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PAST: The Potential ARARs Selection Tool

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ABSTRACT

The 1986 Superfund Amendments and Reauthorization Act specified that any remedial actions at Superfund sites must comply with applicable or relevant and appropriate regulations (ARARs), including federal, state and local environmental statutes. Identifying these legal requirements for a particular hazardous waste site can be a complex and time-consuming process.

The U.S. EPA Risk Reduction Engineering Research Laboratory is developing a prototype knowledge-based system to aid in screening regulations that determine cleanup requirements based on unique site characteristics. The decision logic follows that presented in the U.S. EPA documents such as *CERCLA Compliance with Other Laws Manuals* (Parts I and II). Hence, it takes into consideration the chemicals at the site, the particular location features of the site and the proposed remediation methods.

INTRODUCTION

SARA modified the 1985 NCP to require remedial actions to comply with all federal and state environmental requirements. SARA defines two classes of legal requirements that must be addressed prior to remediation work at a Superfund site. "Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."[1] Collectively these environmental requirements are known as ARARs.

In 1988, 200 U.S. EPA hazardous waste decision-makers were surveyed to identify needs and opportunities for development of automated decision support systems. An ARARs screening aid was among the most frequently expressed needs. Several characteristics of the ARARs selection problem may explain this finding. First, many of the decision-makers have technical rather than legal backgrounds and interests. Although quite competent in their respective scientific fields, many of those charged with ARARs decision responsibility feel uncomfortable operating in the unfamiliar legal domain. Second, most decision-makers have insufficient time to adequately review the large body of federal and state regulations that must be examined in order to conduct a thorough ARARs search. Finally, the criteria and rules for determining whether a regulation is relevant and appropriate have continued to evolve over time. Thus, an acceptable decision 1 year ago may be judged unacceptable by today's standards. The aforementioned characteristics describe a problem which is amenable to solution via an expert system.

Briefly, an expert system is computer software that is constructed using special coding techniques which allow the program to reproduce the knowledge, experience and decision logic used by experts in a certain field of specialization. Expert systems technology can be used to encapsulate the experience of environmental law professionals and subsequently dispense this knowledge to the appropriate scientific community to assist with ARARs selection. The automated system can search the large body of information under consideration much more efficiently than even the most experienced environmental lawyer. Furthermore, by implementing an expert system solution, the process of cataloging the most current regulations and policy enhancements can be centralized, thereby alleviating individual decision-makers of this responsibility. It is anticipated that a system such as the one described will be a valuable asset for use in the U.S. EPA Regional Offices, state environmental departments and the offices of remediation support contractors who currently perform many of the tasks associated with environmental restoration.

Typically, ARARs are identified during the Feasibility Study (FS) stage of a site investigation by project engineers associated with the performing institution (consulting firm, Army Corps of Engineers, Principal Responsible Party, etc.). The list of selected ARARs is reviewed by the U.S. EPA Regional Project Managers (RPMs) and then sent to the attorneys in the respective U.S. EPA Office of Regional Counsel for final review and concurrence. The Policy and Analysis Staff (PAS) in the U.S. EPA Office of Solid Waste and Emergency Response is responsible for establishing the criteria for identification of ARARs under varying circumstances. Hence, the Agency attorneys and the PAS are the experts relative to the selection of ARARs. Therefore, a situation exists in which a number of people in widely scattered geographic areas and organizational entities need the expertise retained by a limited number of recognized experts. This is a typical technology transfer scenario which fits nicely with the paradigm of expert systems. Expert systems provide a means of readily capturing this decision logic in a form that can be easily distributed to others.

The U.S. EPA Risk Reduction Engineering Laboratory has been developing an expert system to facilitate selection of potential ARARs for approximately 1 year. This paper focuses upon and details this development effort.

SYSTEM OBJECTIVES

Clearly, the global objectives of any automated decision support system are that it provide accurate and reliable advice that is of sufficient utility to the targeted users to warrant the time and resources required to use it. More specifically, the system must provide advice that increases the efficiency of targeted decision-makers in addition to improving the quality of their decisions. In terms of ARARs identification, the objective is to provide an easy to use system that accurately selects the ARARs for commonly encountered, typical sites and situations. This point is emphasized because it is not possible to entirely automate the ARARs selection process. The most complex situations will require specialized legal advice which cannot be represented with today's limited knowledge based tools. Furthermore, in these complex cases, the ARARs eventually followed at a site may be the result of negotiation or litigation. However, if an automated approach can be employed to aid in the more routine scenarios, scarce legal resources can be freed to address the more involved cases.

The selection process follows the general approach described in the U.S. EPA published manuals *CERCLA Compliance with Other Laws*[1] and *CERCLA Compliance with Other Laws, Part II.*[2] Options are provided by the system to permit selection of chemical, location and/or action specific regulations. It will provide the capability to assess the regulatory implications of alternative remedial alternatives without requiring the user to consult multiple sources such as the Code of Federal Regulations, State regulations, CERCLA Compliance manuals, supplemental Office of Solid Waste and Emergency Response (OSWER) ARARs publications and NCP information. By having the developers of the PAST System work closely with both the U.S. EPA Policy and Analysis Staff and Agency attorneys, PAST will serve as the mechanism for the implementation of the latest ARARs decisions. As newly hired personnel conduct consultations with the system, it will tend to function as a training tool for these less experienced personnel. Finally, the system will serve to promote completeness and uniformity in ARARs assessment among decision-makers in scattered geographic and organizational entities.

SYSTEM DESCRIPTION

Several initial assumptions shaped the development of the PAST system. It was assumed that the most common computing platform available to potential users of the system is the IBM compatible personal computer. In addition to its wide availability throughout the U.S. EPA, this machine is common in the offices of state environmental protection organizations and Superfund remediation contractors. However, due to the complexity and volume of information required to solve the ARARs problem, a powerful computing environment was required. A compromise was reached which allowed the developers to target the PAST system to more advanced, 386 based personal computers. Specific hardware requirements are documented within the User's Guide for the system.

Another assumption was that the knowledge necessary for solution of the ARARs problem could be best represented in a rule-based format. Furthermore, the system would be originally coded as a prototype and then the iterative development methodology will be applied to refine this prototype into a fully functional system. These refinements will represent the knowledge gained through a number of interviews with persons considered expert in the ARARs selection process. Finally, the system will be coded at the highest possible level, ie., the system developers will concentrate upon representation of knowledge and relationships required for solution of the ARARs problem rather than upon development of the underlying software required to process such knowledge and relationships. All of these factors mandate that a suitable knowledge-based development tool be procured and utilized for implementation of the system. After analysis of the commercial market for such tools, KAPPA, a product of Intellicorp of Mountain View, California, was chosen for the initial prototype.

In addition to providing the rule-based reasoning capabilities required by the ARARs application, KAPPA implements the object-oriented programming paradigm which has been shown to increase programmer productivity and reduce resources necessary for system maintenance. Also, KAPPA runs within the Microsoft Windows computing environment. This emerging standard for personal computing provides operating system support for a graphical user interface, multitasking, and interprocess communications. The graphical user interface simplifies access to and use of the system. It also enables the developers to implement device independent graphics for system I/O with a minimum of programming and maintenance effort. Multitasking and interprocess communications are also used by the developers to build a more sophisticated application than could be built under DOS.

Although the system knowledge base is written in KAPPA, the user interface is written in ToolBook by Asymetrix Corporation of Bellevue, Washington. ToolBook provides for rapid and flexible design of Microsoft Windows user interfaces and as such is more suitable for development of a graphical user interface than KAPPA. As its name implies, ToolBook uses the metaphor of a book for application development. Each screen within the application is called a page. ToolBook can quickly move from page to page within a book. All system interaction with the user is handled by ToolBook. Input data collected by ToolBook is passed to KAPPA for processing. Likewise, conclusions generated by KAPPA are passed to ToolBook for display to the user. Interprocess communication between KAPPA and ToolBook is accomplished through the use of Windows Dynamic Data Exchange (DDE). DDE allows these two distinct applications to share information in a common format. The performance of DDE is such that information can be passed between the two applications almost as quickly as information can be accessed in a single application.

System rules define the relationships between site characteristics and potential ARARs. These rules embody the decision criteria used by the system. For example, the following Action Specific rule:

```
MakeRule( excavation_rule1, [AnInstance excavation]
  AnInstance:exists
  AppendReg( AnInstance, regulation, CFR 40 268 SubpartD )
```

defines the fact that whenever an excavation action takes place at a Superfund site, *40 CFR* 268 Subpart D is a potential ARAR at this site. It is apparent from this example that the system must determine Superfund site characteristics before potential ARARs can be computed. In general, site characteristic information must be supplied to the system by the user.

Within PAST, site characterization information is represented in objects. Objects are created to parallel the real world tangible items and concepts which play a role in the specification and solution of the ARARs problem. Objects can be thought of as repositories of related data. Slots within the objects are used to hold the individual data elements. For example, if excavation of contaminated soils occurs at a site, the system would contain an EXCAVATION object to represent this action. Possible slots within this object might be depth, volume, soil type, etc. The values of these slots would be used by the rules to make determinations concerning ARARs.

Creation and manipulation of objects is controlled via KAPPA Application Language (KAL) code. The user interface initially requests key pieces of site information from the user. For each site datum gathered by the user interface, there is a corresponding slot within a KAPPA object. These slot values are set within KAPPA via a message sent by the user interface. In addition to setting the slot value, the slot is asserted to KAPPA's inference engine. Once asserted, this datum causes system rules that reference this slot in their premise to be examined. Depending upon the format of the rule, additional information may be required and requested from the user. If all the conditions of the premise are TRUE, the rule is executed. At this point, the actions specified in the conclusion of this rule are carried out. Usually this entails either setting additional slot values or concluding that a particular regulation is indeed an ARAR.

Figure 1 shows the most general levels of the KAPPA object hierarchy. This object hierarchy can be thought of as a very large tree diagram. The more specific branches of this tree are not shown in Figure 1 for the sake of readability.

The ARARs object has three children: Location Specific, Chemical Specific, and Action Specific. These objects store each of these three types of regulations after they are identified by the rule base as potential ARARs.

The Regulations object is the root node of a large subtree which contains one object for each regulation defined within the system. Each

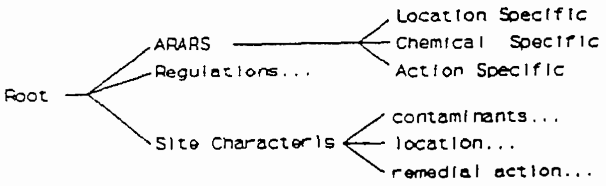

Figure 1
General Levels of the KAPPA Object Hierarchy

specific regulation object contains a brief description of the content of the regulatory citation. In general, these objects are referenced in the conclusions of the system rules.

The Site Characteristics object is the root node of the tree which stores the Superfund site characterization data input by the user. Each of the three classes of site characteristics (contaminants, location, remedial action) is represented as a subtree of Site Characteristics. In general, objects within these subtrees are referenced in the premise of the system rules. As such, they are used as the basis for determining potential ARARs.

The location subtree is the least complex of the three Site Characteristics subtrees. The extent of this subtree is shown in Figure 2. Each of the child objects of location has one or more slots which correspond to user supplied information concerning locational characteristics of the site.

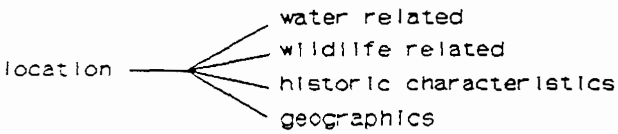

Figure 2
Location Subtree

The knowledge representation for a chemical specific analysis is somewhat more complex. Site characterization information for the chemical specific analysis is found in the contaminants subtree of Site Characteristics. The extent of this subtree, as it exists when the system is originally started, is shown in Figure 3.

The location subtree (Figure 2) described above is a static hierarchy. Although slot values are added as the user inputs information, the number and relationship of the objects is constant. This is not true of the contaminants hierarchy. As shown in Figure 3, the contaminants subtree has several subclass objects which indicate categories of potential pollutants for Superfund sites. These categories correspond to the ToolBook selection menu page named contaminants.

In some cases, when a category is selected from this contaminant menu, a page showing the specific types of contaminants in this category is shown. Each type of contaminant is listed next to a check box so that zero or more of these contaminant types can be selected. By selecting a specific contaminant, the user is defining the existence of this pollutant at the site. Upon doing so, ToolBook sends a message to KAPPA and KAPPA responds by creating a new class object using the CreateContamClass function. This newly created class is a child of the contaminant category class and has the name of the specific contaminant type chosen. A slot named exists is automatically inherited from the contaminants object. This exists slot is Asserted, which will cause rules which reference this slot in their premise to be examined and possibly executed.

Site characterization information for the action specific analysis is represented by the remedial action subtree of the Site Characteristics object. The immediate descendents of remedial action are shown in Figure 4. These immediate descendent objects serve to categorize the specific technologies defined in the system. The full extent of the remedial action subtree is too large to be diagrammed.

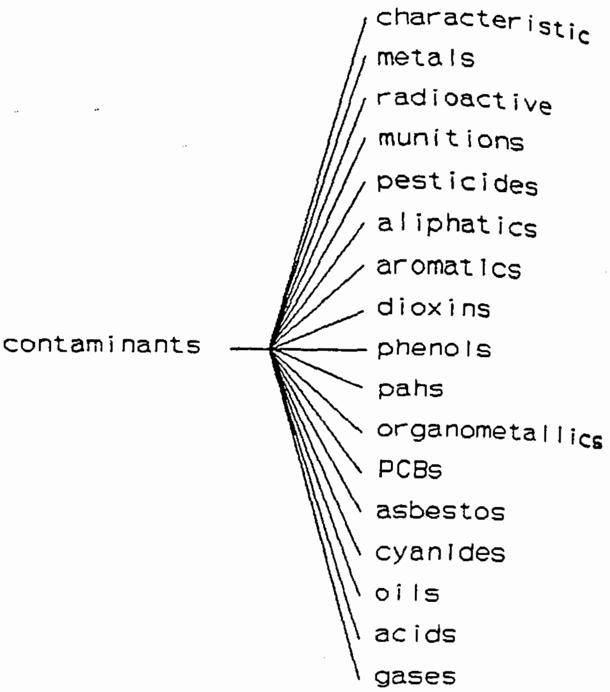

Figure 3
Contaminants Subtree

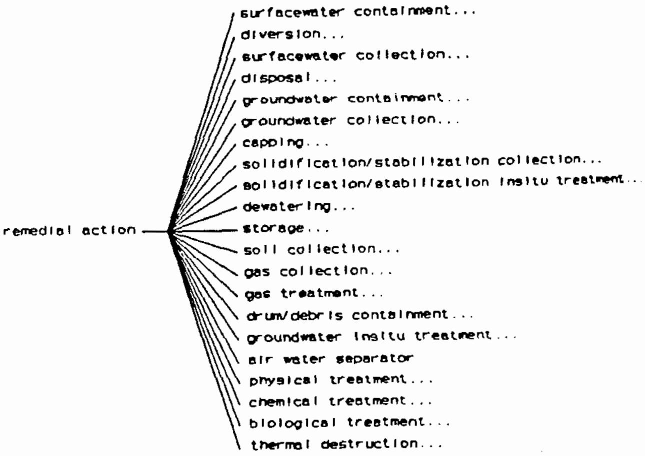

Figure 4
Remedial Action Subtree

Like the contaminants subtree, remedial action is a dynamic hierarchy. As the user defines the remedial alternatives under consideration for a site, instance objects are created to represent these cleanup technologies. This operation is performed by the KAPPA CreateTechnology function. Instance objects are given arbitrary names in the format parentX, where parent is the name of the technology class of which the instance is a descendent and X is some positive integer. These instance objects can be uniquely identified by the value of the stream name slot which is set to the user defined treatment stream in which this technology is implemented. Unlike the location and chemical specific rules, the results of the action specific rules are put into the regulation slot of the technology instance that triggered them. The KAPPA CompileReport function takes the values from the technology instance regulation slots and formats the output in the potential slot of Action Specific so that the triggering technology and stream name is listed prior to the regulatory citations.

As previously mentioned, analysis of action specific ARARs is not a stand alone domain. Often information on site contaminants is necessary to determine all action specific requirements. Within the user interface, each treatment stream can have zero or more contaminants associated with it. The specific contaminants available for association are taken from the list of all site contaminants defined by the user. This is why, if in the preliminary data entry stage the user requests an action specific analysis but no chemical specific analysis, menus for definition of site contaminants still appear. Associating a contaminant with a treatment stream indicates to the system that this contaminant is present in the medium being acted upon by this treatment stream. When this association is made, an instance object is created in the KAPPA object hierarchy to represent this contaminant. This operation is done through the CreateContamInst function. Like technology instances, contaminant instances are given arbitrary names in the format parentX where parent is the name of the contaminant class created when this contaminant is defined at the site (on the ToolBook contaminants page). X is some positive integer. The stream name slot within the contaminant instance is used to uniquely identify the object. If a requirement is dependent upon both a specific remediation technology and a specific contaminant within the media, the rule must check for the existence of the technology and the contaminant and then verify that these exist within the same treatment stream. The following rule is an example:

```
MakeRule( pcb_rule1, [aContam pcbs AnInstance storage],
  aContam:exists And AnInstance:exists And
aContam:stream_name

  # = AnInstance:stream_name,

  AppendReg( AnInstance, regulation, CFR 40 761 65 )
  AppendReg( AnInstance, regulation, CFR 40 761 180 )
```

This rule embodies the fact that *40 CFR* 761.65 and *40 CFR* 761.180 only apply when storage is used to house PCB contaminated waste at a site.

After all such rule inferencing is complete, a function is invoked which generates the system output report. Output citations are segregated into chemical, location and action specific categories. For each citation, a short descriptive title is attached that allows the user to ascertain the subject of this regulation. The report is displayed in a scrollable window for easy viewing. Options which allow the user to print or save the report are also available.

FEATURES (CURRENT AND PROPOSED)

The ARARs selection approach used in the PAST system is similar to that described in the U.S. EPA documents entitled *CERCLA Compliance with Other Laws* and *CERCLA Compliance with Other Laws, Part II.* Searches can be performed for chemical, location and/or action specific regulations. In response to the Chemical Specific option, the system outputs regulatory citations that apply based upon the presence of specific contaminants at the site. Often these are references to the tables of maximum contaminant limits that are contained in the Code of Federal Regulations. Future additions to the system will also include access to the appropriate state regulations. Selection of the Location Specific option causes the system to inquire about the location characteristics of the site. This user supplied location information is used by the system to select and output citations to the CFR that are potentially applicable or relevant and appropriate. Examples of site characteristics that trigger the Location Specific rules are location in a flood plain, wetlands or a historical preservation site. Selection of Action Specific ARARs is a task requiring more complex reasoning on the part of the system and more input from the user. Treatment trains must be specified for each contaminated medium at the site. Additionally, multiple treatment trains for the same medium type may be defined. This process allows the user to represent a case in which the site is segregated into distinct operable units. Based upon the remediation technologies and contaminants of concern within each treatment train, the system provides a list of regulatory citations that are potential Action Specific ARARs.

The prototype system which was completed at the end of September 1991, only contained information about federal regulations that are applicable. The system is currently being expanded to include rules for identification of relevant and appropriate federal regulations. Regulations for a few selected states are also being included. Other features to be added at a later date include an output table that provides a brief description of the regulatory requirements for the potential ARARs. It will also include an ability to access the full text for any of the listed citations. Context sensitive Help and Explanation facilities will be incorporated to define technical terms used by the system and enable the user to interactively examine the system's reasoning process and rationale for selection of potential ARARs.

DISCUSSION

Compliance with ARARs is one of the key considerations in the selection and design of a treatment program for Superfund sites. Hence, it is very important that the ARARs selection process be as accurate as possible. The major concern is that the system not miss any regulations that may potentially be ARARs. This type of error could be very expensive. It might be necessary to perform major modifications to the selected treatment process, result in further contamination to the environment and/or have significant human health consequences. On the other hand, if too many regulations are selected, time and resources will be required by knowledgeable persons to carefully screen the list of selected regulations and/or determine those treatment components that might be unnecessary for the selected design. Hence, it is important that the system be as accurate as possible, erring on the side of over selection of regulations.

One of the concerns with this system is the computer and resource requirements to make it useful while still useable by the targeted user community (project engineers in the Alternative Remedial Contract Strategy [ARCS] firms and U.S. EPA regional project managers). To expedite the design and development process and reduce the anticipated long-term maintenance effort, high level special purpose microcomputer tools are being used (Toolbook for the user interface and KAPPA for knowledge representation and inferencing). These tools are integral with the Windows environment. Also, due to the overhead associated with these tools and the size and complexity of the ARARs selection process, considerable computer memory is needed (approximately 4 megabytes of RAM). Another concern is the distribution costs associated with the KAPPA expert system shell. Due to these concerns, the issues associated with distribution of the end products to targeted users still have not been resolved.

Acquiring accurate and reliable information has been one of the difficulties encountered while developing this system. The final authority relative to ARARs selection rests with the Agency attorneys. Also, the U.S. EPA Policy and Analysis Staff (PAS) formulate guidance for ARARs selection. Since no comprehensive documents exist about the ARARs selection process, it is necessary to rely on the input of the attorneys and representatives of PAS. As might be expected, the supply of knowledgeable persons from these groups is limited, making it very difficult to get the input that is needed. As is normally done, we had to become quite familiar with the regulations ourselves and to rely on the input of persons who perform the initial ARARs selection and review. This is a matter of concern since it has been reported that at least 50% of the initial documents listing the ARARs for sites are in error. Hence, the need for thorough review of the rules and knowledge contained in the system.

Due to the constant evolution of rules/criteria for identifying ARARs and changes in regulations themselves, it is anticipated that maintenance will require a constant commitment of resources. A large proportion of the persons who have provided input to the system caution that without continued maintenance, so that the system reflects current regulations and ARARs selection processes, the system will have limited utility.

CONCLUSIONS

Development of a system to select regulations that may be potential ARARs is a complex and challenging effort. The potential economic and environmental consequences of errors in the selection process warrant, however, the costs of system development. Additionally, when the cost of time currently spent on ARARs selection throughout the

Agency is taken into consideration, it is very likely that use of the PAST system can save the U.S. EPA many times the development and maintenance costs.

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2. U.S. EPA, *CERCLA Compliance with Other Laws: Part II. Clean Air Act and Other Environmental Statutes and State Requirements*, EPA/540/G-89/009, U.S. EPA OSWER Directive 9234.1-02, Washington, DC, August 1989.

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16. ABSTRACT

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The EPA Risk Reduction Engineering Research Laboratory is developing a prototype knowledge-based system to aid in screening regulations that determine clean-up requirements based on unique site characteristics. The decision logic follows that presented in the EPA documents such as CERCLA Compliance with Other Laws Manuals (Part I and II). Hence, it take into consideration the chemicals at the site, the particular location features of the site, and the proposed remediations methods.

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