software for accessing the technology data base will use graphical-user-interface techniques to aid the user in identifying potentially appropriate technologies for more detailed consideration and accessing the particular type of information the user wants.

The computer program will be developed such that additional technology data can be simply added as it becomes available. This will allow for experimentation and improvement of the software using a subset of the data and facilitate maintaining the methodology as additional processes are included in the future. The data from the first phase of technology data collected in the previous subtask will be used in the prototype program to demonstrate the primary features of the user-friendly computer system for accessing technology data. This program will allow external peer review of the prototype technology data base and will form the basis for determining whether the selected hardware and software systems used for the prototype will have sufficient capability for the entire technology data base. If not, these will be revised as required in FY 1991.

In FY 1991, a user manual will be prepared that will facilitate use of the technology data base access program at individual DOE sites. It is anticipated that this document will focus on instructions for using and maintaining the personal computer methodology rather than on documenting the technology data itself. Since it is anticipated that the technology data base will evolve, its documentation will be included as part of the data base itself so that the user manual will not require revision each time additional technologies are added to the data base.

No Task 1 activities are identified in FY 1992.

TASK 2. METHODOLOGY DEVELOPMENT, TESTING, AND DOCUMENTATION

The RAAS methodology is a computer-based advisory tool designed to help in the RI/FS process by assisting in the selection of the most promising remedial options for feasibility testing and in providing a semi-automated vehicle for documenting assumptions, facts, and decisions. Specifically, the RAAS product will provide the following services:

- assisting in the selection of remedial objectives, general response actions, remedial technologies and processes
- evaluation of technologies and processes against EPA criteria (e.g., effectiveness, implementability, and cost)

- assisting in the selection and evaluation of remediation trains against EPA criteria

- archiving assumptions and decisions made by the user and the computer during working sessions

- offering hints, suggestions, and default values to the user at multiple points along the feasibility study pathway

- prompting the user for additional information (e.g., new site characterization data requirements) upon which a technology or process "objects" can evaluate their own capabilities and restrictions before volunteering their services as part of a remediation train

- tailoring to user needs (e.g., technical staff, managers, auditors).

A diagram of the RAAS logic is shown in Figure 1. Development of this methodology is subdivided into the following six subtasks:

1. Development of the Knowledge Base and Governing Rules
2. Identification of the Needs of Potential RAAS Users and Reviewers
3. Development of the Central RAAS Model and Interfaces
4. Development of Supporting Attribute Codes and Data Bases
5. Development of the RAAS User Interface and Output Generator
6. Testing, Documentation, and Tool Acceptance.

It is important that the methodology be developed in parallel with Task 1 for proper interaction among the two tasks. This interaction will ensure that the right type of data is being collected and presented in a manner useful to the methodology development task. Beginning the methodology development task in FY 1990 is also essential to meeting the three-year development schedule. The Office of Environmental Guidance and Compliance has stressed to PNL that a three-year development schedule is extremely important to be useful in preparing RI/FSs at DOE operable units.

Each of these subtasks, with the exception of the testing, documentation, and tool acceptance subtask, is planned to be conducted in a rapid-prototyping approach. This approach calls for developing each subtask for a limited number of technologies and site conditions at a time. The developed prototypes can then be expanded for more types of technologies and site conditions. In FY 1990, the methodology will be developed for prototypic screening and linking modules, incorporating treatment and disposal technologies, and a prototypic user interface. This rapid-prototyping approach will allow adjustments to the developmental techniques to avoid costly mistakes at later stages of development.

<u>Development of the Knowledge Base and Governing Rules</u>

One objective of RAAS is to have computerized "object" modules for key remediation technologies and associated processes in the following waste areas: containment, separation, removal, treatment, and disposal. Each

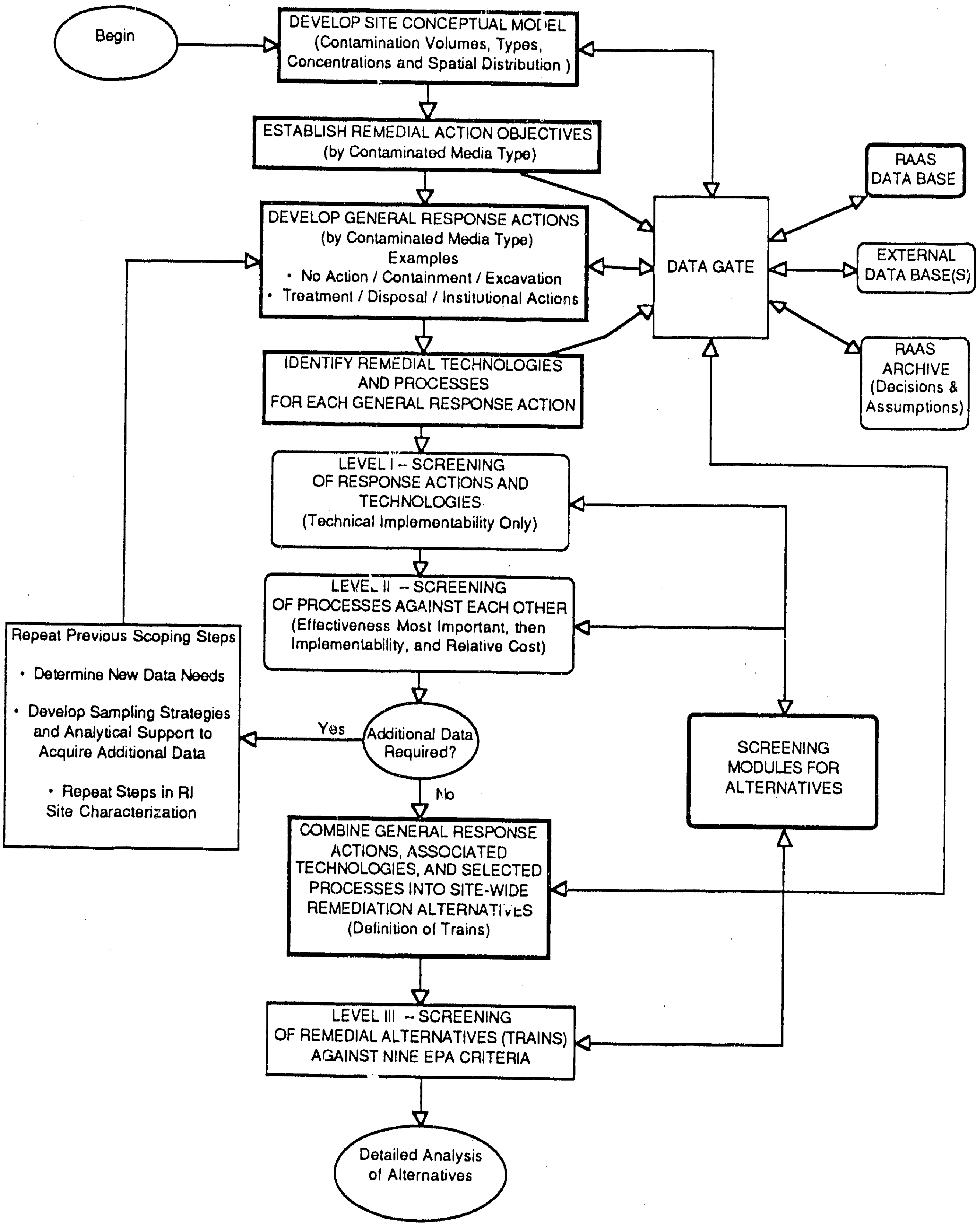

FIGURE 1. Computer Modules and Logical Interconnections of RAAS

"technology and process object" must have its own set of input requirements, processing rules, and output characteristics. The object must know enough about its own capabilities and restrictions to know when to volunteer its services as part of a remediation alternative, to realize its own operating restrictions, and to request assistance or additional information from other computerized objects and the RAAS user.

It is necessary to have a set of rules for combining technologies into potential remediation trains. Such knowledge is partially contained in various EPA guidance documents, vendor-supplied literature, existing computer models like EPA's CORA system, and various data bases like the Independent Project Analysis (IPA) review of 150 post-SARA Records of Decision and EPA's Alternative Treatment Technology Information Center (ATTIC). The knowledge base and operating rules for the individual remediation technologies and remediation trains in RAAS will be built upon such information sources.

The majority of the required knowledge that will be encoded in the form of "rules" is embodied in the human experts, primarily from industry and DOE contractors, who have spent significant time developing technologies and doing RI/FSs for industry, DOD, and DOE. Although DOE's problems involving radioactive and mixed wastes are more complex, the knowledge from these industrial and governmental experts must be captured, to the extent possible, for RAAS to be a robust and useful tool.

Vehicles for accomplishing this major undertaking include small workshops, meetings, telephone interviews, questionnaires, and testing of early RAAS prototypes. It will be necessary to subcontract one or more experienced hazardous waste consulting firms (e.g., CH2MHill, ICF, IT) to have them survey their in-house expertise in a comprehensive manner leading to the development of rules and constraints for remediation technologies. The success of this subtask will determine to a major extent the future value and acceptance of RAAS product(s).

Identification of the Needs of Potential RAAS Users and Reviewers

This subtask is designed to identify and capture user needs and desires by querying a spectrum of people conducting RI/FS studies. RAAS products must meet user needs and be defensible to federal, state, and local regulatory groups and the public. Whether or not RAAS is used in the future will also depend upon the friendliness of the human-computer interface, the difficulty of the learning curve, and the acceptability of its results to EPA and other regulatory groups.

Vehicles for accomplishing this subtask are 1) small interactive meetings with potential users, 2) discussions with EPA and state agencies, 3) early testing of the RAAS products at EPA and selected states, and 4) user-view prototyping. In FY 1990, at least two meetings will be held with potential RAAS users and one with EPA. It is critical that EPA and some representative state environmental bodies be represented in this subtask. Serious consideration should be given to making RAAS available as a tool to federal and state regulatory bodies to further incorporate the special needs of these groups. User-view prototyping is a formal method called NEXTSTEP that captures user needs and interactively solicits user feedback on a developing prototype. In FY 1990, an evaluation of this method will be made, and if deemed appropriate, used in the meetings.

Development of the Central RAAS Model and Interfaces

The activities necessary to develop the methodology for selecting, screening, linking, and evaluating remedial alternatives include 1) object modules for each remediation technology and associated processes, 2) remediation trains decision methodology (i.e., rules and methods for linking of technologies and unit processes), and 3) interfaces and electronic hooks into support codes and data bases.

Object Modules for Each Remediation Technology/Process

Remediation technologies can be subdivided into specific actions performed on the wastes: containment, separation, removal, treatment, and disposal.

These can be further categorized as to "above ground" or "in situ" methods and according to thermal, chemical/physical, or biological technologies. Furthermore, each treatment technology contains a variety of candidate processes. For example, the thermal treatment technology category can refer to fluidized bed incineration, infrared thermal treatment, wet air oxidation, pyrolytic incineration, and vitrification processes.

For each unit process, an "object" module must be developed for RAAS to describe the controlling characteristics, including the inputs, outputs, and the processing rules and constraints. For example, final concentrations of a contaminant from a treatment process might be related to the concentration of the input, the residence time in the unit process, and operating temperature. Similarly, the application of in situ vitrification might be constrained by the percentage of organic litter in the soil. One process may work well for volatile organics, but be totally unsuitable for heavy metals. Each object-oriented module will have its input and output specifications and its own set of internal operating or process rules and local data. To keep the subtask manageable, rapid prototyping will be used and the number of unit processes considered initially will be limited to proven and demonstrated technologies identified in Task 1, especially those targeted towards DOE-type waste problems.

Remediation Trains Decision Structure (Linking of Processes)

A number of ways exist by which a hazardous, radioactive, or mixed waste site might be remediated to attain clean-up goals. Ideally, the remediation would be handled by one all-encompassing in situ treatment process. More realistically, however, there will be a combination of containment and treatment options pursued independently or in series. Furthermore, for treatment type options, several waste removal, separation, treatment, and disposal technologies will be employed to handle a complex, multicomponent DOE waste site. In other words, the unit processes could be combined in any number of ways, withsome combinations resulting in more implementable, effective, and cost-efficient results. Several remediation trains may be employed at a single site to cover the variety of waste types, waste forms, and environmental conditions that may exist.

Numerous ways exist that these unit processes could be combined into waste containment and/or treatment trains in which they cannot be effectively employed (e.g., for heavy metal removal, cation exchange must precede an ion exchange for the treatment to function properly). Therefore, methodology is required to sort these potential combinations and suggest viable alternatives for further considerations. The purpose of this effort is to develop a linking scheme that will allow the RAAS user to identify the "most likely" trains for the particular site problem.

It is impractical to "hard-code" this complex problem. Therefore, a method must be employed that allows the computer program to interact with itself in a free-flowing manner and to interact with the RAAS user and a variety of external data bases during operation. Object-oriented computer programming will be used to link the unit processes. Criteria will be established to describe input requirements to the unit process from 1) preceding unit processes, 2) site and waste characteristic data bases, and 3) user-supplied input and data requirements. The computer program will also use the site and contaminant characteristics to screen all possible treatment technologies potentially applicable to the remediation problem at hand. In addition, the operator will be queried and given the opportunity to remove from consideration any remediation alternatives and technology types that are logistically or institutionally unacceptable at the user's site (some states may not allow incineration or land disposal of residuals).

In this object-oriented approach, a unit process or technology is represented by an object and the objects can send messages and ask questions of each other or request more information. For example, a certain treatment object may "know" that it is good at handling nonvolatile organics as long as the waste stream it receives does not also contain certain quantities of heavy metals and radionuclides. If such waste constituents are present, the object may send out a request message to all other waste separation and/or treatment objects asking if any of them can deal with the heavy metals and/or organics prior to the waste stream being delivered to the organic treatment process. Since all other unit processes (objects) presumably contain local information and rules about what they can and cannot do, return messages will only be received from viable candidate processes or possibly more information will be requested of the original sender.

It is important to understand that the human user can and should interact frequently with this process by sending his or her own messages and asking questions of the system. Inversely, the computer program must be able to solicit additional or clarifying information from the user and expect the user to make certain decisions along the way. RAAS is <u>not</u> a black box that the user just turns on and waits for the final answer. The user is an integral, interactive part of the computer methodology. This object-oriented computational approach minimizes the number of hardwired (hard-coded) connections that are built into the computer model. Although object-oriented programming is very intuitive, powerful, and flexible, it has only recently been made available due to the much greater computing capacity (size, speed) of mini- and micro-computers and commercial software shells now on the market.

Data Base Interfaces and Electronic Hooks

The methodology being developed in Task 2 must access other codes and data bases being developed in Task 1 and outside the RAAS project. The main RAAS code must also be able to input to, request processing by, and receive resulting responses from the supporting attribute codes.

Example data bases needed by RAAS include:

- waste constituent groupings
- site matrix (e.g., soil) constituent groupings
- remediation technologies
  - -containment
  - -separation and/or removal
  - -treatment
  - -disposal
  - -materials handling
- federal, state, and local regulations and performance guidelines
- capital and operations and maintenance cost factors
- human health and environmental risk factors.

The electronic hooks from the central RAAS code into the necessary data bases will be developed by one of the following approaches. The first involves accessing data from a commercially available relational data base (e.g., Oracle, DB III/IV). For example, the Hanford Environmental Information System (HEIS) has been developed in Oracle, and several EPA treatability and remediation technology data bases use DB III/IV. The second and more powerful and flexible approach is to repackage the data into an object-oriented framework like Ontologic's ONTOS® system. Reconfiguring data into such an object data base may prove to be the best approach for RAAS. An evaluation will be performed early in this subtask to determine the most appropriate approach.

The second important interface that must be made is between the main operating RAAS code on one machine and the various attribute codes (e.g., risk, cost, performance) that may be resident on different machines, especially IBM and compatible microcomputers. In other words, RAAS should be able to send input across an electronic network, start an attribute code like MEPAS on another machine, and receive the MEPAS results at some later time. In all cases, Standard Query Language (SQL) will be used to communicate with data bases, and networking protocols will be followed to ensure that RAAS can access data and other codes resident on different machines on an electronic network.

The primary product for this subtask in FY 1990 will be an object-oriented design for the research prototype. This prototype will test proof-

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of-principle of the RAAS concept. One vehicle for accomplishing this subtaskwill be the use of Class, Responsibility, Collaboration (CRC) cards in design sessions. A second product in FY 1990 will be the development of selected objects and their internal sets of rules for representative remediation technologies and processes. At least 6 groundwater treatment processes; 10 ex situ soil treatment processes, and 2 in situ soil processes will be developed. In addition, selected modules may be developed for extraction and disposal technologies. These modules will capture what each object will do with the information it receives and the form of the object's output. A third product in FY 1990 will be an information flow design for the RAAS model that will describe what information will pass between objects, data bases, and the user.

Development of Supporting Attribute Codes and Data Bases

EPA has designated nine attributes upon which a site operator *might* filter remediation options. The RAAS methodology will include these attributes in the following categories:

- Effectiveness
  - -Overall protection of human health and the environment
  - -Long-term effectiveness and permanence
  - -Short-term effectiveness
  - -Reduction of toxicity, mobility, or volume
- Implementability
  - -Compliance with applicable or relevant and appropriate requirements (ARARs)
  - -State acceptance
  - -Community acceptance
  - -Schedule and logistics
- Cost
  - -Capital
  - -Operation and maintenance

The RAAS user will be given the opportunity to tailor these attribute targets to his or her specific site needs, but the default options will be established by the computer methodology. Some attribute models will be simple "on-off" or "yes-no" conditions like compliance with performance standards and state/community acceptance. Schedule and logistical filters will be equally straightforward. Other attributes like protection of human health and the environment, long-term effectiveness and permanence, and cost factors are considerably more involved and will require computer models that can be called and activated from RAAS. The RAAS user will be permitted to adapt his or her own risk assessment tool to the RI/FS process. However, one such risk assessment code will be bundled with RAAS.

Multimedia Environmental Pollutant Assessment System

This risk assessment code included in the process is the Multimedia Environmental Pollutant Assessment System (MEPAS). This is a DOE-sponsored, user-friendly, computer-based, endangerment assessment methodology. It is designed to assess environmental issues and problems on the basis of available site data by performing a physics-based transport, exposure, and health effects assessment. MEPAS is the only fully integrated, physics-based multimedia risk assessment tool and represents one of the most widely tested and reviewed methodologies.

The MEPAS methodology will be interfaced with the RAAS methodology and will assess the long-term risks associated with the no-action alternative (i.e., baseline case) and with implementation of each remedial alternative reviewed by RAAS. The risks that will be assessed are those risks associated with implementing the clean-up action and those due to long-term residual exposure to contamination after cleanup has ceased. Although MEPAS is completed and is an independently functioning transport, exposure, and risk assessment tool, its development was not specifically designed for the feasibility portion of the CERCLA process. It is designed to effectively implement the endangerment assessment portion. As such, modifications to the methodology, in terms of new components and restructuring, are required.

Examples of modifications and restructuring that are envisioned for the MEPAS include the following:

Surface water--transient surface water component (already developed but not integrated into the system as of yet); sediment transport in riverain environments, open water bodies (lakes, reservoirs, etc., already developed but not integrated into the system as of yet); an estuary component; and a marine environment component (the Department of Interior has developed a model that might be appropriate).

Groundwater--back calculation component for calibration purposes; effects of pumping and reinjection, slurry walls, and grout curtains on water table; multiple aquifers; vapor phase movement (Utah State University developed an EPA-approved three-phase transport model that will be investigated to fit this need).

Overland--impermeable membranes/liners and leachate collection component; transient sediment transport component (mathematical formulations completely developed, model not written as of yet).

Atmospheric--secondary atmospheric emissions (e.g., fugitive dust emissions from conveyer belt or truck hauling activities).

Exposure and risk assessment--integrating the EPA-developed Personal Computer-Graphic Exposure Model (PC-GEMS) with MEPAS (a potential cooperative effort with EPA).

General modifications--a number of algorithms in the MEPAS methodology will be modified to effectively interface with unit process activities associated with primary and secondary waste streams.

Cost

Cost is always correlated with the benefits of choosing a clean-up option. Capital, operating, and maintenance costs must be estimated for each candidate remediation train. RAAS will not be developing its own cost module. Every effort will be made to adapt existing cost estimating tools or those under development. For example, EPA has funded the CORA. This excellent tool estimates site-specific remedial action costs for hazardous waste CERCLA sites generally to within +/-50% accuracy. Unfortunately, CORA does not yet deal with complex DOE sites containing mixed wastes. Consequently, a collaboration effort is planned with Los Alamos National Laboratory's cost and scheduling modeling activities, which are anticipated to be supported by DOE's Office of Environmental Restoration. This collaboration effort will ensure that the cost and scheduling models are developed so that they can be accessed by RAAS.

The primary product for this subtask in FY 1990 will be a conceptual design and information flow network showing inputs to and outputs from the supporting attribute codes. In addition, rules at the object level will be developed for compliance with applicable or relevant and appropriate requirements; state acceptance (Washington initially), and community acceptance (Tri-Cities initially) will be developed. Finally, a review of EPA federal and Region X regulations and performance standards will be completed and a letter report prepared.

Development of the RAAS User Interface and Output Generator

The RAAS project is based on a simple premise: Regardless of a tool's potential value to a user, if it is too difficult to learn and understand or too awkward to operate, the tool will have no real value. Therefore, RAAS has a subtask charged with the responsibility of developing or adapting a user interface that employs menus, windows, user help features, linking of text and graphical information, a graphical "flowchart" display of selected technologies, and other interactive features to be determined by the project team. This development will utilize the efforts of the Environmental Restoration Information System (ERIS) project (if funded) and an internal PNL program called the Vertical Integration of Science and Technology Application (VISTA).

Example capabilities of the RAAS user interface will include:

- Prerun Input Requirements--It is envisioned that the RAAS users will typically be the staff working on a specific environmental restoration task (operable unit or waste site). As such, it will be necessary to develop the capability to interactively question the RAAS user to obtain site-specific information prior to the initiation of a RAAS run. Examples of user-supplied information include waste constituent types, concentrations, and spatial distributions; site (e.g., soil) matrix constituents; local logistical constraints like special transportation requirements and electrical or gas power needs, special standards and regulations, and the user's specific scheduling information (e.g., Tri-Party Agreement schedules). RAAS will identify input requirements and guide the user through only those requirements necessary. The user will be able to request a look at all input data as well. RAAS will also check to ensure that the values of user-supplied parameters have magnitudes that are within specified default ranges; this ensures that errors are corrected prior to implementation.

- Intra-Run Input Requirements: RAAS is not a black box that is fed information, turned on, and some time later an answer emerges. RAAS must allow the machine and the expert user to work together at several steps along the way. Therefore, at any point during the operation of RAAS, the user must have the flexibility of interrupting the program to obtain and/or supply new information. Similarly, the computer program must be able to request more information from the user. For example, if RAAS is considering the use of in situ vitrification as a containment technology, one of the questions the computer must ask itself is the percentage of combustible material in the soil/waste mixture. If this information has not been provided previously, then the program must prompt the user for this data. The user can then elect to supply this data (real or dummy number) or select one of the computer's default values. In either case, the user will be forced to document where the number came from and its authenticity.

- User Help Features--A variety of user help features must be built into the RAAS interface. For example, in selecting parameters and values, the user will have the option of using the computer-selected default values. The user will still have the option to override the values suggested by the program.

Examples of capabilities of the RAAS output module will include:

- Simulation and Other Output Requirements--The user-friendly shell will provide the user with options for having the output in tabular or graphical form. Of particular concern is the ability for the user to follow, in near-real time, the operation of RAAS via a graphical representation (flowchart) showing selected and excluded technologies. In other words, RAAS will be a simulation tool with which the user can interact.

- Annotation and Documentation--At each decision point (node), the computer must record its assumptions, data selections, and rule-based decisions, and the user must also record his or her awareness and agreement. If the user elects to override the computer's selection or the user is requested to make a decision the computer cannot make, then this too must be electronically recorded at the node in question. One of the most important "output" features of RAAS must be this auditable track-record of assumptions, data selections, and decisions. It will be equally important for RAAS to be able to subsequently explain why a certain technology was excluded from consideration as it is to explain why a technology was chosen.

In FY 1990, emphasis will be on the development of a storyboard demonstration using Supercard on a Macintosh workstation. The intent is to provide an example of the "look and feel" of the RAAS problem-solving steps and the interactions between a user and the computer program. A diagram of the various steps in the RI/FS process will be developed such that the user can observe where in the process the computer code is currently, what has already been accomplished, and what technologies and processes are still being evaluated.

Testing, Documentation, and Tool Acceptance

It will be necessary to provide adequate documentation that describes the 1) formulations on which RAAS is based, 2) the testing program implemented to ensure the methodology works properly, 3) how the user implements the methodology, and 4) quality assurance and quality control procedures.

- Formulations--This documentation will contain the algorithms, operating rules, assumptions, data, and evaluation attributes (e.g., risk, cost, ARAR performance) on which the RAAS methodology is based. It will also contain supporting information such as technology descriptions, flow sheet diagrams, design data requirements, a technology track record, limiting characteristics, vendors, and references. One of the most important products will be the "influence diagrams" and data flow sheets showing the interrelationships of the various RAAS modules and objects. This may ultimately be a computer-based manual as part of the user help feature.

- Testing--This document will present the testing results associated with the RAAS methodology. This will be accomplished by comparing the RAAS methodology's remedial alternative recommendations and cost/risk performance prediction with those developed by human teams not using RAAS. It may eventually be possible to compare RAAS results against actual remediated site's results. The RAAS project will attempt to involve DOE and its contractors and federal and state regulatory bodies that may wish to use the tool during the testing process.

- Implementation Guidelines--This document will provide case examples of the application of the RAAS methodology using both individual components and the entire system. These case studies will clearly illustrate input requirements, output expectations, referencing procedures, assessment procedures, and procedures the user should follow for conceptualizing the cleanup options.

- Quality Assurance/Quality Control--This document will chronicle the procedures that were used to ensure sufficient quality associated with the development and implementation of the RAAS methodology. It will also document the procedures and results associated with checking to ensure that the quality assurance procedures were followed.

There will be no activities in this subtask in FY 1990.

TASK 3. TECHNOLOGY TRANSFER AND TRAINING

The objective of this task is to develop a training program to teach potential users how to implement the RAAS. The training program will be a 5-day, hands-on class that will use detailed examples as the primary learning tool. It is envisioned that a subcontractor, specialized in training, will help develop the format and perform the training.

Training classes will be held at a selected DOE site(s). A mechanism for providing continued training beyond the development of the RAAS methodology will be identified in the project management task.

The majority of activities in this task are reserved for FY 1992. However, minor technology transfer activities will be initiated in FY 1991 to prepare for training and use of the Remedial Alternatives Data Base computer program prepared in Task 1.

TASK 4. PROJECT MANAGEMENT

The purpose of the project management task is to ensure that the technical activities are conducted in a quality manner within the allotted time and budget described in the Activity Data Sheet associated with this briefing paper. The PNL project manager is responsible for implementing this task. The PNL project manager will implement various tools throughout the course of this project to ensure that the project objectives are met. These tools include the following:

- Activity Data Sheet--proposes scope, schedule, and budget for the entire project, annually.
- Technical Task Plan--describes the detailed, negotiated scope, budget, and milestones for the project's activities. The Technical Task Plan describes the task descriptions, background, technical progress, funding basis, alternatives, benefits, criteria for success, and regulatory requirements. This document describes the agreed-upon deliverables that will be used to evaluate PNL's performance for the RAAS project.
- Project Management Plan--documents internal project control parameters such as staff requirements (key personnel and their time commitment to the project); facility requirements; safety, security, and quality assurance requirements; and change control procedures.
- Quality Assurance (QA) Plan--delineates the procedures necessary to ensure defensibility and traceability of project activities and results. The QA plan is based on the PNL *Quality Assurance Manual* (PNL-MA-70) and specified client requirements.

- Monthly reports--describe significant technical progress, budget and schedule status, and issues or problems that could impact scope, schedule, or budget. The monthly reports will be distributed to DOE by the 15th of each month.

- Program reviews--conducted periodically with DOE to review progress and deliverables and to resolve issues that occur during the development of the methodology.

- Line management face-to-face reviews--the project manager and the immediate line manager review technical progress, costs, and schedule on at least a quarterly basis. This mechanism provides an additional internal PNL mechanism for oversight and review.

- Oversight Committee reviews--a committee comprised of personnel from DOE, DOE contractors, EPA, universities, private industry, and the public, as appropriate, will be established. The Oversight Committee conducts periodic surveillances of technical progress and planned activities. This committee will make specific recommendations to the project manager regarding the approach for developing the methodology, how to best make the interim and final products most useful, and how to transfer the technology to the users. The committee will also ensure that the development effort makes use of existing software systems, as appropriate, to avoid replication of previous developments. The committee will be composed of individuals experienced with the feasibility study process, and they will convene on a quarterly basis.

All of these tools are designed to aid the project manager in meeting the goal of the RAAS project to develop a usable methodology for gaining access to the capabilities and limitations of technologies and remedial alternatives in FY 1991. This methodology will serve as the primary technology data base for the complete RAAS methodology in FY 1992, which will screen, link, and evaluate various technologies and remedial alternatives.

In addition to controlling the quality, schedule, and cost of the methodology development activities, the project management task is responsible for identifying and implementing the appropriate level of EPA involvement. EPA involvement is of paramount importance in gaining acceptance for use of the RAAS methodology. EPA has expressed a desire to be involved with the project. Specific activities in terms of regulatory guidance, review (such as participation on the Oversight Committee), and development of the methodology will be identified and implemented by the project management task.

Lastly, the project management task will be responsible for identifying and implementing a negotiated mechanism for maintaining the RAAS methodology in a useful, updated condition, once the development project is completed. For continued usefulness, it is essential that technology improvements and operating performance data are maintained current in RAAS. Thus, the methodology will ensure that the most cost-effective and current technologies are employed. The mechanism for updating RAAS will include 1) identifying who takes ownership and responsibility for maintaining RAAS in an updated condition (e.g., DOE, EPA, a DOE contractor, or private industry by exclusive license); 2) a funding mechanism for methodology updates (e.g., a nominal charge to the users for providing updates or a long-term funding program); and 3) a funding mechanism for training new users and retraining familiar users for significant updates (e.g., a specific charge to each trainee).

D. TECHNICAL PROGRESS

Progress has been made in FY 1989 in initiating development of RAAS. A limited demonstration model for a selected technology at a select set of site conditions has been developed. In addition, data sets for eight feasibility studies were collected and transformed into a format suitable for implementation by RAAS.

E. RELATIONSHIPS TO OTHER PROJECTS

This project will use experience and results gained from work performed by PNL for the EPA and DOE under several separate projects. The project manager will be responsible for ensuring that appropriate experience from these related projects is properly utilized and coordinated to eliminate duplication of effort.

F. EXPLANATION OF MILESTONES

The following describes the milestone deliverables proposed for the RAAS project.

1. June 1990--select and convene external oversight committee. An external oversight committee composed of experts from DOE and its contractors, EPA, private industry, universities, and the public, as appropriate, will be identified and convened to make specific recommendations on the development of RAAS.

2. September 1990--determine regulatory acceptance of RAAS. Research prototypes of the RAAS methodology will be developed sufficiently such that the oversight committee can determine that the computer technology works for the desired application and that the methodology has EPA support and acceptance.

3. February 1991--develop methodology for accessing remedial technologies. Complete development of a user-friendly, computer-based, technology data base access program. The methodology will collate the unit processes and remedial alternatives suggested at all EPA-controlled CERCLA sites and DOE-suggested cleanup options with a) contaminant type and form; b) source or migration control; c) permanent or temporary categorization; d) treatment mode, method, and process; and e) site characteristics.

4. February 1991--develop prototype RAAS methodology with selected technologies. The RAAS methodology will be developed for a single research prototype, incorporating treatment and disposal technologies.

5. December 1991--develop screening modules for individual technologies. Develop object-oriented modules describing the individual treatment or unit processes (unlinked). These modules would be available to DOE facilities to use at their sites.

6. September 1992--develop the coupled, linked, and integrated RAAS methodology. The methodology will be developed for use by DOE facilities.

G. BUDGET

The budget to accomplish the scope of activities described in this briefing paper is given in the Activity Data Sheet entitled Remedial Action Assessment System (RAAS). The budgets in FY 1991 and FY 1992 have been reduced by $1.5M based on the premise that LANL's enhanced cost and scheduling modeling efforts will be funded and are successfully integrated with the development of RAAS.

END

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12 / 31 / 90