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# IMPACT OF LWR DECONTAMINATION ON RADWASTE SYSTEMS

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## INTRODUCTION

Increased radiation levels around certain reactors in the United States and accompanying increases in personnel exposures are causing a reexamination of options available to utilities to continue operation. One of the options is decontamination of the primary system to reduce radiation levels. The Nuclear Regulatory Commission (NRC) recognized that any decision to proceed with decontamination could have far reaching effects. It was this recognition that lead NRC to ask Battelle-Northwest to identify and assess these effects.

The Battelle-Northwest study of decontamination and its impact on radwaste systems has been directed towards existing reactors and allied systems as they are employed during their operational lifetimes. Decommissioning and cleanup during such work are not within the scope of this project although certain processes and waste systems might be similar. Rupture debris cleanup represents a special situation that requires different design features and concepts and it is not a part of this study.

It is recognized that certain state-of-the-art changes are being made to radwaste treatment systems and to a lesser extent, to reactor primary systems. Consequently the study includes an examination of new designs that might have an effect on decontamination of reactors that will soon be coming on-line. As another restriction on the study, only decontamination processes that have been under study were included. That means that those that are still in the concept stage or speculative in nature, were not examined because it is hard to understand how much waste might be generated, what concentration is desirable or what other significant properties may be involved.

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The authors believe it is important to describe the Battelle-Northwest program because the information now available talks about the state-of-the-art, indicates possible directions to accommodate radiation exposure problems, and provides a background for a better appreciation of the overall problems involved in radiation exposure problems at U.S. reactors. The program description should provide a context for papers that follow on allied subjects. The discussion of the impact study, although brief, also should provide backgrounds for those who are interested in the field and may wish to explore other methods for accommodating the increasing radiation exposure levels found at certain reactors.

Information on the Battelle-Northwest program will be covered in two sections that describe: 1) the study methodology, and 2) preliminary findings and implications.

## STUDY METHODOLOGY

Because of the nature and implication of the work, a methodology was developed to guide the study of the impact of decontamination on radwaste treatment systems. A comprehensive approach was required to provide a balanced assessment. It was recognized that there were a number of different views and several different interests that must be handled in a logical and rigorous manner. It was also recognized that the system being decontaminated exerts the major influence on decontamination chemical selection. The radwaste system exerts little effect. The methodology was developed to accommodate a range of interest, views and data so that an overview would be possible.

The utility should be interested in decontamination and its impact on radwaste because of possible increased radiation exposure to personnel and disposal problems. Decontamination can lower exposure but it generates waste. The NSSS vendor is interested because his system is exposed to chemicals and warranted performance could be affected. This same group must favor procedures that will enhance reactor performance. The chemical service industry has a role in decontamination because they are often asked to apply processes to clean systems and/or reduce radiation levels. Architect-engineers have an important part to play because these individuals specify the designs for parts of the reactor systems. Design can either make the job easy or more difficult. The study put together by Battelle encompassed these varying interests and sought input from these groups so that a fair assessment of the impact of decontamination on radwaste treatment systems could be made.

The study methodology is designed to provide for that input: the proper use of the literature, careful evaluation of information, and a testing of results is shown in Figure 1. Even though both of the authors had extensive experience in radwaste systems and/or reactor decontamination, the first step of the process was to acquire additional background information by consulting the literature. Following that task came contacts with the different groups that were listed above. To help in acquiring information from various groups, a list of informational needs was developed. The reason for each of these informational needs was also given. It was believed that direct contact after each organization had an opportunity to examine our information needs would increase the value of the information provided. The response to this approach proved our belief to be valid. Informational needs of the study are summarized below:

- Decontamination Processes. Information was sought on decontamination processes that had been used or were under consideration. The characteristics of such processes have an effect on decontamination efficiency as well as on the radwaste treatment system that must process waste from such processes.

- Primary System Description. Primary system design and materials are important in determining: 1) the types and amounts of radioactive corrosion products that must be removed by decontamination, 2) the types of cleaning processes to be used, and 3) the effectiveness of these processes once they are applied.

- Decontamination Planning. An important prerequisite to effective decontamination is good planning prior to the operation. Questions were posed and comments solicited on when decontamination planning should occur and who should be involved. Plans affect the amount of solutions generated, the exposure to people undertaking the work and the efficiency of the cleaning operation.

- Definition of Need. One of the informational needs of the study was knowledge of how people define the need for decontamination. Nuclear reactor decontamination is undertaken to reduce the exposure to personnel during maintenance and inspections. When such a cleaning operation is initiated it follows some determination that exposures are excessive, that costs for conventional operation are high and that better conditions are required for optimum operation of the reactor.

- Decontamination Operations. A section of the informational needs document was directed towards finding out how much decontamination work had been done previously. It is an important question because a substantial amount can be learned about the training of people, introducing and removing the solution, and preparing the system for startup following such an operation. Assessing how people undertake the operation is important for the study because it has an impact on the amount of waste which is generated and the care wwith which it is undertaken.

- Radwaste Materials of Construction. Information was sought on the materials of construction of existing and planned radwaste treatment systems because decontamination solutions by their nature are corrosive to a certain degree. It was necessary to learn if existing systems would be able to accommodate this added corrosivity or if changes needed to make such units operational for decontamination.

- Radwaste System Capacity. Information was sought in this category because decontamination processes can generate sizable quantities of waste. The capacity of the system must be known to assess whether current designs and equipment would be able to accommodate these processes.

- Waste Handling Techniques. An important consideration in the radwaste treatment system is how the wastes are ultimately handled. It is important to know if there is to be evaporation and drumming of these wastes, if they are fixed by ion exchange or what will be used to dispose of them. Waste handling can be the constraining variable if existing systems are barely able to operate with existing radiation levels. Therefore, knowledge of this aspect of operation had to be determined.

- Radiation Limits. There are many radioisotopes in the primary system that are normally of little concern in the radwaste treatment operation. When there is decontamination however large quantities of these radioisotopes are transported to the radwaste system in either concentrated solutions or fixed on ion exchange resins when dilute decontamination processes are used. The limits that the current system has in its design are a constraint then on operation with decontamination solutions and we had to question what current conditions were.

The identity of the utilities, nuclear reactor suppliers, architect-engineering companies and chemical service groups contacted is shown in Table 1. The table also shows where a few organizations have interests and capabilities in more than one area.

The selection of the utilities was made for a number of reasons that include: 1) knowledge of and/or plans for decontamination, 2) high personnel exposure, 3) operation of a reactor supplied by one of the four vendors so the authors could cover all suppliers, 4) receptiveness to a visit, and 5) special operating and/or design features. There are four suppliers; four were visited. There are two large chemical service companies and it was decided to visit the largest in acquiring information. Two of the firms prominent in supplying architect-engineering services to the nuclear industry were selected to ensure that the personnel contacted about decontamination and radwaste treatment systems would have a substantial amount of experience with a number of reactors for a number of utilities.

Information acquired from the literature and through contacts will be analyzed. Key questions that will be considered in the evaluation are:

- Suitability of existing systems for decontamination.

- Possibilities of modifying existing systems for decontamination and decontamination waste treatment and disposal.

- Impact of decontamination on costs and radiation exposure after evaluation conclusions will be made and a report prepared on the study.

The conclusions of the study will be "tested" before publication and release of the document. The "testing" will consist of a presentation of the results and conclusions to individuals from the various groups contacted in the course of the study. It is believed that such a presentation and the feedback from these individuals will help clarify and avoid misunderstandings and misleading conclusions.

## PRELIMINARY FINDINGS

Because this study of the impact of decontamination on radwaste treatment systems is still underway, the reader must be cautioned that findings at present are only preliminary. The evaluation must be completed before the findings and their implications are stated with assurance. Consequently, all of the material that follows under several subheadings must be considered as tentative, incomplete and subject to revision as further evaluation and analysis is undertaken.

## VIEWS ON DECONTAMINATION

Interviews with the different groups identified in the previous section provided a range of thoughts on the need for decontamination and how wastes from such operations might be disposed of. Some NSSS vendors that believe that decontamination would not be required for their reactors while others were actively developing processes to reduce radiation levels. Some utilities recognize that radiation exposure problems will lead to decontamination. Others believe there would be no need to decontaminate all or part of their primary system. The architect-engineering firms that were contacted agreed that decontamination was going to be required and that it would have an impact on radwaste treatment systems. Their approach to designing for decontamination varied from organization to organization. One of the chemical service companies is providing a process for the decontamination of reactors; the other contacted expressed interest in being involved in such operations in the future. These organizations were concerned about the lack of information on the constraints that will be or have been imposed on what are acceptable processes. They need information to develop viable processes that can be used to clean the reactors.

## DECONTAMINATION READINESS

Except for N-Reactor and Dresden-I, there are no reactor systems at the present time in the United States that are ready for decontamination without substantial modification. Parts or all of the N-Reactor primary system have been decontaminated nine times. Current conditions do not mean that the modifications could not be made readily to accommodate either on-line or concentrated processes. They indicate that planning must be undertaken and modifications made so that such processes could be used if there is a need. Some U.S. utilities are making preliminary plans for decontamination. Current conditions in the U.S. should be contrasted with those in Canada where reactors are decontaminated, others are being modified for such operations, or planning for cleaning is underway.

## BACKGROUND INFORMATION

Knowledge of decontamination and its impact on radwaste treatment systems in the utilities vary. Some utilities were well aware of the need for decontamination and what it would do to their radwaste treatment system, the exposure of personnel that might be involved in such operations and the special problems that would be encountered in the disposal of such wastes. Most of the utilities, however, had not considered decontamination as being necessary and consequently are awaiting additional information.

## CAPABILITY OF RADWASTE TREATMENT SYSTEMS

Except for N-Reactor and Dresden-I, no radwaste treatment systems are currently available that could accommodate wastes that are produced during the decontamination of a nuclear reactor. This finding is equally applicable whether it be for concentrated processes or for dilute solution decontamination. The former would require extensive changes in the radwaste treatment system especially in tankage for more waste volume and perhaps changes in materials of construction to hold the more corrosive chemicals. If more dilute processes were to be used, larger ion exchange systems with heavier shielding would be required. The radiation levels attendant with such decontaminations would be much higher than existing systems could accommodate. The exact means for disposing of ion exchange resins is not known either.

## PROCESSES

Two types of processes are being considered for the decontamination of power reactors. The first, on-line, process involves the addition of a low concentration of decontamination chemicals directly to the reactor coolant. After the decontamination is complete, the chemicals, including the dissolved deposits, are removed by ion exchange. It does not require large quantities of chemicals but also does not provide a large decontamination factor. The on-line process is viewed much more favorably by utilities because they believe it would be much more economical to apply. There is information that suggests on-line decontamination can be done in 24-48 hours.

The second process uses concentrated chemicals to remove the radioactive corrosion products from the primary system. Fill, drain and flush techniques are used to introduce and remove decontamination chemicals. The process has the advantage that it generally provides large decontamination factors such as might be needed during inspections. However, it uses large quantities of chemicals which must be processed. Utilities are also of the opinion that it would require up to six months to accomplish. However, a well planned concentrated decontamination operation with a modified reactor having a good radwaste system could probably be done in 14-20 days.

Another prevalent belief is that there is no process that could be applied to reactors today if decontamination were required. It is the authors' belief that the alkaline permanganate-citrox process could be used even though it would be expensive and time consuming. This process has been used at N-Reactor. It was also employed with great efficiency on the PRTR in 1965. With the availability of the AP citrox process, even though current examples are for PWRs, there is a standby process if the need were to arise that would demand decontamination.

## FUEL DECONTAMINATION

Interest in concentrated chemical decontamination processes means there is a need to have processes for cleaning nuclear fuel. Currently, if a concentrated process were to be used, the fuel elements must be removed from the reactor and stored while the chemicals are applied to the primary system. This not only makes for a more time consuming process, it can lead to a more rapid buildup of radiation following decontamination because a major portion of the active inventory in the primary system is on the fuel surface. In all likelihood, even with a process for fuel cleaning, the fuel elements would be removed and decontaminated elsewhere. Without fuel removal it is not possible for heat transfer and fuel failure reasons, to drain first and flush by refilling. Flushing by feed and bleed would generate large volumes of waste.

The N-Reactor organization has decontaminated fuel in place with concentrated chemicals although their fuel elements are of much simpler design than most power reactors. There is a precedent and that shows fuel cleaning to be possible. The need for fuel cleaning must be satisfied for concentrated chemical decontamination for this process to be considered viable in other than special situations. It is the authors' belief that a program should be undertaken that would develop a fuel cleaning process for use with fuels when out of reactor.

## DECONTAMINATION

Another of the preliminary findings of the study is the need for a greater awareness by the utilities of what decontamination is, how it is undertaken and earlier experience in such operations. At the present there are different levels of awareness but few understand or appreciate the early work that has been done on decontamination. Some means should be devised to provide this information by an organization that enjoys credibility with the utilities. There is a reluctance by utilities to accept what a chemical service organization provides because some believe they promote their particular process. Also there is a reluctance to accept unequivocably what the vendors might supply because these organizations have over simplified such problems in the past. Architect-engineers are not repositories of needed information but rather are seekers of additional information that would make them competitive and responsive. All of this points up a need to have information supplied by a credible source in such a matter where it will be acceptable and useful at the same time.

## IMPACT OF DECONTAMINATION ON RADWASTE SYSTEMS

There are a number of different factors that influence the design, operation, and efficiency of radwaste treatment systems. A schematic showing these factors is given in Figure 2. The chemicals that are fed into the system are defined by the primary system requirements. The chemicals in turn affect the types of materials that can be used and in turn influence the capital costs that are involved in constructing radwaste facilities. Exposure limitations require special designs and increased shielding to avoid undesirable effects. Current systems do not have designs that minimize exposure that would result from the higher concentrations of radioactivity that would be involved during decontamination operations.

Licensing is an important factor because it influences what designs would be acceptable and perhaps more importantly, the schedules which are involved in putting a facility in place to accommodate decontamination. There is a general feeling among the utilities that licensing reduces their flexibility by requiring protracted periods for approvals. Frequently such organizations start comparable activities in their non nuclear components when the need for cleaning is readily recognized rather than by long term planning.

The radioactivity levels affect personnel exposure, but they also affect the type of equipment used and methods of disposal. These concentrations are related to reactor type, design, and operating conditions.

Disposal is probably the most underrated factor, the one having perhaps the greatest constraint on the operation of radwaste treatment systems. It is not sufficient that there be tankage to receive the liquid waste and a means for concentrating. All wastes generated must be removed to some other place for the operational system to be viable. A very important consideration in the successful operation of a radwaste treatment system is personnel attitudes. All too often it seems that the radwaste treatment system has been considered as an undesirable place to work. This reluctance must be overcome if efficiency is to be improved.

## COMMUNICATIONS

The communication network that is involved in the transmittal of useful information between the various groups involved in nuclear power reactor decontamination has an impact on efficiency and radwaste systems. Figure 3 shows this network. At the center is the utility that is the seeker and user of information. The utility is the organization that must make a decision to decontaminate based on economics. Supplying information to the utility are architect-engineers, NSSS vendors and chemical service groups. Some communication occurs between these organizations but the primary flow of information is to the utility as it is shown in the figure. In some cases, this direct flow to the utility and only marginal exchanges of information between the others involved is detrimental to the broader development and utilization of decontamination. Chemical service organizations, for example, feel they are not privy to enough information about reactor designs to be able to develop chemical cleaning processes that will not affect the materials of the construction or be acceptable to suppliers. In turn, the suppliers are concerned about the warranties that they give to the utility and the need to know all that is put into a chemical cleaning solution so that damage is not done to various reactor components. Both the service company and the NSSS vendor have similar desires and needs; it seems like they are not getting together at the present time to exchange information of greatest benefit to the utilities. Off to the side is the Nuclear Regulatory Commission (NRC) that establishes guidelines to govern the operation of nuclear reactors. The service organizations, and all too often, architect-engineers and suppliers, do not understand NRC philosophy and requirements. Consequently some of things that are developed or suggested cannot be readily applied.

## ACKNOWLEDGMENTS

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During the late sixties most work on decontamination halted in the U.S. As a result, a break is visible in the published literature. In order to assist in bridging the gap, a sampling of some of the older decontamination literature follows:

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TABLE 1. Program Contacts

| | Utility | NSSS Vendor | Architect-Engineers | Chemical Service Companies |
|---|---|---|---|---|
| Commonwealth Edison | X | | | |
| Boston Edison | X | | | |
| Baltimore Gas & Electric | X | | | |
| Portland General Electric Co. | X | | | |
| United Nuclear Industries | X | | | X |
| Duke Power Co. | X | | X | |
| Ontario Hydro | X | | X | |
| General Electric Company | | X | | |
| Westinghouse | | X | | |
| Babcock & Wilcox | | X | | |
| Combustion Engineering | | X | | |
| Dow Chemical | | | | X |
| Halliburton | | | | X |
| Stone & Webster | | | X | |
| Bechtel | | | X | |

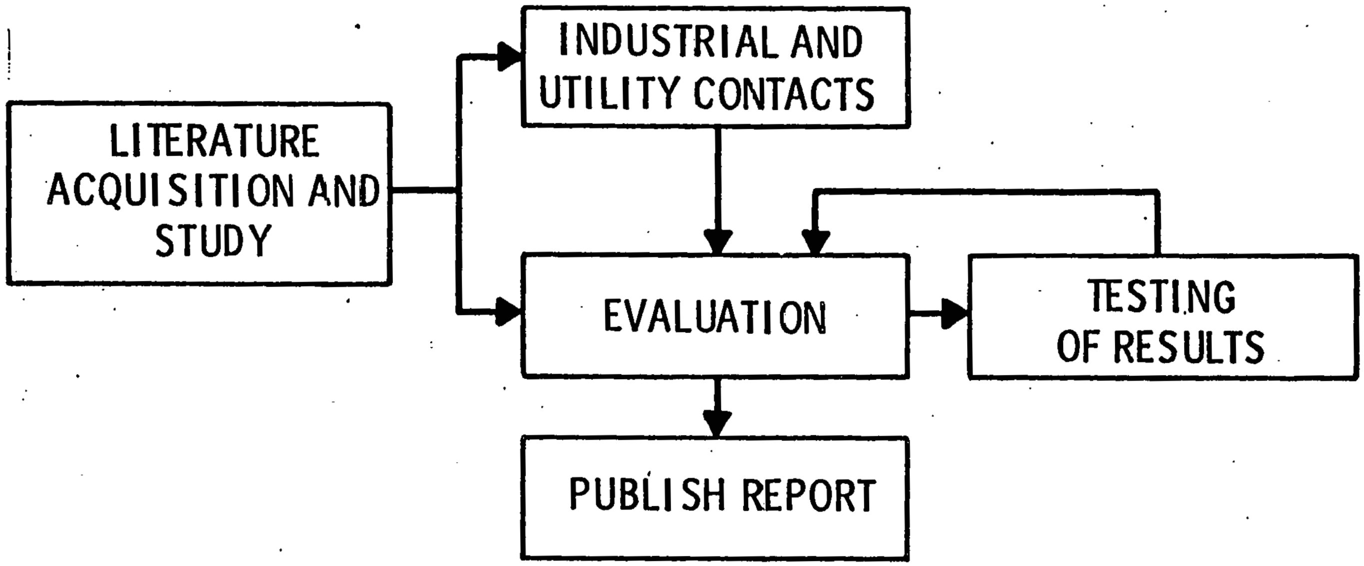


FIGURE 1. STUDY METHODOLOGY

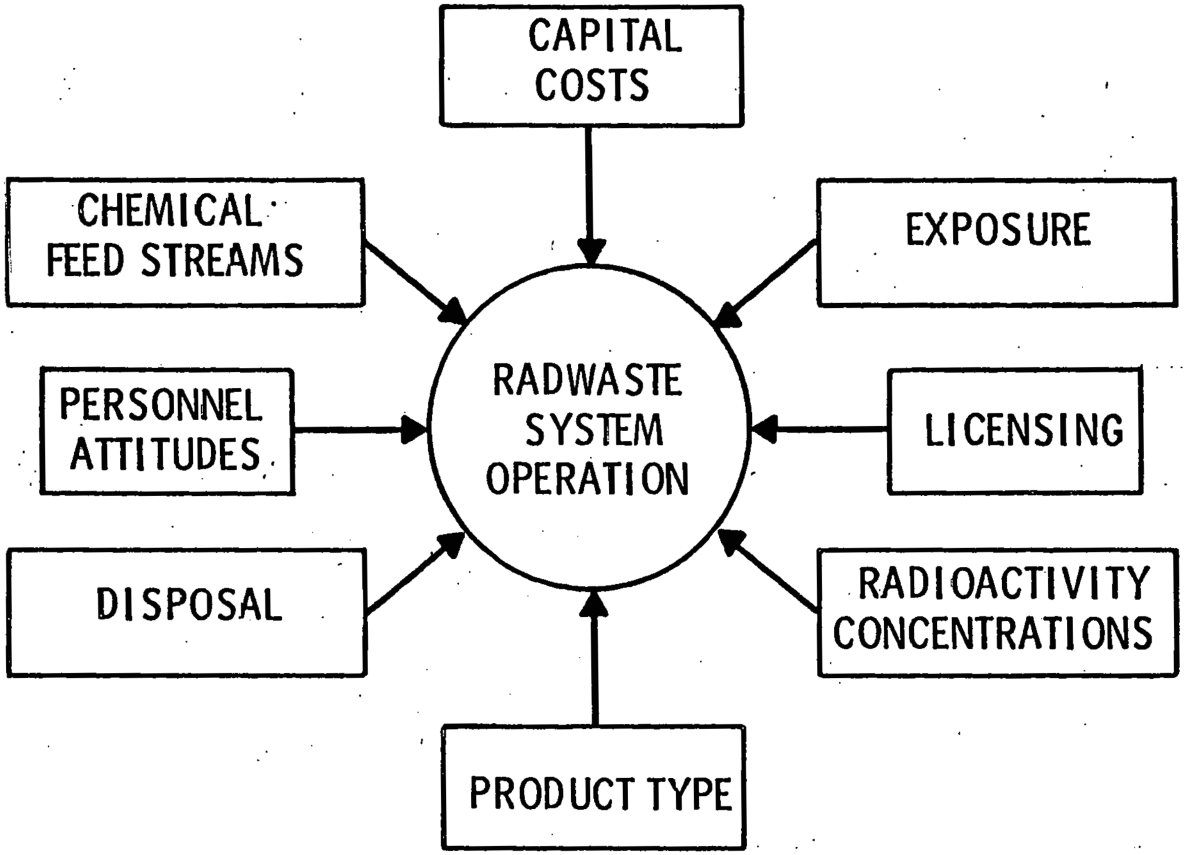


FIGURE 2. FACTORS INFLUENCING OPERATION AND EFFICIENCY OF RADWASTE SYSTEMS

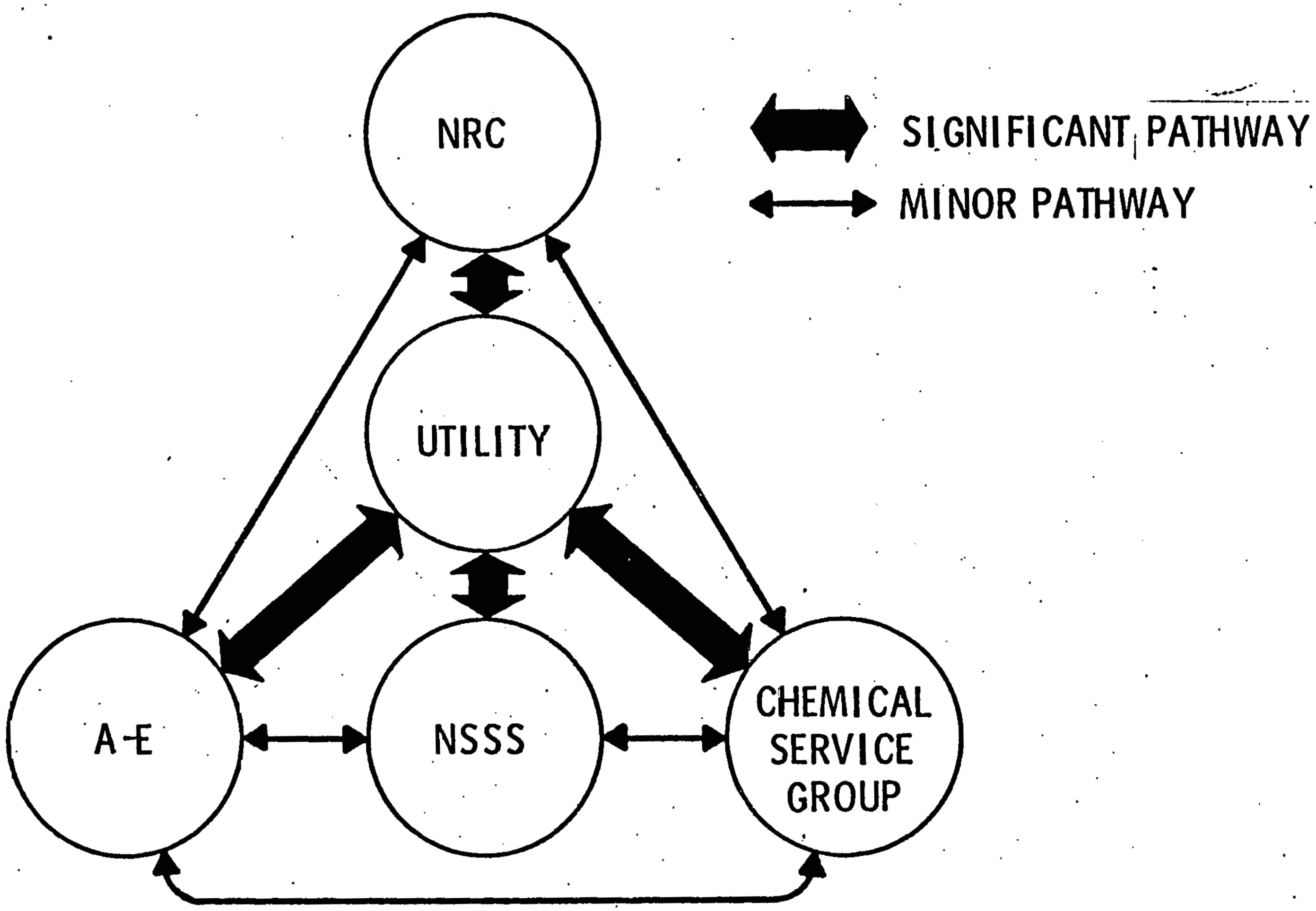


FIGURE 3. COMMUNICATIONS PATHWAYS