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TRANSPORTATION NEEDS ASSESSMENT

EMERGENCY RESPONSE SECTION

MOUNTAIN WEST RESEARCH

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DESCRIPTION OF THE PREFERRED EMERGENCY RESPONSE SYSTEM

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Description of the Preferred System for Nevada (15.2)

Any discussion of a single preferred system for the state of Nevada would be misleading at this time. There are three major reasons why attempting to suggest a single preferred system would be misleading. First, the lack of specificity of DOE and DOT plans for transporting the high-level radioactive waste and the ambiguity which exists concerning modal mix and route selection for transport make it impossible for local and state officials to provide a single preferred emergency management system for transportation of high-level waste forward at this time.

Second, the state and local preferred emergency management system will not only vary to some degree based upon the actual transport routes and other federally specified plans, but will also vary depending upon what is mandated within the state of Nevada. That is, as the siting goes forth and greater specificity concerning the nature of the project and transport of the waste is obtained, the state of Nevada's Legislature and Governor will undoubtedly require agencies within the state to take specific actions to protect the health, safety and welfare of the public. Hence, any preferred system which is postulated must be conditioned upon the understanding of the preliminary nature of its components.

Finally, given the ambiguity in the final details of the Repository transportation system and the project, it is likely that different agencies of the state and local governments in Nevada will have differing opinions and views about what emergency management measures should or must be required. These different perspectives suggest that the details of any state system postulated at this time must acknowledge that differences do exist within the Nevada

emergency management community. Hence, the approach taken in this section is to specify elements of the state preferred system where there is widespread agreement among emergency managers and responders that additional effort and activities must be undertaken, but also to indicate areas where some disagreement exists in the state concerning the necessity of specific measures. This approach will permit us to array a large number of emergency management measures which make-up the state preferred system. The reader must understand that before the necessity of any measure should be accepted the state should undertake further assessment concerning current capabilities, and as DOE's plans become more specific, undertake additional analysis of the emergency management's community needs.

The preferred system postulated here is based upon interviews over a two year period of time with state and local emergency management officials, first responders to disaster incident(s) in Nevada, state directors of various departments which have a role in emergency management or regulating transport of any type of hazardous waste in Nevada, and analyses of various state reports and legislation. It should be emphasized that officials interviewed offered components of an emergency management system which they felt would be the minimum necessary to protect the health, safety and public welfare of Nevada citizens. That is, what they as professionals felt was absolutely necessary in order to tell the public that any potentially hazardous incident involving the shipment of the waste could be handled effectively by the state and local agencies involved in the response and potential clean-up. The preferred system focusses upon activities in the preparedness and planning phases representing the early stages of planning which have been undertaken by Nevada's agencies

and local governments, as well as the ambiguity surrounding the later stages of the project.

The State Preferred System

A. Planning

Prior to the actual operation of any high-level waste Repository at Yucca Mountain, or shipments of high-level waste material into the state there is unanimous agreement that a great many activities must be undertaken. Perhaps most importantly as a first step is the development of a state radiological emergency response plan designating functional responsibilities to the state and local agencies which may be involved in the response to an incident (This responsibility is delegated to the state by the Federal Radiological Monitoring and Assessment Plan developed by DOE). The plan must be developed with the assistance of local emergency management personnel to ensure consistency with local radiological response plans which must also be developed. The plan should address the problems associated with coordination of the response and the ever-present problem of communication among responders which will be particularly important in any incident involving the transportation of materials which can occur any place in the transportation network as opposed to a fixed site incident. It should be pointed out that the plan should also address the problem of response to rail incidents and deal with the difficulty of reaching such incidents which occur on rail lines and can not be reached by emergency response vans.

B. Communications

The state response agencies (Nevada Highway Patrol (NHP) and the Division of Emergency Management (NDEM), along with several state studies which are or

have been conducted (for example the Emergency Response Commission Study under authority of Assembly Bill 352 and 719) have all agreed that some form of communication system for all emergency responders is essential (Mushkatel, 1988a,b; Diversified Communication Engineering, 1988). It seems likely that the long term solution to this problem of emergency response communication will include an 800 MHZ high band system. Hence, any preferred system for the state and local governments will address the issue of communications and the solution will permit communications among all state and local emergency responders. The current inability of all agencies to communicate directly with each other is a function of the use of different wave bands. This different radio band use has resulted in the previously mentioned studies aimed at an 800 MHZ high band system, which is preferred by the state agencies.

C. Information Repository

Closely related to the communication problems confronting the state, is the desirability of being able to track all spent fuel carriers within the state. At least one report commissioned by Nevada has addressed the feasibility of establishing an information data base on high-level and spent fuel transporters which could be used in conjunction with neighboring states (Weschler, 1988). In addition, the NDEM and NHP, using A.B. 352 and 719 as models, are strongly committed to establishing a separate information repository for these types of carriers. A.B. 352 and 719 provide for such a information repository for the carriers of hazardous waste within the state, as well as requiring the feasibility study of a statewide communication system. Using Nevada's mandated response to the national Superfund Amendments and Reauthorization Act of 1986, the NDEM and NHP personnel believe the state should

also be able to develop similar capabilities for tracking the history of transporters and vehicles of high-level nuclear waste (Mushkatel, 1988 a,b).

D. Escorting Transporters, Permitting, Ports of Entry, and Safe Havens

The issue of interstate vs. intrastate transport of high-level waste to the Repository is discussed in several other studies (Mushkatel, 1988 b,c). While the state of Nevada may only place certain permitting fees in place for transporters of intrastate commerce, some form of fee system is desirable to the NHP to offset various costs the section will incur as a result of the Repository's location. Under A.B. 352 the NHP was empowered to devise a permitting system in place for carriers of hazardous materials, and federal statutes along with A.B. 719 authorized the state to impose a surcharge of \$2 per cubic foot of radioactive waste received at Nevada's regional facility. Clearly, the state would prefer some type of permitting system and perhaps surcharge or taxing of shipments. In addition, A.B. 352 mandated inspections of such vehicles and the establishment of an information repository for both producers and carriers of such materials. A.B. 352 also requires minimum notification to the state of four hours before any radioactive waste may be shipped into the state. Once again, the state, relying on the specifications of A.B. 352 and what Nevada's likely response will be to the Repository, will likely impose similar requirements on high-level nuclear waste shipments. This suggests not only some type of permitting system but the advance notification requirement will permit the state to implement an escort system. The Division of Motor Vehicles and Public Safety feels any preferred system will include an escort vehicle for the shipments. These escorts will preferably be highway patrol vehicles which will be manned by well-trained troopers who will meet the shipments as they enter the state and escort them to their destination.

These vehicles will also contain sufficient monitoring equipment to allow for some inspection of the cargoes. Whether there is sufficient need to also escort the transport vehicles out of Nevada is still under discussion. The escort system, would be similar to what is now required of all over-sized loads except highway patrol vehicles and personnel would be utilized.

The inclusion of escorting of transporters of high-level nuclear waste as well as the question of ports of entry for the shipments in the preferred system for Nevada relies in part upon what the Chief of the NHP believes is absolutely essential to ensure public safety. The NHP believes there are two parts to the question of public safety and they will not permit high-level nuclear waste into the state unless both dimensions of public safety are met. First, there is the question of what steps are necessary to ensure that the loads are shipped into Nevada in the safest possible manner. The second dimension focusses upon the public's perceptions of the safety of these shipments (Mushkatel, 1988b). The NHP believes that unless public confidence is gained concerning the safety of the shipments and the states' ability to meet any situation, it is likely that the NHP and other law enforcement officers will be confronted by demonstrations and other unrest. Because of this philosophy, the NHP and other state agencies feel that not only is escorting of waste shipments necessary, but also the shipments must be inspected when they enter the state. Hence, any preferred system for Nevada must include ports of entry manned 24 hours a day, seven days a week for the purpose of inspecting the shipments and vehicles carrying the waste materials. These ports of entry will be constructed on highways which will be utilized to transport the shipments. The NHP and other agency personnel (Public Service Commission (PSC) personnel will be trained in the use of radiological equipment and able to detect any leaks. In addition, shipment

manifests and driver's records will be scrutinized, and the information will be transmitted to the relevant agency computer system to permit the tracking of the shipment.

The question of whether safe havens for the transport vehicles and drivers are necessary in the state preferred system is still unresolved. The NHP is strongly committed to not permitting vehicles to stop once in Nevada until they arrive at their destination. Other agencies feel such havens are necessary in the event of vehicle failure or the necessity of the driver(s) resting. Until DOE plans concerning the transportation routes and number of drivers is clearer the necessity of safe havens in such a system can not be resolved.

E. Monitoring of Railroad Shipments

While the ports of entry, escorting truck transporters, and information repository for truck shipments are all part of the preferred system for Nevada, they address only highway shipments. Increasingly Nevada agencies are concerned that serious incidents can occur on rail routes which they will be ill prepared to handle. Unfortunately, the state is poorly informed concerning DOE's plans about rail shipments. Nevada's PSC through General Order 52 (currently being contested in the courts, and a result of the state's experience with the Union Pacific Railroad's plan of shipping 7200 tons of radon-contaminated soil to the Beatty low-level site) places several requirements on transporters of hazardous materials including explosives and radioactive waste (Nevada Administrative Code, 705.310 through 705.380; Mushkatel, 1988c). Transporters are required to obtain permits from PSC when 1) loading or unloading containers onto or from railroad equipment or property owned by or under the control of a railroad, 2) transferring hazardous materials from property owned by or under the control of a railroad to another means of transportation, or 3) storing

hazardous materials on property owned or controlled by a railroad (NAC, 705.320). Once again this Order raised questions concerning intrastate vs. interstate commerce. Yet, the state maintains that if the materials were being transferred to another mode of transportation or if they were stored for over 12 hours, any resumption of their shipment was a new trip and therefore constituted intrastate commerce.

The above discussion suggests that any preferred system will heighten the PSC's ability to monitor railroad shipments of high-level waste into Nevada. If General Order 52 is upheld it will be necessary to require the PSC to monitor and inspect shipments into the state, or when a new shipment is defined under General Order 52. In addition, as details of rail shipment plans become more definitive the PSC must enter into additional planning to determine what it will require to ensure the public health, safety and welfare of Nevada citizens. The questions involving rail shipments raise several issues concerning the state's emergency response capabilities which are discussed below.

F. Emergency Response

Many of the measures in the preferred system discussed above are designed to provide the state the necessary capability to respond efficiently and effectively to any transportation related incident involving the shipment of high-level waste into the state. For example, the statewide communication system will permit the first responders with the ability to communicate with the state NDEM (in charge of coordination), local responders including law enforcement and hospital personnel, and other state, local and federal agencies which need to respond to an incident. Similarly, the information repository will be a part of a larger monitoring system which will provide information to responders concerning the driver of the vehicle, as well as the truck being used in the

transport of the materials. What has been described above in the preferred system description deals largely with the elements of the system which need to be in place to permit a effective response. At least two additional elements of such a system need some discussion.

The first of these response system elements involves an emergency operations center which would coordinate any state response and which is tied into the statewide communication and information repository system. The PEPCON explosion has provided state and local governments an excellent learning experience as to the importance of a coordinated response (Henderson Commission, 1988). Obviously one key component necessary for a coordinated response is adequate communication. Yet, perhaps of equal importance is a operations center at the state level which is fully manned by trained professionals and has the capacity to take control. The NDEM has identified this operations center as one of its most important needs (Mushkatel, 1989). Such an operations center whether it is located in the NDEM or other agency or local government must be a part of the preferred system. In addition, the state currently does not have a state response team per se. The preferred system for Nevada entails the creation of such a statewide team.

The second component necessary for effective response not discussed above involves planning and capability. One issue which continues to arise involves potential rail incidents and the lack of preparedness by state agencies to handle such an event. The NDEM and PSC are both concerned that sufficient details of rail transport be revealed to permit them to plan for and respond to any rail incident. The preferred transportation emergency management system must provide the state with the capability to reach any rail incident. Depending on the final rail route(s) selected, the terrain may make it impossible for

state emergency response vans to reach the railroad tracks (the need for such vans is discussed in Mushkatel, 1988a; Mushkatel, 1989). Hence, once the route selection for rail transportation is known the state should determine if its current capacity is sufficient to allow it to reach the site of a potential incident. Currently, some state agencies are discussing helicopters which are specially equipped and trailer trains manned by emergency response personnel which would follow shipments through the state.

G. Training

There is widespread agreement among state and local personnel that the current training of first responders, emergency management personnel for radiological incidents is woefully inadequate. The NDEM has developed a white paper or report dealing with the additional training needs of their personnel, as well as hospital personnel, firefighters, police and law enforcement officers, and a variety of decision-making officials that will need to deal with the media (Moore, 1989). The NHP has also undertaken an initial analysis of their training needs which reflects their view that all officers who might be a first responder to a radiological incident are in need of additional training.

The preferred system will involve a complex training program which will provide training to not only first responders to an incident but also all state and local personnel who may become involved in managing an incident, or providing aid to those who are involved in an accident. As is pointed out under FRERP, federal agencies will play mostly a supportive role in the event of an incident. In addition, under the Transportation Institutional Plan (1986) the DOE will arrange for necessary training. The state preferred system will involve the training of its key personnel and its own trainers by federal agencies and

laboratories. Those trained at these facilities will then provide training to state and local personnel. Each state agency's key personnel, and those who will provide training can be trained in a similar vein and then provide training to others in their agency and throughout the state. In addition, the NDEM report suggests that certain key personnel will receive training by taking courses at the states' universities (Moore, 1989). This training must begin well before the scheduled operation of any Repository because of the length of time necessary to train all of the state and local personnel. Training for transportation incidents receives major emphases from all of the state and local personnel, and agency directors interviewed.

H. Intergovernmental and Interagency Coordination

The confusion in the response to the PEPCON explosion, the difficulties in obtaining a coordinated federal response (FEMA and EPA for example), and the large number of command centers which were established throughout Clark County and the state, all indicate the importance of coordination. Yet, coordination is necessary not only in the response to a disaster incident, but also in the planning and preparedness stages of emergency management. Currently, there are several state committees and commissions involved in emergency management issues (for example, the NDEM Hazardous Waste Committee, and the Emergency Response Commission established under A.B. 352). The plethora of such committees extends to the local level of government. What seems to be missing is a coordinating body capable of obtaining interdepartmental and intergovernmental cooperation and coordination of planning and preparedness efforts in the state as it attempts to plan for transportation related incidents from the Repository's siting in Nevada. A preferred system should include some state effort to compose such an intergovernmental interagency organization whose sole focus is on

transportation issues. The composition of such an organization would consist of decisionmakers from state agencies and local governments. The composition of such a body would ensure that resources of the entity being represented could be committed to studies or proposed action. The coordinating organization should be located directly under the Governor and/or state legislature.

The creation of such a coordinating body should not suggest that too little is being done to study and prepare for the transit of high-level waste to the proposed Yucca Mountain Repository. Indeed planning is occurring in almost all the state agencies, and many of the local ones. For example, the NDEM training study has already been alluded to, as have efforts by the NDEM. The state Radiological and Health section has invested time and resources in its preparation efforts. At the local level almost all of the governmental entities in Clark County have been involved in preparedness and planning activities. In Lincoln County a study on the radiological capabilities of small communities has recently been completed (Intertech Consultants, Inc., 1989). These activities and the information gained needs to be systematically shared with all concerned and potentially affected governmental entities in the state. The creation of a intergovernmental interagency coordinating organization will be an important step in the state's continuing efforts to prepare and plan for the transportation of high-level waste to Yucca Mountain.

I. Equipment and Personnel Needs

The specific equipment and personnel needs necessary to implement this state's preferred system will not be arrayed here for several reasons. First, the state and local needs will to some extent depend on what the current capabilities are. No assessment of these capabilities has yet been carried out for all agencies and governmental entities. Hence, any array of such materials

and personnel needs would be premature. Second, the DOE plans are still too ambiguous to specify the exact nature of the equipment and personnel needs for Nevada and her local governments. Finally, a preliminary assessment for some of the state agencies has been completed and is reported on elsewhere (Mushkatel, 1988 a,b,c;1989). As the specific components of the state and local preferred system are better understood with future DOE specification of transportation plans, and as the current capabilities of state and local governments are determined, the specific equipment and personnel needs should be delineated.

ENDNOTES

1. Diversified Communications Engineering, "Report to the State of Nevada Emergency Response Commission: Radio Communication Study," 1988.
2. The Henderson Commission, "Final Report," August 10, 1988.
3. Intertech Consultants, Inc., "Radiological Emergency Response in Small Communities: A Report on Capabilities and Constraints," February 1989.
4. Moore, Susan, "High Level Waste Repository," 1989.
5. Mushkatel, Alvin, "Nevada Division of Emergency Management," Phase IIIA Yucca Mountain Socio-Economic Project. June 1988A
6. Mushkatel, Alvin, "State Level-Cost Analysis and Intergovernmental Relations: the Department of Motor Vehicles and Public Safety," Phase IIIA Yucca Mountain Socio-Economic Project. June 1988C.
7. Mushkatel, Alvin, "State Level-Cost Analysis and Intergovernmental Relations: The Nevada Public Service Commission," Phase IIIA Yucca Mountain Socio-Economic Project. June 1988C.
8. Mushkatel, Alvin, "State Agencies Update: Division of Emergency Management," May 1989.
9. Weschler, Rebecca, "High-Level Radio Active Waste/Spent Nuclear Fuel Transportation Issues: An Assessment of Corridor States' Radiological Emergency Response Capabilities and the Need for Indian Involvement," November, 1988.

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Description of the U.S. DOE Planned
System for Emergency Response (15.3)

The Description of the U.S. DOE planned system for emergency response is based on the Agency's Transportation Institutional Plan (1986), the Federal Radiological Emergency Response Plan (FEMA), FEMA's Guidance for Developing State and Local Radiological Emergency Plans and Preparedness for Transportation Accidents, and the Federal Radiological Monitoring and Assessment Plan (FRMAP) in addition to the relevant regulations found in the Federal Register.

Although the shipper and carrier bear the primary responsibility for assuring that radioactive materials are safely packaged and transported, responsibility for responding to a transportation accident generally falls to the state or local government. The role of the Federal government in responding to transportation accidents is usually one of supporting the lead response role of state and local governments and aiding local areas in developing the appropriate emergency response capabilities.

Based on the Transportation Institutional Plan (1986) the U.S. DOE will serve in an advisory and coordinative role with other agencies to arrange for "any necessary training and technical support." Specifically, the institutional plan suggests that the DOE will cooperate with the FEMA and DOT to

support local emergency agencies that have primary responsibility in accidents involving nuclear waste shipments. Local government and DOE interaction on transportation issues will be based on DOE guidelines as outlined in the Internal Guidelines for Interactions with Communities and Local Governments (DOE, RM-0039, 1985).

According to the institutional plan, DOE's role will be as follows:

- (1) To work with other Federal agencies, Nevada, and local governments to define roles in emergency response;
- (2) to assist in the development of uniform emergency response capabilities (e.g., to revise the FEMA radiological response plan); and
- (3) to formulate advisory guidelines for emergency response activities related to nuclear waste shipments.

The following items have been identified for inclusion in the advisory guidelines: calibration of radiation-monitoring equipment, training standards, and emergency response drills. The institutional plan (1986) also stated that the role of DOE in the development of a comprehensive response system will be made by 1993. To date, DOE has not developed any specific programs created by the NWPA. Also, to date, DOE is relying upon existing Federal emergency response programs.

The report of the NAMP to the Nevada Legislature (December 1988) noted that the DOE is expected to provide technical and financial assistance to states three to five years prior to shipments to the repository. There is disagreement between the State and DOE regarding the Congressional intent of the timing of implementing emergency response plans and development. The NWPO position is to implement emergency response development immediately by funding local and state emergency response planning. The three to five year development period prior to shipments is considered inadequate.

The Federal Radiological Emergency Response Plan

The basis for the current Federal emergency response planning regarding radiological transportation accidents is the Federal Radiological Emergency Response Plan (FRERP) promulgated in 1985 by the Federal Emergency Management Agency (FEMA). Historically, the lead role of FEMA was authorized in 1979 where FEMA would be responsible for establishing policies and coordinating civil emergency planning, management, and assistance of Federal agencies. FEMA is charged with working with state and local jurisdictions to assist in the development of local emergency plans and training. Emergency planning includes transportation accidents involving radioactive materials.

Part 351 of the 44 C.F.R. (1987) identifies the roles and functions of Federal agencies in providing assistance to state and local governments regarding a transportation radiological event.

The FRERP was developed by FEMA and 11 other Federal agencies to define the Federal response to radiological emergencies. The plan covers any radiological emergency event that could require a significant response by several Federal agencies. The FRERP is activated when a state or local jurisdiction requests Federal support or when Federal agencies must respond to meet their regulatory responsibilities. There are three types of incidents identified: fixed nuclear facility incidents; transportation incidents; and other incidents.

The FRERP is primarily concerned with Federal support to state and local governments beyond the immediate site of the emergency (offsite). For emergencies that do not have physical boundaries (e.g., transportation accidents), the state or local government will define an area onsite at the time of the accident and manage all activities within that area. For transportation accidents involving materials shipped by DOD or DOE, those agencies as "Cognizant Federal Agencies" (onsite Federal support is responsibility of that Federal agency) will define and control the onsite area. When shipments are by or for DOD/DOE, these agencies are "Cognizant Federal Agencies" (CFAs) and as such have

a specific coordination function in relation to the state and the owner/operator of the radiological activity. Activities of CFAs are to monitor, evaluate, and provide assistance if required regarding onsite problems and to develop and evaluate recommendations for public protective action measures offsite to appropriate state and/or local offices. The role of FEMA is to promote coordination of Federal assistance including assistance to state and local governments and logistic support to other Federal agencies.

(FRMAP) The Federal Radiological Monitoring and Assessment Plan

To coordinate radiological assistance under FRERP, the DOE developed FRMAP. Although part of FRERP, it may be implemented separately. FRMAP replaces the Interagency Radiological Assistance Plan. Under FRMAP, the DOE has the primary responsibility (if requested by the state or local governments) to provide technical personnel and equipment for radiation monitoring and evaluation in the event of a transportation accident involving radioactive waste. The annotated bibliography summarizes the Federal agencies' response plans for radiological emergencies under the FRERP.

Under FRERP, organizational responsibilities by level of jurisdiction were outlined. The state is responsible for developing a radiological emergency response plan, designating an

emergency radiological response team, and coordinating communications with Federal, state, and local agencies involved in the response. Local areas have the responsibility to develop a local emergency response plans that is compatible with the state's plan. Because local responders will be the first on the scene, they should be able to administer emergency measures and to notify appropriate authorities to obtain expertise. The Federal role is a supporting one. FEMA coordinates the Federal response to accidents which require the direct involvement of more than one Federal agency. Both DOE and EPA are responsible for coordinating radiological monitoring and assessment functions of the Federal agencies. Coordinated assistance by DOE is contained in the Federal Radiological Monitoring and Assessment Plan.

Other Federal Agencies

FEMA has also established the Federal Preparedness Coordinating Committee (FRPCC) (44 C.F.R. Part 351) in order to coordinate Federal assistance. According to the DOE's Transportation Institutional Plan, the FRPCC provides policy direction for the program of Federal assistance to local governments in their efforts to develop plans for radiological emergencies. The Committee developed a guidance document for local emergency response planning, Guidance for Developing State and Local Radiological Emergency Response Plans and Preparedness

for Transportation Accidents (FEMA REP-5, 1983). FEMA also provides financial assistance to support state emergency response activities. Transportation accident planning may be undertaken under these provisions, but the intent is to address response planning for all hazards. Various agencies have information and training centers on emergency response.

To date, the DOE has not developed a program that identifies the state and local needs for emergency response capabilities for radiological transportation accidents nor the level of Federal financial assistance required for planning, training, and equipment. Nor have emergency response planning and resources criteria been established for transportation accidents involving radiological accidents. The DOE's position is to coordinate plans through existing programs such as FEMA's FRPCC and to help FEMA review emergency response plans. It is not until the repository site is selected that DOE will define specific needs for training and equipment to support radiological transportation accident responses by state and local governments.

**EVALUATION OF THE DOE
EMERGENCY RESPONSE SYSTEM**

Evaluation of the U.S. DOE Planned Transportation

System: Emergency Response (15.4)

The DOE effort in developing a program for emergency response for radiological transportation accidents is founded on current Federal assistance and coordination programs and procedures. DOE's role is one of consultation and advisement to FEMA's interagency program for dealing with radiological emergencies. No new program has been established by DOE that specifically addresses the issues of nuclear waste shipment accidents and response as part of the repository program. In addition, the DOE has stipulated that program development and financial assistance in emergency planning would commence just three years prior to shipments.

There are several major problems inherent in DOE's present approach, which are highlighted below.

1. DOE's present effort in emergency response by focusing on Federal agency coordination and assistance has de-emphasized an integrated approach to emergency management. For example, the relationship between route selection, accident reduction, and emergency response needs has not been addressed.

2. There is a need for generic assessment by DOE of emergency response needs which takes into account the various types of potential accidents, shipment modes, and preparedness requirements.
3. There is a serious question whether FEMA has the institutional capacity to coordinate a major effort in developing preparedness plans, training, and providing assistance in the area of radiological transportation emergencies. The fact that the U.S. DOE will commence the implementation of emergency management procedures and programs so soon before actual shipments occurs reinforces this concern. A long lead time for training, emergency planning, and program development is essential for effective response capabilities. It is also not clear how much FEMA will be involved in planning and training with regard to nuclear transportation accidents.
4. There is no guidance at present of appropriate levels of community preparedness, training, equipment, and response procedures to potential accidents. Greater specificity is needed between the Federal, state, and local government roles and responsibilities in response planning.
5. There is a need to define levels of financial assistance for emergency management based on state and Federal

agreement of acceptable standards. These standards have to be developed and established as working principles.

6. There is no established evaluation criteria by DOE by which to develop effective emergency response plans and community response capabilities.
7. There are some capabilities at both state and local levels regarding the handling of problems of radioactive substances. There are questions, however, concerning the quality and quantity of these capabilities at the local level. Radiological emergency plans at the local level may have lagged behind national efforts; there may be a substantial buildup in expertise and training required for state and local areas. In addition, the role of the local first on-scene responders needs clarification.
8. There seems to be some confusion as to the roles of FEMA, DOE, and the EPA in onsite-offsite roles during radiological emergencies and their relationships to other agencies and local jurisdictions.
9. The U.S. DOE does not seem to be addressing the issue of the need for public education and information programs on transportation accidents and emergency response needs.

10. Nonstructural mitigation measures which may include regulations on speed, multiple loads, modification, and routing, have not been applied to rail shipments of nuclear materials. The focus of emergency management has been on truck transport to the exclusion of regulation of rail shipments.
11. The technical requirements of nuclear transportation hazards are different than natural hazards and the core of nuclear response programs are at the Federal level. Current DOE/FEMA positions seem to argue for integration of preparedness, planning, and training programs across hazards. This may present inadequate attention and resources to emergency response programs specifically with regard to radiological accidents.

LITERATURE REVIEW ON EMERGENCY RESPONSE

Emergency Response Related to Radiological Transportation
Accidents: Literature Review (15.5)

The literature found on emergency management related to radiological transportation accidents falls into two categories: those on the actual structure of the emergency response plan (agency roles, notification, procedures, etc.), and those that focus on the content of that plan. The literature overview is structured in the following way. The reports and agency documents that serve as the basis for the U.S. DOE position on emergency management are highlighted first. This is followed by summaries of several key articles on needs and evaluation criteria for emergency response plans for radiological transportation accidents. The last section provides a bibliography on emergency management related to the transportation of hazardous materials and nuclear waste.

The key documents that serve as the bases for DOE's current posture on transportation accidents include the following: Federal Radiological Emergency Response Plan developed by FEMA (1985); Federal Radiological Monitoring and Assessment Plan (DOE); Guidance for Developing State and Federal Radiological Emergency Plans and Preparedness for Transportation Accidents (FEMA, 1983); and A Review of DOT's Regulations for Transportation of Radioactive Materials. These essentially describe the roles and responsibilities of Federal agencies in

responding to radiological transportation accidents and in assistance to state and local governments for emergency preparedness, planning, management, mitigation, and training.

Two key reports on planning for emergency responses in radiological transportation accidents are: Emergency Response in Transportation of Radioactive Materials: An Evaluation Methodology by Sandia Laboratories (1982), and a Guide to Radioactive Materials Transportation by National Conference of State Legislatures (1983). The Sandia report discusses the unique aspects of radiological transport incidents and provides an analysis of evaluation criteria for radiological transportation plans. The criteria include: notification, accident assessment, public information, evacuation, protective response, radiological exposure control, responsibility for planning, and emergency response training. The evaluation criteria were utilized in an assessment of seven state response plans, and four local response plans.

The Guide to Radioactive Materials Transportation (1983) describes the uses of radioactive materials, the laws and regulations that cover their transport, and the interrelationships of Federal, state, and local governments. Of particular importance in this report is the opportunities identified for state action. These include the expansion of state enforcement of regulations, regional cooperation for

training, regional cooperation for inspection, and other safety regulations.

There are several case studies that deal with the evaluation of emergency response capabilities and the preparation of response and evacuation plans. Rittvo's study, The Transportation of Hazardous Materials -- A Case Study, is particularly noteworthy. The analysis of the problem included: (1) an inventory of existing conditions; (2) a route analysis and vulnerabilities; and (3) an assessment of response capabilities. The recommendations included measures to reduce/prevent accidents and measures to reduce and contain the consequences of accidents. The measures were organized into preplanning and preventative activities, training and equipment needs, legislative options, and the bases for an emergency evacuation plan.

A policy-relevant analytical study for emergency management involving hazardous materials transportation accidents was completed by E. L. Quarantelli, Transportation Accidents Involving Hazardous Chemicals Versus Those Involving Dangerous Nuclear Material (DRC, 1982). In comparing both hazards, the author argues that the two kinds of dangers require different rather than similar responses. A summary of policy implications for emergency management for both hazards is discussed. Of particular importance to Nevada's efforts, is the conclusion that despite dissimilarities in the two threats, the existing

literature overemphasizes technical problems and safeguarding measures and provides less attention to social and organizational problems in preparing for and responding to nuclear materials transportation accidents.

A detailed bibliography of relevant articles and reports on emergency management and hazardous materials transport, in addition to summaries of key literature, is included as a separate report that accompanies this brief overview.

EMERGENCY MANAGEMENT
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LITERATURE SEARCH

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INTRODUCTION

Research Topic

What is being recommended as far as emergency management for radioactive transportation. In the event of an accident, what needs to take place.

Literature

Although the shipper and carrier bear the primary responsibility for assuring that radioactive materials are safely packaged and transported, responsibility for responding to a transportation accident generally falls to the State or local government. The role of the Federal government in responding to transportation accidents is usually one of supporting the lead role of State and local governments. Federal agencies usually would not become involved unless specifically requested to do so by State or local government officials. The exception to this rule is situations involving nuclear weapons.

The literature found on emergency management falls into two categories; those on the actual structure of the emergency response plan (agency roles, notification procedures, etc), and those that focus on the content of that plan. Because each State and local jurisdiction has its own emergency response plans, only the actual plan for the Federal government was summarized. Literature on what should be contained in those plans was obtained as it related to State and local governments.

The Report is organized into two parts: a summary of the articles obtained and a bibliography of related material. The Bibliography contains references for hazardous wastes/transportation, radioactive wastes/transportation, and radioactive/emergencies. Sources evaluated included the Government Monthly Publications Catalog, ASU General Stacks, and the Social Science Index. Not all references were found in all sources. The following articles were summarized:

- * The Federal Radiological Emergency Response Plan was prepared by FEMA and is the structural response plan for the Federal government.
- * Guidance For Developing State And Local Radiological Emergency Response Plan And Preparedness For Transportation Accidents was also prepared by FEMA. It gives guidance on what should be contained in State and Local response plans.

- * A Guide To Radioactive Materials Transportation was prepared by the National Conference Of State Legislatures. It provides a States perspective on Radioactive Materials Transportation issues.
- * Transportation Of Hazardous Materials - A Case Study and Training Local Emergency Response Personnel To Handle Transportation Accidents Involving Radioactive Material were both prepared by individual authors. They present radioactive transportation issues from a Local perspective.
- * Evaluation Criteria For Emergency Response Plans In Radiological Transportation was written by a series of authors and discusses emergency management from a social science perspective.
- * Abstracts were found for Federal Assistance In Radiological Emergencies: National Planning And Local Implementation and Protective Action Guidance For Radioactive Material Transportation Accidents.

Federal Radiological Emergency Response Plan. Federal Emergency Management Agency. Federal Register. Vol. 50, No. 217. Friday, November 8, 1985.

Purpose: The Federal Radiological Emergency Response Plan (FRERP) was developed by FEMA and eleven other Federal agencies. Its purpose is to define the Federal response for peacetime radiological emergencies.

Authorities:

Atomic Energy Act Of 1954 - Use of nuclear materials must be regulated for common defense and security, and to protect health and welfare.

Executive Order 12148, July 20, 1979 - Assigns Director, FEMA, responsibility for civil defense and civil emergency planning.

Nuclear Regulatory Commission Appropriation Authorization, June 30, 1980 - Requires President to publish a National Contingency Plan for accidents at commercial nuclear power plants.

Executive Order 12241, September 29, 1980 - Delegates to Director of FEMA responsibility for developing National Contingency Plan for accidents at commercial nuclear power plants.

44 CFR Part 351, March 11, 1982 - Establishes the Federal Radiological Preparedness Coordinating Committee. Also assigned responsibility to DOE for the development of the Federal Radiological Monitoring And Assessment Plan.

Scope: FRERP covers any peacetime radiological emergency response that could require significant response by several Federal agencies. The FRERP is activated when a State or local jurisdiction requests Federal support or Federal agencies must respond to meet their statutory responsibilities. There are three types of incidents: Fixed Nuclear Facility Incidents, Transportation Incidents, and Other Incidents e.g. nuclear-powered satellite re-entry.

The FRERP is concerned with Federal support to State and local governments beyond the immediate site of the emergency i.e. off site. For emergencies at Fixed nuclear facilities "off site" is the area beyond the facility boundary. For a fixed nuclear facility owned, authorized, and regulated by a Federal agency, the onsite Federal support is the responsibility of that Federal agency i.e. the cognizant Federal agency (CFA). For emergencies that do not have physical boundaries, transportation incidents, the State or local government will define an area onsite at the time of the accident and manage all actions within that area. For transportation accidents involving materials shipped by DOD or DOE, those agencies as CFA's will define and control the onsite area.

HOW TO IDENTIFY COGNIZANT FEDERAL AGENCIES

Type of Emergency	Owner/Operator	CFA
Fixed Nuclear Facility	NRC Licensed	NRC
	DOD or DOE owned or authorized	DOD/DOE
	Not Federally owned authorized or licensed	None
Transportation (Shipments by or for DOD/DOE)	DOD/DOE	DOD/DOE
Transportation (All other)	Private, State local, Federal	None
All Other Emergencies	Private, State local, Federal	NRC/DOD DOE/None

Concept of Operations (Summary): The CFA, FEMA, and DOE or EPA each has a specific coordination function in relation to the State and the owner or operator of the radiological activity.

CFA - Conduct and manage Federal onsite actions to support the owner or operator. Activities of CFA are to monitor, evaluate, advise, and provide assistance if required.

DOE OR EPA - Coordinate Federal offsite radiological monitoring and assessment. DOE provides initial response. EPA provides intermediate and long term response.

CFA - Develop or evaluate recommendations for public protective action measures offsite.

CFA (In Coordination With FEMA If Possible) - Present recommendations for offsite protective action measure to the appropriate State and/or local offices.

FEMA - Promote coordination of Federal assistance. This includes assistance to State and local governments and logistic support to Federal agencies.

CFA Initially, FEMA After Mutual Agreement - Coordinate release of information to the public and Congress.

CFA Initially, FEMA After Mutual Agreement - Coordinate release of information to the White House.

Federal Response: Federal response consists of four parts.

1. Alerting appropriate Federal agencies
2. Determining whether State or local requests have been received (if appropriate)
3. Activate and deploy emergency response teams
4. Establish base of operations at scene for coordinated federal response

Full scale response begins with step one and includes all four steps. Not all emergencies may require a full scale response.

Step 1 & 2: Owner/Operator is responsible for notifying the appropriate State and Federal authorities. After receiving such notification, the CFA will notify FEMA headquarters in Washington D.C.. Notification will include location and nature of accident, severity of problem, description of CFA response, and follow on action anticipated by CFA. FEMA will contact the State to verify notification. FEMA and CFA will notify other appropriate Federal agencies. DOE will notify agencies with FRMAP responsibilities.

After a request from a State or local request for assistance, FEMA will designate a Senior FEMA Official (SFO) to provide a single point of contact. State and local governments requests can be made directly to individual Federal agencies with which they have preexisting arrangements or relationships. Federal agencies contacted will inform the SFO.

Step 3 & 4: FEMA will deploy an Emergency Response Team (ERT) headed by an SFO. Prior to its deployment, FEMA will notify the affected State and the CFA of the planned FEMA response. Upon arrival, the SFO will establish the offsite base of operations (Federal Response Center). A Federal Radiological Monitoring and Assessment Center (FRMAC) will be established by DOE, usually at a nearby airport. The CFA, if any, will establish a local base of operations. FEMA, the CFA, and DOE will ensure that activities at various centers are coordinated.

FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT PLAN (FRMAP)

Purpose: To coordinate Federal radiological assistance. Although FRMAP is part of FRERP, it may be implemented separately.

Authority: DOE has responsibility for developing the FRMAP (44 CFR Part 351). FRMAP, originally required under FEMA regulation issued March 11, 1982, replaces the Interagency Radiological Assistance Plan (IRAP). Agencies participating in the FRMAP are FEMA, NRC, EPA, DHS, DOE, USDA, DOD, DCC, and DOI.

FEDERAL AGENCY INTERFACE AND RESPONSE PLAN SUMMARIES

Federal Agency Interface: The FRERP lists agency interfaces in the following categories: Activation and Deployment Procedures, Advise In Transportation Off And To Emergency Housing, Congressional Information, Coordination (Liaison), Coordination (Offsite), coordination (Onsite/Offsite), Designation Of Agency Lead Official, Emergency Shelter Availability, Federal Lands, Federal Response Center, FRMAP (Coordination with FRERP), FRMAP (Liaison), FRMAP (Monitoring Results), FRMAP (Notification), FRMAP (Resources), FRMAP (Transition), Food/Feed Availability, Food/Feed Safety Recommendations, Impact Assessment (Agriculture), Impact Assessment (Health), Indian Tribes, Information Exchange, Information Requirements International Cooperation (CFA), International Cooperation (FEMA), Logistical Support For Federal Agencies, Marine Fishery Produce Safety, Monitoring Resources (EPA), Notification (CFA), Notification (FEMA), Protective Action Recommendations (Development), Protective Action Recommendations (Presentation), Protective Action And Re-Entry Recommendations Dissemination (FEMA), Protective Action Implementation (FOOD), Public Information Releases From Headquarters, Public Information Releases From The JIC, Radiation Victim Care advise, Recovery Planning, Status Updates, Water Projects, White House Information, White House Response

Summaries Of Federal Agency Response Plans

DEPARTMENT OF COMMERCE

Purpose: National Oceanic And Atmospheric Administration provide support through the National Marine Fisheries Service in order to avoid human consumption of contaminated commercial fishery products.

Plan: National Plan For Radiological Emergencies At Commercial Nuclear Power Plants, November 1982.

DEPARTMENT OF DEFENSE

Purpose: DOD is charged with handling, storage, maintenance, assembly, and transportation of nuclear weapons.

Plan: Radiological Assistance In The Event Of Accident Involving Radiological Materials, 10 March 1981, + Others.

DEPARTMENT OF ENERGY (CFA)

Purpose: DCE owns and operates a variety of fixed nuclear facilities. Responsible for all nuclear activities under their jurisdiction.

Plan: Emergency Planning, Preparedness And Response For Operations & August 1981. + Others.

DEPARTMENT OF ENERGY (ERMAP)

Purpose: Responsible for implementing ERMAP.

Plan: ERMAP. + others.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Purpose: Helps ensure the availability of essential human services.

Plan: The Department Of Health And Human Services Response Plan For Radiological Emergencies, March 14, 1983.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Purpose: Provides information on available housing for disaster victims or displaced persons.

DEPARTMENT OF TRANSPORTATION

Purpose: Provides assistance when emergency affects transportation modes.

Plan: Department Of Transportation Radiological Emergency response Plan, August 1985.

ENVIRONMENTAL PROTECTION AGENCY

Purpose: Provides assistance in environmental and water supply monitoring, consequence assessment, and protective action decisions.

Plan: U.S. Environmental Protection Agency Response Plan, Office of Radiation Programs, January 30, 1981, + others.

FEDERAL EMERGENCY MANAGEMENT AGENCY

Purpose: Responsible for coordinating Federal response to all radiological emergencies that require multi-agency Federal response.

Plan: FEMA Emergency Response Operations For Extraordinary Situations: Emergency Support Team Policy and Operations Response Procedures, February 8, 1984.

Guidance For Developing State and Local Radiological Emergency Response Plans and Preparedness For Transportation Accidents. Federal Emergency Management Agency. FEMA-REP-5. March 1983.

Purpose: To provide a basis for State and local governments to develop emergency plans and improve emergency preparedness for transportation accidents involving radioactive materials.

PLANNING BASIS

Transportation Systems

Radioactive materials can be moved by land, sea, or air. The vast majority, however, are moved by land with the major portion going by highway. Spent (used) reactor fuel is limited to movement on certain routes. Unless a State designates otherwise, the routes for spent fuel and other large quantity shipments will be the interstate highways.

Materials and Packaging in Transportation

Packaging requirements are based on type and quantity of radioactive material, form, specific activity, and fissile properties. There are five categories.

Limited Quantity Packaging: Low radioactive. No warning labels required. Packaging requirements are those that apply to hazardous wastes. Transported by common carriers and post office (i.e. medical diagnostic kits, research and industrial samples or test materials and radioactive devices such as smoke devices).

Low Specific Activity (LSA) Packaging: Materials in which radioactivity is uniformly distributed in a large amount of nonradioactive material. If shipped by common carrier must be Type A packaging. If shipped by full load or exclusive-use vehicles, only need strong type packages (i.e. front and back end of nuclear fuel cycle, hospitals, universities, private laboratories).

Type A Packaging: Designed to withstand nonaccident conditions. Majority of shipments made with Type A packaging (i.e. radiopharmaceutical, research and industrial sources and some fuel fissile materials).

Type B Packaging: Designed to withstand accident conditions. Greater quantities than Type A (i.e. larger research and industrial sources and certain fuel cycle materials).

Type B Large Quantity Packaging: Contains large quantities of radioactive materials. Designed to withstand accident conditions and also to prevent significant loss of materials. If packages were severely breached, would cause serious health and safety effects over large areas (i.e. research, industrial, and therapeutic medical sources and spent nuclear fuel).

Accident Characteristics

Low Hazard - High Probability: Type A or Type B packages. Usually no release of dangerous amounts of radioactive materials. If breach in Type A or Type B, area affected would usually be limited to the immediate vicinity of the accident unless contaminated personnel or equipment are allowed to leave.

High Hazard - Low Probability: Large Quantity Type B packages. If severely damaged might release radioactive materials. Accidents or sabotage might require extensive response if package is severely damaged and involved a release of a significant fraction of its contents.

Organizational Responsibilities

State: Has the responsibility to protect citizens from unwarranted radiation exposure. They are responsible for developing a radiological emergency response plan, designating an emergency radiological response team, and coordinating communications with Federal, State, and local agencies involved in the response.

Local: Has the responsibility to develop a local emergency response plan that is compatible with the States. Local governments will probably be the first on the scene and therefore should be able to: administer emergency measures, identify the hazardous materials, and notify the appropriate authorities to obtain expertise.

Federal: Has a supporting role. Federal Government only gets involved if requested to do so by State or local governments. Exception to this is if nuclear weapons or related devices are involved.

* FEMA coordinates the Federal response to accidents which required the direct involvement of more than one Federal agency. With the agencies, they have developed the "Federal Radiological Emergency Response Plan (FRERP).

* Both DOE and EPA are responsible for coordinating radiological monitoring and assessment functions of the Federal agencies. The DOE has the lead Federal role until emergency conditions has subsided, at which time the lead Federal role is transferred to EPA. Coordinated assistance by DOE is contained in the Federal Radiological Monitoring

and Assessment Plan (FRMAP). The FRMAP is included as part of the FRERP.

Shipper: Each shipper is responsible for knowing and complying with all applicable Federal, State, or local regulations pertaining to the shipment of radioactive materials.

Carrier: It is the responsibility of each carrier to know and comply with all applicable Federal, State, or local regulations pertaining to the carriage of radioactive materials.

PLANNING GUIDANCE

Planning Objectives For State and Local Emergency Response Plans

Assignment of Responsibility: To assure that responsibilities have been assigned to both primary and supporting organizations and to insure they are staffed on a 24-hour basis.

Analysis of Radioactive Material Transportation: To determine what materials are being transported and to identify the most likely places of accidents and the general type of problems that might be encountered.

Contiguous State and Local Coordination: To ensure that bordering State and local jurisdictions can coordinate their capabilities for responding to an accident.

Emergency Equipment, Facilities, and Resources: To identify and effectively use assistance resources and to ensure that adequate emergency facilities and equipment are provided to support them.

Notification Methods and Procedures: To ensure that State and local organizations have established procedures for contacting the proper emergency response personnel and to assure that the carrier and shipper are notified.

Emergency Communications: To assure that provisions exist for prompt communications between the principal organizations responding and emergency personnel.

Public Information: To establish methods and systems for communicating to the general public in a timely manner when an accident occurs and to provide accurate information intended to protect lives, public health, and property.

Accident Assessment: To identify, establish, and assure the adequacy of methods, systems, and equipment for determining if radioactive materials have been released and for assessing the actual or potential consequences of any releases.

Protective Actions: To assure that recommended protective actions are consistent with other jurisdictional levels.

Radiation Exposure Control: To assure that means for limiting radiation exposures are established.

Medical Services: To assure that arrangements are made for medical services for injured persons who may be contaminated.

Post-accident Operations: To assure that general plans for post-accident operations, including cleanup and decontamination of property, vehicles and equipment are developed.

Radiological Emergency Response Training: To insure that training is provided for emergency response personnel.

Periodic Review and Update: To assure that plans are revised and kept current.

Appendix A: Radioactive Material (RAM) Transportation Accident Analysis

Appendix B: A Review Of The Federal Regulatory Relationships For The Commercial Transportation Of Radioactive Materials.

Appendix C: Federal Emergency Contacts

Appendix D: Availability of Emergency Response Training Courses And Related Materials.

Appendix E: Overview Of Accident Liability Coverage.

A Guide To Radioactive Materials Transportation, National Conference
Of State Legislatures, July 1982.

Purpose: Describe the uses of radioactive materials, the laws and regulations that cover their handling and transport, and the interrelationships of the federal, state, and local government concerned with their movement.

Uses of Radioactive Materials: medicine, Agriculture, Industry,
Nuclear Power.

RADIOACTIVE MATERIALS TRANSPORTATION REGULATIONS

Definition: A radioactive material is one that spontaneously emits ionizing radiation and has a specific activity greater than .001 microcuries per gram of material and one in which the radioactivity is essentially uniformly distributed.

Dangers: The biological danger of any one type of radioactive material depends upon the kind of radiation emitted and how it is encountered, i.e. ingested, inhaled, penetrated the body. Two hazards of excessive radiation are direct harm to the body and possible genetic effects.

Protective Measures: Three methods are used to formulate transportation regulations for protection against exposure

Time - The shorter the length of exposure, the less the damage. Shipments of large quantity radioactive materials must go by the fastest and safest routes, the interstates, to minimize exposure time.

Distance & Shielding - Safety increases with distance from a radiation source. Packaging requirements reflect the necessity to provide shielding against particular kinds of radiation.

Nuclear Fuel Cycle And Transportation (Spent Fuel): After being in a reactor for three years, the fuel assembly is moved. It is thermally hot and highly radioactive. Nuclear Waste Policy Act of 1982 establishes formation of a permanent repository to store the fuel.

Spent fuel is transported in Type B packages called casks, which are designed to withstand severe transportation accidents. They can weigh 10 to 25 tons. Most goes by highway because of limited rail to reactors. Casks receive additional security through NRC's physical protection requirements. Trucks have disabling devices that would prohibit hijackers from driving away. Vehicles have two-way communication systems, armed guards or escorts through populated areas, and other unpublicized security measures (10 CFR Sec. 73.37).

Licensees that plan to transport Spent Fuel must notify NRC of the planned route and the safeguards taken to protect the shipments (10 CFR Sec. 73.35 (a)(3)). There are 33 states containing portions of an NRC approved route. RM-154 approves all interstates that NRC has approved.

INTERNATIONAL SAFETY STANDARDS FOR TRANSPORTATION

The International Atomic Energy Agency (IAEA) published its first edition of "Regulations For The Safe Transport Of Radioactive Materials" in 1981. Currently 53 countries and the United Nations have adopted the regulations, which are subject to review reflecting changes in technology and shipping practices.

HISTORY OF FEDERAL REGULATIONS

The Federal government began regulating all hazardous materials in 1971. Radioactive materials are not regulated primarily by three agencies: DOT (49 CFR), NRC (10 CFR), U.S. Postal Service (39 CFR). EPA (40 CFR) to some extent.

Nuclear Regulatory Commission: Responsible for the physical safety in civilian possession and use of by-product, source material, and special nuclear material under the Atomic Energy Act of 1954.

Agreement States: In 1959, Congress amended the Atomic Energy Act of 1954 to permit states that met and maintained certain standards to regulate source, by-product, and limited quantities of SNM. Twenty-two states have become agreement states through this amendment.

Department Of Transportation: Responsible for safe transportation of radioactive materials by all modes of shipment. Under the Hazardous Materials Transportation Act of 1974, DOT has authority to designate materials that pose, during transport, an unreasonable risk to health, safety, and property as hazardous materials. The act also gives the power to impose civil and criminal penalties who violate regulations.

NEW FEDERAL REGULATIONS

NRC Regulations: "Advance Notice To State Of Transportation Of Certain Types Of Nuclear Waste And Advance Notification To Governors Concerning Shipments Of Irradiated Reactor Fuel" were published in Federal Register January 6, 1982. Any large shipment of nuclear fuel must be preceded by notice to the governor of any state they will traverse.

DOT Regulations: HM-164 "Federal Routing Requirements For Radioactive Materials So As To Minimize Public Risk". DOT designated interstate highways, rather than State or County Roads, as the preferred routes because of the lower accident rates. Even though these routes may go through populated areas, if left it up to the State to prove that other routes are more desirable. If States wish to use time-of-day restriction, states must designate alternative routes so as not to impede the flow of commerce.

STATE AND FEDERAL PROGRAMS

State Hazardous Materials Enforcement Development Program: Goal of program is to foster uniform enforcement of hazardous materials standards nationwide. States enter into agreement with DOT to participate in program. Program is phased in over three years. Phase one consists of information gathering concerning patterns of movement within borders, degree of compliance with laws, developing enabling legislation and adoption of regulations. Phase two consists of developing an inspection force and procedures and training of inspectors. Phase three consists of developing and implementing an enforcement structure.

STATE ACTIVITIES

Regulation And Enforcement: Federal laws and regulations have preempted the exercise of regulatory authority by State and local governments to regulate the transportation of radioactive materials. Therefore, many States have just adopted the Federal laws. According to the Hazardous Materials Transportation Act, State and local laws and regulation should not be inconsistent with federal laws. If they are, they are subject to preemption. Similarly, State laws will preempt inconsistent local laws.

Emergency Response: FEMA has primary responsibility for coordinating federal assistance to state and local governments in the area of emergency response. FEMA's training and response efforts are authorized in 14 CFR Sec. 300 and its emergency response roles in 44 CFR Sec. 200. FEMA established the Federal Radiological Preparedness Coordinating Committee (FRPCC), a committee composed of federal agencies (including DOT) to assist state and local agencies in developing and testing emergency response plans.

OPPORTUNITIES FOR STATE ACTION

Expanding State Enforcement: States can provide radioactive materials training for their existing personnel to expand enforcement of regulations

Uniform Legislation: Some State have adopted special restrictive legislation governing radioactive wastes. This poses a problem for shippers and carriers who have to follow the detailed Federal regulations and then also comply with differing State. All States should adopt the Federal regulations in 49 CFR.

Good Samaritan Legislation: Because of the complexity of hazardous materials and limited expertise and resources of local emergency response personnel, 31 States have passed legislation providing immunity to those experts responding to an accident.

Regional Cooperation For Training And Emergency Response: To effectively deal with transportation accidents, local, state, interstate, shippers, and carriers must all cooperate. Mutual self-help agreements can be made. These can determine who will pay for what, who will be reimbursed, and who will be liable for what under what circumstances. Several jurisdictions may find it beneficial to do joint training.

Regional Cooperation For Inspection And Enforcement: Inspection and enforcement at all levels of government is inadequate because of lack of funds. By coordinating federal, state, and local resources, enforcement can be deployed more effectively.

Appendix A Conversion, Enrichment, and Fabrication Facilities For Nuclear Fuel

Appendix B Spent Fuel Shipment Routes

Appendix C Nuclear Power Plants In The United States

Appendix D Waste Distribution By State

Appendix E Compact Groupings And Legislative Status

Appendix F Status Of Federal Hazardous Materials Regulations Adopted By States As Of March 18, 1983

Appendix G DOT Inconsistency Rulings And Appeals

Appendix H Federal Laws And Regulations Applicable To Nuclear Materials

Appendix I Hazardous Materials Transportation, Regulatory, and Enforcement Agencies.

Appendix J Colorado Training Institute Chart On Emergency Response

Appendix K Good Samaritan Statutes

Appendix L Resources

Rittvo SM, "Transportation Of Hazardous Materials - A Case Study",
Transportation Quarterly 38(1):107-151.

Purpose: To study transportation patterns of hazardous materials within St. Bernard Parish, Louisiana; to evaluate the emergency response capabilities of the parish; and to prepare a Parish Hazardous Materials Response and Evacuation Plan. There were five components to the study.

1. **Inventory Of Existing Conditions:** First phase involved preparing an inventory of the major generators of hazardous materials shipments located within the parish. This was done in two parts: an industry survey and a truck volume survey.

2. **Analysis Of Hazardous Materials:** Purpose was to identify the potential hazards of the materials and identify the basic labeling and packaging requirements. Results would be used by emergency personnel for response training and equipment acquisition.

3. **Route Analysis:** Purpose was to identify the major materials and rail lines within the parish where shipments of hazardous wastes occurred. Roadway and rail line conditions were also examined.

4. **Assessment Of Response Capabilities:** Most local and state governments around the country have only recently begun to address the transportation of hazardous materials within their communities. This study, published in 1981, represented only a handful of similar studies conducted by local governments around the country. A national survey conducted by the Puget Sound Council of Governments under a grant from DOT in early 1981 found that hazardous materials planning activities were underway in ten states, nine counties and municipalities.

In Saint Bernard Parish, the Fire Department was the designated lead agency for responding to a hazardous materials transportation accident. At the State level, it was the Department of Public Safety. Assessment identified several problems. These included: interagency communication, equipment and training needs, inspection and enforcement procedures, and coordination among response agencies

5. **Recommendations:** Purpose of recommendations was to reduce the possibility of an accident from occurring and to provide training and equipment if one should occur.

Preplanning & Preventative Measures - Included warning devices at highway/roadway grade crossings and collection of material data summary sheets. Also implementation of inspection and enforcement program

Training and Equipment Needs - Identified training programs for personnel and recommended that exercises be conducted. Equipment needs were broken into two parts: protective equipment required of emergency personnel and equipment needed by the Fire Department for controlling the hazard.

Legislative Options - Included designating hazardous materials truck routes within the parish and recommending that an ordinance be passed providing inspection and enforcement powers. At state level, truck drivers would attend short course on the handling of hazardous materials.

Emergency Response and Evacuation Plan - Proposed an emergency response and evacuation plan for the parish. Plan outlined organization responsibilities, procedures for identifying the materials involved, and evacuation procedures.

Amphibious, LL. "Training Local Emergency Response Personnel To Handle Transportation Accidents Involving Radioactive Material". Health Physics, 50(3):404-406, 1986.

Purpose: In 1981, the Oregon State Legislature enacted Senate Bill 109 which led to new rules for certain types of radioactive material transportation in and through Oregon. Oregon State University developed and implemented the training program.

Training Program Content: Accredited training program consisted of a one day course which covers the topics of radiation, its effects and control, instrumentation and monitoring, radioactive material, transportation, and emergency response.

Radiation was characterized by: the type and quantity of shielding to reduce dose rates, its detectability by the civil defense meters, and the typical hazard expected from each. Radiation and contamination were presented as different concepts. Radiation is controlled by time, distance and shielding. Contamination is controlled by restricting access and the use of protective clothing.

How to read the civil defense instruments issued to measure radiation was covered as well as the types and quantities of radioactive shipments made on Oregon Highways. Conclusion covered the important initial action for emergency responders. First aid and life-saving rescue. Inform or notify that radioactive material is involved. Restrict access for radiation and contamination control. Stop or suppress fires.

Training Session: In two years, 750 people took the course. Trainees included fire fighters (44%), local and state law enforcement officers (25%), emergency medical technicians and hospital personnel (12%) and others such as state foresters and highway department personnel.

Testing And Results: Testing was done before and after the class. Average pretest score was 24% and average post-test score was 72.4%. Level of education correlated positively with test scores.

Lindell, Michael K. and Perry, Ronald W.. "Evaluation Criteria For Emergency Response Plans In Radiological Transportation". Journal Hazardous Materials. 3(4):335-348.

Purpose: Identifies a set of general criteria which can be used as guides for evaluating emergency response plans for transporting radiological materials.

Emergency Response Plans Versus Systems

Emergency response system is composed of resources (human and material) which is used to respond to a radiological accident. A plan refers to designations of authority, agreements, general operational concepts, and emergency policy concepts which form the basis for a coordinated emergency response. This paper deals with the evaluation of the general emergency plan (i.e. means of coping with the an incident).

Characteristics Of Hazards - Natural vs Nuclear: Transport accidents can be classified in a way similar to floods. The scope of impact is narrow, the speed of onset is sudden or gradual, duration of impact is short (although variable), and there are secondary impacts both on physical and public health related.

Unique Aspects Of Radiological Transport Incidents: Radiological transport incidents and nuclear disaster in general fit into the definitional and classification framework to examine natural disasters. Radiological transport incidents have one distinctive characteristic: the persistence of the secondary impact.

Evaluation Criteria

Criteria for evaluating emergency response plans fall into two categories: substantive criteria and supporting criteria. Substantive criteria deals with the adequacy of the content of the plan (notification, accident assessment, public information etc). Supporting criteria refers to aspects of the plan that address nonoperational or noncrisis needs. The following criteria deal more with the initiation and maintenance of the plan rather than with the operation or implementation of the plan.

Notification: In order to ensure that all who have a need to know about the incident are alerted, it is necessary to develop an explicit set of criteria for determining who is likely to initiate the notification process, which parties they should notify, which, which communications channels are available and should be used, and what information should be transmitted.

Accident Assessment: Speedy deployment of specialized instruments that can measure the magnitude and location of the release can be greatly facilitated if there is a centralized inventory of resources available for radiological assessment. This should include the location of instruments and the identity and location of personnel trained in their use.

Public Information: Previous research indicates that the public will comply with legitimate requests of those in authority, even if the requests result in discomfort. An effort needs to be made to disseminate information about the incident to those who are not at risk. Conflicting or ambiguous statements can produce mistrust and suspicion.

Protective Response: In any incident involving a continuing threat to health or safety, it is desirable to evacuate the population at risk to safety, to define a controlled access area and to institute other protective action as required. One important finding is that people do not evacuate immediately when they are asked to do so. Adoptive plans, warning confirmation behavior, the lead role of the family, security and property protection, and sheltering have all shown to be associated with the degree of success of an evacuation program.

Radiological Exposure Control: Should have onsite capability for radiological monitoring and decontamination of emergency personnel and others. Protective action guides should be made available in order to regulate the exposure of emergency personnel to radiation.

Responsibility For Planning And Operation: Radiological emergency plan for each state should indicate assignment of responsibility for various functions under the plan and document that interorganizational ambiguities have been resolved.

Emergency Response Training And Exercises: The plan should be tested once a year with field exercises. All parties should have copies of the plan, be aware of their responsibilities, and follow through the steps necessary to perform their functions.

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ABSTRACT: Federal Assistance In Radiological Emergencies: National Planning And Local Implementation. T.A. Rhea and M.V. Adler (Energy Division Environmental And Occupational Safety Division, Oak Ridge National Laboratory).

The Federal Radiological Emergency Plan (FREP) has been developed to coordinate the Federal activities and outline the role of each agency during a response. The responsibilities of 13 Federal agencies are detailed in the plan.

DOE is responsible for coordinating all offsite Federal monitoring and assessment under the FREP. This role is explained in the portion of the FREP known as the Federal Radiological Monitoring and Assessment Plan (FRMAP), which provides the framework for traditional initial DOE assistance following a major accident, through the Radiological Assistance Program (RAP).

DOE's Oak Ridge Operations Office is responsible for the implementation of the RAP in DOE Region II. The RAP is currently being upgraded to include designated personnel, standard response procedures, training, and appropriate equipment. Two air-transportable emergency vehicles, a communications/command post and a mobile laboratory, will provide operational support for the RAP teams.

ABSTRACT: Protective Action Guidance For Radioactive Material Transportation Accidents. B. Dodds and LL. Humonries, Department Of Nuclear Engineering, Radiation Center, Oregon State University.

Very little protective action guidance for radioactive materials transportation accidents has been published. As a result of this, the Oregon Department of Energy sponsored research to determine the hazards from transportation accidents involving typical shipments of radioactive materials.

Data which are directly observable at the scene, such as vehicle type, package type, weather, time of day, and the assumptions and results of the hazards study, are used to provide protective action guidance for the emergency responders and the public. The protective action guidance is intended to be used by state health physics personnel who are in direct communication with the on-scene command posts. The guidance is currently in the process of being computerized and validated.

TRANSPORTATION IMPACT ASSESSMENT:
EMERGENCY RESPONSE

Design of Transportation Impact Studies:

Emergency Response (15.6)

Emergency response is one category of an emergency management system. Prevention and mitigation measures (structural and nonstructural) can reduce the probabilities of accident events and their severity. An effective emergency response capability can reduce the impacts of an accident or the consequences by either containing the threat, evacuating the population, or applying other mitigative measures.

The impact assessment methodology is directed at (1) discerning the current capabilities at emergency response, and (2) analyzing the needs of local and state governments given current capabilities and potential transportation accidents involving nuclear material.

Current capability analysis should include the following dimensions of emergency response:

- * availability of emergency response plan
- * utilization of emergency response plan
- * effectiveness of community response to threat
- * current levels of training (general, chemical hazards, and radiological)
- * current levels of emergency response organizations and arrangements for aid (hospitals, evacuation centers, etc.)

- * experience and expertise of emergency management personnel
- * mutual aid agreements and linkage to state government

Various guides are available to aid committees developing inventories of their preparedness levels. It will be especially important to identify the specific emergency response needs to effectively mitigate and control potential radiological transportation accidents. An understanding of response capabilities should be developed for both community and state levels and should include both programmatic requirements and a preparedness inventory of needs.

A generic assessment will be required at the community and county levels to ascertain preparedness levels in terms of trained personnel, equipment needs, communications requirements, quality and capacity of response institutions (hospitals), and location and size of evacuation centers. Equally important, will be the need for an analysis of institutional agreements with regard to emergency response. What will be the role and responsibility of the first on-scene responder? Who will be responsible for onsite emergency management and for long-term clean up? What financial assistance can communities be assured of in developing and implementing emergency response plans?

Another research need will be to define and develop the elements of an emergency response plan for both the community and

state levels. These include such items as notification methods and procedures, approaches to accident assessment and decision-making, control of radiological exposure, levels of responsibility and coordination procedures, emergency response training and procedures, and financing emergency management efforts.

Impacts of a transportation accident are a function of the severity of the accident in terms of geographical extent of the problem, the amount of hazardous materials released, and population density. It is also a function of emergency response capabilities which include such items as emergency personnel training, specialized knowledge and monitoring equipment, evacuation plans and capabilities, and coordination procedures. The key generic problem areas in emergency response involving radiological events include notification procedures and processes, accident assessment, coordination of emergency response organizations, and public protection measures/equipment. Of critical importance is to assess whether radiological emergency events should be included with other emergency plans or be a distinct planning activity. On the one hand, the integration of emergency management activities reduces duplication of effort and enables poor communities to have at least a minimal response capability. On the other hand, radiological accidents may present difficult and technically

sophisticated response needs which should be developed separately from response activities targeted at other hazards.

DRAFT - CATEGORY TWO

TRANSPORTATION NEEDS ASSESSMENT

TASK 15.2 PREFERRED TRANSPORTATION SYSTEM OPTIONS

PHASE IIIA YUCCA MOUNTAIN SOCIOECONOMIC PROJECT

MOUNTAIN WEST RESEARCH

NOVEMBER 16, 1988

INTRODUCTION

The transportation impacts of moving high level nuclear waste (HLNW) to a repository at Yucca Mountain in Nevada are of concern to the residents of the State as well as to the residents of other states through which the nuclear wastes might be transported. The projected volume of the waste suggests that shipments will occur on a daily basis for some period of time. This will increase the risk of accidents, including a catastrophic incident. Furthermore, as the likelihood of repository construction and operation and waste shipments increase, so will the attention given by the national media. Typically, the media further amplifies or complicates the impact of a situation or event by influencing public perception about the situation. A recent example involved a truck accident in New Burley, Idaho on October 12, 1986. None of the radioactive materials carried by the truck were released in the accident; however, extensive media coverage heightened the fears and perceptions of risk on the part of community members.

This document is not to be construed as a willingness to accept the HLNW repository on the part of the State. Rather it is an initial step in ensuring that the safety and well-being of Nevada residents and visitors and the State's economy will be adequately addressed in federal decision-making pertaining to the transportation of HLNW into and across Nevada for disposal in the proposed repository.

The Preferred Transportation System Needs Assessment identifies critical system design elements and technical and social issues that must be considered in conducting a comprehensive transportation impact analysis. Development of the needs assessment and the impact analysis is especially complex because of the absence of information and experience with shipping HLNW and because of the "low probability, high consequence" aspect of the transportation risk.

This working paper addresses the preferred transportation system by grouping issues within three areas: crosscutting issues, transportation system design, and operational procedures. Four additional reports will be developed to complete the Transportation Needs Assessment. Task 15.5 is the Literature Review for the Assessment. All references identified in the 15.2 report will be cited and annotated in the 15.5 report. In this report, the terms "nuclear waste" and "waste" refer to all of the radioactive wastes to be shipped to a repository. This includes spent fuel from commercial nuclear power reactors, solidified wastes from the reprocessing of commercial spent fuel (West Valley wastes) and the nuclear weapons program (defense high level waste). It is uncertain at this time (but possible) that wastes resulting from spent fuel rod consolidation and "greater than class C" low-level radioactive waste may be disposed of at the repository.

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1.0 CROSSCUTTING ISSUES

Crosscutting issues are those aspects of the preferred transportation system that are involved with or "cut across" most, if not all, components of the system. Factors such as system management, risk evaluation, monitoring and regulatory structure are examples of critical issues that are a part of (cut across) other system components.

1.1 COMPREHENSIVE RISK ASSESSMENT AND RISK MANAGEMENT

Risk assessment refers to the formal process of identifying hazards, estimating the probabilities of their occurrence, and estimating the nature and magnitude of their consequences. It is an inseparable part of risk management. (Hazards herein are defined as threats to humans. Risk is the conditional probability of experiencing harm.) Risk management involves the identification, estimation, and evaluation of risks and the selection and implementation of alternative measures to prevent, control, or mitigate adverse consequences. It includes a risk assessment in the identification and estimation phases. Most of the studies of transportation risks conducted to date are risk assessments and do not attempt to address the broader issues of risk management (McClure and Emerson 1980, NRC 1980, Siv and Garrick 1981, Sandoval et al. 1983, Jefferson 1985, McClure and Tyron-Hopko 1985, Scanlon and Cantilli 1985, Stern 1985). It should be noted that risk assessment and risk management are part of an ongoing, iterative process. They should not be viewed as one-time activities resulting in a final report.

The goal of a comprehensive transportation risk management system is to minimize risks resulting from the transportation of nuclear waste. The goal of a comprehensive transportation risk assessment is to identify all types of potential hazards and to estimate the probabilities and consequences associated with each type of hazard. In order to achieve these goals, the risk assessment and risk management system for the transportation of nuclear waste must meet several objectives. A comprehensive risk assessment should identify all types of potential hazard events and their adverse consequences for all relevant aspects of the transportation system. To assess the risk, the probabilities of occurrence and range of consequences for hazard events must be estimated as thoroughly as possible with available data. Because much of the data necessary to estimate probabilities will not be available or will be uncertain, the risk assessment should incorporate a sensitivity analysis and estimate the uncertainties that result from the use of different assumptions and assessment models. The assessment should also indicate the different risks involved with varying assumptions about modal mix, routing, and so forth.

A comprehensive risk management system should incorporate a comprehensive risk assessment and evaluate risk acceptance or tolerability to establish

priorities for action. Perhaps the most difficult and important objective in risk management is the evaluation of the risks identified during risk assessment. Risk evaluation is necessary to determine what levels of risk are acceptable or tolerable, and, therefore, which risks must be controlled. Whether or not tolerable levels of risk can be identified is a controversial and complex debate (Kasperson 1983, Kasperson and Kasperson 1984). Despite the difficulty in establishing a tolerable level of risk, a comprehensive risk management system cannot ignore this issue.

In establishing a risk management system, it must be recognized that tolerable levels of risk cannot be derived by a formal analytical process and that the public often views risks differently than technical experts. To accommodate this divergence, public participation and consultation will be necessary to determine which risks are or are not tolerable. Three types of analyses can contribute to this process: contextual, equity, and public preference analysis.

The management system will identify a control strategy, means of intervention, and modes of implementation. The process of public involvement and formal analysis will allow the setting of priorities, identification of appropriate control strategies (e.g. risk acceptance, reduction or spreading, or consequence mitigation), means of intervention (e.g. cask redesign, rerouting traffic), and modes of implementation (educate, mandate, or encourage). Once the control options are implemented, the process of evaluation begins. The system should call for an evaluation of the efficacy of risk management efforts. Again, the public should be involved in the evaluation of the implemented management programs. The risk management systems should then be modified according to the result of the evaluation.

1.1.1 Key Issues for Comprehensive Transportation Risk Assessment and Risk Management System Development

Risk Management System Scope

In designing the risk management system and conducting a risk assessment for the transportation of nuclear wastes to a repository at Yucca Mountain, it must be recognized that the comprehensive management system is broader than the assessment of risk. It must consider the entire sequence of transportation from initial packaging and loading to unloading and should not ignore the possibility of retrieval. This includes alternative technologies, routing, model configurations and mixes. It includes consideration of the complete range of initiating and enabling events in addition to the complete spectrum of consequences. Upstream events concerning cask design, loading, and so forth, as well as the generic issues of quality control and human error, can have significant impacts on "downstream" (i.e. within the State of Nevada) events such as a radioactive release in an accident and the occupational exposure of workers unloading casks at the repository. A sequential view of the shipping procedure is a useful aid in the identification of potential hazards (Figure 1). Similarly, the modes of transportation to be evaluated must be decided (e.g. rail, truck, etc.).

Figure 1.

THE SEQUENCES AND PHASES OF NUCLEAR WASTE TRANSPORTATION

To be truly comprehensive, the risk assessment should also identify the hazard events and consequences arising in the transportation of retrieved waste, since the repository is to be designed with such an eventuality in mind. While transportation to the repository is already controversial, it is likely that transport of retrieved waste from the repository will be even more controversial.

Risk Management System Methodologies

Alternative methods should be considered. These include probabilistic assessment (PRA), simulation, analogy, and scenario analysis. Definitions and appropriate measures of risk must be addressed along with availability and quality of data. The design of the methodology should consider consequence modeling and the range of uncertainties.

Risk Management System Response

Key issues to be addressed in designing the system response include:

- evaluation,
- portrayal and dissemination of risk information,
- control strategies,
- means of intervention,
- mode of implementation, and
- reevaluation and modification.

1.1.2 Initiating Events

The risk management system must consider the complete range of initiating events and likely consequence at each stage in the transportation sequence. In the transportation system there are four types of activities which can lead to adverse consequences and should be evaluated in a risk assessment.

Normal Conditions

Workers and members of the public will be exposed to risks from the operation of a nuclear waste transport system even under "normal" or incident-free operating conditions; in the absence of accidents, poor quality control, sabotage, terrorism, or theft. Under normal operating conditions, non-radiological risks include mortality and morbidity associated with exhaust emissions in transport. Radiological risks include latent cancers and genetic effects resulting from low levels of radiation. Radiation will be emitted from even the best designed casks under the most stringent quality control programs. Workers will be exposed during packaging, loading, transporting, and unloading waste materials. The public will be exposed as shipments pass nearby.

Accident Conditions

Accidents include "internal events" or system failures, such as vehicular and loading accidents, and external events that originate outside of the waste

transportation system. Both radiological and non-radiological consequences may be associated with accidents. External events include intentional (e.g., sabotage) and unintentional (e.g., airplane crashes) man-made events, and natural events such as earthquakes and floods. The intentional man-made initiating events of sabotage, terrorism, and theft have been of much concern to experts and the public. Therefore, they are treated separately below.

Sabotage

Sabotage includes the deliberate destruction of vehicles, manipulation of vehicles or crew members, hijacking of trucks and theft of nuclear material. It is almost impossible to quantify the probability of these types of events. However, the related impacts can be very severe.

Human Error and Deficient Quality Control

Quality control failures and human errors have been a continuing major problem throughout the nuclear power industry and in hazardous materials transportation. It has been estimated that up to 62 percent of hazardous material transportation accidents are the result of human errors (OTA 1986). They have also been important contributors to major nuclear accidents such as Three Mile Island (TMI) and Chernobyl and non-nuclear accidents at other facilities handling hazardous substances (e.g. Bhopal). In the transportation system, human error and defective quality control may lead to both radiological (e.g., improper cask closure leading to excess exposure) and non-radiological consequences (e.g., crane accidents). Thus, sufficient attention must be given to potential quality control problems and human errors which might compromise engineered integrity and safety systems.

1.1.3 Probabilities

Having identified the types of hazards and consequences, a comprehensive risk assessment should estimate the probabilities of their occurrence. Strength or weakness of the available data should be indicated by descriptions of the degree of uncertainty. When actuarial data is unavailable, expert judgement may substitute, although it has many associated difficulties in the provision of reliable data. Where expert judgement has been used because of an absence of data, it should be clearly indicated and justified. Other assumptions, such as the choice of particular models, should also be indicated.

A comprehensive risk assessment should incorporate a comprehensive consequence analysis that assesses the nature, severity, and magnitude of adverse effects on health and safety. The emphasis should include long and short term effects, and morbidity as well as mortality. Finally, the risk assessment should be broad and flexible enough to illustrate the impact of different assumptions about the transport system and the levels of risk. The risk estimates should be given for transport systems with and without an MRS facility, and under different assumptions about cask design, volume and timing of shipments, modal mix, and so forth.

1.1.4 Risk Assessment Methodologies

Several methods can be used to conduct risk assessments. These include worst-case analysis, selected scenario analysis, argument by analogy, and probabilistic risk assessment (PRA). Each method has its advantages and disadvantages in its ability to evaluate data and modeling uncertainties, the range of possible consequences, and different measures of risk. All of the methods suffer from a common problem regarding completeness. The scope of an analysis is frequently limited by the imagination of the analysts. There are no methods for logically ensuring that all hazard events and consequences are included.

Worst Case Analysis

Worst-case analysis selects the upper extremes of many variables such as source terms, population density, and meteorology, in their worst combinations without attempting to estimate probabilities. This type of analysis serves as a benchmark for emergency preparedness, but does not indicate the likelihood of occurrence. Usually, the absolute worst case is not chosen for evaluation. Rather a "maximum credible accident" is selected to bound the analysis.

Selected Scenario/Argument by Analogy Analysis

Selected scenario analysis uses a range of scenarios, including the worst case. It does not attempt to estimate probabilities. Argument by analogy is weakened by the fact that some aspects of the transportation system for nuclear waste are very different from other transportation systems such as those for transportation of hazardous materials.

Probabilistic Risk Assessment

PRA is one of the most rigorous methodologies for assessing risks. Its drawbacks are that it requires enormous effort, complex modeling, and high quality data. Also, PRAs tend to use narrow definitions of risk, such as the number of fatalities or injuries. PRA may be misleading by suggesting that the probabilities of events can be estimated accurately when indeed there is often considerable uncertainty.

PRAs have been used extensively with regard to nuclear power plants. The transport of nuclear waste, however, is quite a different system. It is considered technologically less complex and more "open" so that identifying all eventualities may be more difficult. And, whereas a reactor is located in one place, the transport network involves diverse environments, urban and rural populations, and multiple political jurisdictions. Thus the system encompasses a broader degree of computational complexity.

1.1.5 Establishing Priorities for Action

A comprehensive risk management system uses a comprehensive risk assessment as a necessary first step in achieving the goal of minimizing risks. The next step is to evaluate the different risks and to establish priorities for action. It should be noted that the choice of a risk assessment methodology may ultimately influence the setting of priorities for responsive action. For example, focusing on mortality would highlight those particular types of risks, while others might be made more evident had other types of consequences been assessed. Similarly, worst-case scenario analysis may focus attention on low-probability high-consequence events, while underestimating the cumulative impacts of high-probability low-consequence events. This reinforces the importance of clarifying assumptions and the need to be comprehensive. It also illustrates that a risk assessment is not a separate, objective input, but is intimately bound in the design and operation of the entire risk management system.

1.1.6 Conducting Risk Evaluations

There are a number of methods for risk evaluation including: contextual analysis, equity analysis, and preference analysis. Contextual analysis requires putting the risks in context by partitioning them according to a number of attributes such as: other risks, costs of controls, and the benefits of the hazardous activities. Equity analysis involves an evaluation of the distribution of risks, costs, and benefits over space, time (especially intergenerational equity), and social groups. Preference analysis indicates assessing public "preferences" for risks as expressed directly or as revealed by public responses. From such analyses, it has been shown that the risks of most concern to the public are not necessarily those identified as important by risk assessments using limited measures of risk, such as the focus on mortality previously described. The preferred risk assessment approach should be sensitive to this issue and try to incorporate these broader measures of risk that accommodate and integrate areas of public concern. Effective risk communication strategies are an important component to response efforts of the risk management system.

If the strategy chosen is to reduce the risks, portraying the hazardous event as a causal sequence, from initiating events through exposure to consequences, is a useful model to adopt (Hohenemser et al. 1983). This model allows for the easy identification of types and points of intervention and their effects. For example, control strategies may include cask redesign at the design phase, quality control programs at the fabrication phase or rerouting shipments at the operational phase.

1.1.7 Modes of Implementation

The modes of implementation include mandatory requirements, educational programs, and other forms of encouragement. For example, particular cask

designs may be required by legislatively-mandated standards; effective quality control programs may encourage and facilitate good quality control; and educational programs may enhance public response and emergency preparedness. Because the transportation system will be dynamic in both time and space, ongoing iterative evaluations will need to be included with the result that system modifications would be implemented where needed.

1.1.8 Preferred Transportation Risk Management System

The principal attributes of a preferred risk assessment and risk management system include:

- Utilization of a comprehensive systems approach to delineate all relevant aspects of the transportation system.
- Extension and adaptation of existing PRA methodologies.
- Incorporation of human factors which mitigate and exacerbate adverse consequences.
- Ensuring that risk assessment and risk management are integrated in a dynamic, iterative process.
- Incorporation of a socio-technical perspective.
- Satisfaction of the objectives discussed at the beginning of Section 1.1.
- Addressing the key issues outlined in Section 1.1.1

Comprehensive Systems Approach

The transportation of nuclear waste to a repository will be technically and organizationally complex and filled with many uncertainties. The system should be designed to begin its operations in the most reliable and safest manner possible. However, mistakes and modifications to the system are inevitable. In order to ensure the maximum evaluation of system operation and interactions with the external environment, risk assessment and risk management should incorporate a comprehensive systems approach in which individual components are not only conceptualized individually, but also as interacting dynamic components at the total system.

Probabilistic Risk Assessment

In spite of the shortcomings associated with PRAs noted earlier, they are the preferred methodology to assess the risks of nuclear waste transportation; given certain provisos and modifications. The conclusion of Hamilton et al. (1986: 5-1 to 5-2) that no new basic methodological developments for PRAs are required is considered to be correct. Existing methods can be adopted and extended to accommodate the nuances of the nuclear waste transportation

system. However, assessments should be sensitive to the fact that the analytical methodologies for estimating event probabilities and consequences are often more powerful than the available data. In particular, there are many specific factors in the assessment of risks from nuclear waste transportation for which data, theory, and our basic understanding of process are not as well developed. For instance, the impacts of external events such as floods, earthquakes or range fires on transportation risks need to be evaluated.

Additional data development is necessary for cask integrity in accidents, radiological source terms, and the influence of human factors. In particular, understanding human factors that both mitigate and exacerbate the adverse consequences of nuclear waste transportation need more attention. To properly assess adverse health effects requires the development of models for describing and estimating radiological effects at low doses. Current models are often inadequate, and there is little available data to improve them. There are very few data available on severe accidents and incidents. In addition, their applicability is questionable because, for example, different generations of casks were involved in previous accidents and incidents. In contrast, a good database exists for the estimation of non-radiological effects which have often been neglected in risk assessments.

Where preferred actuarial data are not available in these areas, expert judgement may be used as a fallback position. However, attention must be paid to the shortcomings of such an approach. One conclusion from evaluating the conduct of previous risk assessments is the importance of making the assumptions made, methods used, and results obtained clearly understandable to the user and the public. Additionally, the degree of uncertainty in the data used must be analyzed and presented.

In the preferred risk management program, the results of risk assessments need to be integrated with additional socioeconomic and socio political assessments in order to identify additional issues of public concern and how they might be mitigated. Concerns such as economic impacts and questions of institutional legitimacy may have a significant impact on the ability to safely, reliably, and efficiently develop and maintain a transportation system for nuclear waste (NAS 1984). An especially important aspect of such studies is the evaluation of issues related to the social amplification of risk (Kasperson et al. 1988).

The need to identify and respond to all types of social concerns argues for a socio-technical perspective for the risk management of the transportation system. A socio-technical system refers to interacting components such as: system hardware (e.g. spent fuel casks, trucks, trains, cranes), personnel activities (e.g. drivers, crane operators), organizational infrastructure (e.g. operations, maintenance, management), and social factors (regulations, economics, culture). These are illustrated in Figure 2. If types and degree of interactions of different system components and levels are not taken into account in risk management activities, the result may well be the failure to effectively implement many of the suggested measures (National Research Council 1988).

Figure 2.

**A SOCIO-TECHNICAL VIEW OF THE HIGH LEVEL
RADIOACTIVE WASTE TRANSPORTATION SYSTEM**

The preferred approach should make clear that risk estimates are based on specific design and operating criteria, and that these estimates can only approach their real values if the transportation system is operated in accordance with the models and assumptions of the risk assessment. Any modifications to system components (e.g. operations, maintenance, training) should be fed back into the risk assessment process. This again supports the need for a comprehensive systems approach to evaluating the transportation system. Concomitantly, new results from a risk assessment then need to be fed forward into developing new control strategies. This approach is particularly important in the transportation system because the technologies, regulatory environment, and institutional structures change frequently.

The following sections indicate the elements of a preferred PRA and specify the system parameters that need to be modelled. A PRA begins by identifying the initiating events and hazard sequences leading to adverse consequences and attempts to assign probabilities to each event. Consequence analysis follows and involves identifying pathways of exposure, estimating the doses received by different populations at risk, and calculating the likely adverse health effects.

Normal Conditions

Both radiological and non-radiological risks occur in the normal or incident-free transportation of nuclear wastes. The following illustrative (not comprehensive) list indicates some of the parameters to be considered in estimating these risks:

- Quality control
- Human error
- Nature of waste material (amount, form, level of radioactivity)
- Nature of cask (external radiation)
- Nature of individual transportation procedures (number, duration, shielding factors, exposure levels)
- Shipping information (number of casks)
- Population at risk (workers, public)
- Transport modes (truck, rail)
- Transport route (route, length, population density, bridges, etc.)
- Timing of shipping (time of day, duration, stopping times)
- Exposure pathways (inhalation, ingestion, direct)
- Dose-response relationships (modeling, extrapolation)
- Nature of consequences (acute/chronic, morbidity, mortality)

Handlers, crew members, and the public are exposed to the small amounts of radioactivity that penetrate through the walls of the shipping casks and the non-radiological risks of exhaust emissions from trucks and rail locomotives. As such, there are no identifiable initiating conditions except, perhaps, cask design and the decision to ship nuclear waste. Poor quality control and human errors in cask design, fabrication, loading, and handling may exacerbate these normal exposures and can therefore be seen as enabling events. It is possible to identify probabilities for such errors, although the current methodologies are complex, and the databases for so doing are somewhat rudimentary.

The exposure pathways under normal conditions include direct radiation from the waste package during loading and from the cask during shipping. Given the solid waste form and absence of accidents leading to volatilization or dispersion, inhalation of radioactive gases or particulates is unlikely. The primary route of exposure for non-radiological hazards is inhalation, although skin contact with, or ingestion of, lubricants and fuels is possible for crew members and maintenance staff.

The parameters necessary to estimate doses are also indicated in the list (above). To estimate exposure levels at every point in the transportation network, it is necessary to know the nature of the waste material and cask, the nature of the various tasks (e.g. packing, loading, shipping, unloading), and shielding factors. Individual worker doses can be estimated from data on exposure levels during each task, task duration, the number of packages and casks processed, and the number of workers involved. Estimating doses received by the public requires data on exposure levels at various distances from the cask, the number of casks to be shipped, transport mode, transport route (including data on population proximity and density, and the shielding factors of buildings), and the timing of shipping (including the time of day, the number and length of stops and the expected population exposed in each case).

Having estimated doses to the various populations at risk, several models are available to predict possible adverse outcomes, including latent cancer fatalities, and genetic effects. There is considerable disagreement and controversy over the extrapolation from known effects at high doses to effects at low doses, and the assessment should provide several alternative models for calculating the likelihood of adverse health effects, including delayed morbidity.

Accident Conditions

Assessing the probabilities and consequences of accidents is more complicated than assessing the risks of normal conditions, although many of the necessary parameters are the same. Some additional parameters needed are indicated below. Again this list of additional parameters for transportation PRAs under accident conditions is intended to be illustrative only, not comprehensive.

- Frequency of accidents
- External events
- Common cause and common mode failures
- Nature of accidents (frequency, severity)
- Release fractions
- Dispersion modeling
- Post accident behavior
- Emergency response

Human error and quality control take on added significance in accident analysis since they may act as initiating or enabling events in an accident sequence, or they may exacerbate or mitigate the final consequences. Accident frequency, both general transportation accidents and those involving hazardous materials, is an important input for this type of analysis.

Although these data are generally available for both truck and rail transport modes, their accuracy, precision, completeness, and applicability need to be evaluated with respect to PRAs that are to be performed on the transportation system. Special emphasis should be given to external events like plane crashes, bridge failures, earthquakes, and floods. Some of these events such as earthquakes and floods may be common cause failures that initiate and exacerbate accident conditions. An earthquake may initiate an accident by causing a truck to crash and burn and thus result in a breach of the cask integrity. The earthquake may also exacerbate accident consequences by causing infrastructure collapse which will hamper emergency response efforts.

The nature of the cask is also particularly important in accident analysis. The design and fabrication of the cask must allow it to withstand a variety of accident conditions. As yet, data on cask behavior are limited to a handful of experimental crash and fire tests at the national laboratories (Hamilton et al. 1986: 10-25 to 10-28). However, these data are inadequate for a comprehensive PRA, and their validity is in question (Resnikoff 1983). Intimately related to cask design and integrity is the severity of postulated accidents. This highlights a generic problem in risk assessment: what accidents are considered to be incredible and therefore beyond consideration? It is possible to identify a sequence of events leading to a massive release of radiation and a significant number of adverse effects, but is it reasonable to consider accidents with such low probabilities? These are questions that will have to be addressed at the beginning of the analysis. It is recommended that a broad spectrum of accidents including the worst case be assessed.

For each accident scenario postulated, the risk assessment must calculate the release fraction or source term (i.e. the amount and type of different radionuclides released into the environment). This release may be in the form of a plume of radioactive particles and gases which will be distributed through the atmosphere and contaminate soil, water, buildings, and equipment in the area. The proximate population may be exposed by direct radiation from the plume (cloudshine) or from contaminated surfaces (groundshine), by inhalation of radioactive gases and particulates, and by ingestion of contaminated food and water. The risk assessment must estimate the likely distribution of such materials and subsequent population exposures using standardized dispersal and dose-assessment models. As with exposures under normal conditions, the assessment must estimate the likely adverse effects using standard dose-response models. In addition, the assessment must also estimate the likely non-radiological effects resulting from accidents.

Most risk assessments conducted to date ignore post-accident behavior. A comprehensive assessment, however, must assess the impacts of the range of public behavior exhibited and emergency response activities that follow accidents. These activities may exacerbate or mitigate adverse effects and will vary according to political jurisdiction, population distribution, and other locational factors.

Sabotage/Terrorism

Sabotage refers to the deliberate disruption of waste shipments with the intent to steal nuclear materials or to cause harm by the release of such materials. Section 3.9 describes physical protection from sabotage, terrorist attack, and theft and discusses the techniques likely to be used by saboteurs and the options for preventing such interventions.

Although it is almost impossible to quantify the probability of sabotage, the potential consequences can be systematically evaluated. One method of evaluation is vulnerability analysis. The list of parameters to be addressed in such an assessment is almost identical with the list for accidents, since both lead to the potential release of radioactive and toxic materials. In addition, two other parameters are of concern; the probability of sabotage and its severity. Past experience is too limited to allow any reliable estimates of sabotage/terrorism probability. Consequently, either expert judgement must be used, or acts of sabotage should be modeled without reference to probabilities.

The severity of sabotage attacks run the entire spectrum. Many acts of sabotage, such as deliberate tampering with vehicles or bridge destruction, result in sequences of events similar to other accidents and may be modeled in the same way. Other acts of sabotage may be deliberately directed towards exacerbating the consequences. Examples are driving damaged casks into urban areas or dumping them into a reservoir system. In the absence of probabilities, modeling these scenarios becomes a worst-case analysis.

Human Error And Quality Control

Human error and poor quality control, previously listed among the parameters for consideration in assessing risks under normal and accident conditions, may be either enabling or initiating factors in a sequence of events leading to hazardous outcomes. They may occur at any stage of the transportation system. This includes design, fabrication, testing, inspection, maintenance, quality control, operation, emergency response, or even in the risk assessment. In addition, many kinds of human error have the same underlying causal mechanisms (Reason 1987). Consequently, they are treated here as generic factors of concern for both normal and accident conditions.

Key issues to consider (not comprehensive) in an evaluation of human error in the nuclear waste transportation system included:

- Task requirements
- Physiological requirements
- Cognitive requirements
- Performance shaping factors (e.g., work environment, stress factors, fatigue)
- Data availability

- Enabling vs. initiating errors
- Equipment design and operating requirements
- Observation and reversibility of errors when they occur
- Organizational structure
- Social environment (internal and external to transport system)

Human errors may only cause adverse impacts if they are not corrected in time. Thus their effects are dependent to a large degree on their observability and reversibility (Rasmussen 1987). To assess the observability of errors and identify correction methods, the characteristics of the total human/task or human/machine system should be evaluated. The primary interactions are between task requirements (e.g. procedures), equipment and operating characteristics, and human physiological and cognitive capabilities.

In addition, persistent situational features should be evaluated. These include noise and illumination levels, worker fatigue and emotional stress, time pressures, and the organization of the work place. Persistent situational features, often referred to as performance shaping factors, may greatly increase the likelihood and consequences of errors. Emotional stress and time stress are performance shaping factors which have been shown to greatly affect decision behavior.

Socio-Technical Perspective

A complete evaluation of human error in the waste transportation system requires the evaluation of all levels of the socio-technical system portrayed in Figure 2. The organization of the workplace, including management-employee interactions, can have a significant effect on performance. Manager personalities, organizational culture, and the regulatory environment can constrain the types of risk management programs that will be acceptable and effective. Such concerns have recently been identified regarding the operation of nuclear power plants and many similar issues appear in the transportation system for nuclear waste (National Research Council 1988).

Research has shown that the types of errors and the rates of human errors are a function of the situation. Therefore, to fully and effectively evaluate the possible sources and impacts of human error, a comprehensive human factors analysis should be completed for the proposed nuclear waste transportation system. Such analyses should be performed for both transport activities (e.g., driving a truck) and cask handling activities (e.g., loading, packaging). The objective of the analysis is an overall understanding of the work environment, including goals and functions, performance shaping factors, and worker, task, and job requirements. After these issues are evaluated, the sensitivity of the system to human error can be assessed by identifying error types, their probability of occurrence, potential for recovery, and consequences. Steps in

a human/machine systems analysis for nuclear waste transportation are:

1. Describe system goals and functions.
2. Describe situational and performance shaping factors.
3. Describe personnel characteristics (including social issues).
4. Describe task and job requirements (including organizational issues).
5. Determine situations in which human errors may occur.
6. Estimate the probability of error occurrence for each identified error.
7. Estimate the probability that the error will not be corrected for each identified error.
8. Determine the consequences from each uncorrected error.
9. Develop changes in tasks, equipment, or systems to increase the overall system reliability.
10. Re-do steps one through eight to evaluate changes suggested in step nine.

1.1.9 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Comprehensive Risk Assessment and Risk Management	Research risk assessment issues such as the integration of human factors	17 (1986)
	Design risk assessment methodology	16 (1987)
	Collect data needed for risk assessment	14 (1989)
	Conduct baseline risk assessment	13 (1990)
	Identify risk management strategies	11 (1992)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Iterate risk assessment (first time)	10 (1993)
* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.		

1.2 TRANSPORTATION PLANNING AND ANALYSIS SYSTEM

To design the preferred system for transporting nuclear waste to a repository at Yucca Mountain a systems approach must be utilized. Through the use of a systems approach, and accompanying computer technology, the multitude of transportation issues that will require resolution can be evaluated and the preferred system can be modeled. Development of the transportation analysis system is a time and resource intensive activity. It involves the specification of a desired level of analysis capability, definition of important transportation parameters, identification of risk criteria, integration of system elements into a common analysis framework, and development of algorithms which can solve the problem as defined. It also involves design, collection and management of information to support the system design. This would include information regarding the condition of infrastructure, emergency response capability, traffic and rail operations and utilization, and facility construction and maintenance schedules among other factors.

The need to define the system specification and build analytical capability is immediate. A system which can be responsive to the existing transport environment (base case) is needed as a benchmark against which repository transportation issues can be analyzed.

1.2.1 Network Analysis Approach

Earlier approaches to assessing the impacts of nuclear waste shipments using varying risk/cost criteria often lacked a systematic basis, and were not able to identify optimal and/or comparative choices among transport alternatives. New, more powerful network analysis tools have improved accuracy through access to multiple databases and better mapping systems which use a geographic information system (GIS). As a result, systems are now being developed which: (1) can be performed using stand-alone microcomputer workstations; (2) provide enhanced graphics output; (3) permit flexibility in evaluating routing options; (4) provide economies of scale in evaluating multiple origins, destinations and shipments; (5) are designed to accommodate future data collection and modular enhancement; and (6) provide an opportunity for integrating generic approaches with selective customization.

Geo-Coding

At the heart of the network analysis is the concept of data geo-coding. In geo-coding every element in the transportation system is assigned a unique and accurate location. This is accomplished by defining each element in terms of its latitude and longitude. This converts the entire transportation system visually displayed on a printed map to a digitized map for use in analysis. This permits the overlay of digitized U.S. Census geo-coded demographic data on the transportation routing system. From this, special planning and safety analyses can be conducted. It permits the computation of population size within selected distances from the transport site and consideration of significant factors such as specific characteristics of the population (e.g., number of school age children,).

Other databases should be identified or developed to provide additional key information for a comprehensive analysis framework. For example, geo-coded information on topography, wind, temperature, geology, location of fire and police stations, and schools should be integrated into this process. This will assist in emergency response location and investment analyses and evacuation planning. Additional transport segment descriptors should be placed into the system, such as grade, curvature, and accident rates, to provide for more precision in risk and cost assessments associated with moving a specific shipment on a given mode across a particular path.

Much of the geo-coded transportation network has been developed by the United States Geological Survey (USGS). A reasonably recent version of this network is maintained by Oak Ridge National Laboratory and is in the public domain. Collectively, the network represents the U.S. road, rail and barge system, although the characteristics of each segment of the network vary by mode. Although every link in the national road system is not represented, all interstate, U.S. and state highways and some local arterials are included in the existing network.

Figures 3 and 4 display geo-coded road and rail networks at varying levels of detail in the country. Figure 3 depicts the interstate highway network. In Figure 5, the State of Nevada road network is shown, including interstate, state and U.S. highways as well as some local roads. Figure 6 presents routes in the vicinity of Yucca Mountain. Figure 7 provides labels for nodes (number and name), as well as identification of link distances in miles. The U.S. railroad network leading into Nevada is shown in Figure 8, followed by rail system details in Nevada in the vicinity of Yucca Mountain in Figures 9.

Additional local access/egress network representation will be required as a supplement to the existing network to accommodate the local Yucca Mountain transport system. It is also likely that new roadways will be added in Nevada which might be considered for the waste transportation system. And it is important to note that the national network requires constant upkeep and could change; particularly the rail system, where company mergers and/or track abandonment occur rather frequently.

Network Analysis Methodology

Given an accurate representation of the transportation system and associated demographic characteristics, the ability to perform routing studies depends on the development of algorithms which can perform network optimization. This is driven by the definition of an objective function, which is an equation indicating the risk/cost criteria being applied and the weights associated with each criteria. For example, a simple objective function might be as follows:

$$Z_i = x \text{ DIST}_i + y \text{ POP}_i$$

where: Z_i = value of the objective function for segment i of the network

DIST_i = distance of segment i

POP_i = total population residing within 1 mile of segment i

INTERSTATE HIGHWAY NETWORK

Figure 3. Geo-Coded Map of the Interstate Highway Network

RAILROAD NETWORK

Figure 4. Geo-Coded Map of the U.S. Railroad Network

Figure 6. Road System In Yucca Mountain Vicinity with Route Labels

Figure 7. Road System in Yucca County, Utah, showing the location of the Yucca County Jail.

Figure 8. Rail System in Nevada

Figure 9. Existing Rail System in the Vicinity of the Yucca Mountain Site

x, y = coefficients representing the relative importance of
DIST and POP in the objective function.

As this simple function illustrates, several criteria can be included in the objective function at any time. Considerable flexibility is permitted in defining an objective function. More constraining is the availability of data for application. For example, travel time, accident rates, expected losses due to an accident, residential population and emergency response times are just a subset of attributes which could be described at the segment level, and therefore could be included in the objective function.

The coefficients, x and y in this function, allow the analyst to weight or adjust the importance of different criteria according to what is being considered. Criteria can be considered independently also. For instance, using the function above, routing via the shortest path can be determined by setting $POP_i = 0$. This ignores the population criterion in selecting the route.

To find the optimal path between a shipment origin and its destination, many individual network segments are crossed to form a route. Thus, the optimal path for each mode is the one which satisfies the following condition:

$$\text{Minimize } Z = \sum_i^P x \text{ DIST}_i + y \text{ POP}_i$$

where: P = the segments which constitute a feasible path.

The optimal route for each mode is the one where the sum of the individual segment values of the objective function is minimized. In practice, this function does not have to be linear, and may not be where people are shown to be risk averse. The mathematical formulation to this problem is far more complex than treated in this discussion given that the number of possible routes (combinations of segments) between an origin and destination is massive. Thus, very powerful search and solution techniques are needed to drive this process. Another desirable capability would be the ability to model a system that required a shipment to pass through an intermediate point or to avoid a segment or area (e.g., Tribal land, a local jurisdiction or a weak bridge). These restrictions can be accommodated in the system design by imposing mathematical constraints on the range of feasible solutions.

1.2.2 Nevada Enhancements to National Network Models

Because of the number of repository shipments anticipated, it is important to describe in detail the physical transport network, and the demographics of surrounding areas in addition to expanding the list of segment attributes in and adjacent to the State. This information can be used in planning to minimize exposure of vulnerable sites/facilities, minimize the use of high

traffic hazard areas which might increase non-radiological as well as radiological accidents, and select routes which are accessible by emergency response teams. In addition to creating a model with an enhanced local road network, details in the following areas should be integrated with the basic network model:

Distance to Emergency Response Teams

Two categories of response should be considered. First responders are the local police and fire departments. The ultimate response comes from the team which will manage the clean-up effort. The location and capabilities of each unit could be coded into the system to enable direct measurements of response times. From this, emergency response can be evaluated as a risk mitigation strategy.

Mobility-Restricted Population Groups

The people in mobility-restricted population groups are another important consideration because they would be difficult to evacuate in the event of a major incident. Examples include residents of retirement communities, school and day care children, and individuals who are confined to hospitals and nursing homes. For most people in these groups, emergency transportation would have to be provided by local agencies if an incident occurred. Special planning is required for providing appropriate evacuation transport and medical equipment where necessary as well as for identifying adequate temporary facilities for these groups.

To evaluate this factor for the purposes of risk analysis and preliminary selection of a preferred transportation system route, the mobility-restricted population by distance from the route can be estimated using existing data. Census tract data can be used for retirement communities. For schools and hospitals, county and municipal planning documents can be used. These documents list the locations of these facilities and typical occupancies. While these data have not yet been compiled for routes to the Yucca Mountain site, the primary data are available. Also, a sampling technique can be used to estimate the number of mobility-restricted people who live along a typical mile for each route in rural, suburban, and urban settings. Eventually, a thorough inventory should be developed and monitored.

Traffic Volumes and Accident Data

There is a general tendency for greater traffic volumes to increase the likelihood of accidents, regardless of how safely the facilities have been designed. City streets are prone to having more accidents per year than rural highways simply because the traffic volumes are greater. If all other things were equal, nuclear waste shipments should use facilities that have low traffic volumes. However, in common practice, low volume facilities are designed to lower standards and are often poorly maintained. Hence, federal guidelines recommend that hazardous materials shipments move via interstate highways in spite of higher traffic volumes. Both traffic volumes and facilities condition need to be taken into account in selecting desirable routes.

Measurement of existing traffic volume and accident frequency is basic, although the data must be used with some degree of care. For roads in the State of Nevada, accident frequency and average annual daily traffic (AADT) statistics are available from the Nevada Department of Transportation (NDOT). Truck (single unit trucks and tractor-trailer combinations) traffic statistics are available. For railroads, accident frequency and million-gross-ton (MGT) statistics are available on a line-by-line basis for freight and passenger movements combined. Railroad timetables can be consulted to determine train frequencies for both freight and passenger.

For purposes of the preferred transportation system, several measures could be used. Either average traffic density or maximum traffic density encountered could be considered for measuring volume. The latter measure is preferable because it examines the worst traffic conditions to which a shipment would be subjected. This suggests that the traffic conditions on all other segments comprising the route would be better. However, in the absence of conclusive data on which measure is more appropriate, and since the data is computerized, both average and maximum density should be considered.

Quantitatively, the problem with these factors is that the underlying data are not always reliable. For highways, AADT figures are sometimes extrapolations from previous year counts. Also, the truck data are only reflective of a four to six-hour time period during which the data are collected. For rail, the freight train frequency data are an approximation of actual practice. Scheduled trains are sometimes cancelled, and extras are added as needed.

A preferred measure for establishing accident potential is the accident rate. The accident rate can be derived by dividing accident frequency by traffic volume. Again, accident data can suffer from reliability problems. Accident rates are subject to additional bias given that uncertainties in both volume and accident counts are combined in this measure.

All of this information should be tested for statistical validity. Outlying data points should be revealed for a potential data collection or recording error. Sampling techniques such as periodic traffic counts should be implemented to ensure that the data reflect actual conditions.

Facility Conditions

Facility condition refers to the quality of the highways or railroads being used on a given route. All other things being equal, the best route to use is the one with the highest quality facilities. This minimizes the likelihood that facility condition will be the cause of an incident. Examples of areas of concern for highways include pavement condition, signage, geometric standards and lighting. It appears that information on road surface type, surface and grade widths, and geometry (e.g., vertical and horizontal curves, roadway gradient, underpass clearances) are available through NDOT.

Facility quality can be measured by use of a condition index. Nevada, like most states, uses an index for all major roads as an input to the maintenance and rehabilitation decision-making process. For the preferred system, an average condition index could be defined. If marked variations in average

expenditures from mile to mile are found to be common, is the worst facility condition encountered on a given route could serve as the measurement. To expect the difference between minimum and average values to be nominal would require an assumption that capital and maintenance funds are distributed on an equitable basis. If funds are not distributed to maintain all roads equally well, the minimum condition indicator would be more desirable because it would reflect the most deteriorating condition.

Weather Conditions

Weather conditions should be considered in the preferred system. Typically, weather conditions are measured in terms of adversity; the number of adverse weather days encountered per year on a given route. In addition to conditions such as rain, snow, ice, and fog, usually defined by the state police, Nevada and the Yucca Mountain area are subject to wind and dust problems. In the event of a release, weather conditions such as temperature and wind speed and direction, considered with the surrounding topography are essential information items.

Weather characteristics are available for a large number of locations in Nevada from the National Weather Service. This data can be processed with topographic contour data available from USGS. Specific data from the Yucca Mountain/Nevada Test Site vicinity should be available from the DOE.

1.3 TRANSPORTATION SYSTEM IMPACT MONITORING

Monitoring the actual impacts of the nuclear waste transportation system is necessary (1) to determine if the system is operating as designed, (2) to be able to develop responses to unanticipated impacts, and (3) for designing additional measures to reduce the impacts. The impact monitoring system should be capable of monitoring the impacts of all the different elements of the preferred nuclear waste transportation system. The preferred system impact monitoring system is described in detail in the Task 15.6 Working Paper.

Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Assessing and Monitoring the Impacts of the Transportation System	Identify impact assessment criteria	18 (1985)
	Develop route-specific impact assessment models	16 (1987)
	Collect data needed for route-specific impact assessment models	14 (1989)
	Conduct baseline impact assessment	13 (1990)
	Identify impact mitigation measures	11 (1992)
	Iterate impact assessment (first time)	10 (1993)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

1.4 PREFERRED DATA MANAGEMENT SYSTEM

A database management system (DBMS) consists of a centralized database containing all relevant information for the transportation of nuclear waste. This database should be accessible to various and multiple users simultaneously through the use of telecommunications devices such as a modem, for instance. The database itself would be contained on an upper series of the IBM Personal System 2 series, preferably, the Model 80. This model has the capability of 100 meg hard drive memory (the current memory ceiling) and uses a 32 bit 80386 processor in the CPU. The COMPAQ 386 is the other top-of-the-line PC available today. Through the use of software packages such as R-base System V or dBASE IV, all relevant data can be stored in a database environment and easily accessed from a personal computer with 640K RAM and a modem.

These database systems have a security system which specifies who may add data, who may delete data, and who may alter existing data and allows for many distinct levels of access. These systems also allow for the ability to access information through the application of passwords. Each user will have their own password which will dictate not only permission to view the data, but also the level of access, the rights (read-only, read-write, read-write--delete), and the view or window allowed. These characteristics will be particularly useful for diverse needs, ranging from shipment tracking to prediction of probabilities of accident distributions along the route.

1.4.1 Data Management System Users

The data management system must be designed to account for the needs of state agencies, Tribal officials and municipal and county agencies. It will provide key personnel with immediate data access for purposes of analysis, planning, decision-making, emergency operation, and general information on the status of nuclear waste transport throughout the State of Nevada. The data should be distributed according to Figure 10.

State agencies include the Office of the Governor and the Legislature, the Nevada Highway Patrol, the Nevada Department of Transportation, and the Nuclear Waste Project Office. County agencies include the county managers, the Clark County Comprehensive Planning Department and the Regional Transportation Commission, emergency preparedness/public safety and public works departments. Municipal agencies include mayors, city managers, emergency preparedness/public safety and public works departments. Also, Nevada representatives to the U.S. House of Representatives and Senate should have access to the system.

Figure 10. DATA MANAGEMENT SYSTEM

1.4.2 Minimum Functions

The data management system will be central to all aspects of the preferred transportation system since it provides for detailed information flow between all elements making up the system such as legal, regulatory, design, liability, emergency preparedness, operational, and risk management. The preferred data management system should be capable of performing the following minimum functions:

- Serve as a catalogue of local needs for decision-makers including location of hospitals and number of rooms; location of public and private schools and number of students; provide an atlas of all highway and rail routes throughout the local region with current condition and status of emergency routes; etc.
- Provide the capability of performing travel-demand forecasting and of carrying out simulation studies for use in addressing problems related to shipments and other strategic operations.
- Provide a mechanism for routing and rerouting to arrive at the lowest risk scenario.
- Serve as a mechanism for waste shipment monitoring and notification.
- Provide emergency response modules.

In developing these functions, consideration must be given to a number of factors. The system must be compatible with the Nevada Department of Transportation's infrastructure database. Telecommunications tracking systems used by DOE for their nuclear waste management system should be considered for compatibility for monitoring, notification, and emergency uses. Data security, including levels of accessibility and security of the data bank, must be carefully defined and reviewed.

1.4.3 Data Elements

The database should consist of tables detailing groups of related elements including:

Area Characteristics

Minimum data is required to drive most travel-demand software associated with metropolitan areas. This includes average daily traffic volumes for a base year, traffic analysis zone studies, hospital characteristics, employment profile, and other data.

Physical Characteristics

Data is needed on vehicle capacity, structural load, carrying capacity of pavements and bridges, geometrics, roadside characteristics and condition, emergency response capability, traffic and rail operations and utilization, facility construction and maintenance schedules, etc. The need to define the system specification and build analytical capability is immediate. A system which can be responsive to the existing transport environment (base case) is needed as a benchmark against which repository impacts can be compared.

Emergency Response Characteristics

This refers to data depicting the location and capabilities of emergency response units along the routes including hospitals, fire department, and law enforcement units throughout the region which might be impacted by the movement of the waste.

Geographic Information System

A Geographic Information System (GIS) is necessary in the data management system.

Rail Shipment and Other Related Characteristics

The information required to identify and evaluate the rail shipment options includes the following:

- Volume (total number of casks, by size and weight, and expected date of shipment; critical for determining the relevance of various modal options).
- Nature of the nuclear waste.
- The risks associated with each shipment option (accident/incident rates for each candidate route, schedule and operating plan; resulting population exposure levels and consequence distributions, fatalities, injuries, latent diseases, etc.).
- Operating restrictions (the extent to which the planned option requires extraordinary treatment and has potential impacts beyond normal operations).
- Cost (per shipment and total; operating, maintenance, and capital; to whom and how paid; timing of accrual).
- Site access (technical, operational, and economic feasibility).
- Shipment time (elapsed, from the perspective of exposure to radiation and sabotage/terrorism, cost and resource requirements).

- Weather sensitivity (the effects of inclement conditions; expected delays; extraordinary costs and resource commitments required to continue shipment under adverse weather conditions and/or place shipments in temporary storage pending weather condition improvement; importance of weather as a factor in scheduling shipments).
- Security; and safety (extent of personnel and other resources required to protect the shipment; the incremental costs of minimizing the likelihood of accidents or incidents; the complexity of special arrangements required to provide safe parking areas for storage during unforeseen or planned stoppages).
- Carrier qualifications (its safety record; personnel training and qualifications; maintenance practices; vehicle type and monitoring capabilities; financial condition; operation authority).
- Manufacturing details of transport containers.

1.4.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Data Collection/ Management	Identify data needs of federal, state, Tribal and local governments	21 (1982)
	Prepare conceptual system description	20 (1983)
	Design data collection/ management software and hardware	19 (1984)
	Begin data collection	18 (1985)
	Pilot test system	16 (1987)
	Begin system implementation	15 (1988)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

1.5 INSTITUTIONAL RELATIONS

Institutions ranging from federal agencies like DOE to local services providers such as hospital emergency departments will have a stake, or role in the nuclear waste disposal program. Current functions of existing institutions may be expanded or they may be shared with other institutions. In some cases, new institutions will be established to assume these functions and to manage anticipated new responsibilities associated with the waste program. Functions will need to be defined in order that institutional structures and operational processes/procedures can be planned and implemented. Relationships with other involved institutions will need to be considered formally and then developed through both formal and informal processes. In some situations, statutory authority might have to be evaluated and amended in order that inter-organizational authority is clarified or changed so as to eliminate barriers to development of a working system.

The transportation component of the disposal program will, by its nature require the greatest amount of interaction among the different institutions. The Congress has delineated responsibilities and some relationships among DOE, DOT, and NRC. State, Tribal and local institutions will need to work with these federal agencies, and with agencies within and adjacent to their jurisdictional areas to plan for shipments to and through their area. Shipment routing, accident prevention, emergency response and inspection activities will require extensive, even continuous interaction among institutions. Institutional relationships should be structured to encourage the design of a technically sound and equitable transportation system which inspires confidence among participating institutions and the general public.

Experience with ten spent fuel shipping campaigns from 1983 through 1987 revealed the following major institutional issues which needed to be addressed included:

- routing, including restrictions and bans,
- overweight truck permitting,
- documentation of environmental impacts,
- escorts and state fees for inspections,
- cask safety and certification, and
- prenotification procedures

1.5.1 Roles and Responsibilities

The repository will involve many governments in specific areas of the transportation program. Congress has designated the DOE to have overall program responsibility. The NRC and DOT have significant regulatory responsibilities, and other agencies and the DOE defense facilities will have roles in the program. States, Tribes and local governments will also have important regulatory roles.

A framework of roles and responsibilities should be available and updated as needed to clearly identify the responsible authorities and the decision process.

Interaction mechanisms, project schedules, contact and liaison personnel, chain of command and distinct decision points at project milestones should all be identified. The framework should provide all affected and interested regulatory authorities and other parties with an understanding of the program schedule, general decision process and opportunities for meaningful participation in planning and management. Institutional relationships will develop in an iterative fashion over time, so it will be important for state, Tribal and local governments in the host state to be diligent in maintaining their roles in areas where they have or should have program responsibilities.

1.5.2 Program Sequence for Program Milestones

Decisions and investigations which are needed in order to make other decision should be made early in the program. Proper sequencing of project milestones will reduce the likelihood that disputes will arise when significant concerns or objections surface later in the program. Planning will keep the project on schedule and provide information needed for activities which should be integrated with key milestone activities. Key planning milestones include the decision to use and the general location of an MRS, determination of the modal mix, development of scenarios for routing and shipment scheduling, cask designs, comprehensive risk assessment and risk management.

1.5.3 Comprehensive Program Management

Designing the transportation system for the repository will require the integration of technical, policy and business planning for a number of years. Comprehensive and integrated approaches should be used for all aspects of project planning and management. This involves risk assessment and management, program scheduling and milestones, technical investigations, issue and dispute management, and interactions with affected and interested institutional actors and other parties.

1.5.4 Public Interaction by Federal Agencies

Each authority responsible for decisions in the system will be a focus for important interactions with other institutional actors, affected and interested parties, public officials, the media and the general public. Public affairs should be conducted so as to clarify their decision process, to exchange information, to facilitate issue and dispute management, and generally to allow for meaningful and effective participation by affected and interested institutional actors and other parties.

1.5.5 Mechanisms of Interaction

Working relationships will develop while the transportation system is being established. This will range from cooperative participation to conflictive disagreement. The institutional relations of the program should be designed to keep the program on track through sound technical investigations and resolution of disputes. All institutional actors and other parties should have confidence in the integrity and objectivity of the decision process. The interactions should generally utilize the following mechanisms:

Information Exchange

Meaningful interaction and effective planning will require maximizing information exchange among affected and interested institutional groups and other parties. The DOE, NRC and DOT will be the agencies with the greatest regulatory responsibilities and will have important roles in information exchange. The repository program will involve the state of the art in engineering, design and policy planning for radiation control. Since the project is driven by federal authorities, the federal agencies and especially the DOE should take the lead in conducting the extensive technical investigations requires for the program. Affected and interested institutional actors and other parties should be involved in the design of many of these investigations and have access to the information developed. Without such cooperation on information exchange the effectiveness of input from non-federal actors will be significantly reduced.

Other kinds of information will be needed as the repository develops. Extensive comments, suggestions and criticisms will be directed at the program. Many of these should be incorporated into the planning effort. Information about the decision process of the program and its status at any time will constantly need to be conveyed to affected and interested institutional actors and other groups. Information will need to flow in both directions. Federal agencies will need state and local information for their planning and management responsibilities for determining shipment routes, infrastructure, emergency response capabilities, and highway inspection and enforcement.

Management of Planning

This will be a unique and complex planning process. Key investigations and decision which are pivotal for program development should be made early in the process. Parties with institutional responsibilities should have sufficient financial and human resources to prepare for and participate in the planning process. Most important is the involvement of the affected parties in the initial transportation planning process. If decisions are made privately at the federal level, safety and equity will be in doubt.

Issue and Dispute Management

As the transportation system develops, specific issues of concern, controversy and dispute will be identified. Many of the issues will be resolved in a cooperative effort by the various parties, while other issues will be controver-

sial and remain disputed. The institutional relations of the program should utilize flexible approaches to achieve cooperation and dispute management.

Information exchange and joint planning efforts provide the first mechanisms for working cooperatively and managing disputes. Work sessions and dialogue between senior officials from affected institutions will help solve controversies or at least clarify items of dispute. If disputes continue in specific areas, the issues in controversy should be taken up in negotiation, mediation, litigation or political process.

1.6 PREFERRED REGULATORY STRUCTURE/LIABILITY SYSTEM

The primary goal of the preferred regulatory structure for the shipment of nuclear wastes is minimization of the potential for, and consequences of, radiological incidents and accidents to protect the health and well-being of the citizens in Nevada. One method for attaining these objectives is the development and implementation of uniform, national standards, where appropriate. While in certain areas it may be appropriate to preempt, and thus preclude, State, Tribal and local action, this will not always be the case. For some issues, national standards should be viewed merely as minimum requirements. For other issues, there may be no need for a national standard, leaving the area open for regulation by state, Tribal and local governments.

The preferred regulatory structure includes Federal and state statutes, local ordinances, and regulations. A statute, or ordinance, establishes the framework within which the legislative body seeks to accomplish its goals and objectives. Broad proscriptive and prescriptive acts will be determined by a statute or ordinance. Regulations, promulgated pursuant to these laws by administrative agencies, are detailed in nature, enabling the agency to implement the legislative body's goals and objectives. In addressing nuclear waste transportation issues, terminology herein refers to something being "regulated", or that "regulations" be adopted. Within this context, the terms are broadly defined to mean that the issue should be governed by law. It does not refer to rules promulgated by administrative agencies. Where the intent is to refer to an agency's rules, the specific regulations are usually discussed.

In order to construct a preferred regulatory system, the activities of the federal, state, Tribal and local governments must be considered. The State of Nevada will need the cooperation of other governments to achieve the regulatory objectives identified. For that reason, this section refers to all state governments and not only the State of Nevada. Within the framework of federal, state, Tribal and local laws, a preferred regulatory structure should address the following issues:

- Driver Qualifications	- Placarding
- Emergency Response	- Prenotification
- Escorts	- Highway Routing
- Inspection and Enforcement	- Rail Routing
- Liability	- Sabotage/ Terrorism
(Physical Protection)
- Overweight/Oversize Shipments	- Shipping Papers
- Cask Design/Testing	- Vehicle Stoppage
- Permits and Fees	

Permits and fees, and liability, areas which relate to a number of the design and operational elements of the preferred transportation system, are discussed here. The remaining issues are addressed within the applicable transportation system design or operational procedures sections.

1.6.1 Permits and Fees

Roles of State, Tribal and Local Governments

In a preferred transportation system, permits and fees for motor and railroad carriers should be regulated by state and Tribal governments. Local governments should be precluded from adopting permit and fee requirements.

Functions of a Permitting System

Permitting serves as a revenue source, as an information source and as an enforcement mechanism. A primary function of permits is to raise revenues for the funding of inspection programs and emergency response training and equipment. Permits do play a valuable role in providing and obtaining information. For instance, through the permitting process, applicants can be advised of federal, state, Tribal and local laws with which they are expected to comply. Similarly, carriers can be required to provide information that aids the state in emergency response planning and that requires the permit holder to prepare for emergencies. A permit application, for example, may require a carrier to submit contingency plans to the state. This contingency plan should address the specific actions to be taken by the carrier in the event of mechanical problems with the vehicles and in the event of a radiological incident or accident, including clean-up. Thus, in the event of an incident or an emergency, the State of Nevada would know what it could expect of the carrier and which contractors it could contact on behalf of the carrier.

Permits serve as an enforcement mechanism by precluding the transport of radioactive waste within state boundaries. Permits can be revoked for a variety of reasons, including supplying false information on the application, or repeated, serious violations of the law. Ideally, the potential loss of a permit should provide carriers with a strong incentive to comply with all relevant laws.

Contents of Permit Applications

The permit application should include the following:

- The name, address and telephone number of the carrier. If the applicant is a corporation, the date it was qualified to do business in the state should be listed. Also, the name, address and telephone number of the corporation's registered agent should be provided.
- The name and title of the person completing the application.

- A description of any federal, state, Tribal or local enforcement actions relating to hazardous materials transportation taken against the applicant within the past three years.
- A description of the carrier's contingency plans for vehicle problems, incidents and accidents.
- Certification that the carrier has received from the state a copy of a map showing designated routes and parking sites, and a telephone number to call in the event of an emergency.
- Certification that the carrier will comply with all applicable federal, State, Tribal and local laws.
- Certification that the information contained in the application is true and correct.

Administration of Permit/Fee Programs

Permits and fees must be administered by state and Tribal governments rather than local governments for several reasons. With shipments moving around the clock, permit information must be centrally available and accessible 24 hours per day, seven days per week. Most local governments are not staffed to administer such a program. Some, if not most, of the information that may be required in a permit application will relate to emergency response planning, and that must be coordinated at a state level in order to be effective. Finally, because carriers are accustomed to obtaining permits from state governments, their administrative operations will not be burdened by compliance.

Permits and fees should not be administered by the federal government for similar reasons. The federal government lacks sufficient staffing for the performance of inspection and enforcement actions at a level that would cause the carriers to comply with regulations. Furthermore, emergency response would occur within the jurisdiction of the states and permit application information would not be available to these responders if they were administered federally.

The federal government should not have responsibility for fees collection. While there would be some advantage to the carriers, it is outweighed by the necessary costs in establishing and maintaining a federal collection system. Moreover, the agency that would be responsible for collecting and redistributing fees, DOT, objects to the federal government allocating funds to the states for emergency response equipment, although DOT supports preempting the states from imposing fees. Without the permit fees, state, Tribal and local governments would be placed in the situation of either not being adequately prepared to respond to an emergency or requiring their citizens to bear the financial burden for emergency responses for the nuclear waste transportation system. To avoid such an untenable position, state and Tribal governments should regulate permits and fees.

1.6.2 Liability

Despite the goal of designing a safe nuclear waste transportation system, it is likely that an incident or accident will occur. The American tort system is predicated on the theory that, where a duty to an individual has been violated and results in damage, reparation must be as complete as possible. It is fundamental that the victim bears no portion of the damages, unless the victim's own conduct helped in causing the injury. These basic tort law concepts are equally applicable to the nuclear waste transportation system. Therefore, the goal for the preferred liability structure is to compensate individuals, without resorting to taxpayer funds, for damages resulting from the transportation of nuclear waste. Thus a source of funds from which victims may be compensated must be established for incidents and accidents. This fund must be administered in such a manner that victims are fairly and quickly compensated. For this discussion, incidents and accidents are categorized and labelled as Class I Incidents: as radiological incidents and accidents; Class II Incidents: non-radiological incidents and accidents; and Class III Incidents: non-radiological incidents and accidents for which certain radiological emergency response procedures were taken because of the cargo.

Standard of Liability

In order to prevail on a cause of action for negligence, a plaintiff must prove four elements:

- A duty requiring the defendant to conform to a standard of conduct to protect others against risks.
- The defendant's failure to conform to the duty.
- Proximate cause, i.e. the defendant's conduct caused the plaintiff's injury.
- Actual loss or damage as a result of the injury.

In response to a plaintiff's claim, a defendant may assert certain defenses such as that the defendant did not owe a duty to the plaintiff, or that the defendant did conform to the required standard of conduct. Other resources might be that the plaintiff was aware of the risks involved and assumed the possibility of being injured, or that the plaintiff was partially responsible for causing his or her injuries.

Standard of Liability for Class I Incidents

Under a strict liability theory, plaintiffs are relieved of proving the first two elements--a duty and a failure to conform. Concomitantly, the defendant's ability to assert defenses based on these two elements is eliminated. A plaintiff, thus, must only prove the last two elements--proximate cause and damages. One reason for imposing a strict liability standard is that the defendant's conduct involves ultrahazardous activities. Because the transportation of nuclear waste is inherently ultrahazardous,

the Federal government should legislatively impose a standard of strict liability for Class I Incidents. Such legislation would mandate a national, uniform standard available to all claimants.

Standard of Liability for Class II Incidents

For Class II Incidents, a strict liability standard is unnecessary. Because the threat involved does not differ from other motor vehicle incidents or accidents, the standard of liability for Class II incidents would be controlled by the common law of the appropriate state; most likely the state in which the accident occurs.

Standard of Liability for Class III Incidents

For liability standards, Class III incidents present some of the concerns found in both Class I and Class II Incidents. Certain emergency response activities may be undertaken solely because of the ultrahazardous nature of the cargo, but the incident may not result in a release of radiological material. For instance, if a truck transporting nuclear waste bursts into flames and is still burning after 30 minutes, emergency responders may well order a precautionary evacuation. After the fire is extinguished, it is learned that no radiation was released. The question of whether a strict liability standard should be applied then arises. Rather than have parties litigate which liability standard applies, Congress should specifically legislate compensation for certain damages arising from such problems.

Scope of Liability

Congress should mandate compensation for all damages resulting from a radiological incident or accident arising from the transportation of nuclear waste. So that there is no uncertainty, as there is in the current system, Congress should specifically provide by way of illustration, not limitation, that damages arising from the following types of activities are to be compensated: sabotage, terrorism, theft, diversion of a shipment, and clean-up. The element of proximate cause will identify the outer limits of a defendant's potential liability. The element of proximate cause determines whether the defendant's conduct caused the plaintiff's injuries and whether the plaintiff's injuries were foreseeable. Thus, a defendant's potential liability will be limited to those injuries that were foreseeable.

Congress should also legislate that certain specific costs are compensable. For instance, state, Tribal or local government's extraordinary costs in responding to a Class I Incident should be recoverable from the defendants. While there may be a fund available to train and equip emergency responders, the fund will not reimburse state, Tribal and local governments for such things as overtime wages. Similarly, a state, Tribal or local government's reasonable, documented extraordinary costs in a Class III Incident should be recoverable. An effective emergency response should not be based upon budgetary constraints, nor should a state, Tribal or local government's citizens bear the financial burden of responding to an incident. Therefore, the costs should be recoverable from

the defendant, who may argue that the costs are neither reasonable nor documented.

Statute of Limitations

Congress should mandate a statute of limitations for all actions accruing as the result of a Class I or Class III Incident. It is imperative, however, that Congress structure the limitation to permit compensation for injuries that may not develop until years after the date of the incident. This objective may be accomplished by defining when a cause of action accrues to be the date that both the injury and its cause is known or should have been known by the exercise of reasonable diligence. The statute of limitations for Class II Incidents should be governed by the appropriate state's law.

Proof of Causation

Proving that a physical injury has been caused by exposure to radiation is difficult. Federal legislation should allow for innovative methods for demonstrating causation, including a statistical probability standard.

Compensation Fund

The advent of the nuclear age was approached with some temerity by those in the industry because of the potential liability. Just as the courts stepped in to aid the development of the industrial revolution by placing restraints upon tort liability, Congress stepped in to aid the development of atomic energy by adopting the Price-Anderson Act. By indemnifying contractors and licensees against liability and by establishing a fund out of which claims are to be paid, the Price-Anderson Act encouraged private industry to actively participate in the development of atomic energy. In the 31 years since the Price-Anderson Act was initially adopted, private industry is a well-funded, active participant in the field of nuclear energy, obviating the need for public indemnification and subsidization of private enterprises.

A compensation fund should, therefore, be established and maintained by assessing a fee on activities that create radioactive waste in order to "self-insure." The fund's purpose would be to compensate victims of Class I Incidents. It would be administered by the federal government through a trust fund program that must be inviolate. Payments into the trust fund should be treated as an expense by the utility and should not be reimbursable under any circumstances. Fees need to be of sufficient amount that the initial fund will compensate for a serious radiological accident. Fees can continue to accumulate to assure the availability of compensation for victims of a worst-case accident scenario.

To meet the fund's purpose, the federal government should establish a mechanism by which individuals may submit and receive payment for claims that will reduce, if not eliminate, the need for litigation. One element of such a system must be speed. A speedy resolution of claims would aid in avoiding litigation. An arbitration process can also be established to resolve disputes. Further, a mechanism should be established to assure the availability of funds for those individuals who do not discover their injuries until years later. Mandating the

setting aside of a certain percentage of the fund is simplistic and inappropriate. A better method, though not necessarily the best or only method, is to develop actuarial tables from a worst-case scenario and then estimate needed future resources.

If an accident occurs while the fund is accumulating, the public treasury must provide any additional funds necessary to compensate victims. However, if this is necessary, the industry members should be required to sell any assets unrelated to the power plant's operations in order to repay the treasury. The bankruptcy laws should be amended so that the federal government is provided a "superlien," i.e., a priority, for any funds owed. The nuclear industry should not be shielded from liability. To do so simply encourages negligent behavior.

Compensation for damages arising out of Class II and Class III Incidents can be provided for by traditional insurance requirements. Required liability limits for Class III Incidents should reflect the potential costs. A superlien should be imposed on a bankrupt's estate for unpaid liabilities arising out of Class III incidents.

State and Local Governments

State, and local governments should be indemnified by the federal government for any liability they may have arising out of Class I and Class III Incidents. With federal indemnification, state, and local governments should be required to waive their sovereign immunity to the extent of indemnification. For Class II incidents, the potential liability facing a state or local government will be determined by applicable sovereign immunity laws.

1.6.3 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Regulatory Structure/ Liability	Identify gaps/risk reduction opportunities in federal law and regulations	14 (1989)
	Enact Statutory changes	11 (1992)
	Promulgate regulations	9 (1994)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

1.7 EMERGENCY PREPAREDNESS

Emergency response involves a host of activities that range from simple measures, such as stopping traffic; to the more difficult problems, such as extinguishing fires or controlling radiological release; to post-trauma clean-up measures. The activities may be clustered in phases that have a direct correlation to the severity of the incident or accident. At different phases, the function of responding will shift to different parties. The initial phase or phases would rest with proximally-located groups such as state, Tribal and local governments. As the severity of the incident or accident increases, functions would shift to the federal government because of available resources. No state or local government could bear the cost of being fully prepared to respond to a major radiological incident or accident. At the conclusion of the incident or accident, the clean-up phase, it is very likely that the work will be performed by a contractor rather than a governmental entity; particularly in light of the NWPA's mandate to maximize use of the private sector.

A preferred regulatory structure must take into account the phases of emergency response activities and the shifting of responsibilities. Moreover, the objective of minimizing the consequences of radiological incidents must include the individuals responding to the incident or accident as well as the public at-large. Some regulations within this area should, therefore, be national and uniform, and some regulations should merely establish a minimum level of acceptability.

For instance, a preferred regulatory structure would extend the current shipping paper requirements [49 C.F.R. 172.200-172.204 (1987)] to all shipments of nuclear waste, irrespective of whether the shipment is interstate or intrastate. The format for the shipping paper should be established by a national standard in order to assist emergency response and inspection personnel in performing their duties.

1.7.1 Training and Equipment Standards

The best method for protecting the safety of an emergency responder is to provide proper training and equipment. This should be regulated. In order to promulgate regulations, the various phases of emergency response activities must be identified and functional roles ascribed to each phase. The process will delineate the boundaries of the federal, state, Tribal and local governments roles.

Federal minimum standards for the training and equipping of emergency responders should be established so as to permit state, Tribal and local governments to impose more stringent requirements, where necessary. This flexibility is necessary because the number of shipments in or through a state will vary according to the state's proximity to the repository. Corridor states may well decide that more stringent requirements are necessary; whereas states through which very few shipments will pass may find the minimum standards

adequate. By establishing a minimum level of acceptability, bordering states would be in a position to provide aid to one another, if needed.

National, uniform standards are necessary for the training and equipping of the carriers' personnel for their participation in the appropriate phases of responding to an incident. Both rail and truck shipments should carry emergency response equipment with the shipment. Obviously, the rail carrier will be in a position to have more equipment with the shipment than a motor carrier will have in trucks. All of the carriers' personnel involved with any stage of the shipment should have a minimum level of emergency response training. Those personnel that will be with the shipment during transportation should be trained to a higher standard. Because an employee may reside in a different state than the one in which he will respond to an incident or accident, the federal government should regulate the training and equipment standards for the carriers to the exclusion of state, Tribal and local governments.

Within the context of a preferred system, the federal government should adopt minimum training and equipment standards for highway and railroad emergency response escorts. Escorts may serve either emergency response and/or physical protection purposes. Viewed within the context of this role, escorts merely serve as part of the emergency response function. Therefore, training and equipment standards applicable to other emergency responders would be applicable to escorts as well, although there may be some individualized needs to minimize their radiological exposure. As the initial stages of emergency response activity is inherently local in nature, state, Tribal and local governments may perceive a need for more stringent requirements. They should be permitted to regulate so long as the regulations do not conflict with the federal regulations. The need for emergency response escorts may be eliminated if the federal government utilizes and provides state access to a real-time shipment monitoring system.

To assure the viability of its emergency response activities, the federal government should prepare, publish and routinely update a written plan. Regulations for its own activities are unnecessary, except in one area: coordination with state governments. State governments must have a clear understanding of when it may request and receive federal assistance, and the exact nature of the assistance to be received. Enunciated standards will aid in engendering public confidence during a crisis, by reducing uncertainty.

If contractors are utilized during the clean-up phase, they will be providing a critical service--ensuring the health and welfare of the public through a restored environment. The number of contractors will probably be few in number, resulting in their living in one state and being hired to perform clean-up measures in another state. There is, therefore, a need for national, uniform standards governing certain aspects of the contractors' work. For instance, to assure adequate training of the contractors' employees, there should be national training standards, precluding state, Tribal and local regulation of the area. The standards must be set at a level that are (1) attainable and (2) satisfy the concerns of state, Tribal and local governments. If state, Tribal and local governments' concerns are not met, they will be creative in finding a method to assuage them.

1.7.2 State Organization

State governments must regulate to ensure coordination of emergency response activities. Some local jurisdictions may require a fully-staffed and equipped emergency response team, others may not. Multi-jurisdictional agreements with neighboring states and among local governments should be encouraged, where appropriate. State agencies overseeing clean-up activities are usually not the same agencies that respond to the incident or accident. These agencies must be provided with legislative authority for their activities involving nuclear waste transportation incidents or accidents.

1.7.3 Other Elements

The Federal government should establish environmental standards for the clean-up phase that allow reasonable flexibility for state, Tribal and local governments to impose more stringent requirements. Location of the property and other local conditions might suggest clean-up activities that go beyond federal minimums.

Although immunity need not be provided to clean-up contractors, the federal and state governments should provide immunity from civil lawsuits for emergency response personnel. Individuals must be able to perform their jobs without threat of potential personal liability except when their behavior constitutes grossly negligent conduct.

As discussed earlier, reimbursement for documented, extraordinary costs incurred by state, Tribal and local governments in responding to an incident should be available from a compensation fund. State, Tribal and local governments should not bear the burden of responding to a problem resulting from a federal program. Presumably, emergency response planning activities will be funded at the state level, but it is unlikely that the fund will be able to absorb extraordinary costs.

1.7.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Emergency Preparedness (EP)	Provide assistance to state and Tribal governments for EP planning	15 (1988)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Inventory/evaluate existing EP capability of federal, state, Tribal and local governments	14 (1989)
	Design initial EP system	12 (1991)
	Begin provision of assistance to state and Tribal governments to implement EP system	11 (1992)
	Finalize EP system design	5 (1998)

- * Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

[THE PREFERRED EMERGENCY PREPAREDNESS SYSTEM
WILL BE SUBMITTED UNDER SEPARATE COVER]

2.0 PREFERRED TRANSPORTATION SYSTEM DESIGN

Conceptually, the nuclear waste transportation system design process involves the analysis of shipments that will be made, including their sizes and origins, the vehicles and modes that could be employed in their transportation, the routes that could be used, the population characteristics along these routes, and a variety of other parameters that indicate the types and magnitudes of impacts that might occur. These include location-specific accident rates, highway/rail design characteristics, traffic densities (both along the route and on segments of the network with which the route intersects), and the ecological and geographic characteristics of the terrain through which a route passes. The analysis involves a quantification of the expected release rates and other impacts by route and network segment, and translation of these into measures of risk and cost for each route available.

Converting this conceptual process to a tangible system involves the use of sizeable amounts of data and complex mathematical formulations in a network analysis approach. Databases that describe the transportation network, the traffic over it, the population around each network segment, and the geographic characteristics of the area through which each segment passes must be considered. Because the system is multi-modal, the best option from rail or truck for each shipment and for logical subsegments of a given shipment must be selected. Fortunately, the existing availability of some of this information in a computerized format permits the mathematical overlay of multiple databases onto a common map.

The network analysis uses simulation of materials flows and identifies alternative routing, transport modes, and risk environments which minimize undesirable transportation impacts. Segments of the network are defined, and each segment is characterized by such attributes as population, geographic characteristics, road/rail conditions, accident frequencies and severities, and environmental considerations.

Given a baseline characterization of the transportation network; the analyses of impacts and the effectiveness of impact minimization policies/actions are accomplished via changes in parameters -- routes, modes, road/rail quality, emergency preparedness capabilities, etc. By selecting a set of parameters, impacts are traced throughout the segments of the network. The results, when compared with baseline results (accident frequencies, severity, etc.), yield estimates for impacts associated with a repository at Yucca Mountain.

The analytical process involved with the network approach is illustrated in Figure 11. Starting with an estimate of the volume of wastes to be transported, the point of origin, and given criteria to be used for assessing or prioritizing choices; the analysis begins with the elements which directly determine non-accident and accident events such as the transportation mode used, routes used by each mode, and risk mitigation elements. For each transport mode, alternative routes are defined, as are where each route involves chains of segments. A set of risk mitigation elements are also

Figure 11.

Illustration of the "Network" Analytical Process

EXHIBIT 1

specified for each mode-route segment of the network: (1) condition of roads, rail, etc.; (2) weight of trucks; (3) whether or not special trains, dedicated routes or escort vehicles are used; (4) type of packaging; and (5) other regulatory requirements. These data are then used to develop estimates for the likelihood of non-accident events and alternative accident scenarios with and without radiological releases.

For a given set of accident scenarios, the impacts of such accidents will depend in large part on the emergency response capabilities of the area in which the accident occurs. The level of emergency preparedness is thus specified by a set of parameters including response time, and the ability of responders to deal with the posited emergency. When juxtaposed with the accident, the comparison with the level of emergency preparedness translates into the effects, or impacts which could be associated with the accident. The output of this process includes mortality and/or morbidity effects, effects on the environment, clean-up costs, property value effects, effects on the image of the area as it relates to tourism, and the business characterization of the transportation network.

Iterations of this process are used to define optimal, or risk/impact minimizing, choices for the structure of the transportation network (optimal mode/route choices, cost-effective levels for emergency preparedness, etc.). This, in turn, leads to an estimation of the costs associated with selected mitigation programs. Such estimates are of prime importance inasmuch as the issue of who bears such costs should be central to negotiations with the federal government. The remainder of this section describes important components of the preferred nuclear waste transportation system design.

2.1 VOLUMES AND TIMING OF SHIPMENTS

The amount of spent nuclear fuel that can be accommodated by the first repository site has been set at 72,000 tons by the NWPA. Presently, candidate wastes for shipment have been residing at various reactor sites for varying periods of time. Under the authorized system, the transport of spent fuel from waste generation sites to the repository site would amount to approximately 97,000 truck shipments or 14,000 rail shipments, respectively, if all spent nuclear fuel were transported by a single mode using conventional technology. The discrepancy between modes is due to the greater carrying capacity of rail casks in comparison to truck casks.

Considerable uncertainty exists as to the accuracy of these numbers as well as to the impact of an MRS on the number of shipments and shipment size. This is due to ongoing cask design research which will progress toward identification of cask carrying capacity, the extent to which consolidation of spent fuel will occur before transport. Also there are various truck and rail shipment options under consideration, as well as the use of barge on the first leg of an intermodal trip. Currently it is anticipated that shipments made directly from reactor sites will have been out of the reactors for at least a five year period, and spent fuel from an MRS would be out of the reactor for over ten years. In either case, the fuel will have radioactively decayed and thermally cooled to

the point at which cask demands for extensive shielding and cooling systems may be somewhat relaxed. This would expand cask carrying capacity.

In addition to shipment patterns and volumes, the timing of shipments could lead to significant safety problems. If all spent nuclear fuel were transported by truck and the repository operational phase lasted 25 years, an average of ten shipments per day would be received at the repository site. This number of daily shipments would put considerable strain on Nevada's infrastructure, and traffic patterns, and would pose significant risk to the population and the environment. With regard to this latter consideration, risk tolerance of people living along corridors near the repository could become a significant issue.

Clearly, the preferred volumes and timing of shipments must influence and be responsive to cask load carrying capacity and traditional and innovative truck and rail shipment options. This is particularly important at sources where national movements will converge at specific locations, many of which will be in the State of Nevada or just outside the state at major junctions and along heavily utilized transportation corridors. Response to these concerns may include (1) consideration of time-of-day scheduling to avoid certain junctions and daytime employment areas or schools, (2) minimization of traffic interaction and (3) spreading of shipments among different routes to disperse the impacts. Time of day restrictions, per se, are not practical, and would be rejected in court because they would interfere with interstate commerce. But this is not to say that the time-of-day should be ignored when developing the shipment schedules; quite the contrary. We all know that the number of people in close proximity to a given link can vary widely during the day, especially in urban areas where the land use variations are pronounced (e.g., areas which are strictly commercial, industrial, or residential). Hence, it is important to time the trips so that they pass over links when the nearby population is lowest. Routes must be defined in both space and time.

In case of rail, time-of-day sensitive routing is important because the rail lines tend to run through heavily built-up areas. This, coupled with the fact that the alternative light density lines are often not in very good shape, means that it may be wiser to time the shipments carefully and use the major routes than it is to use the paths that avoid the population centers.

The same logic applies to highway movements, with the added fact that risk exposure due to traffic volumes is much during the peak periods than it is during the midday or evening hours. This is irrespective of the density of people in the surrounding land use. A movement which is sensitive to these facts will be far superior to one which is not. In fact, the public might argue quite convincingly that such planning is irresponsible; even without training they can see that moving casks along a heavily used freeway during the peak traffic hours would be asking for trouble.

Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Volumes/Timing of Shipments	Assess optimal decay time prior to repository shipment	17 (1986)
	Assess alternative shipment scenarios	15 (1988)
	Select tentative shipment scenario	13 (1990)
	Finalize shipment scenario	(8) (1995)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.2 CASK DESIGN AND TESTING

Shipping casks for nuclear waste form the main line of defense against a serious release of radiation during transport. The containers to be used in shipments to a repository at Yucca Mountain should be designed, fabricated, tested and maintained to standards that minimize the risk of such a release. Containers developed in the past have had problems in these areas, though none has yet caused a life-threatening radiation release during shipment. The 10-fold increase in the number of casks in use and related (or greater) increase in the number of nuclear waste shipments will increase the probability that a radioactive release might occur. Thus more attention to reducing and eliminating the causes of container failure is needed. A preferred transportation system would include various methods to achieve and verify the safest cask design, minimize opportunities for handling problems and actual failure and, in case of a severe accident, mitigate the extent of a release while aiding the work of emergency personnel.

2.2.1 Current Design and Testing

Spent nuclear fuel shipping casks are classified as Type B packages under Federal regulations, thereby requiring that they meet the most stringent rules in effect for ground transportation of radioactive materials. These rules mandate that one sample cask must survive, without leaking a significant amount of radiation, the following sequential series of stresses:

- A 30-foot drop on an unyielding surface (i.e., one that does not move or flex under impact),
- A 40-inch drop onto a six inch diameter steel plug,
- A 30-minute fire at 1475 degrees F, and
- Eight-hour immersion in three feet of water.

In addition, a second cask must withstand a separate immersion in 50 feet of water for eight hours. A crush test in which a heavy steel weight is dropped on the container is also slated for addition to the test series in the near future. It should be noted that there is no requirement that the hypothetical accident stresses listed above actually be applied to a real cask; in fact, all such tests can be done using mathematical or scale models.

Beyond withstanding these stresses (assumed to be as harsh as any that would occur in all but the most severe accidents), the cask must, in routine operation: (1) contain the nuclear wastes radiation to specified limits, (2) accommodate various fuel assembly size, and (3) be easily loaded and emptied using existing techniques and equipment. Finally, a successful cask design must be economical to manufacture and not exceed the load limits of the mode (i.e., truck or rail/barge) that the carrier uses.

Within these constraints, about two dozen designs have been fabricated in the U.S. to date, totaling over 50 casks. During their lifetimes, they have been used in over 5,000 shipments from and between commercial, research, industrial and military reactors enroute to federal labs, private storage facilities and processing plants. While several incidents have occurred, no serious accidents have yet tested a cask's crash integrity.

In the past, casks have been designed to hold fuel recently removed from the reactor (i.e., less than one year prior to shipment). This has necessitated heavy radiation shielding and occasionally a means to cool the cask. Shipments to a repository will probably, however, involve fuel that has been out of the reactor for 10 years, during which time the fuel has radioactively decayed and thermally cooled appreciably. While the long-lived radioactive materials contained in the fuel are still quite dangerous if dispersed, the total direct heat and radiation output has dropped almost 90 percent during the decade of storage. Cask design will therefore require less shielding and no active cooling system. It is likely that these changes will allow a doubling of cask capacity while remaining within the other design limitations.

2.2.2 Regulatory Structure

Without a doubt, cask design and testing must be governed by uniform, national regulations. The regulations should include a requirement for full-scale destructive testing for each generation and type of cask. Because the potential consequences of a radiological release are catastrophic, full-scale destructive testing should be mandated. This will serve also to garner public confidence in the program. Some of the regulations will need to be promulgated by more than one agency. For example, the ALARA concept is applicable to both cask design and emergency response efforts, although it may be implemented by different methods. At a minimum, both the NRC and the FEMA will need to promulgate regulations to incorporate the ALARA concept within their areas of jurisdiction.

2.2.3 Cask Design and Testing Issues

Several aspects of cask design have generated controversy. For instance, design analysis tools such as computer simulations and empirical mathematical formulae vary in their development from one test to another. This raises the issue of sufficiency of the simplified methods used to model actual behavior of the various cask materials under stress. Also, since the accident tests are only hypothetical; it is not known whether they replicate the worst-case stresses in the real world. Furthermore, since only designs are certified, not the casks themselves, it is not known if the hardware is identical to the plans. Post manufacture quality control has been limited to spot checks in the past. There is a concern that too much faith is placed on examination of paperwork after the cask is built to show that the cask was properly made. All of these

concerns lead to the ultimate consideration of cask performance during an accident.

To avoid some of these problems, cask manufacturers are required to have quality assurance and quality control (QA/QC) procedures acceptable to the NRC. QA/QC procedures include maintenance of documentation and qualifications that can be checked to ascertain the integrity of cask production. As a result of such efforts, some federal and nuclear industry personnel have stated that the casks are accident proof. However, sufficient data has been collected to show that there have been problems that raise questions about all of the above matters. Virtually all of the spent fuel casks certified solely by DOE and recently in use have (as of September, 1987) been withdrawn due to unresolved safety questions regarding their design. In some cases, the designs of their seals were found to be insufficient to withstand a crash, while in others the issues were structural integrity or criticality (i.e., the ability to avoid an uncontrolled nuclear reaction). In almost all cases, the potentially defective casks were used for years while these problems were known to DOE. Similarly, in the last ten years, over half of the casks certified by NRC have been withdrawn or severely restricted due to safety-related problems. All of the available rail casks were found to have faulty pressure-relief valves. Most truck casks were either manufactured improperly or became misshapen during routine use. Two truck casks built up excessive interior or exterior contamination. Again, all of these were in use for extended periods before NRC took action to pull them off the road. These facts seriously challenge the assumption that the casks are as perfect as is necessary to be considered accident proof.

2.2.4 Cask Design and Testing in a Preferred Transportation System

The NWPAA clarified that all shipments to a repository must utilize NRC-certified casks. Taking the existing NRC requirements and guidelines as a starting point, the preferred system would involve the following additions or changes:

Utilize Consistent and Improved Analytical Methods

Safety, the first priority, begins before the design stage with the choice of the best analytical tools. Previous cask designs utilized a variety of techniques, ranging from highly-simplified hand calculations assuming idealized motion and materials to detailed computer simulations involving millions of calculations. The preferred level of analysis should involve simulations of equivalent validity and detail in all phases of the stress tests. Such programs should contain input variables sufficiently complete to model realistic material and fabrications defects in order to determine their safety impacts. These design tools (such as the NIKE2D puncture simulation) must be available for third party use for independent design verification. The state of Nevada should become actively involved in the design process through spot-checking the analyses of the accepted cask designs prior to fabrication.

Adopt the ALARA Principle in Cask Design

Cask designs should seek to make radiation exposure "as low as reasonably achievable" (ALARA) in routine handling and in the worst case accident. This means designing to avoid both close contact and surface (and internal) contamination of the cask. A fuel and cask cleanliness specification (versus the existing standard for removable contamination) for both routine shipments, and under accident conditions, should be included in cask licenses (or as a regulation). Other design efforts may be necessary to meet this requirement. An example is internal shock absorbers to cushion the fuel during impact.

Simplify Cask Design to Avoid Human Error in Fabrication

Existing casks involve numerous shell penetrations for valves, welding joints, multiple layers of different structural and shielding materials. These present opportunities for reversal or interchange of parts and connections that had only one correct configuration (e.g., a valve that would as easily fit backwards as forwards if installed incorrectly, would be allowed to open in transit). Preferred casks would have a single cast shell without penetrations or internal welds, with all moveable parts residing in a replaceable lid and a fuel basket that seals the fuel away from the inside of the cask body. Other ways to avoid human error in manufacturing and handling may also be appropriate, such as different valve sizes to avoid mistakes in replacement or connection.

Toughen Stress Tests for Both Casks and Fuel

Past studies indicate that more severe stresses may occur in transit than are simulated in the present series of tests. Following are needed improvements in testing:

- The fire and puncture tests should be reversed, especially if lead shielding is involved. Puncture is easier when a cask is heated (as in a fire), although present rules assume puncture of a cold cask, followed by a fire.
- The fire test is not long or hot enough. A 1982 gasoline truck fire met or exceeded the present test condition with a single tanker trailer. Now that double tankers are allowed for both gasoline and other extremely flammable materials, they will burn at much higher temperatures than the current testing requirement. Similarly, an accident involving a stationary fuel storage facility near a railroad indicates that a high temperature fire could endure past the present 30-minute test. The fire test used for airborne plutonium casks (one hour fire at approximate 2200 degrees F) should be applied to nuclear waste casks. Depending upon the configuration of the improved fire test, a torch test may also be necessary to simulate a locally intense heat source, such as a leaking propane or ethylene oxide container on fire, impinging on a vulnerable point such as the cask seal.
- A crush test beyond that presently planned is needed. A 1980 study found that a crush environment exceeding the force involved in the

30-foot drop test could exist in a rail accident. One possible scenario not yet investigated involves collision between two 100-ton casks in a multiple-cask shipment. DOE plans shipments from the MRS that would entail 5 to 10 rail casks on a single train.

- Impact and thermal tests of aged fuel are needed to assess leakage potential of previously undamaged fuel and an assembly having pinholes or hairline cracks which is inside the cask.

Remotely Monitor the Internal Conditions of the Cask

Past errors in fuel loading and cask draining could have been detected almost immediately with a transponder inside the cask. It would radio data on temperature, pressure, several types of radiation, and the concentrations of moisture, helium and oxygen. Such a device would also be helpful to cask receivers, to emergency personnel trying to assess cask leakage in an accident, and as a beacon to find a lost or buried cask.

Translate Generic Cask License Changes into Federal Regulations

Some broad changes to existing cask licenses should become regulations, which if violated, carry greater penalties than failure to adhere to a license. For example, all NRC-certified commercial fuel casks must have inert gas atmospheres, but this change which was adopted in 1984 appears only in the licenses for those existing containers. It is more appropriate as a regulation. Codifying such common necessities may also simplify enforcement by reducing the complexity of the license and variations among licenses.

Eliminate Unnecessary Cask Equipment

Pressure relief valves have created maintenance problems but were designed to handle stresses that may have exceeded those in the stress tests. Such contradictions are not appropriate in future casks. Either the stress tests must be made more severe, or the valves excluded. The number of other valves (used in draining, filling, etc.) should be minimized, and mechanical cooling equipment (used in the past only to reduce cooldown time at the receiving point) should be avoided. The extended storage of fuel destined for a repository may make some of these items moot due to the older fuel's much lower thermal output.

Incorporate Fail-Safe Controls in Cask Design

Valves have occasionally come open in transit, and bolts on lids and impact limiters have been found loose or missing, upon arrival. Proper design would make successful loading of the cask onto the trailer impossible unless all such equipment were properly positioned and secured.

Integrate Vehicle and Cask

QA/QC procedures covering both pieces of equipment should be part of an expanded container license to guarantee inspection and oversight by one agency in a coordinated and documented manner. Regulatory contradictions

(such as cask tiedowns which are stronger at the cask connection than at the trailer bed) could also then be avoided.

On-Board Fire-Suppression System

Since some fires can last long enough to challenge almost any container, an extra level of protection at low cost would involve dispersal of a heat-activated foam fire retardant around the cask transporter and over the cask surface. Such a system would protect the valuable cask and reduce downtime for inspection/repair even if the fire were not severe enough to cause leakage.

Perform Full-Scale Cask Testing

To ensure that a high level of compliance has been maintained, one cask out of 40 (approximately) should be chosen at random and independently tested to failure. The results should be made public.

Directly Observe Manufacturing and Materials Qualifications

Past inspections of fabrication have focused on the paper trail created by production records and not on the hardware itself. Maintenance of on-site inspectors would instead allow ongoing visual and other examinations while the cask is assembled. Several types of errors previously found only after years of use could be detected and corrected before the cask is released by the manufacturer.

Mandate Individual Federal Certification of Each Cask

Each container should receive, after a full final inspection, a certificate that indicates the cask has been checked for a specified set of items by a federal inspector and released for unlimited use. This effort would focus responsibility for cask compliance at a specific point in time on a single individual, instead of the existing dispersal among shippers, fabricators and a distant NRC vendor inspection staff.

Create Watchdog Agency for Cask Design, Production and Maintenance

Since the three previous aspects of cask safety (immediately above) are so closely intertwined, a separate squad of well-trained independent inspectors is needed to perform spot checks at all stages in the cask life-cycle. Utilizing private, non-federal personnel would add credibility to the findings since there would be no repercussions regardless of the conclusions. Personnel might be selected from a professional society such as the American Society of Mechanical Engineers (ASME) or American Society for Quality Control (ASQC).

Fuel Assembly/Cask/Vehicle Database

So many characteristics of the equipment and fuel are safety-related that oversight can become an overwhelming burden of details and schedules, especially when there might be over 200 casks in transit at one time. The likely result is error and incomplete inspection. Each fuel assembly has a serial number and a history with the reactor operator that could be used by a

tracking system to verify the legitimacy of the assembly's transfer to a repository and any vulnerabilities due to poor fabrication or damage in the reactor. Each cask and transporter could be similarly supervised by tracking any fabrication or operational problems, and fulfillment of regular maintenance work. Such an effort would also aid dispatching when equipment is pulled out of service and information on replacement availability is needed.

2.2.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Cask Design and Testing	Assess adequacy of cask design and testing standards	17 (1986)
	Develop revised cask design and testing standards, if necessary	15 (1988)
	Develop cask QA/QC program	14 (1989)
	Develop appropriate design analysis tools	14 (1989)
	Design casks	13 (1990)
	Design & implement cask data base	11 (1992)
	Submit for NRC certification	11 (1992)
	Fabricate prototype	10 (1993)
	Perform full-scale testing	9 (1994)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.3 MODAL MIX

The choice of a largely highway or largely rail modal mix would result in significantly different impacts on state, Tribal and local governments. Modal mix choices are dependent on a wide range of interrelated issues such as cask design, routing, emergency preparedness, infrastructure, inspection and enforcement programs, and the overall radiological and non-radiological risk of the transportation system. Furthermore, each mode has unique operating characteristics.

There are significant advantages to focusing on only one mode. Redundant, equal capacity facilities for each mode could be eliminated in favor of a highly efficient, uni-modal complex. Such a solution would have the benefits of fewer carriers, easier carrier selection, fewer contracts, and easier shipment management. However, use of a single mode may be disadvantageous due to "captive" shipper problems and vulnerability to natural or intentional disruption.

The overriding goal is to find the best possible modal choice for shipments from each point of origin (i.e., a reactor site) to a repository. It is highly unlikely that a single solution will emerge. For example, if rail were the only mode selected, access spurs would have to be built for the reactors that are not now served by rail lines. This would involve major capital investment and the spurs might pass through heavily populated areas.

Factors motivating combinations of modes include the fact that many of the reactor sites are not rail served or that the original connections have been abandoned; almost all of the sites are situated on water; in many cases the access roads are secondary in nature; and many of the plants are not near to an interstate or major state highway. The best mode for retrieving the waste from the reactor site may not be best for the long distance leg of the shipment. Considerations working against combination movements include container incompatibility between modes, the dangers of transfer, the sabotage vulnerability of any transfer operation, and the cost of creating such a facility, even if it is a large crane rented temporarily for such use.

2.3.1 Modal Mix Assessment Factors

The assessment of modal mix must be made from an overall system perspective. Performance must be optimized so that the total system functions in the best manner possible. Impacts associated with modal choice would be analyzed via the specification of alternative modal characteristics, reflecting various assumptions concerning these characteristics, which are then used in the transportation analysis framework discussed previously. The determination of the preferred modal mix and the subsequent management of the transportation system, once it is implemented, requires a comprehensive network analysis

which considers information from the following areas:

- Volume (total number of casks, by size and weight, and expected date of shipment; all of which are critical for determining the relevance of various modal options),
- The risks associated with each shipment option (accident and incident rates, by mode and overall, for the best possible routes; resulting population exposure levels and consequence distributions; fatalities; injuries; latent diseases; etc.),
- Operating restrictions (the extent to which the planned option requires extraordinary treatment and impacts beyond normal operations),
- Cost (per shipment and total; operating, maintenance, and capital; to whom and how paid; timing of accrual),
- Site access (technical, operational, and economic feasibility),
- Shipment time (elapsed, from the perspective of radiation exposure and vulnerability to sabotage/terrorism as well as cost and resource requirements),
- Weather sensitivity (the effects of inclement conditions; expected delays; extraordinary resource commitments required to continue shipment under adverse weather conditions and/or place shipments in temporary storage pending weather condition improvement; importance of weather as a factor in scheduling shipments),
- Security and safety (volume and types of personnel and other resources required to protect the shipment; the incremental resources required to minimize the likelihood of accidents/incidents; the complexity of special arrangements required to provide secured areas for storage during unforeseen or planned stoppages), and
- Carrier qualifications (safety record; personnel training and qualifications; maintenance practices; vehicle monitoring capabilities; financial condition; operating authority).

The interrelationship between modal mix, routing and shipment volumes as key decision variables in the preferred transportation system must be recognized. It is expected that a different preferred modal mix may emerge for each set of defined routing options and shipment volume considered.

2.3.2 Truck/Rail Shipment Options

Changes in vehicle size and weight limits, and development of a new generation of casks suggest that shipment volume may increase. This would result in a change in the number of required shipments and a corresponding change in the structure of risks and costs. The use of overweight trucks may be of

interest to the DOE because of their greater productivity. As a result, truck shipment size might increase from the current legal weight limit which can accommodate one pressurized water reactor (PWR) or two boiling water reactor (BWR) spent fuel assemblies to an overweight shipment which can accommodate three PWR and seven BWR assemblies, respectively. Possible truck shipment configurations include the use of either single or double trailers, traveling either alone or in a convoy. Rail shipment options include regular, dedicated and special trains, and "hefty" casks.

Issues relating to various truck/rail shipment options focus on such items as the deterioration of transportation infrastructure, and the probability, frequency and severity of accidents. Central to this debate is the likely scenario that fewer shipments may result in fewer incidents or accidents yet each such event may lead to more catastrophic results because of the increased volume of dangerous cargo which might be released.

2.3.3 Rail Service Options

Three rail service options are available for shipment of the high-level radioactive wastes to Yucca Mountain:

- Regularly scheduled trains: shipment of cars containing spent fuel via regularly scheduled, general merchandise freight trains. The cars would be transferred from one train to another at yards.
- Dedicated (unit) trains: cars would be carried in trainload lots from a single origin (one per trip) to the repository, much as container, coal, grain, and other unit trains operate today. No significant additional operating restrictions would be imposed.
- Special trains: cars would be carried in trainload lots from a single origin (one per trip) to the repository, as with the dedicated (unit) trains described above. However, special operating restrictions would be imposed. No freight other than the spent fuel or other radioactive waste is carried in the special train; special trains would not travel faster than 35 MPH (56 km/hr); and when a special train passes or is passed by another train, one of two would come to a complete stop while the other passes at a speed not faster than 56 km/hr. [OCRWM/OSTI (1986),A-84].

Regularly scheduled trains are a feasible solution for rail. In a worst case scenario where only one repository is ever opened, the maximum influx of waste would reach 6,400 metric tons per year (7055 short tons), assuming the acceptance schedule remains unchanged [OCRWM/NTIS (1986);50]. If 100% rail were used, with "100-ton casks", which are capable of carrying 26.25 tons (23.8 metric tons) [NRC (1986),10], this would mean a traffic level of about 270 cars per year or about 5 per week. It is not uncommon for shipments ten times this size (e.g., 7 cars per day) to be handled by regularly scheduled freight trains. Sabotage vulnerability might actually be reduced since the cask-bearing cars would be intermingled with other loads. They would probably receive

special treatment in classification yards, as high-and-wide cars currently do, being set out on specially designated sidings for storage while awaiting connecting trains. The major drawbacks from carrying the cars this way would be the logistics of making sure escorts were always present, the greater difficulty in car tracing and the need to train wide variety of people about how to handle the cars.

Dedicated trains would be attractive because of their simplicity, traceability, ease of crewing and escorting, and their minor impact on railroad operations outside train dispatching. For the most part, they could be treated in much the same way that other unit trains are handled. Exceptions would be the need for 1) special servicing and the designation of locations where such servicing could be performed, 2) specialized maintenance training for the personnel assigned to such facilities, and 3) special tracks and facilities at such locations set aside for servicing the trains. Also with dedicated trains, fewer shipments might result in fewer incidents, even though each event would have the potential for a more catastrophic result.

Special trains offer the same advantages as dedicated trains, but they have provisions for greater safety as well. The special operating restrictions are designed to reduce the probability that an accident would result in an incident (i.e., failure of the cask). Lower train speeds (35 MPH) and lower passing speeds (one train standing still) should both reduce the severity of any impacts that would occur during an accident.

The use of special trains has been outlined several times by DOE and used in the past, Van Hoomissen, Wallis and Miles, but the most recent description of transportation operations omits their consideration entirely [Stoller/ORNL (1988)]. This is an acceptable outcome because the operating restrictions would probably produce only minor benefits in exchange for losses in operating efficiency and flexibility. It is questionable whether the operating restrictions will reduce the probability that a cask will be breached as a result of an accident. Cask failure is more likely to be sensitive to sabotage, given the results of cask tests performed to date. The most profound effect of the operating restrictions would be to impede carrier operations. This would be especially true for the terminating carrier because it would have the greatest volumes.

2.3.4 Truck Shipment Options

In comparison with rail shipment options, truck alternatives are relatively basic. This is because of their carrying capacity; truck shipments to a repository would be fully dedicated. Thus, dedicated truck service and regular truck service are effectively the same concept. As discussed earlier, DOE is considering the use of overweight trucks to increase shipment productivity. Issues relating to overweight trucks and heavy trains focus on such items as the deterioration of transportation infrastructure, and the probability, frequency and severity of accidents. Central to this debate is the likely scenario that fewer shipments may result in fewer incidents/accidents but that each such

event may lead to more catastrophic results because of the increased volume of dangerous cargo. As with rail, sabotage and terrorism, servicing, and vehicle stoppage are important safety-related issues.

A more restrictive version of the truck convoy would be the use of multiple trailers attached to a single tractor. The relative safety of "singles" and "doubles" has evoked a rather heated debate in the trucking industry, although a close inspection of trailer configuration studies shows that each design has its own inherent safety problems. In the case of doubles, there is a strong rollover tendency of the second trailer due to rearward amplification. It appears that the design of coupling devices may hold the key to improved safety performance of doubles operation.

2.3.5 Interference with Normal Operations

The mere existence of nuclear waste shipments, whether in dedicated trains or not, will have an impact on day-to-day operations which permeates the entire railroad. For example:

- Shipment size restrictions may affect blocking patterns, yard operating plans, and classification track designations. For example, if HLW cars are handled in regularly scheduled trains, and the number that can be positioned side-by-side is limited, then more than one block may be needed for a single destination. It may be necessary to divide the HLW cars into groups of permissible size (e.g., single cars).
- Operating rules may be affected if dedicated trains are required to stop at all railroad crossings, with highways or other railroads. If DOE is unsuccessful in its attempt to have dedicated trains treated as standard unit trains, certain operating restrictions may be imposed. One possibility is that the trains be required to stop at the locations specified.
- Advance consists may be required to ensure that no problems exist with the track over which a waste-carrying train is about to pass. The term "advance consist" refers to the first of two trains which travel as a unit. In the case of spent fuel shipments, the purpose of the lead train would be to ensure that the railroad is safe for the second train which is actually carrying the casks. Broken rails can be detected in this manner, as well as (railroad) switch settings and signal operating conditions (e.g., signals that are not working). The practice of dispatching such advance consists is required when Presidents travel by train.
- Crew requirements may be affected (there may be more crew members on waste-carrying trains) as well as their training (e.g., special training in emergency response and incident management).

- Interchange requirements and procedures may need modification so that waste cars and their location and condition are more tightly controlled. Special procedures may be needed for dealing with waste cars that are found to have defects upon interchange inspection.
- Special car and cask inspection procedures may be needed and the inspection crews may need to have special training.
- A caboose may be necessary to carry the escort party.
- Special "supply crews" may be needed to quickly replace road crews whose hours of service have expired.
- It will not be possible to leave trains carrying nuclear waste unattended. Presently, trains are sometimes left unattended when there is no where for them to go (e.g., no room for them in the yard).
- There may be extra restrictions that determine who is allowed to bid for jobs involving nuclear waste. For example, if a train is carrying wastes, the engineer, conductor, etc., may have to meet certain training criteria to be qualified for the job.
- Special locomotive accommodations may be required for the escort personnel and their equipment, and any special communications equipment used to keep track of train and car location and status. Engine cabs are often designed for two people. If the escort personnel ride in the cab, there may not be room unless two or more locomotives are involved and they can use the cab of one of the trailing locomotives.
- Special foul weather plans may be needed to control the dispatching of trains and the operation of yards during inclement weather conditions. For example, there may be days when trains cannot be dispatched because the weather may not permit the train to reach its destination yard.
- Safety training programs may have to be modified to qualify employees for the special requirements of nuclear waste shipments.

2.3.6 Preferred Transportation System Modal Mix

Decisions regarding modal mix, routing and shipment volumes must focus on safety as the first priority and must be made from an overall system perspective. Risks need to be considered when costs are evaluated. Costs need to be examined from the perspective of all affected parties. Technical considerations need to include the potential for human error. The preferred transportation system calls for performance equal to that of the best option presently available on an origin-by-origin basis. This could be rail in some cases, truck in others, or combinations of these, with or without barge. The ideal system would combine the best performance of each individual mode. For instance,

the objective might be to combine short truck travel times with low rail accident/incident rates and routings which typically avoid the densest parts of urban areas. The lower weather dependence of rail united with the stoppage flexibility of truck might be considered. On the security of rail mated with the shipment tracing capabilities of trucks might become the objective. Ultimately, the design will depend on the weighting of the decision criteria. The goal is to strive to design the safest, most efficient system possible.

The preferred transportation design is not static. It will be important to reevaluate the optimal mix and each component within the context of the decision criteria. Experience has shown for other commodities that what is best initially may not be the best over the long-term. The number of options in use typically decreases over time as the best options are identified and the suboptimal ones are weeded out. Technological improvements also tend to alter the modal balance in terms of safety, cost, or other factors. Carrier performance may improve or decline, again motivating a need to reassess the modal mix in use. New rail lines, highways or other facilities may be built which shift the modal preferences because more attractive routes become available. Finally, events may occur which influence the weighting (priority) of the decision criteria as they relate to individual components or to the overall system.

To define the preferred transportation mode may require the conduct of research which analyzes the specific, separable aspects of the modal question. Results from the analyses would serve as inputs to the network model, as well as form a basis for policy decision-making. For instance it is expected that:

- cask and car designs will fall into a fairly well defined range of options;
- the routes employed will use existing rail lines, no major new line segments will be built;
- some form of automatic, computerized shipment tracking will be provided; and
- the security and safeguard measures already outlined by federal regulations will represent a starting point for developing a refined set of guidelines, custom-tailored to the needs of the shipment campaign.

However, the preferred rail configuration awaits decisions such as:

- the designation of secured areas;
- the design of the communications system that will be used to monitor shipment progress;
- operating procedures for sabotage protection;
- details of the operating plan (e.g., movement of cars through classification yards if they are carried by regularly scheduled trains);
- stoppage procedures to be followed en-route (e.g., during brake inspections);
- notification procedures to be followed.

Because of the limited experience to date with cask shipments via some modes, such as truck, and via all modes in the quantities to be shipped to a reposi-

ory, the performance of each mode is not actually known. Assumptions will have to be made on the basis of limited past performance or pilot tests to determine the risk and performance characteristics of each mode. Again, carrier performance has a great bearing on modal performance because of the human element involved. For example, rail is not an automated system with absolutely repeatable performance. Its performance is dependent on the technical competency and dedication of the people who make it function.

One area for research is review of the road vs. rail controversy. The interest in this controversy arises from a presumed trade-off between lower accident rates but more severe accidents (as measured by the occurrence of fire and the length of time that the fire remains uncontrolled) experienced by rail transport vs. the higher accident rate, but less severe accident experience of road transport. Furthermore, the health effects of exposure to the gamma and neutron dose field around truck versus rail casks needs consideration in the context of potential routes. A better understanding and policy decisions regarding latent health affects are necessary.

Only limited information is presently available on most of the decision criteria (shipment time, route selection, etc.). None of the topics can be considered adequately researched. But the ones about which the least is known are site access restrictions, the weather sensitivity of various modes (in the context of shipping nuclear waste), and the requirements of the various modes for maximizing security and safety.

A key needed analysis is a detailed comparison of the special/dedicated train vs. regular train options. Special, or dedicated, trains are smaller, consisting only of cars with nuclear wastes. They travel at slower speeds and the tracking of waste shipments is simplified. In this regard, risks of delays at switching yards is thought to be minimized. In contrast with regular trains, however, slower speeds of special/dedicated trains may result in increased radiation exposure to populations and environments located along the routes. Again, modal analysis/selection needs to occur in the context of all of the key criteria rather than independently. In this case route selection could reduce exposure rates from dedicated trains. Further, safeguard questions exist on the implications for the use of special/dedicated trains which are easily recognized. The implications of either transportation strategy could be analyzed via the network model.

Access restrictions for the reactor sites must be better understood because they bound the relative role which each mode can play in a cost effective manner. For example, if all of the reactor sites can be reached by barge, then barge should be considered a viable option for at least the first leg of every trip. The same is true for rail and truck.

Additional information about the weather sensitivity of the various modes is needed in order to determine accurately the incremental risks, costs, resource requirements and logistics problems which would accompany various levels of use of each of the modes. Weather is clearly a factor for truck shipments. Highways, especially on the plains and in mountainous regions become impassable under heavy snow conditions. If the volumes moving by truck are small, this may be a detrimental factor because the cost of safe haven arrangements

may be high on a per shipment basis. However, if these costs are spread over a much larger volume of shipments, the truck option may be far more cost effective and its relative attractiveness improved.

Much more information is needed about security and safety because to date the waste shipments have been infrequent. Regardless of what modes are eventually chosen, the shipment of waste to a repository will be far more routine and frequent than it has been in the past. No prior experience exists for correct safety and security provisions for such large numbers of shipments to a single destination. There may be economies of scale. On the other hand, the costs may rise disproportionately to the volumes involved. Hence there is a need to explore the options available and their requisite costs.

2.3.7 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Modal Mix/Truck and Rail Shipment Options	Develop modal mix assessment factors	17 (1986)
	Conduct technical assessment of truck shipment options	15 (1988)
	Conduct technical assessment of rail shipment options	15 (1988)
	Conduct technical assessment of the comparative risks of highway and rail, reactor access, weather sensitivity of modes and security and safeguards	14 (1989)
	Select tentative modal mix	13 (1990)
	Finalize modal mix	8 (1995)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.4 ROUTING

As with transportation modes, the choice of routes is fundamental to the design of the preferred transportation system. Routing decisions will determine the populations most impacted by the transportation system and will have important implications for emergency preparedness, infrastructure and the overall radiological and non-radiological risk of the transportation system. The decision to use one route or several routes will have important advantages and disadvantages to state, Tribal and local governments. The source(s) of the routing decisions -- the State of Nevada, some multi-state organizations, the DOE, and/or the carriers -- will also have important implications.

The issue of equity is an important factor. At the local level, routing exclusively along a particular corridor implies that a select few communities are absorbing the total transport risk associated with nuclear waste shipments. Beyond the geographical equity issue are the distribution of impacts across demographic segments, including Tribes, residential areas, commercial areas, and places of public gathering. Routing analyses must include consideration of impacts upon all affected jurisdictions.

2.4.1 Regulation of Highway Routing

Federal regulations should designate a limited number of principal highway routes. States should follow with regulations governing access to the principal routes. National routes must be selected by the federal government in order to avoid parochial interests, to avoid discontinuity of routes, to ensure the best use of limited emergency response resources, and to evaluate infrastructure needs. With the adoption of a limited number of national routes, state, Tribal and local governments will be able to assess their emergency response capabilities and needs, and allocate their resources accordingly. Without identification of national routes, state, Tribal and local governments will be required to have emergency response capabilities along all routes. Similarly, with the adoption of national routes, state, Tribal and local governments will be able to assess and plan for infrastructure needs.

To attain the safety goal for the preferred regulatory structure, route selection must be based on a technically-sound comparative risk assessment. The assessment must address critical safety concerns, such as the ability of emergency responders to access the scene of an incident or accident. During rush hours, emergency responders cannot readily access an elevated highway that lacks an emergency shoulder. If safety concerns are not addressed, neither the states nor the public at-large will have confidence in the system.

As part of the national routing regulations, carriers should be required to report the route which will be taken and which actually is taken, including diversions for emergency or weather purposes and rest stops. The federal government should then be required to provide monthly routing reports to state emergency response authorities. If the federal government decides to utilize and provide state access to a real-time tracking system, this requirement would become moot.

Once national routes are designated, the states should involve Tribal and local governments in the adoption of intrastate routing regulations that enable carriers to access the national routes as well as to provide for pick-ups and deliveries. Tribes and local governments should propose designated routes within their jurisdictions. Because intrastate routes must dovetail with the national routes, room for alternatives to settle disputes among the jurisdictions is limited. Where there are conflicts, a state can mediate and/or arbitrate.

2.4.2 Regulation of Rail Routing

Routing regulations for railroads should also be adopted by the federal government after a technically-sound comparative risk assessment is conducted. There is a question as to which federal agency has the authority to designate rail routes because trackage rights may be involved. To answer this question, further research is required. Rail routing alternatives are very limited compared with those for highway. Therefore, the methods for attaining objectives differ. Rather than comparing the safety levels between or among routes, a rail risk assessment must identify and prioritize the factors that will minimize the potential for consequences of radiological incidents or accidents. While avoiding heavily populated areas is an obvious factor, there may be other operational factors that can affect a routing decision, such as requiring railroads to transfer the shipment to another carrier in order to ship it via the most direct route, or requiring dedicated trains. Once the federal government adopts national routing regulations, state and Tribal regulations should be permitted to address their safety and other issues. State and Tribal regulations, of course, cannot unreasonably burden the overall system design.

2.4.3 Preferred Transportation System Routing Criteria

Routing decisions in the preferred transportation system should be based upon the following criteria:

- Minimize population-at-risk, perhaps by selecting wider corridors (up to 10 miles) than used in federal studies.
- Minimize exposure of vulnerable sites and facilities along alternative routes.
- Minimize the use of high traffic hazard areas which might increase non-radiological as well as radiological accident risks.
- Select routes which provide emergency response teams rapid access to potential accidents.

In some cases, these choices present trade-offs. For example, emergency response may be better in urban areas, yet this is the area of greater population density; hence the choice might increase risk.

Evaluation of rail shipping versus truck shipping may be more difficult. The federal government has yet to promulgate rail-routing regulations. State, Tribal and local governments may have to develop rail routing regulations which reduce risks in their jurisdictions. Thus the identification of impacts associated with alternative rail routes would serve as a basis for the state, Tribal or local governments' assertion of regulations. Another difficulty in the evaluation is that fewer rail route alternatives exist. This consideration may have direct relevance for the choice of modes. If risks or costs associated with the few available rail alternatives are found to be higher than potential alternatives for truck transport, then rail transport may have to be eliminated from any proposed mode-route consideration. Finally, in contrast to the public highway system, rail lines are generally privately owned.

A wide range of considerations are relevant for assessing the implications of the use of rail transport. For example, different patterns of track ownership and operating rights can give rise to risks and costs associated with circuitous routing, delays and transfers at rail yards. Railroads normally route single-line (single railroad) shipments via the lowest cost route possible, unless contract conditions (e.g., required delivery times) warrant otherwise. When two or more railroads are involved, the originating carrier typically "long-hauls" the shipment, keeping it on its own lines as long as possible, to maximize the percent of revenue received. Even though a shorter time or lower risk route might be available, the railroad is not likely to use it if it means giving the shipment (and the associated revenue) to another railroad earlier or if more railroads would be involved. Clearly these practices are not necessarily those that would result in the best possible routes for waste shipments to a repository.

There are several related issues concerning rail routing which are important:

- Interchange points: This is the designation of locations where cars are delivered from one railroad to another. It might be advantageous to open interchange points which are presently closed (not in use) to expedite the waste shipments.
- Interactions with other dangerous goods: Certain routes might be better than others because of their limited contact with other hazardous materials shipments. Ideally, it would be best to use routes that avoid contact with other dangerous goods altogether so that the probability of a compound event is eliminated.
- Populated areas: Some routes involve greater exposure to populated areas than others. Routing restrictions can help minimize the population exposed. The trade-off is that these routes might have higher expected accident rates because the track may be in poorer condition, the service may be less frequent, or the shipment time may be longer because the speeds are lower.
- Track and roadbed maintenance: These activities are the responsibility of the private companies. State, Tribal and local governments may, therefore, have direct interest in the development, in conjunction with

the railroads, of maintenance requirements for lines used for transporting wastes to the repository. This then raises the issue of funding for such activities.

Assessment of the implications of different routing alternatives. This approach for routing analysis applies both to the state in which the repository is located and (perhaps at a reduced level of detail) to corridor states. A nationwide analysis would focus attention on the heightened risks imposed on corridor states from choosing a repository which is so remote from the sources which generate the wastes.

2.4.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Routing	Develop routing criteria	19 (1984)
	Develop rout-specific analysis capability	17 (1986)
	Analyze alternative routes	15 (1988)
	Select tentative route(s)	13 (1990)
	Finalize route selection	8 (1995)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.5 EQUIPMENT AND VEHICLE STANDARDS

2.5.1 Regulation of Overweight/Oversize Shipments

Truck Shipments

The regulation of overweight and oversize trucks has traditionally been within the purview of state government. Within the context of a preferred regulatory system for the transportation of nuclear waste, overweight trucks should continue to be regulated by state governments. Where states regulate overweight trucks, local governments should be permitted to regulate in a manner that does not conflict with the state regulation (i.e., compliance with the local regulation will not trigger an enforcement action under the state regulation).

State, Tribal and local governments have principal responsibility for all roads and highways within their jurisdiction, although the federal government may provide a significant contribution in the form of aid. Of the total highway mileage in the U.S., 70 percent consists of highways that have been designed, constructed, reconstructed and maintained without federal aid. Within the context of the total highway system, state and local governments pay approximately one-half of all highway expenditures in the U.S.; a substantial investment. State and local governments must be able to continue to protect their investment, for they are the most knowledgeable about the roads within their jurisdictions and they bear the financial burden for maintaining the roads. Establishing a national, uniform overweight truck system for one commodity ignores the breadth of the problem facing state, Tribal and local governments and would establish a system that would argue in favor of less control of other commodities by these local governments. Perhaps if the federally-designed transportation system calls for overweight shipping, the equitable solution would be for the repository program budget to compensate the affected states for the routes.

Another alternative is to allow states to continue to regulate overweight truck shipments, but have the federal government define the term "divisibility" to exclude multi-element casks. The divisibility of the load is the crux of the matter, so defining the term at the federal level is a back-door method for preempting state governments in this area. Moreover, defining divisibility to exclude multi-element casks would provide DOE with unrestrained authority to continue to develop larger, overweight casks without considering the effects on state, Tribal and local governments.

Railroad Shipments

Overweight shipments will have a direct negative impact on railroad tracks. Increased weight and speed increase the wear and tear on the track. As the quality of the track declines, the potential for an accident increases. Consequently, the State of Nevada, as well as other governments, should assume participation in regulating overweight railroad shipments. Although railroad track is owned by the railroad companies, it is subject to regulation. The

question of whether state governments have been preempted from regulating this area requires additional research.

2.5.2 Regulation of Placards

The federal government should adopt regulations establishing a placarding system that distinguishes between the different types of radioactive materials. Placards, diamond-shaped posters displayed on the outside of a transport vehicle, identify the contents of the transport vehicle by hazard class. As part of a hazard communication system, placards aid emergency responders in assessing the problem to determine appropriate action to be taken. Placards must, at a minimum, distinguish between new fuel and spent fuel since their hazards are dramatically different. Because this is an area where uniformity is critical, federal regulations should preempt all other regulation. The preemption for hazard communication purposes should not, however, be confused with preemption for other purposes (e.g. permits).

2.5.3 Other Considerations

In an effort to respond to cask and vehicle design considerations while maintaining weight limitations, several alternative vehicle designs may evolve. Under consideration at this time are designs which remove what may be nonessential items in terms of vehicle operating performance in order to reduce the weight of the basic operating system in favor of boosting cask carrying capacity. For example, elimination of the air conditioning system, if considered nonessential, would reduce vehicle weight, perhaps enough so that a larger cask could be placed on the truck while maintaining legal weight. Again, alternatives must be considered in the context of all components of the system. In this case, driver comfort could preclude this alternative. Human factors considerations may prevail in areas where they present trade-offs with respect to driver performance. Equipment/vehicle standards must consider the effects of noise, temperature, vibration, cab configuration, braking systems, freedom of visibility, etc. on driver performance.

Much new research will be needed to provide conclusive data that can be used in making decisions regarding appropriate equipment and vehicles. Investigations will require that initial modal decisions be proposed in order that the related equipment/vehicles standards can be proposed and analyzed against their criteria and objectives for that component of the system and within the context of the overall system.

2.5.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Equipment and Vehicle Standards	Identify potential vehicle/equipment improvements	19 (1984)
	Conduct technical studies of potential vehicle/equipment improvements	17 (1986)
	Conduct comprehensive assessment of overweight highway and "hefty" rail shipments	17 (1986)
	Develop vehicle/equipment standards including new placarding system	16 (1987)
	Develop tentative vehicle/equipment designs	13 (1990)
	Finalize vehicle/equipment designs	8 (1995)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.6 INFRASTRUCTURE

A preferred transportation system should minimize and mitigate the impacts of repository related transportation on federal, state, Tribal and local highways and ancillary facilities. In the preferred transportation system the federal government would take necessary actions to fully compensate state, Tribal and local governments for any deterioration in the condition of infrastructure in their jurisdictions. Appendix A.4.3 "Special Transportation Infrastructure and Potential Impacts" of the First Year Yucca Mountain Socioeconomic Project report, established that the repository will have a significant impact on the highway infrastructure. It also demonstrated the need for a centralized data base within the Nevada Department of Transportation (NDOT) where the information required for the assessment will be stored. Information from Tribes and local governments should also be included in the centralized data base. Data regarding infrastructure would include support equipment, such as signals, existing facilities and potential new construction, such as highway bypasses and rail spurs. The existing road and rail systems need to be characterized in terms of their vehicle capacity, structural load carrying capacity of pavements, track and bridges, geometrics, roadside characteristics, friction, and accident records. A comprehensive view of infrastructure is necessary. For example, in the rail mode, items in addition to track and bridges that would need consideration include communications equipment, locomotives, car tracing equipment (hardware and software), signal system equipment, buildings for housing crews and escort personnel, special maintenance facilities for repairing the cars, and special storage tracks and safe-haven areas for damaged and disabled equipment. With proper characterization of the existing system and a definition of traffic to be generated by the repository, the economic and safety impact on roads and rail can be described within acceptable limits.

Because the road and rail networks and their usage are constantly changing, the present condition of the network must be established and updated periodically. Projected traffic increases and changes in traffic composition will have to be defined to periodically assess impacts on the networks during operation of the repository. These impacts would include the need for increased maintenance, rehabilitation and reconstruction of the existing system as well as the need for new facilities.

Assessing damages caused by nuclear waste shipments, and repairs necessary to adequately maintain the infrastructure resulting from the shipments will be difficult to accomplish where facilities/structures are not dedicated to the nuclear waste transportation system. Generally, the facilities will be shared with other freight and passenger vehicles. Hence, it will be difficult to ascertain what proportion, if any, of damage to the infrastructure would be accountable to the nuclear waste shipments.

It is expected that the condition of highway pavements and bridges are the most susceptible to potential damage attributable to waste shipments enroute to Yucca Mountain. It is unclear at this time if rail shipments of waste will

place excessive loads on the rail infrastructure compared to the weight of other cargo movements already occurring on the rail system.

The decisions regarding infrastructure need to be made in coordination with the volumes involved and the operating plan to be employed. Selection of the best possible option must strike a balance between shipment safety criteria (e.g., minimum likelihood of accident), the costs of obtaining such safety levels, and the relative payoff from investments in infrastructure and other places in the overall nuclear waste transportation system.

2.6.1 Economic Assessment Model

A mechanism for determining the cost of increased maintenance, rehabilitation and reconstruction of existing facilities and the construction of new facilities needs to be developed. First costs and life cycle costs in terms of current worth and equivalent uniform annual costs are of importance. Guidelines for conducting these types of cost analyses for pavements have been recently developed for the Corps of Engineers by University of Nevada, Reno, and are suggested for use as a starting point.

The initial and recurring costs that should be considered in this economic evaluation include the following:

- o Agency costs
 - initial capital cost of construction
 - future capital cost of reconstruction and rehabilitation
 - maintenance cost
 - salvage value
 - engineering and administration cost
 - traffic control cost
- o User costs
 - travel time
 - vehicle operation
 - accidents
 - discomfort
 - time delay and extra vehicle operating costs during resurfacing or major maintenance
- o Non user costs

Initial and continuing data bases need to be established to provide these cost data. Considerable development work needs to be performed to more adequately define salvage value, user costs and non-user costs. The economic assessment must be performed by a consulting engineering firm, a research facility or a university in cooperation with county and state agencies. Some of the data needed can be obtained from NDOT.

2.6.2 Criteria for Infrastructure Decision Making

The infrastructure decision-making process should consider accident prevention, capital and maintenance costs, operating restrictions, ease of site access, shipment time, weather sensitivity, security and safety, and the impact on other traffic operations. All infrastructure used for nuclear waste shipments should produce risk levels (primarily expected accident rates) at or below that of all other candidate modes. Ideally, the level of risk prevention provided throughout the network should be uniform for all modal segments links being used to carry nuclear waste. The same logic would pertain to all other infrastructure investments.

2.6.3 Highway Infrastructure Needs

The impact that a repository at Yucca Mountain will have on the infrastructure of Nevada's highways requires the evaluation of several components such as routing, capacity of routes, condition of pavements, condition of bridges, safety of routes and cost. A capacity analysis of the routes that will be used to transport waste to the repository using an estimated traffic volume generated by the repository is needed to ensure that the level of service of the highways is adequate or to determine the need for widening or for the construction of new facilities. The condition of pavements and bridges must be established to determine the need for maintenance, rehabilitation or reconstruction. The cost of increased maintenance, rehabilitation and reconstruction of the existing facilities as well as the construction of new facilities needs to be established.

Capacity of Routes

A capacity analysis of the affected highways must be performed to determine the adequacy of the network and to decide if new facilities are required. Projected traffic volume generated by the repository should be used in the analysis. The capacity of a highway is a measure of its ability to accommodate traffic and is expressed as the number of vehicles that can pass a given point in a certain period of time at a given speed. The capacity is affected by a number of factors such as width and number of lanes, width of median and shoulder, one or two-way traffic, access control, vehicular composition (cars, trucks, etc.), horizontal and vertical alignments and design speeds.

Capacity analyses are performed for two general categories of facilities: (1) uninterrupted flow facilities, (those that include two-lane highways, freeways and other multi-lane highways); and (2) interrupted flow facilities, (those that have traffic control devices that cause periodic interruptions of traffic flow).

The Highway Capacity Manual, published by the Federal Highway Administration is the authoritative guide for the performance of highway capacity analysis. The manual reflects over 50 years of comprehensive research by a number of research agencies. The procedures described in the manual are

based on simple graphs or tables for specific standard conditions which are adjusted for prevailing conditions different from those specified. To perform the capacity analysis on the identified routes, it will be necessary to obtain data regarding traffic volume for the peak hour or any other hour of interest, traffic characteristics, and roadway characteristics.

Condition of Pavements

Nevada's 6,000 miles of road are constructed primarily with asphalt (flexible) pavements, although roughly 15% of the roads are concrete (rigid) pavements, used predominantly for high volume urban traffic. A thorough analyses of the impact of the repository on pavements would require detailed data on layer thicknesses and materials, subgrade material use, traffic loading history, drainage structures, and physical and geometric features. These factors contribute to the pavement wear cycle. Standards for evaluating pavement condition include the following indicators: (1) serviceability, (2) ride, (3) rut depth, (4) cracking, (5) patching, (6) bleeding, and (7) raveling. In general, the extended presence of items (3)-(7) reflects a road which has noticeably deteriorated and which may threaten safe transport. Depending on the scale of the problem, either maintenance, overlay or total reconstruction may be warranted.

Partial information on the condition of pavements on the highway routes in the State of Nevada is available from State and local agencies, but some data such as structural capacity, geometrics, roadside characteristics and drainage conditions may not be readily available for all areas considered for routing. The existing pavement information sources include:

- City of Las Vegas Pavement Management System,
- Clark County Pavement Management System,
- Nevada Department of Transportation Pavement Management System, and
- Plans and Specifications for the City of Las Vegas, Clark County and the Nevada Department of Transportation (NDOT).

A Pavement Management System consists of a procedure for systematically scheduling maintenance, rehabilitation and reconstruction of pavements based on maximizing benefits or minimizing cost. It will be necessary to obtain the pavement management records from local governments throughout Nevada as well as State agencies. Since it is likely that a variety of systems are used, they must be correlated to obtain a unified state-wide pavement rating system. It will also be necessary to obtain structural section plans for all routes and to conduct destructive sampling to verify structural sections and to ascertain existing pavement structural capability along routes under consideration for the waste transportation system. A drainage survey must be conducted for all routes although it may duplicate previous work in some sections.

Pavement Performance Models

Performance models for Nevada pavements must be developed and utilized to predict the time to failure given typical traffic, maintenance and rehabilitation efforts and environment. This will encompass a review of existing performance models, an analysis of pavement performance in the State of Nevada and an analysis of environmental data. Available information includes the following:

- Performance models in literature such as the Transportation Research Record, National Cooperative Highway Research Program Reports, International Conference on the Structural Design of Asphalt Pavements, and Proceedings of the Association of Asphalt Paving Technologists
- City of Las Vegas, Clark County and Nevada Department of Transportation pavement management systems
- Agency traffic records
- Agency maintenance and rehabilitation records
- Weather records from the National Oceanic and Atmospheric Administration
- Material properties from NDOT research

To develop a performance model to predict pavement failure, a representative sample of low, medium and high volume pavements can be obtained using NDOT's Pavement Management System data. Traffic, maintenance and structural records are available from local and State agencies. These data must be analyzed to find deterioration rates for existing pavements as a function of traffic, maintenance and rehabilitation, structural design and environment.

Condition of Bridges

The condition of all the bridges used to transport nuclear waste to the repository must be known. NDOT is responsible for keeping records on Nevada's bridges. The procedure for rating an existing bridge requires careful evaluation of many factors. All physical features of the bridge that have an effect on its structural integrity need to be examined, and the absolute maximum permissible load level that the structure may be subjected to must be determined.

Bridge inspection should include piers and abutments, stringers and girders, trusses, bearings and expansion joints, decks, sidewalks and railings. State and national agencies have developed inspection manuals that describe the equipment and type of information needed to evaluate the condition of bridges. The Manual for Maintenance Inspection of Bridges published by the American Association of State Highway and Transportation Officials provides for the evaluation of bridge components by specifying stress carrying capacity in terms of loads producing the design stress and a higher allowable stress due to overweight vehicles.

Information regarding the present condition of Nevada's bridges on the state funded system, can be obtained from NDOT Bridge Sufficiency Rating. Another source of information on the condition of bridges is the National Bridge Inventory published in January 1986 by the Federal Highway Administration. The inventory contains records on more than 575,000 highway bridges with spans of 20 feet or more. Relevant information includes the year the bridge was built, structure type, superstructure condition rating, substructure condition rating, estimated remaining life, structural condition rating, and proposed improvements.

"Strengthening" is defined as a method to extend the lives of bridges that are in fair to excellent condition, but that require additional load-carrying capacity to meet current truck loads. Strengthening needs such as replacing, rehabilitation, widening or other structural work should be determined from a comprehensive Bridge Management System (BMS). A BMS is a systematic approach to organizing and carrying out all the activities related to providing programs for bridges. A BMS must be developed for Nevada's bridges to compare different maintenance, rehabilitation and replacement options. Information relating to Bridge Management Systems and bridge strengthening needs can be found in literature such as Transportation Research Record and National Cooperative Highway Research Program Reports.

Reconstruction, Rehabilitation and Maintenance

The increased volume of heavy trucks transporting nuclear waste will necessitate the evaluation of roads for safety and structural capacity. Using the projected traffic data, the time of reconstruction and rehabilitation of roads and bridges could be estimated and the most cost effective combination selected.

The use of overweight trucks to transport the waste to the repository may be considered by DOE to reduce the number of shipments. The structural integrity of the highways could be threatened by relatively few passes of very heavy loads. According to the American Association of State Highway and Transportation Officials, pavement wear can be diminished by adding axles to the overweight vehicles or by increasing the spacing between axles. Consequently, a properly designed overweight truck would cause less damage. In any event, a complete structural analysis will have to be performed to ascertain whether the existing pavements and bridges will be adversely affected.

New Facilities

Using the projected traffic data, a capacity analysis will have to be performed in order to determine if the existing network could accommodate the increase of traffic volume. New roads and/or bridges may have to be built. Some facilities may have to be widened. Three of the highways that have been postulated as potential routes for high level waste shipments are Interstate 80, U.S. Highway 93 and U.S. Highway 95. They run through Las Vegas. The possibility of a new highway bypassing the city needs to be evaluated.

2.6.4 Rail Infrastructure Needs

The Federal Railroad Administration (FRA) already has extensive safety regulations for virtually every aspect of railroad construction, operation and maintenance. Most railroads expand on the FRA regulations, developing their own safety programs, in order to specify how those requirements are to be met. Examples are track construction, maintenance and inspection procedures, training programs, qualification exams and emergency response procedures. Even so, additional requirements may be required. For example, the FRA regulations only specify minimum performance levels. The special needs of the radioactive waste shipments are only superficially addressed. In addition, the radioactive waste-related FRA regulations are not tailored for a shipment campaign of the magnitude expected for the repository.

Whether these requirements should be promulgated as regulations, or handled through service contracts, is a related issue. The former ensures uniformity and sets out minimum standards, but it also limits the regulatory agency to generic, lowest common denominator descriptions of performance. Incorporating the requirements directly into a contract, on the other hand, allows much tighter and clearer requirements for performance. It takes advantage of the safety programs each carrier has developed and allows for amendment as circumstances change (e.g., as a carrier brings on-line new monitoring techniques, maintenance equipment, and training programs). Uniformity is the key drawback in that one carrier can argue that its performance requirements are more stringent than that of its counterparts.

An excellent example of how to proceed is the methodology of the New York State Public Transportation Safety Board which requires each carrier to submit a safety plan describing how it will proceed to ensure the safety of its passengers and employees. This plan must be based on general guidelines supplied by PTSB, and the carrier's idiosyncrasies of operation. A submitted plan, once accepted by PTSB, becomes legally binding and can be strictly enforced. The carrier is in essence measured against its own standards, and if they are not met, state operating assistance can be withheld. Uniformity is achieved over time by having the carriers share these documents with one another; they are a matter of public record.

At a minimum, the following information is required to make decisions on rail infrastructure:

- Volume (The total number of casks, by size and weight, and expected date of shipment are critical for determining the relevance of various infrastructure options).
- The marginal reductions in risk afforded by all possible improvements in infrastructure (e.g., decreased derailments due to changes in track class or some other measure of track quality).
- A definition/delineation of the other special equipment which will be

required to protect the shipments. Ideally, for each, this should identify the marginal increase in safety that each affords.

The railroad industry has continually argued that spent fuel shipments cause extraordinary damage to the track. They point out that the 6 and 8-axle cars typically used have capacities above 100 tons, which is the de-facto industry standard (DOE is presently contemplating the use of such cars). They further claim that studies of rail wear, and moreover track maintenance, show significant detrimental impacts from 100-ton freight cars, vis-a-vis their 80-ton counterparts, let alone cars with capacities over 100-tons.

Despite these arguments, the railroads regularly buy 100-ton equipment, even opting for cars that have articulated joints (i.e., one set of wheels, called a truck, shared by two adjacent cars), as is the case for double-stacked container cars. This is done to take advantage of the higher axle loadings that 100-ton trucks afford reduce the overall weight of the car. (i.e., eliminate one of the two trucks on each car, which saves weight, and spread the weight out over fewer axles). Clearly, rhetoric and practice are two different things. This also illustrates the fact that the issue is not just one of car capacity, but also axle loadings. A 100-ton capacity car typically weighs 30 tons empty, meaning the car's gross weight is 130 tons, and its weight per axle, about 32.5 tons (130 tons / 4 axles). Thus a car with 8 axles (four at either end) can theoretically weigh 260 tons total (32.5*8), divided between about 210 tons of capacity and 50 tons of empty weight. The only problem is that there may be a significant compounding effect due to the closely spaced wheelsets at either end (130 tons on four axles). Evidence to date suggests this is a problem. If used for the waste shipments the problem could be compounded by dedicated trains that would have a closely-spaced series of such cars. They would mean repeated stressing in rapid succession; a condition with which no US railroad has experience.

A closely allied issue is that of condition assessment. If the nuclear waste shipments cause extraordinary damage, wear rates would have to be monitored closely. This would be important not only to the carrier (i.e., for appropriate compensation), but also to the governmental jurisdictions through which the shipments pass (especially for determining how frequently safety inspections should be performed). There is also a question of whether FRA track class standards would be an adequate basis for measurement. Many railroads think they are not. If not, a substitute track quality index (TQI) would be required.

Construction and maintenance practices are a third, related issue. Perhaps concrete ties should be required on all nuclear waste-carrying lines or a minimum weight of rail specified. Extra-deep ballast may be required, and constraints might be appropriate for the maximum degree of superelevation in curves. Perhaps track surfacing operations should be more frequent, along with rail changeouts. There are advantages to concrete ties in some instances. Preservation of track geometry following a derailment or tie damage is one of them. But rail experts tend to be polarized over the value of concrete ties. Some argue strongly in favor of concrete ties, others feel they have no advantage over wood ties except in special circumstances. The Canadian roads for the most part are installing concrete ties wherever they can, as are railroads such as the Burlington Northern. However, given the traffic levels to

be expected (5 cars per week) the issue may be moot. The track would not have enough wear to warrant concrete ties or extra deep ballast. However, the public may expect to see such things installed on the line segments that have heavy spent fuel tonnage, regardless of whether a valid engineering argument exists or not. The issue is not resolved and will not be resolved until the actual capital investment decisions are made.

Need for Special Facilities

Shipment of the nuclear waste may generate the need for special facilities at selected locations throughout the rail network. At a minimum, this would include spurs to reach reactor sites not now served by rail. But also, there is the possibility that new bypasses would be warranted around heavily populated areas or that new, short links would be needed to connect one line to another where they presently only cross. Special sidings may be needed, as well as set out tracks next to yard towers, and clearance improvements. Any track design and construction upgrades required, discussed earlier, would generate a need for special facilities. But the needs go well beyond track. They include more advanced signal systems, special crew quarters on locomotives, special car tracing hardware and software, track switch hardware and control equipment, secured areas for detained cars and trains, maintenance support equipment (especially for the cars), locomotive on-board communications hardware, train locating capabilities, grade crossing hardware, and advanced dispatcher support systems.

Institutional Responsibility

Normally, each railroad has exclusive responsibility for, and absolute control over, the maintenance of its tracks and other facilities. This is a natural and logical arrangement, but it can have unexpected consequences. AMTRAK is supposed to be able to operate its Montrealer over the Boston & Maine's Connecticut River line, but as of 1987, service had to be suspended due to poor track conditions. The line was riddled with 10 MPH slow orders. Even though AMTRAK was paying Guilford Industries, B&M's parent company, a fee for the use of the line, the track was allowed to deteriorate to a point where AMTRAK could no longer provide a reasonable service. Either the fee was inadequate, or the contract terms did not ensure that the B&M would perform the maintenance. Regardless of the reason, the maintenance was not performed and the line was allowed to deteriorate. AMTRAK was powerless to do anything. Recently AMTRAK asked the Interstate Commerce Commission for permission to buy the line. It plans to sell it to the Central of Vermont, one of B&M's top competitors and a railroad that enjoys meeting AMTRAK's needs. This situation is not unlike that which might arise for the nuclear waste shipments, although probably not to the same degree because of the specter of public condemnation. The OCRWM cannot assume that facility maintenance will occur automatically. It must call for it specifically in its contract with the carriers, incorporating appropriate penalty-incentive clauses and inspection and enforcement procedures. It seems prudent that OCRWM not become involved directly in facility construction, maintenance and operation, except in very special circumstances. Rather, it should contract with the railroads for

this service and take the following actions:

- Agree to cover the cost (construction, operation and maintenance) of any new spurs, connections, sidings, lines or other facilities built specifically to accommodate the nuclear waste shipments,
- Institute severe penalty clauses for poor maintenance performance, and provide attractive incentive payments for trouble-free service, and
- Retain the services of an independent, maintenance auditing consultant which can spot-check carrier performance and recommend corrective actions where required. This includes what maintenance should be performed, how much it should cost, and how it can be ensured, both contractually and through legal proceedings if necessary.

The main missing piece of knowledge in rail infrastructure pertains to the special hardware needed to ensure the safe shipment of nuclear waste. Historically, the focus has been on track quality and track class. Little attention has been devoted to locomotive modifications, special communications and monitoring equipment, and the areas mentioned above. Trade-offs between fewer, larger shipments and more, smaller shipments by rail will need to be investigated in terms of the impact on infrastructure.

2.6.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Infrastructure	Develop criteria for infrastructure decision-making	19 (1984)
	Assess infrastructure condition and utilization along potential routes	17 (1986)
	Develop pavement performance models	15 (1988)
	Develop economic assessment models	15 (1988)
	Assess infrastructure impacts	13 (1990)
	Identify infrastructure improvements/new construction needs	13 (1990)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Develop institutional mechanism for funding and implementation	12 (1991)
	Begin implementation	11 (1992)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

2.7 DEFENSE WASTE

Defense waste consists of spent nuclear fuel and high level radioactive waste generated by defense reactors, nuclear weapons research, development and production by the Department of Energy and its contractors. Defense waste is presently stored at three locations which DOE identifies as the potential sources of shipments to the repository. For purposes of planning, the OCRWM has utilized a figure of 20,000 canisters to describe the volume of defense waste to be shipped to a repository, an amount they equate to "10,000 pounds of heavy metal." DOE has described the defense waste stream as being 15% of the total high-level waste stream of the nation in 1982, and projected to be 3% of the total in 2010. Traditionally, DOE has closely controlled most of the aspects of defense waste shipments, however, under the NWPAA, the NRC will regulate defense waste as to shipment casks and prenotification requirements. DOE has determined that defense waste will be shipped as unclassified so that the extensive DOT regulations will apply as well as state, Tribal and local government regulations. Also, DOE has decided that defense waste is suitable for transportation in many of the same ways as civilian nuclear waste shipments. Verifying this, and in other ways, evaluating defense waste shipments is difficult at this time because many aspects of shipping defense waste have yet to be decided. Details about volume, timing and rate of shipments either do not exist or will not be finalized until site-specific waste management plans are finalized at the DOE facilities now storing the waste. The shipment cask designs and the modal mix of rail/highway/barge transportation have yet to be described. Furthermore, the OCRWM has not provided details in either the Yucca Mountain Environmental Assessment or in the Transportation Institutional Plan of the characteristics of defense waste, or of the vitrified or other forms in which the waste will be shipped.

To ensure that citizens and the environment will be protected from defense waste shipments, all aspects of risks regarding defense waste transportation, including radiological hazards, risks of sabotage or diversion and public perception problems must be reviewed. The emerging regulatory structure for defense waste shipments to a repository, which involves mixed responsibilities among the DOE OCRWM and DOE Office of Defense Programs, the NRC, the DOT, state, Tribal and local governments needs documentation and evaluation. Preferred standards of design and performance for defense waste shipments need to be formulated and implemented on an as-needed basis.

The major defense waste transportation issues are:

- Obtaining details on defense waste volumes, timing and rate of shipments, and transportation modes.
- The components of the preferred transportation system for shipments of spent power reactor fuel to a repository should be evaluated as to their adequacy for defense waste shipments, taking into consideration the particular characteristics of the defense waste form.

- More information must be developed about risks involved in transporting defense waste, such as hazards of radiation, sabotage/diversion, and public perception. Findings as to these subjects will better define performance standards for a preferred system for transporting defense waste.
- Understanding and influencing the emerging defense waste regulatory responsibilities among the NRC, the DOT, the OCRWM and State, Tribal and local governments.

The elements of the preferred system for transporting commercial waste to a repository at Yucca Mountain provide a starting point for the defense waste system. Fortunately the prospects for input and influence as to defense waste shipments have improved with the extension of the NRC and DOT regulatory structures to defense waste shipments to the repository. As special risks of defense waste shipments, if any, are identified over time, they can be integrated into the specific components of the preferred transportation system.

Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Defense Waste	Identify characteristics and quantities of defense waste by origin	21 (1982)
	Clarify applicable regulatory structure	19 (1984)
	Modify federal laws and regulations, if needed	17 (1986)
	Assess need for special defense waste cask(s)	17 (1986)
	Develop revised cask design and testing standards, if necessary	15 91988)
	Design casks	13 (1990)
	Submit for NRC certification	11 (1992)
	Fabricate prototype	10 (1993)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Perform full-scale testing	9 (1994)

- * Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.0 OPERATIONAL PROCEDURES

3.1 OPERATIONS PLANNING

A transportation system of the size and complexity required for the nuclear waste program should include a carefully developed operations plan. This plan does not stand alone, but is part of the overall management planning process. "In reality, personnel at all levels of the organization have strategic (long range), tactical (medium range), and operational (shorter range) views of the organizational systems within which they work" (Sink Industrial engineering, January, 1985). The following discussion is an adaptation of the Department of Energy's Management Oversight Risk Tree (MORT) to the development of the content required for an operations plan. It is an approach that provides a useful framework for the operations of a program in which safety is primary and fundamental. MORT was primarily designed as a system safety management and accident analysis tool. It has over 1500 basic events or causes leading to 98 generic events or problems which can lead to system failure.

Operational planning must be preceded by and compatible with the organization's strategic and tactical plans. The strategic plan is the cornerstone of the tactical and operational plans. It involves a number of steps (Sink Industrial Engineering).

Step 1: Internal strategic audit. Identification of internal factors that should be considered during the design development and potential implementation of the transportation management program.

Step 2: External strategic audit. Identification of external factors that should be considered during the design development and potential implementation of the transportation management program.

Step 3: Planning premises and assumptions.

Step 4: Strategic planning which identifies 2-5 year goals and objectives for the transportation program.

Step 5: Prioritization and consensus of performance objectives in key results areas relative to the transportation program.

Step 6: Identification, prioritization and consensus for/of strategic, tactical and operational action programs. Identification of programs, plans, resources, etc. that will have to be budgeted for in both the short run (1 year) and longer run (2-5 years) in order for this program to succeed. Simultaneous operational focus (1 year) with a strategic (innovation, growth, continued development and support) focus (2-5 years).

Step 7: Program planning and resource allocation.

Step 8: Program evaluation, review, maintenance.

After the strategic planning process, tactical and operational plans can be formulated. The content and execution of the operations plan must be an outgrowth of the strategic planning process and should include an operations plan for upper management, middle management, and first line supervisors and employees. The operations plan for the preferred transportation system should be developed using a process similar to the eight-step process outlined above for strategic planning. This process is a group process of the persons who will manage and conduct the transportation operations.

3.1.1 Elements of the Operations Plan

The transportation operations plan for the preferred transportation system should start with a statement of the operations goals for the transportation system. The goals include those which are universally desirable, such as safety, efficiency and reliability. That which constitutes each goal must be thoroughly examined and specifically determined, so that acceptable levels of operations performance can be verified by measurement. In the operations plan, these should be delivered as measurable objectives as well as overall goals.

The transportation operations plan should include a summary of the situation the operations must satisfy. This includes the identification of constraints, limitations, demands, and resources. The situation assessment should include alternative operations which could meet the situation, the evaluation of these alternatives, and the recommended operations. The plan should include a means for implementing each part of the plan into day by day operations.

3.1.2 Specific Control Factors in the Operations Plan

These are the individual parts of the operations which provide the specific procedures necessary for the accomplishment of the goals and objectives of the transportation system.

- Technical Information System Plan. Those procedures necessary to provide knowledge where and when it is needed. This involves a plan for information gathering. The knowledge can come from codes and manuals, regulations, standards, experts, scientific studies, or investigations of similar situations. The plan should provide the means to communicate the gathered information through internal and external networks. Since complex systems will depart from plans and procedures to some degree, information systems need to be available to operations to detect deviations, determine rates and trends, develop methods and means to make corrections, and thus support the attainment of stated goals and objectives.

- Facility and Vehicle Operational Readiness Plan. At the start up of a new facility or the acquisition of new vehicles and equipment, or after an interruption due to modifications to facilities, equipment, and vehicles the procedures of this plan should be invoked to ensure readiness for use.
- Maintenance and Inspection Plan. Maintenance and inspection plans to ensure the adequate care and monitoring of equipment, processes, utilities, operations, facilities, etc.
- Training Plan. A plan for the training of all personnel in their various roles and responsibilities should be provided. This plan should include needs assessment, behavioral objectives, training systems analysis, measurement, and feedback information for program modification.
- Transportation Plan. The number and mode of shipments, shipment routing, and supporting operations should be provided in the operations plan. These are designed to meet the goals and objectives of the system and are conducted by procedures which are within system policies. The transportation plan should include both normal and emergency operations which must be performed in order for the transportation system to meet its goals and objectives. Each task within each function should be provided with step by step procedures.
- Supervision Plan. If the supervisor is to adequately fulfill his/her responsibilities, he/she must have competent and useful advice and support. The operations plan should make provisions for such help and training where it is needed and when it is needed.
- Higher Supervision Services Plan. Upper levels of management should provide the type of supportive services and guidance needed by the lower organizational levels for adequate control of the work. Management must provide research and fact finding, information exchange, standards and directives, training, technical assistance, program aids, measures of performance, coordination with interface groups, responsiveness to risks referred from lower levels, etc. A means to accomplish these services should be provided in the operations plan.
- Independent Audits and Appraisals Plan. Accountability is essential in a transportation system of this type. The operations plan should include a means for independent audits and appraisals of the functioning of the transportation organization. These should include both normal and emergency operations.

3.1.3 Management Control Factors

These are major factors of the management system which are necessary, sufficient, and organized to assure that the overall transportation program functions and is accountable to the customer, the public, to the organization itself, and to other appropriate groups.

- Policy. There should be a written, up-to-date policy for the transportation system which is broad enough in scope to address the major problems likely to be encountered in system operations.
- Methods, Criteria, Analyses. The operations plan should provide: selective methods for improving human performance, adequate criteria for assessing both the short and long-term impact of these methods, and analyses of these methods and their alternatives to ensure their validity and usefulness.
- Line Responsibility. The operations plan should provide a clear, written statement of the responsibilities of the line organization, from the top line officer, through the first line foremen, to the individual employee. It should include the means to implement these responsibilities.
- Staff Responsibility. The Plan should provide for the assignment and implementation of the specific functions, including safety personnel and their training, engineering, maintenance, purchasing, transportation, etc.
- Budgets. The operating plan should identify an adequate budget to ensure meeting the goals and objectives of the transportation system.
- Document Control. A system of document control should be included in the plan. Change notices should be distributed to all persons who have need of such information to ensure appropriate disciplines and functions have the opportunity to provide inputs to such changes in a timely fashion. This is especially important for human factors and safety engineering functions. Their inputs are required throughout the life cycle, but are most valuable during the early portions of the life cycle of systems, equipment, and facilities design.
- Hazard Analysis and Risk Assessment. The operations plan should include these as continuous and ongoing functions.
- Life Cycle Analysis. The operations plan should be in accordance with life cycle analysis that includes not only the prime mission equipment, but also checkout and test equipment and procedures; personnel; training equipment and procedures; maintenance facilities, equipment and procedures; and support equipment.

3.1.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Operational Plan	Develop strategic and tactical program plans	17 (1986)
	Identify elements of operations plan and operations planning framework	15 (1988)
	Develop tentative operations plan including management control factors and specific control factors	13. (1990)
	Finalize operations plan	8 (1995)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.2 DOE CARRIER REQUIREMENTS

The main goal is to select those carriers which can provide the lowest possible transportation risk, with greatest possible consistency. To be selected, a carrier must be able to demonstrate that it can ensure the security and integrity of each shipment. For example, the carrier must have a plan for safeguarding the vital information about each shipment to see that it is not inadvertently released. It must be able to ensure that no informants can gain access to sensitive information and release it to hostile groups. The carrier must also have a plan for dealing with risk-prone situations, whether hostile or not, and practice the use of that plan on a regular basis.

Carriers must be able to prove that they have sufficient experience to be qualified for hauling nuclear waste. They should be able to do this by demonstrating that they have hauled other, equally dangerous cargoes, such as chlorine, gasoline, and propane, at least in the initial stages of the shipment campaign. There are very few carriers nationwide with broad-based experience in carrying large quantities of high level nuclear waste. The company also needs to be in a financial position which allows it to complete the contract.

A carrier screening process is needed to ensure that acceptable carriers are selected. It should begin with a pre-qualification phase, where carriers demonstrate on paper their potential acceptability. For those that pre-qualify, financial audits and safety audits could follow. Successful completion of these would lead to a test shipment which included planned (but unknown to the bidder) events to assess hands-on capabilities.

Because there are limited carriers with experience in hauling reactor wastes, extra care must be taken to ensure a fair selection. Given the small number of carriers presently in the market, price-fixing and other forms of collusion could easily take place. Provisions must be made to guard against such activities.

Because of the overwhelming adverse publicity that would result from an accident, the carrier should have a superior safety record. The DOE/OCRWM, as the owner of the waste and the shipper of record, carries the primary liability for incidents. The civil suits, justified or not, could represent an enormous cost in damages and legal fees. Any insurance costs the carrier incurs as a result of transporting the waste are likely to be passed through to the DOE. In general, however, one of the selection criteria must be an appropriate financial position for meeting the requirements of the contract.

3.2.1 Carrier Selection Criteria

The primary task is to select one or more carriers (a carrier mix or an alternative) that can provide safe and efficient transport services in keeping with all federal, state, Tribal and local requirements. The criteria to employ

should include:

- Risk (e.g., expected fatalities, injuries, dollar damages, etc. for each carrier mix),
- Reliability (the consistency with which the nuclear waste transport services will be provided, such as making pickups and deliveries on time), and
- Program risk (the "portfolio risk" associated with the carrier mix included in any alternative, such as the number of carriers involved, broken down by mode, geographic region, etc.).

Sub-decisions involved in developing each carrier mix include:

- Number of carriers that should be used,
- Assignment of responsibilities to the carriers and by implication, which ones belong to the shipper,
- Final screening process that should be used to select qualified applicants,
- Final pre-qualification process that should be used to ensure that more than "paper" qualification occurs, and
- Contract length.

3.2.2 Minimum and Ideal Performance

At a minimum, the carrier mix selected should meet or exceed the risk and reliability performance of the best company qualified to bid for each contract being let. Ideally, it should be possible to combine the best performance of all the carriers available (e.g., the lowest risk with the best reliability), but this may be a long-range goal and not a short-term reality.

3.2.3 Information Required

The information needed for selecting carriers is actually too voluminous to be summarized here completely. There are many facets to consider. From a technical perspective, this information includes:

- Shipments per year, by point of origin
- Fleet size estimate, such as the number of cabs (locomotives), trailers (railcars) and escort vehicles
- Fleet size of each carrier, existing and proposed
- Carrier financial condition

- Carrier accident/incident history
- Carrier safety plan
- Proposed plans for maintenance, stoppage, training, inspection, shipment tracking, etc
- Each carrier's prior experience in hauling radioactive materials

3.2.4 Additional Research

Several major areas need to be examined. A set of screening criteria need to be developed and their use outlined. Similarly, pre-qualification processes and test runs need to be described and evaluated.

The division of responsibilities between the shipper and the transporter also needs study. These responsibilities include routing, vehicle and cask maintenance and inspection, stopping plan development, and driver training. Options for dividing these responsibilities among DOE, the carriers, and other contractors and subcontractors must be drawn up and their implications studied, including the legal problems that may arise. The contracting process is probably the least well understood aspect of the transportation plan.

3.2.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
DOE Carrier Requirements	Identify carrier requirements issues	15 (1988)
	Conduct technical studies on carrier requirements issues	13 (1990)
	Develop tentative carrier requirements	11 (1992)
	Develop carrier screening process	11 (1992)
	Develop carrier selection criteria	8 (1995)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Finalize carrier requirements	5 (1998)
* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.		

3.3 PERSONNEL TRAINING AND QUALIFICATIONS

The preferred system for personnel selection and training provides for choosing and educating workers at a level that encourages a consistently low level of risk to the system. Consideration must be given to a broad range of individuals, ranging from state inspectors and mechanics to drivers, engineers, escort personnel and emergency responders.

3.3.1 Regulatory Structure

Driver Qualifications

A method for attaining the objectives of minimizing the potential for and consequences of radiological incidents and accidents is to require highly-qualified drivers for the transport vehicles. Because the drivers will be traversing the U.S., federal regulation is necessary. State governments should be permitted to regulate in a manner that does not conflict with the federal law. The Federal Motor Carrier Safety Regulations [49 C.F.R. Parts 383 and 391 (1987)] governing driver qualifications, with the following changes, may serve as a basis for the regulations in a preferred system:

- **Qualification of Drivers**

In addition to the current requirements, drivers of nuclear waste shipments shall:

- Have a minimum of ten years commercial driving experience in a motor vehicle of the type used for the shipments. The experience must have been gained in the 12 years immediately prior to beginning work as driver for nuclear waste shipments.
- Have a minimum of 250,000 miles driving experience over mountain terrain in a motor vehicle of the type used for the nuclear waste shipments.
- Take and pass two written examinations: one testing the driver's knowledge of the Federal Motor Carrier Safety Regulations; and one testing the driver's knowledge of nuclear waste, and response to nuclear waste transportation incidents and accidents.

- **Disqualification of Drivers**

For drivers of nuclear waste shipments, the following additional factors shall disqualify a driver for the period of time as shown:

- Any accident for the three years immediately prior to beginning to haul nuclear waste shipments. Duration of disqualification: three years.

- Any accident for which the driver is given a citation by a law enforcement officer or for which the carrier determines the driver is at fault. Duration of disqualification: three years.
- The denial, suspension, revocation or withdrawal of a driver's license. Duration of disqualification: five years.
- Substance abuse within five years immediately preceding or while working as a driver for nuclear waste shipments. Duration of disqualification: five years.
- A crime involving the knowing transportation or possession or the unlawful use of an illegal drug. Duration of disqualification: twenty years.
- The arrest and conviction of a felony. Duration of disqualification: twenty years.

- Application for Employment

Drivers of nuclear waste shipments must list the names and addresses of their employers during the ten years preceding the date of the application, along with the dates of employment, the types of motor vehicles driven for that employer, and the reason for terminating employment. The current employment history requirements found at 49 C.F.R. Sections 383.35 (c) and 391.21 (b) (10) (1987) are inconsistent with each other.

- Motor Carriers' Investigations

Drivers' employment and experience must be verified by the motor carrier.

- Written Examinations.

In addition to giving a written examination to test the driver's knowledge of the Federal Motor Carrier Safety Regulations, the motor carrier must test the driver's knowledge of nuclear waste, and response to nuclear waste transportation incidents and accidents. The federal government must develop and publish an appropriate examination.

- Medical Examinations

Carriers shall be required to randomly test for substance abuse.

Railroad Employees

Just as the driver of a truck must be highly-qualified, so must railroad employees. Train engineers, conductors, brakemen, dispatchers and towermen play a vital role in the safe transportation of nuclear waste by railroad. The above qualifying and disqualifying factors should be applied to these individuals as well, although the factors must be amended to reflect appropriate job requirements.

3.3.2 Key Personnel Training and Qualification Issues

Most carriers with experience in hauling radioactive materials have dealt only with low activity substances such as low-level radioactive waste. Obviously, the consequences of accidents with nuclear waste shipments to a repository are more severe. Such shipments also require closer monitoring. Unlike other high level radioactives which are transported quietly, the repository shipments will be very public. This increases the chance of interference with the shipments, ranging from protests to sabotage.

Training programs have been conducted in the past by many different groups, including carriers, government agencies, trade associations and educational institutions. Any new training requirements imposed by the OCRWM, the DOT or the NRC will have to be incorporated into this overall matrix, dividing the workload in a logical and efficient manner. It may be best to have some of the training conducted by the DOE or the OCRWM at a central facility, while other training might best be done at the local level. Examples of the former include cask maintenance, high-speed truck driving skills, and safety plan preparation training. Examples of the latter include more general vehicle maintenance, inspection, enforcement, and emergency response.

The OCRWM has published a list of recommended topics to include in a driver training program. Except for emergency response, training programs for other individuals involved in the shipment campaign have not been addressed. The lack of formal implementation of such a program makes the value and feasibility of these options uncertain.

3.3.3 Preferred System Training and Qualifications Decisions

The principal decision focuses on the design of the training program itself: what should be taught, where, when, and by whom. There is also a question of how the training should be done, considering the wide range of teaching media which can be used. Decisions must consider what information is necessary to a particular functional area and how long the information can be retained. Also, decisions about training frequency, source and facilities requirements for the training must be determined along with considerations of safety objectives and costs.

The personnel training and qualifications system will not only have to fulfill the requirements of 49 CFR 177.825 (d) and the new regulations being proposed for hazardous material drivers, it will also have to meet the standards of the best training programs currently available. These represent the de-facto standard for training. The ideal training program would ensure that the knowledge of all individuals involved is complete, current, comprehensive, well practiced and well understood.

Data for making training decisions include a complete list of potential subjects and estimates of the teaching time for each; the marginal value of the subjects

in risk reduction; testing alternatives and their value; a siting analysis for training centers; and an assessment of the financial responsibility for training among DOE, the carriers, the states, and any other interested parties. Development of the training program will require study in several areas. Alternative educational procedures must be assembled. Existing educational policies may not be adequate to teach all individuals properly. A set of liaison programs need to be developed. In addition, a program that involves regular contact with prior students needs to be developed to act as a cross-check on the quality of the training and as a constant reminder of the importance of the material learned. Finally, alternative strategies for locating training facilities should be developed.

3.3.4 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Personnel Training and Qualifications	Identify personnel training and qualifications needs	18 (1985)
	Conduct technical studies on personnel training issues	17 (1986)
	Revise federal motor carrier regulations concerning qualifications of drivers, disqualification of drivers, application for employment, motor carrier investigation, written examinations and medical examinations	13 (1990)
	Develop personnel training program	13 (1990)
	Begin training program	5 (1998)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.4 CASK MAINTENANCE

Perfection in design and manufacture of casks is not sufficient to guarantee safe transit. The equipment must be carefully maintained during its years of operation, as well. Cask licenses include a section detailing the QA/QC procedures needed to sustain the cask's ability to contain radiation. Such procedures may include schedules outlining when valves are re-tested, seals replaced or measurements taken. These efforts are generally the responsibility of the holder of the cask license, usually the shipper, and may be performed at its terminal or (more likely) at a reactor prior to a shipment. Oversight of such work may be discharged by on-site NRC inspections, but is more often done by examinations of the cask records, sometimes years after the fact.

When cask maintenance problems have arisen, it has been standard procedure for the NRC to amend an individual license (its "certificate of compliance") to include additional QA/QC procedures. Some licenses have been amended over a dozen times to accommodate such changes. Only rarely have actual regulations been changed that affect all containers at one time. Therefore, it is likely that cask maintenance procedures vary a great deal between different licensees.

Experience has shown the need for careful attention to the replaceable parts of a cask and its transport vehicle. The preferred transportation system should seek to minimize cask problems even when not directly related to cask failure in order to avoid symptoms that could mask real hazards. Vehicle safety and structural systems will also require regular attendance. Inspection and repair facilities at the repository and the MRS, or another central site on route, will be essential to maintaining the necessary standards. In lieu of such facilities, a mobile van/lab could perform many inspection functions. Container and vehicle maintenance actually begins at the design stage, where cask design should minimize the amount of equipment requiring constant vigilance.

Cask maintenance issues include insuring that procedures are sufficient to guarantee safety; that they provide for cask maintenance within reasonable time and budget constraints; and that the procedures can be enforced and verified. Also, in the event that maintenance is unsuccessful, cask designs, replacement casks and procedures need to be available for taking the unacceptable cask out of service.

3.4.1 Good Design as the Basis for Good Maintenance

Proper maintenance begins in the design phase. Some previous containers were designed with features that reduced impact hazards for the cask (e.g., with steel fins that also radiated heat) but these same features caused maintenance problems (e.g., the fins were difficult to decontaminate after the cask was immersed in the fuel pool). Cask designs should be evaluated (possibly through the use of full-scale models) through all aspects of usage to find opportunities for improvement and eliminate opportunities for error.

3.4.2 Quality Assurance/Quality Control

The NRC has much less control over casks in the field than it has over a design document, or even at a fabrication shop. It is therefore essential that QA/QC procedures be completely clear, that maintenance staff be qualified and diligent, and replacement parts and methods be tested and workable.

While most QA/QC procedures read well in print, however, some fail in practice. Most documented maintenance failures occurred when the procedures existed and had been made clear to cask personnel. Human error in adhering to them was the problem, partially due to the numerous additions and changes that have occurred when cask licenses are revised. One container had almost two dozen revisions to its license in a ten year period. Better methods are needed to avoid numerous alterations since the likelihood of adherence with over 200 casks (of at least six different designs) will diminish as the number of variations increases. Again, good design (or redesign and physical alteration) could reduce the number of details handled by maintenance personnel.

There is a growing body of data that indicates that occasional operational failures have created opportunities for cask leakage or failure. Scattered throughout inspection reports and correspondence are cases that, taken individually, do not appear serious; together, however, they lead to the conclusion that control over existing QA/QC procedures is insufficient to guarantee safety, especially if several errors were to occur simultaneously. A comprehensive QA/QC plan must cover all aspects of cask maintenance and fuel handling such as assembly choice, fuel inspection and loading, and verification of internal cask conditions.

3.4.3 Cask Ownership/Leasing

Most spent fuel casks have, in the past, been owned by private vendors who rent or lease them to shippers. Loss of a cask due to a maintenance problem therefore causes an immediate loss of revenue. Discovery of a generic problem requiring recall of all casks of one design could be seen as financially disastrous by an owner. Cask owners would naturally be resistant to any recall. There is a need to develop a no-fault contractual relationship with owners to allow them to remain financially unharmed during such recalls. Political altercations would be avoided and safety would be maintained. Alternatively, all casks could be government-owned so faulty containers could be removed from service without private lobbying against such action.

3.4.4 Preferred System Cask Maintenance

Fuel Should Be Cleaned or Canned

Spent fuel is always covered with a thin layer of crud. This sediment from gradual corrosion of the inside of the reactor core walls contains dangerous

isotopes releasable during heat and/or impact. Removing most of the crud prior to loading would eliminate much of the "source term" (releasable quantity of radiation) for an accident as well as avoiding a buildup of crud contamination on the inside of the cask. This process, and its verification, would also reveal some cladding defects that could lead to leakage. Alternatively, fuel could be canned and sealed, as is done with damaged fuel.

Cask Maintenance Database

So many characteristics of the equipment are safety-related that oversight can become an overwhelming burden of details and schedules, especially when there will be over 200 casks in transit at one time. The likely result is error and incomplete inspection. A database should be utilized to track events throughout the life-cycle of each cask, from fabrication, testing, maintenance, utilization, and repair to decommissioning. Such an effort would also aid dispatching when equipment is pulled out of service and information on replacement availability is needed.

Robotic Maintenance Systems

Robotic operations may be useful in the reduction of worker exposure and assurance that procedures and tasks are not forgotten. A human operator should be present, however, watching the machine perform its chores to avoid replication of robotic problems due to software or other failures.

Cask Transponders

A cask transponder would allow maintenance and emergency response personnel to determine what cask problems may exist that require service or special handling. It would also reveal maintenance and handling errors before they caused serious problems. The records of such a detection device would become part of the cask database.

Cask Maintenance Facilities

To avoid traveling with a problem container, a repair terminal at a central location in the Eastern U.S. and another at the repository would serve as the prime rehabilitation facilities. They would have a full complement of parts to allow almost all work to be avoided at the reactors, where oversight on such work becomes problematic. Ideally, the cask design would allow replacement of the entire cask lid or fuel basket whenever a problem arose, thereby avoiding mechanical work by non-factory personnel or use of parts not certified by the factory.

Mobile Maintenance

An additional means of repair/maintenance/inspection would involve a trailer containing spare parts, equipment, inspection devices and trained personnel. It would travel the shipment corridors, responding to vehicles disabled in transit and spot-checking such aspects as driver condition and cask radiation output.

Development of Regulatory Guide

A simplified guidebook should be developed and distributed to state, Tribal and local law enforcement personnel to enable them to carefully check any item on a cask or transporter and impound the shipment when a problem was found.

Safe Stopping Areas

Safe stopping areas should be guarded, fire-protected facilities at points along the highway and rail transportation corridors, including where shipments enter the State of Nevada. The facilities should be available to hold equipment with serious problems, until the problem is documented and resolved. The facilities should be equipped to remove and store a cask in the event that a transportation vehicle could not be repaired immediately. Spare transportation vehicles should be kept at key facilities to eliminate extended storage of casks.

3.4.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Cask Maintenance	Develop cask transponders	13 (1990)
	Identify required fixed and mobile cask maintenance plans	13 (1990)
	Conduct technical studies on cask maintenance requirements	11 (1992)
	Develop cask maintenance QA/QC program	11 (1992)
	Develop cask maintenance database	4 (1999)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.5 VEHICLE MAINTENANCE

Oversight on vehicle maintenance is not as intense as that for containers. There have been cases of a trailer buckling, loose or failed tiedowns and tractor/trailer separations in transit. While shippers and carriers are expected to examine vehicles prior to each shipment, such failures have sometimes occurred shortly after initiation of transit. To a carrier, a nuclear shipment may not be treated much differently than other cargoes and it is likely that the level of mechanical inspection for vehicles hauling nuclear waste is not much greater than for other materials. State spot checks on trailer trucks in general have found more than half have had defects in safety systems serious enough to warrant the need for immediate attention. Since the cask is supposedly designed and manufactured to handle stresses resulting from vehicular accident or failure, however, deficiencies of the trailer are often not seen as life-threatening by shippers.

Vehicle maintenance regulations are much more generic than those for casks. Enforcement is by the divisions of the DOT. In the field, most oversight is by the shipper and the carrier operating (and probably owning) the vehicle and state and local agencies. Minor repairs may be done at the reactor site, but overhauls and major repairs are usually accomplished at the carrier's terminal or nearby garage. It is noteworthy that no DOT agency was able to produce an inspection report for a highway vehicle carrying spent fuel when requested to do so under the Freedom of Information Act. While some inspections may have occurred, it appears that beyond state actions, this area of the business is essentially self-policing. Only high visibility shipping campaigns, such as the emptying of the defunct West Valley reprocessing plant showed extra attention to vehicle components, and that was by the shipper, not by a federal agency.

3.5.1 Key Vehicle Maintenance Issues

Ownership of Vehicles

Ordinarily, the carrier is responsible for keeping vehicles in operating order. If some other party owns the railcar or trailer (e.g., a shipper or leasing agent), then that party becomes responsible for the vehicle's overall maintenance (directly or through contract), with the carrier reserving the right to make running repairs which will ensure the short-run safe operation of the overall train or truck. Nuclear waste shipments are likely to fit this mold in the following way. If trucks are used, the carriers are likely to insist that DOE own the tractors and the trailers, with the carrier maintaining them under contract. This is because the tractors and trailers would be in dedicated service and would be specially equipped.

For rail, if dedicated trains are used, the carriers would be likely to make similar stipulations. The cost of the locomotives might be reflected in the rate or contract terms. Carriers might ask DOE to pay for the locomotives directly; a not too common practice. The mechanism for reimbursement for a

dedicated locomotive will be determined by the way the railroad markets its services. If cars transporting the nuclear waste are carried in general merchandise trains, DOE might not be asked to own the locomotives used, since they would be in more general use, but it might be asked to own the nuclear waste cars as well as any vehicles used by the escorts (e.g., caboose--type vehicles). Under contract, the railroads would most likely be willing to maintain this equipment.

Conflicts in Maintenance Schedules

Each carrier has maintenance priorities for its own equipment and will have to adjust these to fit the needs of DOE. Conflicts in maintenance priorities may create delays for nuclear waste shipments. Contracting provisions will need to stipulate DOE's priority for maintenance resources and what actions it can exercise (e.g., premium payments) to gain a higher priority than that which the contract nominally provides.

Breakdowns

Because sabotage/terrorism is of concern, any equipment failure which requires the vehicle to stop increases risk exposure, regardless of whether an accident occurs or not. Malfunctions and breakdowns which ordinarily result in minor inconveniences should be unacceptable when hauling nuclear waste. A preventive maintenance program should be devised to control the probability of such events.

Due to the sensitive nature of the shipments, the people authorized to repair the vehicle in the field need to be specially qualified. They must be able to repair any specialized equipment on both vehicle and load, and be able to reposition the cask. An adequate supply of spare parts must be available at or near each repair facility. Companies should be retained to provide repair services in each area through which shipments pass.

An issue for both major and minor breakdowns is the question of secured areas. To reduce the risk exposure of a shipment which encounters a maintenance problem, such facilities may be required. They would be areas where the cask could be stored until a vehicle became available to haul it again.

Electronic and Other Special Equipment

Vehicles may be required to carry special equipment that the carrier has no experience in maintaining. These pieces of equipment would be vital to the safe transport of waste. Provision needs to be made to educate the carrier in the servicing of these devices.

Maintenance Requirements

Because of the risk involved in any equipment failure, maintenance standards and preventive maintenance schedules will have to be designed to minimize the number of breakdowns. These would have to be applied to all vehicles

including tractors, trailers and escort vehicles. For rail, special maintenance standards and schedules for locomotives and cars would have to be devised.

3.5.2 Preferred System Vehicle Maintenance

At a minimum, the vehicle maintenance plan should meet or exceed not only existing federal, state, Tribal and local requirements, including those which pertain specifically to nuclear waste, but also the best performance of existing carriers which transport nuclear waste. Ideally, the maintenance plan should be devised so that no elevated risk exposure can be traced to a maintenance--related failure.

The principal decision involves developing a plan for fleet maintenance which strikes a balance between risk exposure and reliability. The preferred vehicle maintenance plan consists of three principal parts: (1) a home maintenance plan for regularly scheduled activities which take place when the equipment is at pre-designated locations for predetermined servicing; (2) a field maintenance plan which indicates what actions should be taken when breakdowns occur in the field (a contingency plan); and (3) a plan for establishing coordination between the two. Moreover, the plan must be all encompassing, addressing the entire spectrum of component maintenance within a given vehicle and the coordination of maintenance activities among all vehicle types involved. Many sub-decisions are involved in developing such a plan. Some examples include:

- How frequently the regular servicing tasks should be performed.
- When the heavy maintenance should be performed.
- What new maintenance tasks need to be incorporated.
- How coordination of maintenance activities should be accomplished.
- What field breakdown procedures should be adopted.
- How should minor malfunctions be corrected.
- Who will be responsible for field service contracts.

Most parts of the home-based maintenance plan can be developed by adapting existing industry practices to nuclear waste needs. It will probably involve shorter-than-normal inspection and preventive maintenance intervals and more extensive and earlier component changeouts to minimize the likelihood of breakdowns. The field-based maintenance plan, however, represents a concept about which very little is known. Contingency planning is not typically so formal. To be determined are what problems are most likely to occur, what actions should be taken by the crew, what maintenance work should be performed, where it should be done, what should be done with the cask while this maintenance work is being performed, where spare parts should be kept to expedite the repairs, what special training and qualifications the repair

facilities should have, and other issues. Information required to develop the plan includes:

- Fleet size involved, overall and by type of vehicle
- Maintenance options available for each component
- Recommended service intervals
- Failure rates by component
- Capabilities of repair shops and where they are located
- Contingency options for dealing with breakdowns

3.5.3 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Vehicle Maintenance	Identify vehicle maintenance issues	17 (1986)
	Research technical vehicle maintenance issues	15 (1988)
	Develop home-based and field-based maintenance plans	13 (1990)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.6 VEHICLE STOPPAGE

At times, the transportation of nuclear waste will be interrupted for a variety of reasons, such as mechanical problems with the vehicle, inclement weather or emergencies. The shipments cannot be left by the side of the road or on a rail siding. Appropriate stopping places must be predetermined. The federal government must establish minimum standards for these stopping places, with state and Tribal governments designating stopping places in consultation with local governments.

Safe stopping areas should be guarded, fire-protected facilities at points along the highway and rail transportation corridors, including where shipments enter the State of Nevada. The facilities should be available to hold equipment with serious problems, until the problem is documented and resolved. The facilities should be equipped to remove and store a cask in the event that a transportation vehicle could not be repaired immediately. Spare transportation vehicles should be kept at key facilities to eliminate extended storage of casks.

The goal is to minimize risk exposure for planned and unplanned vehicle stoppages in a cost-effective manner. The specific considerations include:

- Protection of the vehicle (truck or train) and the crew during stops,
- Minimizing the length of stops,
- Selecting the safest locations possible (e.g., truck stops, military bases, rail yards, interchange locations), and
- Ensuring that stoppage restrictions do not interfere with crew performance (e.g., too much time in the cab or locomotive between rest periods).

3.6.1 Key Issues in Vehicle Stoppage

Exposure of Stopped Vehicles to Sabotage/Terrorism/Interference

Regardless of whether the vehicle being used is a truck or train, the best opportunity for successfully sabotaging or blockading a shipment is when the vehicle is not moving. The vehicle therefore needs to be protected during stops. Its departure route from the stop may also need protection. This may mean armed guards stationed about the truck or train, and a plan for action should trouble arise.

Limiting the Amount of Vehicle Exposure

The number and length of stops needs to be controlled. It would be desirable to keep both the number and duration of the stops to a minimum. However, the crew members (truck drivers, engineers, escorts, etc.) need periodic breaks

in order to do their job well and safely. Hours of service restrictions (12 hours, for both rail and truck) also need to be taken into account.

Extraordinary (Unplanned) Stops

Eliminating unplanned stops will be impossible. Accident tie-ups happen on the freeways, and derailments occur on even the best railroads. Therefore, a contingency plan is needed for unplanned stops which will help to minimize their expected duration and maximize the protection afforded the vehicle and crew. Provision also needs to be made for calling repair people, towing the equipment to the designated repair location, and arranging accommodations for the crew.

Protection of Crew Members During Stops

Along with the vehicles transporting the shipment, the safety of the crew must be considered. Any time crew members leave the truck or train, they expose themselves to potential attack. Both the planned and unplanned components of the stoppage plan must make provision for the safety of the crew when they are away from the vehicle. The procedures will have to be developed through a negotiated rulemaking involving governmental regulatory bodies, management and labor. In the event an attack occurs, procedures must be available for seeking medical attention, moving crew and vehicle from the attack scene, and securing assistance from law enforcement agencies.

Inclement Weather Conditions

The safety of nuclear waste shipments obviously depends on weather conditions. Regardless of whether the shipment is moving by truck or rail, a decision will have to be made as to whether the shipment should proceed. This must be balanced against the risk of stopping. The stopping plan will have to give the crew guidelines to follow and provide contingency routes and the locations of and routes to secured areas.

Preserving the Crew's Comfort and Ability To Perform

In order to ensure both vehicle and crew safety, the crew needs to be in the best mental and physical condition possible. For psychological reasons, the crew needs to be able to leave the vehicle periodically. Hours of service restrictions must also be adhered to (e.g., a maximum of twelve duty hours for both truck drivers and railroad engineers). The crew also needs to attend to physical needs. The plan should have provisions for scheduling such stops and combining them with vehicle-related stops where possible.

Avoiding Interaction with Other Dangerous Goods Shipments

A poorly planned stop could result in a nuclear waste shipment being stopped next to another vehicle loaded with an equally dangerous commodity. For example, a truck with a loaded cask could be parked next to another loaded with propane. Care must be taken to minimize the likelihood that this would occur. Moreover, the crew must have instructions for determining what actions to take if they encounter such a situation (e.g., there is a propane

truck at the place they intend to stop), such as a list of an alternate yards or truck stops which should be used if the planned one cannot be used.

Consistent Versus Randomized Planned Stops

A trade-off exists between using a consistent set of locations for the planned stops versus randomizing them in some predetermined way (e.g., using a computer program to select each shipment's stopping locations). The advantage to consistency is maximum preparation. All parties involved can pre-plan the protection strategies, minimize the uncertainty about actions which should be taken as events unfold, and optimize the defensive actions that would be taken in response to sabotage or other unplanned events. The advantages to randomness are secrecy (saboteurs might not know where the truck or train is going to stop) and equity (the risk exposure due to stoppages would be spread over several stopping locations). Clearly, it takes more planning to be prepared for an unplanned event at any one of the designated locations, and resource requirements may be higher. But the social acceptability of such a plan might be higher.

3.6.2 Preferred System Plan for Vehicle Stoppage

The objective is to develop a plan for planned and unplanned stops which minimizes risk exposure. Risk exposure refers to the additional time added to the trip (perhaps multiplied by the population living nearby) to reflect the amount of vulnerability being added. The plan must address (at a minimum) when and where planned stops should occur. This is based on the reason and time requirement associated with it. Preparation for the vehicle's arrival and protection of the vehicle and its crew during the stop are key decisions. The decision-maker(s), DOE, carriers, states, Tribes, or local governments, has to be determined first. Perhaps the decision will be made by DOE with input and guidance from the others.

Preparation of the plan for expected and unexpected vehicle stoppage requires a list of reasons why vehicles would stop, a delineation of the times when stops will be required for refueling, eating, resting, etc., and servicing times that would be needed. Also, a list of potential facilities and their location for making stops and is needed. For unplanned stops, the data needs to include the definition of a secured area and example lists of such facilities, and a list of the emergency services which would be required and example lists of their capabilities and locations. A contingency plan for each type of unplanned stop must be developed. Furthermore, a delineation of the types of emergency response capabilities that might be required and lists of those that exist in selected areas need to be developed.

Two topics need exploration in the context of developing a vehicle stoppage plan. The most important is the contingency plan for unplanned stops, because none now exists. Consequently, it must be developed, systematically and carefully, to ensure that it affords the best possible protection against unforeseen problems. The second is a need to resolve the issue about consistent versus randomized stoppages for the planned stops. Clear advantages and

disadvantages can be cited for each, but a clear and thorough analysis of their strengths and weakness has yet to be conducted.

3.6.3 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Vehicle Stoppage	Identify vehicle stoppage issues	19 (1984)
	Conduct technical studies including trade-offs between consistent v. randomized stops	17 (1986)
	Identify route-specific vehicle stoppage needs	15 (1988)
	Develop route-specific vehicle stoppage plan for planned and emergency stops	13 (1990)
	Construct necessary facilities	3 (2000)

* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

3.7 SHIPMENT MONITORING AND PRENOTIFICATION

The term prenotification is used to refer to the advanced notice regarding a nuclear waste shipment, such as is currently required for high route-controlled quantities of nuclear material under the NRC regulations. The term monitoring is used to refer to information on the location and status of shipment enroute to a repository.

Because of the potential threats to safety from vehicle accidents/incidents and sabotage/terrorism, state, Tribal and local governments along the transportation routes need current information on the location and status of shipments to a repository. Since decisions related to physical protection and emergency response require current information and rapid deployment, a sophisticated shipment monitoring system to provide real-time information is needed. Also, shipment location information will probably be used by repository site management during the operational phase in scheduling crews to handle local traffic movement and the shipment unloading process.

The shipment monitoring/prenotification system should provide that state, Tribal and local governments along the transportation routes have the information needed to fulfill their roles in the nuclear waste transportation system. This means that the system must provide only valuable information and maximize the reliability of the information distribution process while reducing risk exposure caused by release of information. This must be done while minimizing the costs of providing the information. Continuous monitoring of the position of vehicles carrying wastes to a repository at Yucca Mountain serves several useful purposes, including the following:

- Provision of logistical information to enroute and destination personnel to ensure smooth handling during passage and upon arrival.
- Anomalies in pre-planned shipment strategy implementation can be noted when they occur.
- Assumptions about shipment security can be tested.
- Maintenance assistance or emergency response can be more efficiently directed to the vehicle location.
- Awareness of shipment status is reassuring to the public.

The preferred system will provide increased command and control operations which would reduce response time, thereby minimizing the effects of an enroute accident or undesirable event such as a terrorist attack. Obviously, a considerable amount of damage and injury can be accomplished by intercepting a shipment and scattering its contents. More likely is deliberate harassment of vehicles and people, including such tactics as throwing objects at the vehicles, honking horns, and various driving practices such as sudden decelera-

tion, dangerous lane changes and other activities which act to increase the risk of accidents.

The main security risk to nuclear waste shipments posed by notification is the release of shipment information to people who would misuse it. A method needs to be devised to distribute the required information to responsible parties while simultaneously excluding other people.

The Federal government should impose prenotification requirements on all nuclear waste shipments, irrespective of the shipper's identity. The current NRC prenotification requirements, with changes, constitute the preferred regulatory structure [10 C.F.R. Section 73.37 (f) (1987), also 10 C.F.R. Section 71.97 (1987)]. DOE's development of a real-time tracking system that would be available to state governments should not significantly alter the regulatory structure of prenotification requirements. The regulations may be amended to provide that the information is to be electronically transmitted.

3.7.1. Key Issues

Accuracy of Monitoring Systems

Predictable Accuracy.

This can be thought of as "absolute" accuracy the ability of the system to specify a site's exact geographic location. For example, if one stands at the Washington Monument and uses the system in question to determine one's location, the difference between the resulting estimate and the actual location of the Washington Monument represents error in the system's predictable accuracy. This is the most stringent accuracy measurement.

Repeatable Accuracy.

This refers to the system's ability to direct the user back to a site whose location has already been estimated by using the system. Thus, if one wishes to return to the Washington Monument and, using the system, returns to the previously acquired coordinates, the difference between one's final location and that of the Washington Monument represents error in the system's repeatable accuracy. A system's repeatable accuracy is usually considerably better than its predictable accuracy.

Information Needs of State, Tribal and Local Governments

In the vast majority of incidents involving hazardous materials, the first organization on the scene is the local hazardous materials team or fire department. The actions taken by these people in the early stages of the incident are absolutely critical in controlling the consequences of the incident. Many fire companies have little or no training in hazardous materials, and a large number of hazardous materials teams are volunteer organizations. Providing these people with instructions on recognizing nuclear waste shipments and taking protective actions is essential.

State, Tribal and local officials need to receive shipment information as quickly as practical, including alterations to the original shipping plan. If an elected official is caught unprepared in an accident/incident, the political consequences can be great. Overall public confidence in the HLNW repository program transportation system will be increased by a notification/monitoring system which enables local officials to "know what is going on." The value declines the longer the period of time between notification and shipment. One caution is that the more people that are notified, the greater the risk that the information may be misused to interfere with the shipment.

Prenotification can be used by State, Tribal and local governments for planning purposes, which may include emergency response planning, escorts, inspections and staffing needs. As such, it should be required for all shipments of nuclear wastes and not just those being shipped by NRC licensees. To assist neighboring jurisdictions, states must be provided some information about the location of the shipments before they enter the state.

While the prenotification requirements may meet the needs of most states, it is very likely that the State of Nevada and its local governments will have need for particular information for which other state governments may have no need. For instance, if there is a problem at the repository, it may be necessary to stop one or several of the shipments enroute. National standards in this area should not preclude additional prenotification requirements by the state in which the repository is located.

3.7.2 Alternative Shipment Monitoring Technologies

LORAN C Systems

LORAN C provides its estimate of location by measuring the differences in arrival time of three radio frequency pulses, each originating from a separate transmitter. The first pulse comes from the master transmitter and signals the start of the timing process. This pulse is encoded so that the mobile LORAN C receivers can recognize that it comes from a secondary transmitter. The master pulse also causes each of the two secondary transmitters to pulse in turn, after brief delays. The delays have a constant duration and are deliberately introduced to assure that the pulses will not overlap.

The LORAN C receiver compares the arrival times of the two secondary pulses to the arrival time of the master pulse and computes a pair of time differences (TD's). If the TD's are plotted, relative to the source transmitter's locations, the result is a pair of hyperbolas whose intersection indicates the receiver's location. Each hyperbola is referred to as a line of position (LOP). The intersection can be represented by LORAN C coordinates or these coordinates can be converted to latitude/longitude, or potentially some other location referencing scheme. This flexibility provides an entrance for security of vehicle location during transmission of location from the receiver. A system can be used which would be meaningless to anyone intercepting the transmission.

LORAN C transmitters are land-based units and are located primarily in the coastal areas because the system was originally designed for marine navigation. However, the signals which they produce travel equally in all directions, and, thus are readily available on land. The location of these transmitters in the coastal area has resulted in what is called the mid-continent gap. The new transmitter chains are planned to fill this gap in signal coverage that currently exists from west Texas north to the Canadian border. The stations are expected to be operating within three years. A North Central chain will be formed using new transmitters installed at Havre, Montana, and Gillette, Wyoming; and existing stations in Baudette, Minnesota; and Williams lake, British Columbia. A South Central chain will be based on new transmitters installed at Boise City, Oklahoma; and Santa Teresa, New Mexico; and existing transmitters in Searchlight, Nevada; Raymondville, Texas; and Orangeville, Louisiana. The new Gillette, Wyoming station will serve as a secondary station for the South Central chain and the Boise City Oklahoma, station for the Great Lakes chain. The strengthening of LORAN C by closing the mid-continent gap is pertinent to its potential use for the State of Nevada.

On water, LORAN C provides a predictable accuracy of approximately 150-1500 feet and a repeatable accuracy of approximately 50-300 feet. Both types of accuracy tend to improve as the proximity of the transmitters increases and as the receiver becomes more centrally located, relative to the transmitters. Atmospheric noise levels and weather conditions can degrade accuracy.

The proximity to the transmitters affects accuracy in two ways. The most obvious is the reduction of signal strength as distance increases, which makes it harder for the receiver to track the transmitters. The second is related to the distance of the receiver from imaginary lines running between the master and each of its secondaries. One such line is referred to as the baseline which is associated with a given secondary. For a receiver which is located on a baseline, i.e., directly between the master and one of its secondaries, an error of 0.1 microsecond in the TD which is obtained from the secondary is equivalent to a distance of approximately 50 feet. As the receiver moves away from the baseline, the distance associated with a 0.1 microsecond error increases. Thus, a receiver which is on baseline may achieve excellent accuracy in the TD obtained from the associated secondary while achieving poor accuracy in the second TD, due to the receiver's distance from the second baseline.

Terrestrial use, such as is anticipated for the Nevada application, involves additional influences on accuracy. These include variations in the conductivity of the soil, interference from carrier communications, signals in adjacent radio frequencies, reflections and signal-blockage caused by terrain (such as mountain), and man-made objects (particularly high rise building and objects made of steel), and electromagnetic fields generated by power lines. All of these phenomena perturb and/or reduce the LORAN C signal and thus degrade accuracy or, in some cases, prevent adequate signal reception.

Momentary instabilities and outright loss of signal can occur. Stable perturbations are a serious problem because the receiver will give no indications of their presence. Where there are set paths of travel such as are anticipated

for this application, these anomalies can be anticipated and proper corrections provided.

The most serious problem occurs when the receiver tracks the transmitters improperly, resulting in a phenomenon known as cycle slip. Cycle slip occurs when the LORAN C signal becomes overly distorted (a problem which is typically associated with poor signal strength), and causes the TD's to be in error by multiples of 10 microseconds. Depending upon the receiver's location, each 10 microsecond slip will be equivalent to an error of one mile or more. Receivers utilizing signal averaging techniques can minimize such errors and reduce variability.

Difficulties in receiving the LORAN C signal can be alleviated in two ways. The first is to construct one or more additional secondary transmitters, specifically to service the problem areas. These transmitters need not be as powerful as those which are operated by the Coast Guard in the LORAN C system because the required coverage area would be much smaller. For example, LORAN C mini-transmitter having a peak radiated power of 150 watts provides coverage over a radius of approximately 150-1500 miles, depending mainly upon the terrain and the height and location of the broadcasting tower. Full-sized transmitters, on the other hand, operate at a peak radiated power of 400 kilowatts. A mini-station would probably consist of something like the following: a 300-foot tower and a protective shed which would house temperature control equipment, the transmitter, a cesium clock, and a remote control interface, suitable for link-up with a telephone line or radio. A second solution is to install repeaters, which boost existing LORAN C signals rather than generating new ones. These devices have been successfully demonstrated to cure dead spots within a city. Such augmenters have been installed at street level and broadcast at approximately 100 milliwatts, using simple wire antennas.

NAVSTAR-GPS

The NAVSTAR Global Positioning System involves a network of 24 orbiting satellites which will provide continuous worldwide coverage. Predictable accuracy, using the most sophisticated receiving equipment, is expected to be 30 - 100 feet. Less expensive receivers should provide an accuracy of 300 - 600 feet. Additionally, because the signals do not have to travel over land, accuracy should not be subject to as many potential disturbances as LORAN C. NAVSTAR's operational life should extend well past the year 2000.

The potential accuracy of NAVSTAR is superior to that of LORAN C, but it is doubtful that the improvement is significant to this application. That needs further examination. Also, it suffers from a major drawback. Since NAVSTAR is not yet on line, it is likely that there will be a considerable time-lag in the availability of affordable receivers. It has been estimated that the cost of a receiver will be many, many times that of LORAN C. Also, a question exists about the level of accuracy that will be available for users outside of the Department of Defense. It seems probable that NAVSTAR will replace LORAN C eventually. This does not mean that LORAN C will become obsolete at that time because civilian use of LORAN C (particularly in general aviation) has exceeded predictions. The primary drawback is that GPS is not available at

this time. Its completion and activation schedule have been seriously affected by the general problems which have recently beset the U.S. space program. When it will be available and to what extent it can be utilized for the purpose of AVM remain to be seen.

3.7.3 Criteria for Designing a Preferred Monitoring/Prenotification System

Development of the system requires decisions regarding the notification mechanism and monitoring technology and information distribution in light of reliability and security considerations.

Prenotification

The criteria to consider in shipment prenotification system development include:

- Value of the information provided to a recipient,
- Reliability of the information provided,
- Reliability of the process used, and
- An assessment of the risk exposure that occurs by releasing a piece of information to a given recipient.

Monitoring

Candidate systems for monitoring should be evaluated according to the following features, which are desirable for monitoring waste transport to a repository:

- Provides security of the vehicles' locations so that terrorists or others cannot easily anticipate their passage along a given route.
- Provides sufficient accuracy to locate a vehicle easily in an emergency and to dispatch emergency response teams to that location.
- Provides reliable information not easily disrupted by interferences of various types, including weather.
- Provides a reliable communication link with the command and control center responsible for monitoring vehicle location.
- Is amenable to computer generated displays such as digital maps.
- Is amenable to programming for delivery of annunciator displays to alert the command and control center regarding important or critical anomalies in the transportation process.
- Delivers emergency signals initiated aboard the vehicle.

- Provides the above features at a reasonable cost.

This entire area needs to be researched in greater detail. For the volume and frequency of nuclear waste to be shipped to a repository, all notification procedures and requirements should be re-examined. The information required to develop a preferred shipment notification plan includes:

- An assessment, with input from experienced persons in emergency response, on what information would be most pertinent (e.g., description of contents, emergency response procedures, routing, and time of passage).
- A review of what information state, Tribal and local officials would like to have and what information is necessary for them to fulfill their responsibilities.
- An estimate of how much time should be allowed between notification and shipment, including an assessment of the downside risks of information leaks.
- An analysis of the technological options for obtaining and distributing information.
- Assessment of the risk of unauthorized people intercepting information, by distribution option.
- Technical specifications and performance tests on alternate vehicle/tracking options.

3.7.4 Preferred Shipment Monitoring/Notification System

At a minimum, the system must satisfy current regulatory requirements as set forth in 10 CFR 71.97. This includes a complete description of the contents, names of the shipper, carrier and receiver, route and approximate time of shipment, a contact phone number, and other information to be sent to the governor's designee. The monitoring system must include radio communications and immediate ongoing computer processing of the location estimates. Ideal performance would be achieved when no additional risk reduction would result from either expanding the type and distribution of information or providing it in a more timely fashion.

Prenotification for nuclear waste shipments should include the following information:

- The name, address and telephone number of the shipper, carrier and receiver.
- A telephone number, which must be staffed 24 hours a day, at which the shipper may be contacted in case of an emergency.

- A description of the shipment as required by 49 C.F.R. Sections 172.202 and 172.203(d).
- A listing of the routes to be used within the State of Nevada and the routes to be used within the 12 hours immediately preceding entering the State.
- The estimated date and time of departure from the point of origin of the shipment.
- The estimated date and time of entry into a state.
- Planned stops, if any, in a state.
- The mode of transportation.
- A statement that the notification must be protected in accordance with the requirements of 10 C.F.R. Section 73.21.

If the shipment is to be made by rail and dedicated trains are not used, the railcar carrying the cask should be identified by car initial and number and position on the train. Also, identification of the railcar containing emergency response equipment by car initial and number and position on the train should be provided.

The requirements should include written notification to be received within a certain time before the shipment arrives in the state. Individuals who are to receive prenotification information should be broadly described by the federal regulations as those who will plan for or respond to an incident or an accident involving the shipment.

Past errors in fuel loading, cask draining, etc., could have been almost immediately detected with a transponder inside the cask. The transponder would radio data on temperature, pressure, several types of radiation, and the concentrations of moisture, helium and oxygen. Such a device would also be helpful to cask receivers, to emergency personnel trying to assess cask leakage in an accident, and as a beacon to find a lost or buried cask. A cask transponder would allow maintenance and emergency response personnel to determine what cask problems may exist that require service or special handling. It would also reveal maintenance and handling errors before they can become serious. The records of such a detection device would become part of the cask database.

It is recommended that any system employed include an Emergency Locator Transmitter (ELT). This is a device which could be manually triggered or triggered by shock. Thus, if there is an emergency such as an accident or derailment, the transmitter would be activated to help emergency personnel locate the vehicle.

3.7.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Shipment Monitoring and Prenotification	Assess information needs of state, Tribal and local governments	15 (1988)
	Pilot test TRANSCOM system	14 (1989)
	Assess alternative technologies for providing needed information	11 (1992)
	Design shipment monitoring and prenotification system	10 (1993)
	Promulgate implementing regulations	9 (1994)
* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.		

3.8 INSPECTION AND ENFORCEMENT

The principal goal is to develop an inspection and enforcement plan which maximizes the risk reduction benefits. The marginal rate of risk reduction on inspection and enforcement should be set so that it matches that which can be derived from any other risk reduction action (e.g., cask improvements, infrastructure investments, training programs, etc.) From an institutional standpoint, the objective is to ensure that shipments are in compliance with federal, state, Tribal and local regulatory requirements and to take appropriate enforcement actions if violations are found.

3.8.1 Regulatory structure

Inspection and enforcement of nuclear waste shipments must be accomplished by state, Tribal and local governments, because the federal government does not have adequate personnel to properly perform the functions. However, a preferred regulatory system should include federal regulations creating minimum standards for inspection training. Since the early 1980s, DOT has encouraged states to take a more active role in inspection and enforcement activities pertaining to hazardous materials shipments. This is most cost-effective because state government personnel already have vehicle inspection and enforcement responsibilities. Training for these functions should be provided at a level that will enable neighboring jurisdictions to rely on each other's inspections, creating a need for national minimum standards.

Pursuant to the Federal Railroad Administration's State Safety Participation Program, states are encouraged to participate in investigative and surveillance activities with respect to the federal railroad safety laws. These provisions should be broadened to ensure that states may actively participate in the inspection of nuclear waste rail shipments.

National standards that allow state regulation should also be established for the timing of inspections. Certain inspections--point of origin, interchange, point of destinations, and accidents--are so clearly necessary that federal regulations can be easily articulated and achieved. Other conditions do not so readily present themselves, nor are they necessarily found throughout the country, making it essential that states be permitted to regulate in the area.

A copy of all notices of violations issued should be sent to the carrier as well as DOE. A copy should be sent to the carrier to ensure corrective action is taken. DOE should receive a copy so that it may oversee a carrier's safety record. Safety records should be taken into consideration by DOE in deciding whether to contract with a particular carrier.

The regulatory structure of the federal, state, Tribal and local governments must also provide for civil and criminal penalties. These penalties must be set at a level that encourages compliance with the laws.

3.8.2 Key Issues for the Preferred Inspection/Enforcement Program

Consistent Inspection Criteria and Procedures

NRC, DOT, DOE, and the DOE Office of Defense Programs all currently have inspection procedures for transporting nuclear materials. The OCRWM is considering another such program. This multiplicity of inspections needs to be coordinated to maximize consistency and ensure complete coverage of the significant inspection issues. Otherwise, there is a possibility that nuclear waste shipments would be caught in political wrangling between agencies, and safety would suffer.

There should also be consistency among modes. Inspection procedures for truck must parallel those for rail or any other mode, using common procedures wherever possible, and ensuring, most importantly, a consistent level of safety assurance regardless of mode.

Role of State, Tribal and Local Governments

DOT, in particular, has encouraged the states to take an active role in inspecting vehicles and enforcing the DOT standards. This policy has fostered considerable state activity. States are likely to continue this role in the future, building upon the programs already in place, to address the special needs and concerns of the nuclear waste shipments. From the OCRWM's perspective, this means that if states elect to conduct border inspections, or institute any other type of local inspection programs, provision will need to be made for these activities. For instance, border inspections would become a planned stop for the vehicle; and local/state inspections would have to be conducted at opportune times and locations. Perhaps, a comprehensive inspection process could be developed which satisfied all states' requirements, with each state being notified by mail of the inspection results and corrective actions taken. A simplified guidebook should be developed and distributed to state, Tribal and local law enforcement personnel to enable them to carefully check any item on a cask or transporter and impound the shipment when a problem was found.

Field Inspections

Some equipment on the vehicles is prone to failure on short notice. Truck air brakes are a good example. Point of origin inspection will not be capable of detecting potential failure of these components. If the vehicle then fails state inspection, the shipment may be immobilized until a replacement arrives. This process could extend more than a day. New equipment could also fail unexpectedly during operation, possibly resulting in an accident. Periodic field inspections during transport by the crew could detect many more impending failures than point of origin inspection could. The risk incurred by this policy would be the extended field stoppage which would increase the chance of sabotage.

Inspection of Carriers and Other Contractors

The OCRWM will need to periodically inspect the carriers and the retained service facilities to ensure that the terms of their contract are being fulfilled. The carrier's financial and shipping records should be audited to verify whether shipping papers have been filed correctly and other record-keeping obligations met. Vehicle maintenance records should be verified and crew training should be audited. The driving records of the crews should also be examined. Service and maintenance person qualifications should also be verified.

3.8.3 Inspection and Enforcement in a Preferred Transportation System

At a minimum, the inspection and enforcement program must be as stringent as the current program used for nuclear waste shipments. Ideally, the system should perform in such a way that the risk protection being afforded by inspection and enforcement is equal to or greater than that for any other area (e.g., cask design). Development of the inspection and enforcement procedures involves the following decisions:

- How inspection responsibilities should be divided among the carriers, DOE, NRC, DOT, and states, Tribal and local governments;
- Decisions as to consistency among inspection criteria/procedures, and if so, development responsibility and composition;
- When and how often inspections should take place (by type);
- Where the inspections should be conducted; and
- What items need to be inspected and how often.

Development of the enforcement plan involves other decisions including the division of enforcement authority among the carriers, DOE, NRC, DOT, and states, Tribal and local governments. Also, violations need to be defined and related penalties adapted along with enforcement proceedings.

3.8.4 Information Needs

To develop a preferred inspection and enforcement plan, the following information is needed:

- Comparison of present carrier, DOE, DOT, NRC, state, Tribal and local inspection requirements.
- Development of technically-based inspection and out-of-service criteria.

- Technical analysis of transportation equipment failure frequency suggesting a criterion (miles traveled or time elapsed) for inspection frequency for tractors/locomotives, trailers/railcars, casks, tiedowns, rails, etc.
- Marginal benefits of each inspection procedure.
- Comparison of present carrier, DOE, DOT, NRC, state, Tribal and local enforcement procedures.
- Alternative enforcement plans and their benefits.
- Alternate plans for distributing the inspection and enforcement responsibilities and the benefits for each.
- Assessment of the relationships between inspection frequencies, enforcement penalties, and compliance.

All of the areas outlined require significant research. One of the least understood aspects of the inspection and enforcement procedures is the integration between them. A comprehensive examination of the alternative enforcement options that should follow from inspection results should be compiled. Alternative enforcement plans then must be assembled and their potential effects studied.

3.8.5 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Inspection and enforcement	Identify inspection and enforcement issues	17 (1986)
	Research technical inspection and enforcement issues	15 (1988)
	Clarify roles of federal, state, Tribal and local governments	14 (1989)
	Develop inspection protocol	5 (1998)
* Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.		

3.9 PHYSICAL PROTECTION

It is the major objective of physical protection to prevent, by means of technical, organizational, and political measures, the deliberate destruction or disturbance of waste transports. Such measures should be designed to avoid or counteract human intrusion aimed at releasing or stealing radioactive material. Although it is almost impossible to quantify the probability of sabotage or terrorist attacks, one can systematically address and calculate the potential consequences. The consequences analysis itself allows for design and evaluation of management options.

Similar to deficient quality control, sabotage or terrorism can affect incident-free and accidental release of radioactivity. Disgruntled operators or terrorists might be interested in the increase of surface radiation or in the creation of small leaks for increasing the incident-free exposure level. This would, of course, result in a higher dose for operating personnel and bystanders. It is difficult to assign credible motives for undertaking this form of sabotage. Slight rises in radiation levels, which may well go undetected during transportation, do not make for the drama of nuclear blackmail or public threats. This leaves the prospective terrorist with the unrewarding option of harming bystanders without gaining any recognition or political advantage in the bargain.

More probable are attempts to cause an accident. Manipulation of vehicles or containers, blackmailing or manipulation of operating personnel (intoxicating drivers, for example), or placing obstacles on the transportation routes are examples of actions that are easy to accomplish, that have a low probability of prior detection, and that will trigger high publicity and social amplification that might jeopardize the continuation of the nuclear program in the United States. Other forms of human intrusions include stealing vehicles or casks, blocking routes, abducting drivers or other handling personnel, or threatening shipment companies. Figure 12 lists the various options available for human intrusion. They focus on attacks induced by outside forces, manipulation of vehicles, or voluntary or forced compliance by personnel.

Social risks, such as sabotage and terrorism, are difficult to quantify. Since these actions are directed towards deliberate destruction of containers or vehicles, however, a few attempts may be sufficient to release a large amount of radioactivity or, in the case of manipulation, to cause an accident. Hence, a small probability of occurrence is superceded by the near-certainty of the effect. That is why risk management has to deal with these risks in great detail; for just one incident may well cause tremendous damage. But even incidents causing only minor damage are likely to yield a long-lasting impact on social and political perceptions. This could not only weaken public confidence and trust in official decision-makers and decision-making institutions, but also hurt economies in the host state and corridor states.

Figure 12 . Options for Terrorism and Sabotage

1.	Use of explosives: <ul style="list-style-type: none">- airblasts- contact or breaching charges- shaped charges- platter charges
2.	Hijacking of transportation vehicles <ul style="list-style-type: none">- stealing a vehicle during a work break- gaining control over the vehicle in a remote area- taking a driver as hostage- stopping a vehicle and threatening to blow it up
3.	Manipulating the vehicle <ul style="list-style-type: none">- initiating malfunctions of safety related devices (brakes, steering wheel, tires)- placing obstacles on the road (like glass splinters)- loosening the links between vehicle and container
4.	Manipulating the vehicle's operator <ul style="list-style-type: none">- smuggling drugs into operator's diet- exerting physical power on the operator- blackmailing the operator- exerting psychological power on operator (like threatening to kill family members)
5.	Theft <ul style="list-style-type: none">- initiating an accident for obtaining material- initiating a hijacking for obtaining material- theft of a vehicle during a night stop- exchange of vehicles during a night stop- armed robbery during loading or unloading

According to the OTA report on transportation (OTA 1986, 186), attempts to attack or manipulate vehicles transporting nuclear material have not been reported in the United States. But with an increasing number of transports each year and a regular schedule of shipments, the likelihood of a terrorist attack may increase. The consequences of such an attack can be far-reaching. An early NRC estimate for a terrorist attack on a transport vehicle carrying a cask with spent fuel included five to nine early fatalities and as many as 1,888 latent cancers. Simulation tests conducted after this initial assessment relativised this outcome and yielded no early fatalities and only 14 latent cancers in the case of a successful attack (OTA 1986).

Sabotage and terrorism are probably the most serious threats associated with the transportation of radioactive material. Therefore, special safeguard measures are usually taken to protect the crewmembers and the shipment. Transportation of radioactive material has to meet governmental and state regulations. It should be noted, however, that overdoing safeguards measures, in particular monitoring crewmembers and investigating their private and political activities, creates a risk of its own and endangers civil liberties. In addition, police responses against demonstrators of protestors may be over-protective and thus challenge the right of free speech and free assembly. Absolute security against sabotage or terrorist attack is impossible. Any attempt toward perfect protection would inevitable result in the loss of substantial civil liberties. Protective actions need to strike a balance between high-cost overprotection, and its resulting frustration of personnel and citizens, and underprotection and its resulting health risks.

3.9.1 Regulatory Structure

The threat of sabotage or terrorism affects federal, state, Tribal and local governments as well as the nuclear waste transportation carrier. A preferred system must address the several facets of the problem. Both federal and state governments must declare radiological sabotage and threats against or diversion of nuclear waste to be a felony, punishable by incarceration and a hefty fine. Both levels of government must also be sure that agencies and personnel that may be involved in responding to such an incident have appropriate statutory authority.

The NRC physical protection requirements [10 C.F.R. Section 73.37 (1987)] along with the following changes should become part of the preferred regulatory system, for they comprehensively prescribe the carrier's conduct:

- The purview of the regulations must be extended to govern all nuclear waste shipments and all shippers.
- The prenotification requirements should be regulated as part of the emergency response system rather than as part of the physical protection requirements.
- The term "heavily populated area" should be defined.

- Escorts in separate vehicles in all circumstances rather than in "certain" circumstances.
- The NRC should be required to notify appropriate state officials of explicit or potential threats to a shipment within an appropriate period of time.

3.9.2 Preferred Management Options

All safeguard provisions seek to discourage, prevent, or mitigate sabotage actions. They should be designed to keep a proper balance between overreaction, which poses the political risk of social unrest and disintegration; and underreaction, which may encourage terrorists to target nuclear waste transportation. A preferred management plan should consist of the following analyses:

Scenario Assessment

Traditional risk assessment methods rely on a sufficient data base to derive meaningful probabilities for each investigated incident. Furthermore, the occurrences of failures must follow a specific pattern including random variation. But sabotage and terrorist attacks meet neither of these criteria. Past data on human intrusion does not allow any numerical extrapolation to determine relative frequencies nor do we have a good model on the underlying distribution function of such incidents. Apparently, terrorist attacks are not randomly distributed, but depend on political and psychological circumstances. Unless we find an adequate model to explain and predict such circumstances, we are unable to determine probabilities for different types of incidents. Using expert judgement to elicit probabilities does not overcome this conceptual problem, because experts themselves lack the necessary knowledge to make such judgments.

An alternative is the construction of scenarios and their rank ordering on the basis of an interpretive methodology. The methodology requires that researchers or group of experts play the role of political terrorists and design actions that they consider most cost-effective in reaching a desired terrorist goal. Analyses of terrorist actions have revealed that most attacks were designed according to the traditional concept of economic cost-effectiveness. Thus, although the goals may be irrational, the terrorists' planning approach might be duplicable by a group of experts and might reveal the most probable means to accomplish the terrorists' goals.

The result of such role playing is a set of scenarios that can be ordered according to the frequency with which different teams selected them. In contrast to the traditional risk analysis, these frequencies represent only ascending degrees of perceived cost-effectiveness and are not based on past occurrences. An example might be an attack by a radical antinuclear group determined to end the nuclear program in the United States. Although bombing has been a preferred option by terrorists so far, the peculiar situation

of waste transportation may render this option less effective than the manipulation of vehicles or transport routes since the same effect can be obtained at lower cost. Such manipulations are less costly and less detectable than the purchase and undetected emplacement of explosives. In addition, a radical antinuclear group is unlikely to endanger "innocent" bystanders, but would be content with causing a major accident, even without a radioactive leak and thereby jeopardize the continuation of the waste-transportation program as a result of the social amplification of such an event.

This example illustrates the hermeneutic method of mentally identifying with a potential intruder and deducting the most likely scenarios of reaching the pretended goals. It is important to simulate different groups in such an analysis: from political terrorists, to antinuclear radicals, to right-wing extremists, to disgruntled employees. Based on an array of different motives and goals, a set of scenarios can be generated and classified for which protective actions should be taken.

Vulnerability Analysis

Given the set of scenarios, the next step encompasses the analysis of opportunities for each scenario to be implemented. Times and location that are best suited for different forms of attacks have to be determined and specified. For example, the risk of vehicle manipulation is larger during overnight stops or before a shipment is placed. Special attention is therefore necessary during these time spans in order to compensate for the given opportunity.

A vulnerability analysis should result in a systematic classification of opportunities for each identified scenario. The ultimate objective is to avoid opportunities for attacks through organizational and technical measures, or to reduce the risks of such opportunities to make them less attractive for potential intruders.

Screening of Management Options

The third step in the analysis is the generation and preselection of measures that would be able to prevent, ensure avoidance, or counteract human intrusion. Based on the scenario and vulnerability analysis, measures must be designed to offer adequate protection against each scenario and reduce the opportunities for terrorists to implement any of these attacks. The following types of measures should be considered:

- Technical measures:
These include vehicle construction and maintenance, bullet-proof windows, cask design, radiation protection and detection devices, accident prevention systems safety features, protection against unauthorized driving (i.e. via access card), and others.
- Organizational measures:
These include screening of personnel, inspection of vehicles prior to any start, notification system for all waste transportation, real time monitoring through remote sensing devices, changing of routes, regular inspection of routes, and others.

- **Safeguard measures:**
These include escorting service, guarding of the vehicle, armament of drivers or handling operators, prior notification of police, installment of alarm systems, and others.
- **Mitigation measures:**
These include routing through deserted areas, improvement of post-accident management, protection against unauthorized access to material inside the cask, automatic detection system for stolen vehicles, and others.
- **Political measures:**
These include psychological incentives for waste handlers and operators to identify with their task, risk communication programs, observation of radical groups, severe penalties for terrorist attacks, and others.

Greatest emphasis might be given to technical and organizational measures as they usually do not intervene with conflicting goals such as civil liberty and modesty in displaying governmental power. But many scenarios may demand a combination of all types of measures in order to sustain a desirable level of protection.

The screening of options should result in a list of measures assigned to each scenario from which a final selection can be made. A preselection may be done on the basis of transportation system cost-effectiveness for options that provide the same degree of protection. The final selection, however, should occur at a latter state.

Resilience Analysis:

Since all the scenarios are based on subjective judgments of experts, management options should be designed to meet also unexpected or still unforeseen intrusions. It is difficult, of course, to provide protection against an unknown form of attack. But several principles of resilience have been proposed to cope with this challenge:

- **Redundance:**
Essential safety systems should be engineered on the basis of redundant systems so that the failure of one system can be compensated by another. For example, two independent braking systems may be installed in the vehicle so that cutting the brake fluid hose by terrorists would not result in malfunctioning of the total braking system.
- **Diversity:**
Redundant systems have to operate on the basis of independent technical or organizational principles. For example, two driver may be required to accompany each shipment so that blackmailing or physically attacking one driver (i.e. poisoning, intoxicating, etc.) can be detected and the damage prevented.

- Worst-case mitigation:
Assuming the worst case accident, mitigation methods have to be available to prevent a major catastrophe. For example, evacuation plans for communities along the transportation routes should be constructed and tested.
- Avoidance of regularities:
Potential intruders rely on repeated patterns of transportation and routing in order to plan for a successful attack. Changing routes, using different times for shipments, altering schedules, organizing random checks and inspections, and changes in safeguard procedures are potential tools to confuse intruders and impede long-term planning of terrorist attacks. The less time is available for planning and designing a terrorist attack, the better the chance that it can be detected and counteracted.
- Interactive game-theoretical simulation:
Assuming that the terrorists are aware of all the physical protection measures, an interactive computer simulation may be devised to suggest new strategies by terrorist groups and potential countermeasures. Such a simulation might provide new clues for advanced physical protection and could help to be always one step ahead of the potential intruders.

The goal of the resilience analysis is to test the proposed management options and amend the list of protective actions if deficiencies are detected. The total system of protective actions should be examined for comprehensiveness and resiliency against human intrusion.

Decision Analysis

The final selection of elements and components for inclusion in a physical protection system cannot be based on a single criterion. Therefore, techniques such as multicriteria analysis or multiattribute decision analysis should be employed to ensure a satisfactory solution. Criteria for finding the best solutions might include:

- Physical protection: the degree to which the management option can prevent or mitigate the effect of the scenario of the scenario under consideration,
- Cost: the material and social resources necessary to implement the option,
- Feasibility: the compliance with technical and legal requirements,
- Political acceptability: the public perception and acceptance of the proposed measures, or
- Social impacts: the secondary effects triggered by the implementation of the proposed measures, such as social disturbance, political apathy or protest, alienation, employment opportunities, and others.

It is inevitable that the decisions evolve from conflicting goals; and therefore, value judgments have to be made with respect to the relative weight of each criterion. Thus, the decision should be made on a broad basis of public support by involving different stakeholder groups and the affected public. Through a carefully designed and open decision process, the selected measures will be more readily accepted by all involved groups. This in itself may be an

indirect measure to reduce the probability of dissatisfaction of employees with the safeguard measures. Similarly, such a process may prevent the radicalization of citizens with respect to the nuclear transportation program.

Sensitivity Analysis

The last step before implementation is to ensure that the system of selected measures is consistent and robust vis-a-vis changes in scenario parameters. Although the resilience analysis provides an initial check to test the flexibility and persistence of the system, the sensitivity analysis examines whether the protection system is able to cope with variations of the existing scenarios. The selected measures may provide ideal protection against the consequences of the proposed scenarios but may fail if the scenarios are slightly altered. In this case, a second round of decision making is necessary to create a more flexible response system.

The six-step analysis cannot guarantee absolute protection, but it can reduce the probability of human intrusion and mitigate the consequences of such an incident. A monitoring program is also essential after the measures have been implemented. The State of Nevada may use this model to design its own management plan or to evaluate and improve existing DOE procedures.

3.9.3 Preferred Decision Schedule

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
Physical protection	Analyze the probability of various shipment interference scenarios	19 (1984)
	Analyze consequences of worst-case scenario(s)	19 (1984)
	Identify potential physical protection improvements	17 (1986)
	Assess trade-offs between physical improvements and other impacts of the transportation system	15 (1988)
	Initial design of physical protection system	13 (1990)

Preferred Decision Schedule (continued)

<u>ISSUES</u>	<u>DECISION/ ACTIVITY*</u>	<u>NUMBER OF YEARS BEFORE REPOSITORY OPERATION (YEARS)*</u>
	Finalize design of physical protection system	8 (1995)
	Promulgate regulations	5 (1998)

- * Completion of activity unless indicated otherwise; assumes repository operational in the year 2003.

- o Shipping papers
- o Placarding
- o Inspection and enforcement
- o Sabotage/terrorism (physical protection)
- o Escorts
- o Permits and fees

1.5 EMERGENCY PREPAREDNESS

To be provided under separate cover.

2.0 TRANSPORTATION SYSTEM DESIGN

This section of the report outlines the transportation system design issues that should be considered in conducting the impact assessment. The transportation system design issues are presented in terms of seven major elements:

- o Volumes and timing of waste shipments.
- o Cask design and testing.
- o Modal mix/truck and rail shipment options.
- o Equipment/vehicle standards.
- o Routing.
- o Infrastructure.
- o Defense waste.

2.1 VOLUMES AND TIMING OF SHIPMENTS

Considerable uncertainty exists as to the rate at which nuclear waste should or will be shipped to the repository. Additional uncertainty is created by the absence of decisions on an MRS, modal mix, fuel consolidation and the capacity of the casks to be utilized.

Thus, the impact assessment should assess a number of different scenarios including (at a minimum):

- o Varying cask load carrying capacity.
- o Several truck and rail shipment options (as described in section 2.3 of the Preferred Transportation System report).
- o Various annual distributions of the 70,000 tons of uranium (MTU) to be shipped to the first repository.
- o Various periods (up to 100 years) of waste storage prior to shipment to a repository.
- o Various seasonal and daily patterns of waste shipments.

2.2 CASK DESIGN AND TESTING

The impact assessment should include assessment of the safety of cask design, including cask design features to minimize opportunities for handling problems and actual failure, and in a severe accident, mitigating the extent of a release while aiding the work of emergency personnel.

In the past, casks have been designed to hold fuel recently removed (i.e., less than one year prior to shipment) from the reactor, necessitating heavy radiation shielding and occasionally a means to cool the cask. Shipments to the first repository will probably, however, involve fuel that has been out of the reactor for 10 years, during which time the fuel has radioactively decayed and thermally cooled appreciably. While the long-lived radioactive materials contained in the fuel are still quite dangerous if dispersed, the total direct heat and radiation output has dropped almost 90 percent during the decade of storage. Cask design will therefore require less shielding and no active cooling system. It is likely that these changes will allow a doubling of cask capacity while remaining within design limitations.

2.2.1 Cask Design and Testing Issues

Several aspects of cask design have generated controversy, specifically:

- o Design analysis tools, such as computer simulations and empirical mathematical formulae, vary in their development from one test to another: are simplified methods sufficient to model actual behavior of the various cask materials under stress?
- o The accident tests are only hypothetical: do they replicate the worst-case stresses in the real world?
- o Only designs are certified, not the casks themselves: is the hardware identical to the plans?
- o Cask manufacturing has only been spot-checked in the past: does examination of paperwork after the cask is built demonstrate that the cask was properly made?
- o Human error, in design and/or fabrication, can compromise cask integrity under routine conditions as well as during an accident: could simple mistakes seriously jeopardize cask performance?

The Nuclear Waste Policy Amendments Act of 1987 (NWPAA) clarified that all shipments to a repository must utilize United States Nuclear Regulatory Commission (NRC)-certified casks. At this time, however, it is not clear that the existing NRC cask certification program is adequate to ensure that casks meet their design specifications.

2.2.2 Impact Assessment Methodology

In addition to assessing compliance with existing NRC requirements and guidelines, the impact assessment should assess whether the cask design and testing program achieves an equivalent level of safety and reliability as the additions/changes recommended in section 2.1 of the Preferred Transportation System report as summarized below.

- o Utilize consistent and improved analytical methods.
- o Implement as low as reasonably achievable (ALARA) radiation exposure principle in cask design.
- o Simplify cask design to avoid human error in fabrication.
- o Toughen stress tests for both casks and fuel.
 - The fire and puncture tests should be reversed
 - Increase the fire test to one hour fire at approximately 2,200 degrees Fahrenheit
 - A crush test exerting forces equivalent to a collision between two 100-ton casks in a multiple-cask rail shipment
 - Impact and thermal tests of aged fuel to assess leakage potential of undamaged fuel and an assembly having pinholes or hairline cracks
- o Remotely monitor the internal conditions of the cask.
- o Translate generic cask license changes into federal regulations.
- o Eliminate unnecessary cask equipment.
- o Incorporate fail-safe controls in cask design.
- o Integrate vehicle and cask.
- o On-board fire-suppression system.
- o Perform full-scale cask testing.
- o Directly observe manufacturing and materials qualifications.
- o Federal certification of each cask.
- o Utilize "watchdog" agency for cask design, production and maintenance.
- o Establish fuel assembly/cask database.

2.3 MODAL MIX

This section addresses how the modal mix issues should be considered in the transportation impact assessment. The discussion focuses primarily on questions of rail versus truck; the transfer of shipments from one mode to another (e.g., rail to truck); the trade-offs between such options from the standpoint of risk, cost and other factors; and the implications of such options to the state, Tribal and local governments in Nevada.

2.3.1 Modal Mix Assessment Factors

The assessment of modal mix must be made from an overall system perspective. Performance must be assessed on the total system. Impacts associated with modal choice will be analyzed via the specification of alternative modal characteristics, reflecting various assumptions concerning such characteristics, which are then used in the transportation analysis framework discussed previously.

Among the most important objectives to consider in modal choice are the following:

- o Risk (measured by population exposure, expected fatalities, injuries or property damage, etc.).
- o Cost (both monetary and nonmonetary, to the DOE, the carrier, states, Tribes, local governments and other affected parties).
- o Site access (cost, technical and operational feasibility of the various modes).
- o Shipment time (days of exposure, vulnerability to sabotage/terrorism).
- o Weather sensitivity (the weather-dependency of the mode and the difficulties of compensating for it, such as safe parking areas to be used in the event that snow blocks mountain passes).
- o Security and safety (both for the cask and the personnel accompanying it).
- o Carrier qualifications (such as safety records, driver performance, maintenance practices and financial stability).

2.3.2 Truck/Rail Shipment Options

Changes in vehicle size and weight limits and development of a new generation of casks suggest that shipment size may increase, resulting in a change in the number of required shipments and a corresponding change in the

structure of risks and costs. The use of overweight trucks is of interest to the DOE because of their greater productivity. As a result, truck shipment size might increase from the current legal weight limit which can accommodate one pressurized water reactor (PWR) or two boiling water reactor (BWR) spent fuel assemblies to an overweight shipment which could accommodate three PWR and seven BWR assemblies, respectively. It is also possible, that through spent fuel consolidation and/or the allowance of a fuel burn-up credit, the quantity of waste per cask could increase several fold. There is also the possibility of the development of "hefty" rail casks which would carry an even larger quantity of spent fuel.

Issues relating to overweight trucks and various rail shipment options focus on such items as the deterioration of transportation infrastructure and the probability, frequency and severity of accidents. Central to this debate is the likely scenario that fewer shipments may result in fewer incidents/accidents, yet each such event may lead to more catastrophic results because of the increased volume of dangerous cargo which might be released.

The impact assessment should include an assessment of the following rail shipment issues.

Rail Service Issues

Dedicated rail service would require significant changes in procedures. The use of dedicated ("special" or otherwise) trains would permit the dispatch of multiple casks in a single shipment, thereby reducing the number of shipments required. Dedicated trains are attractive because of their simplicity, trackability, ease of crewing and escorting, and their "minimal" impact on railroad operations outside train dispatching. However, this "minimal" impact can be profound. It can make network travel times increase for all other traffic if trains encounter delays when passing the dedicated trains. Dedicated trains may also be more susceptible to sabotage/terrorism because they are more easily recognized. Other impacts of dedicated trains include the need for special servicing and the designation of locations where such servicing can be performed, specialized maintenance training for the personnel assigned to such facilities, and special tracks and facilities at such locations set aside for servicing the trains. Train priority rules may have to be established to ensure that the dedicated trains receive proper treatment without special orders being given to the train dispatchers.

In regular rail service, on the other hand, wastes would be moved with other freight on general merchandise trains, perhaps with speed restrictions, without disrupting normal operations significantly. Sabotage/terrorism vulnerability might actually be reduced since it would be more difficult to find and gain access to the cars. Rail cars transporting wastes could be gathered into shipment blocks, as is normally done, to minimize delivery costs. The cars might receive special treatment in classification yards, as high-and-wide cars currently do, being set out on specially designated sidings for storage while awaiting connecting trains. Major drawbacks would be

increased shipment time (resulting in increased radiation exposure), greater difficulty in car tracing and the need to conduct safety and security awareness training more fully among the ranks of rail employees.

Maximum train, cask and shipment sizes are related issues. The trade-offs are efficiency on the one hand and vulnerability to accident or attack by terrorist groups using black market anti-tank weapons on the other. Large trains (or large shipment sizes) would increase efficiency but generate greater vulnerability to attack and sabotage. This increase in risk can be partly offset by using a small cask size. For example, if an attack were to be made on a dedicated train, cars with relatively small casks would release only "small" amounts of radioactive material from any one punctured cask; multiple punctures would be required to gain the same level of release as would have occurred from a much larger one.

Interference with Normal Operations

The mere existence of nuclear waste shipments, regardless of configuration, will have an impact on the day-to-day operations of the carrier's entire system. For example, in rail operations:

- o Shipment size restrictions may affect train consists, blocking patterns, yard operating plans and classification track designations.
- o Operating rules may be affected if dedicated trains are required to stop at all railroad crossings with highways or other railroads.
- o Advance consists may be required to ensure that no problems exist with the track over which a waste-carrying train is about to pass (e.g., to check for broken rails and misaligned switches).
- o The yard treatment of nuclear waste cars should be different than that for other cars, necessitating changes in yard operations.
- o Crew requirements may be affected (there may be more crew members on waste-carrying trains), as well as their training (e.g., special training in emergency response and incident management).
- o Interchange requirements and procedures may need modification so that waste cars and their location and condition are more tightly controlled. Special procedures may be needed for dealing with waste cars that are found to have defects upon interchange inspection.
- o Special car and cask inspection procedures may be needed, and the inspection crews must have special training.
- o Restrictions may be needed for the placement of nuclear waste cars within trains (e.g., next to the locomotives, in the middle, at the end, next to the car carrying the escort personnel).

- o A caboose may be necessary to carry the escort party.
- o Special "supply crews" may be needed to quickly replace road crews whose hours of service have expired.
- o It will not be possible to leave trains carrying nuclear waste unattended as is sometimes done presently.
- o There may be extra restrictions that determine who is allowed to bid for jobs involving nuclear waste.
- o Special locomotive accommodations may be required for the escort personnel and their equipment and any special communications equipment used to keep track of train and car location and status.
- o Special foul weather plans may be needed to control the dispatching of trains and the operation of yards during inclement weather conditions.
- o Safety training programs may have to be modified to qualify employees for the special requirements of nuclear waste shipments.

Advantages of a Single Mode

There are significant advantages by focusing on only one mode. Redundant, equal capacity facilities for each could be eliminated in favor of a highly efficient, uni-modal complex. Such a solution would have the benefits of: fewer carriers, easier carrier selection, fewer contracts and easier shipment management. However, use of a single mode may be disadvantageous due to: "captive" shipper problems and vulnerability to natural or intentional disruption.

Information Required

At a minimum, the modal mix transportation impact analysis requires the following information for every shipment origin and destination:

- o Volume (total number of casks by size and weight, both of which are critical for determining the relevance of various modal options).
- o The risks associated with each shipment option (accident and incident rates, by mode and overall, for the best possible routes; resulting population exposure levels and consequence distributions; fatalities; injuries; latent diseases; etc.)
- o Operating restrictions (the extent to which the planned option requires extraordinary treatment and impacts beyond normal operations).

- o Cost (per shipment and total; operating, maintenance, and capital; to whom and how paid; timing of accrual).
- o Site access (technical, operational, and economic feasibility).
- o Shipment time (elapsed, from the perspective of radiation exposure and vulnerability to sabotage/terrorism, as well as cost and resource requirements).
- o Weather sensitivity (the effects of inclement conditions; expected delays; extraordinary resource commitments required to continue shipment under adverse weather conditions and/or place shipments in temporary storage pending weather condition improvement; importance of weather as a factor in scheduling shipments).
- o Security and safety (extent of personnel and other resources required to protect the shipment; the incremental resources required to minimize the likelihood of accidents/incidents; the complexity of special arrangements required to provide secured areas for storage during unforeseen or planned stoppages).
- o Carrier qualifications (safety record; personnel training and qualifications; maintenance practices; vehicle monitoring capabilities; financial condition; operating authority).

2.4 ROUTING

As with transportation modes, the choice of routes is fundamental to transportation impact and impact minimization issues. Routing decisions will determine the populations most impacted by the transportation system and will have important implications for emergency preparedness, infrastructure wear and the overall radiological and non-radiological risk of the transportation system. Whether one route or several routes are utilized will have important advantages and disadvantages to state, Tribal and local governments. Who makes routing decisions--the State of Nevada, some multi-state organization, the DOE, or the carriers--also has important implications.

Most routing issues are influenced by modal mix. In fact, the impacts of mode and route are so interdependent that an impact analysis must focus on assessing mode and route options in an integrated fashion. In the previous section on Modal Mix, considerable discussion was devoted to these joint considerations and will not be repeated here. However, it should be understood that the depth of routing impact assessment is on a par with dimensions of the modal mix.

The issue of equity is also important in assessing routing impacts. At the local level, routing exclusively along a particular corridor implies that a select few communities are absorbing the total transport risk associated with nuclear waste shipments. Beyond the geographical equity issue is the distribution of impacts across demographic segments, including Tribal lands, residential areas, commercial areas and places of public gathering. Finally, routing analyses must include consideration of impacts upon all affected jurisdictions.

2.4.1 Impact Assessment Methodology

Section 1.2 on Impact Assessment Models describes the analytical system for assessing the impacts of routing decisions and alternatives. Following are a number of important factors which the impact assessment should address concerning routing:

- o Population-at-risk and the geographic area of potential impact.
- o Exposure of vulnerable sites/facilities along alternative routes.
- o The use of high-traffic hazard areas which might increase non-radiological as well as radiological accident risk.
- o Routes which provide rapid access to potential accidents by emergency response teams.
- o The use of interchange points to expedite shipments.

- o The use of routes that avoid contact with other dangerous goods altogether so that the probability of a compound event is eliminated.

In some cases, however, these choices present trade-offs. For example, emergency response may be better in urban areas, yet this corresponds to areas of larger population-at-risk.

2.5 EQUIPMENT AND VEHICLE STANDARDS

In an effort to respond to cask and vehicle design considerations while maintaining weight limitations, several alternative vehicle designs may evolve. Under consideration at this time are designs which remove what may be nonessential items in terms of vehicle operating performance in order to reduce the weight of the basic operating system in favor of boosting cask carrying capacity. Elimination of the vehicle components considered nonessential would reduce vehicle weight, perhaps enough so that a larger capacity cask can be placed on the truck while maintaining legal weight.

Of course, human factors considerations may prevail in areas where this presents trade-offs with respect to driver performance. Therefore, equipment/vehicle standards must also take into consideration the effects of noise, temperature, vibration, cab configuration, braking systems, freedom of visibility, etc. Improved standards in these areas may offer an opportunity to mitigate certain impacts which will result from the transportation system.

Because of the limited experience to date with cask shipments via some modes (e.g., truck) and via all modes in the quantities to be shipped to a repository, the performance of each mode is not actually known. Assumptions will have to be made, based on past performance or pilot tests, to determine the risk and performance characteristics of each mode. However, it should be noted that carrier performance has a great bearing on modal performance because of the human element involved. For example, rail is not an automated system with absolutely repeatable performance; its performance is dependent on the technical competency and dedication of the people who make it function.

The impact assessment should also assess potential improvements (e.g. dead man breaks) to highway and rail equipment design that would reduce the risk from shipments of nuclear waste to a repository.

2.6 INFRASTRUCTURE

This section outlines a methodology for assessing the impacts nuclear waste shipments to a repository at Yucca Mountain will have on the highways and railways in the State of Nevada. This section does not address other repository-related transportation impacts such as the transportation of personnel and equipment.

The magnitude of the impact will depend on the increase of traffic volume and change of traffic composition. The potential use of overweight highway and "hefty" rail shipments are of particular concern. In this discussion, infrastructure includes support equipment, such as signals, and considers both existing facilities and potential new facilities.

The damages caused by nuclear waste shipments and repairs necessary to adequately maintain the infrastructure are controversial issues because, in most cases, these facilities are shared with other freight and passenger vehicles. Hence, it may be difficult to ascertain what proportion, if any, of damage to the infrastructure would be accountable to the nuclear waste shipments.

The existing road and rail systems need to be characterized in terms of its vehicle capacity, structural load, carrying capacity of pavements, track and bridges, geometrics, friction, accident records and ancillary facilities, etc. With proper characterization of the existing system and a definition of traffic to be generated by the repository, the economic and safety impact on roads and rail can be described within acceptable limits.

Because the road and rail networks and their usage are constantly changing, the present condition of the network must be established and updated periodically. Projected traffic increases and changes in traffic composition will have to be defined to periodically assess the impact on the transportation networks during the years of repository operation.

In conducting the impact assessment, a comprehensive view of infrastructure is necessary. For example, in the rail mode, infrastructure components in addition to track and bridges need consideration, including communications equipment, locomotives, car tracing equipment (hardware and software), signal system equipment, buildings for housing crews and escort personnel, special maintenance facilities for repairing the cars, and special storage tracks and secured areas for damaged and disabled equipment. In the highway mode, in addition to pavements and bridges, infrastructure elements such as safe parking areas need to be addressed.

Impacts will include the need for increased maintenance, rehabilitation and reconstruction of the existing system as well as identification of the need for new transportation facilities. Initial costs and life cycle costs need to be defined.

2.6.1 Impact Monitoring Process

The monitoring process deserves special attention because an initial outline is needed for what data to collect and how, both during the baseline period before the shipment program begins and during its operation. Categorically, two types of data can be collected: the first relating to roadway and track and the second relating to other types of infrastructure such as bridges, locomotives, and signal and communications equipment.

Insofar as roadway and track condition is concerned, baseline charts and maintenance cost data should be collected for the routes to be used, and special test measurement sections should be designated (e.g. rail profilometer readings, ballast borings and tie condition inspections). Once the shipment program is underway, the track charts and cost data should be recollected periodically and the field measurements repeated to determine whether heightened rates of wear have occurred. Observations will have to be frequent enough that the effects of rail changeouts, tie renewal programs and other programmed maintenance activities cause minimal problems for the impact assessment process.

For other infrastructure requirements, it seems sufficient to monitor the types of investments made, their capital cost and the attendant operating and maintenance costs. This applies to bridges, communications equipment, locomotives, car tracing equipment (hardware and software), signal system equipment, buildings for housing crews and escort personnel, special maintenance facilities for repairing the cars, and special storage tracks and safe parking areas for damaged and disabled equipment.

2.6.2 Impact Assessment Methodology

Types of Infrastructure Impacts

Assuming that highway and rail shipments of nuclear waste to the repository will occur in Nevada, the infrastructure impact assessment should consider the following aspects of both the highway and rail infrastructure in Nevada.

- o Traffic.
- o Reconstruction, rehabilitation and maintenance.
- o Pavements/rails.
- o Condition of bridges.
- o Need for new facilities.
- o Need for special facilities due to the nature of nuclear waste.

- o Capital and maintenance costs.
- o Accident prevention.
- o Operating restrictions.
- o Shipment time.
- o Weather sensitivity.
- o Security and safety.
- o Impact on other traffic.
- o Special facilities (such as safe stopping areas and inspection sites).

Economic Assessment Model

The costs of increased maintenance, rehabilitation and reconstruction of existing facilities and the construction of new facilities need to be assessed. Initial design and construction costs and life cycle costs in terms of current worth and equivalent uniform annual costs are of importance. Guidelines for conducting these types of cost analyses for pavements have been recently developed for the Corps of Engineers by the University of Nevada, Reno and are suggested for use as a starting point.

The initial and recurring costs that should be considered in this economic evaluation include the following:

- o State and local costs.
 - Initial capital cost of construction
 - Future capital cost of reconstruction and rehabilitation
 - Maintenance cost
 - Salvage value
 - Engineering and administration cost
 - Traffic control cost
- o User costs.
 - Travel time
 - Vehicle operation

- Accidents
 - Discomfort
 - Time delay and extra vehicle operating costs during resurfacing or major maintenance
- o Non user costs.

Need for New Facilities

New routes, such as a new highway bypassing the Las Vegas Valley and potential rail spurs to Yucca Mountain, should also be assessed for reducing the risk of the waste shipments. Since Yucca Mountain is not currently served by rail if the rail mode is to be used for shipments to the repository (without an intermodal transfer) a new rail spur to Yucca Mountain would have to be constructed. Several alternatives could be utilized for the location of the spur connection to the mainline and for the routing of the spur. The analysis of potential new routes (and alternatives) should be conducted in accordance with the network approach discussed under Routing (section 2.4).

Highway Infrastructure Impacts

The impact that a repository at Yucca Mountain will have on the infrastructure of Nevada's highways requires the evaluation of several components such as capacity of routes, condition of pavements, condition of bridges, safety of routes and cost. A capacity analysis of the routes that will be used to transport waste to the repository using an estimated traffic volume generated by the repository is needed to ensure that the level of service of the highways is adequate or to determine the need for widening or for the construction of new facilities. The condition of pavements and bridges must be established to determine the need for maintenance, rehabilitation or reconstruction. The cost of increased maintenance, rehabilitation and reconstruction of the existing facilities as well as the construction of new facilities needs to be established.

Traffic

The impacts of increased truck traffic related to waste shipments needs to be assessed for each of the various truck shipment options (single legal weight, convoy and overweight).

Reconstruction, Rehabilitation and Maintenance

The increased volume of trucks transporting nuclear waste needs to be evaluated for impacts on highway safety and structural capacity. Using the

projected traffic data, the time of reconstruction and rehabilitation of roads and bridges should be estimated and the cost defined.

The use of overweight trucks to transport waste to the repository is being considered in order to reduce the number of shipments. The structural integrity of the highways could be threatened by relatively few passes of very heavy loads. According to the American Association of State Highway and Transportation Officials, the pavement wear can be diminished by adding axles to the vehicles or by increasing the spacing between axles. Consequently, a properly designed overweight truck could cause less damage. In any event, a complete structural analysis will have to be performed to ascertain whether the existing pavements and bridges will be adversely affected.

Pavements

A thorough analysis of the impact of waste transportation to the repository on pavements requires detailed data on layer thicknesses and materials, subgrade material, traffic loading history, drainage structures, and physical and geometric features. These factors contribute to the pavement wear cycle. Standards for evaluating pavement condition include the following indicators: (1) serviceability, (2) ride, (3) rut depth, (4) cracking, (5) patching, (6) bleeding and (7) raveling. In general, the extended presence of items (3)-(7) reflects a road which has noticeably deteriorated and which may threaten safe transport. Depending on the scale of the problem, either maintenance, overlay or total reconstruction may be warranted.

A pavement management system for systematically scheduling maintenance, rehabilitation and reconstruction of pavements based on maximizing benefits or minimizing cost should be utilized. It will also be necessary to obtain structural section plans for all identified routes and to conduct destructive sampling to verify structural sections and to ascertain existing pavement structural capability. A drainage survey must be conducted for all routes.

Pavement Performance Models

Performance models should be developed (specifically for Nevada pavements) and used to predict the time to failure given typical traffic, maintenance and rehabilitation efforts and environment. This will encompass a review of existing performance models, an analysis of pavement performance in Nevada and an analysis of environmental data.

To develop a performance model to predict pavement failure, a representative sample of low, medium and high volume pavements can be obtained using the Nevada Department of Transportation (NDOT) Pavement Management System data. Traffic, maintenance and structural records are available from local agencies and NDOT. These data must be analyzed to find deterioration rates for existing pavements as a function of traffic, maintenance and rehabilitation, structural design and environment.

Condition of Bridges

The impact assessment should consider potential damage to bridges and other highway structures. The beginning point for the impact assessment is to understand the existing condition of all the bridges and other structures along the routes to be used to transport nuclear waste to the repository. The procedure for rating an existing bridge requires careful evaluation of many factors. All physical features of the bridge that have an effect on its structural integrity need to be examined, and the absolute maximum permissible load level that the structure may be subjected to must be determined.

Bridge inspection should include piers and abutments, stringers and girders, trusses, bearings and expansion joints, decks, sidewalks and railings. State and national agencies have developed inspection manuals that describe the equipment and type of information needed to evaluate the condition of bridges. The "Manual for Maintenance Inspection of Bridges," published by the American Association of State Highway and Transportation Officials, provides for the evaluation of bridge components by specifying stress carrying capacity in terms of loads producing the design stress and a higher allowable stress due to overweight vehicles.

Bridge Strengthening Needs

Strengthening is defined as a method to extend the lives of bridges that require additional load-carrying capacity to meet current and projected truck loads. Strengthening needs such as replacing, rehabilitation, widening or other structural work should be determined from a comprehensive bridge management system (BMS). A BMS should be used to compare different maintenance, rehabilitation and replacement options for Nevada's bridges.

Rail Infrastructure Impacts

This section addresses the assessment of rail infrastructure impacts caused by the transportation of nuclear waste to the repository at Yucca Mountain. There are two primary facets to this assessment, both of which have relevance to the before and after assessment activities. The first relates to heightened wear rates caused by the type of equipment used for the nuclear waste shipments; the second, to the incremental infrastructure investments required to accommodate the shipment program, not only track and bridges but other types of infrastructure as well, such as special communications equipment which might be installed in the locomotives used to power the trains carrying the wastes.

In the period before the shipment program begins, the purpose of the rail infrastructure impact assessment is to predict what the impacts will be for various combinations of rail shipment patterns and infrastructure options. This would include a comparative analysis of the impacts on the existing physical plant versus those that would be anticipated if the physical plant

were to be upgraded in some way.

In the period after the shipment campaign is underway, the methodology provides a mechanism for comparing the impacts observed with those which were anticipated. If a given impact is smaller or greater than expected, it provides a mechanism for reassessing the infrastructure decisions. For example, if concrete ties prove to minimize the recurring maintenance costs associated with cask-carrying cars, then capital investments should be considered on a widespread basis. Alternately, if concrete ties prove to have an effect indistinguishable from wood, then such action would be unnecessary.

Damage, Condition Assessment, and Construction and Maintenance Practices

The railroad industry has continually argued that spent fuel shipments cause extraordinary damage to the track. They point out that the 6 and 8-axle cars typically used have capacities above 100 tons, which is the de-facto industry standard (DOE is presently contemplating the use of such cars). They further claim that studies of rail wear, and moreover track maintenance, show significant detrimental impacts from 100-ton freight cars, vis-a-vis their 80-ton counterparts, let alone cars with capacities over 100 tons. Evidence to date suggests this could be a problem, and it may be compounded by the fact that dedicated trains would have a closely-spaced series of such cars (which means repeated stressing in rapid succession), a condition with which no U.S. railroad has experience.

A closely allied issue is that of condition assessment. If the nuclear waste shipments cause extraordinary damage, wear rates would have to be monitored closely. This would be important not only to the carrier (i.e., for appropriate compensation), but also to the governmental jurisdictions through which the shipments pass (especially for determining how frequently safety inspections should be performed). There is also a question of whether the United States Department of Transportation (DOT), Federal Railroad Administration (FRA) track class standards would be an adequate basis for measurement (many railroads think they are not) and if not, what other track quality index (TQI) would be appropriate.

Construction and maintenance practices are a third, related issue. Perhaps a minimum weight of rail should be specified. Constraints might be appropriate for the maximum degree of superelevation in curves. Also, track surfacing operations should perhaps be more frequent, as should rail changeouts.

Need for Special Facilities

Shipment of nuclear waste to a repository will generate the need for special facilities at selected locations throughout the rail network. There is the possibility that new bypasses would be warranted around heavily populated areas or that new, short links would be needed to connect one line to another

where they presently only cross. Special sidings may be needed, as well as set out tracks next to yard towers and clearance improvements. Track design and construction upgrades, discussed above, would also generate a need for "special facilities."

The needs go well beyond track. They include advanced signal systems, special crew quarters on locomotives, special car tracing hardware and software, track switch hardware and control equipment, secured areas for detained cars and trains, maintenance support equipment (especially for the cars), locomotive on-board communications hardware, train locating capabilities, grade crossing hardware and advanced dispatcher support systems.

Institutional Responsibility

Normally, each railroad has exclusive responsibility for, and absolute control over, the maintenance of its tracks and other facilities. However, it cannot be assumed that facility maintenance will occur automatically. Are the railroads transporting nuclear waste to a repository subject to contracts incorporating appropriate penalty-incentive clauses and inspection-enforcement procedures? Will the DOE contract with the railroads for facility construction, maintenance and operation including the following actions:

- o Cost of (construction, operation and maintenance) of any new spurs, connections, sidings, lines or other facilities built specifically to accommodate the nuclear waste shipments.
- o Penalty clauses for poor maintenance performance and provide attractive incentive payments for trouble-free service.
- o Services of an independent, maintenance auditing consultant who can spot-check carrier performance and recommend corrective actions where required (e.g., maintenance which should be performed, how much it should cost, and how it can be ensured, both contractually and through legal proceedings if necessary).

Impact Assessment

The rail infrastructure impact assessment methodology is best thought of as consisting of two distinct parts, one being a decision support system for determining what initial or subsequent rail infrastructure investments should be made to provide the safest shipment program possible and the other being a monitoring program to assess the heightened maintenance costs and other impacts caused by the shipments. The relationship between them is one of inputs and outputs: as the shipment program progresses, the impacts from the monitoring program become inputs to the decision-making process, and the decisions made affect the impacts observed in the future.

All infrastructure used for nuclear waste shipments should produce risk

levels (primarily expected accident rates) at or below that of all other candidate modes. Ideally, the level of risk prevention provided throughout the network should be uniform for all rail links being used to carry nuclear waste.

Information Required

At a minimum, the following information is required to assess rail infrastructure impacts:

- o Volume (total number of casks, by size and weight of shipment, critical for determining the relevance of various infrastructure options).
- o The marginal reductions in risk (e.g., due to decreased derailments) afforded by all possible improvements in infrastructure (e.g., changes in track class or some other measure of track quality), and the associated incremental costs.
- o A definition/delineation of the other special equipment which will be required to protect the shipments. Ideally, for each, this should identify the marginal increase in safety that each affords as a function of funds expended.

2.7 DEFENSE WASTE

The Preferred Transportation System report provides a baseline for assessing the impacts of defense waste shipments to a repository. The preferred system for defense waste transportation consists of all of the elements of the Preferred Transportation System (for nondefense waste) plus an assessment of the special needs of defense waste shipments. The Nuclear Waste Policy Act Amendments of 1987 (NWPAA) has resolved two important issues: defense waste will be transported in NRC-certified casks; and NRC prenotification requirements will apply to defense waste shipments to a repository.

The following issues have been identified as requiring special consideration in the impact assessment of defense waste transportation to the repository.

2.7.1 Design and Maintenance of Casks

The NWPAA requires that the NRC certify casks used by the DOE to ship defense waste to a repository. Since the defense waste casks will differ from civilian waste casks, their design and maintenance should be reviewed, and the NRC certification process should be monitored.

2.7.2 Shipment Volume, Rate and Timing

The DOE has utilized a figure of 20,000 canisters to describe the volume of defense waste to be shipped to a repository, an amount they equate to "10,000 pounds of heavy metal." The DOE has described the defense waste stream as being 15 percent of the total high-level waste stream of the nation in 1982, and projected to be 3 percent of the total in 2010. Details about volume, timing and rate of shipments either do not exist or will not be finalized until site-specific waste management plans are finalized at the DOE facilities now storing the waste. There has been no indication of the rate at which defense waste shipments will be implemented, and the modal mix of rail/highway/barge transportation has yet to be described. Furthermore, the DOE has not provided details in either the Yucca Mountain Environmental Assessment or in the Transportation Institutional Plan of the characteristics of defense waste, or of the vitrified or other forms in which the waste will be shipped.

2.7.3 Institutional Developments

Several government processes are or will be underway which should be monitored: the NRC will be asked to certify the casks proposed for shipment of defense waste; the physical protection systems utilized by both NRC and DOE are both subjects of proposed modifications; and the DOT regulatory system governing transportation will be further developed at federal, Tribal, state

and local levels to accommodate waste shipments.

2.7.4 Physical Protection/Safeguard Procedures

It is recommended that the safeguard systems which DOE proposes to utilize be compared with the physical protection requirements described in Section 3.9 of the Preferred Transportation System report.

The DOE has traditionally used internal safeguard procedures which are supposed to be equivalent to NRC procedures and approved by the DOT. However, the NWPA requires that NRC prenotification requirements be utilized for defense waste shipments to a repository. At the present time it appears that the DOE is free to implement the other components of its safeguard procedures.

3.0 TRANSPORTATION SYSTEM OPERATIONAL PROCEDURES

This section of the report outlines the transportation system operational procedure issues that should be considered in conducting the impact assessment. The operational issues are presented in terms of nine major elements:

- o Operations plans.
- o Carrier requirements.
- o Personnel training and qualifications.
- o Cask maintenance.
- o Vehicle maintenance.
- o Vehicle stoppage.
- o Shipment monitoring and prenotification.
- o Inspection and enforcement.
- o Physical protection.

3.1 OPERATIONS PLANS

To assess the impacts of transporting nuclear waste to a repository at Yucca Mountain from an operations planning perspective, the planned transportation system's operations plan (or planning approach) should be assessed against that discussed in section 3.1 of the Preferred Transportation System report.

Section 3.1 of the Preferred Transportation System report discusses the elements (subplans) of the operations plan. Following is a summary of these elements (subplans) that the impact assessment should address:

- o Technical information system plan.
- o Facility and vehicle operational readiness plan.
- o Maintenance and inspection plan.
- o Training plan.
- o Transportation plan.

- o Supervision plan.
- o Higher supervision services plan.
- o Independent audits and appraisals plans.

In addition to these subplans, the impact assessment should compare the planned transportation system's management control factors to those described in section 3.1 of the Preferred Transportation System report, including:

- o Policy.
- o Methods, criteria, analyses.
- o Line responsibility.
- o Staff responsibility.
- o Budgets.
- o Document control.
- o Hazard analysis and risk assessment.
- o Life cycle analysis.

3.2 CARRIER REQUIREMENTS

To assess the impacts concerning carrier requirements for the transportation of nuclear waste to a repository at Yucca Mountain, the planned transportation system's carrier requirements should be assessed against those described in section 3.2 of the Preferred Transportation System report. The impact assessment should, at a minimum, assess the following issues concerning carrier requirements.

- o The responsibilities assigned to each carrier and the responsibilities retained by the shipper (DOE).
- o The screening process used to select qualified applicants.
- o The screening criteria, including carrier experience.
- o The pre-qualification process used (e.g., test shipments) to ensure that carriers can achieve their "paper" qualifications.
- o Carrier selection criteria including:
 - Risk (e.g., expected fatalities, injuries, dollar damages, etc., for each carrier mix).
 - Reliability (the consistency with which the nuclear waste transport services will be provided, such as making pickups and deliveries on time).
 - Program risk (the "portfolio risk" associated with the carrier mix included in any alternative, such as the number of carriers involved, broken down by mode, geographic region, etc.).

Once the shipment program is underway, the impacts relate to incremental impact "penalties" due to a poor choice of carriers, comparing one carrier's performance with another. The methodology associated with measuring the impacts due to DOE carrier selection is relatively simple, involving performance monitoring on a carrier specific basis. The aim is to identify incremental impact "penalties" associated with specific carriers, with each one being monitored for its performance in several areas: accidents, incidents, unplanned stoppages and extraordinary risk exposure or impacts due to the above. A comparison of these data will indicate where the state has incurred extraordinary impacts due to poor carrier choice on the part of DOE.

In the period before nuclear waste shipments get underway, baseline data should be collected for carriers who pass the pre-qualification test. This will provide a starting basis for time-series analyses of trends for individual carriers. After the shipment program is underway, these data should be updated yearly, or on a more frequent basis if necessary to keep pace with changing performance levels.

3.3 PERSONNEL TRAINING AND QUALIFICATIONS

To assess the impacts concerning personnel training and qualifications for the transportation of nuclear waste to a repository at Yucca Mountain, the planned transportation system's personnel training and qualification requirements should be assessed against those described in section 3.3 of the Preferred Transportation System report.

The impact assessment should, at a minimum, assess the following elements of a personnel training and qualification program.

- o The scope of the personnel training and qualifications program (are qualification and training standards required for all job classifications.)
- o Clear responsibility for conducting training for the various job classifications.
- o When is training/retraining provided. How frequently the training is conducted, considering the risk entailed in not providing refresher training.
- o Where is training/retraining provided. It may be best to have some of the training conducted by the DOE at a central facility, while other training might best be done at the local level.
- o Recognition of nuclear waste as a unique commodity.

During the operation of the transportation system, assessment of the impacts of the personnel training and qualification program involves the monitoring of the following factors:

- o Accidents and/or incidents caused by poor training/inadequate qualifications.
- o Accidents or incidents prevented, or reduced in severity, due to good training/adequate qualifications.
- o Increases in impacts or reductions in risk exposure levels due to either of the above.

3.3.1 Information Required

In order to assess the impacts of a training/qualification program, the following information is needed:

- o A complete list of potential subjects.

- o Estimates of the teaching time for each.
- o Their marginal value in risk reduction.
- o Testing alternatives and their value.
- o An assessment of the financial responsibility for training among DOE, the carriers, the states and any other interested parties.

3.4 CASK MAINTENANCE

To assess the impacts concerning cask maintenance for the transportation of nuclear waste to a repository at Yucca Mountain, the planned transportation system's cask maintenance program should be assessed against that described in section 3.4 of the Preferred Transportation System report.

The impact assessment should, at a minimum, assess the following cask maintenance issues/elements of the Preferred Transportation System.

- o Inclusion of maintenance considerations in cask design.
- o Successful maintenance of cask designs within usual time and budget constraints.
- o Sufficient quality assurance/quality control (QA/QC) to guarantee safety.
- o Provide enforceable and verifiable QA/QC procedures.
- o Consideration of human error in QA/QC.
- o Cask ownership.
- o Ensure the prompt recall of casks, when necessary.
- o Require that fuel meet a cleanliness standard or be canned.
- o Utilize robotic maintenance systems.
- o Utilize cask transponders.
- o Develop adequate cask maintenance facilities.
- o Develop a field-based maintenance capability.
- o Provide secured stopping areas.
- o Develop regulatory guide.
- o Establish and maintain a database on cask maintenance.

3.5 VEHICLE MAINTENANCE

To assess the impacts concerning vehicle maintenance, the planned vehicle maintenance program should be compared to the vehicle maintenance program described in section 3.5 of the Preferred Transportation System report.

The preferred vehicle maintenance plan consists of three principal parts: (1) a home maintenance plan for regularly scheduled activities which take place when the equipment is at pre-designated locations for predetermined servicing; (2) a field maintenance plan which indicates what actions should be taken when breakdowns occur in the field (a contingency plan) and (3) a plan for establishing coordination between the two. Moreover, the plan must be all encompassing, addressing the entire spectrum of component maintenance within a given vehicle and the coordination of maintenance activities among all vehicle types involved.

At a minimum, the planned transportation system should be compared to the following specific vehicle maintenance aspects of the Preferred Transportation System.

- o Frequency of regular servicing.
- o When the heavy maintenance is performed.
- o Coordination of maintenance activities.
- o Field breakdown procedures.
- o Correction of minor malfunctions.
- o Responsibility for field service contracts.
- o Ownership of vehicles by the shipper or transporter.
- o Resolution of conflicts in carrier maintenance schedules.
- o Secured stopping areas.

Before the shipment program begins, the principal focus is on benchmarking the extraordinary resources needed to maintain a fleet of vehicles to acceptable standards. Afterward, it is on monitoring the incremental impacts and risk exposure due to faulty or insufficient maintenance being performed, overall for the program and on a carrier or maintenance-contractor specific basis. This includes the incremental resource commitments required to make the maintenance performance meet acceptable standards should it fail to do so.

In the period before the nuclear waste shipments get underway, baseline data should be collected for carriers or maintenance contractors who pass the

pre-qualification test. This will provide a cross-sectional database and a starting basis for time-series analyses of trends for individual carriers or contractors. After the shipment program is underway, these data should be updated yearly, or on a more frequent basis if necessary to keep pace with changing performance levels.

3.5.1 Information Required

The information required includes:

- o Fleet size involved, overall and by type of vehicle.
- o Maintenance options available for each component.
- o Recommended service intervals.
- o Failure rates by component.
- o Capabilities of repair shops and where they are located.
- o Contingency options for dealing with breakdowns.

3.6 VEHICLE STOPPAGE

To assess the impacts concerning vehicle stoppage the planned vehicle stoppage system should be compared to the vehicle stoppage program described in section 3.6 of the Preferred Transportation System report. At a minimum, the assessment should consider the following:

- o Protecting the vehicle (truck or train) and the crew during stops.
- o Minimizing the length of stops.
- o Selecting the safest locations possible (e.g., truck stops, military bases, rail yards, interchange locations).
- o Ensuring that stoppage restrictions do not interfere with crew performance (e.g., too much time in the cab or locomotive between rest periods).
- o Protecting stopped vehicles from sabotage/terrorism/interference.
- o Limiting the radiation exposure during stops.
- o Managing unplanned stops.
- o Inclement weather conditions.
- o Avoiding interaction with other dangerous goods shipments.
- o Trade-offs consistent versus randomized planned stops.
- o When and where the planned stops should occur (based on the reason for and timing of each stop).
- o How the stopping areas should prepare for the vehicle's arrival.
- o How the vehicles should be protected during stops.
- o Who should decide where planned stoppages occur and the procedure for unplanned stoppages: the DOE, carriers, state, Tribal or local governments.

Before the shipment program begins, the focus is on estimating the impacts and risk exposure that will be due to both planned and unplanned stops and the resource commitments required (e.g., for emergency response teams) to achieve a given level of risk control. After the program is underway, the focus will be on tracking the impacts of stoppages as they occur, including the number of incidents associated with stoppages, the impacts of those incidents, and the resources expended to control them; as well as additional resource commitments made to ensure that such incidents do not occur in the future.

As with many of the preceding areas, the methodological focus is on measuring the impacts due to the quality of the planned and unplanned vehicle stoppage plans and their execution by all the parties involved. In the period before nuclear waste shipments get underway, existing information on the consequences of stopping for nuclear waste-carrying vehicles should be compiled into a baseline database. This will provide a starting basis for time-series analyses of trends for individual carriers, escort contractors and/or emergency responders. After the shipment program is underway, these data should be updated yearly, or on a more frequent basis if necessary to keep pace with changing performance.

3.6.1 Information Needed

The information needed to assess the impacts of vehicle stoppage includes:

- o A list of reasons why vehicles would stop.
- o The times when the stops will be required for refueling, eating, resting, etc.
- o Example lists of potential facilities for making the stops and where they are located.
- o Servicing times required.
- o The definition of a safe parking area and example lists of such facilities.
- o A contingency plan for each type of unplanned stop.
- o A definition of the types of emergency response capabilities that would be required and example lists for those that exist in selected areas.

3.7 SHIPMENT MONITORING AND PRENOTIFICATION

To assess the impacts concerning shipment monitoring and prenotification for the transportation of nuclear waste to a repository at Yucca Mountain, the planned transportation system's provisions for shipment monitoring and prenotification should be assessed against those discussed in section 3.7 of the Preferred Transportation System report. At a minimum, the assessment should include the following features of the shipment monitoring system:

- o Provides information needed by state, Tribal and local governments.
- o Provides sufficient accuracy and timeliness to locate the vehicle easily in an emergency and to dispatch emergency response teams to that location.
- o Provides reliable information not easily disrupted by interferences of various types, including weather.
- o Provides a reliable communication link with the command and control center responsible for monitoring vehicle location.
- o Provides security of the vehicles' locations so that terrorists or others cannot easily anticipate its passage along a given route.
- o Is amenable to computer generated displays such as digital maps.
- o Is amenable to programming for delivery of annunciator displays to alert the command and control center of important or critical anomalies in the transportation process.
- o Delivers emergency signals initiated on-board the vehicle.
- o Provides these features at a reasonable cost.

The assessment of shipment prenotification systems should consider the following criteria:

- o Adequacy of information provided to each level of government.
- o Value of the information provided to a recipient.
- o Reliability of the information provided.
- o Reliability of the process used.
- o An assessment of the risk exposure that occurs by releasing a piece of information to a given recipient.

3.7.1 Information Needed

The information required includes:

- o An assessment, with input from experienced persons in emergency response, on what information would be most pertinent (e.g., description of contents, emergency response procedures, routing and time of passage).
- o A review of what information state, Tribal and local officials need to fulfill their responsibilities.
- o An estimate of how much time should be allowed between prenotification and shipment, including an assessment of the downside risks of information leaks.
- o An analysis of the technological options for obtaining and distributing information.
- o Assessment of the risk of unauthorized people intercepting information, by distribution option.
- o Technical specifications and performance tests on alternate vehicle tracking options.

3.8 INSPECTION AND ENFORCEMENT

To assess the impacts of transporting nuclear waste to a repository at Yucca Mountain from the perspective of inspection and enforcement, the planned transportation system's provisions on inspection and enforcement should be assessed against those described in section 3.8 of the Preferred Transportation System report. At a minimum, the assessment should include the following:

- o Division of inspection responsibilities among the carriers, DOE, the NRC, the DOT, states, Tribes and local governments.
- o Consistency of inspection criteria/procedures.
- o When and how often inspections are conducted.
- o Where the inspections are conducted.
- o What items are inspected and how often.
- o How violations are defined.
- o What penalties for violations are imposed.
- o What enforcement proceedings are used.

Initially, the focus is on the resources required to carry out the inspection and enforcement activities, and the trade-off between these and the level of risk protection (i.e., impact mitigation) provided. After the shipment program is underway, the emphasis is on keeping track of what incidents arose because of poor or insufficient inspection or enforcement and what additional resource commitments will have to be made or have been made to ensure such incidents do not recur.

The methodological focus is again on monitoring, with a need to assess the impacts due to the type of inspection and enforcement procedures being followed. In the period before nuclear waste shipments get underway, existing information on the resources presently required to carry out existing nuclear waste shipment-related inspection and enforcement activities should be documented. This will provide a baseline database. Also, a quantitative or qualitatively-developed quantitative measure of the level of safety and security this provides should be developed. After the shipment program is underway, these data should be updated yearly, or on a more frequent basis if necessary to keep pace with changing performance.

3.9 PHYSICAL PROTECTION

To assess the physical protection (sabotage/terrorism) impacts of transporting nuclear waste to a repository at Yucca Mountain, two analyses should be conducted. First, the probabilities and consequences of a full range of sabotage and terrorism events should be analyzed with the risk assessment approach described in section 1.1 of the Preferred Transportation System report. Second, the planned transportation system's provisions on physical protection should be assessed against those described in section 3.9 of the Preferred Transportation System report. At a minimum, the impact assessment should include the following:

- o Technical measures.
- o Organizational measures.
- o Safeguard measures.
- o Mitigation measures.
- o Political measures.

3.9.1 Difficulty in Quantifying the Probability of Sabotage/Terrorism

The impact assessment should recognize the difficulty in quantifying social risks, such as sabotage and terrorism. Because these actions are directed towards deliberate destruction of containers or vehicles, a few attempts are sufficient to release a large amount of radioactivity or, in the case of manipulation, to cause an accident. Hence, a small probability of occurrence is accentuated by the near-certainty of the effect. That is why risk management has to deal with these risks in great detail; for just one incident may cause tremendous damage.

3.9.2 Trade-Offs Between Increased Protection and Social Costs

The impact assessment should also consider the trade-offs between increased physical protection and social costs. It should be noted that overdoing safeguard measures, in particular monitoring crew members and investigating their private and political activities, creates a risk of its own and may endanger civil liberties. In addition, police response against demonstrators or protesters may be overprotective and thus challenge the right of free speech and free assembly.

Absolute security against sabotage/terrorist attack is illusory, and the attempt to perfect protection would inevitably result in the loss of substantial civil liberties. Thus protective actions have to achieve a balance between the costs and undesirable social consequences of overprotection and the

resulting frustration of personnel and the health and property risks of underprotection. Considering the options that terrorists may choose from, guarding of vehicles, inspection of vehicles, routine investigations of personnel and frequent rerouting decisions are some of the risk management options that should be considered.

4.0 FIRST YEAR RESEARCH NEEDS

INTRODUCTION

This section of the report presents the high priority, immediate research needs that should be addressed during the first year, November 1, 1988, through June 30, 1989, of the University of Nevada, Las Vegas (UNLV), Nuclear Waste Transportation Research Center (NWTRC). The scope of work that follows is that which has been developed for the NWTRC.

This section is intended to provide a general description of the first year efforts of the NWTRC. The descriptions in the scope of work are limited to the activities to be conducted during the NWTRC's first year. The discussion of the major areas of emphasis provides a general indication of some of the NWTRC anticipated activities for the second and subsequent years.

Clearly, the resources available to the NWTRC are bounded. Consequently, one cannot expect the NWTRC to strive to duplicate all the technical activities that the DOE is carrying out in developing the nuclear waste transportation system. However, it is clear that state, Tribal and local governments in Nevada must be cognizant of and have the technical capacity to review and provide input on all nuclear waste transportation issues.

PROGRAM OBJECTIVES

The primary goal of the NWTRC is to provide the technical resource base to assist state, Tribal and local governments in Nevada in addressing the full range of nuclear waste transportation issues impacting the State of Nevada. This includes: (1) assessing the impacts from the DOE nuclear waste transportation system, (2) analyzing alternatives which minimize impacts and increase safety and (3) investigating potential mitigation and compensation strategies for those impacts which cannot be avoided. In order to assist the Nevada Waste Project Office in achieving these goals, the NWTRC will:

1. Develop programs to pursue the transportation research needs recommended in sections 4 and 5 of this report.
2. Continue research on the Preferred Transportation System developed in the Transportation Needs Assessment.
3. Implement the Transportation Impact Assessment System described in sections 1, 2 and 3 of this report.
4. Investigate potential mitigation and compensation strategies for those impacts which cannot be avoided.

Ultimately, the NWTRC seeks to become the center for transportation issues of all types in Nevada and the southwestern United States. These issues include not only the transport of nuclear materials, but the transport of hazardous materials of all types, as well as the general transportation requirements of the rapidly growing areas of Nevada and the Southwest. The strategic plan for meeting this long-range objective includes the development of a recognized transportation research program and the establishment of a curriculum to meet the public education needs of the surrounding region as they pertain to transportation.

MANAGEMENT APPROACH

Management Structure

The NWTRC has been constituted within the UNLV Howard R. Hughes College of Engineering. The director of the NWTRC will report to the Dean of Engineering, Dr. William R. Wells. In the period before a permanent director is functioning, a management team will oversee the planning, administration and technical activities of the NWTRC. The management team consists of Dr. William R. Wells, Dr. Russell di Bartolo (NWPO) and Mr. Leonard C. Slosky (consultant to the UNLV/NWTRC).

Management Philosophy

The long-term goal is for the NWTRC to have as much in-house expertise on the broad range of technical nuclear waste transportation issues as resources will permit. When a certain expertise is needed, an attempt will be made to identify qualified personnel in the State of Nevada and particularly at UNLV and the University of Nevada, Reno (UNR). It is recognized, however, that in order to be responsive to the short-term needs of the NWPO, Tribal and local governments, the use of external consultants will be necessary during the first year of NWTRC operations.

SCOPE OF WORK

The scope of work is described in terms of eight areas of emphasis, outlined below.

Areas of Emphasis

- o Building the capacity of the NWTRC and liaison with state, local and Tribal governments and agencies.
- o Development of the Nuclear Waste Transportation Information and Analysis System (TMIAS).

- o Monitoring and reviewing developments in the DOE transportation system and maintaining relationships with national, regional and Tribal groups.
- o Assessing emergency preparedness needs in Nevada.
- o Incorporating Needs Assessment Information in the NWTRC.
- o Establishing cask design and testing review capacity.
- o Special projects.
- o Establishing infrastructure baseline information.

4.1 Build the Capacity of the Nuclear Waste Transportation Research Center

Background

The development of a nationally recognized transportation research center will require the sustained commitment of the NWPO and the UNLV. Important steps will be taken in the first year to lay the foundation for the long-term development of the NWTRC.

4.1.1 Management, Supervision and Coordination

As the NWTRC gets underway, it is important to establish a management structure which will plan, coordinate, supervise and integrate all administrative and technical efforts. Until a director is hired, a three-person management team consisting of representatives from UNLV, NWPO and the contracting firm which conducted the Transportation Needs Assessment will carry out this task. In view of the vital role and interests of State, local and Tribal governments in repository-related transportation, it is essential that NWTRC establish and maintain cooperative relationships with these entities.

4.1.2 Recruitment

A major milestone for the first year is the hiring of a director and several key staff members of the NWTRC. It is hoped that a director will be hired early in 1989. The criteria for selection of senior personnel in the NWTRC will be submitted to the SLGPG for review and comment.

4.1.3 Technical Library

A major transportation information center will be developed within the UNLV library system. The acquisition of documents has already begun. During

the first year monographs, periodicals and documents will be added to the UNLV library.

4.1.4 Curriculum Development

Over the long-term, the NWTRC will become a regional center for nuclear waste transportation education and training. In the first year, colloquia will be planned and presented and planning will begin on curriculum development for undergraduate and graduate courses, specialized training, and public information.

4.2 Develop the Nuclear Waste Transportation Analysis System (TMIAS)

Background

In order to meet the challenges of nuclear waste transportation to a repository at Yucca Mountain, it is essential that the State of Nevada develop a systems approach to impact analysis, built around a transportation network model orientation. The advent of a systems approach, using the latest in computer technology, will prepare Nevada for the multitude of transportation issues, such as modal mix, alternative routing, risk analyses and infrastructure impact assessment, which require analytical study. Capitalizing on geographic information systems, Nevada databases, information management capability, state-of-the-art display graphics and user friendly menu operation, Nevada will be forging a pioneering effort in transportation analysis which will meet or exceed the ability of the DOE.

The transportation analysis system will consist of two basic components: (1) the models to perform analyses and (2) the databases which supply the information necessary for the models. Developing a transportation analysis system customized to Nevada's needs is a time and resource intensive activity. It involves the specification of a desired level of analysis capability, definition of important transportation parameters, identification of risk criteria, integration of system elements into a common analysis framework and development of algorithms which can solve the problems as defined. It also involves design, collection and management of information to support the analysis system. This will include information on infrastructure geometrics and condition, traffic and rail operations and utilization, facility construction and maintenance schedules, emergency response capability, etc. The analytical system can also be applied to managing everyday transportation concerns within the state, such as road and bridge repair, traffic management, routing of hazardous materials and emergency response planning.

Beginning in the second year, the Transportation Analysis System will be used to explore issues related to routing, modal mix, volume and timing of shipments, infrastructure improvements, etc. In the second and subsequent years, efforts will be directed towards overcoming the shortcomings of the

basic models and tailoring the models to meet the specific needs of state, Tribal and local governments in Nevada. Database improvement and maintenance will also be a long-term effort.

The goal of this effort is the development of a "Nevada Model" (and accompanying) database which accurately assesses the impacts of and alternatives to the DOE nuclear waste transportation system. With the draft Yucca Mountain EIS scheduled to be released by DOE in 1993, the Nevada Model should be fully operational prior to that time.

4.2.1 Specifications for the Transportation Analysis System (TMIAS)

The conceptual approach for impact assessment models described in the Transportation Needs Assessment will be translated into a "blueprint" which is far more precise in terms of analysis modules, how each issue is represented, the relationships between modules, the source of needed data and how it will be managed, output formats, and a number of additional model design considerations. The beginning point of this effort is the enumeration of the transportation issues and questions which state, Tribal and local governments in Nevada must address. It is also important to recognize the imperative of coordinating the development of the analytical system with the design and implementation of the databases. This effort will be closely coordinated with the NWPO, Tribal and local governments so that the system will provide the capabilities needed by state, Tribal and local governments. The result of this effort will be an architectural layout (blueprint) for constructing the transportation impact analysis system for Nevada.

4.2.2 Assessment of Available Models

Available models such as HIGHWAY, INTERLINE, RADTRAN III, DANTRAN and those from Lawrence Livermore National Laboratory, NCAR and Vanderbilt University will be reviewed. This will include consideration of model reviews which have been previously conducted, such as the Mountain West review of RADTRAN. One or more models will be put on-line at the NWTRC in order to provide Nevada with some short-term analytical capability and to understand the strengths and limitations of existing models. This review will result in a determination of which model presents the best framework upon which to base the development of a model tailored to Nevada's needs (or if the development of an original model is necessary). The review will also identify deficiencies in the basic model which will be corrected in development of the Nevada Model.

The urgency here is that the base case must be established before repository issues can be investigated. Given that the DOE will be making policy decisions in the near future that affect how the repository transportation program will be structured, it is essential that the NWTRC move quickly to build the capability to respond to these issues as they arise.

4.2.3 Design Data Collection and Information Management System and Begin Implementation

The transportation data collection and information management system is central to the transportation analysis system since it provides the information upon which all planning and analysis is based. The development of the databases must be closely linked with the development of the analytical models, as neither can usefully function without the other. While the models should generally drive the design of the databases, the data requirements of the chosen models must be reasonably achievable.

The first step in developing the information management system is to assess existing data sources. This will include (but not be limited to) databases maintained by the Nevada Department of Transportation (NDOT), the regional transportation commissions, UNR, DOE and the United States Department of Transportation (DOT). At a minimum, data will be needed on rail and highway infrastructure location and conditions, traffic utilization and safety, emergency response location and capability, land usage topography and weather near existing and planned transport facilities, demographic characteristics and location of environmentally sensitive areas along transport corridors.

Following the assessment of existing data sources and the selection of the basic transportation analysis models, a detailed information management system specification will be developed. This is envisioned as a document describing the overall structure of the data collection and information management system, including: where each pertinent existing database is stored; who has responsibility for database maintenance and updates; the accuracy and completeness of the data; how the data can be accessed; and how the data can be networked to support the transportation analysis system. Where data is not presently available, it must be collected through survey or inventory review. In these cases, sampling methodology and survey design work will be necessary prior to data collection.

Implementation of the data collection and information management system will begin in the first year. At an early stage in this effort, the collection of baseline data is important in that it establishes a benchmark (the base case) against which repository impacts can be compared. This effort will be closely coordinated with the NDOT and the regional transportation commissions. Maximum use will be made of existing data collection efforts and database management systems.

4.3 Monitor and Review Developments in the DOE Nuclear Waste Transportation System. Maintain Cooperation with National, Regional and Tribal Groups Involved in Nuclear Waste Transportation

Background

During the first year, there are several federal actions anticipated

which will have important influence on the development of the nuclear waste transportation system and the State of Nevada's role therein. Therefore, it is essential that the NWTRC immediately develop the capability for monitoring and reviewing federal activities.

In the second and subsequent years, NWTRC will pilot test the TRANSCOM system, assess state, Tribal and local government monitoring and prenotification needs, and investigate alternatives for providing shipment monitoring and prenotification information.

During the second and subsequent years, the NWTRC will conduct an independent assessment of the probabilities and consequences of sabotage and terrorism and assess the trade-offs between features of the nuclear waste transportation system which have the potential to improve safety but which may have adverse physical protection consequences.

A number of national, regional, state and Tribal groups and agencies are involved in monitoring DOE transportation activities or are otherwise interested in the transportation of nuclear materials. The State of Nevada is represented on some of these groups and maintains institutional relationships with those with whom it is not officially affiliated. These groups have concerns about repository-related transportation which are similar to those of Nevada, and it is incumbent upon the State to maintain interaction with them in order to develop cooperative policies, plans and actions to help assure the safe and uneventful transportation of nuclear waste to a repository.

4.3.1 Monitor and Review Developments in the DOE Nuclear Waste Transportation System

In order for the NWTRC to be able to provide technical support to state, Tribal and local governments in Nevada to address transportation issues, the NWTRC must be knowledgeable of the current status of DOE and related transportation activities. Therefore, the NWTRC will monitor the technical and regulatory activities (including the release of technical documents) and decisions of federal agencies concerning nuclear waste transportation including the DOE, DOT, the United States Nuclear Regulatory Commission (NRC), the Congressional Office of Technology Assessment (OTA) and the Congressional Government Accounting Office (GAO). The NWTRC will alert the NWPO, Tribal and local governments of important developments.

During the first year, it is anticipated that the NWTRC will review the technical transportation and emergency preparedness aspects of the following:

- o DOE Nuclear Waste Policy Amendments Act (NWPAA) Section 175 Report.
- o DOE/Yucca Mountain Project Office (YMPO) highway routing study.
- o DOE/YMPO rail access study.

- o DOE/YMPO aircraft overflight study.
- o Commercial Vehicle Safety Alliance (CVSA) vehicle inspection standards.

The NWTRC will assemble technical teams composed of UNLV/UNR and external personnel, as necessary, to conduct technical reviews of the transportation and emergency preparedness aspects of these reports for the NWPO. The Preferred Transportation System described in the Transportation Needs Assessment and the Impact Assessment System described in sections 1, 2 and 3 of this report will serve as the "yard sticks" against which these reports will be measured.

Section 175 Report

Section 175 of the NWPA requires the DOE to report to Congress in December 1988 on the potential impacts of locating a repository at the Yucca Mountain site, including recommendations for mitigation of such impacts. The statute requires the report to include impacts on:

...transportation, including any roads, terminals, airports, bridges, or railways associated with the facility and the repair and maintenance of roads, terminals, airports, bridges, or railways damaged as a result of the construction, operation, and closure of the facility...[and]...equipment and training for State and local personnel in the management of accidents involving high level radioactive waste...

DOE/Yucca Mountain Project Office (YMPO) Highway Routing Study

During the first year, the YMPO is expected to release a preliminary evaluation of the Nevada highway routes identified in the Environmental Assessment: Yucca Mountain Site, May 1986.

DOE/YMPO Rail Access Study

In the first year, the YMPO is expected to release a preliminary study identifying and evaluating potential rail spurs from the Southern Pacific and Union Pacific mainlines to Yucca Mountain.

DOE/YMPO Aircraft Overflight Study

During the first year, the YMPO is expected to release an assessment of the extent of the United States Department of Defense aircraft flights over the Nevada highway and rail routes identified in the Environmental Assessment: Yucca Mountain Site, May 1986.

CVSA Proposed Vehicle Inspection Standards

The Commercial Vehicle Safety Alliance (CVSA) is working in cooperation with the OCRWM to develop uniform and reciprocal vehicle inspection procedures for highway shipments of spent fuel. Review is continuing on the draft inspection procedures prepared in November 1987. Plans for a pilot test of the draft inspection procedures are being developed at this time. The test will be administered by the Pacific States Agreement on Radioactive Materials Transportation Management, which consists of Idaho, Oregon and Washington, and is scheduled to begin in fiscal year 1989. When the draft inspection procedures have been sufficiently refined, they are expected to be proposed for adoption by the CVSA.

As required by the National Environmental Policy Act (NEPA), the DOE is scheduled to conduct hearings during the first quarter of 1989 on the scope of matters to be considered in the preparation of the draft environmental impact statement (EIS) for the repository at Yucca Mountain.

Based upon the Impact Assessment described in sections 1, 2 and 3 of this report, the NWTRC will provide technical support to the NWPO in preparing recommendations (related to transportation and emergency preparedness) which will be presented at the EIS scoping hearings. The NWTRC will also review any transportation-related documents prepared by the DOE in advance or subsequent to the hearings.

Two specific areas to be evaluated, shipment monitoring/prenotification and physical protection are covered in sections 4.3.2 and 4.3.3, respectively.

4.3.2 Review & Evaluate Developments Concerning Shipment Monitoring and Prenotification

The NWPAA now requires the DOE to comply with the NRC prenotification requirements for all shipments to a repository or an MRS facility. With the frequency of shipments planned for the Yucca Mountain repository, it is in the State of Nevada's interest to have a more efficient prenotification system. Real-time shipment location and condition information is invaluable for physical protection and emergency response. Shipments through Nevada to the Waste Isolation Pilot Plant (WIPP) in New Mexico, which are scheduled to begin in 1990, will present an ideal opportunity to test improved shipment monitoring and prenotification technologies and procedures.

The NWTRC will monitor technical developments by the DOE, the NRC and other public and private entities (e.g., Railstar) regarding shipment monitoring and prenotification, including the pilot test of the DOE TRANSCOM system with the Pacific States Agreement on Radioactive Materials Transportation Management, consisting of Idaho, Oregon and Washington.

4.3.3 Monitor Developments Concerning Physical Protection (Sabotage/Terrorism)

The probability and consequences of sabotage and terrorism against nuclear waste shipments is an area which has received little attention, at least in unclassified contexts. Although the probability may be low, the consequences of a certain sabotage or terrorist incident probably represent the upper boundary of the risk events spectrum.

The NWTRC will monitor the activities of the federal agencies (e.g., NRC, FAA) and the technical literature concerning the physical protection of nuclear materials.

4.3.4 Interact with National and Regional Groups Regarding Repository Transportation. Prepare Status Reports and Issues Papers

NWTRC staff will participate in meetings, workshops and conferences of such groups as the Western Governors' Association, the Western Interstate Energy Board, the National Conference of State Legislatures, the National Association of Attorneys General, and Indian tribal groups and nations. Concerns common to Nevada and any of these groups may be addressed in a cooperative manner.

Upon request, the NWTRC will prepare status reports and issues papers on developments in nuclear waste transportation at federal, regional, state and Tribal levels. The NWTRC will also develop the capability to alert the NWPO, Tribal and local governments in Nevada of emerging issues and new developments in nuclear waste transportation.

4.4 Assess Emergency Preparedness Needs in Nevada

Background

The shipment of nuclear waste to a repository at Yucca Mountain will subject state, Tribal and local governments in Nevada to a level of radiological transportation risks never experienced in the United States. The number, frequency and high radioactive content of shipments to Yucca Mountain will require a sophisticated emergency preparedness program in order to minimize the impacts upon public health and safety and the environment.

In the second and subsequent years, the NWTRC will review DOE's emergency preparedness capabilities; describe the preferred emergency preparedness system for nuclear waste shipments to Yucca Mountain; and define state, Tribal and local governments' emergency preparedness needs for the nuclear waste transportation system.

4.4.1 Inventory of Existing Emergency Preparedness Capabilities

The NWTRC will become familiar with the state, Tribal and local emergency preparedness structure in Nevada. This will entail understanding the legal roles, responsibilities, authorities and the institutional interrelationships of the state, Tribal and local emergency response agencies in Nevada.

The NWTRC will then inventory the emergency preparedness capabilities of the state, Tribal and local emergency response agencies. The inventory will include: training, equipment, communications, actual response experience, emergency response drills, emergency preparedness planning, mutual aid agreements, funding levels and sources, etc. This will establish a baseline which will be assessed against the preferred emergency preparedness system.

4.5 Provide Technical Assistance in Incorporating Transportation Needs Assessment Information into NWTRC Program

In the first few years of operation of the NWTRC, it is important to accomplish the transfer of information from the Transportation Needs Assessment to the NWTRC. Mr. Slosky will be responsible for this effort and will draw upon other members of the Transportation Needs Assessment study team as necessary.

4.6 Establish Cask Design and Testing Review Capacity

Background

Cask performance during routine transportation and conditions of severe accidents, sabotage and terrorism is the most important determinant of radiological risk (including transportation and repository operations) to the citizens of Nevada. The DOE is currently in the process of designing a new generation of casks which will contain a much larger amount of spent fuel per cask than current packages.

Current design efforts are focusing on "from-reactor" casks, which are intended for shipping spent fuel from commercial reactors to a repository or to a monitored retrievable storage (MRS) facility. Three types of from-reactor casks are being designed: legal weight truck, overweight truck and rail and/or barge. (It has become unclear if design of the overweight truck cask has been delayed.)

Cask performance is judged on the basis of three criteria: containment, limitation of exposure and criticality prevention. Under the NWPA, all casks used to transport waste to a repository must now comply with the NRC requirements. Serious questions have been raised regarding the adequacy of NRC's cask design standards and testing procedures as well as the development, implementation and oversight of cask design, testing and maintenance quality

assurance and quality control (QA/QC) programs.

It is not intended that the State of Nevada conduct basic research or duplicate the cask design and testing being conducted by the DOE, however, Nevada needs the capability to critically review the DOE cask development program.

Ultimately the NWTRC seeks to have the capacity to address the entire spectrum of cask issues. The Transportation Needs Assessment identified a number of technical cask issues with which the NWTRC will become involved over time. They include: cask performance during severe accidents, sabotage and terrorism conditions; cask sensors; fuel cleanliness; human factor issues in design, fabrication and maintenance; burn-up credit; results of cask testing models versus full-scale physical tests; special considerations for defense high-level waste casks; and QA/QC programs, including human factors. Many of these issues are complex and require a substantial commitment of funding and time to be fully addressed.

4.6.1 Review DOE Preliminary Cask Design Report

The DOE is scheduled to release a preliminary cask design report in mid-1989, therefore, the NWTRC must begin to establish the capability to review cask issues. During the first year, the NWTRC will establish an initial capacity to review the preliminary DOE cask design report and to begin a critical review of the NRC's cask design and testing requirements.

4.7 Special Projects

Background

The NWTRC has begun building the technical capacity to respond to special transportation needs of the state, Tribal and local governments in Nevada. During the first year the following two specific studies will be conducted to determine lead time necessary for major highway and rail infrastructure improvements and new construction, baseline and forecasted traffic demand on highways which may be used for shipments of nuclear waste to Yucca Mountain and, if requested, a study to clarify the impacts on local governments and upon the selection of rail access routes by DOE. The NWTRC will seek to maintain the flexibility to undertake other studies as requested by NWPO, local governments and tribes.

4.7.1 Develop Lead-Time Necessary for Major Highway and Rail Infrastructure Improvements and New Construction

It is important that DOE make important transportation decisions far enough in advance of the initiation of waste shipments to allow sufficient time

for needed infrastructure improvements to be completed. A study will be conducted to determine the realistic time needed to implement major new infrastructure additions such as a highway bypass and a rail spur. The study will consider the time needed for planning, design, funding, permitting, right-of-way acquisition and construction.

4.7.2 Develop Information on Current and Forecasted Utilization of Highway Infrastructure on Potential Repository Routes

In order to assess the impacts of the repository on Nevada's transportation infrastructure, it is necessary to have baseline information on the current utilization of transportation infrastructure in the State. An assessment will be conducted of current highway infrastructure utilization in Nevada. The assessment will consider the major highway routes in Nevada which may be used for waste transportation to Yucca Mountain and will include design capacity, existing traffic volumes and recent accident rates and other risk and safety factors.

4.7.3 Determine Socioeconomic and Transportation Impacts of Relocation of Union Pacific Rail Yard from Las Vegas to North Las Vegas

The Union Pacific Railroad (UP) is planning to move its Las Vegas rail yard to North Las Vegas in the spring of 1988. This move may have significant socioeconomic implications for the two cities, with regard to economic and industrial development, cost to their governments, traffic patterns and population exposure to hazardous materials, among others. These potential impacts need to be identified and evaluated by NWTRC so that State monitoring of DOE rail routing, service options and access to Yucca Mountain may be carried out with meaningful and timely baseline information.

(Note: Subtasks 4.7.1 and 4.7.2 are to be developed by staff of the College of Engineering, University of Nevada, Reno.)

4.8 Conduct Baseline Infrastructure and Safety Factors Survey of Potential Nevada Highway and Rail Routes to a Yucca Mountain Repository

Background

In order for NWTRC to conduct any risk routing or impact studies, it is necessary that baseline information on infrastructure and safety factors be collected and included in the Transportation Information and Analysis System. Such information may be used in current risk and routing models and may also be used to assess and/or predict impacts of repository construction and operation. It is essential that this survey be conducted for all rail and highway routes under consideration for repository shipments and that the information is continually updated and reviewed. As potential highway and rail

access routes are identified by DOE, it will also be necessary to survey these routes using the same factors as those in the present project.

(Note: Subtasks under Task 4.8 are to be developed by staff of the College of Engineering, University of Nevada, Reno.)

5.0 OUT-YEAR RESEARCH NEEDS

Structure of Discussion

The discussion of research needs to be addressed following June 1989 is structured in the same general manner as the discussion on the impact assessment framework (sections 1, 2 and 3 of this report). The following outline summarizes topics of the out-year research needs.

CROSSCUTTING ISSUES

- Risk assessment and risk management
- Transportation information and analysis system
- Transportation impact monitoring
- Data collection and management
- Monitor activities affecting nuclear waste transportation
- Regulatory structure and liability
- Emergency preparedness

TRANSPORTATION SYSTEM DESIGN

- Volumes and timing of waste shipments
- Cask design and testing
- Modal mix/truck and rail shipment options
- Equipment and vehicle standards
- Infrastructure
- Defense waste

TRANSPORTATION SYSTEM OPERATIONAL PROCEDURES

- DOE carrier requirements
- Personnel training and qualifications
- Cask maintenance
- Vehicle maintenance

Vehicle stoppage

Shipment monitoring and prenotification

Inspection and enforcement

Physical protection

Responsibility

For each research need, there is a recommendation of whether the federal government and/or the State of Nevada should be responsible for conducting the necessary research.

Importance

The importance of each research need is categorized as essential, major, significant or minor.

Urgency

Each research need is classified as immediate, near-term (3-5 years) or long-term (5-10 years). Although the actual shipments of waste to a repository at Yucca Mountain are a number of years away, decisions on the configuration of the transportation system are now being made. In addition, in several areas such as infrastructure, long lead times are necessary to prepare for the waste shipments.

5.1 RISK ASSESSMENT AND RISK MANAGEMENT

Seven major risk assessment and risk management research areas have been identified as important to the performance of a comprehensive impact assessment for the transportation of nuclear waste to a repository.

5.1.1 Full-Scale Comprehensive, Integrated Risk Assessment

Study Design

Building upon the Transportation Information and Analysis System (TMIAS) begun in the first year, a full-scale comprehensive and integrated risk assessment of the transportation of nuclear wastes to a repository should be conducted. This type of risk assessment needs to be undertaken as soon as possible and should be updated periodically throughout the lifetime of the planning for and operation of the repository. The risk assessment should follow the guidelines outlined in section 1.1 of this report and section 1.1 of the Preferred Transportation System report. The risk assessment should:

- o Be comprehensive by covering all the sequences and phases of the nuclear waste transportation system.
- o Be integrated by assuring that all methodologies, data and assumptions used in each specific area are compatible with those used in other areas.
- o Include the transport of defense and commercial wastes.
- o Include a full range of plausible technological configurations such as: new cask designs, emergency response mechanisms, potential routing and modal choices, among others.
- o Consider potential noncompliance or oversight inadequacies in estimating failure modes.
- o Include a full scale "vulnerability analysis" to determine the most sensitive geographic areas and populations.
- o Include the assessment of the potential for human activities to initiate, exacerbate or mitigate events.

The output of the risk assessment will provide an indication of the risks resulting from different activities in the transportation of nuclear wastes to a repository. By insisting on a comprehensive and integrated assessment, the current gaps in data, methodology and planning can be determined more readily. Periodic updates of the risk assessment will provide valuable information to the design, implementation and operation of the risk management system.

Expertise

Risk assessment, nuclear waste transportation, transportation systems analysis, regulatory.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Near-term.

5.1.2 Independent Review of the Comprehensive Integrated Risk Assessment

The risk assessment conducted in section 5.1.1, above, should be subjected to continued vigorous independent reviews.

Expertise

Risk assessment and nuclear waste transportation.

Responsibility

The State of Nevada and a joint committee comprised of members of the National Academy of Sciences advisory boards for Transportation and Radioactive Waste Management.

Importance

Essential.

Urgency

Near-term.

5.1.3 Develop Criteria for Evaluating Risk Assessment Information

As discussed in section 1.1 of the Preferred Transportation System report, risks are multidimensional in nature. Historical risk assessment studies have focused on the consequence measures of mortality and morbidity to drive the types of methodologies employed and the types of information developed by those risk assessments. While these certainly are important components of risk, they may not be the only important measures. This research

area is proposed to determine what criteria are important for the evaluation of risk information, the subsequent design of a risk management system and the choice of priorities for action.

This research should consider the following areas, among others:

- o Measures of mortality and morbidity.
- o Both qualitative and quantitative risk attributes.
- o Social perception of different risks.
- o Those risks that have a high potential for social amplification.
- o The distribution of risks over space, time, social groups and political jurisdictions.
- o Issues that determine the degree of risk tolerance by the public.
- o Rare catastrophic risks as well as the cumulative impacts of high probability/low consequence events.

Study Design

A number of methods for carrying out this type of work are available, some of these are listed below:

- o Development and use of risk taxonomies.
- o Psychometric studies of perceptions and attitudes towards different kinds of risks.
- o Survey research to determine the public's preferences towards risks and methods for mitigating them.
- o Retrospective studies of transport accidents.
- o Contextual media analysis of previous events.
- o Use of available socioeconomic data in integrated impact assessments to determine severe data and methodological gaps.

This research will likely suggest modifications to the risk assessment/management portion of the TMIAS.

Expertise

Risk assessment and sociology.

Responsibility

The State of Nevada.

Importance

Significant.

Urgency

Mid-term.

5.1.4 Incorporation of Human Errors in Risk Assessment and Management

Human error is important to the evaluation of incidents and accidents in the transportation system as an enabling or initiating factor. While human errors cannot be completely eliminated, the probability of their occurrence and the resulting consequences of errors may be prevented, mitigated or "made recoverable."

Study Design

Research is needed on human factor analysis, including incorporating human reliability assessments into risk assessments. The research should include:

- o Human cognitive models and causal models of human error that are both prescriptive and descriptive.
- o Studies of group, organizational and social effects on performance.
- o Taxonomic development.
- o Personnel training and staffing methods.
- o Development of a database for human error in radioactive waste transportation.
- o Development of analytical methodologies for incorporating human error into risk assessments.

This research will likely suggest modifications to the risk assessment/management portion of the TMIAS.

Expertise

Human factors, risk assessment, nuclear waste transportation.

Responsibility

Federal and the State of Nevada.

Importance

Major.

Urgency

Near-term.

5.1.5 Lack of Experiential Data and Large Data Uncertainties

For many of the activities of the radioactive waste transportation system, and especially in the early years of operation of a repository, there will not be a sufficiently long data record to help determine the types of risk management activities that are most effective. The lack of a long operational history also indicates that a large degree of uncertainty is inherent in analysis that will be performed. It is important, therefore, to have research that will allow for the evolution and adoption of "decision protocols" about the design and operation of the transport system under conditions characterized by a large degree of uncertainty. This research area is proposed to study the ways in which these types of decisions can and should be made.

Study Design

Methodologies for performing this research include:

- o Analysis of analogous situations (such as the transport of hazardous materials) to overcome lack of historical data on the transport of large amounts of radioactive wastes.
- o Scenario development and simulation studies to develop "synthetic" data about potential hazardous conditions.
- o Sensitivity analysis.
- o Decision analysis techniques.
- o Use of multiobjective analysis, dynamic programming and other operations research techniques to evaluate the trade-offs in the timing of decisions, the associated risks and costs, and the types of available options that may or may not be precluded by those decisions.

Expertise

Risk assessment, hazardous and nuclear materials transportation.

Responsibility

Federal.

Importance

Major.

Urgency

Near-term.

5.1.6 Flexible, Effective and Adaptive Risk Management System

The risk management system for the transport of radioactive wastes should be an "evolving," organic system capable of adapting to changing conditions and needs and capable of using new information, methodologies and technologies as they become available. The initial design of the risk management system should reflect these attributes and criteria. The following is a list of research questions that should be used to guide the research into the design of such a risk management system.

- o How should "information needs" be developed from ongoing comprehensive risk assessments?
- o What level of detail for data and analysis is sufficient to assure adequate protection from intolerable risks? For example, much greater levels of detail and accuracy may be required for the most vulnerable geographical areas and populations.
- o What types and in what ways can information be fed-back to and fed-forward from the risk management system?
- o What is the best design for an ongoing event monitoring system to provide information on normal operating conditions, accident conditions, sabotage and terrorism, and human reliability?
- o How can we evaluate the available risk management options (for example: regulations and performance requirements, performance monitoring, personnel training, economic incentives, liability provisions, insurance, timely notification, among others) to choose those that are most effective?
- o What lessons can be learned from a review of successful analogous systems, organizational analysis and sociological analysis of complex systems, operations research and systems analysis?

This research may suggest modifications to the TMIAS.

Expertise

Risk assessment, nuclear waste transportation specialist, transportation systems analysis, regulatory.

Responsible Parties

Federal and the State of Nevada.

Importance

Essential.

Urgency

Mid-term.

5.1.7 Public Acceptance of the Nuclear Waste Transportation System

Study Design

The radioactive waste transportation system should be designed and operated in such a way as to maximize public acceptance. The research suggested here is to complement the research to be undertaken in the substantive areas of the transportation system. This research will also broaden the scope of those studies by including research into the ways in which the public can be involved in the issues concerning the nuclear waste transport system in order to enhance public acceptance. This research should address four main questions:

- o How can the system be designed to assure?
 - A low number of unanticipated events and system failures
 - Rapid recovery and response to accidents to assure the protection of the population
- o How can public involvement in the decision-making process be enhanced?
- o How can trust in the institutions responsible for the oversight and operation of the transportation system be developed? In general, this has been a function of the perception by the public of the truthfulness of the institutions involved, their history of safe operations and competence and the way in which institutions demonstrate the degree to which they care about affected populations.
- o What are the critical elements in the design of effective risk communication programs?

Available methods for undertaking such studies include: public attitude analysis and surveys; organization analysis and sociological studies of organizations and evaluative reviews of analogous systems.

Expertise

Sociology, risk assessment, nuclear waste transportation, transportation systems analysis, regulatory.

Responsibility

Federal and the State of Nevada.

Importance

Major.

Urgency

Near-term.

5.2 TRANSPORTATION INFORMATION AND ANALYSIS SYSTEM (TMIAS)

5.2.1 Refinement of Transportation Information and Analysis System (TMIAS)

Study Design

Building upon work in the first year, the TMIAS will be enhanced and refined as new information becomes available and additional model features are specified. The goal is to develop in the TMIAS needed capabilities that the national models currently lack.

The TMIAS will be enhanced by providing additional detail on the physical transport network, expanding the list of transportation segment attributes and expanding the demographic detail of surrounding areas. These features will enable the state, Tribal and local governments to conduct analyses to minimize exposure of vulnerable sites/facilities along alternative routes, minimize the use of high traffic hazard areas which might increase non-radiological as well as radiological accident, and select routes which provide rapid access to potential accident locations by emergency response teams. To achieve this, the following factors must be integrated into the TMIAS:

- o Distance to emergency response teams.
- o Location and size of mobility-restricted population groups (e.g., people in retirement communities, schools, hospitals).
- o Existing and forecast traffic volumes (e.g., average daily traffic level, truck traffic volume, freight train frequency, passenger train frequency).
- o Facility condition (e.g., highway and track condition, such as geometrics, surface condition, signage, lighting and adequacy of snow removal forces).
- o Weather conditions (e.g., extent of dust, wind, also wind direction and speed distributions, rain, fog, snow, ice).

For each of the factors listed above, the text below discusses how the condition can be measured, what data are available and what data gathering strategies would be appropriate to fill the voids that exist.

Emergency Response

Two categories of response should be considered: (1) first responders (e.g., local police and fire departments) and (2) ultimate response (i.e., from the team which will manage the clean-up effort). The location and capabilities of each unit could be coded into the system so that direct measurements of response times can be derived. Consequently, emergency response as a risk mitigation strategy can be evaluated.

Mobility-Restricted Population Groups

The people in mobility-restricted population groups are another important consideration because they would be difficult to evacuate in the event of a major incident. Examples include residents of retirement communities, school and day care children, and individuals who are confined to hospitals and nursing homes. For people in each of these groups, transportation would, in most cases, have to be provided by local agencies if an incident occurred; for people in hospitals, life support systems would have to be maintained.

The best way to measure this factor is to determine how many mobility-restricted people are within a specific distance of a given route. For elderly people, census data can be used because those data indicate the age of all persons living in each census tract. For schools and hospitals, county and municipal planning documents can be used. These documents list the locations of these facilities and typical occupancies.

While these data have not yet been compiled for routes to the Yucca Mountain site, the primary data are available. Initially, a sampling technique can be used to estimate the number of such people who live along a typical mile for each route in rural, suburban and urban settings. Eventually, a thorough inventory could be developed and updated periodically.

Traffic and Accident Data

There is a general tendency for greater traffic volumes to increase the likelihood of accidents, regardless of how safely the facilities have been designed. City streets are likely to have more accidents per year than rural highways simply because the traffic volumes are greater. Hence, all other things being equal, it is best to have hazardous shipments use facilities that have low traffic volumes.

The countervailing trend is that the low volume facilities are usually designed to lower standards and are the most poorly maintained. This is why federal regulations suggest that hazardous materials shipments move via interstate highways in spite of the higher traffic volumes. Hence both traffic volumes and facility conditions need to be taken into account in selecting desirable routes (see separate discussion on facility condition).

Measurement of existing traffic volumes and accident frequency is basic, although the data must be used with some degree of care. For roads in the State of Nevada, accident frequency and average annual daily traffic (AADT) statistics are available from the Nevada Department of Transportation (NDOT), as well as the percentage of trucks (for single unit trucks and tractor-trailer combinations). For railroads, accident frequency and million-gross-ton (MGT) statistics are available on a line-by-line basis for freight and passenger movements combined, and railroad timetables can be consulted to determine train frequencies (both freight and passenger).

For the impact assessment, several measures could be used. For measuring

traffic volume, either average traffic density or maximum traffic density encountered could be used. In many respects, the latter measure is preferable because it monitors the worst traffic conditions to which a shipment would be subjected, implying that the traffic conditions on all other segment comprising the route would be better. In the absence of conclusive data on which is more appropriate (and since the data would already be computerized), both should be used.

Quantitatively, the problem with this factor is that the underlying data are not always reliable. For highways, AADT figures are sometimes extrapolations from previous year counts, and the percent truck data are only reflective of a four- to six-hour time period during which the data were collected. For rail, the freight train frequency data are an approximation of actual practice; scheduled trains are sometimes cancelled and extras are added.

A preferred measure for accident potential is the accident rate, which can be derived by dividing accident frequency by traffic volume. As is the case for collecting traffic volume data, accident data can suffer from reliability problems. In fact, accident rates can be subject to additional bias given that uncertainties in both volume and accident counts are combined in this measure.

For purposes of the initial model enhancement, existing data will have to be accepted as adequate. However, the information should be tested for statistical validity, and outlying data points should be studied to see if a data collection or recording error created the suspect information. Eventually, sampling techniques (e.g. periodic traffic counts) could be used to ensure that the data reflect actual conditions.

Facility Condition

Facility condition refers to the quality of the highways or railroads being used on a given route. All other things being equal, the best route to use is the one with the highest quality facilities. This minimizes the likelihood that facility condition will be the cause of an incident. Example areas of concern for highway include pavement condition, signage, geometric standards and lighting. It appears that information on road surface type, surface and grade widths, and geometry (e.g. vertical and horizontal curves, roadway gradient, underpass clearances) are available through NDOT.

Facility quality can be measured most easily by a condition index. Most states, including Nevada, develop such an index for all major roads as an input to the maintenance and rehabilitation decision-making process. For purposes of the impact assessment, an average condition index could be defined. If marked variations in average expenditures from mile to mile are discovered, an alternate measure is the worst facility condition encountered on a given route.

Of course, assuming capital and maintenance funds are distributed on an equitable basis, the difference between the minimum and average values would be nominal. On the other hand, if the funds are not being distributed to maintain

all roads equally well, the minimum condition indicator is more desirable because it reflects the most deteriorating condition.

Weather Restrictions

Weather conditions should also be considered in the impact assessment. Ideally, adverse weather conditions should be avoided to minimize the likelihood of accidents. Moreover, given Nevada's climate and the location of the Yucca Mountain site, such things as dust and wind are important along with more traditional factors such as rain, snow, ice and fog.

Measuring the degree of weather adversity is rather basic. The simplest measure to use is the number of adverse weather days encountered per year on a given route. These conditions, typically defined by the state police, reflect adverse combinations of dust, wind, rain, snow and fog. Weather conditions should also be reflected in measuring dispersion should a release occur. Here, temperature, wind speed and direction, and surrounding topography are essential information items.

To determine weather characteristics, no major data collection effort should be required. The National Weather Service reports climatic conditions for a large number of locations. One would only need to process these data to determine how to measure these effects, with the exception, of course, in measuring topographic contours. This information should be available from USGS. Specific data from the Yucca Mountain/Nevada Test Site vicinity should certainly be available from the DOE.

Expertise

Transportation planning and systems analysis.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Near-term.

5.2.2 Economic Cost Modules

Once the TMIAS can produce forecasts in terms of safety, facility usage, etc., these impacts need to be translated into economic terms. After the methodology has been developed to translate transportation impacts and risk mitigation strategies into monetary values, it should be integrated into the

overall analysis package so that economic impacts are ultimately produced as an output from the model.

Expertise

Economics, transportation systems analysis, nuclear waste transportation, transportation engineering.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Near-term.

5.3 TRANSPORTATION IMPACT MONITORING

Study Design

A program is needed for monitoring the impacts of the nuclear waste transportation system. The impact monitoring program should be developed to address at least three distinct phases: pre-waste shipment, waste shipment and post waste shipment. As Nevada is already experiencing impacts from the planning for the waste shipments (pre-waste shipment phase), development of the impact monitoring program should begin as soon as possible. During the waste shipment phase, the measurement of actual impacts should be used to assess the accuracy of predicted impacts and to modify the waste transportation system to reduce and/or mitigate impacts. Shipments to the WIPP present an ideal opportunity to develop and test a prototype system for the waste shipment phase.

The general tasks include:

- o Preparation of a conceptual design for the monitoring plan.
- o Development of the individual steps involved in carrying out the plan, broken down by functional area (e.g., transportation planning, personnel training, emergency response, etc.).
- o Performance of a trial application of the monitoring plan on a small geographic area using some other regularly occurring commodity shipment as the case study.
- o Iteration until a suitable monitoring plan is developed.
- o Collection of baseline data statewide using the monitoring plan.

Expertise

Impact assessment, nuclear waste transportation, transportation systems analysis, regulatory.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Near-term.

5.4 DATA COLLECTION AND DATABASE MANAGEMENT

Study Design

Following the design and initial implementation of the data collection/information management portion of the TMIAS, ongoing management of the system will be needed so that it remains current over the extended time frame during which repository planning and transportation operations are expected to occur. This will be particularly challenging given the high growth rates which Southern Nevada is experiencing.

Expertise

Database management, transportation data collection and analysis.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Near-term.

5.5 MONITOR ACTIVITIES AFFECTING NUCLEAR WASTE TRANSPORTATION

Study Design

Building upon the monitoring program initiated in the first year (task 4.3), Nevada should implement a comprehensive system for monitoring all activities worldwide, governmental and nongovernmental, relating to the transportation of nuclear waste. The system should monitor research and development activities, technical publications, laws and regulations and policy decisions.

Expertise

Institutional/intergovernmental relations, transportation planning, nuclear waste transportation.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Near-term.

5.6 REGULATORY STRUCTURE AND LIABILITY/COMPENSATION

5.6.1 Liability/Compensation--Price-Anderson Act

Study Design

In the fall of 1988, the United States Congress amended the Price-Anderson Act. In reviewing its position on liability and compensation, the State of Nevada should review and compare the new law to the Preferred Transportation System (section 1.6).

Expertise

Legal.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Immediate.

5.6.2 Mixed Wastes

If any of the nuclear waste to be transported to the repository are considered "mixed waste" under the federal Resource Conservation and Recovery Act (RCRA), the State of Nevada may be able to more extensively regulate it.

Study Design

This research will investigate if any of the waste to be transported to the repository is mixed waste and, if so, to determine whether the state may impose additional regulations on the transportation of mixed wastes.

Expertise

Hazardous and nuclear waste, and legal.

Importance

Major.

Urgency

Near-term.

5.6.3 Commercial Motor Vehicle Safety Act Regulations

Pursuant to the Commercial Motor Vehicle Safety Act of 1986, the DOT is in the process of promulgating regulations for commercial driver testing and licensing standards. States will be required to test drivers' knowledge of the federal hazardous materials regulations, among other things. The final regulations were published in the Federal Register on June 21, 1988, with corrections published on July 22, 1988.

The proposed regulations, among other things, establish minimum standards for state tests. These regulations should be utilized to ensure a proper level of knowledge of drivers being licensed by the State of Nevada. If Nevada takes the lead in this area, other states, and particularly the "corridor" states, may utilize Nevada's work in adopting their tests.

Study Design

Formulate a test for commercial drivers of hazardous materials.

Expertise

Driver training, test design, nuclear materials transportation, legal.

Importance

Essential.

Urgency

Immediate.

5.6.4 Statutory and Regulatory Changes Affecting Nuclear Waste Transportation

Study Design

Building upon task 3 of the first year work plan, Nevada should develop the capability to critically analyze all proposed statutory and regulatory changes affecting nuclear waste transportation to a repository. During the pre-operational and operational repository periods, there will be many such changes, most of which are not known at this time. Following are two examples of such proposed changes that should be analyzed.

Highway Routing of Non-Radioactive Materials. On April 7, 1988, the DOT published an Advance Notice of Proposed Rulemaking for the highway routing

of nonradioactive hazardous materials. The State of Nevada and its local governments should vigorously participate in this process. Additionally, the NWPO should closely follow these proceedings to determine what effect, if any, proposed rules may have on the transportation of radioactive materials.

Hazardous Materials Transportation Act Reauthorization. The federal Hazardous Materials Transportation Act (HMTA) controls most issues involving nuclear waste transportation. It is, therefore, of paramount importance that the State of Nevada take an active role in the reauthorization of this critical piece of legislation. The objectives of this effort should be to incorporate elements of the Preferred Transportation System into federal statute and to protect against preemption of state and local governments rights in regulating the transportation of hazardous materials, including radioactive materials. This can be accomplished by ensuring that all relevant players have accurate and timely information.

Nevada should develop a program to organize relevant groups to lobby local, state and federal governing bodies to adopt laws supportive of state and local governments. Written materials should be prepared for three groups of people: the lay public, state and local governments, and legislators and members of Congress. In order for the members of the public to actively participate in the reauthorization process, it will be essential that they have "fact sheets." Fact sheets should provide the lay public with information that will assist them in lobbying legislators and members of Congress (e.g., what the law is about, why they should be concerned, and explanation of the standard myths, and what they can do about the law. Fact sheets for the lay public are best prepared in a question and answer format.

Fact sheets for legislators and members of Congress are also helpful. These individuals are attempting to legislate in a complex area and tend to receive most of their material from industry lobbyists or in a form that does not lend itself to quick review. At the same time, however, it is important that the staff to these individuals are also provided with a thorough analysis of the issues. Two forms of written material must be prepared and provided to legislators and members of Congress: fact sheets addressing legislative concerns and an analysis of legislative issues.

State and local governments must also be provided an analysis explaining the issues, their relevancy to state and local governments, and the goals and objectives in formulating proposed legislation. The materials provided to legislators and members of Congress should also be provided to state and local governments.

A network must be developed whereby timely and accurate information can be disseminated, particularly during legislative and Congressional sessions. The network should include a mechanism for alerting participants to issues that require immediate action. Additionally, each new bill introduced into Congress should be analyzed, and the analysis should be distributed.

Expertise

Institutional/intergovernmental, hazardous nuclear materials transportation and legal.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Near-Term.

5.6.5 Federal/State Agreements

In the course of preparing for the repository, the federal government or the State of Nevada may desire to enter into an agreement to resolve certain transportation matters. For instance, the federal government may wish to enter into an agreement similar to the agreement that it entered into with the State of New Mexico whereby the state designated routes pursuant to the terms of the agreement. Before entering into such an agreement, the state must be assured of being able to protect its citizens by conforming its laws, where appropriate, to changes in federal laws.

Study Design

To determine whether the State of Nevada may amend its laws if it enters into an agreement with the federal government. At a minimum, the following question requires legal research: If a state enters into an agreement with the federal government and the federal law subsequently changes, does the federal law supersede the terms of the agreement?

Expertise

Legal, intergovernmental nuclear waste transportation.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-Term.

5.6.6 Indian Nations

As sovereign entities, Indian nations possess the right to regulate their members and their territories. This right, however, may be limited by a tribe's own codes or constitutions, a treaty or other agreement with the federal government or by virtue of Congress' law-making authority. In order to determine the extent and nature of the interaction between the laws of the Indian nations and the laws of the State of Nevada, the documents of the particular tribes must be evaluated in the context of the relevant federal and state laws.

Study Design

Research is needed to determine to what extent Indian nations in the State of Nevada may regulate the shipments of hazardous materials and radioactive materials. At a minimum, the research should attempt to determine the extent to which federal and state laws preempt the Indian nations from regulating in the field of hazardous and radioactive materials transportation. In answering this question, the research should focus on the specific topics identified in the Regulatory Structure section of the Preferred Transportation System report (section 1.6).

Expertise

Legal, hazardous and nuclear materials transportation.

Responsibility

State of Nevada.

Importance

Significant.

Urgency

Mid-term.

5.6.7 Rail Routing

Unlike highway routing, it is unclear which federal agency has the authority to mandate national railroad routing. It is also unclear whether a state government may regulate railroad routing, should it wish to do so.

Study Design

To determine which federal agencies have jurisdiction to establish national railroad routing and whether state governments may regulate rail routing. At a minimum, the following questions require legal research:

- o Given that trackage rights may be involved, which federal agencies have jurisdiction to establish national railroad routing?
- o Is the jurisdiction exclusive with the agency or agencies?
- o Are states preempted from regulating railroad routing?

Expertise.

Legal, hazardous and nuclear materials transportation.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Mid-term.

5.6.8 Development of a Model Hazardous/Radioactive Materials Transportation Statutes and Ordinances

Nevada's statutes regulating the transportation of hazardous materials, including radioactive materials, have developed over the last several years. There may be portions of those statutes that conflict with federal law and are, thus, preempted thereby. The problems could be identified and rectified through appropriate piecemeal legislation. However, to ensure a comprehensive state regulatory structure, Nevada should develop a model law that can also be adopted by other states or Indian Nations that have identical or comparable concerns.

At least three jurisdictions within the State of Nevada have adopted ordinances to address their concerns about the transportation of radioactive materials. No doubt, others will follow. Rather than scrutinizing each ordinance to determine its consistency with federal and state laws, a model ordinance should be developed that can then be adopted by Nevada's local governments as well as other local governments.

Goals and Objectives

To develop comprehensive model state, Tribal and local statutes and ordinances that will regulate to minimize the risks involved in the transportation of hazardous materials, including radioactive materials, and enhance the ability of state, Tribal and local governments to be prepared to respond to an accident or incident.

Study Design

A meeting of the State and Local Government Planning Group (SLGPG) should be held to discuss the members' concerns about the transportation of all hazardous materials, including radioactive materials, and to elicit the members thoughts about how those concerns could be abated by regulations. A draft statute and ordinance should be prepared and distributed to the SLGPG for comment by the members. Those comments, to the extent practical, should be incorporated and another draft distributed. A second meeting should be held to resolve any remaining problems.

Expertise

Legal, hazardous radioactive materials transportation, institutional/intergovernmental.

Responsibility

State, Tribal and local governments in Nevada.

Importance

Essential

Urgency

Near-term.

5.7 EMERGENCY PREPAREDNESS

To be provided under separate cover

5.8 TRANSPORTATION SYSTEM DESIGN RESEARCH NEEDS

5.8.1 Volumes and Timing of Shipments

Spent Fuel Storage Period

Conduct an assessment of the "optimum" period of spent fuel storage prior to shipment to a repository. When the repository begins operation, waste will have been out of reactors (or discharged from reprocessing) for five to ten years prior to shipment to the repository. However, after the backlog of this "old" waste has been shipped, it is possible that waste more recently removed from reactors or discharged from reprocessing will be shipped to the repository. The amount of radioactivity contained in the waste initially decreases rapidly. After this initial decay period, the activity of the waste declines less rapidly over an extended period of time. Thus an assessment should be conducted to determine the time period resulting in the maximum amount of decay (safest waste for shipment) that can be achieved for a reasonable storage period (less than 100 years).

Expertise

Nuclear engineering.

Responsibility

Federal. The DOE should develop and provide this information. If the DOE does not provide this information, the State of Nevada should develop it.

Importance

Essential.

Urgency

Immediate.

Flow Map and Matrix

Study Design

A map and flow matrix must be prepared showing origin locations and

quantities of material to be shipped with and without an MRS facility. This is critical to many of the other issues which have been identified in the research work: rail shipment options, truck shipment options, routing (all modes), modal choice, emergency response, cask design, etc. The general tasks include:

- o Preparation of a database showing the tons to be shipped by reactor site (and by the MRS, if developed).
- o Assumption of shortest interstate and mainline rail routes from these origins (and by the MRS, if developed) to the repository at Yucca Mountain and preparation of a map showing the resulting flow patterns (i.e., line width proportional to shipment volume).
- o Preparation of both of the above pieces of information in machine-readable format.

Expertise

Transportation planning, database management, computer graphics.

Responsibility

Federal. The DOE should develop and provide this information to all states for their use in preparing for the shipments to a repository. If the DOE does not provide this information, the State of Nevada should develop it.

Importance

Essential.

Urgency

Immediate.

5.8.2 Cask Design and Testing

Cask and Fuel Assembly Response to Stress

Study Design

Research is needed on the response of casks and fuel assemblies to specific stresses which have not been assessed in previous studies, including:

- o Cask responses to stresses when a defect exists in design and/or manufacture.
- o Fuel assembly response to stresses with and without cladding damage and/or deficient manufacture (this is of special interest when fuel

has undergone grain swelling or has a failed grain matrix; i.e., where the fuel pellet disintegrates to a powder under shock).

- o Fuel response to impact and heat through testing of irradiated fuel assemblies. While not an easy task, such destructive testing would clarify the potential of the fuel to leak, and demonstrate any need for internal shock absorbers in the cask (used in older designs, but not shown on current designs).
- o Crush stressing in a rail accident.
- o Development of a methodology for factoring cask defects into analyses (both long-term use of a defective cask, and failure causation due to a one-time defect).

Expertise

Materials and mechanical engineering, laboratory and machine production technicians, risk assessment and computer simulation.

Responsibility

Federal. Preferably implemented by a neutral party such as the Government Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Essential.

Urgency

Near-term.

Severe Accidents and Sabotage Consequences

Research is needed on potential severe accidents and realistic consequence assessments of severe accidents and sabotage/terrorism, including:

- o Development of an updated accident distribution model benchmarked against incidents that have occurred since 1975, including potential stresses that could occur by hazards not considered previously, such as a fire involving a propane tanker, liquified plastic or other high temperature thermal sources, or a stationary source such as a fuel tank farm near a railroad line.
- o Estimation of realistic accident/sabotage consequences, (e.g., an analysis that examines the minute-by-minute actions during a worst-case accident rather than the usual separate analyses of the four major stresses). Such a study should address the potential for

fuel re-oxidation during and after a fire, the ability of a fire to disperse particulates and vapors, the necessary evacuation even when a radiation release does not occur, and the specific details of cleanup in an urban area.

- o Critical evaluation of assumptions used in accident consequence analyses involving evacuation, cleanup and urban structures. The most detailed analysis to date (NUREG/CR-0743) assumes near-perfect population control, a very short cleanup period and a grossly oversimplified model of air flow in an urban environment.
- o Development of a database of all spent fuel shipments and the conditions of the containers used, so that actual design, manufacturing and maintenance deficiencies of all types can be factored together to demonstrate the past likelihood of serious cask vulnerability. This database would then be used with the simulation above to determine the spectrum of responses to stresses that would have been possible with the actual shipments that have occurred. That result would then be factored into the updated distribution model of accident stresses to determine the real risk of past shipments.
- o An expanded and integrated accident simulation model capable of accepting and utilizing information describing manufacturing defects, maintenance failures, fuel defects and/or failures (including re-oxidation), and the thermal inputs, due to a fire, that can be localized on specific cask areas to simulate a torch or partial engulfment of the container.

Expertise

Materials and mechanical engineering, laboratory and machine production, risk assessment and computer simulation.

Responsibility

Federal. Preferably implemented by a neutral party such as the Government Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Essential.

Urgency

Near-term.

Cask Design Methods

Study Design

Research is needed on proposed cask designs, the methods used to develop them, other available design tools with which to compare the presently used methods, and an evaluation of foreign experience in cask design and manufacture. The ability of "goof-proofing" cask designs to avoid manufacturing and maintenance problems and defects should be explored.

A computerized cask simulation should be developed that would create a cask design based on a set of stress parameters (i.e., accident conditions) and produce a computer-aided drawing of the end product. It should generate a family of designs to demonstrate the sensitivity of cask shape, size and weight to stresses greater than presently required by regulations (one could input a set of stresses and see what a cask capable of withstanding them would look like).

Expertise

Materials and mechanical engineering, laboratory and machine production, computer simulation.

Responsibility

Federal. Preferably implemented by a neutral party such as the Government Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Essential.

Urgency

Near-term.

Mass Production of Large Metal Castings

Study Design

Research on problems in mass production of devices similar to casks, especially rail casks including large steel, uranium and lead castings and forgings, is needed to assess problem areas in manufacturing and ways to avoid them. An evaluation of the German storage cask manufacturing experience should be included.

Expertise

Materials and mechanical engineering, laboratory and machine production.

Responsibility

Federal. Preferably implemented by a neutral party such as the Government Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Major.

Urgency

Near-term.

Cask QA/QC Program

Study Design

Research is needed to develop an appropriate QA/QC program for cask design, fabrication, testing and maintenance. The research should include:

- o A review of past performance of the NRC, the DOE and the DOT in addressing design, manufacturing and testing deficiencies, and the ways in which those agencies will assure compliance with the cask license and its QA/QC procedures. At present, the DOE field offices may hold much of this responsibility, and some have a poor history in QA/QC.
- o A more complete database on past spent fuel shipments and their problems (including those involving research and defense containers) is essential to production of a risk assessment that reflects the real incidence and types of human error and equipment deficiency.

Expertise

Materials and mechanical engineering, QA/QC, database management.

Responsibility

Federal. Preferably implemented by a neutral party such as the Government Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Essential.

Urgency

Near-term.

5.8.3 Modal Mix

Modal Mix Selection Methodology

Study Design

Development of a modal mix selection methodology which is clear, concise, consistent, robust and acceptable to all interested parties is essential for a quantitative assessment of transportation impacts. The general tasks include:

- o Development of a conceptual framework for how modal decisions should be conducted.
- o Determination of a detailed procedure for making modal decisions.
- o Performance of a trial application of the selection methodology.
- o Iteration until an acceptable selection methodology is identified.
- o Documentation of the results.

Expertise

Transportation engineering and risk assessment.

Responsibility

Federal and the State of Nevada. Nevada needs to develop its methodology so that it can evaluate the expected impacts from the perspective of state, Tribal and local governments and perform sensitivity analyses to identify best and worst case conditions.

Importance

Essential.

Urgency

Near-term.

Measures for Modal Mix Criteria

Study Design

The second, important modal mix research area is the need for specific measures (i.e., quantitative indicators) for the criteria to be used in comparing modes (e.g., should expected fatalities be used as the measure of risk, or population exposed or dollar damages). The measures must be suitable,

acceptable, quantifiable and reliable. The general tasks include:

- o Identification of the criteria to be employed.
- o Determination of suitable measures for each.
- o Performance of one or more trial uses of the measures.
- o Iteration until an acceptable set of measures is identified.
- o Documentation of the findings and recommendations.

Expertise

Transportation engineering and risk assessment.

Responsibility

Federal and the State of Nevada. Nevada needs to develop its methodology so that it can evaluate the expected impacts from the perspective of state, Tribal and local governments and perform sensitivity analyses to identify best and worst case conditions.

Importance

Essential.

Urgency

Near-term.

Weather Sensitivity of Modes

Study Design

Additional information about the weather sensitivity of the various modes is needed in order to determine accurately the incremental risks, costs, resource requirements and logistics problems which would accompany various levels of use of each of the modes. For example, weather is clearly a factor in truck transportation. Highways, especially on the plains and in mountainous regions, become impassable under heavy snow conditions. If the waste volumes moving by truck are small, this may be a detrimental factor because the cost of secured parking areas may be high on a per shipment basis. However, if these costs are spread over a much larger volume of shipments, the truck option may be far more cost effective and its relative attractiveness improved.

Responsibility

Federal. If the DOE does not provide this information, the State of Nevada should develop it.

Importance

Major.

Urgency

Near-term.

Security and Safety

Study Design

Much more information is needed about security and safety because, to date, nuclear waste shipments have been infrequent. Regardless of what modes are eventually chosen, the shipment of waste to a repository will be far more routine and frequent than they have been in the past. No prior experience exists for correct safety and security provisions for such large numbers of shipments, particularly to a single destination. There may be economies of scale. On the other hand, the costs may rise disproportionately to the volumes involved. Hence there is a need to explore the options available and their requisite costs.

In addition, there are important trade-offs between security and potential risk mitigation measures. For example, to improve emergency preparedness and to focus needed infrastructure improvements it would be preferable to minimize the number of modes and routes utilized. However, from a security standpoint, the number of routes should be maximized. Research is needed to be able to weight the trade-offs between security and other risk reduction/mitigation strategies.

Expertise

Security (sabotage/terrorism) and risk assessment, transportation planning and transportation operations.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Near-term.

Comparative Risks of Highway and Rail Transport

Study Design

The interest in this controversy arises from the trade-off between lower accident rates but potentially greater accident consequences (larger source term, the occurrence of greater forces, etc.) experienced by rail transport vs. the higher accident rate, but less severe accident experience of road transport.

Expertise

Highway and rail engineering, risk assessment, transportation systems analysis, and nuclear materials transportation.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Near-term.

Assessment of Truck Shipment Options

Study Design

An assessment of single trucks, doubles, convoys, overweight trucks and other potential truck shipment options needs to be conducted. Issues to be addressed include:

- o Assessment of the relationship between vehicle (and axle) weight and damage to pavements and structures.
- o Assessment of the accident rates and other risk factors associated with single, double and overweight trucks.
- o Assessment of the risks of fewer, larger shipments versus more, smaller shipments.

Expertise

Trucking operations, risk assessment, nuclear materials transportation.

Responsibility

Federal and State of Nevada. Nevada needs to develop its methodology so that it can evaluate the expected impacts from the perspective of state, Tribal and local governments and perform sensitivity analyses to identify best and worst-case conditions.

Importance

Essential.

Urgency

Near-term.

Assessment of Rail Shipment Options

A comprehensive and detailed assessment is needed on potential rail shipment options: special, dedicated, "hefty" rail and regular trains. Concern with this issue is motivated by trade-offs between regular, special and dedicated train service. Section 2.3 of the Preferred Transportation System report discusses the apparent trade-offs among the rail service options.

Study Design

Research is needed in three key areas:

- o Development of a detailed description of potential rail shipment options.
- o Development of an evaluation methodology for rail shipment options.
- o Development of measures for rail options evaluation criteria.

A thorough description of the rail options available is needed so that the evaluation process can proceed and the relative strengths and weaknesses of the various options identified. The general tasks include:

- o Preparation of a list of the options which should be considered.
- o Development of a thorough descriptions of each.
- o Selection of one or more reactor sites (or the MRS) for detailed examination to develop examples of how each option would work.

- o Iteration until a complete list of the options is developed and they have all been described and illustrated.

A rail shipment options evaluation methodology, similar to the one used for modal mix, which is clear, concise, consistent, robust, and acceptable to all interested parties needs to be developed. Without this, an identification of the best options and their appropriate conditions of use is impossible. The general tasks include:

- o Adaptation of the modal choice methodology for use in evaluating the rail shipment options.
- o Adaptation of the steps involved as appropriate.
- o Performance of a trial application of the evaluation methodology.
- o Iteration until an acceptable selection methodology is identified.

There is a need for specific measures (i.e., quantitative indicators) for the criteria to be used in comparing options. The measures must be suitable, acceptable, quantifiable and reliable. The general tasks include:

- o Adoption of the criteria and measures used by modal mix with additions and/or deletions as required.
- o Determination of suitable measures for any additional criteria.
- o Performance of one or more trial uses of the new measures.
- o Iteration until an acceptable set of new measures is identified.

Expertise

Rail operations, risk assessment, nuclear materials transportation.

Responsibility

Federal and State of Nevada. Nevada needs to develop its methodology so that it can evaluate the expected impacts from the perspective of state, Tribal and local governments and perform sensitivity analyses to identify best- and worst-case conditions.

Importance

Essential.

Urgency

Near-term.

5.8.4 Equipment and Vehicle Standards

Study Design

An assessment of equipment and vehicle standards needs to be conducted, including:

- o Special needs for truck tractors and trailers.
- o Special needs for rail engines and cars.
- o Standards for cask tiedowns.
- o Assessment of the benefits and costs of potential vehicle improvements (e.g. deadman breaks).

Expertise

Rail and highway vehicle engineering, and risk assessment.

Responsibility

Federal and State of Nevada.

Importance

Important.

Urgency

Mid-term.

5.8.5 Infrastructure

New Routes

Study Design

A comprehensive assessment of the benefits to state, Tribal and local governments from potential new routes, such as a Las Vegas Valley highway bypass and a rail spur to Yucca Mountain, need to be conducted.

Expertise

Transportation planning, risk assessment, nuclear waste transportation, intergovernmental/regulatory.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Near-term.

Economic Assessment Model

Study Design

An economic assessment model recently developed for the U.S. Army Corps of Engineers by the University of Nevada, Reno should be adapted to assess the cost of increased maintenance, rehabilitation and reconstruction of existing facilities and the construction of new facilities necessitated by nuclear waste shipments to a repository. The model should consider initial design and construction costs and life cycle costs in terms of current worth and equivalent uniform annual costs are of importance. Guidelines for conducting these types of cost analysis for pavements have been and are suggested for use as a starting point.

The initial and recurring costs that should be considered in this economic evaluation include the following:

- o State, Tribal and local government costs for highway and the railroads costs for rail.
 - Initial capital cost of construction
 - Future capital cost of reconstruction and rehabilitation
 - Maintenance cost
 - Salvage value
 - Engineering and administration cost
 - Traffic control cost
- o Transportation facility user costs.
 - Travel time
 - Vehicle operation

-Accidents

-Discomfort (including time delay and extra vehicle operating costs during resurfacing or major maintenance)

o Non-user costs.

Initial and continuing databases need to be established to provide these cost data. Considerable development work needs to be performed to more adequately define salvage value, user costs and non-user costs.

Expertise

Rail and highway engineering and economics.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

Highway

The research required for the evaluation of the impact on the infrastructure of Nevada's highways of nuclear waste shipments to a repository at Yucca Mountain includes: capacity of routes, condition of pavements, condition of bridges and cost.

Capacity of Routes

Study Design

A capacity analysis of the affected highways, roads and streets must be performed to determine the adequacy of the network and to decide if new facilities are required. Projected traffic volume generated by the repository should be used in the analysis.

The Highway Capacity Manual published by the Transportation Research Board is the authoritative guide for the performance of highway capacity analysis. The manual reflects over 50 years of comprehensive research by a number of research agencies. The procedures described in the manual are based on simple graphs or tables for specific standard conditions which are adjusted

for prevailing conditions different from those specified.

To perform the capacity analysis on the identified routes, it will be necessary to obtain data as specified by the Highway Capacity Manual. These include:

- o Traffic volume for the peak hour or any other hour of interest.
- o Traffic characteristics.
- o Roadway characteristics.

The routes must be divided into segments with uniform characteristics. A change in any of the data indicates the need to separate the route into additional segments for analysis. Acceptable levels of service must also be defined in order to establish the capacity of a facility. This will require input from the citizens of Nevada.

Expertise

Transportation engineering.

Responsibility

State of Nevada.

Importance

Minor.

Urgency

Mid-term.

Condition of Pavements

Study Design

Data on structural capacity, geometrics, roadside characteristics and drainage conditions of Nevada highways may not be readily available. The existing pavement information sources include:

- o City of Las Vegas Pavement Management System.
- o Clark County Pavement Management System.
- o Nevada Department of Transportation Pavement Management System.
- o Plans and Specifications for the City of Las Vegas, Clark County and the Nevada Department of Transportation.

The pavement management records from NDOT and local governments along potential routes need to be integrated into a Pavement Management System for systematically scheduling maintenance, rehabilitation and reconstruction of pavements based on maximizing benefits or minimizing cost. It will also be necessary to obtain structural section plans for all potential routes and to conduct destructive sampling to verify structural sections and to ascertain existing pavement structural capability. A drainage survey must be conducted for all routes.

Expertise

Pavement management, database management.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

Pavement Performance Models

Study Design

Performance models must be developed specifically for Nevada pavements to predict the time to failure given typical traffic, maintenance and rehabilitation efforts and environment. This will encompass a review of existing performance models, an analysis of pavement performance in Nevada and an analysis of environmental data. Available information includes:

- o Performance models in literature such as:
 - Transportation Research Record
 - National Cooperative Highway Research Program Reports
 - International Conference on the Structural Design of Asphalt Pavements
 - Proceedings of the Association of Asphalt Paving Technologists
- o City of Las Vegas, Clark County and Nevada Department of Transportation pavement management systems.

- o Agency traffic records.
- o Agency maintenance and rehabilitation records.
- o Weather records from the National Oceanic and Atmospheric Administration.
- o Material properties from NDOT research.

To develop a performance model to predict pavement failure, a representative sample of low, medium and high volume pavements can be obtained using NDOT's Pavement Management System data. Traffic, maintenance and structural records are available from local and state agencies. These data must be analyzed to find deterioration rates for existing pavements as a function of traffic, maintenance and rehabilitation, structural design and environment.

Expertise

Pavement engineering and maintenance.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

Condition of Bridges

Study Design

The condition of all bridges and other structures along potential nuclear waste transport routes to the repository must be assessed. NDOT is responsible for keeping records on Nevada's bridges. The procedure for rating an existing bridge requires careful evaluation of many factors. All physical features of the bridge that have an effect on its structural integrity need to be examined, and the absolute maximum permissible load level that the structure may be subjected to must be determined.

Bridge inspection should include piers and abutments, stringers and girders, trusses, bearings and expansion joints, decks, sidewalks and railings. State and national agencies have developed inspection manuals that described the equipment and type of information needed to evaluate the

condition of bridges. The "Manual for Maintenance Inspection of Bridges," published by the American Association of State Highway and Transportation Officials, provides for the evaluation of bridge components by specifying stress-carrying capacity in terms of loads producing the design stress and a higher allowable stress due to overweight vehicles.

Information regarding the present condition of Nevada's bridges on the state-funded system, can be obtained from NDOT "Bridge Sufficiency Rating." Another source of information on the condition of bridges is the National Bridge Inventory published in January 1986 by the Federal Highway Administration. The inventory contains records on more than 575,000 highway bridges with spans of 20 feet or more. Relevant information includes the year the bridge was built, structure type, superstructure condition rating, substructure condition rating, estimated remaining life, structural condition rating, proposed improvements, etc.

Expertise

Bridge engineering.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

Bridge Management System

Study Design

A comprehensive bridge management system (BMS) should be developed for assessing bridge strengthening needs such as replacing, rehabilitation, widening or other structural work. The BMS should be used to compare different maintenance, rehabilitation and replacement options for Nevada's bridges. Information relating to Bridge Management Systems and bridge strengthening needs can be found in literature such as Transportation Research Record and National Cooperative Highway Research Program Reports.

Expertise

Bridge engineering and database management.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

Rail

Within rail infrastructure, the main missing piece of knowledge, besides a plan for monitoring the impacts of rail transportation of nuclear waste pertains to the special hardware needed to ensure the safe shipment of the nuclear waste. Little if any attention has been devoted to the subjects of locomotive modifications, special communications and monitoring equipment, and special maintenance facilities. Rather, the focus has been on track damage, condition assessment, and construction and maintenance practices, with the intent of determining incremental wear impacts. While this information needs to be reviewed, and previous research results distilled into a position statement on how rail infrastructure will be affected, the more important question to answer is what additional infrastructure requirements will need to be met.

Incremental Wear Assessment

Study Design

Determine what incremental wear will be caused by the shipments of nuclear waste. The general tasks include:

- o Survey of the literature for findings on incremental wear rates.
- o Estimate of the incremental wear per shipment for the various rail shipment options available (the incremental wear rate due to dedicated trains may be different from that due to individual shipments in general merchandise freight trains).
- o Distribution of these incremental wear rate models for review and comment among the railroads, the DOE, and various consultants to the railroad industry.
- o Modification and enhancement of the models as appropriate based on the comments received.

- o Documentation of the results.

Expertise

Rail engineering and maintenance.

Responsibility

The railroads. The State of Nevada may want to conduct its own wear assessment. If so, it should base its assessment on prior research results conducted by the Association of American Railroads individual railroads, and various academic institutions (e.g., MIT, Illinois Institute of Technology), rather than trying to develop new wear rates based on original empirical research.

Importance

Significant.

Urgency

Mid-term.

Special Infrastructure Needs

Study Design

Determine what special infrastructure may be needed to ensure the safety and security of nuclear waste shipments to a repository. The general tasks include:

- o Work with railroad experts to develop a comprehensive and logical list of what the special infrastructure needs might be.
- o Determination of where these infrastructure investments might be required within the State of Nevada.
- o Preparation of a working paper describing these findings.

Expertise

Rail engineering and operations, and nuclear waste transportation.

Responsibility

The railroads will be especially thorough about determining what special infrastructure needs exist. The DOE will counter with a needs assessment of its own. The State of Nevada must determine what special needs exist in order to satisfy its own concerns about the safety and security of the shipments.

- o Documentation of the results.

Expertise

Rail engineering and maintenance.

Responsibility

The railroads. The State of Nevada may want to conduct its own wear assessment. If so, it should base its assessment on prior research results conducted by the Association of American Railroads, individual railroads, and various academic institutions (e.g., MIT, Illinois Institute of Technology), rather than trying to develop new wear rates based on original empirical research.

Importance

Significant.

Urgency

Mid-term.

Special Infrastructure Needs

Study Design

Determine what special infrastructure may be needed to ensure the safety and security of nuclear waste shipments to a repository. The general tasks include:

- o Work with railroad experts to develop a comprehensive and logical list of what the special infrastructure needs might be.
- o Determination of where these infrastructure investments might be required within the State of Nevada.
- o Preparation of a working paper describing these findings.

Expertise

Rail engineering and operations, and nuclear waste transportation.

Responsibility

The railroads will be especially thorough about determining what special infrastructure needs exist. The DOE will counter with a needs assessment of its own. The State of Nevada must determine what special needs exist in order to satisfy its own concerns about the safety and security of the shipments.

For example, the state might want to insist on high-quality communications and tracking equipment, signalized track wherever the shipments move, and centralized traffic control so that the condition of the railroad is known at all times. Further, the state might want to insist on special bypass tracks being built to avoid heavily populated areas or busy railroad yards.

Importance

Major.

Urgency

Mid-term.

5.8.6 Defense Waste

Shipment Information

Study Design

Additional information is needed on the defense waste that will be shipped to the repository. Research should be undertaken to obtain the following details on defense waste, by facility of origin: volumes, radiological and other physical characteristics and modal access.

Expertise

Nuclear waste and transportation planning.

Responsibility

Federal.

Importance

Essential.

Urgency

Mid-term.

Assess Special Requirements for Defense Waste Transportation

Study Design

The components of the preferred transportation system should be evaluated as to their adequacy for defense waste shipments, taking into consideration the

particular characteristics of defense waste. More information must be developed about special risks, if any, involved in transporting defense waste, such as hazards of radiation, sabotage or terrorism, and public perception. Findings as to defense waste shipment information will need to be incorporated into the risk assessment work.

Expertise

Regulatory, nuclear engineering and risk assessment.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Mid-term.

Monitor Federal Institutional Developments

Study Design

The DOE now believes that there are no outstanding issues concerning the transportation of defense waste to the repository. The State of Nevada should closely monitor and exert influence on defense waste transportation issues and regulatory structure including: NRC certification of defense waste casks; pending rulemaking by NRC which would relax NRC safeguard requirements; and DOE's "equivalent" safeguard requirements.

Expertise

Nuclear waste transportation and intergovernmental/regulatory.

Responsibility

State of Nevada.

Importance

Essential.

Urgency

Immediate.

5.9 TRANSPORTATION SYSTEM OPERATIONAL PROCEDURES RESEARCH NEEDS

5.9.1 DOE Carrier Requirements

The contracting process is probably the least well understood aspect of the DOE nuclear waste transportation plan system. A set of screening criteria needs to be developed and its use outlined. Similarly, pre-qualification processes (e.g. test runs) need to be described and evaluated.

Contract terms and conditions must be delineated and brought to a status acceptable to state, Tribal and local governments as well. While DOE and the carriers may be the only direct parties involved in the contracts, their terms and conditions should be accepted in principle by all actors involved in the transportation process. One important focal point is the division of responsibility between the shipper (DOE) and the transporter. This includes decisions regarding routing, vehicle and cask maintenance and inspection, stopping plan development and employee training. Options for dividing these responsibilities among the DOE, the carriers and other contractors and subcontractors must be drawn up and their implications studied, including legal problems that may arise.

Contractor Pre-qualification Process

Study Design

Develop a process and criteria for determining which carriers are potentially qualified to transport nuclear waste to a repository. The general tasks include:

- o Determination of what qualifications must be met.
- o Determination of how to test each carrier's ability to meet the qualifications established. This might include test shipments, interviews of various company employees from the chief executive officer on down to truck drivers, mechanics, etc., financial audits, and safety audits.
- o Distribution of the testing procedure for review and comment.
- o Modification and enhancement of the procedure as appropriate, based on the comments received.
- o Preparation a working paper describing the screening process.

Expertise

Transportation contracting and nuclear waste transportation.

Responsibility

Federal.

Importance

Essential.

Urgency

Long-term.

Contract Terms and Conditions

Study Design

Develop contract terms and conditions for the transport of nuclear waste to a repository. The general tasks include:

- o Preparation of a list of topics which must be covered by a contract and desirable terms and conditions for each.
- o Circulation of these to a selected group of potential carriers for review and comment.
- o Update of the contract terms and conditions based on the feedback received.
- o Preparation of a working paper describing these findings.

Any aspects of the Preferred Transportation System which do not become regulatory requirements should be implemented through contract requirements.

Expertise

Transportation contracting and nuclear waste transportation.

Responsibility

Federal. The DOE will have prime responsibility for developing the contract terms and conditions. The carriers will counter with their own terms and conditions in disputed areas. The State of Nevada needs to sketch the structure of such contracts on a broad basis so that it knows what terms and conditions (including any aspects of the Preferred Transportation System not required by regulation) it would like to see included to protect the safety and security of its citizenry.

Importance

Essential.

Urgency

Long-term.

Case Study on WIPP Carrier Selection

Study Design

A case study of the carrier selection process utilized for the WIPP shipments may provide valuable information which could be useful in selecting carriers for repository (and MRS) shipments. The case study should examine: the type of contract utilized, the criteria (and weighting of criteria) for carrier selection, the expertise of those evaluating carrier qualifications, the terms and conditions of the contract and the procedures for appealing selection decisions.

Expertise

Transportation contracting and nuclear waste transportation.

Responsibility

State of Nevada.

Importance

Important.

Urgency

Near-term.

5.9.2 Personnel Qualifications

Study Design

Research is needed to ensure that all personnel involved in the nuclear waste transport system have qualifications commensurate with their responsibilities. The general tasks include:

- o Identification of all of the various job categories that the nuclear waste transportation system will require.
- o Conduct surveys to determine the most stringent personnel qualifications currently used in government or the private sector for

each job category or similar job description.

- o Convention of a national-level conference to assess if the most stringent personnel requirements for each job category are sufficient for the special characteristics of nuclear waste and for the magnitude of shipments to the repository (and an MRS, if one is developed).
- o Preparation and distribution of a personnel qualifications proposal for review and comment.
- o Modification and enhancement of the qualifications proposal as appropriate based on the comments received.
- o Preparation of a working paper describing the personnel qualifications requirements.

Expertise

Personnel recruitment and management and nuclear waste transportation.

Responsibility

Federal. The DOE has responsibility for developing qualifications requirements for the majority of personnel. The State of Nevada needs to develop some personnel requirements for its own inspection/enforcement and emergency preparedness personnel.

Importance

Essential.

Urgency

Long-term.

5.9.3 Personnel Training

Development of training programs will require study in several areas. Alternative educational procedures must be assessed. Existing educational policies may not be adequate to teach all individuals properly. A set of liaison programs need to be developed. In addition, a program that involves regular contact with prior students needs to be developed. It should act as a cross-check on the quality of the training received and a constant reminder of the importance of the material learned. Finally, alternative strategies for locating training facilities should be developed.

Study Design

Develop a comprehensive training program which ensures all personnel

involved in the nuclear waste transport system have qualifications and training commensurate with their responsibilities. The general tasks include:

- o Convention of a national-level conference to determine what training should be provided.
- o Determination of how best to provide each of the types of training needed. Also when, where, and to whom the training should be given; what types of testing procedures should be used; how they should be administered and when; and what follow-up procedures should be used to ensure material learned is not forgotten.
- o Distribution of this training plan for review and comment.
- o Modification and enhancement of the training plan as is appropriate based on the comments received.
- o Preparation of a working paper describing the training plan.

Expertise

Training and nuclear waste transportation.

Responsibility

Federal. The DOE has responsibility for developing the training program for the majority of personnel. The State of Nevada needs to develop some training programs of its own for inspection/enforcement and emergency preparedness personnel.

Importance

Essential.

Urgency

Long-term.

5.9.4 Cask Maintenance

Many of the issues covered in the Cask Design and Testing Research section also apply to the question of cask maintenance. The simulations and shipment database discussed in the Cask Design and Testing Research section will suffice for handling the risk assessment aspects of maintenance, provided they include attention to maintenance failures. The database, for example, should include past valve problems, weld failures in the field, etc., and the accident simulation should allow inclusion of such failure data to properly demonstrate its impact on the cask under various accident stresses. Finally, the cask design simulation should be capable of creating a cask that reduces

stresses on a part that is easily damaged; e.g. a seal that could not remain viable at a given temperature could require a thicker rim to protect it against heat from a fire.

Study Design

The cask maintenance research program should be designed to address the following issues:

- o Parts that will require maintenance in the cask designs.
- o Cask response to stresses when a defect in maintenance or a replacement part occurs.
- o Evaluation of foreign experience in cask maintenance.
- o Qualifications of cask maintenance firms and methods of investigating their past handling of similar equipment. Cask maintenance vendor availability, testing and installation methods.
- o Precise delineation of the role of the DOE personnel in cask maintenance QA/QC. Past performance of the NRC, the DOE and the DOT in addressing maintenance violations.

Expertise

Experts in engineering, testing data handling and computer simulation.

Responsibility

Federal. Preferably implemented by a neutral party such as the General Accounting Office (GAO) or the Underwriters' Laboratories.

Importance

Essential.

Urgency

Maintenance research related to cask design is immediate. Other cask maintenance research is long-term.

5.9.5 Vehicle Maintenance

Two research needs regarding vehicle maintenance have been identified: one which focuses on "home-based maintenance," repair, servicing and inspection work which is performed on a regularly scheduled basis by the carrier, the DOE, or a maintenance contractor; the second, called "field-based maintenance," focuses on impromptu repairs which are performed on the road in

response to component failures. Both are critical to the overall success of the nuclear waste shipment program.

Most portions of the home-based maintenance plan can be developed by adapting existing industry practices to nuclear waste shipment needs. The plan will probably involve shorter-than-normal inspection and preventive maintenance intervals and more extensive and earlier component changeouts to minimize the likelihood of in-service breakdowns. The field-based maintenance plan, however, represents a concept about which very little is known. Contingency planning is typically not so formal. One must determine what problems are most likely to occur, what actions should be taken by the crew, what maintenance work should be performed, where it should be done, what should be done with the cask while this maintenance work is being performed, where spare parts should be kept to expedite the repairs, what special training and qualifications the repair facilities and personnel should have, etc.

Home-based Maintenance Plan

Study Design

Develop a home-based vehicle maintenance program which ensures the greatest possible safety for the nuclear waste shipments. The general tasks include:

- o Determination of what components need servicing, when they should be serviced, and how.
- o Identification of the best possible techniques for maintaining the components.
- o Preparation of a plan for maintaining these components which minimizes the likelihood that maintenance-related breakdowns will occur enroute.
- o Circulation of this plan for review and comment to DOE and selected carriers and other vehicle maintenance experts.
- o Iteration until an acceptable home-based maintenance plan is identified.
- o Documentation of findings in a working paper.

Expertise

Rail and highway vehicle maintenance and nuclear waste transportation.

Responsibility

Federal. The State of Nevada should perform its own analysis on the topic to be prepared to intelligently assess the merits of the plan developed

by the DOE. For example, the state may want to suggest more stringent changeout intervals for certain components and would want to have a technical basis for making such an argument.

Importance

Essential.

Urgency

Long-term.

Field-Based Maintenance Plan

Study Design

Develop a well-reasoned plan for dealing with maintenance activities which must be performed in the field (i.e. while the vehicle is enroute or otherwise absent from a normal maintenance location). The general tasks include:

- o Determination of what guidelines apply (e.g. see the issues listed above in the introduction to this section).
- o Development of a field-based maintenance plan which satisfies these guidelines and provides maximum security and safety.
- o Determination of what resources are required to affect the plan.
- o Documentation of the findings in a working paper.

Expertise

Rail and highway vehicle maintenance and nuclear waste transportation.

Responsibility

Federal. The DOE should have responsibility for developing the field-based vehicle maintenance plan. Nevada state, Tribal and local governments should insist on an adequate level of safety and security and appropriate coordination with state, Tribal and local inspection and enforcement agencies. Hence the state, Tribal and local governments should develop their own ideas for such a plan and submit these to the DOE for its use. The state should also be well versed in the details of such plans so they are prepared to provide well-informed comments on the DOE plan.

Importance

Essential.

Urgency

Long-term.

5.9.6 Vehicle Stoppage

Two topics need exploration in the context of developing a vehicle stoppage plan. The most important is a contingency plan for dealing with unplanned stops, because none now exists. It must be developed systematically and carefully to ensure that it affords the best possible protection against unforeseen problems. The second is a need to resolve the issue about consistent versus randomized stoppages for the planned stops. Advantages and disadvantages can be cited for each, but a clear and through analysis of their strengths and weaknesses has yet to be conducted.

Contingency Plan for Unplanned Stops

Study Design

Develop a well-reasoned contingency plan for dealing with unplanned stoppages. The general tasks include:

- o Determination of what guidelines apply (e.g., conditions which must apply for the vehicle to remain still, maximum distance to nearest secured area, conditions under which help should be called in, such as additional security forces, company officials, DOE officials, or emergency response teams).
- o Development of an action plan which satisfies these guidelines and provides maximum security and safety.
- o Determination of what resources are required to affect the plan.
- o Documentation of the findings in a working paper.

Expertise

Rail and highway transportation operations, security and nuclear waste transportation.

Responsibility

Federal. The DOE should have responsibility for developing the contingency plan. Nevada state, Tribal and local governments should be

insistent on the level of safety and security necessary and the plan's interface with state, Tribal and local government agencies and emergency response organizations. Hence state, Tribal and local governments should develop their own ideas for a contingency plan and submit these to the DOE for incorporation into the final plan. The state should also be well versed in the details of such plans so it is prepared provide well-informed comments on the DOE plan.

Importance

Essential.

Urgency

Long-term.

Comparative Analysis of Consistent Versus Randomized Stoppages

Study Design

Determine whether consistent or randomized planned stoppages affords the least risk. The general tasks include:

- o Determination of what types of planned stoppages will occur, and where and when.
- o Development of two analyses for a region in which the stoppages might occur; one that assumes the stoppages occur at selected locations on a random basis and a second which assumes they consistently occur at one or two locations in the region.
- o Comparison and contrast of the relative degree of risk afforded by each.
- o Distribution of this assessment to various state, Tribal and local government agencies for review and comment.
- o Iteration until all interested parties agree that the comparison is accurate and comprehensive.
- o Preparation of a working paper regarding the relative merits of consistent versus randomized stoppages.

Expertise

Risk assessment, rail and highway operations, security and nuclear waste transportation.

Responsibility

Federal. The DOE should have prime responsibility for developing the stopping plan. The State of Nevada, however, should conduct an analysis of the trade-offs involved in this issue.

Importance

Major.

Urgency

Long-term.

5.9.7 Shipment Monitoring and Prenotification

This entire area needs to be researched in great detail. For the volume and frequency of nuclear waste shipments to a repository, all existing notification procedures and requirements should be re-examined. The main topics to address are:

- o What information should be given to whom, considering the value of distributing the information and the risk exposure consequences.
- o What notification mechanism should be employed, considering reliability and security.
- o What shipment monitoring and prenotification technology should be used.

Information Release Guidelines

Study Design

Develop a logical and acceptable set of guidelines for releasing shipment information. The general tasks include:

- o Contact selected state, Tribal and local government representatives to determine what information they need, when they need to have it and how they would like to receive it.
- o Summarize this information in a working document and distribute it for comment.
- o Modification and enhancement of the guidelines as appropriate, based on the comments received.
- o Documentation of the findings in a working paper.

Expertise

Intergovernmental/regulation, data management, nuclear waste transportation, security.

Responsibility

Federal and the State of Nevada.

Importance

Major.

Urgency

Long-term.

Information Distribution Technology

Study Design

Determine what information distribution technology should be employed. The general tasks include:

- o Survey of available communications technologies to determine which ones would be suitable for use.
- o Assessment of the technologies based on availability, ease of use, security, etc., and distribution to state, Tribal and local governments for review and comment.
- o Update of the assessment, based on the comments received.
- o Documentation of the findings in a working paper.

Expertise

Intergovernmental, communications, computers and nuclear waste transportation.

Responsibility

Federal. The DOE should have prime responsibility for determining how the information should be disseminated. The State of Nevada, however, should provide suggested mechanisms (i.e., what they would most welcome) so that the DOE does not propose unacceptable solutions.

Importance

Minor. Many alternate technologies could be used, all of which would

produce the same end result. The key question is whether one of these is better than any other, that it should be adapted as the standard and/or customized to meet the special needs of the nuclear waste shipment campaign.

Urgency

Long-term.

Shipment Monitoring Technology

Study Design

Determine what shipment monitoring technology should be employed. The general tasks include:

- o Survey available tracking technologies to determine which ones would be suitable for use.
- o Conduct trial applications of the most promising options and, by process of elimination, determine which one or ones are most suitable for use.
- o Documentation of the findings in a working paper.

Expertise

Shipment tracking, security, computers, intergovernmental/regulatory and nuclear waste transportation.

Responsibility

Federal. The DOE should have prime responsibility for developing the shipment monitoring technology. The State of Nevada, however, should help the DOE by providing design guidelines and offering to conduct trial runs of alternate technologies, including staged attempts at sabotaging it.

Importance

Essential.

Urgency

Immediate. The long research, development and implementation times associated with such technological developments demands high priority now for this activity.

5.9.8 Inspection and Enforcement

Many areas need research under the topic of inspection and enforcement. These include:

- o Comparison of present carrier, DOE, DOT, NRC, state, Tribal and local inspection requirements.
- o Development of technically-based inspection and out-of-service criteria.
- o Technical analysis of transportation equipment failure frequency: how often (miles traveled or time elapsed) do tractors/locomotives, trailers/railcars, casks, tiedowns, rails, etc., need to be inspected.
- o Marginal benefits of each inspection procedure.
- o Comparison of present carrier, DOE, DOT, NRC, state, Tribal and local enforcement procedures.
- o Alternate enforcement plans and their benefits.
- o Alternate plans for distributing the inspection and enforcement responsibilities and the benefits for each.
- o Assessment of the relationships between inspection frequencies, enforcement penalties and compliance.

These can be grouped into two broad categories for initial research and development: (1) inspection plans, techniques and designations of responsibility and (2) enforcement plans, strategies and designations of responsibility.

Inspection Plan

Study Design

Develop a comprehensive inspection plan for all vehicles and facilities involved in the nuclear waste transportation system. The general tasks include:

- o Determination of what inspections should be performed at what intervals based on the special needs of nuclear waste shipments to a repository and historical data on the reliability of all components used by either the vehicles or the facilities involved.
- o Identification of the best possible techniques which can be used to conduct these inspections; i.e. techniques which proved the greatest degree of safety protection possible.

- o Determination of what agency or organization is in the best position to conduct the required inspections (note that in some cases, this may involve regular inspections by one organization and spot checks by another).
- o Circulation of this inspection plan for review and comment to the DOE, State of Nevada, Tribal and local government agencies and to carriers who would potentially be involved in carrying the nuclear waste.
- o Iteration until an acceptable solution is identified.
- o Documentation of the findings in a working paper.

Expertise

Inspection procedures, rail and highway operations, intergovernmental/regulatory and nuclear waste transportation.

Responsibility

Federal and the State of Nevada.

Importance

Essential.

Urgency

Long-term.

Enforcement Plan

Study Design

Develop an enforcement plan. The general tasks include:

- o Determination of what types of enforcement actions are possible and when they would be appropriate.
- o Identification of the inspection activities or other events (e.g., accidents) to which these enforcement actions should be attached.
- o Determination of what agencies should be given what enforcement responsibilities.
- o Development of an enforcement plan from the results of above analyses.
- o Distribution of this plan to the DOE and State of Nevada, Tribal and local government agencies for review and comment.

- o Iteration until all interested parties agree that the enforcement plan is workable and acceptable.
- o Documentation of the findings in a working paper.

Expertise

Inspection, legal, intergovernmental and nuclear waste transportation.

Responsibility

Federal and the State of Nevada.

Importance

Major.

Urgency

Long-term.

5.9.9 Physical Protection

There are three key issues in physical protection (sabotage/terrorism) requiring additional research:

- o Response of casks and fuel assemblies to sabotage/terrorism (see section on Cask Design and Testing Research Needs).
- o Understanding the types of sabotage/terrorism actions that are possible and the appropriate response by state, Tribal and local governments in Nevada.
- o Understanding the trade-offs between otherwise desirable risk reduction actions and potentially increased sabotage/terrorism vulnerability.

Sabotage/Terrorism Typology and Response

Study Design

The research effort should include:

- o Development of a full range of possible sabotage, terrorism and other shipment interference actions.
- o Assessment of cask and fuel assembly response to the full range of possible actions.

- o Discussions among the various federal agencies (the DOE, the United States Department of Defense, the Federal Bureau of Investigation), state, Tribal and local agencies should be held to clarify roles and responsibilities.
- o State, Tribal and local governments should develop plans to fulfill their responsibilities.

Expertise

Intergovernmental, sabotage/terrorism, public safety, and nuclear materials transportation.

Responsibility

Federal and the State of Nevada. The federal government should develop the typology. The state, Tribal and local officials should review typology, hold discussions with the federal agencies and develop response plans.

Importance

Major.

Urgency

Mid-term.

Weighting Sabotage/Terrorism Trade-Offs in Risk Management

From an emergency preparedness and infrastructure standpoint, planning will be easier and much less expensive if the number of modes, routes and vehicle stopping locations are minimized. Emergency response will be aided by maximizing the amount of shipment notification and monitoring information. However, all of these actions will tend to increase the vulnerability of the shipment to sabotage and terrorism.

Study Design

Research should be directed toward weighting the trade-offs between increased shipment vulnerability to sabotage/terrorism and each of the following:

- o Minimizing the number of routes and modes for emergency preparedness.
- o Minimizing the number of routes and modes for infrastructure impacts.
- o Minimizing the number of vehicle stopping areas for emergency response and infrastructure impacts.

- o Maximizing the amount and timeliness of shipment monitoring information for emergency response.

Expertise

Sabotage, terrorism, public safety, risk assessment and management, emergency preparedness, infrastructure and nuclear materials transportation.

Responsibility

State of Nevada.

Importance

Major.

Urgency

Mid-term.

DRAFT - CATEGORY TWO

TRANSPORTATION NEEDS ASSESSMENT

**TASK 15.3 DESCRIPTION OF THE UNITED STATES
DEPARTMENT OF ENERGY PLANNED SYSTEM FOR THE
TRANSPORTATION OF NUCLEAR WASTE TO A
REPOSITORY AT YUCCA MOUNTAIN**

PHASE IIIA YUCCA MOUNTAIN SOCIOECONOMIC PROJECT

MOUNTAIN WEST RESEARCH

DECEMBER 2, 1988

TASK 15.3 WORKING PAPER

DESCRIPTION OF THE UNITED STATES DEPARTMENT OF ENERGY PLANNED SYSTEM FOR THE TRANSPORTATION OF NUCLEAR WASTE TO A REPOSITORY AT YUCCA MOUNTAIN

12/2/88

1.0 INTRODUCTION

This report is the working paper for Task 15.3 of the Transportation Needs Assessment. The Transportation Needs Assessment includes the following tasks:

<u>Task</u>	<u>Title</u>
15.1	Refine Statement of Work
15.2	Describe (Preferred) Transportation System Options
15.3	Describe the DOE Planned Transportation System
15.4	Evaluate the DOE Planned Transportation System
15.5	Review and Evaluate Existing Studies and Data Sources
15.6	Design Transportation Impact Studies

This report describes the United States Department of Energy's (DOE) current plans for the transportation of nuclear waste to a repository. In Task 15.4 the description of the DOE planned transportation system (DOEPTS) will be compared to the Preferred Transportation System, developed under Task 15.2.

1.1 STRUCTURE OF THE REPORT

The DOEPTS is described below in terms of seven crosscutting issues, seven design elements and nine operational elements of the transportation system. (This is the same structure used to describe the Preferred Transportation System.)

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This report presents currently available information on the DOE planned transportation program, ongoing and planned studies, and the DOE's decision schedule for each of the system issues and elements described above.

1.2 TERMINOLOGY

In this report the terms "nuclear waste" and "waste" refer to all of the radioactive wastes to be shipped to a repository. This includes spent nuclear

fuel (SNF) and consolidated SNF from commercial nuclear power reactors, solidified high-level wastes (HLW) from the civilian reprocessing of commercial spent fuel (CHLW, e.g., West Valley wastes) and defense high level wastes (DHLW) from the nuclear weapons program. It is uncertain at this time whether or not miscellaneous wastes resulting from spent fuel rod consolidation, transuranic wastes from sources other than the nuclear weapons program and "greater than Class C" low-level radioactive wastes may be disposed at the repository. Since the divisions of the Department of Energy (DOE) are at times reorganized and renamed, the term DOE is used generally to refer to any of the particular divisions of the DOE unless a division is specifically referenced, such as the DOE's Office of Civilian Radioactive Waste Management (OCRWM).

1.3 BACKGROUND

To date, the DOE has not issued decisions regarding many of the key issues concerning the system for transporting nuclear waste to a repository at Yucca Mountain. The DOE intends that its transportation system will evolve gradually over the next 15 years, making it difficult to describe the DOEPTS in the meantime.

This description of the DOEPTS is based primarily upon the following official publications of the DOE:

- o DOE (U.S. Department of Energy), 1985. Mission Plan for Civilian Radioactive Waste Management Program, DOE/RW-0005, Washington, D.C., referred to as the "1985 Mission Plan."
- o DOE (U.S. Department of Energy), 1986. Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, DOE/RW-0073, Washington, D.C., referred to as the "EA."
- o DOE (U.S. Department of Energy), 1986. Transportation Business Plan, DOE/RW-0046, Washington, D.C., referred to as the "TBP."
- o DOE (U.S. Department of Energy), 1986. Transportation Institutional Plan, DOE/RW-0094, Washington, D.C., referred to as the "TIP."
- o DOE (U.S. Department of Energy), 1988. Draft 1988 Mission Plan Amendment, DOE/RW-0187, Washington, D.C., referred to as the "1988 MPA."
- o DOE (U.S. Department of Energy), 1987. Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation, DOE/RW-0184.
- o Sandia National Laboratories, for the U.S. Department of Energy, 1986. Transportation Impacts of the Commercial Radioactive Waste Management Program, (SAND85.TTC-0633).
- o DOE (U.S. Department of Energy), 1986. Report of the Task Force on the MRS/Repository Interface, DOE/RW-0044.

This working paper refers to the Nuclear Waste Policy Act (NWPA), 42 U.S.C. 10100, *et. seq.*, as amended, and the changes instituted by the Nuclear Waste Policy Amendments Act of 1987 (NWPAA). The working paper also incorporates findings of the Nevada Nuclear Waste Project Office presented in their Report on Repository-Related High-Level Radioactive Waste Transportation Under Assembly Concurrent Resolution No. 8, dated November 4, 1988 (ACR 8).

In April 1988, the OCRWM modified its management structure to place transportation issues under a new Office of Systems Integration and Regulations. Mr. Keith A. Klein, Deputy Associate Director, Office of Systems Integration and Regulations, OCRWM, and Ms. Ellen Livingston-Behan, Transportation Policy Analyst, Roy F. Weston, Inc., Technical Support Team (an OCRWM contractor), have also provided information to clarify DOE plans in particular areas.

2.0 CROSSCUTTING ISSUES

This portion of the report describes the crosscutting elements of the DOE's planned transportation system (DOEPTS).

2.1 COMPREHENSIVE RISK ASSESSMENT AND RISK MANAGEMENT

Background

Risk assessment studies on nuclear transportation in general have focused on the integrity of casks in accident conditions and on radiological and non-radiological risks during normal operating conditions. Some of these studies address the generic problems of human error and deficient quality control and the intractable problems of sabotage, terrorism and theft.

Program Description

The DOE's approach to transportation risk management is generally to indicate assurances that applicable United States Department of Transportation (DOT) and United States Nuclear Regulatory Commission (NRC) regulations will be met and that safety is the overriding goal of the program.

The DOE's risk assessment studies may aid in developing risk management programs for waste shipments. For example, the DOE has recognized that automated equipment may be desirable for loading casks because normal operations for loading casks may expose workers to radiation. Similarly, it has been recognized that using casks with larger payloads may reduce the number of shipments required and reduce the overall radiological exposure.

The main approach of the DOE to comprehensive risk assessment in nuclear waste transportation is to assess risks for specifically defined scenarios. The EA contains a risk analysis based on evaluating specific scenarios that characterize risks from rail, truck and barge transportation under the DOEPTS. These scenarios include disposal with and without a monitored retrievable storage facility (MRS), different routing options and different cask capacities.

The consequence analysis in the EA evaluates both radiological and non-radiological impacts of normal and accident conditions. The impacts that were analyzed have been assumed to cover the most severe consequences that could reasonably be expected from the transportation of waste to the repository. Accident condition impacts are evaluated for three individual exposure levels corresponding to three types of accident severities (TIP, page A-21). Two additional scenarios are evaluated for population exposure to severe accidents.

The consequence analysis in the EA addresses the impacts from an accident but does not provide the expected risk to the public from such accidents. To estimate risk, the RADTRAN II model was run, using two transportation scenarios (one without an MRS and one with an MRS) and three population density zones surrounding the transportation corridor. Accident rates for radioactive waste shipments were assumed to be represented by accident statistics for general commerce (EA, page 7-95).

Ongoing and Planned Studies

Additional risk assessment work is expected to be contained in the Environmental Impact Statement for the Yucca Mountain site (EIS).

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YEARS BEFORE REPOSITORY OPERATIONAL
Research risk assessment issues such as the integration of human factors	None known
Design risk assessment methodology	14 (1989)
Collect data needed for risk assessment	11 (1992)
Conduct baseline risk assessment	10 (1993)
Identify risk management strategies	Unknown
Iterate risk assessment (first time)	None known

2.2 TRANSPORTATION PLANNING AND ANALYSIS SYSTEM

The DOE has utilized a network approach to analyzing route level impacts of risk and cost in evaluating route selection for truck and rail transport. Oak Ridge National Laboratories (ORNL) has taken the lead in this area, using a highway transportation network model called HIGHWAY, and a rail network called INTERLINE, which is available thorough ORNL. At the present time the DOE methodology is based on national level estimates of risk and cost factors.

The determination of risks and costs which serve as inputs to the routing problem are derived by software programs entitled RADTRAN and WASTES. RADTRAN models predict radiological and non-radiological risks for each transport segment based on segment characteristics and are available through Sandia National Laboratory's TRANSNET. WASTES computes capital and operating costs associated with the shipment in question, based on such factors as distance. Ultimately, the DOE intends to produce a "network optimization model" which it will utilize in determining modal mix and shipping schedules.

Ongoing and Planned Studies

More route-specific analysis is expected to be contained in the Yucca Mountain EIS.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YEARS BEFORE REPOSITORY OPERATIONAL
Identify impact assessment criteria	14 (1989)
Develop route-specific impact assessment models	14 (1989)
Collect data needed for route-specific assessment models	11 (1992)
Conduct baseline impact assessment	10 (1993)
Identify impact mitigation measures	Unknown
Iterate impact assessment (first time)	None known

2.3 TRANSPORTATION SYSTEM IMPACT MONITORING

Program Description

The DOE has no formal plan for monitoring the impacts of transporting nuclear waste to a repository at Yucca Mountain. The DOE presently plans for transportation impacts to be monitored as part of their normal management operations.

Ongoing and Planned Studies

None known.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YEARS BEFORE REPOSITORY OPERATIONAL
Identify impact assessment criteria	14 (1989)
Develop route-specific impact assessment models	14 (1989)
Collect data needed for route-specific assessment models	11 (1992)
Conduct baseline impact assessment	10 (1993)
Identify impact mitigation measures	Unknown
Iterate impact assessment (first time)	None known

2.4 DATA MANAGEMENT SYSTEM

Program Description

The DOE is not known to have any centralized or coordinated plan or program for transportation data management.

Ongoing and Planned Studies

None known.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YEARS BEFORE REPOSITORY OPERATIONAL
Identify data needs of federal, state, Tribal and local governments	None known
Prepare conceptual system description	None known
Design data collection/management software and hardware	None known
Begin data collection	None known
Pilot test system	None known
Begin system implementation	None known

2.5 INSTITUTIONAL RELATIONS

Program Description

The 1988 MPA sets out the DOE's latest statement of institutional plans and activities. The 1988 MPA overviews the new entities established by the NWPAA and reviews the DOE's interactions with: state, Tribal and local governments in Nevada, the public, other federal agencies, specific transportation-related groups, national and regional organizations, foreign nations and international organizations and the Office of Subseabed Disposal Research.

In addition to provisions in the NWPAA and the 1988 MPA, the DOE's institutional relations will continue to be guided by the earlier policy statements contained in the NWPA, the 1985 Mission Plan, as amended, and the TIP.

The TIP outlines the basic process for interaction among parties specified by the DOE to have roles in the repository/MRS system: governmental interests, utilities, the transportation industry, special interest groups, the media and the public at large. The transportation program schedule is presented in the TIP.

The OCRWM Bulletin is identified in the TIP as a primary vehicle for news and updates about the waste program. The TIP reports that OCRWM policy decisions will be announced in the OCRWM Bulletin and/or the Federal Register. Discussion papers are presented in the TIP to discuss what are identified by the DOE as the seventeen major issue areas of the waste transportation program.

New Entities Created by the NWPAA

The following entities were created by the NWPAA and are reviewed in the 1988 MPA:

- o The MRS Review Commission: Appointed by leaders of both Houses of Congress, the MRS Review Commission is to recommend to Congress by June 1, 1989, whether an MRS should be developed.
- o Nuclear Waste Technical Review Board: This group is appointed by the President for terms up to four years from members of the National Academy of Sciences. It is to provide technical review of the DOE's waste management activities and report to the Congress and the Secretary of Energy twice each year. The Board is to be disbanded after waste acceptance begins at the repository.
- o Repository/MRS Review Panel: If the DOE enters into a Benefits Agreement, discussed below at "Modes of Interaction," with a state or Tribe for either a repository or MRS, a Review Panel is to be established. Its members will serve four-year terms and will represent state and/or Tribal governments, affected local government, utilities and the general public.

- o Office of the Nuclear Waste Negotiator: The Nuclear Waste Negotiator is to be appointed by the President, confirmed by the Senate and serve a term through January 1993. The Negotiator is to work with state, Tribal and local officials, and federal agencies, towards developing a repository or an MRS. Congress will have to approve any agreement negotiated by the Nuclear Waste Negotiator.

Modes of Interaction

The DOE's basic approach to public outreach and participation is presented in the 1985 Mission Plan. The mechanisms utilized by the DOE include: advanced notification about public meetings, information sharing, briefings, meetings, workshops, a speakers' bureau, community information offices, formal hearings and responses to public comments. The DOE reports it is reviewing all outreach materials since the changes made by the NWPA and will be updating and supplementing these materials as appropriate. The 1988 MPA provides the latest statement as to modes of interaction envisioned by the DOE for its relations with state, Tribal and local governments in Nevada.

Informal Cooperation: The DOE refers to joint participation with State, Tribal and local governments in information collection and review, briefings, workshops and other instances of mutual cooperation as "informal cooperation."

The DOE reports it is developing an "Outreach-and-Participation Plan" for the Yucca Mountain repository, and the plan will be available in draft version for review and comment. The plan is to include a component for reviewing the effectiveness of the DOE's outreach-and-participation efforts.

Technical Participation: The DOE considers technical participation to be generally provided through briefings, formal and informal meetings, and opportunities for comments. The agency indicates it will review the effectiveness of these mechanisms for technical participation at some time in the future with State, local and Tribal governments. A Consultation and Cooperation Agreement, see below, may be used to formally establish technical participation. On-site representatives may be designated by a state, Tribe or local government to oversee the development of a repository or MRS, under the NWPA.

Consultation and Cooperation: DOE will enter into binding consultation and cooperation agreements to specify formal procedures for interactions with the agency. These agreements are governed by Section 117 of the NWPA and Section 4.2 of the 1985 Mission Plan, as amended.

Benefits Agreements: The NWPA authorizes the DOE to enter into a Benefits Agreement with Nevada for a repository. A Benefits Agreement can provide \$10 million and \$20 million annual payments to Nevada before and after waste acceptance begins at a repository, respectively. A Benefits Agreement is also available to a state or Indian Tribe willing to host an MRS.

Once a Benefits Agreement is reached, a State or Tribe may nominate a representative to a Review Panel and participate more formally in information sharing, design of the facility and health/safety review. In exchange the

state or Tribe must waive objections to the facility and impact-assistance grants. Two forms of financial assistance, payments-equal-to-taxes and grants to participate in program activities, would appear to remain available to states or Tribes which enter into a Benefits Agreement according to the 1988 MPA.

Financial Assistance: Financial assistance provisions are set out at Sections 116 and 118 of the NWPA and have been modified by the NWPAA. Participation grants may be used to enable participation in program activities, and impact assistance grants may be used to mitigate impacts from the development of a repository or an MRS. Payments-equal-to-taxes are also available to state, Tribal and local governments. Impact assistance grants are waived by entering into a Benefits Agreement. The NWPAA also established that financial assistance can be provided to affected units of local government, and units of government contiguous to these local governments, and that corridor states may receive financial and technical support for training.

The DOE expects its Transportation Coordinating Group to provide a forum for discussion of technical and institutional transportation issues by representatives of states, Tribes, utilities and the transportation industry. Workshops are anticipated by the DOE to address specific issues.

Interaction with Federal Agencies

Under the NWPA and NWPAA, the NRC has specific licensing responsibilities in areas of site characterization, packaging and cask designs. The DOE has a Memorandum of Understanding in effect with the NRC for the site characterization period. The semiannual site-characterization progress reports DOE will submit to the NRC and Nevada are intended to enhance relations with the NRC.

The DOE has executed Memoranda of Understanding with the Mine Safety and Health Administration of the Department of Labor and the DOT. The DOE also will be interacting with the Departments of Agriculture, Defense and Interior. A Project Decision Schedule is presented in the 1988 MPA to specify activities and agency responsibilities and timelines.

Training Public Safety Officials

Section 180(c) of the NWPAA directs the DOE to provide technical assistance and funds to states for training public-safety officials in local and Tribal governments where waste may be transported. The DOE is using a phased approach to undertaking this responsibility, whereby the first task is defining roles and responsibilities among governments for inspection, enforcement and emergency response.

The Commercial Vehicle Safety Alliance (CVSA) is developing draft inspection procedures for highway shipments of radioactive materials and a possible model agreement for reciprocal recognition of state inspections, under agreement between the CVSA and the DOE. The Pacific States Agreement on Radioactive Materials Transportation Management plans to conduct a pilot test of the draft inspection procedures as part of a multi-year effort beginning in

fiscal year 1989. The Western States Interstate Energy Board and the Utilities Nuclear Transportation Group were reported in the July 1988 OCRWM Bulletin to have commented to the OCRWM and the CVSA on the draft CVSA procedures.

The DOE is currently working on a report to describe the DOE's emergency response equipment, personnel and procedures, which it reported would be completed during 1988. Additional assistance in clarifying roles in emergency response is anticipated from workshops being planned by the DOE and through materials now being prepared by the Federal Emergency Management Agency (FEMA).

When the DOE identifies potential routes for waste transportation, the DOE will assess the specific training needs of local jurisdictions along the routes. A determination will be made as to the sufficiency of existing federal programs to train the relevant personnel, and supplemental training will be implemented by the DOE as needed. The DOE expects to identify the need for and to implement any specific training programs three to five years before shipments begin.

Ongoing and Planned Studies

Section 175 of the NWPAA directs the DOE to report to the Congress by December 22, 1988, on the potential impacts of a repository at Yucca Mountain and the appropriate governmental and funding responsibilities associated with these impacts.

The DOE is developing a report describing its equipment, personnel and procedures for emergency response, which it reported would be completed in 1988.

The OCRWM is preparing a Comprehensive Transportation Plan to review policies and procedures for institutional, business and program activities, reported to be available late in 1988.

Draft vehicle inspection procedures are being developed by the Commercial Vehicle Safety Alliance and the OCRWM, and pilot testing of the draft procedures is scheduled to start in fiscal year 1989.

The MRS Review Commission reports to Congress by June 1, 1989, whether an MRS should be developed.

The Nuclear Waste Technical Review Board will continue to review technical matters in the waste program through the period of site development and will report findings to the Congress and the DOE.

2.6 REGULATORY STRUCTURE/LIABILITY

Background

Generally, the DOE has indicated that it does not intend to address changes to the existing regulatory structure because the existing regulatory

structure affords an adequate level of safety. Therefore, the current federal regulatory structure applicable to the transportation of nuclear waste is described in this section.

Regulatory aspects of cask design and testing, routing, and standards for vehicles and equipment are discussed in Section 3, "Transportation System Design." Regulatory aspects of personnel training and qualifications, vehicle stoppage, shipment monitoring and prenotification, inspection and enforcement, and physical protection (sabotage/terrorism) are discussed in Section 4, "Transportation System Operational Procedures." Please refer to the appropriate section for discussion of these issues.

Program Description

2.6.1 Placards

Placards are diamond-shaped posters which are required to appear on the outside of transport vehicles to aid in communicating the hazard of certain cargos. The DOT's Hazardous Materials Regulations describe placarding requirements which would apply to shipments of nuclear waste to a repository: the size, location and content of the placards; the person responsible for placarding; and special requirements for rail, freight containers, aircraft unit load devices, cargo tanks and portable tanks, 49 C.F.R. Part 172.500-172.558, (1987).

2.6.2 Shipping Papers

The DOT has adopted regulations governing the applicability and contents of shipping papers, 49 C.F.R. Part 172.200-172.205 (1987), Hazardous Materials Transportation Act (HMTA), 49 U.S.C.S. Section 1801, et seq. (1981). Among other things, the shipping papers must identify for each regulated material its proper shipping name, hazard class, identification number and total quantity. Additional information is required for radioactive materials, including the name of each radionuclide, the transportation index, a description of the physical and chemical form of the material and the activity contained in each package.

2.6.3 Permits & Fees

Under HMTA, the DOT has the authority to promulgate regulations for permits and fees. The DOT has not done so, but has issued a policy statement announcing state permits and fees are preempted by the HMTA, 49 C.F.R. Part 177, Appendix A (1987). The DOT's policy statement is not a regulation and has no preemptive effect under the HMTA. This is an uncertain area because the fees of some states have been ruled inconsistent, while a fee program imposed by Illinois was ruled consistent. There have been no rulings on the fees of some other states.

2.6.4 Liability

The purposes underlying the Price-Anderson Act (the "Act"), 42 U.S.C.S. § 2210 (1978), are to encourage private sector development of nuclear energy and

to ensure a source of funds to pay public liability claims resulting from a "nuclear incident." The private sector's active participation in the development of nuclear energy has been encouraged by two mechanisms: the limitation of liability and government indemnification. The Act ensures a source of funds to pay claims resulting from a nuclear incident through insurance and indemnification provisions.

For public liability to exist, a nuclear incident must occur at certain licensed facilities or contractor-operated facilities or occur during the course of transportation to or from certain facilities. It is defined as:

any occurrence, including an extraordinary nuclear occurrence, within the United States causing, within or outside the United States, bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosives, or other hazardous properties of source, special nuclear, or byproduct material...

42 U.S.C.S. § 2014 (q).

Under the Act, three types of insurance are involved: facility form insurance, industry retrospective premium insurance, and suppliers and transporter insurance. Suppliers and transporters insurance provides \$160 million coverage for suppliers of parts and services to the nuclear industry and for transporters of nuclear materials. These policies are optional and are intended to provide coverage in the event an incident is not already covered by facility form insurance or a government indemnity agreement.

The facility form insurance provides primary coverage in the event of a nuclear incident. Licensed nuclear power plants with a capacity of more than 100 megawatts of electricity ("MWe") must provide financial protection in an amount equal to the maximum amount of insurance commercially available--\$160 million of insurance.

The industry retrospective premium insurance is triggered only in the event damages exceed \$160 million. In this event, the excess damages will be decided equally among all of the nuclear power plants with a capacity of more than 100 MWe. The NRC is then authorized to assess a retroactive premium or up to \$63 million per facility for each incident, in order to pay the excess damages. The NRC's assessment authority is limited to a \$10 million per year maximum assessment for each incident, providing each utility with over six years to pay the maximum premium. If the NRC does not have sufficient funds to pay valid claims, it may request an appropriation from Congress or it may borrow the funds. This secondary coverage provides a \$7.056 billion fund with 112 reactors having a 100 MWe capacity, which totals \$7.216 billion when added to the facility form coverage. As reactors are decommissioned, the potential fund will be reduced. The industry's potential liability is limited to the costs of insurance and the retroactive premium.

To entice the private sector's active participation in the development of nuclear energy, the Act also provides indemnification for certain licensees and

contractors. DOE, pursuant to the Price Anderson Amendments Act of 1988 (the "1988 Act"), is required to indemnify its contractors whenever their activities involve a risk of public liability. The indemnification agreements furnish coverage similar to that offered under insurance policies, but DOE provides the coverage at a token or no cost. DOE's liability under this provision is the same as for commercial nuclear power plants as of August 1988, i.e., \$7.216 billion. However, claims arising out of activities paid for by the Nuclear Waste Fund shall be compensated by the Fund.

The NRC also indemnifies some of its licensees for certain activities. It may not indemnify a licensee beyond \$500 million.

For damages exceeding the mandated sums, the NRC or the Secretary of DOE is required to survey the causes and extent of damaged and submit a report to Congress. Within ninety days of a court's determination that liability may exceed the mandated sums, the President is required to submit to Congress an estimate of the excess damages, recommendations for raising the funds, and one or more compensation plans.

Congress, as part of the 1988 Act, has directed the President to appoint a Presidential Commission on Catastrophic Nuclear Accidents by November 19, 1988. (As of the date of writing this report, the Commission had not yet been appointed.) The Commission is to conduct a comprehensive study of appropriate means of fully compensating victims of a nuclear accident where the liability exceeds the funds available from the insurance or indemnity provisions. The Commission is to report its results to Congress by August 20, 1990.

The Act does not address the standard of liability to be used in prosecuting a court action. Therefore, the law of the appropriate state will control the issue. Under state law, certain defenses may be available to the defendants. These may include the statute of limitations, which can bar an action if it is instituted after the time permitted by the relevant statute; assumption of the risk, which prevents recovery if a court finds the plaintiff was aware of the risk involved and voluntarily agreed to accept it; contributory negligence, which can limit recovery to the degree that the plaintiff was partially responsible for his injuries; and sovereign immunity, which can bar an action against a governmental entity. These defenses are required to be waived by all parties insured or indemnified under the Act, if the NRC declares an incident to be an extraordinary nuclear occurrence.

If payments are to be made under the indemnity agreements, the NRC is required to consult with the indemnified person. That person may take charge of, settle or defend any action brought for damages. Persons indemnified shall not collect its expenses in settling claims with the NRC. The NRC has settlement authority for the United States.

The NRC is authorized to established procedures for the prompt handling, investigation and settlement of claims. Credit against a judgment shall be given for payments made.

Ongoing and Planned Studies

The DOE has not yet begun the review of placarding it reported it would undertake in the TIP (Page a-111).

Decision Schedule

DECISION/ACTIVITY
(Completion of activity unless
otherwise indicated)

DOE TIMELINE/YEARS
BEFORE REPOSITORY
OPERATIONAL

Identify gaps/risk reduction opportunities
in federal law and regulations

None known

Enact statutory changes

None known

Promulgate regulations

None known

2.7 EMERGENCY PREPAREDNESS

Legal/Regulatory Background

Pursuant to the Disaster Relief Act of 1974, 42 U.S.C.S. 5121, et seq. (1982), the President is authorized to establish a program of disaster preparedness that utilizes the services of all appropriate federal agencies, and includes:

- o preparation of plans for disaster preparedness, mitigation, warning, emergency operations, rehabilitation and recovery;
- o training and exercises;
- o post disaster critiques and evaluations;
- o annual review of programs;
- o coordination of federal, state and local preparedness programs;
- o application of science and technology;
- o research.

The FEMA has promulgated regulations pursuant to the Disaster Relief Act, at 44 C.F.R. Parts 350, 351 (1987). Part 350 establishes procedures for review and approval of state and local emergency preparedness plans for the off-site effects of a radiological emergency at a commercial nuclear power plant. Part 351 sets forth the roles and tasks of the various federal agencies when providing federal assistance to state and local governments that may respond to a fixed site or transportation radiological incident. Federal agencies' responsibilities for responding to a radiological incident are

addressed in the "Federal Radiological Emergency Response Plan," 50 Fed. Reg. 46,452 (1985).

The FEMA has also promulgated regulations, pursuant to Executive Order 12148, 44 Fed. Reg. 43,239 (1979), that outline assistance available to the states for training and education in comprehensive emergency management. 44 C.F.R. Part 360 (1987). States may request financial support from the FEMA and negotiate an agreement with the FEMA for the training of state and local officials. Once an agreement is finalized with the FEMA, the state must offer radiological defense training as part of its program. 44 C.F.R. Part 360.1(b) (1987).

The FEMA has a Memorandum of Understanding with the NRC, under which the FEMA provides NRC with assessments and determinations of the adequacy of state and local government emergency preparedness plans for use in licensing procedures. Nuclear power reactors cannot obtain a license unless the NRC has received reasonable assurances that adequate protective measures can be taken in the event of a radiological emergency. It is unclear to what extent this applies to transportation issues, or whether it applies to a repository, see 10 C.F.R. Part 50.47 (1987).

During 1987, the FEMA also implemented a Memorandum of Understanding with the DOT. It delineates the roles and responsibilities of each agency and establishes joint programs for emergency response planning, training and the development, dissemination and exchange of information. As of the date of this working paper, this agreement has not been published in the Federal Register.

The DOT may have authority to promulgate emergency response regulations pursuant to the HMTA, but it has done so only to a very limited extent. As part of the DOT's routing requirements, drivers are required to receive written training on "procedures to be followed in case of an accident or other emergency." 49 C.F.R. Part 177.825(d) (1987). The Commercial Motor Vehicle Safety Act requires drivers to demonstrate a working knowledge of the operation of emergency equipment used in responding to hazardous materials incidents and of the appropriate emergency response procedures to be followed. 49 U.S.C.S. Appx. 2701, 2704 (Cum. Supp. 1987).

The Federal Motor Carrier Safety Regulations identify emergency equipment requirements for trucks which require a fire extinguisher, spare fuses and warning devices for stopped vehicles. 49 C.F.R. Part 393.95 (1987); 49 U.S.C.S. 3102, et seq., (Cum. Supp. 1987).

Program Description

To date, the DOE has not developed any specific programs to address the emergency preparedness needs created by the NWPA and the NWPA. The DOE has indicated that it expects to define its role in emergency preparedness, training and equipment needs, and financial assistance to state and local governments in 1998 (five years before shipments begin).

Section 180(c) of the NWPA requires the DOE to provide: "technical assistance and funds to states for training public safety officials of

appropriate units of local governments and Indian Tribes through whose jurisdiction the Secretary plans to transport spent nuclear fuel or high-level radioactive waste (to a repository or an MRS facility). Training shall cover procedures required for safe routine transportation of these materials, as well as procedures for dealing with emergency response situations." The DOE plans to develop a program addressing this directive from the Congress by the year 2000.

Since the DOE is relying almost entirely upon existing federal emergency preparedness programs, the major provisions of existing federal emergency preparedness programs are briefly summarized below:

Federal Coordination

The FEMA is responsible for establishing policies and coordinating all civil defense and civil emergency planning, management, mitigation and assistance functions of the federal agencies. The FEMA has developed the Federal Radiological Emergency Response Plan (FRERP) which defines the roles of all federal agencies regarding all types of peacetime radiological accidents, including transportation accidents. 50 Fed. Reg. 46,542 (1985).

The FRERP includes the Federal Radiological Monitoring and Assessment Plan (FRMAP). Under the FRMAP, the DOE provides technical personnel and equipment to state, Tribal or local governments, if requested. Additionally, the DOE will perform radiation monitoring and evaluation activities in the event of an incident involving nuclear waste. The DOE has eight regional emergency response teams to assist with incident response, one of which is presently located at the Nevada Test Site.

The FEMA has promulgated a regulation establishing the Federal Radiological Preparedness Coordinating Committee (FRPCC) and Regional Assistance Committees to coordinate federal assistance to state, Tribal and local governments for peacetime radiological emergencies, 44 C.F.R. Part 351. The FRPCC assists the FEMA in providing planning guidance to state, Tribal and local governments.

Training

The FEMA operates the National Emergency Training Center (NETC) in Emmitsburg, Maryland. State, Tribal and local emergency response personnel are eligible to attend the NETC training courses. The DOE's Radiation Emergency Assistance Center/Training Site in Oak Ridge, Tennessee, provides training courses for physicians, health physicists and paramedic personnel. The DOE also sponsors a series of radioactive material emergency response workshops throughout the country. The DOT assists in training state, Tribal and local emergency responders at the Transportation Safety Institute in Oklahoma City, Oklahoma.

Federal Information Services

The DOE operates the Joint Nuclear Accident Coordinating Center at Kirkland Air Force Base in Albuquerque, New Mexico, in conjunction with the

Defense Nuclear Agency of the Department of Defense. This center maintains and exchanges information on radiological assistance capabilities and also functions as a point of coordination for assistance activities for radiological accidents.

Federal Financial Assistance for Emergency Planning and Response

The FEMA provides financial assistance to the states under comprehensive cooperative agreements to support various emergency response activities. On the average, each state receives about \$1 million per year, primarily directed to planning for nuclear attack.

Recent Studies

Transportation of Hazardous Materials: State and Local Activities, OTA-SET-301, March 1986. Contains a review of emergency response training programs.

It is expected that the FEMA and the DOT will be conducting a survey of states' training programs.

Ongoing and Planned Studies

The DOE is planning to conduct a workshop on emergency preparedness in the spring of 1989.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YEARS BEFORE REPOSITORY OPERATIONAL
Provide assistance to state and Tribal governments for EP planning	5 (1998)
Inventory/evaluate existing EP capability of federal, state, Tribal and local governments	None known
Design initial EP system	5 (1998)
Begin provision of assistance to state and Tribal governments to implement EP system	5 (1998)

3.0 SYSTEM DESIGN

This portion of the report describes the design elements of the DOE's planned transportation system (DOEPTS).

3.1 VOLUMES AND TIMING OF SHIPMENTS

Two different types of high-level nuclear waste will be shipped to the repository: spent fuel from nuclear power reactors (SNF) and solidified wastes from the reprocessing of spent nuclear fuel (HLW). The DOE has also indicated that certain transuranic and "miscellaneous" wastes which are appropriate for intermediate-depth disposal could also be shipped to the repository if suitable disposal facilities are not developed for these wastes by the time the repository begins operating. This section of the working paper incorporates findings on this subject by the Nevada Nuclear Waste Project Office presented in the ACR 8 report, pp. 12-26.

Spent Nuclear Fuel

About 90% of the nuclear waste shipped to the repository will be spent fuel (SNF) from civilian nuclear power plants, primarily pressurized water reactors (PWRs) and boiling water reactors (BWRs). Because there are dozens of different SNF designs, the DOE has designated a "reference" PWR fuel assembly and a "reference" BWR fuel assembly for planning purposes. The "reference" PWR fuel assembly used in DOE planning documents is about 13 feet long and 8.5 inches wide and deep. It holds almost 300 long, thin fuel rods containing 0.46 metric tons of uranium (MTU). The reference BWR assembly has a slightly different configuration and contains 0.19 MTU uranium fuel.

The repository will receive spent fuel assemblies of more than two dozen different standard designs, including fuel that is defective or damaged or that requires special handling because of unusual design.

Spent fuel assemblies may be consolidated and repackaged before shipment to the repository. The consolidation process would involve removal of the fuel rods from the fuel assembly structural skeletons. Depending upon the waste package design, fuel rods from as many as twelve assemblies would be grouped together in one specially designed canister. Structural hardware remaining after consolidation would be compacted and placed in a separate canister.

Although Congress has not determined whether to utilize an MRS facility, the DOE is currently planning to transport spent fuel from civilian reactors to an MRS facility where the fuel rods will be removed from the assemblies and consolidated into disposal containers. DOE presently is planning that the MRS

would prepare canisters containing consolidated rods from six PWR assemblies for disposal at Yucca Mountain. A final decision on consolidation details will not be made for several years.

If an MRS is constructed, DOE plans to ship canisters of consolidated fuel to the repository in dedicated trains, called unit trains by DOE, along with canisters of radioactive hardware and secondary wastes resulting from disassembly operations. If the MRS is not constructed, DOE expects most reactors to ship intact spent fuel assemblies directly to the repository, although some utilities are planning to consolidate their fuel at reactor sites prior to shipment.

The DOE reports that spent fuel is to be cooled at least five years before shipment to the repository, however, it is expected that spent fuel will, at least initially, be ten years out of reactor by the time it is shipped.

High-Level Waste

About ten percent of the waste to be shipped to the repository will be solidified HLW resulting from the reprocessing of spent nuclear fuels. During reprocessing, all but trace amounts of the uranium and plutonium are removed, leaving behind a mixture rich in strontium-90, cesium-137, and other fission and activation products.

From the standpoint of geologic disposal, HLW may be a preferable waste form to spent fuel, since the very long-lived isotopes of uranium and plutonium and the products of their radioactive decay have been removed. From a transportation standpoint, however, HLW is no less dangerous than spent fuel and possibly more dangerous, since fission products are present in larger quantities per metric ton unit (MTU) of waste shipped.

Most HLW is presently in liquid form, stored in underground tanks. DOE plans to construct solidification (vitrification) facilities at each of these four sites during the 1990s to prepare the waste for shipment to the repository.

Certain characteristics of the HLW to be shipped to the repository are not known at this time. Future weapons production and reprocessing plans at DOE facilities are uncertain. The DOE has provided little information regarding the composition of HLW at the Idaho National Engineering Laboratory (INEL), claiming national security considerations. The DOE has not decided whether certain categories of defense HLW stored at INEL and Hanford will require shipment to the repository. It is also possible that civilian waste reprocessing might some day resume.

Some important characteristics of defense HLW can be anticipated. At each of the four sites, DOE plans to mix the HLW into molten borosilicate glass inside 10-foot high stainless steel canisters. The loaded canisters will weigh about 4,800 pounds each. Each canister is roughly equivalent to a spent fuel assembly in terms of radioactivity and thermal output.

Given the DOE's schedules for on-site vitrification and construction of the repository, it appears likely that most solidified HLW will be ten years old (ten years after canister filling) when shipped to the repository. As is the case with spent fuel, the radioactivity in solidified HLW decreases considerably during the 10-year cooling time. The total radioactivity in a canister of HLW waste would decline from about 234,000 curies to about 146,000 curies over ten years. However, the remaining radioactivity is sufficient to make ten-year old HLW extremely hazardous.

Miscellaneous Wastes

In addition to SNF and HLW, the DOE has identified several categories of "miscellaneous" wastes which may be shipped to the repository if intermediate-depth disposal facilities do not become available before the repository opens. These wastes could include transuranic wastes from the MRS facility, West Valley and commercial operations; reactor decommissioning wastes; radioisotope capsules; and/or greater than Class C (GTCC) wastes from routine reactor operations.

Total Volumes of Wastes

The total amount of nuclear waste shipped to the repository is shown in Table 1. Shipments total 70,000 metric tons of uranium (MTU), which refers to the initial mass of uranium present in the fuel assembly before it is used in a nuclear reactor. For purposes of this report, MTU is interchangeable with the units "metric tons of heavy metal" (MTHM) and "metric tons of initial heavy metal" (MTIHM) in the DOE base case presented in the 1988 MPA.

Table 1 also shows that 114,640 MTU of waste would be the total amount which might be shipped to the repository if a second repository is not built and if maximum defense waste shipments are assumed. This total could be even larger if higher nuclear power growth rates occur and the NWPA is amended to eliminate the 70,000 MTU capacity limit of Yucca Mountain. Approximate total shipments to the repository for four shipment scenarios, by truck, rail and dedicated trains, are shown in Table 2. Table 3 shows the approximate annual shipments to the repository during full operations (2008 to 2025) for the DOE base case and four shipment scenarios.

According the 1988 MPA and the DOE's present waste acceptance schedule, once the repository reaches full-scale operations around 2008 about 3,000 MTU of civilian spent nuclear fuel will arrive at the repository each year. 2,700 MTU would be shipped from an MRS facility, assuming an MRS facility is operating, and 300 MTU would be shipped directly from 12-15 reactors in western states. The repository will also receive about 800 canisters containing 400 MTU of solidified HLW each year.

Using the assumptions in the waste characteristics report (DOE/RW-0184, Vol. 1), the assumptions in the DMPA regarding MRS operations, and the EIA 1987 "no-new-orders" scenario for commercial nuclear operations, the Nevada NWPO staff has calculated the following maximum potential quantities of transuranic

and GTCC wastes which may require disposal in a repository by the year 2020:

- 1) OCRWM generated waste from rod consolidation at the MRS: 4,700 cubic meters;
- 2) transuranic waste from West Valley, commercial reactors and other industrial and institutional facilities: 1,500 cubic meters;
- 3) reactor decommissioning: 1,600 cubic meters;
- 4) radioisotope capsules (including Hanford): 500 cubic meters;
- 5) GTCC wastes from routine reactor operations ("no-new-orders" case, 1990-2020): 8,500 cubic meters.

The total quantity of miscellaneous wastes possible requiring deep geologic disposal by 2020 is estimated to be 16,800 cubic meters. A total of about 20,600 cubic meters is estimated if EIA's "upper reference" case for nuclear power is assumed.

The Oak Ridge characteristics report further states: "If these (miscellaneous wastes) are disposed of in HLW-type canisters, 2 feet in diameter by 10 or 12 feet long, one canister could hold up to one cubic meter." Using this assumption, it appears that if miscellaneous wastes require deep geologic disposal, as now seems the case (absent other disposal facilities for "intermediate-level" wastes), the repository could receive 16,800 to 20,600 canisters of waste in addition to the amounts shown in Table 1.

Recent Reports

Annual Capacity Report, OCRWM, June, 1988, DOE/RW-0191.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Assess optimal decay time prior to repository shipment	None known
Assess alternative shipment scenarios	None known
Select tentative shipment scenario	10 (1993)
Finalize shipment scenario	1 (2002)

Table 1

Total Amount of Nuclear Waste to be Shipped to the Repository
(Metric Tons of Uranium)

	<u>DOE Base Case^a</u>	<u>No Second Repository/ Maximum Defense Waste Case^b</u>
Spent Nuclear Fuel	63,020	87,000
Civilian HLW ^c	640	640
Defense HLW ^d	<u>6,340</u>	<u>27,000</u>

^a - Based on DOE, 1988 MPA, Waste Acceptance Schedule, Table 2.2, and 70,000 MTU capacity limit.

^b - Assumes no second repository, 70,000 MTU capacity limit removed, and EIA spent fuel inventory projected for "no new orders" scenario through 2036 [1988 MPA, p. 11]; and maximum defense waste scenario (including Hanford single-shell tank wastes) through 2020 based on DOE/RW-0184.

^c - 1 canister equals 2.0 MTU.

^d - 1 canister equals 0.5 MTU.

Table 2

Total Nuclear Waste Shipments to the Repository
DOE Base Case, Four Shipment Scenarios
(70,000 MTU to Repository)

	DOE Proposed Plan/MRS ^a	DOE Alternative No MRS ^b	Minimum Shipment Scenario <u>MRS/All Rail</u> ^c	Maximum Shipment Scenario <u>No MRS/Truck</u> ^d
Dedicated Train ^e	1,388	0	570	0
RAIL CASKS ^f	2,091	7,978	2,579	0
(SNF)	(415)	(6,302)	(0)	
(HLW)	(6,148)	(1,648)	2,536	
(Civilian HLW)	(28)	(28)	(43)	
TRUCK CASKS ^g	7,243	26,600	0	76,000
(SNF)	(2,700)	(22,600)		(63,020)
(HLW)	(4,438)	(4,438)		(12,680)
(Civilian HLW)	(105)	(105)		(300)

^a - Based on DOE, 1988 MPA; 57,620 MTU of spent fuel shipped to Repository from MRS in 100-ton casks, capacity 8.3 MTU consolidated spent fuel in disposal containers suitable for direct emplacement in repository, per Yucca Mountain EA, DOE/RW-0073, Vol. 2, p. A-12; 5,400 MTU of intact spent fuel shipped directly from western reactors to repository, 50 percent rail/50 percent truck, based on current reactor rail capability; 12,680 canisters of defense HLW, shipped 65 percent rail/35 percent truck; and 300 canisters of civilian HLW, shipped 65 percent rail/35 percent truck.

^b - Based on DOE, 1988 MPA; No MRS; all spent fuel shipped direct to repository, 65 percent rail/35 percent truck; defense and civilian HLW shipped 65 percent rail/35 percent truck.

^c - All spent fuel shipped to repository from MRS in 150-ton casks, capacity 22.1 MTU consolidated spent fuel in canisters, not overpacked for disposal; defense and civilian HLW shipped 100 percent rail.

^d - No MRS; all spent fuel shipped directly to repository by legal-weight truck; defense and civilian HLW shipped 100 percent by legal-weight truck.

^e - Each train consists of 5 spent fuel casks and 4 hardware/secondary waste casks.

^f - Rail cask capacities: spent fuel, 6.5 MTU; HLW, 5 canisters; and civilian HLW, 7 canisters (EA)

^g - Truck cask capacities: spent fuel, 1.0 MTU; HLW, 1 canister; and civilian HLW, 1 canister (EA).

Table 3

Annual Nuclear Waste Shipments to the Repository
During Full Operation (2008-2025)
DOE Base Case, Four Shipment Scenarios
(70,000 MTU to Repository)

	DOE Proposed Plan/MRS ^a	DOE Alternative No MRS ^b	Minimum Shipment Scenario MRS/All Rail ^c	Maximum Shipment Scenario No MRS/Truck ^d
Dedicated Trains ^e	65	0	25	0
RAIL CASKS ^f	127	404	160	0
(SNF)	(23)	(300)	(0)	
(HLW)	(104)	(104)	(160)	
TRUCK CASKS ^g	430	1,330	0	3,800
(SNF)	(150)	(1,050)		(3,000)
(HLW)	(280)	(280)		(800)

- ^a - Based on DOE, 1988 MPA; 57,620 MTU of spent fuel shipped to repository from MRS in 100-ton casks, capacity 8.3 MTU consolidated spent fuel in disposal containers suitable for direct emplacement in repository, per Yucca Mountain EA, DOE/RW-0073, Vol. 2, p. A-12; 5,400 MTU of intact spent fuel shipped directly from western reactors to repository, 50 percent rail/50 percent truck, based on current reactor rail capability; 12,680 canisters of defense HLW, shipped 65 percent rail/35 percent truck; and 300 canisters of civilian HLW, shipped 65 percent rail/35 percent truck.
- ^b - Based on DOE, 1988 MPA; No MRS; all spent fuel shipped direct to repository, 65 percent rail/35 percent truck; defense and civilian HLW shipped 65 percent rail/35 percent truck.
- ^c - All spent fuel shipped to repository from MRS in 150-ton casks, capacity 22.1 MTU consolidated spent fuel in canisters, not overpacked for disposal; defense and civilian HLW shipped 100 percent rail.
- ^d - No MRS; all spent fuel shipped directly to repository by legal-weight truck; defense and civilian HLW shipped 100 percent by legal-weight truck.
- ^e - Each train consists of 5 spent fuel casks and 4 hardware/secondary waste casks.
- ^f - Rail cask capacities: spent fuel 6.5 MTU; HLW, 5 canisters; and civilian HLW, 7 canisters (EA).
- ^g - Truck cask capacities: spent fuel, 1.0 MTU; HLW, 1 canister; and civilian HLW, 1 canister (EA).

3.2 CASK DESIGN AND TESTING

3.2.1 Procurement Process

The DOE's plans for cask procurement are summarized in the TBP. In its first equipment acquisition phase, the DOE will use private contractors to the maximum extent to develop potential cask designs based on accepted standards and federal regulations. The DOE will require that its contractor(s) obtain NRC certification of all cask designs. If private companies are unable to provide the necessary services, the DOE will use its existing contractors and the national laboratories for cask development.

If significant problems develop in cask design, it is possible for the DOE to work with the NRC through their procedural agreement and through applied technology tasks sponsored by the OCRWM.

A cask development contractor will be responsible for providing a test prototype of each accepted cask design. Any tests which are needed will be conducted by the DOE or its contractor(s). Actual destructive testing, e.g. crash tests, will be conducted by the national laboratories, if conducted at all.

In its second equipment acquisition phase, the DOE will contract with private industry to supply a transportation fleet of casks from qualified designs obtained in the first phase. During fabrication, the OCRWM supervision will include the implementation of a quality assurances program, and the DOE will have independent supervision of this activity to ensure that all quality assurance requirements are met. The DOE has deferred choosing whether the DOE or its contractors will own the shipping casks until just prior to fabrication of the casks.

3.2.2 Type of Casks

Shipping Cask Capacity

This section has incorporated findings of the Nevada Nuclear Waste Project Office presented in the ACR 8 report, p. 26. Shipping cask capacity is restricted by safety requirements. Safe transportation of spent nuclear fuel requires heavy shielding to prevent excess radiation exposure during routine operations and rugged structures capable of containing the spent fuel in the event of an accident. The cask must be designed to prevent the spent fuel from forming a critical mass which could sustain a fission chain reaction. Even after five years cooling, the heat produced by the spent fuel must be considered in cask design. These considerations result in heavy casks (22-36 metric tons for trucks, and about 60 metric tons for rail) with relatively small carrying capacities. Legal weight truck casks can carry one PWR or two BWR assemblies. Rail casks can carry 7 PWR or 18 BWR assemblies.

For shipments to the repository, and to the MRS if constructed, the DOE is planning to develop a new generation of spent fuel shipping casks with carrying capacities at least twice as great as the current casks. Current casks are designed for hauling spent fuel which may be as little as six months out of the

reactor. By designing and gaining NRC certification for new casks for spent fuel five years or more out of reactor, the DOE plans to increase capacity by reducing shielding and cooling requirements. The cask the DOE hopes to develop for rail shipments to the MRS or the repository would hold 14 PWR or 36 BWR assemblies.

A corresponding legal weight truck cask would be developed to carry two PWR or five BWR assemblies. Legal weight truck cask designs with capacities for up to four PWR and nine BWR assemblies are under consideration. The larger cask capacities proposed by DOE contractors involve allowance for "burn-up credit" in criticality design. The DOE is also planning to develop new casks for shipping canisters of solidified HLW.

If these larger capacity casks are utilized and the extended fuel burn-up credit allowance is authorized, the number of shipments indicated in Tables 1 and 2 would be reduced to 25% to 33% of the presently anticipated numbers.

According to the TBP, the DOE is currently developing designs for ten casks:

- o Two legal weight truck designs for standard fuel shipments from reactors to an MRS or final repository. Casks for consolidated fuel shipments by truck will be designed in the future using the standard fuel cask(s).
- o Two rail designs for standard fuel shipments from reactors to an MRS or final repository.
- o Two rail designs for consolidated fuel shipments from an MRS to the final repository.
- o Two legal weight truck designs for nonstandard fuel and components from reactors to an MRS or final repository.
- o Two rail designs for nonstandard fuel and components from reactors to an MRS or final repository.

3.2.3 Regulatory Structure

Packaging requirements to transport radioactive materials are regulated by the NRC, see 10 C.F.R. Part 71 (1987). Although casks are not subjected to actual testing, they must be designed to withstand the following hypothetical accident conditions, in sequence, 10 CFR Section 71.73 (1987):

- o Free Drop. A free drop of nine meters, or thirty feet, onto a flat, essentially unyielding surface, striking the surface in a position for which maximum damage is expected.
- o Puncture. A free drop of the cask from a distance of one meter, or forty inches, onto the upper end of a vertical steel bar. The bar must be 15 cm (six inches) in diameter and not less than 20 cm (eight inches) long, with its top edge rounded to a radius of not more than 6 mm (one-quarter of an inch).

- o Thermal. The entire cask must be exposed for not less than thirty minutes to a heat flux of not less than 800 degrees C (1475 degrees F).
- o Immersion-Fissile Packages. For fissile material, which includes the waste to be shipped to a repository, the cask must be immersed in at least 0.9 meters (three feet) of water for at least 8 hours in the position in which maximum leakage is expected.
- o Immersion-All Packages. Casks must be capable of withstanding immersion in at least 15 meters (fifty feet) of water for at least 8 hours.

In addition to the above hypothetical accident conditions a licensee must demonstrate that the cask is suitable to meet the following normal conditions of transport, 10 CFR Section 71.71 (1987):

- o Heat. An ambient temperature of 38 degrees C (100 degrees F).
- o Cold. An ambient temperature of minus 40 degrees C (minus 40 degrees F).
- o Reduced External Pressure. An external pressure of 24.5 kilopascal (3.5 psi) absolute.
- o Increased External Pressure. An external pressure of 140 kilopascal (20 psi) absolute.
- o Vibration. Normal to transport.
- o Water Spray. A spray that simulates exposure to rainfall of approximately 5 cm (2 inches) per hour for at least one hour.
- o Free Drop. A free drop from 0.3 to 1.2 meters (one to four feet), depending on the weight of the cask.
- o Compression. A specified compressive load is applied for 24 hours.
- o Penetration. The hemispherical end of a vertical steel cylinder of 3.2 cm (1 1/4 inches) in diameter and 6 kg (13 pounds) of mass is dropped from a height of one meter (forty inches) onto the exposed surface of the package that is expected to be most vulnerable to penetration.

Prior to the first use of the cask, the licensee must conduct a visual examination and certain pressure tests to verify the cask's structural integrity. 10 CFR Section 71.85 (1987). Finally, prior to each shipment, the licensee must make certain determinations to ensure that the package and its contents comply with the NRC requirements.

3.2.4 Cask Development Program Description

According to the TBP, the DOE's plan for cask development is designed to:

- o Meet the NRC and the DOT rules;
- o Maximize payload (the amount of waste in each shipment);
- o Minimize turnaround time and maintain compatibility with cask handling equipment at the reactors;
- o Not exceed gross vehicle size and weight limits. Only legal weight truck casks are presently under development according to the DOE;
- o Minimize radiation exposure of operating personnel;
- o Control contamination;
- o Minimize cask development, fabrication and life-cycle costs.

Management Structure

Regulatory aspects of cask design and testing are handled by the OCRWM Licensing and Compliance Division, and equipment specifications and contracts is controlled by the Systems Integration and Transportation Division. These divisions also interface with the DOE Idaho Operations Office through a Transportation Systems Acquisition Project Office which solicits, awards and manages the cask development contracts. State, local and tribal governments may provide input to this process through the OCRWM Office of External Relations and Policy.

EG&G Idaho, Inc., based at the Idaho Operations Office, is the DOE's program management/quality assurance support contractor to provide technical overview of the various cask development contractors. Sandia National Laboratories in New Mexico provides independent technical assistance and test evaluations and will address regulatory and technical issues of overall cask development program.

Effects of an MRS

If an MRS becomes part of the waste management system, significant changes in cask design are expected. If a fuel consolidation facility is developed as part of an MRS or as a separate facility, new casks will be designed in order to transport a larger quantity of spent fuel. DOE is interested in designing such casks to reduce the number of shipments and the resultant costs of transportation. MRS-to-repository casks will be developed specifically for rail transportation.

Recent Reports

Quality Assurance Plan for Transportation Cask Systems Development Program, February 1988.

Shipping Container Response to Severe Highway and Railway Accident Conditions, NUREG/CR-4829, February 1987.

Ongoing and Planned Studies

A draft cask-testing plan is under development by the DOE. This plan will not require testing, such as full-scale destructive testing, beyond what is required by the NRC.

The Transportation Quality Assurance Plan scheduled to be released in 1987 is on hold awaiting direction from the OCRWM's new Office of Quality Assurance.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Assess adequacy of cask design and testing standards	None known
Develop revised cask design and testing standards, if necessary	None known
Develop cask QA/QC program	Unknown
Develop appropriate design analysis tools	None known
Design casks	13 (1990)
Design & implement cask data base	None known
Submit for NRC certification	12 (1991)
Fabricate prototype	10 (1993)
Perform full-scale testing	6 (1997)

3.3 MODAL MIX/RAIL AND TRUCK SHIPMENT OPTIONS

Background

The DOE does not consider modal mix to be an important decision since the agency believes that any modal mix is safe. Thus, the DOE's treatment of modal mix has been superficial. The TIP states:

it is the OCRWM's position that it is neither necessary nor desirable at this time to establish a firm quantitative position on the fraction of spent fuel and high-level radioactive waste to be transported by truck, rail and barge. The OCRWM will continue to solicit and analyze the many views and concerns related to modes of transport including relative safety, efficiency, capital costs, hauling costs, carrier capabilities and willingness to provide transportation services, shipping and receiving facility operations, environmental impacts, and overall public acceptance. (page A-88).

Legal/Regulatory Background Overweight Truck Shipments

The nations' roads are controlled by the states in which they are located. However, the Surface Transportation Assistance Act of 1982, 49 U.S.C.S. Appx. 2301, et seq. (Cum. Supp. 1987) amended the Federal-Aid Highway Act, 23 U.S.C.S. 127 (1983), to establish a national, uniform weight limit. States are required to allow 80,000 pounds gross vehicle weight on the interstate system or be penalized by the loss of federal highway funds. Exceptions are provided for loads that cannot be easily dismantled or divided, and for state limits that were in effect on certain dates prior to the adoption of the law. The weight requirement does not apply to roads that are not part of the interstate system.

Program Description

The DOE has considered using overweight truck shipments in order to maximize payloads and decrease costs but presently is not pursuing this option, apparently due to the varying state permitting requirements. However, at some point the DOE may reconsider the use of overweight truck shipments.

The DOE has proposed using dedicated trains for spent fuel shipments. A dedicated rail shipment has been defined by the DOE as a 10-car train comprised of five railcar-casks for consolidated fuel and five railcars for hardware, high-activity and transuranic wastes.

The use of dedicated trains would permit the dispatching multiple casks in a single shipment, thereby reducing the number of shipments required. Although barges will not be a primary mode of transportation, they can be considered in certain situations, particularly train/barge combinations.

The DOE has ruled out the use of special trains as not being necessary for safety. The American Association of Railroads has defined special train

service to consist of rail service which is dedicated to transporting one commodity, which is restricted to a maximum speed of 35 miles per hour, and where at least one train must be at a full stop whenever the special train passes or is passed by another train.

The following shipment configuration options have been and/or are being used for planning by the DOE:

- o Legal weight truck (LWT): gross vehicle weight (GVW) not to exceed 80,000 pounds.
- o Overweight truck (OWT): larger and heavier casks will be used and the GVW of the truck will not exceed 120,000 pounds.
- o Regular rail-unrestricted (RRU): regular railroad flatcars carrying casks up to 100 tons.
- o Heavyweight rail (HWR): casks up to 150 tons on special rail cars.
- o Tug-barge/motor vessel: water-based shipment of casks, either by barge or by self-powered vessels.
- o Intermodal transportation: rail/barge and rail/truck, with an intermediate transfer point and use of casks with 25-ton to 150-ton capacity.

While the DOE has made no final decisions on shipment configurations, it has assumed for purposes of planning that movements from an MRS facility to a repository would be made by dedicated train. Movements from the reactors to an MRS facility or from the reactors directly to the repository would be made by regular train, with trucks used when rail access to a reactor is not available (TIP, page A-83). Without an MRS, the DOE's current planning assumption is that, without an MRS, 65 percent of the waste by weight (not volume) will be transported by rail to the repository, and 35 percent of the waste will be transported by highway, see Tables 1-3.

Recent Studies

Overweight Truck Shipments to Nuclear Waste Repositories: Legal, Political, Administrative & Operational Considerations, March 1986, BMI/OTSSP-01.

Ongoing and Planned Studies

The DOE is currently evaluating federal and state highway weight limits, the relationship between highway damage and vehicle weight, state permit requirements for overweight trucks, and the cost and safety factors associated with their use.

The DOE has provided financial assistance to the American Association of State Highway and Transportation Officials (AASHTO) and the International Bridge, Tunnel & Turnpike Association to assess the feasibility of uniform state permitting requirements for overweight truck shipments.

An evaluation of using truck convoys study is reported to have been completed in draft form by Battelle and is being reviewed by the DOE. It is expected to be available in February 1989.

An Evaluation of Dedicated Trains for the Transportation of Spent Nuclear Fuel; Risks and Costs. Recently completed by Battelle in draft form, this report is being reviewed by the DOE.

The EIS is expected to contain an analysis of a specific modal mix, truck and rail shipment configuration.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Develop modal mix assessment factors	None known
Conduct technical assessment of truck shipment options	Unknown
Conduct technical assessment of rail shipment options	8 (1995)
Conduct technical assessment of the comparative risks of highway and rail, reactor access, weather sensitivity of modes and security and safeguards	None known
Select tentative modal mix	4 (1999)
Finalize modal mix	0 (2003)

3.4 ROUTING

Legal/Regulatory Background - Highway

The DOT's routing regulation for the highway transportation of highway route-controlled quantities of radioactive materials is found at 49 C.F.R. Section 177.825 (1987). It is often referred to by its docket number, HM-164. The regulation instructs carriers to operate vehicles on routes that minimize radiological risk, unless only one practicable route is available or the vehicle is operated on a preferred highway. The carrier must prepare a written route plan and provide a copy of it to the driver and the shipper. Deviations from the written plan must be reported to the shipper within 30 days after completion of the shipment.

The shipper's routing responsibilities are found at 49 C.F.R. Section 173.22(d) (1987). Within 90 days of delivery of a shipment to the carrier, the shipper must notify the DOT of the route, plus additional information. This

requirement does not apply to shipments transported in accordance with NRC's physical protection plans.

Although the NRC requires routes to be approved in advance, 10 C.F.R. Section 73.37(b)(7) (1987), the goal is to protect against sabotage or theft. The DOT's routing requirement is designed to minimize radiological risks. Route approval by the NRC is not required for waste shipments by the DOE to a repository.

Legal/Regulatory Background - Rail

The DOT has not adopted routing regulations specifically applicable to rail, although HMTA authorizes such regulations. Neither the DOT or the DOE plan to adopt rail routing regulations at this time.

Program Description

The DOE plans to comply with the DOT routing regulation which applies to highway route-controlled radioactive material. The regulation instructs carriers to operate vehicles on routes that minimize radiological risk, unless only one practicable route is available or the vehicle is operated on a preferred highway. A preferred highway is defined as an interstate highway or state-designated alternative route. Alternative routes must be designated in accordance with the DOT guidelines. Deviations from preferred routes are permitted in the event of emergencies and to make necessary stops.

The DOE plans to develop route-planning criteria as an element of transportation operational procedures. The criteria will direct the carrier's selection of routes in conformance with the DOT requirements and will further address factors such as stopping places, construction delays, adverse weather and preferred time of day for travel through urban areas (TIP, page A-42).

Although the Federal government has not promulgated rail-routing regulations, the DOE has indicated it expects rail routing procedures to generally parallel those for highway shipments. At a minimum, route planning criteria for rail shipments will require the carriers to select rail routes that limit shipping costs and transit times, avoid population centers where possible, and avoid adverse seasonal weather conditions.

Ongoing and Planned Studies

The DOE's plan to apply rudimentary route-planning criteria to R&D shipments in 1988 has not begun.

The detailed planning for rail-routing analyses which the DOE was scheduled to begin in 1987 has not been started.

The DOE is currently reviewing what is needed to evaluate the cost and risk of routing alternatives.

The EIS is expected to contain some route-specific analyses.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Develop routing criteria	8 (1999)
Develop route-specific analysis capability	11 (1992)
Analyze alternative routes	10 (1993)
Select tentative route(s)	None known
Finalize route selection	None known

3.5 EQUIPMENT AND VEHICLE STANDARDS

Legal/Regulatory Background

The Surface Transportation Assistance Act of 1982 regulates the length and width of commercial motor vehicles. 49 U.S.C.S. Appx. 2301, *et seq.* (Cum. Supp. 1987). Regulations promulgated pursuant to this Act are found at 49 C.F.R. Part 350 (1987) and 23 C.F.R. Part 658 (1987).

Both the Interstate Commerce Act, 49 U.S.C.S. 11101 (1979), and the Federal Motor Carrier Safety Act, 49 U.S.C.S. Section 3102 (Cum. Supp. 1987), regulate equipment standards. Regulations promulgated pursuant to these Acts are found at 49 C.F.R. Parts 391-399 (1987).

Program Description

The DOE is not known to have conducted a comprehensive analysis of alternative equipment and vehicle standards to improve the safety of nuclear waste shipments. In an effort to respond to cask and vehicle design considerations, the DOE is studying vehicle designs which may remove nonessential items in order to reduce vehicle weight which increase the amount of waste which each vehicle can transport. The DOE is also investigating human factors effects on safety and the implications this may have on the determination of nonessential items.

Ongoing and Planned Studies

See program description.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify potential vehicle/equipment improvements	None known
Conduct technical studies of potential vehicle/equipment improvements	None known
Conduct comprehensive assessment of overweight highway and "hefty" rail shipments	10 (1995)
Develop vehicle/equipment standards including new placarding system	None known
Develop tentative vehicle/equipment designs	None known
Finalize vehicle/equipment designs	None known

3.6 INFRASTRUCTURE

Program Description

The DOE has compiled information on the existing truck and rail infrastructure at the Yucca Mountain site and its immediately surrounding area. The DOE presently contends that the existing infrastructure should meet or exceed the requirements of the shipment program. The EA states that "no upgrading or reconstruction of local highways or rail lines is required" (EA, p. 6-103).

The DOE does anticipate that the repository transportation program in general will create unique infrastructure needs, nor will it contribute significantly to the deterioration of infrastructure at a national level. The DOE considers that infrastructure improvements needed to support repository transportation will generally be needed to support the transportation of other commodities (TIP, p. 97).

In the case of potential overweight truck shipments, the DOE contends that a properly designed overweight truck will cause only marginally greater wear on highway pavement than would legal weight trucks. Additionally, the DOE contends that overweight shipments will reduce the number of highway shipments and thus would actually reduce highway pavement wear compared to legal-weight shipments.

The only departure from this position is the DOE's acknowledgment that some infrastructure improvements may be required on a case-by-case basis. The DOE intends to review each situation individually and to work with appropriate state, local and Tribal governments to determine mechanisms for establishing infrastructure maintenance or improvement needs.

The most pressing concern is the quality of infrastructure near the reactor sites and the repository, according to the DOE, and consequently funds may be directed to upgrade links between nuclear power plants and existing transportation lines.

Ongoing and Planned Studies

On December 22, 1988, the DOE is directed by the NWPAA to report to the Congress on the potential impacts of a repository at Yucca Mountain, and the appropriate governmental and funding responsibilities associated with these impacts.

The Yucca Mountain EIS is expected to contain a more detailed analysis of infrastructure impacts within the State of Nevada.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITCRY OPERATIONAL
Develop criteria for infrastructure decision-making	None known
Assess infrastructure condition and utilization along potential routes	10 (1993)
Develop pavement performance models	None known
Develop economic assessment models	None known
Assess infrastructure impacts	10 (1993)
Identify infrastructure improvements/ new construction needs	8 (1995)
Develop institutional mechanism for funding and implementation	None known
Begin implementation	None known

3.7 DEFENSE WASTE

Background

The DOE Office of Defense Programs has traditionally controlled the shipment of defense waste with minimal oversight or involvement by other federal agencies. State, local and Tribal governments have had virtually no role in defense waste shipments. Recent developments, however, have expanded the roles of the DOT and the NRC.

The NWPAA makes all DOE (including defense) shipments to a repository or an MRS subject to the NRC cask certification and prenotification requirements. The DOE has reported that defense waste shipments to the repository will not be classified for national security. Classified shipments would be exempt from the DOT's authority to regulate the transportation of hazardous/radioactive materials.

Generally these regulations cover: placarding, labeling, marking, routing, motor carrier financial responsibility and liability limits, driver training and qualifications, parking and driving rules, post shipment information reporting, and railroad transportation requirements.

The following discussion summarizes the aspects of defense waste transportation which differ from civilian shipments to a repository.

Program Description

3.7.1 Volumes/Timing of Shipments

According to the DOE, defense waste was approximately 15% of the total curies of radioactivity in spent fuel and high-level waste of the nation in 1982, is projected to be 3% of the total in 2000, TIP, pp. A-12-13. The following tables summarize the anticipated shipments of defense waste to the repository, see ACR 8, pp. 23-25:

Table 4

Total Amount of Defense Waste to be Shipped to the Repository

(Metric Tons of Uranium)

	<u>DOE Base Case^a</u>	<u>No Second Repository/ Maximum Defense Waste Case^b</u>
Defense HLW ^c	<u>6,340</u>	<u>27,000</u>

^a - Based on DOE, 1988 MPA, Waste Acceptance Schedule, Table 2.2, and 70,000 MTU capacity limit.

^b - Assumes no second repository, 70,000 MTU capacity limit removed, and EIA spent fuel inventory projected for "no new orders" scenario through 2036, see 1988 MPA; and maximum defense waste scenario (including Hanford single-shell tank wastes) through 2020 based on DOE/RW-0184.

^c - 1 canister equals 0.5 MTU.

Table 5

Total Defense Waste Shipments to the Repository
DOE Base Case, Four Shipment Scenarios
(70,000 MTU to Repository)

	DOE Proposed Plan/MRS ^a	DOE Alternative No MRS ^b	Minimum Shipment Scenario MRS/All Rail ^c	Maximum Shipment Scenario No MRS/Truck ^d
Rail Casks ^e				
HLW	(1,648)	(1,648)	(2,536)	
Truck Casks ^f (HLW)	(4,438)	(4,438)		(12,680)

^a - Based on DOE, 1988 MPA; 57,620 MTU of spent fuel shipped to Repository from MRS in 100-ton casks, capacity 8.3 MTU consolidated spent fuel in disposal containers suitable for direct emplacement in repository, per Yucca Mountain EA, DOE/RW-0073, Vol. 2, p. A-12; 5,400 MTU of intact spent fuel shipped directly from western reactors to repository, 50 percent rail/50 percent truck, based on current reactor rail capability; 12,680 canisters of defense HLW, shipped 65 percent rail/35 percent truck; and 300 canisters of civilian HLW, shipped 65 percent rail/35 percent truck.

^b - Based on DOE, 1988 MPA; No MRS; all spent fuel shipped direct to repository, 65 percent rail/35 percent truck; defense and civilian HLW shipped 65 percent rail/35 percent truck.

^c - All spent fuel shipped to repository from MRS in 150-ton casks, capacity 22.1 MTU consolidated spent fuel in canisters, not overpacked for disposal; defense and civilian HLW shipped 100 percent rail.

^d - No MRS; all spent fuel shipped directly to repository by legal-weight truck; defense and civilian HLW shipped 100 percent by legal-weight truck.

^e - Rail cask capacities: spent fuel, 6.5 MTU; HLW, 5 canisters; and civilian HLW, 7 canisters (EA).

^f - Truck cask capacities: spent fuel, 1.0 MTU; HLW, 1 canister; and civilian HLW, 1 canister (EA).

Table 6

Annual Nuclear Waste Shipments to the Repository
During Full Operation (2008-2025)
DOE Base Case, Four Shipment Scenarios
(70,000 MTU to Repository)

	DOE Proposed Plan/MRS ^a	DOE Alternative No MRS ^b	Minimum Shipment Scenario MRS/All Rail ^c	Maximum Shipment Scenario No MRS/Truck ^d
Rail Casks ^e (HLW)	(104)	(104)	(160)	
Truck Casks ^f (HLW)	(280)	(280)		(800)

- a - Based on DOE, 1988 MPA; 57,620 MTU of spent fuel shipped to repository from MRS in 100-ton casks, capacity 8.3 MTU consolidated spent fuel in disposal containers suitable for direct emplacement in repository, per Yucca Mountain EA, DOE/RW-0073, Vol. 2, p. A-12; 5,400 MTU of intact spent fuel shipped directly from western reactors to repository, 50 percent rail/50 percent truck, based on current reactor rail capability; 12,680 canisters of defense HLW, shipped 65 percent rail/35 percent truck; and 300 canisters of civilian HLW, shipped 65 percent rail/35 percent truck.
- b - Based on DOE, 1988 MPA; No MRS; all spent fuel shipped direct to repository, 65 percent rail/35 percent truck; defense and civilian HLW shipped 65 percent rail/35 percent truck.
- c - All spent fuel shipped to repository from MRS in 150-ton casks, capacity 22.1 MTU consolidated spent fuel in canisters, not overpacked for disposal; defense and civilian HLW shipped 100 percent rail.
- d - No MRS; all spent fuel shipped directly to repository by legal-weight truck; defense and civilian HLW shipped 100 percent by legal-weight truck.
- e - Rail cask capacities: spent fuel 6.5 MTU; HLW, 5 canisters; and civilian HLW, 7 canisters (EA).
- f - Truck cask capacities: spent fuel, 1.0 MTU; HLW, 1 canister; and civilian HLW, 1 canister (EA).

3.7.2 Cask Design and Testing

The DOE has acknowledged that the waste form, radiological and thermal characteristics of defense waste differ from the spent fuel shipments, and that these factors will be considered in the design of casks for defense wastes. The DOE has described the following features of the cask it intends to develop for defense waste, (EA, pp. A11-A16). The cask will be a truck cask capable of carrying one two-by-ten foot canister of vitrified defense waste. It will be constructed of stainless steel with a shielding sleeve of depleted uranium and steel. The cask will have features for remote handling, and impact limiters that will not need to be removed during loading and unloading. A rail cask may also be developed with a capacity of five canisters of vitrified waste, however, the DOE has not described any plans for barge casks for defense waste. The DOE is required to obtain NRC certification of casks for transporting spent fuel and high-level waste under Section 5061 of the NWPA.

Ongoing and Planned Studies

The DOE is not planning any studies because it does not consider transportation of defense waste to be an issue in transportation planning.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify characteristics and quantities of defense waste by origin	4 (1999)
Clarify applicable regulatory structure	None known
Modify federal laws and regulations, if needed	None known
Assess need for special defense waste casks(s)	3 (2000)
Develop revised cask design and testing standards, if necessary	-1 (2004)
Design casks	Unknown
Submit for NRC certification	Unknown
Fabricate prototype	Unknown
Perform full-scale testing	Unknown

4.0 OPERATIONAL PROCEDURES

This section of the report describes the operational procedure elements of the DOE's planned transportation system (DOEPTS).

4.1 OPERATIONS PLAN

Program Description

The DOE has begun work on some aspects of operations planning which could become part of the comprehensive operations plan.

Recent Reports

"Siting Alternative Cost Study for a Spent Fuel Shipping Cask Maintenance Facility," December, 1986, ORNL, H&R 284-1/R1, which is to be superseded by "Cask Maintenance Facility Feasibility Study," due December 1988.

Cask Fleet Operations Study, January 1988, ORNL/Sub/87-00421/1, (legal weight cask).

Cask Fleet Operations Study, March 1988, ORNL/Sub/87-06604/1, (overweight cask).

Ongoing and Planned Studies

A management configuration study is currently underway.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Develop strategic and tactical program plans	Unknown
Identify elements of operations plan and operations planning framework	Unknown
Develop tentative operations plan including management control factors and specific control factors	10 (1993)
Draft operations procedural manual	8 (1995)

4.2 DOE CARRIER REQUIREMENTS

Program Description

The OCRWM has not proposed requirements as to contracting, screening or other aspects of carrier selection. The federal acquisition regulations of the General Accounting Office (GAO), however, will apply to the selection of carriers by the DOE. The DOE has not proposed any new carrier selection criteria. The DOE recently selected a carrier for shipments to the Waste Isolation Pilot Project, and selected a trucking firm with no experience at hauling hazardous or radioactive waste. In denying a protest from a competing bidder, the GAO determined the DOE plainly stated that cost could be the determining selection factor and that experience with hazardous waste was one of the least important selection criteria.

Ongoing and Planned Studies

Some aspects of carrier requirements are included in the management configuration study currently underway.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Finalize operations plan	Unknown
Identify carrier requirements issues	None known
Conduct technical studies on carrier requirements issues	Unknown
Develop tentative carrier requirements	Unknown
Develop carrier screening process	Unknown
Develop carrier selection criteria	Unknown
Finalize carrier requirements	4 (1999)

4.3 PERSONNEL TRAINING AND QUALIFICATIONS

Program Description

Operation of the waste transportation system will require trained personnel for a range of activities including loading waste packages, operating trucks and trains, and unloading wastes at the repository. The DOE has made no significant decisions regarding personnel training programs, but is expected to define personnel training standards about ten years before repository operations begin. Existing federal regulations address driver qualifications

for commercial vehicles and training for drivers of hazardous material shipments.

Driver qualifications are governed by the Commercial Vehicle Safety Act, 49 U.S.C.S. Appx. 2701, et seq. (Cum. Supp. 1987). This Act specifically addresses qualifications of drivers of commercial motor vehicles. Among other things, it requires drivers to have only one license, to notify the licensing state and employers of violations and suspensions, to pass a written and a driving test, and it establishes disqualifying factors for obtaining a license. Regulations promulgated pursuant to this Act are found at 49 C.F.R. Part 383 (1987).

Both the Interstate Commerce Act, 49 U.S.C.S. 11101 (1979), and the Federal Motor Carrier Safety Act, 49 U.S.C.S. Section 3102 (Cum. Supp. 1987), regulate driver qualifications and maximum hours of service. Regulations promulgated pursuant to these Acts are found at 49 C.F.R. Parts 391-399 (1987).

The HMR, 49 C.F.R. 177.825 (d), requires written training for drivers on the DOT's requirements relating to radioactive materials, on the properties and hazards of radioactive materials being transported, and on procedures to be followed in the event of an accident or emergency. No similar training requirements exist for railroad personnel (TIP, p. A-98). The DOE has been encouraged to develop training programs, but it has not yet done so (TIP, p. A-102-3).

Ongoing and Planned Studies

None known.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify personnel training and qualifications needs	None known
Conduct technical studies on personnel training issues	None known
Define training standards	10 (1993)
Revise federal motor carrier regulations concerning qualifications of drivers, disqualification of drivers, application for employment, motor carrier investigations, written examinations and medical examinations	None known
Develop personnel training program	None known

4.4 CASK MAINTENANCE

Program Description

The DOE's plans for maintenance, as discussed in the TBP, consist of:

- o Hiring a service contractor (or possibly several on a regional basis) to handle equipment servicing.
- o Developing inspection criteria and guidelines to meet the NRC and the DOT standards. The DOE personnel will audit and verify acceptability of the contractor's maintenance efforts.
- o Reactor personnel performing routine in-service inspections and repairs and the DOE contractors doing the same tasks at the repository.
- o Utilities performing the required loading and inspection activities necessary for transportation, as is presently done.
- o The DOE scheduling of the shipments and contractors being responsible for meeting those deadlines.

The DOE plans to monitor criteria related to maintenance including quality assurance procedures, when maintenance is required, equipment availability and utilization, worker exposure during handling, amount of training of maintenance personnel, and repair and maintenance cost per cask.

Management Structure

The OCRWM will be acting through the existing Transportation Operations Project Office at the DOE Oak Ridge Operations Office. The Oak Ridge Project Office will solicit, award and manage all service contracts, including those involving maintenance. The service contractors will, in turn, be responsible for the actual day-to-day transportation operations. No program management firm has yet been designated to oversee the service contractors. The DOE has indicated it may consider having the Oak Ridge Project Office hire separate contractors to "watchdog" the other contractors if the need for independent evaluations is apparent.

Changes with an MRS

An MRS will almost certainly require a separate regional service center and an expansion of the staffing requirements for maintenance and oversight of the work. No fundamental effects in cask maintenance are likely, however, since an MRS will simply require more of the same services which contractors will perform for the repository.

Recent Reports

"Siting Alternative Cost Study for a Spent Fuel Shipping Cask Maintenance Facility," December, 1986, ORNL, H&R 284-1/R1, which is to be superseded by "Cask Maintenance Facility Feasibility Study," due December 1988.

Ongoing and Planned Studies

A management configuration study is currently underway.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Begin training program	3 (2000)
Develop cask transponders	None known
Identify required fixed and mobile cask maintenance plans	8 (1995)
Conduct technical studies on cask maintenance requirements	Unknown
Develop cask maintenance QA/QC program	Unknown
Develop cask maintenance database	None known

4.5 VEHICLE MAINTENANCE

Program Description

The DOE has not developed vehicle maintenance plans.

Recent Reports

"Siting Alternative Cost Study for a Spent Fuel Shipping Cask Maintenance Facility," December, 1986, ORNL, H&R 284-1/R1, to be superseded by "Cask Maintenance Facility Feasibility Study," due December 1988.

Ongoing and Planned Studies

A management configuration study is currently underway.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify vehicle maintenance issues	None known
Research technical vehicle maintenance issues	None known
Develop home-based and field based	8 (1995)

4.6 VEHICLE STOPPAGE

Legal/Regulatory Background

The Federal Motor Carrier Safety Regulations govern certain aspects of stopped vehicles. Part 392 of 49 C.F.R. governs stops at railroad crossings and in the event of hazardous conditions.

While federal regulations contain no additional provisions for stoppage of nuclear waste shipments, there are additional requirements for attendance, surveillance and parking of motor vehicles containing Class A or Class B explosives, 49 C.F.R. 397.5 and 397.7 (1987). Section 397.5 provides an exception to its requirements for vehicles located in a "safe haven." A safe haven is defined as "an area specifically approved in writing by local, state, or federal governmental authorities for the parking of unattended vehicles containing Class A or Class B explosives," 49 C.F.R. Section 397.5(e) (1987). No other guidance of what constitutes a safe haven is offered.

Program Description

The DOE has not decided whether to develop any special requirements or restrictions on vehicle stoppage.

The current DOT requirements state that no unnecessary delay of highway shipments can occur, 49 C.F.R. 177.853 (1987). For rail shipments, layovers at interchanges, yards or other transfer points are limited to 48 hours or less, 49 C.F.R. 174.14 (1987).

Recent Reports

Some information on vehicle stoppage is contained in the ALARA report, Analysis of Radiation Doses from Operation of Postulated Commercial Spent Fuel Transportation System, DOE-CH/TPO-001 (1987).

Ongoing and Planned Studies

The DOE intends to study the use of prearranged stopping areas. The effect of planned and unplanned stops is also to be studied (TIP, p. A-106).

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify vehicle stoppage issues	Unknown
Conduct technical studies including trade-offs between consistent v. randomized stops	Unknown
Identify route-specific vehicle stoppage needs	None known

Develop route-specific vehicle stoppage plan
for planned and emergency stops

8 (1995)

Construct necessary facilities

None known

4.7 SHIPMENT MONITORING AND PRENOTIFICATION

Background

DOE commonly ships radioactive materials used in research, development and defense activities. DOE shipments which are unclassified follow all DOT requirements for radioactive shipments. Under current procedure the DOE periodically provides written information to states, referred to as "generic shipment notification," which has been approved by the DOT as part of the physical protection system for the DOE's shipments. Generic shipment information provides information about radioactive materials being shipped, packaging, liability coverage, available emergency assistance and carrier training. Generic shipment notification is not shipment-specific and does not indicate transportation routes, (TIP, p. A-16, 17).

"Courtesy communication" is also provided to the Governor of a state before waste shipment through or within a state, (TIP, p. A-16 and 17):

- o General shipping information including: expected length of shipment campaign, shipping schedule, number of shipments in the shipping campaign and number of shipments per month.
- o Planned transportation routes; origin and destination of the shipment.
- o Type of transportation cask.
- o Identification of the commercial carrier.
- o Emergency response contact at DOE.

The time and date of shipment is normally not revealed, however, under a new policy the DOE provides this as prenotification information in the case of spent fuel shipments (only). If there has been an interruption of generally six months or more between shipments, the DOE will renew its courtesy communication before resuming a shipment campaign.

Program Description

4.7.1 Prenotification

Section 180 of the NWPA requires that all DOE shipments of spent fuel and high-level nuclear waste to a repository or an MRS comply with the NRC's prenotification requirements. The NRC's prenotification requirements for spent fuel are found at 10 C.F.R. Part 73.37(f) (1987), and the prenotification requirements for nuclear waste are found at 10 C.F.R. Part 71.97 (1987). DOE has made no commitment to notification of localities, but indicates it will discuss the issue with them (TIP, p. A-19, 20).

4.7.2 Shipment Monitoring

The DOE Office of Defense Programs has developed a satellite tracking system called TRANSCOM that provides real-time information on the location of shipments that are equipped with the necessary transponders. The DOE is establishing a control center at the ORNL. To date, the OCRWM has not decided whether or not to utilize the TRANSCOM system for monitoring shipments to a repository.

Recent Reports

Options for Gathering Information about Shipments of Radioactive and other Hazardous Materials, DOT/RSPA/DHM-61-86-2 (1986).

Ongoing and Planned Studies

A test of the TRANSCOM system is planned to be conducted with the Pacific States Agreement on Radioactive Materials Transportation Management in early 1989.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Assess information needs of state Tribal and local governments	Unknown
Pilot test TRANSCOM system	14 (1989)
Assess alternative technologies for providing needed information	None known
Design shipment monitoring and prenotification system	8 (1995)
Promulgate implementing regulations	Unknown

4.8 INSPECTION AND ENFORCEMENT

Legal/Regulatory Background

Pursuant to the Surface Transportation Assistance Act of 1982, 49 U.S.C.S. Appx. 2301 et seq. (Cum. Supp. 1987), states are encouraged to adopt and enforce the Federal Motor Carrier Safety Regulations (49 C.F.R. Parts 390-399) and the Federal Hazardous Materials Regulations (49 C.F.R. Parts 107-178).

States must adopt these regulations and fulfill other requirements to be eligible for federal grants. 49 C.F.R. Part 350 (1987). The ability of states to adopt requirements that are more stringent than those adopted by the federal

government is governed by the preemption principles that vary with the particular area of federal law. Some states have adopted more stringent transportation regulations. The state of Illinois has an aggressive rail and highway inspection and enforcement program.

General qualifications for state rail inspectors are found at 49 C.F.R. Parts 212.201-212.227 (1987). States are permitted to adopt more stringent requirements than those adopted by the federal government (49 C.F.R. 212.201(a) (1987)).

Program Description

Currently, the NRC, the DOT and the DOE all have or are developing inspection standards of some kind related to nuclear waste transportation (TIP, p. A-44 - 48). The items currently examined by these agencies or proposed for their review is summarized in Table 7.

TABLE 7

FEDERAL ENTITIES WITH EXISTING OR PENDING VEHICLE REQUIREMENTS

<u>AREAS COVERED BY REQUIREMENTS</u>	<u>AGENCY IMPOSING REQUIREMENTS</u>		
	<u>NRC</u>	<u>DOT</u>	<u>DOE/OCRWM</u>
Preparation of Empty Casks for Transport	X		X
Preparation of Loaded Casks	X		X
Loading of Casks on Vehicle	X		X
Cask Maintenance	X		
Physical Protection Plan		X	X
Route Plans (highway shipments)		X	
Radiation Monitoring	X	X	X
Vehicle Safety		X	X
Package Labeling and Vehicle Placarding		X	X
Shipping Papers		X	
Driver Training		X	X

SOURCE: Derived from TIP, p. A-44, 45 and 48

The OCRWM plans to elicit state cooperation in the inspection program. The actual criteria used for inspections is not expected to be developed for some time (TIP, page 49).

Ongoing and Planned Studies

The Commercial Vehicle Safety Alliance (CVSA) is working in cooperation with the OCRWM to develop uniform and reciprocal vehicle inspection procedures for highway shipments of spent fuel. The July 1988 OCRWM Bulletin reported that CVSA task force members completed draft inspection procedures in November 1987. Comments submitted by the Western States Interstate Energy Board, and the Utilities Nuclear Transportation Group have been reviewed by the OCRWM and the CVSA.

Plans for a multi-year pilot test of the draft inspection procedures are being developed at this time and should begin during fiscal year 1989. The pilot test will be administered by the Pacific States Agreement on Radioactive Materials Transportation Management, which is comprised of Idaho, Oregon and Washington, and the pilot test will be conducted within the region of these states.

When the draft inspection procedures have been sufficiently refined, they will be proposed for adoption by the CVSA, which will assist the OCRWM in achieving adoption by the states and their legislatures.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Identify inspection and enforcement issues	Unknown
Research technical inspection and enforcement issues	None known
Clarify roles of federal, state, Tribal and local governments	None known
Develop inspection criteria	8 (1995)
Develop inspection protocol	Unknown

4.9 PHYSICAL PROTECTION (SABOTAGE/TERRORISM)

Program Description

Legal/Regulatory Background

The NRC regulates the physical protection plans for spent fuel shipments. The requirements, which govern only NRC licensees, are found at 10 C.F.R. 73.37 (1987) and include the following:

- o Prenotification of shipments to the NRC;
- o Procedures for responding to threats to damage the shipments;
- o Monitoring of the shipment by a communications center;
- o A written log for recording shipment and event information;
- o Advance arrangements with local law enforcement agencies to respond to an emergency;
- o Advance route approval;
- o Plans to avoid intermediate stops;
- o At least one escort must maintain visual surveillance of the shipment when the vehicle is stopped;
- o Training for escorts, following the requirements established in Appendix D to 10 C.F.R. Part 73;
- o Calls to the communications center every two hours by the escorts;
- o Prenotification of shipments to governors or their designees;
- o Protection of the information from disclosure.

There are additional specific requirements for shipments by road, rail and sea.

Because the DOE is not a licensee of the NRC as a shipper, the DOE is not governed by the NRC regulations. However, the regulations of the DOT require the DOE to submit to the DOT and obtain DOT approval of an "equivalent" physical protection plan, 49 C.F.R. Section 173.22(c) (1982). The DOE has submitted and obtained the DOT's approval of an "equivalent" plan. While the DOE has indicated that it will follow the NRC's physical protection/safeguard requirements, enforcement is not possible because the NRC requirements do not legally apply to the DOE.

Program Description

The DOE's "equivalent" requirements are interim physical protection procedures for unclassified DOE-shippments of spent fuel, DOE Order No. 5632, approved by DOT 1982, summarized as follows:

- o An escort is needed for each shipment. The escort may be a second driver or two escorts in a second vehicle.
- o The driver or escort must remain with the shipment at all times.
- o The shipment must be equipped with a two-way communication device for contact with a central communication center, state or local law enforcement agency or other reliable contacts to permit a timely response to a security incident involving the shipment. Any escort vehicle is to be similarly equipped.
- o Communication with a central control station is required every four hours, at a minimum, and preferably every two hours.
- o A method shall be used to enable the communication center or response force to locate the vehicle if an incident occurs.
- o "As necessary to effect unimpeded traffic flows," periodic contact will be coordinated through the the Director, Transportation Operations Staff, with appropriate state officials or, where jurisdictional needs require, appropriate local law enforcement agencies where spent fuel is being routed. Information will be provided about the spent fuel shipments and appropriate emergency procedures.
- o A list is to be maintained by the DOE's regional shipping and receiving operations office of emergency coordination telephone numbers and contact points including, where appropriate, those of local law enforcement agencies. This list is to be coordinated through and updated every six months by the Director, Transportation Staff.
- o To the maximum extent practicable, carriers are to use interstate or limited access divided state highways.
- o High density urban areas should be avoided where feasible.
- o Circumferential interstate quality highways should be used.
- o The carrier must inform DOE officials of route information that could impact on shipment security or safety.
- o DOE is required to check the package and transport vehicle to ensure that no conditions exist which could compromise the security of the shipment.

The DOE recently revised its "equivalent" physical protection plan. The revised DOE plan differs from the NRC's requirements in that the DOE plan:

- o Does not require advanced route approval by the NRC;
- o Does not require armed guards in populated areas;
- o Requires the driver/escort to call a control center every four hours rather than every two hours as required by the NRC;
- o Does not require the maintenance of a written log.

Ongoing and Planned Studies

None known.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE YEARS YEARS BEFORE REPOSITORY OPERATIONAL
Analyze the probability of various shipment interference scenarios	None known
Analyze consequences of worst-case scenarios	None known
Identify potential physical protection improvements	None known
Assess trade-offs between physical improvements and other impacts of the transportation system	None known
Initial design of physical protection system	8 (1995)
Finalize design of physical protection system	Unknown
Promulgate regulations	None known

DRAFT - CATEGORY TWO

TRANSPORTATION NEEDS ASSESSMENT

**TASK 15.4 EVALUATION OF THE UNITED STATES
DEPARTMENT OF ENERGY PLANNED TRANSPORTATION SYSTEM**

PHASE IIIA YUCCA MOUNTAIN SOCIOECONOMIC PROJECT

MOUNTAIN WEST RESEARCH

DECEMBER 22, 1988

INTRODUCTION

This report is the working paper for task 15.4 of the Transportation Needs Assessment. The Transportation Needs Assessment includes the following tasks:

<u>Task</u>	<u>Title</u>
15.1	Refine Statement of Work
15.2	Describe (Preferred) Transportation System Options
15.3	Describe the DOE Planned Transportation System
15.4	Evaluate the DOE Planned Transportation System
15.5	Review and Evaluate Existing Studies and Data Sources
15.6	Design Transportation Impact Studies

This report evaluates the United States Department of Energy (DOE) planned transportation system, as described in the task 15.3 working paper, against the Preferred Transportation System, developed under task 15.2.

STRUCTURE OF THE REPORT

The evaluation of the DOE planned transportation system is organized using the following seven crosscutting issues, seven design elements and nine operational elements of the Preferred Transportation System. (This is the same structure used to describe the DOE planned transportation system and the Preferred Transportation System).

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This working paper evaluates currently available information on the DOE planned transportation program and the DOE decision schedule for each of the system issues and elements described above.

TERMINOLOGY

In this report the terms "nuclear waste" and "waste" refer to all of the radioactive wastes to be shipped to a repository. This includes spent nuclear fuel (SNF) and consolidated SNF from commercial nuclear power reactors, solidified high-level wastes (HLW) from the civilian reprocessing of commercial spent fuel (CHLW, e.g. West Valley wastes) and defense high level wastes (DHLW) from the nuclear weapons program. It is uncertain at this time whether or not miscellaneous wastes resulting from spent fuel rod consolidation, transuranic wastes from sources other than the nuclear weapons program and "greater than Class C" low-level radioactive wastes may be disposed at the repository.

The term "Preferred Transportation System" is used to refer to the preferred transportation system which was developed under task 15.2 of the Transportation Needs Assessment. The Preferred Transportation System report is the task 15.2 deliverable.

BACKGROUND

To date, the DOE has not issued decisions regarding many of the key issues concerning the system for transporting nuclear waste to a repository at Yucca Mountain. The DOE intends that its transportation system will evolve gradually over the next 15 years, making it difficult to evaluate the DOE planned transportation system at this time.

1.0 CROSSCUTTING ISSUES

This portion of the working paper evaluates the crosscutting elements of the DOE planned transportation system.

1.1 COMPREHENSIVE RISK ASSESSMENT AND RISK MANAGEMENT

The magnitude of the transportation program for the repository (and an MRS, if one is developed) and the hazards of nuclear waste will involve risks never before planned for in the United States. The spectrum of possible hazard events is enormous, considering that the equivalent of 76,000 truck shipments will be transported thousands of miles across the United States over several decades. Accordingly, assessment and management of risks will be among the most complicated and important responsibilities facing the program. Serious risks may require extensive changes in program direction, or may even cause catastrophic consequences to health, safety and property later in the repository program.

The need for comprehensive risk assessment and management is particularly important given the DOE approach to these problems. The DOE risk assessments have been focused on specific subjects rather than systematically reviewing the entire transportation sequence. This incremental and limited approach to risk assessment may not only fail to identify potentially serious hazard events, but it will also limit the effectiveness of risk management efforts by the resulting ignorance of potential risks.

Comprehensive Risk Assessment

The components of comprehensive risk assessment and management are developed in detail in section 1.1 of the Preferred Transportation System report. Generally, a comprehensive risk assessment consists of the following components:

Identification of all Potential Hazard Events and Adverse Consequences for the Entire Transportation Program. The main approach of the DOE to risk assessment in nuclear waste transportation is to assess risks for specifically defined scenarios. The DOE Environmental Assessment, Yucca Mountain Site, Nevada Research and Development Area, May 1986, (EA) contains a risk analysis based on evaluating specific scenarios that characterize risks from rail, truck and barge transportation. These scenarios include disposal with and without a monitored retrievable storage facility (MRS), different routing options and different cask capacities.

However, the investigation of specific areas of the program is too narrow and fails to systematically review the spectrum of possible transport events

from reactor-to-repository. There is no indication that the DOE will review the full spectrum of the transportation system and the potential hazards and consequences. The absence of such a complete review will cause many potential hazard events to not be considered, which will flaw all subsequent components of comprehensive risk assessment and management analyses for the repository.

Assess Probabilities of Occurrence of Potential Hazard Events, Adverse Consequences and the Extent of Uncertainties. Since the DOE has not identified the range of hazard events and adverse consequences, this second step in risk assessment cannot be accomplished except as to the limited and specific hazard scenarios which the DOE has considered. The DOE has not adequately assessed the probability of risks from human factors, deficient quality assurance and quality control (QA/QC), sabotage or terrorism. As discussed in more detail in the cask design and testing section of this report, the DOE cask design and testing programs have not adequately assessed the consequences of the most severe accidents. As a result, the DOE risk assessment models may significantly underestimate the consequences of severe accidents/sabotage/terrorism.

Identify Assumptions Used. The DOE identified some assumptions for the limited scenarios analyzed, covering matters such as the number of shipments, shipment modes, cask capacity and activity levels. However, the DOE has made several key assumptions which have not been clearly identified or justified:

All regulations and procedures are followed.

Equipment such as casks are properly fabricated to specification and function correctly.

Transportation personnel perform their handling and shipping tasks without error.

Capabilities in state, Tribal and local emergency response are assumed to be adequate to respond to transportation accidents.

Actual destructive tests on casks or vehicles are not needed, and theoretical testing will accurately represent actual accident conditions.

Theoretical accident conditions are no worse than: 30-foot drop; one-meter drop onto a blunt spike; a 30-minute fire; being underwater immersion for eight hours in up to fifty feet of water.

Severe seasonal weather can be avoided during transportation, and shipment interruptions due to weather will not be significant.

Accident rates for radioactive waste shipments were assumed to be represented by accident statistics for general commerce.

Use Consequence Analyses Indicating the Nature, Severity and Magnitude of Adverse Effects. The DOE consequence analyses conducted to date utilize nationally aggregated data for input parameters which are known to vary widely from state to state and within states. The DOE has used such aggregate data, rather than route specific data for the population along transport routes and highway accident rates, to name a few. A previous report prepared for the Nevada Nuclear Waste Project Office (NWPO), Review of Radtran III Documentation and Assessment of Theoretical Background, January 1987, discusses a number of shortcomings in the Radtran III model which is the cornerstone of the DOE risk assessment. The results of the DOE consequence analysis are also extremely limited in the nature of impacts considered.

Estimate the Risks Resulting from Different Assumptions about the Transport System. The DOE has provided insufficient information on the sensitivity of the results to the assumptions used.

In conclusion, the risk assessment program of the DOE lacks key components needed for effective comprehensive risk assessment. It is limited to events related to only limited features of the transportation program and does not address the spectrum of events from reactor-to-repository. Unrealistic assumptions have been utilized. Lacking a comprehensive list of possible events, the assessments will not be able to assess probabilities of occurrence, adverse consequences and degrees of uncertainty. There has been no indication the DOE will analyze the sensitivity of their findings to data uncertainties. The consequence analyses by the DOE, already limited by the lack of a complete events spectrum, do not provide expected risks to the public from accidents. Sensitivity of risks to different assumptions are not being prepared.

Comprehensive Risk Management

The DOE approach to risk management is generally to indicate that applicable United States Department of Transportation (DOT) and United States Nuclear Regulatory Commission (NRC) regulations will be met, and that safety is the overriding goal of the program. It appears that the DOE does not consider the risks of nuclear waste transportation to be sufficient to warrant a systematic risk management system. As indicated above and as discussed more fully in section 1.1 of the Preferred Transportation System report, the state-of-the-art approach to this subject utilizes a comprehensive risk assessment as a starting point for developing comprehensive risk management strategies. Without this approach, risk management efforts will be ad-hoc and likely to ignore potential hazard events which could otherwise have been foreseen, and perhaps avoided or mitigated.

The DOE does not appear to be utilizing any of the elements of the comprehensive risk management approach as presented in Preferred Transportation System report, which include:

- o Beginning the risk management analysis with the findings of a comprehensive risk assessment.
- o Evaluating the acceptance or tolerability of identified risks and prioritize the risks for management action.
- o Identifying control strategies, means of intervention and modes of implementation for managing risks.
- o Implementing the control options selected to manage risks.
- o Evaluating effectiveness of risk management efforts and modifying strategies as needed.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Research risk assessment issues such as the integration of human factors	None known	17 (1986)
Design risk assessment methodology	14 (1989)	16 (1987)
Collect data needed for risk assessment	11 (1992)	14 (1989)
Conduct baseline risk assessment	10 (1993)	13 (1990)
Identify risk management strategies	Unknown	11 (1992)
Iterate risk assessment (first time)	None known	10 (1993)

The failure of the DOE to conduct a comprehensive transportation risk assessment, and to assess risk management alternatives in a timely fashion does not allow for the rational planning of the nuclear waste transportation system and does not allow for state, Tribal and local governments to prepare for the shipments of nuclear waste through their jurisdictions.

1.2 TRANSPORTATION PLANNING AND ANALYSIS SYSTEM

The DOE approach to transportation planning for the shipment of nuclear waste to the repository at Yucca Mountain (and to an MRS, if one is developed), appears to be highly fragmented rather than the coordinated and integrated methodology recommended in section 1.2 of the Preferred Transportation System report. Following are comments on some specific aspects the DOE transportation planning analyses which are flawed.

The EA inadequately addresses the operating characteristics of the highway network. For example, the average annual daily traffic volumes are a point estimate for a single year. Trend analysis is important, in that if the area is experiencing traffic growth over the duration of repository operation, traffic growth could cause significant safety and maintenance problems. The EA does not address these concerns.

Furthermore, reported accident rates for road network segments apply to the general vehicular traffic stream, rather than to heavy truck operation. Even so, the network segment accident rates are not used in the DOE risk models; rather the accident rates used to evaluate transportation to the repository at Yucca Mountain are based on national estimates derived from California accident experience.

Transportation assessment results are reported in numerical terms as either averages or expected impacts, and these numbers are subsequently used in the decision process. Given that many of the impacts are subjective, and the assumptions and variations on the transportation scenario are subject to uncertainty, it is irresponsible for the DOE to report their findings in this manner. Extensive sensitivity analyses and the reporting of variation in results as ranges is more appropriate. It is argued by the DOE that a conservative approach is taken; therefore, the reported results reflect a worse-case scenario.

There is evidence to indicate that several issues have not been adequately considered. For example, the number of rail and truck accidents in the region and their corresponding consequences are likely to be significantly understated because they are derived from accident databases that are acknowledged to be incomplete and inaccurate. In recent work on hazardous materials transport safety conducted for the U.S. Congress, Office of Technology Assessment, it was demonstrated that the actual number of accident occurrences exceeds the reported number by at least a factor of two or three, and for those accidents which were reported, the consequences were underestimated by an order of magnitude in terms of monetary damage, due to a principle focus on damage only to the vehicle and its cargo, and not the costs of emergency response, clean-up, and damage to other parties and property at the scene. The ramifications of these biases are that the impact of transportation "risk" may be 20 times greater than is publicly reported.

The absence of several key elements in the transportation environment is

also recognized. This includes the lack of explicit treatment of human factors, particularly in light of the competitive nature of the truck and rail industries, and the manner in which this affects scheduling, driver hours, stress, fatigue, etc. The costs and impacts of improved emergency response training, equipment and inspection capability are also largely ignored.

Perhaps the greatest problems are in the area of the DOE risk assessment methodology. First, accident likelihood and conditional incident severity appear to be dependent on historical data. It is commonly known that the historical database is not extensive enough at this time to support the derivation of low-probability, high-consequence events that should be of a primary concern to the DOE.

There is no evidence that the use of fault tree and other methodologies were applied to overcome this deficiency. Furthermore, the methodology is veiled in a "black box" approach where results are given without adequate documentation of the procedures used to derive these estimates. Differences between observed and perceived risk are also not addressed.

The application of national unit risk factors to analyze all transportation impacts is a serious modeling deficiency. In effect, this dilutes the transportation assessment to one where the impacts are strongly correlated with distance, since all risk factors are distance-based. The exception, the use of population density, is weakened by the use of gross classes (urban, suburban, rural), rather than actual population densities. The use of disaggregate risk factors that are based on local conditions and reflect segment variables such as average annual daily traffic, track class, road classification, etc., is paramount. The DOE even admits that a more detailed site analysis of transportation impacts is appropriate at this juncture.

The decision to present radiological risk solely in terms of expected fatalities is a significant oversight. It presents a binary response variable (death, no death) which is not appropriate to this problem, since the greatest impact may be to people who are hurt or suffer a debilitating injury. There is a large economic and social cost associated with these consequences, which is entirely ignored in the DOE approach.

The economic cost analysis is extremely narrow in focus, dealing only with vehicle operations (acquisition, operation and maintenance), and not with infrastructure maintenance and rehabilitation costs, which may exceed the reported costs, particularly if overweight vehicles are used. The DOE argues that the contribution to infrastructure wear and tear that could be attributed to vehicles transporting nuclear waste would be negligible compared to general commerce activities, but this was not addressed in the report in a scientific fashion.

In general, the qualifying discussion was not based on defined thresholds, but rather on definitions that allowed for loose and non-uniform interpretations. As a result, many of the conclusions reached concerning transportation to a repository at Yucca Mountain were not adequately justified.

1.3 TRANSPORTATION SYSTEM IMPACT MONITORING

Since the DOE has no formal plan for monitoring the impacts of transporting nuclear waste to a repository at Yucca Mountain it is totally deficient with regard to the preferred approach for monitoring the impacts of the nuclear waste transportation system as presented in section 1.3 of the Preferred Transportation System report.

The DOE does not recognize the importance of monitoring the impacts resulting from the nuclear waste transportation system. While it is acknowledged that a sufficient degree of uncertainty exists about the size of the estimated work force to warrant some monitoring of vehicle traffic, the DOE concludes that no potentially significant impacts to transportation are anticipated at or around the site (from site characterization activities). Therefore, no transportation monitoring program or mitigation plan is included. Mitigation strategies are simply not discussed.

This view of monitoring and mitigation for transportation has three major flaws. First, it ignores the need for a monitoring and mitigation structure that can be used throughout the various phases of the project. Secondly, but inextricably related to the above, if (or when) a transportation problem becomes evident, requisite planning and data required to deal with the problem will not be readily available. In the transportation sector, traffic delays and infrastructure repairs often cannot be put on hold while mitigation studies are initiated. Impact mitigation requires plans that anticipate possible problems and in-place strategies for dealing with them. Thirdly, monitoring and mitigation plans are totally absent from considerations by the DOE. The perceived effects of transportation may be heightened during site characterization and later phases of the project, particularly in communities along corridors to the Yucca Mountain repository.

To be effective, a comprehensive monitoring and mitigation plan should be developed, consisting of two major components: (1) requisite baseline information which must be established and (2) requisite monitoring activities. The importance of the baseline information should be immediately apparent; monitoring and mitigation activities are, by design, intended to provide early warnings of changes in transportation indicators which require mitigation. Monitoring, of course, is the mechanism which picks up such changes. The ultimate value of such a plan rests on its effectiveness in anticipating future impacts which may arise from the transportation aspects of the project.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify impact assessment criteria	14 (1989)	18 (1985)
Develop route-specific impact assessment models	14 (1989)	16 (1987)
Collect data needed for route- specific assessment models	11 (1992)	14 (1989)
Conduct baseline impact assessment	10 (1993)	13 (1990)
Identify impact mitigation measures	Unknown	11 (1992)
Iterate impact assessment (first time)	None known	10 (1993)

The failure by the DOE to begin an impact monitoring program at the beginning of the pre-operational phase of the repository almost guarantees that it will not be possible to assess the full impacts of the nuclear waste transportation system. The absence of a coordinated impact monitoring and mitigation program does not allow for the rational planning of the nuclear waste transportation, and does not allow for state, Tribal and local governments to prepare for the shipments of nuclear waste through their jurisdictions.

1.4 DATA COLLECTION AND MANAGEMENT

Since the DOE is not known to have any centralized or coordinated plan or program for transportation data management, it is totally deficient with regard to the preferred data management system as presented in section 1.4 of the Preferred Transportation System report.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify data needs of federal, state, Tribal and local governments	None known	21 (1982)
Prepare conceptual system description	None known	20 (1983)
Design data collection/management software and hardware	None known	19 (1984)
Begin data collection	None known	18 (1985)
Pilot test system	None known	16 (1987)
Begin system implementation	None known	15 (1988)

The failure by the DOE to develop a comprehensive transportation data collection and management system in a timely fashion does not allow for the rational planning of the nuclear waste transportation system and does not allow for state, Tribal and local governments to prepare for the shipments of nuclear waste through their jurisdictions.

1.5 INSTITUTIONAL RELATIONS

The area of institutional relations is perhaps the broadest of the transportation subjects because interactions regarding the various issue areas of the transportation program will be focused in the institutional affairs among the interested parties. For example, the NWPO has identified a number of issues of system design and operations which need to be addressed through institutional relations. See A Report to the Nevada Legislature, A Report on High-Level Nuclear Waste Transportation: Prepared Pursuant to Assembly Concurrent Resolution #8 of the 1987 Nevada Legislature, November 1988 (A.C.R. 8).

These issues will be addressed through processes ranging from cooperative to adversarial. The success of the program will depend greatly on the abilities of the various interested parties to cooperate in a process which is fair, which inspires public confidence and which has a common goal of developing the safest nuclear waste repository program.

The preferred approach to institutional relations is described in detail in the Preferred Transportation System report. The major elements of preferred institutional relations are compared with the DOE plans for institutional relations below.

Roles and Responsibilities of all Governments and Interested Parties Should Be Clearly Delineated.

Regulatory roles of states, Tribal, local governments and, at times, corridor states are unclear as to their authority to regulate important aspects of waste transportation. It appears the federal government is working to preempt states, Tribal and local governments as to permits and fees, inspection/enforcement and shipment routing. The role of these governments in these matters is thus unclear, since these are traditionally matters of local concern and suitable for local regulation.

Responsibilities for emergency response actions, training and equipment are unclear. The speed and effectiveness which can be expected of federal emergency response efforts is uncertain. It also appears the DOE will offer only cursory training for state, Tribal and local emergency response personnel, and it is unclear who will pay for emergency response training, readiness, responses and equipment. The failure by the DOE to implement section 180(c) of the NWPA in a timely manner inhibits state, Tribal and local governments from fully participating in the planning for the nuclear waste transportation system.

Responsibility for paying for needed improvements to transportation infrastructure for the repository program is unclear. In addition, the frequent reorganization of the DOE and changes in personnel complicate interactions with state, Tribal and local governments.

Program Milestones Should Be Properly Sequenced.

The DOE is planning to do some risk assessment analysis on waste transportation, however, there is no indication the DOE will conduct a comprehensive risk assessment, or that comprehensive risk management will be undertaken. However, under the DOE timeline, their baseline risk assessment will not be conducted until 1993. It is unknown at this time if, or when, the DOE plans to develop risk management strategies, but it appears the earliest this could occur would be perhaps 1995. A preferred process would be to have the outcome of comprehensive risk management analysis by 1992, to allow for program changes and adjustments needed to reduce risks.

Clarification of a potential MRS location is needed early in the process for joint planning along transportation corridors to proceed. According to the Nuclear Waste Policy Amendments Act (NWPAA), the MRS Review Commission will report to Congress on June 1, 1989, whether an MRS should be developed, and the Nuclear Waste Negotiator will have a term through January 1993 to negotiate agreement for an MRS (and/or a repository). This suggests a decision about using an MRS may be years away, which will in the meantime preclude effective risk assessment/management and joint planning being undertaken along shipment routes.

Shipment routes and transportation modal mix analyses and decisions should be made early in the process to allow transportation planning to proceed, including risk assessment/management, transport system engineering, emergency response preparation and infrastructure improvements. Studies as to modal mix and routing should have begun in 1984-1986, so that tentative route and modal mix could have been developed by 1990. Instead, the DOE is scheduled to select tentative modal mix in 1999, and it is unknown when tentative routes will be announced; however, the DOE will not conduct alternative route analyses until 1993, so tentative routes will not be announced until after then. Under this timeline, much of the important information needed for transportation planning will not be available until the last few years before the repository is to open.

Program Management Should Be Comprehensive, Not Fragmented.

Decisions made as to several key components of the program are interrelated, such as risk assessment/management, cask design, routing, modal mix, transportation infrastructure and emergency preparedness. However, it appears that these matters are developing on separate tracks, making it difficult for states, Tribal and local governments to participate in the planning process. The major program components should be incorporated into one process under a comprehensive transportation plan and consolidated in a joint planning process.

Public Interactions by Federal Agencies Should Promote Meaningful and Effective Participation by Non-Federal Interested Parties. The Primary Mechanisms of Interaction Should Be Cooperation in Information Development and Exchange, and in Planning.

Benefits agreements are impractical to provide resources for joint planning, since no state or Tribe should be expected to waive objections to a repository or MRS before they can collect and evaluate information needed to make an informed waiver.

Funding under Section 180(c) of the NWPA for emergency response training must be implemented immediately to allow planning by states for emergency preparedness. Delaying this assistance until the year 1998 to 2000, as the DOE plans to do, excludes all states except Nevada from participating effectively in planning for the transportation of nuclear waste to a repository.

Program planning should be consolidated into a comprehensive joint planning effort because state, Tribal and local governments and other interested parties lack the resources to participate in simultaneous planning efforts on different issues.

Delay by the DOE in identifying potential shipment routes is precluding effective participation in joint planning by states, Tribal, local governments and other interested parties who do not know whether, or to what extent, they will be impacted by waste transportation as corridor states.

The DOE has no plans for providing transportation planning assistance to Nevada Tribes, which is presently denying them effective participation in the planning process.

The DOE and the DOT have not supported important aspects of regulatory authority needed by states such, as vehicle operation regulations covering permits and fees, shipment routing, vehicle stoppage, and inspection/enforcement. This prevents planning on these important matters of particularly local concern.

In conclusion, many of the DOE institutional plans are quite good on paper. However, in practice many of the fundamental components of the institutional plans are frequently ignored. One example is the commitment by the DOE to involve state, Tribal and local governments in the transportation planning process. After the passage of the NWPA, the DOE agreed to allow the State of Nevada to review the Section 175 impact assessment report. However, during its development, the State of Nevada was denied access to a draft of the report and the final report was issued without any meaningful involvement of state, Tribal or local governments in Nevada.

1.6 REGULATORY STRUCTURE/LIABILITY

The failure of the DOE to systematically review federal laws and regulations to identify potential risk reduction measures is a major shortcoming in the nuclear waste transportation system. The Preferred Transportation System report identified a number of statutory/regulatory changes which would result in significant risk reductions.

This section specifically discusses only placards, shipping papers, permits and fees, and liability/compensation. The regulatory aspects of the various design or operational procedure elements of the nuclear waste transportation systems are discussed in the appropriate system design or operational procedure sections of the report.

Placards

Federal regulations set forth a system to designate hazardous materials, including radioactive materials, and to communicate the hazard by requiring shipping papers, marking and labeling of packages and placarding the transport vehicle. By failing to distinguish between fresh nuclear fuel and spent nuclear fuel, the DOT regulations undermine the very system it establishes and could result in emergency responders taking inappropriate action.

Shipping Papers

Shipping papers constitute part of the hazard communications system established by 49 C.F.R. Part 172. However, the DOT does not require an emergency contact to be listed on the shipping papers. As radiological incidents require unique responses, the shipping paper requirements should be amended to include a contact and telephone number, staffed 24 hours a day, that the carrier, driver or emergency response personnel may call in the event of an incident of suspect incident.

Although the DOT requires the shipper to include the term "highway route-controlled quantity" as part of the description of the shipment, it does not require the shipper to specifically identify the type of highway route-controlled quantity of radioactive material contained in the shipment. The shipping papers fail to provide emergency responders with essential information, and the regulations should be amended to address this problem.

Permits & Fees

Both the DOT and the DOE have opposed state and local efforts to adopt and implement programs containing many aspects of the Preferred Transportation System. The DOT, in its policy statement published as Appendix A to 49 CFR Part 177, has taken the position that a permit or fee is inconsistent with HMTA

if it effectively redirects, or otherwise significantly restricts or delays the movement by public highway of motor vehicles containing hazardous materials, and applies because of the hazardous nature of the cargo.

However, a review of the DOT's advisory opinions, known as inconsistency rulings (IR), reveals that the DOT has been inconsistent in applying its own policy. In IR-2, the DOT determined that a "bare" permit requirement is consistent with HMTA. Then on several occasions (e.g. IR-8 and 15) the DOT relied on its policy statement to find a state permit or fee requirement preempted, but in IR-17, the DOT upheld a \$1.00 per shipment fee imposed by the State of Illinois.

The DOE has been consistent in its position: through its employees and contractors, it has repeatedly stated its opposition to permits and fees, and the DOE has aggressively participated in the DOT's advisory opinion process. Although the DOE was not the petitioner in IR-17, it appealed the ruling. Additionally, the DOE has filed an inconsistency petition with the DOT, seeking a determination that Colorado's nuclear materials transportation statute and regulations, which include a permit and fee requirement, are preempted by HMTA.

The DOT and the DOE have taken these positions in spite of the fact that there are no federal regulations governing permits and fees. Nevada should, therefore, focus on implementing the preferred system.

Standard of Liability

Although the Price-Anderson Act (PAA) does not specifically address the standard of liability, it does establish the concept of an extraordinary nuclear occurrence (ENO). An ENO is defined as

any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the [Nuclear Regulatory] Commission determines to be substantial, and which the Commission determines has resulted or will probably result in substantial damages to persons offsite or property offsite. 42 U.S.C.S. § 2014(j).

In order to make the determination, the NRC evaluates the following two criteria, which are found at 10 C.F.R. §§ 140.84 and 140.85:

1. Whether there has been a substantial discharge or dispersal of radioactive material offsite, or whether there is a substantial level of radiation offsite (Criterion I); and
2. Whether the event has resulted or will probably result in substantial damages to persons offsite or property offsite (Criterion II).

To assist in the determination, Criterion I lists dose levels, which were developed in 1966, and Criterion II lists specific physical injuries and damages. If the NRC finds that both criteria are met, it is to declare the nuclear incident an ENO, requiring all parties insured or indemnified under the PAA to waive defenses relating to the fault of the defendants, charitable or governmental immunity, and the statute of limitations.

The concept of an ENO presents a major obstacle in achieving the goal of fully compensating individuals injured as a result of a nuclear incident because of the problems associated with applying the criteria, as can be seen from the Three Mile Island experience. Criterion I was not met, the NRC later suggested, because the radiation dose levels are too high for today's standards. Criterion II was not met, because it proved to be too difficult to evaluate. Criterion II is met if either certain physical injuries are found OR if any one of the following is found:

\$2,500,000 or more damage offsite has been or will probably be sustained by any one person, or \$5,000,000 or more of such damage in the aggregate has been or will probably be sustained, as the result of such event; or \$5,000 or more of such damage will be sustained by each of 50 or more persons, provided that \$1,000,000 or more of such damage in the aggregate has been or will probably be sustained, as the result of such event.

Despite the fact that at least \$29,000,000 in damages was eventually paid, the NRC was unable to assess the property damage to find that the conditions for Criterion II had been met. Yet, the NRC has not amended its ENO regulations to correct this problem.

By establishing a standard of strict liability for Class I incidents, as recommended in the Preferred Transportation System report, both of these problems would be eliminated, and Congress would take a major step towards ensuring the full compensation of victims.

Scope of Liability

Under the PAA, the scope of liability is defined by the terms "public liability" and "nuclear incident." Public liability is, with some exceptions, "any legal liability arising out of, or resulting from, a nuclear incident or precautionary evacuation (including all reasonable additional costs incurred by a state, or a political subdivision of a state, in the course of responding to a nuclear incident or a precautionary evacuation)." 42 U.S.C.S. § 2014(w).

A nuclear incident, however, must occur at certain licensed facilities or contractor-operated facilities or occur during the course of transportation to or from certain facilities. See 42 U.S.C.S. § 2014(q). If an incident occurs outside of these parameters, it will not fall within the purview of the PAA scope of liability. There will be no public liability for an incident resulting from sabotage or terrorism, for example.

Congress should remedy this problem, as described in the preferred system, by mandating compensation for all damages resulting from a radiological incident or accident. This should include radiological incidents or accidents arising out of sabotage, terrorism, diversion of shipments and the negligence of federal government employees. To avoid unintentionally eliminating activities that may cause damages, Congress' statement of purpose should enunciate its intent to be broad, all-encompassing and that examples provided are by way of illustration, not limitation.

Statute of Limitation

Under the PAA, a plaintiff will have only twenty years from the date of the nuclear incident within which to initiate a lawsuit. Under the preferred system, the statute of limitations will not begin to run until the injury manifests itself and its cause is known or should have been known. The preferred system recognizes that radiation injuries may be latent for many, many years.

Proof of Causation

The PAA does not address the problems facing a plaintiff in proving a radiation injury. The preferred system recognized the problem and states that it should be addressed. No solution is offered at this time, as this is a cutting-edge issue and should be closely monitored.

Compensation Fund

Under the PAA, large nuclear power plants--those with a capacity of more than 100 megawatts of electricity--are required to provide financial protection in an amount equal to the maximum amount of insurance commercially available, which is currently \$160 million. Every utility meets this requirement by purchasing insurance at an average rate, in 1984, of \$425,000 per plant. However, under the Industry Credit Rating Plan, the utilities receive refunds. About seventy percent of each year's premium is designated for payment of losses and loss-related expenses.

At the end of ten years, any money remaining in this fund is returned to the utilities. For the years 1957 through 1971, the utilities paid about \$33 million in premium and were refunded about \$18.4 million, or approximately 56 percent. The current system creates incentives for the utilities to balk at and fight every claim--legitimate or not. For every claim not paid, a refund is made.

The Preferred Transportation System, to avoid these problems, calls for the establishment of a compensation fund that would continue to grow, from which there are no refunds. The fund would be generated from fees on activities that create radioactive waste, which would involve more than large

nuclear reactors. Using the above figures, for example, the compensation fund, at the end of 1971, would have contained at least \$33 million and would have continued to grow rather than to decrease. There would not, therefore, be a limit of \$160 million of readily-available funds to pay claims. Assuming that each of the 112 nuclear power plants currently operating paid the average premium during the last four years, the fund would have already contained another \$190,400,000.

In the event the damages from an incident exceed the money available in the fund, the NRC should assess a retroactive premium. However, the Preferred Transportation System requires the utilities to be responsible for all damages; liability would not be limited.

The Preferred Transportation System report also calls for a mechanism by which claims will be paid in a speedy fashion. A claims' system should be established whereby all undisputed claims are paid within a short, stated time-frame. Living and medical expenses may fall within these claims. An arbitration system should be established for those claimants wishing to take advantage of it, but a claimant should not be deprived of his right to a jury trial, if he wishes one.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify gaps/risk reduction opportunities in federal law and regulations	None known	14 (1989)
Enact statutory changes	None known	11 (1992)
Promulgate regulations	None known	9 (1994)

The failure by the DOE to review and remedy gaps in the federal regulatory structure creates uncertainty and policy/political concerns for state, Tribal and local governments attempting to plan for nuclear waste shipments through their jurisdictions.

1.7 EMERGENCY PREPAREDNESS

To be provided under separate cover.

2.0 TRANSPORTATION SYSTEM DESIGN

This portion of the report evaluates the design elements of the DOE's planned transportation system.

2.1 VOLUMES AND TIMING OF SHIPMENTS

The DOE has not conducted the type of analysis described in section 2.1 of the Preferred Transportation System report to determine:

- o The timing of shipments that minimizes the transportation impacts on state, Tribal and local governments along the transportation routes.
- o The impacts resulting from alternative volumes of waste shipments.
- o The length of waste storage prior to transportation to a repository that minimizes the radiological risk in transportation.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Assess optimal decay time prior to repository shipment	None known	17 (1986)
Assess alternative shipment scenarios	None known	15 (1988)
Select tentative shipment scenario	10 (1993)	13 (1990)
Finalize shipment scenario	1 (2002)	8 (1995)

The DOE's failure to adequately assess the timing of shipments to the repository at Yucca Mountain (and an MRS, if one is developed) does not ensure that the radiological risks from the nuclear waste transportation program will be minimized.

2.2 CASK DESIGN AND TESTING

The DOE cask design and testing program is deficient with respect to the Preferred Transportation System in four basic areas:

The DOE program does not call for any enhancement of the regulatory test standards, design methodologies or testing methods; it accepts the status quo as sufficient for qualifying a cask design and meeting public demands for safety.

The DOE program does not seek design improvements to address human error in manufacturing and/or handling.

The DOE program does not provide any process to track fuel assemblies or cask/vehicle utilization or problems.

The DOE program does not consider involvement of non-federal personnel (except contractors) in overseeing any aspect of fuel or cask handling or transportation.

The DOE cask design and testing program does address some of the elements in the Preferred Transportation System in a general or vague manner:

"Contamination control" is mentioned, but the cask design shown in the EA reveals no equipment to keep the cask free of radiation contamination, despite its (probably) porous surface.

Inspection during manufacture is suggested, but there is no indication that the inspectors will follow procedures that go beyond today's typical examination of the cask's "paper trail."

Finally, the DOE has specified the field offices that will be used for cask and transportation activities but fails to discuss the staffing, experience or track record of these offices.

In essence, the DOE transportation system suffers from ignorance of the deficiencies in the present methods used to design, certify, test and maintain casks.

Analytical Methods

The DOE cask design and testing program does not address the analytical methods (e.g. computer models) used to design casks. It leaves the choices up to the contractors, and their acceptability up to the NRC (when the design is confronted by the certification process). The Preferred Transportation System report suggests a uniform minimum level of detail in simulations and improved methods that answer various criticisms (many of them originating from within the NRC and the DOE). The DOE is in an especially poor position to judge the

suitability of a contractor's design abilities: virtually all the DOE-certified spent fuel casks in use over the past three years had to be withdrawn due to open safety questions related to their designs. The DOE field offices had used private contractors (or their own laboratories) to produce the designs.

ALARA

While it is admirable that the DOE plans to employ the as low as reasonably achievable (ALARA) principle in developing cask design and handling procedures (as does the Preferred Transportation System), there are two significant differences with the Preferred Transportation System:

The DOE does not call for adoption of this principle in regulations, thereby assuming voluntary compliance that has no force of law if violated.

The Preferred Transportation System applies ALARA to all those affected by spent fuel transport (including the public), but the DOE applies it only to cask handlers; implicit in the Preferred Transportation System's approach are efforts to mitigate a radiation release (such as through fuel cleaning or canning) due to an accident or human failure.

Simplify Cask Designs

The DOE does not acknowledge the need to "goof-proof" and simplify the cask design to eliminate opportunities for human error. This effort is a cornerstone of the Preferred Transportation System and will not create a significant difference in design or production cost.

Adequacy of Testing Standards

The DOE accepts present cask testing standards, despite the fact that several government-sponsored studies have indicated that in a serious accident such stresses could be exceeded. Similarly, the DOE states that "confirmatory tests" (apparently large or full-scale tests) will be done by Sandia Laboratories, an agency that has been criticized for its crash testing and its efforts to simulate cask sabotage. The Preferred Transportation System report recommends an independent laboratory (such as Underwriters' Laboratories or the Insurance Institute for Highway Safety) to review present standards relative to real accident stresses, and to perform full-scale tests that also simulate possible cask flaws caused by human error. Finally, the DOE fails to address the need for stress tests on the spent fuel after irradiation and extended storage, an open item mentioned in a recent NRC study, and covered in the Preferred Transportation System report.

Fuel Assembly/Cask Database

While the Preferred Transportation System calls for inspector certification of each cask and monitoring of each cask through manufacture and use, the DOE plan has no means to individually track the 200 (or more) containers that will be produced under its auspices. In the past, record-keeping has sometimes been quite poor allowing undocumented casks to remain in use. Generic cask problems must be traceable in order to be corrected, and the Preferred Transportation System would mandate such a method independent of the fabrication contractor.

Integrate Vehicle and Cask

The DOE is making no attempt to integrate the cask and its vehicle. Integration of the vehicle with the cask allows easy addition of safety features (such as a fire suppression system) that could reduce cask and vehicle damage, thereby "insuring" the equipment at a very low cost. The DOE's plan seems to assume that minor accidents would not do much damage and major ones will destroy the vehicle. There is, however, a spectrum of real accidents between those extremes that is ignored by the DOE. The Preferred Transportation System seeks to design the vehicle/cask unit to survive those accidents and allow it to quickly return to duty.

QA/QC

While the DOE pays some attention to quality assurance in manufacturing (even stating that it will maintain a supervisory presence independent of the DOE's own QA efforts), it does not indicate how its oversight would differ from the present system of merely following the "paper trail" of documentation. The DOE maintained a supposedly continuous presence during the 1985 manufacture of the two casks used to ship wastes from the Three Mile Island reactor, yet serious welding and materials questions still arose due to the process of examining documentation instead of hardware. The Preferred Transportation System recommends a more direct approach, with inspectors on the assembly lines instead of at the filing cabinets.

Independent Watchdog Agency

The DOE's planned use of its own laboratories and private contractors to monitor cask testing and fabrication differs from the Preferred Transportation System's employment of independent "watchdog" agencies trained and oriented to finding problems. Experience with the DOE casks has shown that the DOE laboratories and field offices have not been sufficiently diligent in "watching their own store," and cask design contractors have too often given their client (i.e. the DOE) support for its position instead of constructive criticism. The case of the MH-1A cask (withdrawn in 1985) showed that the DOE's orientation was more toward keeping the casks on the road, despite safety question, than on rectifying their problems.

It is likely that many of the same DOE transportation management personnel who participated in the DOE's past container difficulties will end up supervising the DOE's transport office--unless that option is avoided through the Preferred Transportation System's use of non-DOE personnel to fulfill the role of inspectors-general. Even if all inspections were to be done by the NRC personnel, there would still be a need for a drastic increase in available staff: the NRC presently has only half a dozen nuclear waste shipping inspectors in the field. Despite any positive statements from the DOE regarding cooperation with and support for state inspection personnel, the DOE has refused to pay state-levied user fees and has challenged state fee systems.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Assess adequacy of cask design and testing standards	None known	17 (1986)
Develop revised cask design and testing standards, if necessary	None known	15 (1988)
Develop cask QA/QC program	Unknown	14 (1989)
Develop appropriate design analysis tools	None known	14 (1989)
Design casks	13 (1990)	13 (1990)
Design & implement cask data base	None known	11 (1992)
Submit for NRC certification	12 (1991)	11 (1992)
Fabricate prototype	10 (1993)	10 (1993)
Perform full-scale testing	6 (1997)	9 (1994)

The DOE time schedule for cask development does not seem unreasonable, except that it does not include all of the steps recommended in the Preferred Transportation System.

2.3 MODAL MIX, RAIL AND TRUCK SHIPMENT OPTIONS

Modal Mix

The DOE position that any modal mix is "safe" ignores the reality that the various transportation modes present vastly different levels of overall risk, different profiles of accident rate versus consequence and different geographical risk distributions, as described in section 2.3 of the Preferred Transportation System report. There is no evidence that the DOE plans to make modal mix decisions in the systematic way recommended in the Preferred Transportation System. The DOE approach also does not appear to consider the trade-offs involved in the use of a single mode versus multiple modes.

Truck Shipment Options

The DOE approach to the evaluation of the various truck shipment options does not appear to be based upon a comprehensive analysis of the risks of the options (single trailers, multiple trailers and convoys) as described in section 2.3 of the Preferred Transportation System report.

The evaluation of the potential use of overweight truck shipments, as approached by the DOE, does not appear to be based upon a comprehensive analysis of the risks of a larger number of smaller shipments versus a fewer number of larger shipments. In fact, the DOE has indicated they want shipment casks to be considered to be nondivisible loads, which would allow them to obtain overweight permits from the states.

By attempting to use a legal loophole to ship larger amounts of waste, rather than assessing the risks involved in overweight truck shipments, the DOE is avoiding cooperation with states and is potentially risking public health and safety.

Rail Shipment Options

The DOE approach to the evaluation of the various rail shipment options does not appear to be based upon a comprehensive analysis of the risks of the options (regular, dedicated and special train service) as described in section 2.3 of the Preferred Transportation System report. The DOE appears to have prematurely ruled out the use of special trains as not being necessary for safety. The DOE seems to assume that the use of "hefty" rail (casks up to 150 tons on special rail cars) poses no problems without providing the evidentiary basis for such a conclusion.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Develop modal mix assessment factors	None known	17 (1986)
Conduct technical assessment of truck shipment options	Unknown	15 (1988)
Conduct technical assessment of rail shipment options	8 (1995)	15 (1988)
Conduct technical assessment of the comparative risks of highway and rail reactor access, weather sensitivity of modes, security and safeguards	None known	14 (1989)
Select tentative modal mix	4 (1999)	13 (1990)
Finalize modal mix	0 (2003)	8 (1995)

The DOE schedule does not provide state, Tribal and local governments sufficient lead time to prepare for the waste shipments and will preclude effective planning on modal mix.

2.4 ROUTING

Highway

The intention of the DOE to rely on the DOT's routing regulation demonstrates the DOE's lack of understanding of the importance of routing decisions in determining the risk from the nuclear waste transportation system. By doing so, the DOE is also abdicating a critical federal responsibility to a contractor, because under the DOT's regulation, the carrier selects the route. However, the carrier's overwhelming priority is to minimize costs, not to maximize risks from the entire transportation system. Moreover, the DOE's reliance on the DOT's routing regulation will force state, Tribal and local governments to maintain emergency response capabilities along the entire interstate system.

The DOT's routing regulation, designating the interstate system as preferred routes, is based on two premises: the interstate system has a lower accident rate than other roads and the interstate system will reduce transit times. The DOT's routing regulation, which may be sufficient for intermittent shipments of highway route-controlled quantities of radioactive materials, is fundamentally different than the risk-based routing described in section 2.4 of the Preferred Transportation System.

Rail

The DOE's plan not to develop risk-based rail routes for nuclear waste shipments to a repository at Yucca Mountain (and an MRS, if one is developed), as recommended in section 2.4 of the Preferred Transportation System report, results in the same problems as discussed in the highway routing section, above. In addition, since there currently are no federal rail routing regulations, rail carriers are legally permitted to use any rail trackage in the country regardless of its condition.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Develop routing criteria	8 (1999)	19 (1984)
Develop route-specific analysis capability	11 (1992)	17 (1986)
Analyze alternative routes	10 (1993)	15 (1988)

Select tentative route(s)	None known	13 (1990)
Finalize route selection	None known	8 (1995)

The DOE schedule to complete highway and rail route selection criteria in 1995 does not provide sufficient time for state, Tribal and local governments to adequately plan for the waste shipments.

2.5 EQUIPMENT AND VEHICLE STANDARDS

The DOE is not known to have conducted a comprehensive analysis of alternative equipment and vehicle standards to improve the safety of nuclear waste shipments as described in section 2.5 of the Preferred Transportation System report.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify potential vehicle/ equipment improvements	None known	19 (1984)
Conduct technical studies of potential vehicle/equipment improvements	None known	17 (1986)
Conduct comprehensive assessment of overweight highway and "hefty" rail shipments	10 (1995)	17 (1986)
Develop vehicle/equipment standards including new placarding system	None known	16 (1987)
Develop tentative vehicle/ equipment designs	None known	13 (1990)
Finalize vehicle/equipment designs	None known	8 (1995)

The failure of the DOE to have issued a schedule for decisions on equipment and vehicle standards creates an uncertainty which inhibits state, Tribal and local governments from adequately planning for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

2.6 INFRASTRUCTURE

The DOE apparently does not intend to make a careful evaluation of the existing road and rail network to ascertain the infrastructure impacts of the nuclear waste transportation program. The DOE approach to the consideration of infrastructure impacts contains numerous assumptions and inaccuracies which must be questioned. The DOE position of reviewing specific needs on a "case-by-case" basis provides no assurance that the DOE will actively participate in rectifying infrastructure problems resulting from the activities associated with the repository.

The DOE has defined infrastructure to be only national transportation facilities. This is a narrow definition, and it should be broadened to include other facilities which could be affected by the development of the repository, either due to its construction and operation, or development which will be needed to accommodate personnel and families. A broader definition should include such elements as local and regional roads and streets, and ancillary facilities which will be needed for the nuclear waste transportation system (e.g. safe parking areas).

The DOE does not appear to be addressing infrastructure impacts and needs in the comprehensive and systematic fashion recommended in section 2.6 of the Preferred Transportation System report. The essential components of the preferred approach to infrastructure consists of the following:

- o Development of economic assessment model.
- o Assessment of the need for new facilities (e.g. highway bypass, rail spur).
- o Highway network:
 - Traffic impact assessment
 - Consideration of reconstruction, rehabilitation and maintenance
 - Development of pavement performance models
 - Assessment of bridge conditions
 - Assessment of bridge strengthening needs
- o Rail network:
 - Damage, condition, construction and maintenance assessment
 - Assessment of the need for special facilities

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Develop criteria for infra- structure decision-making	None known	19 (1984)
Assess infrastructure condition and utilization along potential routes	10 (1993)	17 (1986)
Develop pavement performance models	None known	15 (1988)
Develop economic assessment models	None known	15 (1988)
Assess infrastructure impacts	10 (1993)	13 (1990)
Identify infrastructure improvements/new construction needs	8 (1995)	13 (1990)
Develop institutional mechanism for funding and implementation	None known	12 (1991)
Begin implementation	None known	11 (1992)

The DOE schedule calling for a statement on the extent of infrastructure improvements required for transportation to the repository at Yucca Mountain in 1995 does not provide sufficient lead time for the infrastructure improvements to be in-place when waste shipments are scheduled to commence.

2.7 DEFENSE WASTE

Although the DOE contends that all defense waste transportation issues have been resolved, there are a number of critical uncertainties of concern to state, Tribal and local governments. These concerns are discussed in some detail in section 2.7 of the Preferred Transportation System report and are summarized below.

The DOE has been inconsistent as to whether defense waste shipments will be classified for national security. The Preferred Transportation system report recommends that defense waste shipments should be subject to all of the same (identical, not "equivalent") requirements as civilian shipments.

Adequate details have not been provided by the DOE on the quantities, characteristics and timing of defense waste shipments from each of the DOE facilities where the wastes are currently stored. Such information is needed to allow state, Tribal and local governments to plan for defense waste shipments through their jurisdictions.

The DOE plans that no adjustments will be needed in the existing regulatory structure due to defense shipments. The DOE should clarify what the existing regulatory structure is, first of all, and then should assess whether or not regulatory modifications will be needed.

Current plans of the DOE call for determination of the need for special defense waste casks to be made in 2000. For effective joint planning and co-operation regarding cask designs between the DOE and other interested parties, this process should already be underway.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify characteristics and quantities of defense waste by origin	4 (1999)	21 (1982)
Clarify applicable regulatory structure	None known	19 (1984)
Modify federal laws and regulations, if needed	None known	17 (1986)
Assess need for special defense waste cask(s)	3 (2000)	17 (1986)

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Develop revised cask design and testing standards, if necessary	-1 (2004)	15 (1988)
Design casks	Unknown	13 (1990)
Submit for NRC certification	Unknown	11 (1992)
Fabricate prototype	Unknown	10 (1993)
Perform full-scale testing	Unknown	9 (1994)

The DOE's failure to provide sufficiently detailed information on defense waste shipments creates uncertainty which inhibits state, Tribal and local governments from adequately planning for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.0 TRANSPORTATION SYSTEM OPERATIONAL PROCEDURES

This section of the report evaluates the operational procedure elements of the DOE's planned transportation system.

3.1 OPERATIONS PLANNING

There is no indication that the DOE is preparing a comprehensive operations plan as described in section 3.1 of the Preferred Transportation System. Following is a summary of the elements (subplans) recommended in the Preferred Transportation System:

- o Technical information system plan.
- o Facility and vehicle operational readiness plan.
- o Maintenance and inspection plan.
- o Training plan.
- o Transportation plan.
- o Supervision plan.
- o Higher supervision services plan.
- o Independent audits and appraisals plans.

In addition to these subplans, the preferred operations planning approach should include the following control factors:

- o Policy.
- o Methods, criteria and analyses.
- o Line responsibility.
- o Staff responsibility.
- o Budgets.
- o Document control.
- o Hazard analysis and risk assessment.
- o Life cycle analysis.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Develop strategic and tactical program plans	Unknown	17 (1986)
Identify elements of operations plan and operations planning framework	Unknown	15 (1988)
Develop tentative operations plan including management control factors and specific control factors	10 (1993)	13 (1990)
Draft operations procedural manual	8 (1995)	8 (1995)

The DOE's failure to address operational procedure issues early in the nuclear waste transportation shipment planning process creates uncertainty and inhibits state, Tribal and local governments from adequately planning for nuclear waste shipments through their jurisdictions.

3.2 DOE CARRIER REQUIREMENTS

The DOE has not proposed any contracting or screening process for carriers other than what is required by the federal acquisition regulations. This approach does not satisfy the recommendations in section 3.2 of the Preferred Transportation System report. Experience with the contract issued to the carrier for the transuranic waste shipments to the Waste Isolation Plant in Carlsbad, New Mexico, provides an indication of how carriers will be selected for shipments to a repository (or an MRS, if one is developed). In its request for proposals, the DOE listed hazardous materials hauling experience as a criterion; the contract was awarded to a company that had no experience hauling hazardous materials.

The DOE, with the assistance of state, Tribal and local governments, should identify the criteria and the basis for the criteria that the DOE will use in selecting one or more carriers. To ensure the DOE's compliance with the criteria, interested parties should be permitted to observe the selection process.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify carrier requirements issues	None known	15 (1988)
Conduct technical studies on carrier requirements issues	Unknown	13 (1990)
Develop tentative carrier requirements	Unknown	11 (1992)
Develop carrier screening process	Unknown	11 (1992)
Develop carrier selection criteria	Unknown	8 (1995)
Finalize carrier requirements	4 (1999)	5 (1998)

It is not known if the DOE schedule for decisions on carrier requirements provides adequate time for state, Tribal and local governments to properly plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.3 PERSONNEL TRAINING AND QUALIFICATIONS

The DOE has not made decisions on personnel training and qualifications programs for the nuclear waste transportation program. It is not known whether the DOE will impose driver or railroad engineer training or qualifications in addition to those currently required under federal regulations.

Although driver qualifications are specifically governed by the Commercial Vehicle Safety Act, 49 U.S.C. Appx. 2701, et seq. (Cum. Supp. 1987), neither this Act nor the regulations promulgated thereunder specifically addressed the issue of drivers transporting nuclear waste. Although the DOT's regulations require written training for drivers of highway route-controlled quantities of radioactive materials, the regulation, found at 49 C.F.R. § 177.825 (d) is woefully inadequate.

Following is a summary of the personnel training and qualifications (in addition to those currently required by federal regulations) recommended in section 3.3 of the Preferred Transportation System report.

- o Qualification of drivers, including minimum driving (time and mileage) experience.
- o Pass written examinations on the Federal Motor Carrier Safety Regulations and nuclear waste transportation.
- o Disqualification of drivers for specified accidents, substance abuse or criminal activity.
- o Background checks on applicants.
- o Medical examinations, including random tests for substance abuse.

While the DOT's regulation may be inadequate for truck drivers, it is entirely nonexistent for railroad personnel. There should be minimum national, uniform standards for the training of railroad personnel who will be involved with the transportation of nuclear waste.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify personnel training and qualifications needs	None known	18 (1995)
Conduct technical studies on personnel training issues	None known	17 (1986)

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Define training standards	10 (1993)	15 (1988)
Revise federal motor carrier regulations concerning qualifications of drivers, disqualification of drivers, application for employment, motor carrier investigations, written examinations and medical examinations	None known	13 (1990)
Develop personnel training program	None known	13 (1990)
Begin training program	3 (2000)	5 (1998)

It is expected that the DOE schedule for decisions on personnel training and qualifications may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.4 CASK MAINTENANCE

The DOE plans for cask maintenance do not address a number of the recommendations contained in section 3.4 of the Preferred Transportation System report.

The DOE plans for cask maintenance do not address cleaning spent fuel prior to loading it into a cask as a means to avoid internal cask contamination and reduce the contaminant level in the spent fuel pool (thereby avoiding external contamination when the cask is immersed in the pool).

While the Preferred Transportation System tracks fuel assemblies and casks by a computerized database in order to monitor problems with either, the DOE plan shows no awareness that casks can have repeated maintenance difficulties, or that some production runs of fuel have shared common failures.

The DOE is not planning for repair facilities or parts depots beyond those which may exist at the reactors, the repository (and the MRS, if one is developed). If the number of out-of-service casks is to be minimized and the highest level of safety maintained, the enroute maintenance facility and its centrally located parts depot(s) suggested for the Preferred Transportation System will be essential.

The DOE system provides no inspection facilities for casks or vehicles except at the end of the shipments (when it is either unlikely to find a problem affected by motion or too late to avoid its effect), nor does it have a way for inspectors to take enforcement action without creating a local hazard due to vehicle stoppage.

The Preferred Transportation System calls for mobile facilities to spot check equipment in transit, and impoundment facilities (which could double as a maintenance garage housing spare vehicles) to hold defective equipment until repaired. Such facilities would allow careful documentation of problems, leading to better enforcement and a clear basis for design or procedural improvements.

As indicated regarding the cask design, the DOE system makes no effort to incorporate design measures that would limit or eliminate human errors in maintenance.

Finally, while the DOE indicates that it may hire independent contractors to oversee its maintenance firm, it is unclear how either group will perform more than spot checks, since the lack of a central maintenance facility will require that most the the work continue to be done at the nuclear power reactors. The Preferred Transportation System addresses cask repair with personnel answering to an agency other than the DOE, and operating at facilities in addition to the reactors and the repository.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Develop cask transponders	None known	13 (1990)
Identify required fixed and mobile cask maintenance plans	8 (1995)	13 (1990)
Conduct technical studies on cask maintenance requirements	Unknown	11 (1992)
Develop cask maintenance QA/QC program	Unknown	11 (1992)
Develop cask maintenance database	None known	4 (1999)

It is expected that the DOE schedule to make decisions on cask maintenance in 1997 may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.5 VEHICLE MAINTENANCE

To date, the DOE has not released any specifics on its intentions regarding vehicle maintenance. It does not appear that the DOE is systemically and comprehensively planning for vehicle maintenance as recommended in section 3.5 of the Preferred Transportation System report. The Preferred Transportation System recommends that, at a minimum, the nuclear waste transportation system address the following vehicle maintenance issues.

- o Frequency of regular servicing.
- o Performance of heavy maintenance.
- o Coordination of maintenance activities.
- o Field breakdown procedures.
- o Correction of minor malfunctions.
- o Responsibility for field service contracts.
- o Ownership of vehicles by the shipper or transporter.
- o Resolution of conflicts in carrier maintenance schedules.
- o Secured stopping areas.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify vehicle stoppage issues	Unknown	19 (1984)
Conduct technical studies including trade-offs between consistent v. randomized stops	Unknown	17 (1986)
Identify route-specific vehicle stoppage needs	None known	15 (1998)
Develop route-specific vehicle stoppage plan for planned and emergency stops	8 (1995)	13 (1990)
Construct necessary facilities	None known	3 (2000)

The DOE schedule to define general operational procedures (presumably including vehicle maintenance plans) by 1995 may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.6 VEHICLE STOPPAGE

The DOE has not decided to develop any requirements or restrictions on vehicle stoppage. Currently, federal regulations do not govern the stoppage of vehicles transporting nuclear waste to a repository (or an MRS, if one is developed). Thus, the DOE plan (or rather the absence of a plan) for vehicle stoppage is totally deficient with respect to the Preferred Transportation System.

Section 3.4 of the Preferred Transportation System report recommends that, at a minimum, the vehicle stoppage plan address:

- o Protection of the vehicle (truck or train) and the crew during stops.
- o Minimization of the length of stops.
- o Selection of the safest locations possible (e.g. truck stops, military bases, rail yards, interchange locations).
- o Ensurance that stoppage restrictions do not interfere with crew performance (e.g. too much time in the cab or locomotive between rest periods).
- o Protection of stopped vehicles from sabotage/terrorism/interference.
- o Limitation of the radiation exposure during stops.
- o Management of unplanned stops.
- o Preparation for inclement weather conditions.
- o Avoidance of interaction with other dangerous goods shipments.
- o Trade-offs consistent versus randomized planned stops.
- o Selection of when and where the planned stops should occur (based on the reason for and timing of each stop).
- o Preparation for vehicle's arrival at stopping areas.
- o Determination of who should decide where planned stoppages occur and the procedure for unplanned stoppages: the DOE, carriers, state, Tribal or local governments.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify vehicle stoppage issues	Unknown	19 (1984)
Conduct technical studies including trade-offs between consistent v. randomized stops	Unknown	17 (1986)
Identify route-specific vehicle stoppage needs	None known	15 (1988)
Develop route-specific vehicle stoppage plan for planned and emergency stops	8 (1995)	13 (1990)
Construct necessary facilities	None known	3 (2000)

The DOE schedule to define general operational procedures (presumably including vehicle vehicle stoppage) by 1995 may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.7 SHIPMENT MONITORING AND PRENOTIFICATION

Shipment Monitoring

The TRANSCOM satellite tracking system being developed by the DOE Office of Defense Programs appears to provide the technical capability to provide state, Tribal and local governments with the needed information. It is not known if or how the DOE plans to address the institutional and regulatory issues regarding the use of such a system as described in section 3.7 of the Preferred Transportation System report. To date, the DOE has not decided whether to use this system for nuclear waste shipments to a repository (or to an MRS, if one is developed).

Prenotification

It is not known if or how the DOE plans to evaluate potential improvements to the current requirements in federal regulations for providing prenotification of shipments to a repository (or an MRS, if one is developed). The current prenotification requirements are clearly not optimum for state, Tribal and local governments in Nevada, given the expected frequency of shipments to the Yucca Mountain repository (or an MRS, if one is developed). It is not known if the DOE or the NRC plan to conduct the type of prenotification assessment recommended in section 3.7 of the Preferred Transportation System report. It is not known whether the DOE will include local governments in the prenotification system.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Assess information needs of state Tribal and local governments	Unknown	15 (1988)
Pilot test TRANSCOM system	14 (1989)	14 (1989)
Assess alternative technologies for providing needed information	None known	11 (1993)
Design shipment monitoring and prenotification system	8 (1995)	10 (1993)
Promulgate implementing regulations	Unknown	9 (1994)

The DOE schedule for decisions on general operational procedures (presumably including shipment prenotification and monitoring) by 1995 creates an uncertainty which inhibits state, Tribal and local governments from adequately planning for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.8 INSPECTION AND ENFORCEMENT

There is no evidence that the DOE is following a systematic approach to vehicle/cask/operator inspection and enforcement as recommended in section 3.8 of the Preferred Transportation System report. The Preferred Transportation System reports that, at a minimum, the following inspection/enforcement issues need to be addressed:

- o Division of inspection responsibilities among the carriers, DOE, the NRC, the DOT, states, Tribal and local governments.
- o Consistency of inspection criteria/procedures.
 - When and how often inspections are conducted.
 - Where the inspections are conducted.
 - What items are inspected and how often.
- o Definition of violations.
- o Imposition of penalties for violations.
- o Determination of enforcement proceedings.

Although states are encouraged to adopt and enforce the Federal Motor Carrier Safety Regulations, 49 C.F.R. Parts 390-399, and the Federal Hazardous Materials Regulations, 49 C.F.R. Parts 107-178, there is no assurance that inspections and enforcement are being conducted in a uniform, consistent manner. The Commercial Vehicle Safety Alliance (CVSA) has approximately 38 member states, many of which have entered into a memorandum of understanding (MOU) delineating the standards by which member states shall inspect vehicles carrying hazardous materials. CVSA, under contract to the DOE, is currently developing analogous standards for shipments of radioactive materials. While such minimum standards are desirable, there are no standards for the training of inspectors, although the DOT does provide a "train the trainer" program for hazardous materials inspectors.

It appears that the DOE is pursuing a strategy of developing uniform national inspection standards to effectively preempt individual states from implementing stringent inspection procedures. While consistency in inspection procedures and standards is a laudable goal, there is concern that uniform national standards may turn out to be a "lowest common denominator" system not adequately protecting public safety.

Although there are general qualifications for state rail inspectors, 49 C.F.R. §§ 212.201-212.227 (1987), there are no training standards. Since states are permitted to adopt more stringent requirements than those adopted by the federal government, Nevada should also develop and adopt standards for training of rail inspectors.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Identify inspection and enforcement issues	Unknown	17 (1986)
Research technical inspection and enforcement issues	None known	15 (1988)
Clarify roles of federal, state, Tribal and local governments	None known	14 (1989)
Develop inspection criteria	8 (1995)	
Develop inspection protocol	Unknown	5 (1998)

The DOE schedule to define general operational procedures (presumably including inspection and enforcement plans) by 1995 may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

3.9 PHYSICAL PROTECTION (SABOTAGE/TERRORISM)

There is no evidence that the DOE is conducting the type of systematic and detailed physical protection planning recommended in section 3.9 of the Preferred Transportation System report. The Preferred Transportation System report recommended that physical protection planning include the following elements:

- o Scenario assessment.
- o Vulnerability analysis.
- o Screening of management options
 - Technical measures
 - Organizational measures
 - Safeguard measures
 - Mitigation measures
 - Political measures
- o Resilience analysis.
 - Redundance
 - Diversity
 - Worst-case mitigation
 - Avoidance of regularities
 - Interactive game/theoretical simulation
- o Decision analysis.
- o Sensitivity analysis.

Although there are reports that the DOE has recently revised its equivalent physical protection plan, no copy is publicly available, and presumably has not been approved by the DOT. Therefore, it is possible only to compare the "equivalent" physical protection plan as approved by the DOT to the NRC requirements. The DOE's "equivalent" plan does not include the following requirements of the NRC regulation:

- o Advance route approval by the NRC.

- o Armed guards in populated areas.
- o Driver/escort call a control center every two hours.
- o Maintenance of a written log.
- o Prenotification of specific shipments to governors or their designees.
- o Plans to avoid intermediate stops.
- o Training for escorts that follows the requirements established in Appendix D to 10 C.F.R. part 73.
- o Procedures for responding to threats of damage to the shipment.

Decision Schedule

DECISION/ACTIVITY (Completion of activity unless otherwise indicated)	DOE TIMELINE/YRS BEFORE REPOSITORY OPERATIONAL	PREFERRED TIMELINE
Analyze the probability of various shipment interference scenarios	None known	19 (1984)
Analyze consequences of worst-case scenarios	None known	19 (1984)
Identify potential physical protection improvements	None known	17 (1986)
Assess trade-offs between physical improvements and other impacts of the transportation system	None known	15 (1988)
Initial design of physical protection system	8 (1995)	13 (1990)
Finalize design of physical protection system	Unknown	8 (1995)
Promulgate regulations	None known	5 (1998)

The DOE schedule to define general operational procedures (presumably including physical protection plans) by 1995 may not provide time for state, Tribal and local governments to adequately plan for the shipment of nuclear waste to a repository (and an MRS, if one is developed).

DRAFT-CATEGORY TWO

TRANSPORTATION NEEDS ASSESSMENT

TASK 15.5 LITERATURE REVIEW

PHASE IIIA YUCCA MOUNTAIN SOCIOECONOMIC PROJECT

MOUNTAIN WEST

DECEMBER 2, 1988

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1.0 CROSSCUTTING ISSUES

The challenge to develop a comprehensive risk assessment and risk management system is formidable in that it requires identification of all types of potential hazards of the proposed waste shipment, estimation of the probabilities and consequences of their occurrence, and development of management strategies to minimize risk. Risk assessment involves estimating the frequencies and consequences of undesirable events, and then evaluating the associated risk in quantitative terms (Glickman 1985). Risk is commonly expressed as a single number, known as the societal risk or expected risk. When adequate information is available, this number can be computed directly from historical data; otherwise, more theoretical approaches to risk estimation are required. The risk measure of interest can vary considerably, but typically risk in hazardous materials transport is expressed in terms of expected property damage, injuries, or fatalities (Abkowitz, List, and Radwan).

Expressing risk in terms of a single number may simplify the tasks of estimation and evaluation, but it does not provide as much information as a risk profile, which is a probability distribution of incident likelihood and consequence (Phillipson, Napadensky, and Maxey 1983). The shape of the risk profile is of particular help in distinguishing between the contribution to the expected risk of high probability/low consequence events and low probability/high consequence events.

Golding et al. 1988 suggests a multistage framework for implementing a risk management program to help guide decision-makers in addressing the major problems attendant on the transportation of nuclear waste. That report identifies the key elements of a preferred methodology for effective risk management that takes into account the scope of the entire transportation system, the full range of alternative methodologies, and the broad spectrum of potential responses to observed and perceived risks. Specific issues include the performance of a comprehensive risk assessment, development of on-going risk communication and public participation programs, identification and implementation of hazard control options, and the evaluation of the efficacy of risk management efforts.

Risk estimation is characterized by a sequential process, beginning with understanding the level of exposure such as the number of shipments or tonnage carried; the frequency and type of incident occurrence (e.g., tank truck rollover, loose fitting, etc.), and the consequence for a given incident such as property damage, latent cancers, etc.

The manner in which these components are defined and measured depends on the data available, the purpose of the risk assessment, and the preferences of the risk analyst.

Substantial literature exists for the assessment of specific types of risks (such as the potential compromise of cask integrity) in the transportation of spent fuel and other high-level radioactive wastes. However, few studies have attempted comprehensive risk assessments or developed integrated risk-management approaches to the transportation system. A detailed review of existing conceptual approaches to risk estimation reveals that most transportation studies have utilized whatever historical data is available without concern for the quality of the data, its uncertainties and biases (Abkowitz and Cheng). Many studies have resorted to the use of statistical inference for the sake of convenience. There have been problems with the representation of incident consequence and severity with strong reliance on empirical data from fault trees and Poisson models to establish event probabilities. The preferred approach to risk assessment and management is a comprehensive approach (Figure 1). This review focuses on the key literature and data that contribute to the identification and development of a comprehensive risk-management system for the transportation of spent fuel.

1.1 RISK MANAGEMENT

Effective and reliable risk management requires detailed information about the actual operating conditions of the transport system and about the implementation of institutional and regulatory structures that affect reliability and safety in such a dynamic and complex system. In particular, important issues of institutional structure, quality assurance, and data analysis call for careful consideration. Several previous studies have reviewed integrative approaches that combine risk assessment and risk management in a comprehensive way (National Research Council 1983; Ruckelshaus 1983, 1984; Kates, Hohenemser, and Kasperson 1985; Covello and Abernathy 1984; Kasperson and Kates 1984). Although some of these writings (e.g., National Research Council 1983, Ruckelshaus 1983, 1984) argue for a separation of risk assessment and risk management--in effect, a division of science and policy--none fails to acknowledge the inextricable linkages that blur clear distinction.

Figure 1. COMPREHENSIVE APPROACH TO RISK ASSESSMENT AND MANAGEMENT

1.1.1 Risk Perception

Within the context of risk analysis, the attempt to understand how various publics evaluate and judge the risks of technology has commanded much of the total scientific effort. Indicators of this concerted attention appear in literature reviews, in the content of journals and conferences, in the priorities of research agenda.

In his literature review of risk perception, Vincent Covello (1983) listed some 166 scholarly references. An analysis of 59 books on comparative risk analysis revealed that 35 included substantial attention to risk perception (Kasperson and Kates 1984). Even a recent annotated bibliography on risk communication assigns the descriptor "receiver perception" to 25 of its 216 annotations (Diggs 1988). Studies of perception have constituted 20 percent of the articles of Risk Analysis since the topic's inception in 1981. Issues of Risk Abstracts regularly include a major section on "Psychological Aspects". The Society for Risk Analysis devoted its entire second conference to the "analysis of actual versus perceived risks" (Covello, et al. 1983). Funding for risk perception studies has constituted a long-standing priority for the risk analysis program of the National Science Foundation. Mary Douglas (1985, 7-9) points to a flourishing of research in this "subdiscipline" over the past three decades. In short, much knowledge can be brought to bear on the issues involved in the public perceptions of the risks attendant on the transportation of radioactive waste.

Research on public perceptions has yielded several representative findings that are directly applicable to the transportation of radioactive wastes:

- Many members of the public have problems coping with assessing the complexity posed by technological risk, and knowledge is often quite limited. On the other hand, publics tend to know quite well what are the large and small risks and lay people are quite rational in their approach to risk in terms of the understanding they possess (Slovic, Fischhoff, and Lichtenstein 1982).
- Many laypersons are highly concerned over the qualitative attributes of risks--their newness, catastrophic potential, and the extent to which they are imposed (involuntary) rather than accepted or tolerated. These attributes are directly relevant to the transportation of nuclear materials. Thus, measures of such risks will need to be multidimensional rather than simply unidimensional indicators.

- Experts tend to assess risk in formal quantitative terms (probability of events x consequences); whereas lay people take a much broader approach. As a result, formal technical assessments of risk are often poor indicators of public response.
- In their taxonomy of technological controversies, von Winterfeldt and Edwards (1984) found that the most volatile and acrimonious conflicts are those in which public response oscillates between the perception of risk and value conflicts. Debates over nuclear power and radioactive waste invariably fall into this category.
- Currently, efforts under way to develop a general theory of the social amplification of risk, interrelating the technical and social assessment of risk (Kasperson, Renn, Slovic, et al. 1988), suggest that impact statements are incomplete unless they address how risk events interact with social structures and processes.

Indication of public perception of high risk in the handling of nuclear materials, whether for transportation or storage, are apparent in public opinion surveys and polls conducted over the past two decades (National Science Board 1981, 171-173, 346-349; National Research Council 1984, 15-47; Cambridge Reports 1974-1986, Lee, Brown, and Henderson 1984; DOE 1987, 190-191). It is apparent that many publics fear the risks and that radioactive wastes have continually ranked at or near the top of public concerns over technology. Extensive attempts by states and localities to restrict or regulate the transportation of radioactive wastes also suggests these concerns. A review by the U.S. Office of Technology Assessment (OTA 1986) found public concerns about nuclear materials transportation to be a major public policy problem for the deployment of a nuclear waste management system in the United States.

Despite the potential for applying the results of risk-perception research to the issues presented by radioactive waste transportation, empirical studies are few (but see Wynne 1987), and, as a result, substantial knowledge gaps exist. The filling of these gaps will require certain research priorities:

- Survey research to document the specific nature of public attitudes to radioactive waste transportation and the levels of concern as compared with other technological hazards.
- Psychometric studies to indicate how publics deal with probabilities, uncertainties, and differing types of risk consequences.
- Longitudinal research to assess how perceptions and concerns are changing over time in response to new events and information.

- An examination of patterns and dynamics of media coverage of risk events in the transportation of nuclear and other hazardous wastes.
- Case studies documenting patterns of the social amplification of risk that have been associated with prior hazardous events specific to waste transportation, as well as analogous accidents, large and small.

1.1.2 Risk Communication

Risk communication is both a very old and new field of inquiry and planning. Efforts to prepare publics for extreme events of nature (floods, hurricanes, tornadoes, etc.) and to provide health care education have a history extending over decades. Conversely, more recent developments in the assessment and management of natural hazards and technological risks, and especially the apparent limitations of regulatory approaches, have called attention to the need for increased efforts to communicate these risks to those who may need to protect themselves from potential risk events. Bibliographies and overviews of the literature of risk communication (Covello, von Winterfeldt, and Slovic, 1989; Diggs 1988; Hoffman 1988) as well as the first manuals to guide practitioners (Hance et al. 1988) and special issues of journals (Journal of Communication 1987; Science, Technology, and Human Values, La Follette 1987) address this issue.

As yet, there have been few attempts to communicate the risks of radioactive waste transportation to concerned publics. This is not surprising in view of the fact that the public has experienced relatively little past transportation of high-level radioactive waste and, even there, much has involved defense wastes or TMI-related wastes, Brian Wynne (1984, 246) goes so far as to suggest that transportation "is certainly the part of the nuclear fuel cycle which is the most vulnerable to public hostility." Although this may be an overstatement, it is apparent that public concerns over waste transportation will almost certainly be intense; especially in the early stages. Media coverage will be extensive. TMI waste shipments were followed, in some cases, by media-laden helicopters. Even minor mishaps or failures will receive searching scrutiny, and public officials will be called upon to engage in extensive risk communication. Given the highly uncertain nature of the risks and the public fears surrounding nuclear materials and radiation hazards, this will challenge the best of the system's abilities to perform this task without suffering serious losses in credibility.

Preparing for this challenge requires substantial background, research, and planning to overcome the very limited work accomplished thus far. Prominent among these needed efforts, which will build upon the perception research suggested above, would be:

- A needs assessment to define what publics want to know about as well as what experts believe are essential understandings. It should be expected that this needs assessment will address matters of technology and management as well as to the risks involved in transport.
- Effective message design to create appropriate information content. Particular attention should be given to framing effects associated with alternative presentation and packaging of messages. The use of focus groups might assist in the development and evaluation of messages.
- Psychometric studies to define the mental models that publics employ in structuring information and thinking about radioactive waste transportation risks and accidents. Such mental models will help identify key requirements of a risk-communication program.
- Careful examination and delineation of credibility problems in a risk communication effort. It is likely that credibility will be a condition for the success of the communication program.
- Development and field testing of a pilot program built out of the work described above and in the discussion of risk perception.
- A careful and rigorous evaluation program (for example, Kasperson and Palmlund 1987) addressing the various stages of evaluation (formative, process, outcome, impact) and utilizing baseline studies, pre and post-testing, control groups, and careful efforts to deal with confounding variables.

1.1.3 Equity Analysis and Risk Tolerability

Equity is a major social objective in modern industrial societies. Nowhere is this more apparent than in the institutional arrangements surrounding high-level radioactive waste management. Few technological problems pose such difficult equity problems--across generations, among regions of the country, between state and nation, between the host region and the state, and between public and private sector. Radioactive waste transportation compounds these problems because many people across the nation are exposed to the risks of waste transportation without compensating benefits and have little say in the controls and restrictions under which the radioactive waste transportation system works.

Analyzing these equity issues is intrinsically difficult because (1) conceptual frameworks by which to formulate equity relationships are few and underdeveloped,

and (2) equity-relevant information and data either are often not available or are generally not disaggregated so that equity distributions can be empirically established, and (3) agreed-upon theories of social justice to support normative judgments do not exist. In short, methodological shortcomings confound equity analysis, which seldom makes its way into technology assessments and environmental impact analyses (Shrader-Frechette 1985). Thus it is not surprising that relatively few serious efforts to conduct equity analyses of radioactive waste disposal, much less waste transportation, have been undertaken.

Notable exceptions are the analysis of economic issues in intergenerational equity by Kneese et al. (1983) and Ben-David, Kneese, and Schulze (1977), the collection of studies edited by Kasperson (1983), the research of Colglazier and English (forthcoming), and a book by Edith Weiss (forthcoming), which will include a chapter on intergenerational equity. The attempt of the U.S. Department of Energy (DOE 1980) to address equity issues in its generic environmental impact statement was unsuccessful. Meanwhile equity problems have been addressed, but not analyzed in depth, in various treatments of hazardous waste facility siting. Several classic works by philosophers (Rawls 1971; Nozick 1974) and economists (Sen 1970) are often noted, whereas MacLean (1986) and Gibson (1986) brought together useful and relevant general treatments. Some research has addressed the ethical aspects of providing for future generations (Partridge 1981, Sikora and Barry 1978, Routley and Routley 1981). Meanwhile, empirical analyses treating equity issues in radioactive waste management remain scarce. Much remains to be done.

These equity questions will be important in gauging the level of risk tolerability that ought to prevail in radioactive waste transportation. It is now widely recognized that judgments about the tolerability, or acceptability, of risk to support the enactment of regulatory requirements and management choices are difficult. Involved are such issues as:

- The types and probabilities of risks,
- The reducibility of the risks,
- Comparisons with other similar risks,
- The size of associated benefits,

- The distribution of risks, benefits, and management costs, and
- The fairness of outcomes and process.

This subject has commanded an extensive literature; overviews of which abound (see, for example, Council for Science and Society 1977, Fischhoff et al. 1982, Kasperson and Kasperson 1983), that will need to be consulted in determining whether proposed management systems for radioactive waste transportation will prove to be socially acceptable over time.

These crucial questions call for thoughtful research and appraisal. In areas characterized by intermingling of facts and values, studies need not resolve these thorny issues to be valuable for policy making. Rather, the intent should be to clarify (1) the nature of the equity problems, (2) the distribution of risks and social impacts relevant to those problems, (3) the social values that will be at stake, and (4) the burdens and benefits accruing to different groups and generations.

This suggests that useful studies would include:

- Conceptual studies that provide structural frameworks, replete with supporting rationales, for conducting analyses of equity and risk tolerability with supporting rationales.
- Empirical analyses that show in detail the pattern of effects of the overall radioactive waste transportation system as it will operate over the lifetimes of waste disposal upon the nuclear industry, consumers of nuclear electricity, the defense program, communities and persons along transport routes, state and local public services, etc.
- Policy assessments that clarify:
 - o the equity implications of alternative technology, regulatory, and management choices,
 - o provisions of rights and responsibilities that might increase the fairness of decision processes, and
 - o the best means for redressing inequity through alternative system design or compensation.

1.2 RISK ASSESSMENT

A comprehensive probabilistic risk assessment (PRA) requires extensive data on many components of the transport system, including cask integrity under accident conditions,

vehicle performance, accident rates, human-error rates, and estimates of human radiological exposure.

The primary constraints to performing comprehensive risk assessments are due to data unavailability and uncertainty. Table 1 identifies issues relevant to managing the risks of transporting spent fuel. Drawing upon two recent reviews of the use of PRAs for nuclear power reactors (Gallagher et al., 1984, NRC 1984), Table 2 suggests the current state of the art and improvements that are still needed. A recent study evaluated the use of PRAs in the spent fuel disposal system (Hamilton et al. 1986). Another volume (Kasperson and Kasperson 1987) reviews the increased use of risk methodology in five countries. "Nuclear Probabilistic Risk Analysis" is the title of a special issue of Risk Analysis (Vesely 1984).

In the Task 15.2 report, Preferred Transportation System Options, the work of Golding et al. (1988) was used to suggest a systematic classification of the important issues for analysis. Classifications were for "normal" conditions, accident conditions, sabotage, and human error. The following sections review some of the studies focussed on these areas.

1.2.1 Normal Conditions

Under normal operating conditions the risks to workers and the public have been estimated by previous studies as exceedingly small. In 1977, the NRC Office of Standards Development reported its assessment of the risks of transporting all radioactive materials (NRC 1977). The assessment was not restricted to waste shipments. Based on the levels of 1975 shipments, the assessment expected no short-term fatalities, 1.7 genetic effects per year, and 1.2 latent cancer fatalities over 30 years for each year of shipment.

Another report by Sandia National Laboratories (DuCharme et al. 1977) focussed on nuclear waste transportation only, and estimated an average exposure of only 1.4 person-rem per shipment year to populations in urban areas. This estimate was based on levels of waste shipped in 1976, which would have to be increased tenfold to compare with expected shipments to the planned repository. Even then the comparative risk is estimated to be much smaller than that resulting from transport of radioactive materials for medical purposes, which produces an exposure of 685.9 person-rem per shipment year (DuCharme et al. 1977).

TABLE 1

**KEY ISSUES IN THE DECISION OF A COMPREHENSIVE
RISK-MANAGEMENT SYSTEM**

SCOPE

- breadth of the risk assessment
- sequence of transportation to be covered
- alternative cask technologies
- the range of initiating and enabling events
- the spectrum of consequences
- routing assumptions
- transport modal mix assumptions

METHODS

- probabilistic risk analysis
- simulation
- analogous cases
- scenario analyses
- extrapolation from experience
- cost-effectiveness
- consequence modeling
- uncertainty assessment
- sensitivity analysis

RESPONSE

- evaluation
- "acceptable" risk determination and standard-setting
- control strategies
- quality assurance and quality control
- modes of implementation (including regulations, incentives, etc.)
- reevaluation and modification
- risk communication

TABLE 2
STATE OF THE ART OF PROBABILISTIC RISK ASSESSMENT (PRA) OF NUCLEAR REACTORS

<u>Aspect of Probabilistic Risk Assessment</u>	<u>Level of Development</u>	<u>Range of Uncertainty</u>	<u>Improvement Needed</u>
Qualitative systems analysis (logic modeling)			
• internal accident initiators	High confidence in qualitative insights	± Factor of 10	Modeling common cause failures.
• external accident initiators	Medium confidence in qualitative insights	± Factor of (10 to 30)	Modeling common cause failures.
Modeling human performance		± Factor of 10	Errors of mis-diagnosis. Potential recovery actions.
Data base:	Fairly good		Not likely to improve substantially.
• high frequency events	Poor		
• low frequency events			
• internal accident initiators	Fair degree of confidence		
• external accident initiators	Poor degree of confidence		
• equipment and human failure	Needs improvement		
Source terms due to internal reactor phenomena	Poor confidence	Very large	Extensive research; source terms to remain quite large. Stochastic uncertainty.
Consequences, given source terms and meteorology	Reasonably high confidence		
• mean early fatalities		~0 to 5X	
• mean population dose		± Factor of (3 to 4)	
• Latent cancer deaths		± Factor of 10	
Consequences, actual		As a function of location cannot be predicted with such precision	
Actual behavior of affected population in an emergency	Not well understood		
Difference between analysts		Factor of 3	

NOTES:
 High frequency = often observed in plant operations.
 Low frequency = less than once in 100 reactor years.
 X = nominal estimate
 Source: NRC (1984).

The actual exposure risks under normal conditions, however, may not be negligible. Models developed by Sandia National Laboratories estimate risks from "normal" conditions that assume that: 1) casks were manufactured and maintained properly with respect to design standards, and 2) all operations were accomplished without error. In particular, it is assumed that all casks comply with governmental regulations and that warehouse workers, handlers, loaders, and crew members do not make any errors compromising cask integrity (Jefferson 1985, Sandquist et al. 1985). Any modelling based on such assumptions will almost certainly underestimate the risk. Sufficient attention has not yet been given to the various potential quality control problems that might compromise cask integrity. If quality control is poor and the casks are leaky, faulty, mishandled, or otherwise operating below design standards, then the risks will be larger than estimated. In fact, some data show that, due to defective quality control in manufacture, operation, and maintenance, worker exposure during normal conditions in transporting waste has exceeded the allowable standards (Nebraska Energy Office 1987). In addition, these prior studies were conducted for older generations of cask designs.

1.2.2 Accident Conditions

Several risk analyses have calculated the probabilities of likely consequences of transportation accidents. Generally, these suggest that: 1) the risks posed by accidental releases of radiation are extremely small--less, in fact, than those under normal operations; and 2) the nonradiological consequences will almost certainly exceed the radiological consequences (OTA 1986).

Data on accident probabilities for truck and rail transport are generally available and, therefore, estimates of nonradiological risks (based on much more extensive data than estimates of radiological risks) are less prone to statistical bias and uncertainty. Many federal and state databases exist for both rail and truck accidents and for commodity flow rates (Tables 3 and 4). For example, transportation flow data are available from the Department of Transportation (DOT) and other private associations (e.g., the American Association of Railroads). Databases also exist for population census data and for accident and incident statistics. The probabilities of severe truck and rail accidents have been calculated using historical data (Dennis et al. 1978, McClure and Emerson 1980, McClure and Tyron-Hopko 1985). The data analyzed cover a range of accident scenarios (e.g., truck/object, truck/truck, truck/train), accident-related velocities, and fires.

TABLE 3
INCIDENT/ACCIDENT DATABASES

Databases	Kept by	Years	Modes
Hazardous Materials System	DOT, Office of Hazardous Materials Transportation, Research and Special Programs Administration	1971 to present	ALL
Commercial Vessel Casualty	U.S. Coast Guard	1963 to present	Marine
Pollution Incident Reporting System	U.S. Coast Guard	1971 to 1985	All
Truck Accident File	DOT, Bureau of Motor Carrier Safety, Federal Highway Administration	1973 to present	Highway
Railroad Accident File	Association of American Railroads	1973 to present	Rail
Air Accident File	Federal Aviation Administration	--	Air
National Accident Sampling System	National Highway Traffic Safety Administration	1983 (Hazardous materials flags added in 1983)	Highway
Fatal Accident Reporting System	National Highway Traffic Safety Administration	1983 (Hazardous materials flags added in 1983)	Highway
National Response Center	U.S. Coast Guard	--	All
National Transportation Safety Board File	National Transportation Safety Board	--	All
U.S. Department of Energy Data Base	Sandia National Laboratories	1979 to present	All
Washington State Accident File	Washington State Utility and Transportation Commission	1978	Highway

SOURCE: OTA (1986, 73).

TABLE 4

COMMODITY FLOW DATABASES

Databases	Kept by	Years	Modes	Commodity codes	Conversion table	Strengths	Weakness/drawbacks
Federal: Commodity Transportation Survey (CTS)	Bureau of the Census	1977	All	5-digit STCC	Yes	<ul style="list-style-type: none"> • Multimodal • Consistent selection procedure for all sample data points for all modes • Cross checked against the census of manufacturers 	<ul style="list-style-type: none"> • Only 5-digit level of commodities • No hazardous materials flags • Only shipments from manufacturing sites to first destinations • Only "principal" mode is reported
Truck Inventory and Use Survey	Bureau of the Census	1977, 1982	Highway	Simple classes	No	<ul style="list-style-type: none"> • Covers all trucks used in the United States • Contains hazardous materials-related data items • Sample biased toward heavy trucks 	<ul style="list-style-type: none"> • No flow data • Only rudimentary commodity information • Tractor database, not a trailer database--reflects tractor use, not trailer use
Motor Carrier Census	Bureau of Motor Carrier Safety, FHWA	Most recent 5 years	Highway	Hazard classes	No	<ul style="list-style-type: none"> • Comprehensive listing of carriers and truck fleet operators 	<ul style="list-style-type: none"> • No flow data • Mileage and fleet size data are sparse
Radioactive Materials Routing Report	Office of Hazardous Materials Transportation	1982 to present	Highway	Not applicable		<ul style="list-style-type: none"> • Almost complete flow data for highway route controlled quantities of radioactive materials • Gives highway route data 	<ul style="list-style-type: none"> • Data is often not recorded for months after shipment • Material description not always complete
Waybill File	Interstate Commerce Commission	At least past 12 years	Rail, TOFC/COFC	7-digit STCC	Yes	<ul style="list-style-type: none"> • Well-organized sample (1%) of all rail flows • Database is consistent enough to allow trend analyses • Contains some routing information 	<ul style="list-style-type: none"> • Not all hazardous material flows use the special hazardous materials STCC
Waterborne Commodity Statistics	Army Corps of Engineers	At least 12 years	Water, domestic and international	4 digit WCSC code	Only to a limited extent	<ul style="list-style-type: none"> • "100%" sample of all vessel movements • Complete routing information 	<ul style="list-style-type: none"> • Only 163 commodity codes in all, so level of detail is weak • Conversion table has some incorrect cross-references
States: Hazardous Waste Shipment Data	States, for the EPA	Varies	Primarily highway	Either EPA codes of OHMT	No	<ul style="list-style-type: none"> • "100%" sample of all hazardous waste shipments • Actual flow data 	<ul style="list-style-type: none"> • Many States do not computerize the data • No consistency to commodity code usage • No routing information

TABLE 4 (continued)

Databases	Kept by	Years	Modes	Commodity codes	Conversion table	Strengths	Weakness/drawbacks
Private: TRANSEARCH, FREIGHTSCAN, etc.	Consulting firms	Varies	All	Varies, up to 7-digit for rail	Yes	<ul style="list-style-type: none"> • Cross-checked against other production/consumption data • Merging of the best available for each mode 	<ul style="list-style-type: none"> • Truck flows predominantly based on the CIS data (see above)
TRAIN II	Association of American Railroads	Current	Rail, TOFC/COFC	7-digit STCC	Yes	<ul style="list-style-type: none"> • "100%" data on all movements for participating railroads • Routing information 	<ul style="list-style-type: none"> • Not specifically designed to record car movement histories • Not in the public domain
National Motor Truck Data Base	Consulting firms	1977 to present	Highway	Varies up to 7-digit STCC	Yes, where commodity code is provided	<ul style="list-style-type: none"> • Focuses on long-distance highway flows • True flow data • Describes the vehicle used to carry the commodity 	<ul style="list-style-type: none"> • Purposely excludes short-haul truck movements, especially in the Northeast • Not in the public domain

ACRONYMS: EPA = Environmental Protection Agency; FHWA = Federal Highway Administration; OHMT = Office of Hazardous Materials Transportation, Research and Special Programs Administration; STCC = Standard Transportation Commodity Code; TOFC/COFC = Trailer on flatcar (piggyback)/container on flatcar; WCSC = Waterborne Commerce Statistics Center (Army Corps of Engineers).

SOURCE: OTA (1986, 42).

Hamilton et al. (1986) conclude that despite "some differences in interpretation of data and the results, it can be considered that these probabilities are available and reliable. In other words, the initiating event can quite easily be determined (probabilistically) for transportation accidents (Hamilton et al. 1986). On the other hand, the OTA report cites many problems of nonreporting of incidents and accidents to federal agencies, thus questioning the reliability and completeness of the data bases (OTA 1986).

Even more difficult problems with data arise with respect to the behavior of casks and fuel during severe accident conditions. Because of the lack of historical data on these factors, most studies rely on accident simulations to develop synthetic data. The small number of spent-fuel shipments actually undertaken accounts for a paucity of accident information. The meager database does not provide sufficient evidence to conclude that the risk from these types of shipments is low enough to be ignored. The operation of a national waste repository would greatly increase the frequency of shipments from nuclear power plants and interim storage locations to the proposed site. An analysis performed by OTA estimates two transportation accidents per year with a monitored retrievable storage (MRS) facility and nine per year without the facility (OTA 1986, 105), suggesting the importance of the MRS role. The railroads estimate that by 1990, at least two accidents involving casks and severe fires in regular trains travelling at 50 miles per hour, and ten such accidents with accompanying fires in regular trains travelling at 30 miles per hour could occur (Paschall 1978).

Several of the key studies conducted over a number of years and by different organizations that assess the risks of spent fuel transportation accidents are discussed in the following paragraphs. In 1980, the NRC completed a study, widely cited as NUREG/CR-0743, on the transportation of radionuclides in urban areas (Finley et al. 1980). The report, which serves as a benchmark in more recent studies, classifies accident severities into eight categories and enlists engineering judgment to assign radiological hazards. The study estimates that radiological releases in accidents might result in one additional latent cancer fatality and one additional genetic effect for 200 years of shipping, compared with two additional nonradiological injuries per year and one additional fatality every few years (Finley et al. 1980, iv-v).

For truck and rail shipments, the report concludes that 91% of truck accidents and 80% of rail accidents would result in no significant radiological hazard. Table 5 shows the potential for release of radioactive material from different accident/severity categories in the report. Also, the study estimates 0.4% of truck and 0.2% of rail accidents involve a complete release from the cask of certain gaseous and volatile materials. These results rest upon the assumption that spent fuel casks are designed with adequate margins of safety to withstand accident conditions even more severe than those covered by regulations.

A similar study by Sandia National Laboratories of the risks of transporting all nuclear materials estimated 0.003 latent cancer fatalities, 0.007 genetic effects, 7×10^{-4} early morbidities, and 2×10^{-5} early fatalities per year. The study concluded "the risk is dominated by small, dispersible shipments of medical-use isotopes ... Spent fuel by truck is also a significant risk factor" (DuCharme et al. 1977, 128). The study notes that severe accidents yield the potential for causing thousands of latent cancers and tens to hundreds of early effects. Such accidents, however, have such low probabilities of occurrence that they do not contribute in any significant way to the expected risk values. A later study by Sandia placed the overall probability of a truck or rail shipment of spent fuel's being involved in an accident severe enough to cause some release of radioactive material at less than 2.5×10^{-8} per vehicle mile, or less than one for every 40 million miles travelled (Shepherd 1981).

Wilmot et al. (1983) estimated the risks of transporting nuclear wastes, both with and without processing, over a 26-year period to each of the five potential repository sites. The report indicates that the small number of fatalities expected from accidents is consistently larger for truck transportation. It is also significant that the estimated fatalities are relatively few (Table 6). Moreover, most recent studies have confirmed these results. In an overview of risk assessments, Hamilton et al. (1986) show the high degree of congruence among 11 different studies (Table 7). Any apparent differences are due largely to the different assumptions about accident scenarios and source terms and do not reflect major discrepancies in statistical and modelling techniques. The report also includes a review of state-of-the-art transportation risk assessment methods for severe truck accidents. The issues addressed include: the impact environment, fire environment, source

TABLE 5

**CORRELATION OF NUREG-0170 ACCIDENT FRACTIONAL OCCURRENCE AND
RADIOLOGICAL HAZARDS AS A FUNCTION OF ACCIDENT SEVERITY**

Accident Severity Category	Truck Fractional Occurrences	Train Fractional Occurrences	Fraction of Radioactive Material Released ^{a/}	Fraction of Equivalent Unshielded Fuel ^{b/}
I	0.55	0.50	0	0
II	0.36	0.30	0	0
III	0.07	0.18	0.01	0
IV	0.016	0.018	0.10	0
V	0.0028	0.0018	1	0
VI	0.0011	1.3x10 ⁻⁴	1	3.18x10 ⁻⁷
VII	8.5x10 ⁻⁵	6.0x10 ⁻⁵	1	3.18x10 ⁻⁵
VIII	1.5x10 ⁻⁵	1.0x10 ⁻⁵	1	3.12x10 ⁻³

^{a/} Radioactive gases and vapors

^{b/} Approximates the reduction in radiation shielding

Source: Finley et al. (1980).

TABLE 6

TOTAL RISKS FOR 26-YEAR PERIOD

	REPOSITORY LOCATION				
	GTR	PERMIAN	PARADOX	YUCCA MT	HANFORD
Once-Through Fuel Cycle					
100% Truck					
Radiological (latent cancer fatalities)	6	8	10	12	13
Nonradiological (fatalities)	15	22	29	36	38
100% Rail					
Radiological (latent cancer fatalities)	13	16	20	25	26
Nonradiological (fatalities)	1.1	1.4	1.8	2.2	2.3
Reprocessing Fuel Cycle					
100% Truck					
Radiological (latent cancer fatalities)	7.7	11	13	14	16
Nonradiological (fatalities)	26	45	61	69	78
100% Rail					
Radiological (latent cancer fatalities)	17	24	31	35	36
Nonradiological (fatalities)	2.3	3.9	5.1	6.1	6.2

SOURCE: Wilmot et al. (1983, 12)

TABLE 7
HUMAN ERROR/INCIDENT/ACCIDENT DATA BASES

DATABASES	KEPT BY	YEARS	MODES
Hazardous Materials Information System	DOT, Office of Hazardous Materials Transportation, Research and Special Programs Administration	1971 to present	All
Radioactive Materials Incident Report	Department of Energy, Oak Ridge National Laboratory	1971 to present	All
National Transportation Safety Board File	National Transportation Safety Board	---	All
Monthly Accident/Incident Reports	DOT, Federal Railroad Administration	1957 to present	Rail
Railroad Accident File	Association of American Railroads	1973 to present	Rail
SAFETYNET	DOT, Federal Highway Administrator, Motor Carrier Safety Assistance Program	Demonstration only	Highway
Truck and Rail Inspections	Illinois, Department of Nuclear Safety	1983 to present	Rail, Highway
Washington State Accident File	Washington State Utility and Transportation Commission	1978	Highway
Hazardous Material Spill Database	North Carolina, Department of Environmental Management	1978 to present	Highway
Inspection Reports	NRC, DOE, DOT	---	All

terms, probabilities of occurrence, and radiation doses. Although the discussion focuses on truck transportation, most parameters would also be relevant for rail accidents.

A risk assessment not reviewed by Hamilton et al. is the "Shipping container response to severe highway and railway accident conditions" (NRC 1986). It attempts to: 1) assess the effectiveness of spent fuel casks in withstanding severe highway and railway accidents and, 2) to assess the consequences to the public resulting from these accidents. This study assumed that casks were designed, manufactured, operated, and maintained in accordance with regulatory requirements and standards, and did not consider the effects of human error, although it suggests that any future study ought to do so. The first step of this study was to determine the range of accident scenarios with loads and cask responses exceeding those implied by NRC cask test standards. The second phase of the study was to assess representative truck and rail cask responses to these accident scenarios and to show they could withstand the postulated accident conditions. Figure 2 shows a schematic representation of the development of the report (NRC 1986). The estimates are smaller than those in NUREG/CR-0170 (NRC 1977). The report concludes that at least 99.4% of truck and train accidents involving spent fuel will result in negligible radiological hazards (i.e., fewer than those implied by current regulations in 10 CFR 71). The remaining 0.6% accidents will result in less overall radiological risk than that estimated in NUREG/CR-0170.

In 1986, DOE completed the Yucca Mountain, Nevada Environmental Assessment (EA) as required by the Nuclear Waste Policy Act (NWPA). Hamilton et al (1986) did not review this assessment, which included evaluation of specific scenarios that characterize the planned spent fuel transportation system. The study assesses risks from rail, truck, and barge transportation, and is the main example of the DOE approach to performing a comprehensive risk assessment of the transportation system for spent fuel and other high level radioactive waste to the Yucca Mountain repository. Scenarios included:

- A disposal system with and without a monitored retrieval storage (MRS) facility,
- Different routing options, and
- Different cask models.

Figure 2. SCHEMATIC REPRESENTATION OF THE REPORT

The consequence analysis of the DOE EA evaluates both radiological and nonradiological impacts of normal and accident conditions. The impacts that were analyzed are assumed to cover the most severe consequences that could reasonably be expected from the transportation of high level radioactive waste to the repository. Accident condition impacts are evaluated for three individual exposure levels, corresponding to three classes of accident severity (DOE 1986, A-21). The accident classes (4, 5, and 6) are taken from Wilmot et al. (1983) and all would produce consequences well in excess of those covered by NRC regulations. Two additional scenarios are evaluated for population exposure to severe accidents (DOE 1986: A-23): 1) an accident where material is released during an accident, dispersed, and deposited on the ground, and 2) an accident where the radionuclides released are deposited in a reservoir that supplies drinking water.

The consequence analysis does not provide estimates of the expected risk to the public from an accident. Rather, it estimates the severity of impacts given that an accident occurred. To estimate consequences, the RADTRAN II model was operationalized using two transportation scenarios (one with and one without an MRS) and three population-density zones. Accident rates for shipments of radioactive waste were assumed to be represented by accident statistics for general commerce (DOE 1986: 7-95).

Much of the EA analysis is based on previous research for accident consequences and rates (Sandquist et al. 1985) and are consistent with other prior research (Wilmot 1981, Wilmot et al. 1983, Neuhauser et al. 1984). The calculations in the report predict 22 early fatalities from ground-deposition and 13 from water-deposition scenarios for the most severe accident in an urban area. The results are based on the assumption that no mitigating actions, such as evacuation, are undertaken.

The results of these studies allow many experts to conclude that "there would be no significant loss of contents of shielding if an accident did occur" (Yu and Judd 1985, 24) and "that both expected and maximum health effects from severe transportation accidents are very low compared to other risks to which individuals and the public at large are exposed" (Hamilton et al. 1986, 10-30). The OTA concludes, similarly, that "the probability of an accident severe enough to cause extensive damage to public health and the environment caused by a radioactive

release from a properly constructed cask (emphasis added) is extremely remote" (OTA 1986, 109).

Other experts, however, have contested the view that the risks are negligible. They point out that current cask-performance tests do not cover the range of accident conditions for either truck or rail. Resnikoff (1983, 263) notes, for example, that in 1982, truck fires occurred that burned as long as 1.75 hours at temperatures reaching 1800 degrees Fahrenheit and train fires have lasted as long as five days. These benchmarks exceed those specified in current tests. Railroad representatives also argue that the probability of long and severe fires has been underestimated and that some events have not been considered in risk assessments, such as storage facilities near tracks as well as cargo in the train can be set afire (Paschall 1978).

Important deficiencies in the studies discussed above when viewed with respect to performing adequate risk assessments include:

- Design standards are assumed to be adequate to withstand severe accident conditions,
- Tests of cask integrity generally rely on simulation and not real casks,
- Casks are assumed to be fabricated, used, and maintained properly with respect to design standards, and
- The roles of defective quality control and of human error are minimized or ignored.

To complete a comprehensive risk assessment, many data are unavailable and the development of a reliable data base may require further research, the identification of substitutes (e.g., expert judgment), or the use of analogous situations. It is noteworthy that the NRC is currently performing a study to update its 1980 report, NUREG/CR-0170 (Finley et al. 1980).

1.2.3 Sabotage

Intentional human acts, or sabotage, as causes for accidental release of radioactive material remain a consideration. Sabotage includes deliberate destruction of vehicles, manipulation of crewmembers, hijacking of shipments, and theft of nuclear material. The release of material in such cases depends not only on kinetic energy

due to possible accident conditions, but also on interactive effects with explosives, fires, water pressure, and external hazardous material. Although it is almost impossible to quantify the probability of such events, their consequences have been studied.

A scenario of sabotage in a densely populated urban environment of a truck carrying three fuel assemblies was evaluated using the METRAN model to assess the consequences of a major incident releasing 100% of the noble gases, 1.6% cesium, and 1% respirable solid material from a spent fuel shipment. The potential damage from that type of release was estimated to be up to 44 early fatalities, 2400 early morbidities, and 910 latent cancer fatalities for different incident scenarios (SAND76 1977, 194).

Both the NRC and DOE have conducted more recent studies on the potential consequences of sabotage. The NRC experiments used model small-scale explosives against simulated casks containing irradiated fuel (Schmidt et al., 1982). The DOE experiments included one full-scale and several small-scale tests (Sandoval et al., 1983). The estimates of consequences from these studies suggest that no early fatalities and fewer than 15 latent-cancer fatalities would result. The assumptions in the scenario were very favorable to the saboteurs, and the study used worst-case or near worst-case values for parameters, including fuel age, population density, and lifetime of respirable materials. More recent studies have been performed for the NRC by Battelle Columbus Laboratory (1986a, 1986b) but have not yet been released by the NRC.

1.2.4 Human-Task Mismatches

The role of human factors in the transportation of spent fuel has been little studied in the past, although these factors may play a significant role in initiating or contributing to accidents or incidents in the transportation of spent fuel and other high level radioactive wastes. The importance of human-task mismatches in many activities, including design, manufacture, operation, maintenance, and inspection, has been clearly shown in many complex technological systems including process plants, nuclear power plants, airline travel (Turner 1978, Rasmussen 1980, Bellamy 1983, OTA 1986). Similarly, many methodologies for the evaluation of human factors in error causation may be applied to the transportation system for spent fuel. CENTED researchers drafted a review of the literature and the

development of a human-factors approach for the transportation of spent fuel for the Yucca Mountain Socioeconomic Project (Tuler, Kaspersen, and Ratick 1988).

The quality control programs of the NRC and DOE have been previously reviewed and found deficient in a number of areas, including the very limited number of regulatory inspections and the inadequate system of enforcement and penalties (Resnikoff 1983, Rothberg 1984, USGAO 1986, USGAO 1987). The unanticipated discovery that one of the casks in Sandia's own destruction tests was improperly manufactured (leading to the outer layer cracking in two places, and the lead shielding's beginning to vaporize during a fire test) exemplifies these existing quality-control problems (Resnikoff 1983, 257).

On the other hand, much effort has been expended on the analysis of error causation and the development of human reliability management programs (e.g., training) in a wide range of systems. In particular, methodologies have been developed for the design, evaluation, and modification of technological systems to improve human reliability (e.g., Meister 1971, Kantowitz and Sorkin 1983, Embry 1984, Pedersen 1985, Rasmussen 1986, Boff, Kaufman, and Beattie 1986, Salvendy 1987, Gael 1988).

Many studies that focus on other types of systems are relevant to the design, implementation, operation, and maintenance of spent-fuel transportation system components, including quality-control programs. A recent report by the National Research Council (1988) provides an overview of the literature and important research needs for human factors in nuclear power plant safety. Others have addressed issues related to the design of systems and to the training of workers (Bainbridge 1984, Dhillon 1986, Gael 1988). Additional reports have focussed on transportation systems in general, including truck transportation (Waller and Li 1979, Insurance Institute for Highway Safety 1985, Waller 1985, Jones and Stein 1987, Hertz 1987). The Office of Technology Assessment is currently preparing a report on motor carrier safety, which will include a chapter on issues of human factors in truck safety (Page 1988).

One cannot assume that human factors issues in spent fuel transportation are insignificant. Indeed, databases on spent fuel transportation show that failures occur as a result of inappropriate human activities and poorly designed or

implemented human-task systems and procedures. For example, the annual transportation incident reports provided by the Nuclear Regulatory Commission (NRC) clearly demonstrate that more than 50% of all incidents recorded in NRC files, exclusive of those also reported by the DOT, may be attributed to human error (Sandia National Laboratories 1977). In particular, packaging, handling, and stowage account for the majority of cases involving human errors or deviations from quality control. Similarly, the CENTED report lists a number of human errors that have occurred in the transportation of spent fuel (Tuler, Kasperon, and Ratick 1988).

The collection of data on human error is fraught with difficulties that stem from the association of the reporting of failures with the assignment of blame and responsibility. To counter similar problems in the nuclear power industry, the NRC has proposed an "unobtrusive, voluntary, anonymous, third-party managed, nonpunitive human factors data gathering system" (NRC 1985a, NRC 1985b, NRC 1985c). The system is designed to encourage the reporting of incidents, accidents, and other nonreported, but significant events related to human reliability. The data are intended for use in identifying and quantifying factors that contribute to reduced safety and reliability.

Human error databases with both qualitative and quantitative information have been developed for a variety of systems (Rasmussen 1980, Swain and Guttman 1980, Lucas 1987). Unfortunately, no databases for spent fuel transportation, or even truck and rail transportation in general, contain useful data related to human error. Databases do exist for accident and incidents in truck and rail transportation that identify human error as primary causal factors and contain some information on human error (Table 7). The CENTED report (Tuler, Kasperon, and Ratick 1988) on human reliability in the transportation of spent fuel provides a more thorough evaluation of capability of these databases to support human-factors analyses.

A recent report by OTA (1986) includes a discussion on human errors in the transportation of hazardous materials and suggests possible error types in the transportation of spent fuel. Based on a review of the DOT Hazardous Materials Incident System (HMIS) data base, this study identified human error as a major cause of hazardous materials transportation accidents, a factor reported as the

primary cause of 62% of the accidents and incidents reviewed. The HMIS database, however, is not completely reliable. For example, the OTA (1986) study found that compliance rates of reporting were not 100%. When a reportable incident or accident occurred it was not always reported to DOT. Also, human error was only identified when it was a primary cause of failure and not when it was a contributory cause. Thus, the estimates of human error rates are probably underestimated.

Only a few previous risk analyses have considered the consequences of human error in the transportation of spent fuel, and these have generally focused on failures related to cask usage (e.g., cask closure, maintenance, valve operation). However, other important sources of human error can affect cask integrity. For example, failures in vehicle and other support equipment operation and maintenance (e.g., cranes) can also lead to incidents involving casks.

The general neglect of human error issues in previous risk assessments arises from the assumption that the probability associated with simultaneous human and technical failures leading to major accidents is negligible (Finley et al. 1980). This lack of concern stands in marked contrast to government and industry concern over human errors and recoverability in the operation of nuclear plants. The primary rationale for this is that the transportation system is a much simpler system that does not require complex problem solving tasks. In addition, it is generally assumed that cask technology is sufficient to ensure against the release of radiation under extreme accident conditions and that, therefore, human errors will not be able to create sufficiently severe conditions to cause cask failure. This assumption, however, is based on the highly suspect assumptions noted earlier on accident conditions. Even the limited historical data available on spent-fuel shipments suggest that human error has been a significant cause of incidents and minor errors in the transportation system. Three studies that have evaluated human errors in spent fuel transportation are reviewed.

An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck, PNL-2588 (Battelle Pacific Northwest Laboratory 1978).

A survey of industry cask handlers was used to determine the conditions of casks during spent-fuel transportation, and the information was ultimately to be used in risk analyses. The report attempts to estimate error types and rates in loading, packaging, and normal transport of spent fuel in both truck and rail casks during

the period of 1970-1977. Certain limitations apply to the data resulting from this study:

- None of the companies surveyed was subject to NRC oversight.
- The study assumes strict quality control requirements that were to result in "a significant reduction in package errors," but this assumption has proven erroneous. For example, since 1978 the frequency of exterior cask contamination has been observed to be much higher than assumed in this study (Nebraska Energy Office 1987).
- The survey approach used anecdotal information, which is subject to uncertainties about the time period of observations and the circumstances surrounding events.
- The full range of relevant error types was not considered.

Transportation of Radionuclides in Urban Environs, NUREG/CR-0743 (Finley et al. 1980).

This report concludes that the potential contribution of human error to severe accidents is negligible. This conclusion results from the assumption that a circumferential crack in a cask is the mode of radioactivity release in an accident, and that "human error...would not create the kinds of forces necessary to cause a circumferential crack in the cask wall." Yet this is not the only route by which a cask might release radioactivity (Resnikoff 1983).

Numerous methodological and data deficiencies plague this report. Specific problems result from:

- The failure to address the increased vulnerability of a cask, incorrectly designed or manufactured due to human error.
- Inadequate sources of data. The primary sources were PNL-2588 (Battelle Pacific Northwest Laboratory 1978) and DOT and NRC incident reports. However, these data cannot support the claim of a "detailed error analysis" because the PNL-2588 survey lacked rigor and its results were incomplete.
- Failure to use all of the available human error from the survey completed in PNL-2588. The analysis did not include known cases of human errors in cask inspection, maintenance, and handling (Resnikoff 1983).
- The incorrect use of data. In fact, more than twice the number of errors could have been identified from available data (Nebraska Energy Office 1987).

Consequently, serious flaws mar the conclusions of the report. The full range of human error types is not identified and, therefore, estimates of accident probability are too low. This is a significant problem because the report forms the basis of the evaluation of human error in spent-fuel transportation for a worst-case transportation accident and for DOE's (1986) assessment of transportation risks. When it was suggested that human error in transportation was not treated adequately in the DOE generic environmental impact assessment, the DOE response was: "The DOE has considered the potential for human error in the assessment of transportation risks...The results (of NUREG/CR 0743) indicate that the risks from

human errors or deviations from accepted QA practices are extremely small (i.e., 0.00012 latent-cancer fatality per shipment year for packages tested to accident conditions), and thus it is not meaningful to include these risks in the radiological risk analysis for transportation" (DOE 1980, Appendix C.2.4.1.23).

A Review of the Effects of Human Error on the Risks Involved in Spent Fuel Transportation (Nebraska Energy Office 1987).

This study emphasizes human error in spent-fuel cask design, construction, use, and maintenance. The report examines problems caused by a variety of types of human error, including errors of judgment. It also addresses the issue of imperfectly fabricated casks and improper use of casks due to human error, which had received little attention in the past relative to the efforts made to assess the effects of impacts and fires on casks. An important part of this study is an extensive review of PNL-2588 (Battelle Pacific Northwest Laboratory 1978) and NUREG/CR-0743 (Finley et al. 1980), which identified many of the problems listed above.

The primary effect of a human error may be associated with a single shipment, a single cask, or a specific cask design. Previous analyses examined only the first category, and consequently they assume 1) that errors are randomly distributed among all shipments, and 2) low probability of human error and severe accidents events occurring simultaneously. On the other hand, if an error affects a cask design or a particular cask, errors are not randomly distributed across all shipments and, therefore, they may affect multiple shipments.

Human error databases with both qualitative and quantitative information have been developed for a variety of systems (Rasmussen 1980, NRC 1980b, Lucas 1987). Unfortunately, there are no databases for spent fuel transportation, or even truck and rail transportation in general, that contain useful data related to human error. Databases do exist for accidents and incidents in truck and rail transportation that identify human error as primary causal factors (Table 7). The CENTED report on human reliability in the transportation of spent fuel provides a more thorough evaluation of databases available to support human factors analyses.

1.3 IMPACT MONITORING

Concurrent activities have occurred in the development of systems which can be broadly classified as impact assessment models. Such efforts have been undertaken principally by DOE contractors and researchers at Vanderbilt University.

DOE contractor activity has yielded several system components: (1) RADTRAN, (2) HIGHWAY, (3) INTERLINE, (4) WASTES, and (5) STRATEGEN (ORNL, October 1983; ORNL, November 1985; Sandia, February 1986; Sandia, October 1987). RADTRAN predicts radiological and non-radiological risks for each transport segment based on segment characteristics. WASTES computes capital and operating costs associated with the shipment in question, based on such factors as distance. HIGHWAY and INTERLINE represent transportation network models for national road and rail systems, respectively. STRATEGEN and its derivatives permit a state to enter their own network and segment characteristics. From this, certain routing analyses can be undertaken.

The major problem with the DOE effort has been its fragmented nature and lack of flexibility to integrate to a full-scale impact assessment model as is needed in the preferred transportation system design. Furthermore, none of the models, either individually or collectively, can handle the complex problem of identifying the preferred shipment size and modal mix in addition to preferred routes from Nevada's perspective.

Researchers at Vanderbilt University have taken a different approach to this problem through the creation of a highly sophisticated computational environment that can accommodate both routing and risk assessment, including consideration of shipment size and modal mix (Abkowitz and Cheng, November 1988; Abkowitz, Cheng, and Lepofsky, November 1988; Abkowitz and Cheng, 1988). The mapping system, data management, and solution processes employed in this system permit considerably more flexibility for handling the immediate needs of the preferred transportation system assessment and the evaluation of future policy alternatives.

With respect to the preferred transportation system for Nevada, the development of a comprehensive impact assessment model is a central and high priority consideration as a decision support system for the entire transportation evaluation effort. Because of the need to address several aspects of this problem specific to Nevada and radioactive waste movement, any impact assessment model to be utilized in Nevada will require much new development building off of the foundation of existing systems. At this juncture, it appears that the Vanderbilt approach is far more conducive to the interest of the State in meeting preferred system needs. Furthermore, the Vanderbilt model architecture also permits the use of outside system developments as modules in the assessment process. Consequently, attractive aspects of DOE contractor developments (such as economic cost or radiation exposure models) can be fully integrated into the preferred impact

assessment design. Additional network data gathered by the Nevada Department of Transportation and other State agencies could also be easily integrated into the impact assessment structure as previously defined.

1.4 LEGAL CITATIONS

1.4.1 Case Annotations

Atomic Energy Act

1. An ordinance prohibiting the transportation and storage of spent nuclear fuel or radioactive waste within a town is preempted by Atomic Energy Act and Hazardous Materials Transportation Act, because Congress established pervasive scheme of regulation under both Acts providing for federal regulation of the safety aspects of nuclear power industry and the transportation of hazardous materials in commerce. Jersey Central Power & Light Co. v. Township of Lacey, 772 F.2d 1103 (3rd Cir. 1985), cert. denied, 475 U.S. 1013 (1986).

2. In enacting the Atomic Energy Act, Congress intended that the federal government regulate the radiological safety aspects involved in the construction and operation of nuclear plants but that the states retain their traditional responsibility in the field of regulating electrical utilities for determining questions of need, reliability, costs and other related state concerns. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

3. The primary purpose of the Atomic Energy Act is the promotion of nuclear power. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

Administrative Law

4. The United States, challenging a state statute which prohibits carriers from transporting government property at rates other than those approved by the state public utilities commission, need not first seek relief instate administrative proceedings before a remedy will be supplied by the courts, where the issue presented by the challenge to the state statute is a constitutional issue that the state commission can hardly be

expected to entertain. Public Utilities Commission of the State of Colorado v. United States of America, 355 U.S. 534 (1958).

5. The fact that the Department of Transportation had issued an inconsistency ruling did not dispose of preemption issue, as the inconsistency rulings are not derived from adversary proceedings and simply present advisory opinions of the Department of Transportation. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

6. Agency has authority to interpret its own regulations, and court must show considerable respect to any such interpretation. National Tank Truck Carriers v. Burke, 698 F.2d 559 (1st Cir. 1983).

7. In ascertaining the validity of a state's regulations governing carriers of liquefied natural gas and liquefied petroleum gas, a district court could properly resort for guidance to the rulings of the Department of Transportation. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

8. When the meaning of an administrative regulation is in doubt, the construction given it by the agency which promulgated it can be conclusive. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

9. The doctrine of primary jurisdiction did not require resort to the Department of Transportation prior to seeking a court ruling on the question of inconsistency between city and federal regulations dealing with the transportation of hazardous materials. City of New York v. Ritter Transportation Inc., 515 F.Supp. 663 (S.D.N.Y. 1981), modified sub nom., National Tank Truck Carriers, Inc. v. City of New York, 667 F.2d 270 (2d Cir. 1982).

CLEAN WATER ACT

10. One of the primary features of the 1972 amendments to the Clean Water Act is the establishment of the National Pollutant Discharge Elimination System (NPDES), a federal permit program which (1) is designed to regulate the discharge of polluting effluents; and (2) pursuant to 301(a) of the Act, generally prohibits the discharge of any effluent into a navigable body of water unless the point source has obtained an NPDES permit

from the Environmental Protection Agency. International Paper Company v. Ouellette, 479 U.S. ___, 93 L.Ed.2d. 883 (1987).

COMMERCE

11. Federal statutes under which steam vessels and their equipment, including their boilers, are inspected, approved, and licensed to operate in interstate commerce in accordance with a comprehensive scheme of federal regulation, do not, under the doctrine of preemption, bar a city from applying its smoke abatement code to steam vessels operating in interstate commerce, notwithstanding that, unless they undergo structural alteration, such vessels cannot, without violating the code, perform within the city the necessary cleaning of their fires. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

12. In the exercise of the police power, the states and their instrumentalities may act, in many areas of interstate commerce, concurrently with the federal government. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

13. Evenhanded local regulations to effectuate a legitimate local public interest in the areas of interstate commerce is valid unless they are preempted by federal action or they are unduly burdensome on commerce. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

14. A municipal smoke abatement code which does not exclude federally licensed steam vessels from the port of the city, or destroy the right of free passage, does not so burden the federal license granted a steam vessel as to be constitutionally invalid, merely because, unless the vessel undergoes structural alterations, it cannot, without violating the code, engage, while within the city, in necessary cleaning of its fires. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

15. Routing requirements of New York City Fire Department regulations dealing with the transportation of tank truck quantities of liquefied petroleum gases and other hazardous compressed gases were based on a legitimate local safety interest and did not impose a disproportionate burden on interstate commerce. City of New York v. Ritter Transportation Inc., 515 F.Supp. 663 (S.D.N.Y. 1981), modified sub nom., National Tank Truck Carriers, Inc. v. City of New York, 667 F.2d 270 (2d Cir. 1982).

16. Those who would challenge bona fide state safety regulations must overcome strong presumption of validity. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

17. Burden of showing unconstitutionality of statute is on party asserting it who must demonstrate such fact beyond reasonable doubt. People of the State of New York v. Dempsey, 466 N.Y.S.2d 923 (N.Y.C. Crim. Ct. 1983).

18. The Commerce clause of the federal constitution does not prevent states from charging for services they provide. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

19. No state, consistent with the commerce clause of the United States Constitution may impose a tax which discriminates against interstate commerce by providing a direct commercial advantage to commercial business. Permitting the individual states to enact laws that favor local enterprises at the expense of out-of-state businesses would invite a multiplication of preferential trade areas destructive of the free trade which the commerce clause protects. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

20. Only undue or discriminatory burdens upon interstate commerce are forbidden by the commerce clause of the federal constitution. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

21. A state, consistent with the commerce clause of the federal constitution, may not put a barrier around its borders to bar trade from other states under the guise of taxation that produces an excluding or discriminatory effect. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

22. Under the commerce clause of the federal constitution, a state may not tax in a manner that discriminates between two types of interstate transactions in order to favor local commercial interests over out-of-state businesses. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

23. Participants in interstate commerce may be assessed a fee by more than one jurisdiction and not violate the commerce clause of the federal constitution as long as the revenue measures maintain state boundaries as a neutral factor in the economic decision making so that free trade among the states is unimpaired. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

24. A state tax that favors in-state business over out-of-state business for no other reason than the location of its business is prohibited by the commerce clause of the federal constitution. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

25. Interstate commerce has no immunity from state taxation. The proper test to determine whether the tax violates the commerce clause is whether it produces a forbidden effect. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

26. City fire department regulations which prohibited transportation of hazardous gases by tank truck within city except when no practical alternative route exists and which established a routing requirement for the authorized transportation of gases were based on a legitimate local safety interest and did not unconstitutionally burden interstate commerce as they applied both to intrastate and interstate commerce. National Tank Truck Carriers, Inc. v. City of New York, 677 F.2d 270 (2d Cir. 1982).

27. The inconvenience of driving around city or waiting for city curfew to lift were not unconstitutionally disproportionate under the commerce clause when balanced against public interest in avoiding catastrophic accident involving hazardous gases transported in densely populated urban area. National Tank Truck Carriers, Inc. v. City of New York, 677 F.2d 270 (2d Cir. 1982).

28. States are not prevented from propounding laws that affect interstate commerce provided the laws serve a legitimate state interest and do not discriminate against interstate commerce. National Tank Truck Carriers, v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

29. The legal standard for determining whether a state's highway safety legislation contravenes the commerce clause requires a determination of whether the strong

presumption of validity accorded state highway safety measures has been overcome by showing that safety benefits were slight or problematical or merely illusory. American Trucking Associations, Inc. v. Larson, 683 F.2d 787 (3rd Cir. 1982), cert. denied, 459 U.S. 1036 (1982).

30. Under the commerce clause, discrimination against interstate commerce entails imposing burden on out-of-state vehicles that is not imposed on in-state vehicles or favoring those from in-state over those from out-of-state. American Trucking Associations, Inc. v. Larson, 683 F.2d 787 (3rd Cir. 1982), cert. denied, 459 U.S. 1036 (1982).

31. Statute requiring all motor carrier vehicles to be periodically inspected did not impose an unconstitutional burden on interstate commerce where the state had a reasonable basis to believe that inspection of motor carrier vehicles was likely to discover some defective vehicles and that some vehicles defects contributed to accidents, thereby meeting minimal requirement of showing that statute contributed to highway safety. American Trucking Associations, Inc. v. Larson, 683 F.2d 787 (3rd Cir. 1982), cert. denied, 459 U.S. 1036 (1982).

32. The commerce clause requires that some aspect of trade generally must remain free from interference by states. When a state ventures excessively into regulation of these aspects of commerce, it trespasses upon national interests, and courts will hold the state regulation invalid under the commerce clause. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

33. The state's power to regulate commerce is never greater than in matters traditionally of local concern. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

34. In considering the constitutionality of state regulations that touch upon safety and the safety justifications are not illusory, the court will not second-guess legislative judgment about their importance in comparison with related burdens on interstate commerce. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

35. State regulations designed for purpose of promoting public health or safety nevertheless may further purpose so marginally and interfere with commerce so substantially as to be invalid under the commerce clause. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

36. While the Supreme Court has been most reluctant to invalidate state regulations that touch upon safety, especially highway safety, the constitutionality of such regulations nevertheless depends upon sensitive consideration of weight and nature of state regulatory concern in light of the extent of burden imposed on interstate commerce. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

37. A state cannot constitutionally promote its own parochial interests by requiring safe vehicles to detour around it. Kassel v. Consolidated Freightways Corporation of Delaware, 450 U.S. 662 (1981).

38. Even where Congress has not acted, the commerce clause prevents states from enacting barriers that obstruct free flow of interstate commerce. State legislation and regulation designed to foster legitimate state interest and applied without discrimination against interstate commerce do not violate the commerce clause, even if there is an effect on interstate commerce. People of the State of New York v. Dempsey, 466 N.Y.S.2d 923 (N.Y.C. Crim. Ct. 1983).

39. Statutes and regulations that prohibit transportation of flammable liquids within New York City during rush hours comprise a reasonable regulatory scheme designed to promote public safety, do not attempt to discriminate against non-local carriers in order to protect economic interest of local carriers, and the minimal and incidental inconveniences which result from such a curfew are not unconstitutionally disproportionate when balanced against the state's interest in avoiding a potential catastrophe in a densely populated urban environment. Thus, the statutes and regulations are not unconstitutional under the commerce clause. People of the State of New York v. Dempsey, 466 N.Y.S.2d 923 (N.Y.C. Crim. Ct. 1983).

40. While no state may completely exclude federally licensed commerce, a federal license or certificate of compliance with minimum federal standards does not immunize the licensed commerce from inconsistent or more demanding state regulations. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

41. A state statute under which the federal government is barred from receiving more advantageous shipping rates in the state than those applicable to other interstate shippers is not unconstitutional. The fact that the economic incidence of state price regulation or taxation falls upon the government does not give rise to an implied constitutional immunity from such regulation. Public Utilities Commission of the State of Colorado v. United States of America, 355 U.S. 534 (1958).

DUE PROCESS

42. Regulations requiring the use of a two-way radio to alert appropriate federal, state or municipal agencies of any accident or mishap occurring within the state did not violate the due process clause's proscription against vagueness. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

EQUAL PROTECTION

43. A state statute requiring hazardous materials and waste transporters to obtain a state license for an annual fee did not violate the equal protection clause of the Fourteenth Amendment. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

44. Applying the rational basis standard, a state regulation must be upheld if the state's classification is rationally related to a legitimate state interest. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

45. States are given broad discretion to create classifications where social concerns such as the safety of the state's citizens and property are involved, but they cannot act in a patently arbitrary or irrational way. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

46. Regulations concerning two-way radios, immediate reporting of accidents, illumination of headlights, and vehicle inspection did not contravene the equal protection or commerce clauses. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

47. A state statute requiring all motor carrier vehicles to be periodically inspected was not unconstitutional as a violation of equal protection by regulating chassis but not automobiles where the state could reasonably decide that tractor-trailer combinations represented distinct category of vehicles with special safety problems that warranted more stringent safety inspection requirements than those imposed on automobiles. American Trucking Associations, Inc. v. Tarrson, 683 F.2d 787 (3rd Cir. 1982), cert. denied, 459 U.S. 1036 (1982).

48. Charges of one dollar levied by a state and by a municipality on persons enplaning a scheduled commercial airliner to help defray costs of airport construction and maintenance did not violate federal constitution, where both interstate and intrastate flights were subject to the same charges. The charges reflected a fair, if imperfect, approximation of use of facilities for whose benefit they were imposed, and there was no showing that the charges were excessive in relation to costs incurred by taxing authorities. Evansville-Vanderburgh Airport Authority District v. Delta Airlines, Inc., 405 U.S. 707 (1972).

49. Regulations relating to the transportation of flammable liquids within New York City during rush hours impose far more stringent restrictions on carriers picking up and making final delivery of hazardous cargo within New York City than on their counterparts who merely pass through the city en route to other destinations, thus vitiating a claim of unfair discrimination against non-local carriers who are subject to curfew regulations only. People of the State of New York v. Dempsey, 466 N.Y.S.2d 923 (N.Y.C. Crim. Ct. 1983).

50. A state statute prohibiting the transportation or sale in the state of avocados containing less than eight percent of oil, by weight, excluding the skin and seed, is not an irrational discrimination between persons or groups of persons and therefore is not invalid under the equal protection clause of the Fourteenth Amendment. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

HAZARDOUS MATERIALS TRANSPORTATION ACT

51. The purpose of statutes and regulations relating to transportation of flammable liquids within New York City during restricted hours is to promote public safety, as times of travel have been restricted in order to keep hazardous cargo movement out of extremely heavy rush hour traffic. People of the State of New York v. Dempsey, 466 N.Y.S.2d 923 (N.Y.C. Crim. Ct. 1983).

52. The State of Ohio has standing to seek judicial review of a federal regulation which by its terms preempted a state statute requiring prenotification of shipments into or through the state of any large quantity of special nuclear material or by-product material. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

53. An ordinance prohibiting the transportation and storage of spent nuclear fuel or radioactive waste within a town is preempted by Atomic Energy Act and Hazardous Materials Transportation Act because Congress established pervasive scheme of regulations under both Acts providing for federal regulation of the safety aspects of nuclear power industry and the transportation of hazardous materials in commerce. Jersey Central Power & Light Co. v. Township of Lacey, 772 F.2d 1103 (3rd Cir. 1985), cert. denied, 475 U.S. 1013 (1986).

54. Although a primary Congressional objective in enacting the Hazardous Materials Transportation Act would be the promulgation of uniform, national standards in hazardous materials transportation, preemption of state regulations regarding highway safety is not to be undertaken lightly. Given the legitimate concern the state has for the persons and property within its boundaries, the propriety of local highway safety regulation has long been recognized. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

55. While states and localities are not prevented entirely from issuing regulations in the area of hazardous materials transportation, the scope of such regulations is limited by the dominant role assigned to the Department of Transportation by Congress. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

56. The relationship between a federal statute and a state regulation must be evaluated as the statute and regulation are interpreted and applied, and not solely as they are written. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

57. A regulation must actually conflict with the Hazardous Materials Transportation Act in order to be deemed inconsistent with it and thus preempted. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

58. As to "accident report" requirement, interpretation by Department of Transportation of its regulation as forbidding similar state regulations aimed solely at hazardous materials carriers and not justified by an emergency was reasonable. The Department could readily have found conflict between Rhode Island's requirement and the Department regulation as so interpreted and for that reason requirement was inconsistent with federal law and therefore invalid. National Tank Truck Carriers v. Burke, 698 F.2d 559 (1st Cir. 1983).

59. If a state regulation is inconsistent with the Hazardous Material Transportation Act, then that regulation is invalid by mandate of Congress. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

60. City fire department regulations which governed routing of hazardous gases transported by tank truck in city as enforced were entirely consistent with and in furtherance of federal regulations and their underlying purposes. They were, thus, not preempted by federal statutes and regulations as there was no direct conflict between city routing and curfew regulations and federal regulations, and the city routing requirements imposed only a necessary delay and allowed a practical alternative to travel through a heavily populated area. National Tank Truck Carriers v. City of New York, 677 F.2d 270 (2d Cir. 1982).

61. Regulations concerning two-way radios, lighting of headlights, immediate reporting of accidents to the state police, and inspection requirements were not unreasonable, and their promulgation was authorized by the General Assembly. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd, 698 F.2d 559 (1st Cir. 1983).

62. Regulations concerning a permit and application, curfew, and subsequent written notice of an accident were preempted by the Hazardous Materials Transportation Act, but the requirements concerning two-way radios, immediate reporting of accidents, illumination of headlights, and vehicle inspection were not inconsistent with HMTA. National Tank Truck Carriers v. Burke, 535 F. Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st cir. 1983).

63. HMTA does not call for complete preemption of all state regulations in this area. National Tank Truck Carriers v. Burke, 608 F.2d 819 (1st Cir. 1979).

64. The Hazardous Materials Transportation Act empowers the Secretary of Transportation to protect the nation adequately against the risks of life and property that are inherent in transportation of hazardous materials in commerce and permits Secretary to exercise discretion in determining appropriate level of safety. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

65. Congress did not intend the Hazardous Materials Transportation Act regulations to maximize public safety, particularly on jurisdiction-by-jurisdiction basis, as evidenced by nonpreemption procedure that was added so that the Department of Transportation could limit preemptive force of federal regulations to secure more stringent regulations by local authorities. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

66. Under the Hazardous Materials Transportation Act, Congress did not intend to impose requirement on Department of Transportation to compare modes of transportation to determine which mode is safest, thereby pitting the various modes of transportation in direct competition because only one mode of transportation can be the safest mode for any given task. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

67. The inclusion of the express preemption provision makes it clear that Congress did not intend the HMTA and its regulations to occupy the field so completely as to preclude any state or local action. Undated Speech by E. Economides, HM-164: Highway Routing of Radioactive Materials.

68. Appendix A is not a regulation which imposes obligations to act. It was not intended to replace the two-prong test for determining the inconsistency of an existing state or local rule. Rather, it was intended to advise state and local governments contemplating rulemaking action as to the likelihood of such actions being deemed inconsistent. Undated Speech by E. Economides, HM-164: Highway Routing of Radioactive Materials.

69. New York City Fire Department regulations prohibiting the transportation of tank truck quantities of liquefied petroleum gases and other hazardous compressed gases in New York City, except when authorized by the fire commissioner and then only when in conformance with routes prescribed by the commissioner, were consistent with, and in furtherance of, federal regulations issued under the Hazardous Materials Transportation Act and motor carrier safety regulations issued under the Interstate Commerce Act. Thus, they were not preempted by federal law, notwithstanding that the effect of such regulations was to require trucks of liquefied gas going from New Jersey to Long Island to use a circuitous route through less heavily populated areas of the city. City of New York v. Ritter Transportation Inc., 515 F. Supp. 663 (S.D.N.Y. 1981), modified sub nom., National Tank Truck Carriers v. City of New York, 667 F.2d 270 (2d Cir. 1982).

INTERSTATE COMMERCE COMMISSION

71. A rail carrier may not ask the Interstate Commerce Commission to take cognizance of a claim that a commodity is too dangerous to transport where there are Department of Transportation and Nuclear Regulatory Commission regulations governing such transportation and those regulations have been met. Railroads cannot refuse to haul any materials which meet the regulations, but they may seek approval of stricter practice that was shown to be just and reasonable. Akron, Canton & Youngstown Railroad Company v. Interstate Commerce Commission, 611 F.2d 1162 (6th Cir. 1979), cert. denied, 449 U.S. 830 (1980).

72. The long history of the railroads' carriage of nuclear materials and the continuing national need for such carriage took the railroads' transport of nuclear materials from realm of "accommodation or special engagement" where the Interstate Commerce Act's rate-making provisions do not apply. Akron, Canton & Youngstown Railroad Company v. Interstate Commerce Commission, 611 F.2d 1162 (6th Cir. 1979), cert. denied, 449 U.S. 830 (1980).

73. Question of possible liability for damage resulting from carriage or commodity is within Interstate Commerce Commission's jurisdiction as regulator of economics of interstate rail transport. Akron, Canton & Youngstown Railroad Company v. Interstate Commerce Commission, 611 F.2d 1162 (6th Cir. 1979), cert. denied, 449 U.S. 830 (1980).

74. While the Department of Transportation and the Nuclear Regulatory Commission have exclusive authority to promulgate industry-wide standards for carriage of radioactive materials, the Interstate Commerce Commission may allow individual rail carriers to make more, but not less, stringent rules for their carriage of hazardous materials. Akron, Canton & Youngstown Railroad Company v. Interstate Commerce Commission, 611 F.2d 1162 (6th Cir. 1979) cert. denied, 449 U.S. 830 (1980).

75. A state statute requiring hazardous materials and waste transporters to obtain state license for an annual fee did not conflict with and, thus, was not preempted by the Interstate Commerce Act. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

76. Interstate Commerce Commission's preference of rail over truck carriage of spent nuclear fuel was both within Commission's primary jurisdiction and supported by substantial evidence. Akron, Canton & Youngstown Railroad Company v. Interstate Commerce Commission, 611 F.2d 1162 (6th Cir. 1979), cert. denied, 449 U.S. 830 (1980).

NATIONAL ENVIRONMENTAL POLICY ACT

77. Although transportation of radioactive materials through city poses risks that warrant careful consideration, Department of Transportation did not violate National Environmental Policy Act in deciding that environmental impact statement was not required when Department promulgated regulations governing transportation of large quantities of radioactive materials by highway. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

78. The Department of Transportation's assessment of risks of failure of casks used for transportation of radioactive materials was not arbitrary and was not susceptible to attack on judicial review of regulations promulgated by Department governing the

transportation of large quantities of radioactive materials by highway. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

79. The Department of Transportation adequately considered potential effect of human error in connection with transportation of large quantities of radioactive materials by highway and, therefore, probability assessments were not insufficient for failing to consider human error. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

80. In promulgating regulations to govern transportation of large quantities of radioactive materials by highway, the Department of Transportation did not abuse its discretion in declining, on jurisdictional grounds, to consider possibility that saboteurs or terrorists could disrupt nuclear shipments and precipitate high-consequence accidents. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

81. The Department of Transportation had discretion to apply overall risk analysis in its environmental assessment of regulations promulgated to govern transportation of large quantities of radioactive materials by highway. City of New York v. United States Department of Transportation, 715 F.2d 732 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984).

PERMITS & FEES

82. A charge designed only to make user of state-provided facilities pay a reasonable fee to help defray costs of their construction and maintenance may constitutionally be imposed on interstate and intrastate users alike. Evansville-Vanderburgh Airport Authority District v. Delta Airlines, Inc., 405 U.S. 707 (1972).

83. Charges of one dollar levied by a state and by a municipality on persons enplaning a scheduled commercial airliner to help defray costs of airport construction and maintenance did not violate federal constitution, where both interstate and intrastate flights were subject to the same charges. The charges reflected a fair, if imperfect, approximation of use of facilities for whose benefit they were imposed, and there was no showing that the charges were excessive in relation to costs incurred by taxing

authorities. Evansville-Vanderburgh Airport Authority District v. Delta Airlines, Inc., 405 U.S. 707 (1972).

84. A state may impose a reasonable charge on vehicles engaged exclusively in interstate commerce as their fair contribution to the cost of construction and maintaining the public highways. American Trucking Associations, Inc. v. Scheiner, 483 U.S. ___, 97 L.Ed.2d 266 (1987).

85. A state statute requiring hazardous materials and waste transporters to obtain state license for annual fee of \$25 or single-trip of \$15 imposed a "user fee" that was not constitutionally excessive in relation to costs. It, thus, did not violate the commerce clause of the federal constitution, where record showed significant numbers of hazardous materials trucks and spills; showed hazardous material transport imposed significant costs upon state when state sought to prevent, or had to deal with, consequences of the spills; and showed state had made significant prevention, enforcement, and cleanup efforts. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

86. Burden of proving excessiveness of a user fee under the commerce clause of the federal constitution falls upon the party challenging the fee, not the state. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

87. In an action challenging a state's user fee under the commerce clause of the federal constitution, the question is the relationship between the amount the fees raise and the amount the state likely spends. The commerce clause does not require states or courts to trace individual dollars. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

88. The fact that 75 percent of the state license fees actually collected from hazardous materials and waste transporters would not be spent on hazardous materials transport did not render such fees unlawful under the commerce clause of the federal constitution, since the manner in which the fees themselves were actually spent was irrelevant in determining the constitutionality of the fees. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

89. State license fees required of hazardous materials and waste transporters reflected a fair, if imperfect, approximation of the use of facilities for whose benefit they were imposed, since relevant expenditures were those made for, or on account of, hazardous materials truckers, and there was no other group identified who in fact should have paid a portion of the fees. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

90. The commerce clause of the federal constitution does not prevent states from charging for services they provide. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

91. The fact that other states could impose license fees upon hazardous materials and waste transporters did not render state statute requiring such transporters to obtain a license invalid under the commerce clause of the federal constitution. The federal Department of Transportation could promulgate regulations pursuant to the federal Hazardous Materials Transportation Act prohibiting or controlling the imposition of excessive license fees, if the resulting system of state license fees greatly raised transport costs or seriously burdened interstate commerce. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

92. The fact that a license to transport hazardous materials and waste could be purchased only during regular office hours and, apparently, not at night or on weekends did not place state's statute requiring transporters to obtain the license in conflict with speedy transport mandate of federal Hazardous Materials Transportation Act so as to require preemption of the statute by the federal Act, since such impediment was inherent in the administration of any licensing scheme. New Hampshire Motor Transport Association v. Flynn, 751 F.2d 43 (1st Cir. 1984).

PREEMPTION

93. Within constitutional limits, Congress may preempt state authority by so stating in express terms. Absent explicit preemptive language, Congress' intent to supersede state law altogether may be found from a scheme of federal regulations so pervasive as to make reasonable the inference that congress left no room to supplement it. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

94. Even where Congress has not entirely displaced state regulation in a specific area, state law is preempted to the extent that it actually conflicts with federal law. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

95. In enacting the Atomic Energy Act, Congress intended that the federal government regulate the radiological safety aspects involved in the construction and operation of nuclear plants but that states retain their traditional responsibility in the field of regulating electrical utilities for determining questions of need, reliability, costs and other related state concerns. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

96. In view of state's avowed economic purpose behind enactment of statute conditioning the construction of additional nuclear power plants on a finding by the state Energy Resources Conservation and Development Commission that adequate means of disposal are available for nuclear waste, the statute was not preempted by congressional regulation of the field of nuclear safety. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

97. State law is preempted if it stands as an obstacle to the accomplishment of the full purposes and objectives of Congress. Pacific Gas and Electric Company v. State Energy Resources Conservation & Development Commission, 461 U.S. 190 (1983).

98. Conflicts between state and federal regulation are not to be sought out where none clearly exists. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

99. In determining the validity of state's exercise of its police power which is challenged under supremacy clause, there is an assumption that the state's powers were not to be superseded by federal statute unless that was the clear and manifest purpose of Congress. One of the legitimate inquiries is whether the Congress has explicitly or implicitly declared that states are prohibited from regulating the subject matter in question. Even if Congress has not completely foreclosed state participation in the particular area, a state statute is void to the extent that it actually conflicts with a valid federal statute and such conflict will be found where compliance with both federal

and state regulations is a physical impossibility. Ray v. Atlantic Richfield Company, 435 U.S. 151 (1978).

100. A state or city is not prevented from enforcing local laws having purposes other than purposes of the federal law. Ray v. Atlantic Richfield Company, 435 U.S. 151 (1978).

101. Inasmuch as the Secretary of Transportation has neither promulgated his own tug requirements for Puget Sound tanker navigation nor decided that no such requirement should be imposed at all, the State of Washington's tug escort requirements in its Tanker Law have not been preempted under the supremacy clause Ray v. Atlantic Richfield Company, 435 U.S. 151 (1978).

102. It is not necessary for a federal statute to provide explicitly that particular state laws are preempted. Although courts should not lightly infer preemption, it may be presumed when the federal legislation is sufficiently comprehensive to make reasonable the inference that Congress left no room for supplementary state regulation. In addition to express or implied preemption, a state law also is invalid to the extent it actually conflicts with a federal statute, and stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. International Paper Company v. Ouellette, 479 U.S. ___, 93 L.Ed.2d. 883 (1987).

103. Federal law may preempt state law in any of three ways: (1) by Congress, in enacting federal law, explicitly defining the extent to which it intends to preempt state law (2) absent express preemptive language, by Congress indicating an intent to occupy an entire field of regulation, in which case the states must leave all regulatory activity in that area to the federal government; and (3) if Congress has not displaced state regulation entirely, by preempting state law to the extent that state law actually conflicts with federal law, as when compliance with both state and federal law is impossible or when the state law stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. Michigan Canners and Freezers Association, Inc. v. Agricultural Marketing and Bargaining Board, 467 U.S. 461 (1984).

104. A provision within a federal statute that it "shall not be construed to change or modify existing state law" does not eliminate the preemptive effect of the statute on a

state law to the extent that it actually conflicts with the federal statute. Michigan Canners and Freezers Association, Inc. v. Agricultural Marketing and Bargaining Board, 467 U.S. 461 (1984).

105. In determining whether a state regulation has been preempted by federal action, the intent to supersede the exercise by the state of its police power as to matters not covered by the federal legislation is not to be inferred from the mere fact that Congress has seen fit to circumscribe its regulation and to occupy a limited field. Such an intent on the part of Congress is not to be implied, unless the act of congress, fairly interpreted, is in actual conflict with the law of the state. Huron Portland Cement Company v. City of Detroit, 362 U.S. 440 (1960).

106. Where state legislation is in conflict with federal legislation, the state legislation must fall. Kelly v. State of Washington, 302 U.S. 1 (1937).

107. State action in a matter affecting interstate commerce is not excluded, except to the extent to which Congress has exercised its paramount authority. Kelly v. State of Washington, 302 U.S. 1 (1937).

108. An exercise by a state of its police power is superseded by a federal action only where the repugnance or conflict is so direct and positive that the two acts cannot be reconciled or consistently stand together. Kelly v. State of Washington, 302 U.S. 1 (1937).

109. A state statute is not invalid where it regulates areas not regulated by the federal government. Kelly v. State of Washington, 302 U.S. 1 (1937).

110. In considering whether a state is precluded from enforcing its laws in a particular area because of federal laws based on the commerce clause of the federal constitution, the United States Supreme Court's first inquiry is whether Congress, pursuant to its power to regulate commerce, has prohibited state regulation of the particular aspects of commerce involved. Jones v. Rath Packing Co., 430 U.S. 519 (1977).

111. In a field which Congress is said to have preempted has been traditionally occupied by the states, it will be assumed that the historic police powers of the states were not to be superseded by the federal act unless that was the clear and manifest purpose of

Congress. Such an assumption provides assurance that the federal/state balance will not be disturbed unintentionally by Congress or unnecessarily by the courts. Jones v. Rath Packing Co., 430 U.S. 519 (1977).

112. Under the supremacy clause of the federal constitution, Congressional enactments that do not exclude all state legislation in the same field nevertheless override state laws with which they conflict. Jones v. Rath Packing Co., 430 U.S. 519 (1977).

113. With regard to the criterion for determining whether state and federal laws are so inconsistent that the state law must give way, the United States Supreme Court's task is to determine whether under the circumstances of the particular case, the state's law stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. Such an inquiry requires the Court to consider the relationship between state and federal laws as they are interpreted and applied, not merely as they are written. Jones v. Rath Packing Co., 430 U.S. 519 (1977).

114. A regulation must actually conflict with the Hazardous Materials Transportation Act in order to be deemed inconsistent with it and thus preempted. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st Cir. 1983).

115. A state law is void if it conflicts with a federal statute. A conflict exists where compliance with both is a physical impossibility or where the state law stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st Cir. 1983).

116. The relationship between a federal statute and a state regulation must be evaluated as the statute and regulation are interpreted and applied, and not solely as they are written. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st Cir. 1983).

117. Although a primary Congressional objective in enacting the Hazardous Materials Transportation Act would be promulgation of uniform, national standards in hazardous materials transportation, preemption of state regulations regarding highway safety is not to be undertaken lightly. Given the legitimate concern the state has for the persons and property within its boundaries, the propriety of local highway safety regulation has

long been recognized. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st Cir. 1983).

118. State highway safety regulations carry a strong presumption of validity. National Tank Truck Carriers v. Burke, 535 F.Supp. 509 (D.R.I. 1982), aff'd 698 F.2d 559 (1st Cir. 1983).

119. An ordinance prohibiting the transportation and storage of spent nuclear fuel or radioactive waste within a town is preempted by the Atomic Energy Act and the Hazardous Materials Transportation Act, because Congress established pervasive scheme of regulation under both Acts providing for federal regulation of the safety aspects of nuclear power industry, and the transportation of hazardous materials in commerce. Jersey Central Power & Light Co. v. Township of Lacey, 772 F.2d 1103 (3rd Cir. 1985), cert denied, 475 U.S. 1013 (1986).

120. The test of whether both federal and state regulations may operate or whether the state regulations must give way is whether both regulations can be enforced without impairing the federal superintendence of the field, not whether they are aimed at similar or different objectives. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

121. A holding of federal exclusion of state law is inescapable and requires no inquiry into Congressional design where compliance with both federal and state regulations is a physical impossibility for one engaged in interstate commerce. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

122. A federal regulation that is comprehensive for some purposes does not displace state regulations adopted for other purposes. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

123. A state regulation in the exercise of its historic police powers is not deemed displaced by federal law in the same area unless that was the clear and manifest purpose of Congress. Florida Lime and Avocado Growers, Inc. v. Paul, 373 U.S. 132 (1963).

124. Federal law preempts state and local law where compliance with both federal and state regulations is a physical impossibility. City of New York v. Ritter Transportation, Inc., 515 F.Supp. 663 (S.D.N.Y. 1981), modified sub nom., National Tank Truck Carriers, Inc. v. City of New York, 667 F.2d 270 (2d Cir. 1982).

125. In the absence of a direct conflict, federal law will preempt a state law which stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. City of New York v. Ritter Transportation, Inc., 515 F.Supp. 663 (S.D.N.Y. 1981), modified sub nom., National Tank Truck Carriers, Inc. v. City of New York, 667 F.2d 270 (2d Cir. 1982).

PREEMPTION -- RAIL

126. The Federal Railroad Safety Act evinces total preemptive intent and is intended to preempt field of railroad safety and authorizes Federal Railroad Administration to issue preemptive accident reporting regulations. National Association of Regulatory Utility Commissioners v. Coleman, 542 F.2d 11 (3rd Cir. 1976).

127. The Congressional mandate of Federal Railroad Safety Act to provide broad federal regulatory authority over all areas of railroad safety necessarily includes authority to fashion uniform national accident reporting requirements as well as substantive safety standards. National Association of Regulatory Utility Commissioners v. Coleman, 542 F.2d 11 (3rd Cir. 1976).

128. The savings clause in Federal Railroad Safety Act, under which states are permitted to adopt regulations to eliminate essentially local safety hazards, was designed to enable states to respond to local situations that are not statewide in character and not capable of being adequately encompassed within uniform national standards. National Association of Regulatory Utility Commissioners v. Coleman, 542 F.2d 11 (3rd Cir. 1976).

129. Regulations, under Federal Railroad Safety Act, providing nationally uniform requirements for reporting of railroad accidents to Federal Railroad Administration preempts states only with respect to monthly accident reporting requirements and does not prevent states from requiring rail carriers to provide immediate notification of accidents in order to enable states promptly to launch their own investigations, nor does

it forbid states from requiring railroads to furnish copies of monthly reports filed with Federal Railroad Administration and submission of reports. National Association of Regulatory Utility Commissioners v. Coleman, 542 F.2d 11 (3rd Cir. 1976).

PRIMARY JURISDICTION

130. The doctrine of primary jurisdiction requires the complainant first to seek relief in the administrative proceeding before a remedy will be supplied by the courts. Public Utilities Commission of the State of Colorado v. United States of America, 355 U.S. 534 (1958).

131. If an administrative proceeding might leave no remnant of a constitutional question for decision by the courts, the administrative remedy plainly should be pursued. Where the only question is whether it is constitutional to fasten the administrative procedure onto the litigant, the administrative agency may be defied and judicial relief sought as the only effective way of protecting the asserted constitutional right. Public Utilities Commission of the State of Colorado v. United States of America, 355 U.S. 534 (1958).

STANDING

132. The State of Ohio has standing to seek judicial review of a federal regulation which by its terms preempted a state statute requiring prenotification of shipments into or through the state of any large quantity of special nuclear material or by-product material. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

133. To have standing, a plaintiff must point to some harm the defendant has inflicted or is about to inflict on him, and that is susceptible to judicial remedy through an award of damages or equitable relief. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

134. To have standing, a plaintiff must allege that challenged action has caused him injury in fact, economic or otherwise. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

135. A party who shows that it has suffered actual or threatened injury as result of putatively illegal conduct of defendant has standing. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

136. Standing requires that asserted interest of a party be within zone of interests to be protected or regulated by the statute or constitutional guaranty in question. State of Ohio v. United States Department of Transportation, 766 F.2d 228 (6th Cir. 1985).

1.4.2 Law Review Annotations

1. Comment, Federal Supremacy versus Legitimate State Interests in Nuclear Regulation: Pacific Gas & Electric and Silkwood, 33 Cath. U.L. Rev. 899 (1984). This comment reviews the history of nuclear power regulation by the federal and state governments and discusses the constitutional basis for challenging state regulation on preemption grounds.

2. Thompson, The Hazardous Materials Transportation Act: Chemicals At Uncertain Crossroads, 15 Transp. L. J. 411 (1987). This article addresses the relationship between constitutional and statutory rules affecting hazardous materials transportation and the evolving common law of hazardous materials transportation.

3. Note, The Role of Localities and the Transportation and Disposal of Nuclear Waste, 18 U. Rich L. Rev. 655 (1984). This note discusses federal preemption principles as applied to the attempts to regulate nuclear transportation and disposal by Louisa County, Virginia and Spotsylvania County, Virginia.

4. Low Level Radioactive Waste Disposal Sites, 18 Gonz. L. Rev. 605 (1982-1983). This note discusses the Court of Appeals Decision in Washington State Building & Constr. Trades v. Spellman, 684 F.2d 627 (9th Cir. 1982), cert. denied, 103 S. Ct. 1891 (1983).

5. Norton, Policy Issues in the Routing of Radioactive Materials Shipments, 21 Nat. Resources J. 693 (1981). This article reviews a number of aspects of the U.S. DOT guidelines for selecting routes and reviews a number of aspects of hazardous materials routing decisions from a methodological viewpoint.

6. Montange, The Initial Environmental Assessments for the Nuclear Waste Repository under Section 112 of the Nuclear Waste Policy Act, 4 J. Envtl. L. 187 (1985). This article focuses on the requirements for the environmental assessments required under Section 112 of the Nuclear Waste Policy Act.
7. Marten, Regulation of the Transportation of Hazardous Materials: a Critique and Proposal, 5 Harv. Envtl. L. Rev. 297 (1981). This article is a description and analysis of the regulatory system for hazardous materials transportation and a proposal for reform.
8. Hogue, Regulating the Transportation of Hazardous Materials Over the Nation's Roadways, 15 Transp. L. J. 149 (1986). This article discusses the controls that have been placed upon the transportation of hazardous materials through federal, state and local legislation and formulated a number of goals that might be accomplished through legislation.
9. Goldberg, State and Local Nuclear Transportation Permit and Fee Requirements, 15 Transp. L. J. 389 (1986). This paper addresses the legality of state and local nuclear transportation, permit and fee requirements, and discusses the constitutional, judicial and administrative principles involved.
10. Giglio, Transportation of Spent Nuclear Fuel: Need for Flexible Regulatory System, 12 Envtl. Aff. 51 (1985). This article discusses the risks involved in transporting spent fuel by highway, the current federal regulatory scheme regarding the transportation of spent nuclear fuel, the balance of federal and non-federal regulatory powers, and the litigation concerning the validity of HM-164; and it evaluates the possibility of utilizing barging or shipping as a method of transporting spent fuel.
11. Cummings and Utton, Managing Nuclear Wastes: An Overview of the Issues, 21 Nat. Res. J. 693 (1981). This article discusses an overview of the issues involved in the management of nuclear waste.
12. Brown, Insurance and Indemnity Coverage for Public Liability Associated with Nuclear Materials in Transportation, 17 Forum 1326 (1982). This article discusses the Price-Anderson Act.

13. Bracken, Transportation Controls Under the Clean Air Act: A Legal Analysis, 15 B. C. Ind. & Com. L. R. 749 (1974). This article examines the efforts of Congress and the states to reduce air pollution caused by motor vehicle emissions, and it discusses the constitutionality of the Clean Air Act.
14. Note, Banning the Transportation of Nuclear Waste: A Permissible Exercise of the States' Police Power? 52 Fordham L. Rev. 663 (1984). This note analyzes whether, under the supremacy and commerce clauses of the United States Constitution, a state has the authority to impose a ban on the highway transportation of nuclear waste within its borders.
15. Comment, A Federal Regulation of Certain Bulk Hazardous Cargo: Focus on the Great Lakes, 28 Buffalo L. Rev. 795 (1979). This comment examines federal regulation of the transportation of bulk hazardous cargo on the Great Lakes so that the analysis of the problem of hazardous cargo transport may be comprehensive.
16. Trosten & Ancarrow, Federal-State-Local Relationships in Transporting Radioactive Materials: Rules of the Nuclear Road, 68 Ky. L. J. 251 (1979-1980). This article explores the constraints under the supremacy clause of the United States Constitution on state and local regulation of transportation of radioactive materials.
17. Overcast & Dively, Options for Gathering Information About Shipments of Radioactive and Other Hazardous Material, 53 Tenn. L. R. 559 (1986). This is a report of a study conducted by the Battelle Human Affairs Research Center, commissioned by the United States Department of Transportation and the United States Department of Energy, of state and local approaches to gathering information concerning shipments of radioactive and other hazardous materials.
18. Notes, Radioactive Material Transportation: Federal Regulators Pose Roadblocks To Local and State Initiatives, 35 Syracuse L. Rev. 1235 (1984). This note analyzes local and federal efforts to regulate highway transportation of radioactive material and, in particular, the preemption of local laws under the Commerce Clause and the Atomic Energy Act.
19. Comment, Preemption of Local Laws by the Hazardous Materials Transportation Act, 53 U. Chi. L. Rev. 654 (1986). This comment analyzes preemption under HMTA.

20. Cain, Routes and Roadblocks: State Controls on Hazardous Waste Imports, 23 Nat. Resources J. 767 (1983). This article explores means by which states may restrict hazardous waste imports.
21. Notes, Transportation of Nuclear Material: The Public Challenge, 11 Camden L. J. 63 (1979). The note analyzes deficiencies in the regulatory scheme and examines the constitutionality of state and local restrictions.
22. Note, City of New York v. United States Department of Transportation: Urban Radioactive Waste Transportation Gets Another Green Light, 7 J. L. & Pol'y 177 (1986). This note analyzes the Department of Transportation's actions in failing to prepare an environmental impact statement in adopting HM-164.
23. Note, The Need for Exacting Legislation Regulating the Shipment of Radioactive Wastes in Vermont, 8 Vt. L. Rev. 407 (1983). This note addresses the inadequacies of the federal regulations and the need for regulation within the state of Vermont.
24. England, Recent Regulatory Developments Concerning the Transportation of Nuclear Fuel and Other Radioactive Materials, 7 Env'tl. L. 203 (1977). This article examines the regulatory framework as it existed at the time of its publication and proceedings before the ICC concerning rail transportation of nuclear fuels.
25. Church & Norton, Issues in Emergency Preparedness for Radiological Transportation Accidents, 21 Nat. Resources J. 757 (1981). This article discusses preparedness for transportation accidents, outlining the major issues and decision areas regarding preparedness for radiological emergencies.
26. Quarles, Rail Transportation of EPA-Regulated Hazardous Waste, 17 Forum 857 (1981-1982). This article discusses the regulations with which railroad carriers must comply in order to transport hazardous waste.

The following articles address the issue of hazardous materials transportation.

27. Air Transportation of Radioactive Materials and Passenger Protection Under International Law, 5 Calif. W. Int. L. J. 425 (1975).
28. Increasing Complexity in the Regulation of Hazardous Materials Transportation, 54 Transp. Prac. J. 68 (1986).
29. International Regulation of Transfrontier Hazardous Waste Shipments: A New EEC Environmental Directive, 21 Tex. Int'l L. J. 85 (1986).
30. Preemption under the Atomic Energy Act of 1954: Permissible State Regulation of Nuclear Facilities' Location. Transportation of Radioactive Waste Disposal, 11 Tulsa L. J. 397 (1976).
31. Radioactive Material - Passenger Notice of Carriage - Injunction to Order an Air Carrier to Give Adequate Warning to Passengers When a Significant Amount of Radioactive Material Was to be Shipped on its Flights was Properly Denied Because the Doctrine of Primary Jurisdiction was Required Prior to Agency Action, 42 J. Air. L. 906 (1976).
32. Recent Developments in the Transportation of Hazardous Materials, 10 Transp. L. J. 97 (1978).
33. Regulating the Transportation of Dangerous Goods, 21 Alta L. Rev. 488 (1983).
34. Transportation of Dangerous Substances, 31 U.N.B. L. J. 135 (1982).

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2.0 SYSTEM DESIGN

2.1 VOLUMES AND TIMING OF SHIPMENTS

There really is no benchmark literature in this area. The schedule for transport of spent fuel from waste generation sites to the repository site is subject to considerable uncertainty at this time, as issues related to cask carrying capacity, consolidation, and truck/rail/barge shipment options are investigated. Recently, DOE revised its own waste acceptance schedule, beginning in the year 2003 (DOE/OCRWM June 1988).

For the development of the preferred transportation system, Nevada's Nuclear Waste Project Office has an opportunity to take the lead in identifying preferred schedules and shipment sites through application of its comprehensive risk assessment and risk management system. This could include both the identification of preferred shipment sizes and modal mix, and also preferred numbers of annual, daily, and time-of-day movements. Potential actions also include consideration of restrictions on travel during the peak hours, or through heavy employment areas during the daytime and heavy residential areas at night (Cox and Turnquist 1986). It may also be appropriate to avoid time periods when schools are either beginning or ending.

2.2 CASK DESIGN AND TESTING

Since the Nuclear Regulatory Commission, not the Department of Energy, is responsible for content of the sections of the Code of Federal Regulations controlling cask design, testing and quality assurance, most of the analytical publications on these subjects have been sponsored by NRC. Contractors performing the studies have, however, often been DOE labs or the private firms that operate DOE labs. To understand DOE's proposed transportation system as it regards cask questions thus requires examination of both DOE and NRC publications.

2.2.1 Basic Rules and Guidance Documents

The primary operant document on cask design, testing and maintenance is Part 71 of Title 10 of the Code of Federal Regulations; also known as 10 CFR 71. Entitled "Packaging and Transportation of Radioactive Material," it governs the spent fuel containers to be used by DOE for NWPAs-sponsored shipments. Written in technical terms by legal minds, its 25 pages are not easily fathomed by the non-specialist.

To ease its interpretation, NRC has issued "Regulatory Guides" that expand on such items as the "Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity and Fissile Radioactive Material" (Reg. Guide 7.9) and "Establishing Quality Assurance Programs Used in the Transport of Radioactive Material" (Reg. Guide 7.10). These Guides, in conjunction with 10 CFR 71, form the backbone of the rules on the acceptability of a cask.

DOE has recently (March 1987) issued a guide of its own for DOE certification of containers entitled, "Packaging Review Guide for Reviewing Safety Analysis Reports for Packagings." This 100 page loose-leaf book was prepared by Lawrence Livermore National Laboratory (LLNL), a DOE lab, to centralize and correct the rather loose and disjointed certification processes previously performed by DOE's regional offices. It is a readable approach to 10 CFR 71 and also guides the reader into the "DOE-Orders" that perform much the same function as NRC's Regulatory Guides, while usually shorter and limited in scope. Under the amended NWPA, DOE must use NRC-certified containers, so it is essential to understand NRC's approach to design approval. Since it is unclear, however, where DOE's responsibility for the actual casks begins, it is also essential to understand DOE's interpretation of its powers as delineated in its Orders. For example, while NRC has established rules for an acceptable quality assurance program and requires that such a program be part of the cask design's license (called a Certificate of Compliance), DOE's field offices will likely consult DOE Order 5700.6B on "Quality Assurance" should a question arise at the repository, MRS or cask maintenance facility. The DOE Packaging Review Guide appears, in its early drafts, to suggest (in at least some areas) that DOE may be striving for a more rigorous cask analysis for casks used by its own labs than NRC presently requires for casks to be used under NWPA. Such an ambitious step may lead to confusion and conflict on the proper safety level for NWPA shipments. In light of DOE's poor past safety performance at its own facilities, this may also be unrealistic.

2.2.2 Analytical Documents

Many studies have been published by NRC and DOE concerning specific topics related to casks, e.g., leak tightness of seals or fracture resistance. No one study focuses sufficiently on cask questions to give a full background on the issues. Three studies stand out, however, in their overviews of the interrelation between cask design and testing standards, and real world conditions. "An Assessment of

the Risk of Transportation of Spent Nuclear Fuel by Truck" (DOE November 1978) is unique in its effort to quantify the effects not only of severe accidents, but also of cask design variations, mechanical failures, and human error. Some of its assumptions are dated now (e.g., use of 150-day-old-fuel), and others have been proven erroneous (e.g., likelihood of certain problems was underestimated); but its general approach is good. For example, it examined an idealized cask's response to fires longer and hotter than the regulatory standard, developing some possibilities that have yet to be answered by subsequent analyses (e.g., the danger of a release may be greater after a fire is out than during the blaze because of the delayed transfer of heat to the fuel in the cask). PNL-2588 also attempted, via somewhat unprofessional surveys, to determine the incidence of various types of human errors in cask maintenance. It is the only federal study to have made this effort. Thus its somewhat amateur analyses then became the bases for later studies (e.g., in NUREG/CR-0743) of human error.

A second document of note is "Shipping Container Response to Severe Highway and Railway Accident Conditions" (NRC February 1987). The "Modal Study" is the NRC's most recent effort to reassure the public that the casks would have survived intact even if involved in the worst actual accidents to occur in recent U.S. history. Via computer simulations of an idealized, perfectly manufactured and maintained cask, the LLNL authors concluded that the present test parameters (e.g., 30-minute fire at 1475 degrees F) were sufficient to guarantee containment in over 99% of all accidents. Careful examination of this study indicates that too many simplifying assumptions may have been made. For example, the Caldecott Tunnel gasoline fire in 1982 was assumed to last a total of 40 minutes in the simulation. While it is true that the fire may have equaled or exceeded the regulatory standard temperature for about 40 minutes, it actually lasted significantly longer. Since a cask surface would not have reached the flame temperature still prevalent after 40 minutes, heat transfer into a cask could have continued until the fire was extinguished; fully an hour later. Other questions of this study (which is being distributed in a simplified booklet form) have arisen concerning its peer review by Denver Research Institute, an organization with no background in the handling of radioactive materials. While a useful analysis of the response of a perfect container to an approximated reality, this study needs in-depth, independent confirmation prior to further acceptance or use.

The third study of note is "A Scoping Study of Spent Fuel Accidents" (NRC June 1979). A remarkably candid document on what is needed to properly assess cask responses to severe accidents, this study attempted to quantify the level of knowledge, and ignorance, presently held in this area. It concluded that much more needs to be done in the manner of analysis and actual tests, to support present federal conclusions about cask safety. Since little has been done over the past 9 years to fill the gaps revealed by this study, it is still substantially accurate although it is occasionally based on overly conservative assumptions (e.g., 150-day-old-fuel). It is essential reading for those who may be swayed by the idealized technical analyses that form the basis for DOE and NRC claims about the risks involved in spent fuel shipments.

2.2.3 DOE Versus Preferred Transportation System

There are four areas in which major differences exist between the DOE planned transportation system and the preferred system:

- Enhancements of test standards, design methodologies and testing methods,
- Design improvements to reduce human error,
- Tracking equipment utilization or problems, or fuel assemblies, and
- Use of non-federal personnel in overseeing parts of the plan.

In general, very few of the available formal studies address these differences. Most of them support the existing methods and standards. This is not surprising since most do not pay any attention to the critiques from either inside or outside of the nuclear industry. To do so would admit that the status quo, which many of the authors and their labs helped to create, had serious deficiencies. Thus a situation such as that which existed prior to the Three Mile Island accident prevails in the area of nuclear transportation (i.e., everything would be fine if only the critics would just be quiet).

There have been a few studies that do question specific aspects of the design or testing standards. The present puncture analysis method is criticized in NUREG/CR-0930 and the magnitude of a crush environment is found to exceed the test standard by NUREG/CR-1588. Failures in manufacturing are discussed in SAND-79-1424 and SAND-78-0309. Ways to avoid steel fracture are covered in

NUREG/CR-1815. For the most part, however, the bases for pressing for improvements in design and testing can be best understood by starting with the following studies and utilizing the references cited by them. Many of these are internal or unpublished documents not generally available.

- The Next Nuclear Gamble: Transportation and Storage of Nuclear Waste by the Council on Economic Priorities.
- Transportation of Hazardous Materials by the Office of Technology Assessment.
- A Review of the Effects of Human Error on the Risks Involved in Spent Fuel Transportation by the Nebraska Energy Office.
- Report to the President by the Interagency Review Group on Nuclear Waste Management by the U.S. Department of Energy (the IRG study).
- Social and Economic Aspects of Radioactive Waste Disposal by the National Research Council.

The validity of the critiques is based on the collection of many isolated items from numerous sources, not on any single major study. The best sources for such items are obtained through analysis of the dockets on existing casks certified by the NRC and DOE. Such data is maintained in the document rooms of these agencies in Washington, D. C. and is obtainable either by specific document purchase from the agencies or under the Freedom of Information Act (FIOA).

The need to track equipment utilization is based specifically on the records of the NAC-1 and IF-300 casks, the workhorses of the nuclear industry (most spent fuel shipments used the seven NAC-1 casks or the four IF-300 casks). The history of the NAC-1 is documented in NRC docket no. 71-6698 and is synopsized in The Next Nuclear Gamble. Aspects of the IF-300's story are discussed in the Review of the Effects of Human Error and detailed in docket no. 9001. Fuel assembly problems have also been caused by manufacturing deficiencies. Discussions of these problems often show up in annual studies of fuel utilization by both NRC and DOE. Such studies are available from those agencies, but are not in a form easily useable by the lay reader. Professional papers are the best starting point to an understanding in this area.

The use of non-federal personnel is covered in the CEP, OTA, and IRG studies, as well as several NRC-sponsored studies of radioactive materials transportation in

individual states. Most convincing evidence in this area, however, comes from action notices and press releases covering problems in container contamination found by state personnel in states having low-level nuclear waste dumps (i.e., Washington, South Carolina, Nevada). These documents are mentioned in the NRC Weekly Bulletin and background is obtainable via specific document purchases and the FOIA.

2.2.4 Sufficiency of Existing Data Sources

A recent Congressional publication sheds some interesting light on past problems with cask design, construction and maintenance. In response to criticisms of existing spent fuel casks, NRC, DOE and DOT were asked by a Congressional committee for details and comments. The "Hearings before the Subcommittee on Surface Transportation on the Transportation of Hazardous Materials, April-May, 1987" covers the withdrawal, or restriction, from service of numerous casks used over the past two decades. Of note in these proceedings is the different way in which each agency treats the same facts regarding container design, testing and use. It is obvious that the analytical approaches of these three certifying agencies are not equivalent; as prescribed by federal regulations. It is also obvious that the communication of facts between levels of the same agencies and among the different agencies is spotty or non-existent. This leads to the conclusion that studies and their reviews of cask-related subjects may also be lacking in depth. This suspicion is borne out by inconsistencies between technical studies and between analytical methods involved in cask designs, plus the almost total ignorance of actual cask problems by those responsible for quality assurance programs. The value of official data sources in decision-making is therefore quite limited.

There is thus a need for more thorough research and presentation of the unpublished documents that form the basis of the critiques of the DOE's planned system. To successfully confront the supporters of a technical status quo has, in the past, required a major accident, usually involving loss of life and property. The hazards of nuclear materials do not allow the "luxury" of such proof of deficiencies. It is therefore essential that the basis of the preferred system be better documented through the following actions:

- More thorough research of studies in related industries (e.g., other hazardous materials transportation cases);

- Develop probabilistic risk assessments and perform simulated and real accident tests that include examples of human error and equipment/fuel failures in order to quantify their impact;
- Perform a thorough review of foreign experience and innovations in this area to demonstrate the opportunities and methods to improve the existing situation.

Comparison of the results with those of the past formal studies will show the value of better design, testing, inspection and maintenance of the containers, fuel and equipment.

2.3 MODAL MIX

Modal mix and truck and rail shipment options under consideration are unique to the DOE repository program. Consequently, there exists little external literature relevant to these subject areas. The principal literature on these issues appears in DOE position statements and DOE contractor reports (DOE 1986).

While the studies of rail and truck shipment options provide some operating detail and potentially usable information in defining various vehicle configurations under consideration, DOE's treatment of modal mix has been superficial. Consequently, it is expected that although salient aspects of the DOE effort will be utilized in developing the preferred system, much new development effort, particularly for examining modal mix, will be needed. The interrelationship between modal mix, routing and shipment volume as key decision variables in the preferred transportation system must be recognized in the context of this effort.

2.4 ROUTING

Routing decisions have significant implications on the level and distribution of societal risk associated with hazardous materials shipments. In a formal sense, this involves the selection of paths through the transport network connecting the shipment origin and destination (Abkowitz and Cheng 1988; Saccamanno, Aerde, and Queen 1987). The criteria may include avoiding high accident locations, highly populated corridors, or congested areas, including highway reconstruction sites where traffic concentration is expected to be heavy. In most if not all cases, a tradeoff exists between societal risk

and carrier cost. Routing decisions are likely to increase the length of haul for the carrier, which will serve to raise the shipment cost.

Route selection has been a primary focus for hazardous materials and an issue of lesser concern for hazardous wastes, except radioactive wastes (NRC 1977; Neuhauser, Cashwell, Reardon, and McNair 1984). For hazardous materials, the techniques involve simple decision rules based on minimum "cost" paths (Brogan and Cashwell 1985; Joy, Johnson, Fore, and Peterson 1984). Many routing studies have been patterned after a methodology developed by Barber and Hildebrand (1980) for the Federal Highway Administration (FHWA). Unfortunately, these approaches do not reflect an attempt to spread the flows and reduce the additive risks of concentrating flows on a limited number of links. Also, the use of average values ignores the spectrum of consequences that can result as well as the "risk profile" attached to shipping a given commodity via a given route.

This suggests an immediate need for more fundamentally sound routing methodologies. A key element in this process is the notion of perceived risk (as opposed to technical risk) and the major role this difference plays in the route evaluation process. Our society appears to be risk averse. This is revealed in public surveys which indicate that the perception of risks involved in a hazardous materials transport shipment generally exceeds that of the technically-measured risk. Hence, risk evaluation functions are typically non-linear and convex. This means that larger consequence incidents, and sometimes even greater accident frequencies, are given a disproportionately heavier weight than the smaller ones. Despite this phenomenon, most route selection methods have characterized risk and expected consequences by linear objective functions. Thus, development of the preferred system will require some fundamental development of improved routing methodology. Principal areas of development should focus on non-linear route optimization techniques and the implications of imposing risk equity constraints.

2.5 EQUIPMENT AND VEHICLE STANDARDS

One major research emphasis has been concern for the balance between vehicle design considerations and the maintenance of weight limitations corresponding to the vehicle weight and payload (cask). DOE has initiated efforts to study removal of "non-essential" items from the basic operating system in favor of boosting carrying

capacity. The effects of human factors on safe operating performance have also been considered in this regard, with implications from noise, temperature, vibration, cab configuration, and braking systems. Most recent attention has been focused on standards related to safe truck operations. Definitive pieces in this area have recently been completed by Battelle (Abkowitz, Abkowitz, and Lepofsky September 1988) and the Office of Technology Assessment (OTA September 1988).

As it relates to the preferred system design, however, neither DOE nor any other organization has gone much beyond the stage of Issue Identification. It is expected that further development will take place in this area as modal mix, and truck and rail shipment options become more clearly identified.

2.6 INFRASTRUCTURE

A starting point for evaluating the impact of transporting the HLNW to Yucca Mountain on Nevada's highways is an inventory of the routes that might be used to transport the spent fuel. Much of the required data can be obtained from the Nevada Department of Transportation. Information required includes the volume capacity of the routes, the condition of pavements and bridges and the cost for maintaining, rehabilitating and constructing new facilities. The Highway Capacity Manual is the guide for performing highway capacity analysis. An impressive amount of research has been conducted in the development of new materials and technology to design, construct and maintain bridges. Numerous publications discussing pavement management, surface treatments, performance, rehabilitation and design are available. Also, economic assessment models have been developed to evaluate the cost of maintenance, rehabilitation and reconstruction of existing facilities and construction of new facilities.

2.6.1 Data Bases

The Nevada Department of Transportation maintains a considerable volume of useful highway information. However, not all of the data required for impact analysis or system management is assembled in a central data base. Information is maintained by several divisions within NDOT. Some of the data is in the form of logs, and is readily available. Other information must be obtained from construction plans.

The NDOT Research Division can provide data on the width and number of lanes for federal aid and state routes in the form of multiple log books. Information

regarding the thicknesses of pavements can be obtained from the Research Division. However, this information is contained in the construction plans and is not readily available. Information regarding horizontal and vertical curves, grades and passing-sight distances are not readily available either.

The Research Division publishes several useful documents. The Federal Aid Urban Route Log (NDOT Urban System 1987) contains the description of all routes that are on the Federal Aid Urban System. The log gives information on road type, road width, number of lanes, mileage, year of last construction and 1990 functional classification. The functional highway classification is defined as the character of service the routes are expected to provide in 1990. Bridges and overpasses are included, if they are at least 20 feet long. The Federal Aid Primary Route Log (NDOT Primary Routes 1987) contains the descriptions of all routes in the Federal Aid Primary System. The total mileage of this system is 1,875. The log gives information on road type, road width, number of lanes, mileage, year of last construction and 1990 functional classification. Bridges and overpasses are included, if they are at least 20 feet long. The Federal Aid Secondary Route Log (NDOT Secondary Routes 1987) contains the descriptions of all routes in the Federal Aid Secondary system. The total mileage of the secondary system is 2,361. The log gives information on road type, road width, number of lanes, mileage, year of last construction and 1990 functional classification. Bridges and overpasses are included, if they are at least 20 feet long. The Federal Aid Interstate Route Log (NDOT Interstate Routes 1987) contains the descriptions of all routes in the Interstate System. The log includes routes under construction and proposed Interstate alignments. The log also indicates if the Interstate is under federal, state or local domain. There are 545 miles of Interstate highways (including under-construction and proposed miles) in the state. This log also gives information on road type, road width, number of lanes, mileage, year of construction and 1990 functional classification. Bridges and overpasses are included, if they are at least 20 feet long.

The Structure Division has structural information on bridges, culverts, dams, etc. The Structure Index by Routes (NDOT) gives structural information on the federal aid interstate routes, primary routes, secondary routes, urban routes, state aid routes and frontage roads. The structures included in this log are: bridges, culverts, dams, railroad-grade separation structures, highway-grade separation

structures which are not interchanges, interchange structures, including ramps, multiple pipes, pedestrian structures, sign structures, and tunnels. The log gives the structure number, location (name and milepost), type, length, horizontal clearance and capacity.

The Traffic Division has traffic data. The 1986 Annual Traffic Report Permanent Traffic Recorder Telemetry System report (NDOT) contains traffic data collected between October 1985 and September 1986 at 2,475 stations on Nevada's various systems of highways. These data were collected with portable machines. Annual daily traffic volumes were also collected with automatic traffic recorders at 34 stations. In addition, manual counts were taken at 39 sites which produced vehicle types for various road sections throughout the state. The data are presented in two ways: 1) Tables show annual average daily traffic for all vehicles, Nevada vehicles, other state vehicles and trucks, 2) Maps show the location of the counting stations and the annual average daily traffic for all vehicles. Other important information contained in this report is the 30th highest hour which is a tool used in design. It represents the volume the highway needs to accommodate. It is used to determine pavement widths and other geometric features.

The Materials Division can provide information on pavement conditions. The Safety Engineering Division can provide data on accidents. One publication of the NDOT Safety Engineering Division is Nevada Traffic Accidents (1986). It presents statistical data of all motor vehicle traffic accidents that occurred in Nevada during 1986. The report includes graphs and tables showing various relationships affecting traffic accidents.

The Planning Division can provide maps of all of the highways and forecast traffic demand for some highways. This division also keeps information regarding the weight of trucks travelling through Nevada. Nevada's Maps of Federal and State Highway Systems (NDOT 1986) includes all the Interstate highways, federal aid primary, secondary and urban highways and SAR in Nevada. The roads maintained by NDOT are clearly shown on the maps. Maintenance stations are also marked. All of the Interstate highways, U.S. routes, state routes and roads not maintained by NDOT are found in Nevada's Maps of Milepost Locations on Federal and State Highway Systems (NDOT 1985). The maps are arranged by counties. Much of the

information kept at NDOT is given by milepost locations. Therefore, it is necessary to have this publication as reference.

The Nevada Map Atlas (NDOT) shows the State of Nevada divided into Quadrangles, each approximately 800 miles square. All of the highways are clearly labeled as well as cities and towns. The Planning Division also publishes the Level I Technical Report Las Vegas Metropolitan Area Transportation Study Plan. This report has information regarding number of lanes, lane width, present ADT, forecast traffic demand, maintenance needs and costs.

Other useful information is contained in the Clark County Department of Comprehensive Planning CCRIS Data Base Documentation. This report has information about the geographic resource inventory and automated data base developed by Environmental Systems Research Institute for Clark County.

2.6.2 Pavements

The anticipated increased volume of trucks transporting nuclear waste needs to be evaluated for impacts on highway safety and structural capacity. Using the projected traffic data, the time of reconstruction and rehabilitation of roads and bridges should be estimated and the most cost effective combination selected. There are a number of publications which deal directly with the policies concerning the conditions of pavements.

NDOT has established procedures on the rating of pavement conditions (Materials Division, 1982 and 1983). These procedures are a detailed means for conducting visual surveys of pavement conditions and should be used in the evaluation of pavements considered for shipping the nuclear waste. This would ensure a continuity of information used by various state agencies and would allow any future studies to use the existing data base which dates back to 1980. In addition, the Maintenance Management System Manual of Instructions (Maintenance Division, 1980) provides guidelines on the types of maintenance to be performed for various types of pavement distress. This manual provides a data collection, storage and analysis system to monitor, control, evaluate and improve a large number of elements in the maintenance program. Again, any future work should use the existing MMS for a starting point to provide continuity.

Although NDOT has the necessary pavement management and maintenance management systems, it would be desirable to review the procedures and policies in force to examine if any improvements can be made. NCHRP Report No. 215 could be used as a starting point in this process. The analysis of the pavement management system development and implementation could be compared with the existing NDOT documents to see whether an expansion or improvement of the NDOT methods are warranted. Information in Transportation Research Record Nos. 814 and 846 could also provide good comparisons for the NDOT procedure. These reports contain papers describing pavement management systems, rehabilitation, and resurfacing of concrete pavements; and discussions of pavement monitoring programs, load restrictions and permits, and priority programming for maintenance and rehabilitation of pavement networks. It should be emphasized that the NDOT system has been in existence for eight years and the information collected needs to be retained in a usable form. A review of the NDOT MMS can be done using information in Transportation Research Record Nos. 846 and 1117 which discuss pavement evaluation and rehabilitation.

Existing pavement inventory and condition data bases at the city, county, and state levels provide an excellent starting point for evaluating the infrastructure impact of nuclear waste shipments through Nevada. While these are fairly comprehensive in scope, some improvements could be made in the level of information available. For instance, additional information on construction records, roadway geometrics, roadside characteristics, and drainage conditions should be available in a computerized format which can be used interactively with the inventory and condition data. Also, an attempt should be made to standardize the format of all pavement data at the various governmental levels.

Since the proposed shipments may include vehicles with unusual axle configurations as well as being overweight, it may be difficult or impossible to assess their impact with existing analytical procedures. This implies that a more rational pavement design process is needed. NCHRP Synthesis No. 116 presents methods for rationally designing flexible pavement overlays to strengthen existing pavements. Transportation Research Record Nos. 1007 and 1136 present methods of applying the newest concepts in pavement design for expected loads. Kim et al. (1988) have researched the impact of high pressure tires on Oregon roads. Forsythe et al. (1988) presented a new method for evaluating the economics of incremental or

stage-by-stage construction of pavements to improve structural capacity. The results of this study show that considerable savings are possible on the cost of initial structural sections by using incremental pavement design. Deficiencies and problems with existing empirical and mechanical design procedures prompted a different design approach.

2.6.3 Pavement Performance Models

Pavement performance models are specific to particular regions or environments as well as types of pavements. Given that performance models have not been developed for Nevada, it is apparent that this is a critical area for evaluating the impact of a nuclear repository. The development of models in other parts of the U.S. and world should provide guidelines for Nevada. Climatological factors in Nevada affecting pavements have been identified by Fraser and Newcomb (1987). This report is a reference guide to the various climatological factors affecting the performance of rigid and flexible pavements in Nevada's highways. Data were compiled from 68 weather stations throughout the state to develop the climatological maps.

The development of simplistic pavement performance equations for different types of construction could follow the method outlined by Mahoney et al. (1988). Regression equations were developed for three pavement surface types: bituminous surface treatments, asphalt concrete and portland cement concrete. The equations predict pavement condition rating which is a measure of pavement surface distress. The Washington State DOT Pavement Management System data base was used.

Another approach used by Seeds and Medus (1988) is considerably more complex, but addresses the problem of nonstandard loads. Kim et al. (1988) also examine performance in the context of higher tire pressures. Additionally, Transportation Research Record No. 888 presents approaches used by engineers in rationally modeling the performance of pavements. This compilation of 11 papers addresses joint and thickness design on prestressed pavements, structural performance models and structural design analysis of flexible pavements.

2.6.4 Bridges

The Bridge Department at NDOT keeps information regarding the structural adequacy of bridges. The substructure as well as the superstructure are inspected

and rated periodically. The ratings of all bridges are contained in the Bridge Sufficiency Rating. The Bridge Sufficiency Rating contains information regarding the condition of the bridges in Nevada. The bridges are rated according to a formula using: 1) structural adequacy, 2) serviceability and 3) essentiality for public use.

For development of the preferred transportation system, it will be necessary to review the procedures used for rating bridges. If deficiencies are identified, methods would need to be developed to evaluate these deficiencies. It would also be helpful to develop a bridge management system. NCHRP Report No. 300 could be used to implement such a system. This report shows the findings of a study undertaken to describe the elements of a network-level bridge management system and defines the concepts for its implementation.

If overweight trucks are used to transport the radioactive materials, some bridges may have to be strengthened. In assessing the strengthening needs of bridges, information found in Transportation Research Record No. 1118 could be helpful. This publication contains 14 papers addressing topics such as design, needs and performance of bridges ranging from bridge design and fatigue behavior to bridge strengthening needs. Standard Specifications for Highway Bridges (AASHTO 1983) provides specifications that are used for the design and analysis of bridge structures. The specifications contain information about design method, materials, loads, foundations, retaining walls, culverts, railings, etc. The Manual for Maintenance Inspection of Bridges (HSBS 1983) serves as a standard to provide uniformity in the procedures to determine the physical condition and maintenance needs of highway bridges.

2.6.5 Economic and Other Information

The cost of increased maintenance, rehabilitation and reconstruction of existing facilities and the construction of new facilities need to be determined. Guidelines for conducting these types of cost analyses have been developed for the Corps of Engineers at the University of Nevada-Reno. These guidelines are based on a U.S. Department of Transportation report entitled Economic Analysis of Airport Pavement Rehabilitation Alternatives: An Engineering Manual. The NDOT Design Manual (1986) establishes uniform policies and procedures to be followed by the Roadway Design Division for the design and preparation of plans. Also important

is the Highway Capacity Manual from the Department of Commerce (1986). Two key Nevada documents are the Short Range Transit Plan, Clark County, Nevada (Clark County Regional Transportation Division 1987); and the Final Report, Regional Transportation Plan (Regional Transportation Commission and NDOT 1987). The Transit Plan contains information regarding the changes that are taking place in transit service in the community as a result of rapid development in the county. It presents an update of on-going transit projects in the City of Las Vegas, and it shows alternative plans for system expansion with recommendations by the RTC. The Regional Transportation Plan identifies short-range and long-range transportation projects needed to respond to the future mobility needs of the Las Vegas Valley.

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3.0 OPERATIONS

3.1 KEY REPORTS

A Guide for the Inspection of Radioactive Material Shipments by Motor Vehicle or at Freight Facilities (DOT RSPA 1984) provides a uniform procedure for applying the Federal hazardous materials regulations contained in Parts 171-179 of 49 CFR. It is designed to serve as a basis for radioactive materials inspection and may be modified by states (etc.) to fit their regulations. It may also be used by carriers to develop their own inspection procedures. The procedure may be used for training purposes or as an aid to the actual inspection process.

The procedure is broken down into six steps, setting forth the sequence of critical items that should receive coverage. Color-coded to each step is a guide containing the specifics of each area. It is intended that the user conduct an inspection one step at a time in order to reduce confusion. The six steps encompass the following areas:

- 1) Shipping papers
- 2) Packaging
- 3) Markings
- 4) Placarding
- 5) Highway requirements
 - o Routing and training
 - o Loading requirements
 - o Vehicle contamination restrictions
 - o Securing, blocking and bracing

Pictorials, graphics, and indicators of inter-relationships are used throughout the guide to increase understanding of the total inspection coverage. The document is top-bound and indexed to facilitate its use with a clipboard. There is also an appendix listing possible violation citations and their basis in 49 CFR.

Neuhauser et al. analyzed the relative costs and risks of transporting nuclear wastes to the nine candidate repositories which were under review as of 1984. The calculations, vis-a-vis older assessments, reflect new programmatic assumptions about cask and repository capacities consistent with the environmental assessments written in response

to the Nuclear Waste Policy Act. The absolute values cannot be taken as precise indicators, but on a relative scale, the values can be seen as reflecting the comparative risks of transportation to the alternative sites.

Results of this study are reflected in the environmental assessments. This document provides additional technical details not discussed in the assessments. Those responsible for mode choice and route selection should treat this document as prior art and an officially-recognized methodological approach to the assessment of transport risk for high-level radioactive waste shipments.

A Review of the DOT Regulations for Transportation of Radioactive Materials (DOT RSPA 1983) focuses almost entirely on what shippers must do to prepare radioactive shipments for transport. Its admonitions to carriers are perfunctory at best. As the document thus illustrates, there is a general lack of quality and consistency in the guidance being provided by DOT to the carriers, present and future, of spent nuclear fuel.

NRC's Advance Notification of Shipments of Nuclear Waste and Spent Fuel (1982) is intended to describe an acceptable method for carrying out the advance notification rule for shipments of high-level radioactive waste as specified by 10 CFR 73. It specifies 1) when notification is required, 2) what parties must be contacted, 3) what filing dates pertain, 4) what information must be provided, 5) the format to be used, and 6) advice regarding complex situations where the guidelines do not seem to apply (an example of this might be the DOE shipments because of the magnitude and duration of the shipment campaign).

Shippers and carriers should use it as a reference document for developing their own advance notification procedure and form. Assuming advance notification is provided for the most part electronically during the shipment campaign, this document provides a starting point for development of a record layout and/or a communications protocol for the information transfer. The document is not a substitute for 10 CFR 73, but provides a suitable starting point for development of a reporting protocol that does embody the requirements of the regulations.

Another document addressing notification of shipments was developed by Dively et al. in 1985. This 167-page document describes federal, state and local notification

requirements for radioactive material shipments as well as other types of hazardous materials, including wastes. Both pre-notification and reporting requirements are encompassed.

The report begins by identifying and summarizing federal, state, and local notification requirements: purpose and use of information, geographic distribution, date of adoption, commodities covered, shipments covered, timing of notification, form of notification, information required, parties involved, degree of enforcement, implementation costs, and carrier and shipper impacts. The notification requirements of the U.S. Nuclear Regulatory Commission (NRC) and 14 states, localities, and facilities are subsequently examined in more detail. Finally, conclusions are drawn about the extent, purposes, uses, and impacts of state and local notification requirements.

There are a number of useful documents that address issues surrounding HLNW transportation. Chapter Five of DOE's Yucca Mountain Environmental Assessment (DOE 1986) addresses the expected impacts of transportation activities, and Appendix A outlines the transportation envisioned circa the date of the report (May 1986). The document is particularly useful because of its summary of the regulations related to shipment activities and its description of the risk assessment process used by DOE to evaluate the relative merits of the candidate sites.

RADTRAN III (Madsen et al. 1986) describes the model which has historically been used by DOE to evaluate the risks associated with specific shipment routes for spent nuclear fuel and other types of high-level radioactive waste. It has been challenged numerous times, especially in light of the fact that it ignores actual population densities and land uses along the route. Instead, it relies on impact models based on California data and estimates of the percent route miles in urban, suburban, and rural conditions.

State and local governments need to be familiar with the model so they can determine if its assumptions understate the impacts to be expected on specific routes. Carriers also need to understand its strengths and weaknesses so that they can evaluate 1) the "official" measures of risk attributed to any route and/or the 2) relative strengths and weaknesses of any other model used in place of or in addition to RADTRAN III in evaluating the risks of various routing alternatives.

Sandoval et al. (1981) examined the risks of radioactive release from spent fuel shipping casks due to sabotage. Their report describes the results of a program designed to provide an experimental database for estimating the radiological consequences from a hypothetical sabotage attack on a spent fuel shipping cask. The primary objectives were 1) to evaluate the effectiveness of selected high energy devices in breaching full-size spent fuel casts, (2) to quantify and characterize relevant aerosol properties of the released fuel and 3) to use the resulting data to evaluate the radiological health consequences of a hypothetical sabotage attack on a spent fuel shipping cask in a densely populated area. Both sub-scale and full-scale tests were conducted.

The results showed that previously held theories regarding the consequences of such attacks greatly overestimated the impact of malevolent acts directed at spent fuel casks. Their work has become a credible "worst case" statement defining the anticipated results of such an event which is well beyond any expectation of cask failures in accident environments. The program provided significant new information on the behavior of spent fuel and surrogate materials under severe shock and thermal environments. These now serve as the basis for a better understanding of spent fuel transport risks and safety analyses.

Carriers and DOE should use this document to determine expected risks from sabotage and to evaluate the safety of alternate routes. They can also use it as a guide for determining the level of risk associated with any unplanned stop, whether of a truck or rail car, so that appropriate safeguard countermeasures can be taken.

Two reports which describe experiences with spent fuel shipping are: (1) Analysis of Illinois Spent Nuclear Fuel Vehicle Inspection and Escort Program (Nash and Schilling 1985) and (2) Recent Spent Fuel Shipment: A Case History (van Hoomissen et al.). The Illinois Program report provides an unbiased presentation of the program's experience, draws from it lessons that might be applicable to other states, and identifies implementation issues. Conclusions are drawn from an analysis of inspection forms and written materials, supplemented by a series of interviews with persons involved in the program.

The study revealed that on-the-road truck inspections had not identified problems with radiation safety as of the date of the report. Safety aspects identified were primarily routine problems such as leaking air brakes. Other observations pertained to the

internal efficiency and effectiveness of the program. A need for constant retraining was identified, attributed by the authors to the cyclical nature of the shipping campaigns, staff turnover, and the use of staff whose primary responsibilities were in other areas. Government shipments were particularly difficult to handle due to their use of different standard operating procedures.

Communications were hampered because the program involved too many agencies, in the opinion of the report's authors. They also observed that the program required delicate handling from an administrative standpoint because of the many agencies involved. Some people interviewed seemed to question whether the program had provided a substantial increase in the safety of spent fuel transportation. Regardless, there was widespread agreement that the program was a reasonable and cost-effective response to public concerns relative to other possible actions.

The case history by GE Company is one of very few written records of spent fuel shipment in the public domain. It describes how the shipment plan was developed, public acceptance was established and the shipment accomplished.

The document should serve as a basis for developing plans and procedures for shipping the high level wastes to Yucca Mountain. Obviously, certain facets of the plan described will need modification to fit appropriately with the magnitude and character of the shipment campaign anticipated. These changes will include more efficient ways to deal with the large volumes expected, eliminating redundancy in notification, escort protection requests, and schedule announcements, among other issues.

Preliminary Description of the Transportation Operations System (ORNL 1988) presents a preliminary description of the transportation system DOE plans to use to ship spent fuel and high-level waste from waste generator sites to authorized waste receiving facilities. It identifies the activities and system components necessary to provide complete transportation capability. It is intended to be a project-level working document which facilitates a dialogue for further identification of system elements and functional requirements. Section 2.0 focuses on requirements which must be met for the operating plan to be acceptable. Section 3.0 describes the chronology of events expected to occur

for a typical shipment. Section 4.0 describes the facilities, equipment and services which will be needed. These include:

- Facilities
 - o Operations control center
 - o Emergency response center
 - o Cask maintenance facility
 - o Training center
 - o Fleet maintenance facilities
 - o Intermodal transfer facilities
 - o In-transit contingency facilities
 - o Supply facilities
- Equipment
 - o Casks
 - o Transport vehicles
 - o Ancillary transport equipment
 - o Cask handling equipment (load, unload, transfer)
 - o Communications gear
 - o Monitoring equipment (hardware and software)
- Services (presumably one or several private contractors)
 - o Development/delivery of the system
 - o System operation

Section 5 presents a detailed description of the activities anticipated during system operation: 1) empty cask dispatching, 2) transport of casks to load points 3) handling at the load points, 4) movement to the repository or MRS facility, 5) intermodal transfer, 6) delivery to the repository or MRS, 7) handling at the repository or MRS, 8) release from the repository or MRS, and 8) maintenance of casks and other equipment at designated facilities.

While preliminary in nature, the report serves as a starting point for development of a system operating plan. To illustrate one shortcoming, the authors have not yet recognized that handling of the HLNW cars may not quite be "business as usual" for the railroads. Two cars simultaneously waiting for the same outbound train may not be able

to travel together. Section 49 CFR 174.89 stipulates that a car placarded "radioactive" may not be placed next to any other placarded car (other than one placarded "combustible"), an engine, occupied caboose, or carload of undeveloped film. This means that radioactive cars waiting for the same train cannot travel side by side even though they may be going to the same destination. Other cars will have to be interspersed or additional blocks created, containing perhaps just one car each (i.e., the second radioactive car). Also, at the destination yard, radioactive cars will have to be delivered to the repository one at a time or the cars will have to be separated from one another in the local (train) by cars going to other destinations. This makes operation of the local inefficient.

Details yet to be addressed include:

- o Procedures for dealing with defective rail cars when problems are found upon interchange to another railroad,
- o Rail car handling in yards, especially security and safety concerns (e.g., making sure a radioactive car is not standing next to another placarded car while in the yard),
- o Similar handling restrictions for trucks parked at truck stops,
- o Safeguards for sabotage attempts, etc., and
- o Procedures for dealing with unplanned stops.

All that is said about these items is that "specific requirements for the transportation operations system will be defined by the institutional program and will result in the development of specific procedural directives and supporting equipment needs, including communications, as well as emergency response arrangements and training with state and local governments" (p. 5-43).

The Transportation Institutional Plan, draft and final reports (DOE/RW-0031, 1985 and DOE/RW-0094, 1986) describe relevant regulations, agency responsibilities and various institutional structures relevant to HLNW shipping. The draft is a preliminary version of the final Transportation Institutional Plan (DOE/RW-0094). Of special note is Appendix A (Attachment 1) which contains a detailed discussion of the Federal agency responsibilities and regulations applicable to the shipment of spent nuclear fuel and other high-level radioactive wastes. Cited are the Department of Transportation (49 CFR 172, 173, 174, 176, 177; 33 CFR 1; 23 CFR Chapter 1; 46 CFR; and 49 CFR

Chapters 2, 3, and 5), the Nuclear Regulatory Commission (10 CFR Parts 9, 19, 20, 51, 71 and 73; and 19 CFR Part 21), the National Transportation Safety Board (49 CFR Chapter 8), the Interstate Commerce Commission (49 CFR Chapter 10, Subchapter D), the Federal Emergency Management Agency (44 CFR Chapter 1) and the Environmental Protection Agency.

The document also outlines memoranda of understanding that exist among the federal agencies (Attachment 2). For example, 44 Federal Register 38690 outlines the delineation of responsibility between DOT and the NRC. DOT is responsible for regulating safety in the transportation of all hazardous materials, while the NRC is responsible for regulating safety in receipt, possession and transfer of radioactive materials. DOT regulates carriers of radioactive material and the conditions of transport (e.g., routing, handling and storage, vehicle requirements and driver requirements); whereas, NRC regulates those who possess and use radioactive material and the design, construction, use, and maintenance of shipping containers for the radioactive material exceeding certain quantity and radioactive limits (which includes containers for spent fuel and nuclear waste). In addition, the NRC enforces special transport controls (physical protection requirements) to protect against acts of sabotage. In all transportation accidents or incidents involving actual or suspected leakage of packages regulated by the NRC, the Memorandum of Understanding assigns the NRC with the responsibility to act as lead agency for investigating the cause of the leakage and preparing a report of the investigation.

The final Transportation Institutional Plan represents a foundation for projected interactions with state and local governments, Indian tribes, and other organizations in the course of transporting spent fuel and high level radioactive waste under provisions of the Nuclear Waste Policy Act. It represents one of three elements that will comprise a comprehensive transportation plan. The second is the Transportation Business Plan (DOE/OCRWM January 1986). The third is the Operations Plan, a draft of which was released in March 1988.

This Institutional Plan is divided into three chapters. Chapter 1 provides background information, discusses the purposes of the plan and the policy guidance for establishing the transportation system, and describes the projected system and the plans for its integrated development. Chapter 2 discusses the major participants who must interact to build the system. Chapter 3 suggests mechanisms for interaction that will foster

wide participation in program planning and implementation and provides a framework for managing and resolving the issues related to development and operation of the transportation system. A list of acronyms and a glossary are included for the reader's convenience. Also included in this plan are four appendices. Of particular importance is Appendix A, which includes a detailed discussion of specific transportation issues. Appendix A is of particular interest from an operational perspective because it discusses prenotification requirements, the selection of modes, rail routing, highway routing, emergency response, training, inspection and enforcement, vehicle size, and infrastructure requirements. Few definitive statements are made. The document consists mostly of action plans for reaching decisions regarding key issues. Appendices B, C, and D provide supporting material to assist the reader in understanding the roles of the involved institutions.

The Transportation Business Plan (DOE OCRWM 1986) outlines strategies for procuring shipping casks and transportation services. Chapter Five outlines a business strategy regarding enlistment of contractors, arrangement for carriage, training, inspection, maintenance and repair and contractor interface with the utilities supplying the spent fuel. It also discusses a procurement/technical plan, including early carrier discussions, pre-procurement planning, service contractor selection, fleet acquisition, pre-operational actions, and transportation operations. Finally, the chapter discusses a management/control plan, focusing on a management structure, guidelines for procurement, system performance measures, an implementation schedule, and contingency plans. Much of the information is in the form of an introduction to a subject rather than an in-depth discussion of the issues.

When examining route selection, Information Sources for Flow Analyses of Hazardous Materials (List et al.) is quite useful. It provides a comprehensive discussion of data sources available for analyzing the historical flow patterns for hazardous materials. There are several corridors in the nation where the flow of such materials is quite large. These should be avoided, where possible, in shipping the high-level waste to minimize the likelihood that hazardous material incidents would lead to compounded situations where spent nuclear fuel was also involved. Carriers and DOE should use such information to select routes. Also, where necessary, they should gather information about the time-of-day patterns for such shipments (where it is impractical to avoid overlapping routes for the spent nuclear fuel). In these instances, judicious scheduling can minimize the likelihood of compound events even though both

commodities share the use of the same corridor. A related document is Scheduling Truck Shipments of Hazardous Materials in the Presence of Curfews (Cox and Turnquist). This document provides excellent thumb rules which should be followed in the scheduling of nuclear waste shipments. It indicates when such shipments will and will not be sensitive to scheduling constraints. The algorithms it presents should be used to set departure times for shipments, from the initial loading point as well as intermediate locations, when delays are encountered or route adjustments must be made. Interactive Selection of Minimum-Risk Routes for Dangerous Goods Shipments (Saccamano, van Aerde, and Queene) illustrates an interactive procedure which has been used to select low-risk routes through urban environments for hazardous material (dangerous goods) shipments.

Baldwin's report for the National Cooperative Highway Research Program presents an analysis of the responses to a 1978 AASHTO survey regarding hazardous materials transportation. It identifies critical problem areas and lists a series of recommendations for state action. Major needs identified include state regulations, a clear definition of the role and authority of individual agencies, improved communications, development of incident response capabilities, training for all levels, enforcement, and a public information program.

States should review the document for guidance in setting up their own programs. Carriers should consult it to determine what requirements they may face. DOE should use it as a reference for determining actions it should take to meet state concerns before they become problem issues. The document also contains an appendix listing 1) colleges and universities (as of 1980) offering courses in hazardous materials packaging and transportation and 2) schools offering emergency response training for hazardous materials incidents as part of their curriculum. This is an important piece of information for carriers seeking training programs for their employees.

Transportation of Hazardous Materials (OTA 1986), which focuses on hazardous materials in general, is a very useful document, especially because of its discussion of state and local emergency response and enforcement programs. It also provides an excellent summary of the regulations pertaining to the transport of all hazardous materials by truck and rail, including spent nuclear fuel. A list of 670 laws adopted by federal, state and local governments that affect the transportation of radioactive materials are provided in a report by Knox et al. (1986). The report was generated from information

contained in a legislative database developed at Oak Ridge National Laboratory. The report's contents, and more importantly the database from which it is derived will be invaluable to DOE, carriers, and shippers alike in assuring that all regulatory requirements have been met for specific shipments of waste to the repository.

Physical Protection of Shipments of Irradiated Reactor Fuel: Interim Guidance (Kasun 1979) should be regarded as a companion to 10 CFR 73. It outlines pictorially the implications of the 10 CFR 73 federal regulations regarding advance notification, route approval, police notification, stoppage while en route, response to threats and emergencies, etc. For shipments by road, it outlines requirements for drivers, escorts and their training, communication provisions, and vehicle immobilization requirements. The latter pertains to safeguards which must be provided so that the vehicle can be disabled in the event of a terrorist attack or other breach of safety. Similar discussions are provided for shipments by rail. The document specifies what other provisions must be made and safeguards taken when shipments move through heavily populated areas. This document should serve as the basis for the development of an operating plan for shipment of spent nuclear fuel. It is not a substitute for 10 CFR 73, but it is a useful precursor to a document which can be used for operations and training purposes.

Two significant reports on the use of rail for transporting HLNW are Track Safety Standards (DOT Federal Railroad Administration) and Klassen's report for Sandia (1981), Transportation of Radioactive Material by Rail: Special Train Issue. The first document indicates what standards must be met to have railroad track classified as being a member of one of six federally-recognized classes. Class 1 is the poorest, and is intended for slow speed operation, 10 MPH for freight trains, 15 MPH for passengers. Class 6 allows train speeds up to 110 MPH regardless of whether they are freight or passenger. The subparts are as follows A) General, B) Roadbed, C) Track Geometry, D) Track Structure, E) Track Appliances and Track-Related Devices, and F) Inspection. There are appendices detailing maximum allowable operating speeds for curved track, a schedule of civil penalties, and descriptions of the codes used by federal inspectors to identify defects when found.

This is the document by which track quality will be judged when reviewing routes for shipping the high-level wastes. While many railroads have their own track quality indexes, they are not officially recognized by FRA as a substitute for those given in

this document. Once a minimum class is identified for HLNW shipments (e.g., Class 4), inspectors will be able to determine whether all segments of the route meet these standards or not. Routes may be run periodically with track geometry cars to double-check the adherence to track class requirements.

Transportation of Radioactive Material by Rail: Special Train Issue is one of several documents focusing on the merits of special operating restrictions for trains carrying spent nuclear fuel. In the event that such restrictive practices are imposed, this document should be consulted for suggestions as to ways to deal with the situation.

Transportation Public Information Program Guidance Document (DOE Battelle Project Management Division) outlines procedures which DOE intends to follow in keeping the public apprised of activities related to the transport of the high-level radioactive waste. It focuses principally on techniques which should be employed to gain public support for and approval of the shipment campaign. Operators and other service providers who encounter public resistance to carrying out their duties and responsibilities for DOE might find the contents of benefit. Another document intended primarily as a public relations brochure to acquaint the general public with the safeguards built into present cask technology is by Lahe (1987). It serves also as a useful source of information about the transportation of spent fuel in general. Of particular note are the pseudo engineering drawings showing cask designs, breakdowns of cask weight, including contents, illustrations of accident scenarios and expected consequences, and exemplary tests which have been performed, worldwide, to test the durability of casks. This report can be used to determine what situations should be avoided: bridges, underpasses, difficult turns, roads that pass close to industrial sites where conflagrations would be possible, etc. While none of these situations may ever result in a cask failure, avoiding them would enhance a carrier's public credibility and image.

ATTACHMENT 1

APPENDIX A: FEDERAL AGENCY TRANSPORTATION
RESPONSIBILITIES AND APPLICABLE REGULATIONS AND ORDERS¹

Department of Transportation

The Department of Transportation Act of 1966 recognized the need to organize transportation policies to assure national economic growth, security, and stability, and therefore, established the Department of Transportation (DOT). The DOT is thus empowered to be the lead agency with jurisdiction over the regulation of commercial nuclear materials transportation. It carries out its responsibilities through four administrations (Federal Highway Administration, Federal Railroad Administration, Federal Aviation Administration, and U.S. Coast Guard) and its various offices.

The Federal Railroad Safety Act of 1970 was enacted to promote safety in railroad operations and to reduce railroad-related accidents, deaths, injuries, and damage involving any carrier of hazardous materials, including nuclear materials. The Secretary of Transportation, through the Federal Railroad Administration, has the responsibility for prescribing appropriate rules, regulations, orders, and standards for all areas of railroad safety, including nuclear materials transportation.

Because of increasing public concern, the Hazardous Materials Transportation Act of 1974 (HMTA) was passed to minimize risks to life and property (that are inherent in commercial transportation of hazardous materials) by increasing the regulatory and enforcement authority of the Secretary of Transportation. The HMTA is the principal Federal statute that governs the regulation of hazardous materials transportation and the relationship between Federal, State, and local regulation in this field. The Act outlines the areas over which DOT has authority (e.g., packaging, labeling, routing, and container fabrication). It also prohibits transportation of nuclear materials on passenger aircraft unless the materials are to be used for research or medical diagnosis/treatment.

The Code of Federal Regulations describes the details and procedures for nuclear materials transportation accorded to the DOT.

49 CFR Part 172

Subpart B of Part 172 lists the materials designated by the Department of Transportation as hazardous for commercial transportation. A table includes a description of nuclear materials, and requirements for the shipping name, class, labeling, and packaging.

Subpart C gives the requirements for the shipping papers for all hazardous materials, including nuclear materials, with a description of the materials and the shippers' certifications.

¹Transportation Institutional Plan (Draft), Appendix A. DOE/RW-0031, DOE OCRWM (1985).

Subpart D discusses marking requirements (e.g., proper shipping name) according to type of package and mode of transport. Subpart E focuses on the required labels, based on the properties and amounts of all hazardous materials including radioactive materials being carried.

Part 172 defines nuclear materials as hazardous, and states ways in which the hazardous properties of each shipment are to be made known to the proper authorities and the public through use of shipping papers, marking requirements, placarding and labeling.

49 CFR Part 173

Subpart I defines the types, classes, and quantities of materials including fissile materials. This subpart also outlines general packaging and shipment requirements for approved packages, and for international shipments and foreign-made packages. The latter must meet IAEA requirements. The discussion of packaging requirements is based on the individual radioactive properties of the individual nuclear materials. The packaging properties considered include leak resistance, corrosion resistance, absorption rate, cushioning, and resistance to explosive materials.

49 CFR Part 174

Subpart K states the special requirements for radioactive materials carried by rail. This includes lading techniques, number of packages to be placed per car, labeling, decontamination and cleaning of cars after use, and actions to take following incidents involving leakage. Subpart K focuses on the general shipping regulations for nuclear materials for carriage by rail.

49 CFR Part 176

Subpart M gives the requirements for nuclear materials transportation by vessel. Three major issues of interest are the location (placement) of each package on the vessel; the actions to be taken following leakage or shifting of radioactive materials; and contamination control for the compartments used for the nuclear materials transportation.

49 CFR Part 177

Part 177 presents the regulations generally required for hazardous materials to be transported by public highway; i.e., accident and missing shipments reporting procedures; tunnels, rules for the use of labels, and shipping papers; retesting cargo tanks, etc. Of special note is Section 177.825, which provides routing and training requirements for highway shipments of radioactive materials. Appendix A of Part 177 provides a DOT policy statement of the relationships between Federal, State, and local routing requirements.

33 CFR Chapter 1

Chapter 1 describes Coast Guard regulations that affect shippers and carriers of nuclear materials in a general fashion, such as aids to navigation, navigation requirements for inland waters, anchorages, security of vessels, bridges, marine oil pollution liability and compensation, boating safety, etc.

23 CFR Chapter 1

Chapter 1 of Title 23 provides background information about the general management and administration of the Federal Highway Administration (FHWA), and its functional responsibilities; for example, research and development, engineering and traffic operations, right-of-way, environmental impact of highways, and public transportation.

46 CFR

The entire title pertains to barge transport.

49 CFR Chapter 2

Chapter 2 of 49 CFR is a discussion of the operating structure for the Federal Railroad Administration and of the numerous regulatory areas under DOT jurisdiction, for example, safety enforcement procedures, noise emission compliance regulations, track safety standards, freight car standards, power brakes, signal systems, etc.

49 CFR Chapter 3

Chapter 3 is divided into two parts that, together, outline the general and safety regulations for motor carrier transportation. Subchapter A, "General Regulations", touches lightly upon the organization and delegation of powers and duties within the FHWA, and explains bridge and tolls rules and noise emissions standards. The bulk of the Chapter, Subchapter B on motor carrier safety regulations, deals with a number of issues that affect general motor carrier arrangements with States, qualifications of drivers, and reporting of accidents.

49 CFR Chapter 5

Chapter 5 details the institutional structure and responsibilities of the National Highway Traffic Safety Administration (NHTSA), and presents guidelines for highway safety. The former focuses on the bureaucratic structure of the NHTSA, delegation of powers and tasks, information-gathering powers, and adjudicative procedures.

This chapter does not deal with nuclear materials transportation per se, but does affect such commerce by outlining safety procedures that concern all shippers and carriers that utilize national highways.

Nuclear Regulatory Commission

The Energy Reorganization Act of 1974 abolished the Atomic Energy Commission and divided its roles and tasks between two agencies. The Energy Research and Development Administration (now DOE) was given responsibility for commercial nuclear energy research, development, and demonstration activities, and also for military applications and naval reactor programs. The Nuclear Regulatory Commission (NRC) was given the responsibility for licensing and regulating commercial activities.

The NRC has three offices that review the transportation of nuclear materials: the Office of Nuclear Material Safety and Safeguards, the Office of Inspection and Enforcement, and the Office of Nuclear Regulatory Research.

The Transportation Certification Branch of the Office of Nuclear Materials Safety and Safeguards, evaluates the design of packages used for high-level radioactive waste and spent-fuel transportation, according to standards developed and implemented by the NRC.

The Office of Inspection and Enforcement has responsibility for inspecting the fabrication of transportation packages, and inspecting the licenses for high-level radioactive waste and spent-fuel transport, according to both NRC and DOT standards and regulations. In addition to the main office in Washington, inspection and enforcement activities are carried out through five field offices.

Through the Transportation Research Branch of the Office of Nuclear Regulatory Research the Commission contracts for research deemed necessary for performing licensing and regulatory functions related to high-level nuclear materials transportation. The Office of Nuclear Regulatory Research is responsible for writing regulations, including those that affect transportation of high-level radioactive waste and spent nuclear fuel.

The Code of Federal Regulations describes the details and procedures for nuclear materials transportation accorded to NRC.

10 CFR Part 9

The regulations in Part 9 implement: 1) the provisions of the Freedom of Information Act, 5 U.S.C. 552, with respect to availability of NRC records to the public for inspection and copying; 2) the provisions of the Privacy Act, with respect to disclosure and availability of certain NRC records maintained on individuals; and 3) the provisions of the U.S. Government in the Sunshine Act, 5 U.S.C., 552b, with respect of opening NRC meetings to public observation.

Part 9 influences nuclear materials transportation by contributing to the public information process. The regulations provide the public with opportunities to be knowledgeable about NRC decisions and policies on transportation as well as other related issues.

10 CFR Part 19

The regulations in Part 19 formulate requirements for notices and instructions for, and reports by, licensees to individuals responsible for ascertaining licensee compliance with the provisions of the Atomic Energy Act (as amended), 42 U.S.C. 2021; Title II of the Energy Reorganization Act, 42 U.S.C. 5801; and regulations, orders, and licenses regarding radiological working conditions. The regulations apply to all persons who receive, possess, use, or transfer nuclear materials that are licensed by the NRC.

Part 19 affects nuclear materials transportation by assuring that all individuals working in any type of restricted area shall be kept informed of storage, use, or transfer of nuclear materials, and of related radiation levels. Workers will be advised of health precautions and procedures to minimize radiation exposure during transport. The regulations provide for NRC inspector consultation with workers concerning matters of occupational radiation protection and other related concerns. Moreover, Part 19 establishes procedures for addressing violations of these regulations.

10 CFR Part 20

Part 20 sets out the standards for personnel protection against radiation. It establishes a foundation by defining units in a radiation dose and units of radioactivity in general. Several additional topics are covered in this part. First, standards on permissible doses, levels, and concentrations include such issues as dose standards for people in restricted areas, in unrestricted areas, exposure of children, medical diagnosis and therapy, etc. Second, standards on precautionary procedures include worker and personnel monitoring for radiation doses; caution signs, labels, signals and controls; procedures for handling and storing packages; etc. Third, standards on waste disposal address procedures for obtaining approval of proposed disposal procedures; and different methods of disposal, such as in soil and by incineration. Finally, standards are set out to clarify the requirements for records, reports, and notification of incidents.

19 CFR Part 21

The regulations in Part 21 establish procedures and requirements for reporting defects in nuclear components and materials and for noncompliance with components and materials manufacturing standards. The regulations apply to any individual director or responsible officer of a firm constructing, owning, operating, or supplying the components or materials of an NRC licensed or regulated facility. If the responsible person has information reasonably indicating: 1) that the component or material fails to meet the standards; or 2) that serious defects may exist and create a safety hazard, they must immediately notify the NRC of such failure to comply or such defect. Part 21 affects nuclear materials transportation by requiring manufacturers and suppliers of components and materials to identify faulty products, preferably before shipments occur.

10 CFR Part 51

Part 51 establishes standards for protecting the environment against the potential hazards presented by the nuclear industry. Specifically, it establishes requirements for environmental impact statements; environmental reports of all nuclear facilities at the construction permit and operating license stages; environmental reports and administrative procedures for materials licensing; and, finally, for administrative procedures on communicating with the public, for example, through public hearing and notices in the Federal Register.

Part 51 establishes radiation standards to protect the environment against exposure to radiation during transport, delivery, and disposal activities; and outlines public hearing procedures on transportation and disposal methods, and requirements for notices to the public.

10 CFR Part 71

Part 71 establishes criteria for shipping licensed nuclear materials in various types of packages. The discussion focuses on several areas. First, general licensing procedures for shipment are set out. Second, the requirements for the actual license application (e.g., package description, package evaluation, quality assurance) are explained. Third, NRC standards for all packaging are laid out according to type of material to be contained. Finally, Part 71 describes operating procedures, quality assurance instructions, and inspection and testing requirements.

10 CFR Part 73

Part 73 prescribes requirements for the establishment and maintenance of physical protection systems. Sections 73.25 through 73.37 focus on special nuclear material and spent fuel in transit, and deal with requirements for physical communications requirements.

Part 73 outlines shipper and carrier requirements for planning and scheduling, such as obtaining advance approval of routes prior to shipment, and making arrangements to be made with law enforcement agencies along the route in the event of an emergency.

National Transportation Safety Board

The mission of the National Transportation Safety Board, created in 1971, is to promote transportation safety by conducting independent investigations of accidents and other safety problems and by formulating safety improvement recommendations.

The Board is responsible for investigating accidents and determining their cause, making safety recommendations, and reporting the facts and circumstances of all transportation accidents that are catastrophic, involve problems of recurring character, or should otherwise be investigated in the judgment of the Board. In addition, the Board makes recommendations on matters pertaining to transportation safety and is a catalyst for transportation accident prevention.

The Board previously reported to the DOT, but the Independent Safety Board Act of 1974 declared the National Transportation Safety Board an independent body and strengthened its power to investigate transportation accidents and make recommendations on regulations.

The section of the Code of Federal Regulations that describes the details and procedures for nuclear materials transportation according to the National Transportation Safety Board is Title 49, Chapter VIII. The regulations make provisions for independent inquiries and determinations about causes of transportation accidents, and make recommendations on safe highway carriage of nuclear materials.

Interstate Commerce Commission

The Interstate Commerce Commission (ICC) regulates certain economic aspects of interstate surface transportation, including trains, trucks, buses, inland waterway and coastal shipping, freight forwarders, and express companies. The regulations vary with the type of transportation; however, they generally involve certification of carriers seeking to provide transportation for the public, rates, adequacy of service, purchases, and mergers. The ICC's mission is to ensure that regulated carriers will provide the public with rates and services that are fair and reasonable.

On matters within its jurisdiction in the transportation economics area, the ICC acts to prevent unlawful discrimination, destructive competition, and rebating. It also has jurisdiction over the use, control, supply, movement, distribution, exchange, interchange, and return of railroad equipment. Under certain conditions, it is authorized to direct the handling and movement of traffic over a railroad and distribution over other lines of railroads.

In the transportation service area, the ICC grants operating authority to trucking companies, bus lines, freight forwarders, water carriers, and transportation brokers.

Nuclear materials transportation is impacted through the authority entrusted to the ICC to establish rules and tariffs for carrier traffic, to certify and license carriers, and to establish the value of property owned and used by each carrier.

The section in the Code of Federal Regulations that describes the details and procedures for nuclear materials transportation according to the ICC is Title 49, Chapter X, Subchapter D. Under the guidelines discussed in Subchapter D on tariffs and schedules, ICC regulates economic aspects of surface nuclear materials shipments including rate setting for all modes of transport except aircraft.

Federal Emergency Management Agency

Under the provisions of Executive Order 12148 (July 20, 1979), the Federal Emergency Management Agency (FEMA) is responsible for establishing Federal policies for, and coordinating, all civil emergency planning, management, mitigation and assistance functions of Federal executive agencies. In addition, the FEMA is responsible for coordinating Federal and state participation in developing emergency response plans.

Under this mandate, the FEMA has assumed the responsibility for coordinating the development of the Interim Federal Radiological Emergency Response Plan (49 Fed. Reg. 35896). The interim plan has application in the event of an accident involving the transportation of spent fuel and radioactive waste, and is designed to provide coordinated Federal response in support of state and local governments. It is important to note that under the FEMA's coordinated response plan, State and local governments have primary emergency responsibilities, and Federal assistance is to be made available only if requested.

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In order to assist state and local agencies in developing and testing radiological emergency response plans, the FEMA established the Federal Radiological Preparedness Coordinating Committee (FRPCC). In December 1982, the FRPCC's Subcommittee on Transportation Accidents (composed of representatives from the U.S. Department of Energy, Nuclear Regulatory Commission, FEMA, and other Federal and State agencies) issued a draft guidance document to provide a basis for State and local governments to develop emergency plans and improve emergency preparedness for transportation accidents involving radioactive materials. The guidance document, entitled Guidance for Developing State and Local Radiological Emergency Response Plans and Preparedness for Transportation Accidents, provides optional support to State and local governments in their planning efforts.

U.S. Environmental Protection Agency

In 1970, the Presidential Reorganization Plan No. 3 established the Environmental Protection Agency (EPA). EPA has authority to establish generally applicable environmental standards for the protection of the environment from radioactive materials.

As specified in the Interim Federal Radiological Emergency Response Plan issued by the FEMA, the EPA also is responsible for providing assistance to other Federal agencies, and State, Tribal, and local governments in the event of radiological emergencies (including transportation accidents involving radioactive materials). Under the interim plan, the EPA is to assist the DOE in monitoring radioactivity levels in the environment in the event of a radiological emergency, and assist (as needed) in developing recommended measures to protect public health and safety.

ATTACHMENT 2
APPENDIX B: SUMMARY OF AGENCY AGREEMENTS²

Memorandum of Understanding: Transportation of Radioactive Materials

Agencies: Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC)

Date of Publication: July 2, 1979 Reference: 44 Fed. Reg. 38690

Title: Transportation of Radioactive Materials; Memorandum of Understanding

Summary: The DOT is responsible for regulating safety in the transportation of all hazardous materials, while the NRC is responsible for regulating safety in receipt, possession, and transfer of radioactive materials. This agreement delineates agency responsibilities as follows:

- ç DOT: Regulates carriers of radioactive material and the conditions of transport (e.g., routing, handling and storage, vehicle requirements, and driver requirements).
- ç NRC: Regulates those who possess and use radioactive material, and the design, construction, use, and maintenance of shipping containers for radioactive material exceeding certain quantity and radioactive limits (which includes containers for spent fuel and nuclear waste). In addition, the NRC enforces special transport controls (physical protection requirements) to protect against acts of sabotage. In all transportation accidents or incidents involving actual or suspected leakage of packages regulated by the NRC, the Memorandum of Understanding assigns the NRC with the responsibility to act as lead agency for investigating the cause of the leakage and preparing a report of the investigation.

²Transportation Institutional Plan (Draft), Appendix B. DOE/RW-0031, DOE OCRWM (1985).

Memorandum of Understanding: Transportation Packaging

Agencies: Department of Energy (DOE) and Nuclear Regulatory Commission (NRC)

Date of Publication: 11-14-83

Reference: 48 Fed. Reg. 51875

Title: Spent Fuel and High-Level Waste Transportation Packaging; NRC/DOE
Procedural Agreement

Summary: Pursuant to DOT regulations [49 CFR Section 173.7(d)], the DOE has the authority to certify its packaging for radioactive materials using standards that are equivalent to NRC requirements (found at 10 CFR Part 71). However, pursuant to the procedural agreement reached by the DOE and NRC in 1983, the DOE has announced its intent to use packaging approved by the NRC for DOE shipments performed under the NWPA from NRC-licensed facilities to NWPA facilities. The agreement further provides procedures for consultation and information exchange in order to resolve issues related to packaging design, testing, and certification.

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DRAFT - CATEGORY TWO

TRANSPORTATION NEEDS ASSESSMENT

TASK 15.2 PREFERRED TRANSPORTATION SYSTEM OPTIONS

PHASE IIIA YUCCA MOUNTAIN SOCIOECONOMIC PROJECT

MOUNTAIN WEST RESEARCH

NOVEMBER 16, 1988

INTRODUCTION

The transportation impacts of moving high level nuclear waste (HLNW) to a repository at Yucca Mountain in Nevada are of concern to the residents of the State as well as to the residents of other states through which the nuclear wastes might be transported. The projected volume of the waste suggests that shipments will occur on a daily basis for some period of time. This will increase the risk of accidents, including a catastrophic incident. Furthermore, as the likelihood of repository construction and operation and waste shipments increase, so will the attention given by the national media. Typically, the media further amplifies or complicates the impact of a situation or event by influencing public perception about the situation. A recent example involved a truck accident in New Burley, Idaho on October 12, 1986. None of the radioactive materials carried by the truck were released in the accident; however, extensive media coverage heightened the fears and perceptions of risk on the part of community members.

This document is not to be construed as a willingness to accept the HLNW repository on the part of the State. Rather it is an initial step in ensuring that the safety and well-being of Nevada residents and visitors and the State's economy will be adequately addressed in federal decision-making pertaining to the transportation of HLNW into and across Nevada for disposal in the proposed repository.

The Preferred Transportation System Needs Assessment identifies critical system design elements and technical and social issues that must be considered in conducting a comprehensive transportation impact analysis. Development of the needs assessment and the impact analysis is especially complex because of the absence of information and experience with shipping HLNW and because of the "low probability, high consequence" aspect of the transportation risk.

This working paper addresses the preferred transportation system by grouping issues within three areas: crosscutting issues, transportation system design, and operational procedures. Four additional reports will be developed to complete the Transportation Needs Assessment. Task 15.5 is the Literature Review for the Assessment. All references identified in the 15.2 report will be cited and annotated in the 15.5 report. In this report, the terms "nuclear waste" and "waste" refer to all of the radioactive wastes to be shipped to a repository. This includes spent fuel from commercial nuclear power reactors, solidified wastes from the reprocessing of commercial spent fuel (West Valley wastes) and the nuclear weapons program (defense high level waste). It is uncertain at this time (but possible) that wastes resulting from spent fuel rod consolidation and "greater than class C" low-level radioactive waste may be disposed of at the repository.

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1.0 CROSSCUTTING ISSUES

Crosscutting issues are those aspects of the preferred transportation system that are involved with or "cut across" most, if not all, components of the system. Factors such as system management, risk evaluation, monitoring and regulatory structure are examples of critical issues that are a part of (cut across) other system components.

1.1 COMPREHENSIVE RISK ASSESSMENT AND RISK MANAGEMENT

Risk assessment refers to the formal process of identifying hazards, estimating the probabilities of their occurrence, and estimating the nature and magnitude of their consequences. It is an inseparable part of risk management. (Hazards herein are defined as threats to humans. Risk is the conditional probability of experiencing harm.) Risk management involves the identification, estimation, and evaluation of risks and the selection and implementation of alternative measures to prevent, control, or mitigate adverse consequences. It includes a risk assessment in the identification and estimation phases. Most of the studies of transportation risks conducted to date are risk assessments and do not attempt to address the broader issues of risk management (McClure and Emerson 1980, NRC 1980, Siv and Garrick 1981, Sandoval et al. 1983, Jefferson 1985, McClure and Tyron-Hopko 1985, Scanlon and Cantilli 1985, Stern 1985). It should be noted that risk assessment and risk management are part of an ongoing, iterative process. They should not be viewed as one-time activities resulting in a final report.

The goal of a comprehensive transportation risk management system is to minimize risks resulting from the transportation of nuclear waste. The goal of a comprehensive transportation risk assessment is to identify all types of potential hazards and to estimate the probabilities and consequences associated with each type of hazard. In order to achieve these goals, the risk assessment and risk management system for the transportation of nuclear waste must meet several objectives. A comprehensive risk assessment should identify all types of potential hazard events and their adverse consequences for all relevant aspects of the transportation system. To assess the risk, the probabilities of occurrence and range of consequences for hazard events must be estimated as thoroughly as possible with available data. Because much of the data necessary to estimate probabilities will not be available or will be uncertain, the risk assessment should incorporate a sensitivity analysis and estimate the uncertainties that result from the use of different assumptions and assessment models. The assessment should also indicate the different risks involved with varying assumptions about modal mix, routing, and so forth.

A comprehensive risk management system should incorporate a comprehensive risk assessment and evaluate risk acceptance or tolerability to establish

priorities for action. Perhaps the most difficult and important objective in risk management is the evaluation of the risks identified during risk assessment. Risk evaluation is necessary to determine what levels of risk are acceptable or tolerable, and, therefore, which risks must be controlled. Whether or not tolerable levels of risk can be identified is a controversial and complex debate (Kasperson 1983, Kasperson and Kasperson 1984). Despite the difficulty in establishing a tolerable level of risk, a comprehensive risk management system cannot ignore this issue.

In establishing a risk management system, it must be recognized that tolerable levels of risk cannot be derived by a formal analytical process and that the public often views risks differently than technical experts. To accommodate this divergence, public participation and consultation will be necessary to determine which risks are or are not tolerable. Three types of analyses can contribute to this process: contextual, equity, and public preference analysis.

The management system will identify a control strategy, means of intervention, and modes of implementation. The process of public involvement and formal analysis will allow the setting of priorities, identification of appropriate control strategies (e.g. risk acceptance, reduction or spreading, or consequence mitigation), means of intervention (e.g. cask redesign, rerouting traffic), and modes of implementation (educate, mandate, or encourage). Once the control options are implemented, the process of evaluation begins. The system should call for an evaluation of the efficacy of risk management efforts. Again, the public should be involved in the evaluation of the implemented management programs. The risk management systems should then be modified according to the result of the evaluation.

1.1.1 Key Issues for Comprehensive Transportation Risk Assessment and Risk Management System Development

Risk Management System Scope

In designing the risk management system and conducting a risk assessment for the transportation of nuclear wastes to a repository at Yucca Mountain, it must be recognized that the comprehensive management system is broader than the assessment of risk. It must consider the entire sequence of transportation from initial packaging and loading to unloading and should not ignore the possibility of retrieval. This includes alternative technologies, routing, model configurations and mixes. It includes consideration of the complete range of initiating and enabling events in addition to the complete spectrum of consequences. Upstream events concerning cask design, loading, and so forth, as well as the generic issues of quality control and human error, can have significant impacts on "downstream" (i.e. within the State of Nevada) events such as a radioactive release in an accident and the occupational exposure of workers unloading casks at the repository. A sequential view of the shipping procedure is a useful aid in the identification of potential hazards (Figure 1). Similarly, the modes of transportation to be evaluated must be decided (e.g. rail, truck, etc.).

Figure 1.

THE SEQUENCES AND PHASES OF NUCLEAR WASTE TRANSPORTATION

To be truly comprehensive, the risk assessment should also identify the hazard events and consequences arising in the transportation of retrieved waste, since the repository is to be designed with such an eventuality in mind. While transportation to the repository is already controversial, it is likely that transport of retrieved waste from the repository will be even more controversial.

Risk Management System Methodologies

Alternative methods should be considered. These include probabilistic assessment (PRA), simulation, analogy, and scenario analysis. Definitions and appropriate measures of risk must be addressed along with availability and quality of data. The design of the methodology should consider consequence modeling and the range of uncertainties.

Risk Management System Response

Key issues to be addressed in designing the system response include:

- evaluation,
- portrayal and dissemination of risk information,
- control strategies,
- means of intervention,
- mode of implementation, and
- reevaluation and modification.

1.1.2 Initiating Events

The risk management system must consider the complete range of initiating events and likely consequence at each stage in the transportation sequence. In the transportation system there are four types of activities which can lead to adverse consequences and should be evaluated in a risk assessment.

Normal Conditions

Workers and members of the public will be exposed to risks from the operation of a nuclear waste transport system even under "normal" or incident-free operating conditions; in the absence of accidents, poor quality control, sabotage, terrorism, or theft. Under normal operating conditions, non-radiological risks include mortality and morbidity associated with exhaust emissions in transport. Radiological risks include latent cancers and genetic effects resulting from low levels of radiation. Radiation will be emitted from even the best designed casks under the most stringent quality control programs. Workers will be exposed during packaging, loading, transporting, and unloading waste materials. The public will be exposed as shipments pass nearby.

Accident Conditions

Accidents include "internal events" or system failures, such as vehicular and loading accidents, and external events that originate outside of the waste

transportation system. Both radiological and non-radiological consequences may be associated with accidents. External events include intentional (e.g., sabotage) and unintentional (e.g., airplane crashes) man-made events, and natural events such as earthquakes and floods. The intentional man-made initiating events of sabotage, terrorism, and theft have been of much concern to experts and the public. Therefore, they are treated separately below.

Sabotage

Sabotage includes the deliberate destruction of vehicles, manipulation of vehicles or crew members, hijacking of trucks and theft of nuclear material. It is almost impossible to quantify the probability of these types of events. However, the related impacts can be very severe.

Human Error and Deficient Quality Control

Quality control failures and human errors have been a continuing major problem throughout the nuclear power industry and in hazardous materials transportation. It has been estimated that up to 62 percent of hazardous material transportation accidents are the result of human errors (OTA 1986). They have also been important contributors to major nuclear accidents such as Three Mile Island (TMI) and Chernobyl and non-nuclear accidents at other facilities handling hazardous substances (e.g. Bhopal). In the transportation system, human error and defective quality control may lead to both radiological (e.g., improper cask closure leading to excess exposure) and non-radiological consequences (e.g., crane accidents). Thus, sufficient attention must be given to potential quality control problems and human errors which might compromise engineered integrity and safety systems.

1.1.3 Probabilities

Having identified the types of hazards and consequences, a comprehensive risk assessment should estimate the probabilities of their occurrence. Strength or weakness of the available data should be indicated by descriptions of the degree of uncertainty. When actuarial data is unavailable, expert judgement may substitute, although it has many associated difficulties in the provision of reliable data. Where expert judgement has been used because of an absence of data, it should be clearly indicated and justified. Other assumptions, such as the choice of particular models, should also be indicated.

A comprehensive risk assessment should incorporate a comprehensive consequence analysis that assesses the nature, severity, and magnitude of adverse effects on health and safety. The emphasis should include long and short term effects, and morbidity as well as mortality. Finally, the risk assessment should be broad and flexible enough to illustrate the impact of different assumptions about the transport system and the levels of risk. The risk estimates should be given for transport systems with and without an MRS facility, and under different assumptions about cask design, volume and timing of shipments, modal mix, and so forth.

1.1.4 Risk Assessment Methodologies

Several methods can be used to conduct risk assessments. These include worst-case analysis, selected scenario analysis, argument by analogy, and probabilistic risk assessment (PRA). Each method has its advantages and disadvantages in its ability to evaluate data and modeling uncertainties, the range of possible consequences, and different measures of risk. All of the methods suffer from a common problem regarding completeness. The scope of an analysis is frequently limited by the imagination of the analysts. There are no methods for logically ensuring that all hazard events and consequences are included.

Worst Case Analysis

Worst-case analysis selects the upper extremes of many variables such as source terms, population density, and meteorology, in their worst combinations without attempting to estimate probabilities. This type of analysis serves as a benchmark for emergency preparedness, but does not indicate the likelihood of occurrence. Usually, the absolute worst case is not chosen for evaluation. Rather a "maximum credible accident" is selected to bound the analysis.

Selected Scenario/Argument by Analogy Analysis

Selected scenario analysis uses a range of scenarios, including the worst case. It does not attempt to estimate probabilities. Argument by analogy is weakened by the fact that some aspects of the transportation system for nuclear waste are very different from other transportation systems such as those for transportation of hazardous materials.

Probabilistic Risk Assessment

PRA is one of the most rigorous methodologies for assessing risks. Its drawbacks are that it requires enormous effort, complex modeling, and high quality data. Also, PRAs tend to use narrow definitions of risk, such as the number of fatalities or injuries. PRA may be misleading by suggesting that the probabilities of events can be estimated accurately when indeed there is often considerable uncertainty.

PRAs have been used extensively with regard to nuclear power plants. The transport of nuclear waste, however, is quite a different system. It is considered technologically less complex and more "open" so that identifying all eventualities may be more difficult. And, whereas a reactor is located in one place, the transport network involves diverse environments, urban and rural populations, and multiple political jurisdictions. Thus the system encompasses a broader degree of computational complexity.

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