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THE MONITORED RETRIEVABLE STORAGE (MRS) FACILITY AND ITS IMPACT ON SPENT FUEL TRANSPORTATION

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ABSTRACT

The Department of Energy has identified nine potential sites for a repository to permanently dispose of radioactive wastes. DOE has released several sets of maps and tables identifying expected transportation routes between nuclear reactors and repository sites. More recently, the DOE has announced three potential Monitored Retrievable Storage Facility (MRS) sites in the state of Tennessee. Obviously, if a large portion of the spent fuel is routed to Tennessee for consolidation and repackaging, there will be significant changes in the estimated routes. For typical scenarios, the number of shipments in the vicinity of the repository will be reduced. For example, with direct reactor to repository shipments, 995 highway and 262 rail shipments are expected to arrive at the repository annually. With a MRS these numbers are reduced to 201 and 30, respectively. The remaining consolidated fuel would be transported from the MRS in 22 dedicated trains (each train transporting five casks). Conversely, the MRS would result in an increase in the number of spent fuel shipments traveling through the eastern part of Tennessee. However, the operation of a MRS would significantly reduce the number of shipments through the central and western parts of the state.

THE MONITORED RETRIEVABLE STORAGE (MRS) FACILITY AND ITS IMPACT ON SPENT FUEL TRANSPORTATION

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In response to the Nuclear Waste Policy Act of 1982, the Department of Energy has taken a number of steps toward establishing a permanent disposal facility for radioactive wastes. Nine separate candidate repository sites have been identified and a draft environmental assessment (EA) has been issued for each site. The nine sites have been compared and ranked. The top three candidate sites in the draft EAs are a basalt formation near Hanford, Washington; a tuff formation at Yucca Mountain, Nevada; and a bedded salt formation in Deaf Smith County, Texas. A repository is scheduled to be constructed, presumably at one of the above sites, and to be in operation by 1998.

In the spring of 1985, the DOE announced three potential sites for a Monitored Retrievable Storage Facility (MRS). A MRS facility would be designed to receive spent fuel shipments from the commercial power rectors, consolidate the spent fuel, package it for disposal, and transport the consolidated fuel to the repository. Temporary storage would also be provided at the MRS. The current projections indicate that the MRS will start to receive fuel from the commercial power reactors in 1996.

During the site selection process, DOE looked at a number of potential MRS sites primarily in the southeastern part of the

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United States. The three sites selected are located in the state of Tennessee. Two of the sites are in east Tennessee near Oak Ridge. The preferred site is the abandoned Clinch River Breeder Reactor site and an alternate site is close to the old Exxon reprocessing plant site. The two Oak Ridge sites are within a few miles of each other. The second alternate site is located in central Tennessee, at the site of the cancelled Hartsville nuclear plant.

Characterization of the MRS Sites

The MRS sites are centrally located with respect to most of the commercial nuclear power plants. Thirty-three plants are within 500 miles of the potential MRS sites. These reactors are projected to supply approximately 45% of the fuel scheduled to be transported to the first repository.

The MRS sites are also favorably located with respect to existing transportation facilities. For example, the Clinch River site is only seven miles from I-40, a major east-west Interstate highway. Rail service is available at two nearby DOE plants. A spur on the Southern Railway is less than three miles west of the site, while a Seaboard System Railroad spur is located approximately twelve miles to the northeast. The Clinch River, which flows along the perimeter of the site, is navigable and is part of the Tennessee River system.

The Hartsville site, which is located northeast of Nashville, Tennessee, is approximately 120 miles west of the Oak Ridge sites. If this site is selected, the MRS would be located at the site of a partially constructed but abandoned Tennessee Valley Authority nuclear plant. The Hartsville site is relatively near two Interstate highways: I-40, which is 16 miles to the south, and I-65, which is 41 miles west of the site. Rail service to the Hartsville site is not as convenient as at the Oak Ridge sites. At one time, the town of Hartsville had direct rail service. However, now the nearest rail line terminates at Trousdale, Tennessee, 13 miles to the west. The spur line at Trousdale connects to the major Seaboard System Railroad main line between Cincinnati, Ohio, and New Orleans, Louisiana.

Old Hickory Lake, which is part of the Cumberland River, is a navigable waterway and lies adjacent to the Hartsville site.

Transportation Scenarios

Two transportation scenarios are described in this paper. The first scenario assumes that all spent fuel shipments are made directly from the reactors to the repository. Three candidate repository sites are considered: Hanford, Washington; Yucca Mountain, Nevada, and Deaf Smith County, Texas. The second transportation scenario includes a MRS facility. In this scenario, the reactors east of the Rocky Mountains are assumed to make spent fuel shipments to a MRS facility. After repackaging, the consolidated fuel will eventually be shipped from the MRS to a repository. Reactors located west of the Rocky Mountains are assumed to make fuel shipments directly to the repository. In this scenario, the MRS is assumed to be located at the preferred Clinch River site near Oak Ridge, Tennessee.

In each scenario, 62,000 metric tons of uranium (MTU) will be shipped and stored in a repository. However, the timing of the fuel shipments are different in the two scenarios. When all shipments are made directly to the repository, the first shipments will take place in 1998. By the year 2003, the repository will be operating at its designed level and approximately 3,000 MTU of spent fuel will be transferred each year. The repository will contain the 62,000 MTU after 25 years of operation (in the year 2022).

In the MRS scenarios, 62,000 MTU will also be shipped to a repository. However, the MRS should be ready to receive and consolidate fuel in 1996. By 1998 when the repository starts operation, the MRS will be receiving approximately 3000 MTU per year. Once the repository is ready to receive, fuel shipments will start flowing from the MRS and western reactors. The MRS is expected to continue receiving fuel through the year 2018 (a 23-year period) at which time all of the fuel from the eastern reactors destined for the first repository will have been shipped to the MRS. The repository will continue receiving fuel shipments from both the western reactors and the MRS through the year 2022. The reader is referred to the DOE Mission Plan[1] for more details.

Transportation Patterns

The next two sections will show how the MRS facility will impact the expected transportation patterns. The expected number of shipments from each reactor was calculated by McNair et al.[2–4] This information was annualized to give average number of shipments per year by dividing by 25 if the shipment is being transported to a repository or by 23 if the shipment is going to the MRS facility. Estimated transportation routes were calculated using the HIGHWAY[5] and INTERLINE[6] routing models.

Traffic Patterns at a Repository Site

Approximately 995 truck and 262 rail shipments would be required each year to transport 62,000 MTU of spent fuel directly to the repository from the reactors. A unique traffic pattern will be established for each candidate repository site. The estimated transportation routes for the Yucca Mountain site are shown in Fig. 1. In this figure, highway routes are shown as solid lines, while a dashed line is used to represent rail routes. The numbers along the route indicate the number of shipments expected each year.

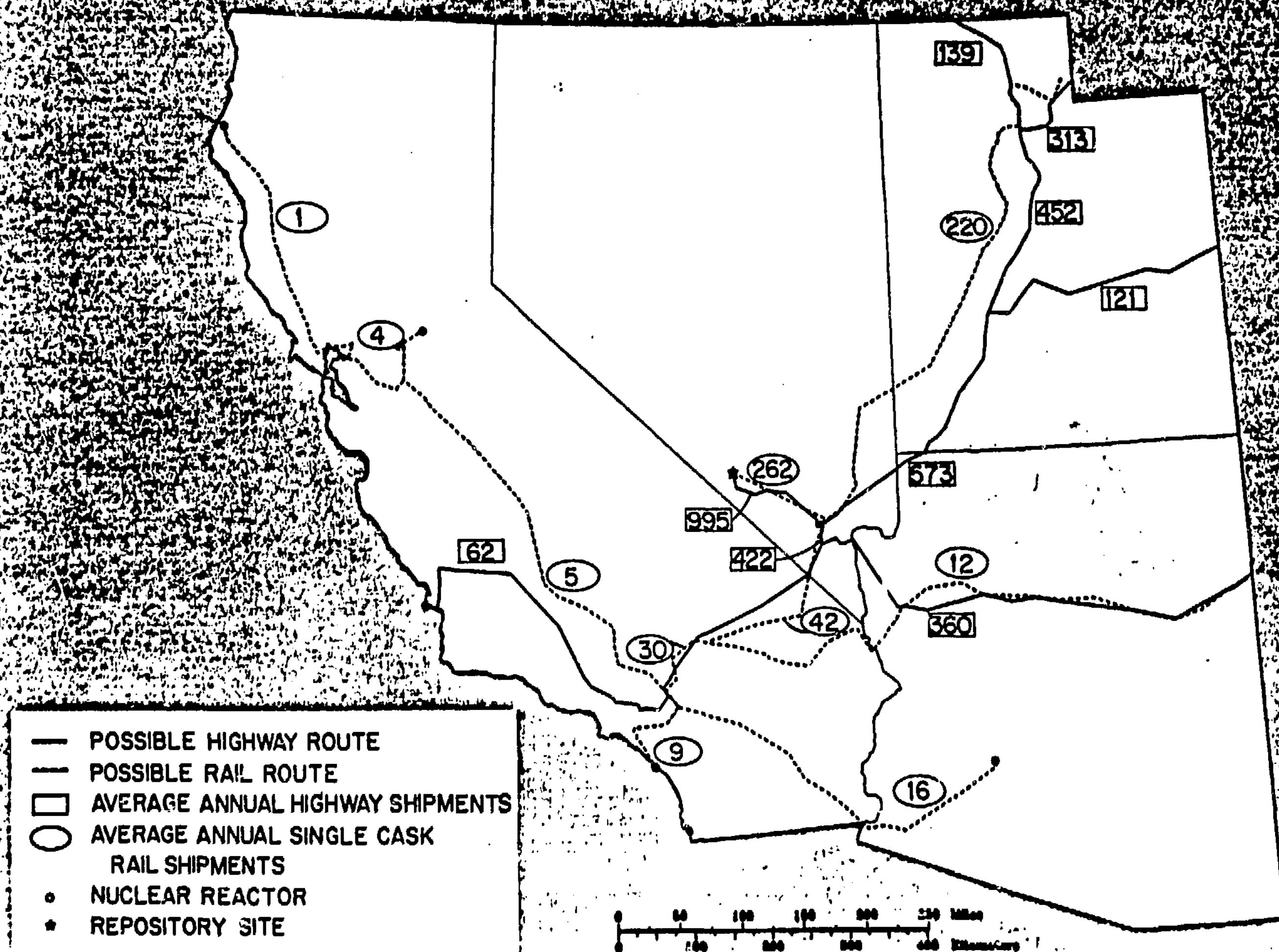
For the Yucca Mountain site, highway shipments will approach the Las Vegas area from three directions. Approximately 58% of the shipments will be traveling along I-15 in southern Utah and northwestern Arizona. Interstate 40 through northern Arizona is a second transportation corridor carrying approximately 36% of the annual highway shipments. These shipments are expected to leave I-40 at Winslow, Arizona and travel along US-93 to the Las Vegas area. A small number of truck shipments (about 6% of the total) originate in southern California and are expected to follow the

Figure 1. Average annual direct shipments from all reactors to a repository in Yucca Mountain, NV.

DOE/OCRWM/TRAN 2-M10

AVERAGE ANNUAL DIRECT SHIPMENTS FROM ALL REACTORS TO A REPOSITORY IN YUCCA MOUNTAIN, NV

(Nevada and vicinity)



Interstate highway system in southern California. Between Las Vegas and the Yucca Mountain site, all shipments will travel along US-95.

Approximately 85% of the rail shipments to the Yucca Mountain site are expected to be transported along the Union Pacific line between central Nebraska and southern Nevada. This is the rail line in Fig. 1 which roughly parallels the highway routes in Utah. The remaining 15% of the shipments will transfer to the Union Pacific from other railroad companies in southern California.

When an MRS is included in the waste management scheme, the transportation patterns in the vicinity of the repository change significantly. This can be seen by comparing Fig. 2 which shows the estimated transportation routes for the MRS scenario with Fig. 1. The number of shipments and distance traveled each year for the two scenarios are summarized in Table 1. It is immediately evident that the presence of an MRS would significantly reduce the number of shipments in Nevada and Utah. At the repository site, the number of truck shipments will be reduced from 995 per year to 201 per year, approximately an 80% reduction. There will be a similar reduction in the number of rail shipments. In the direct shipment scenario, 262 single cask shipments will be made by rail. For the MRS scenario, only 30 single cask rail shipments will be made each year from the western reactors. The remaining fuel will be transported from the MRS in approximately 22 dedicated train shipments each year.

Smaller reductions are identified in Table 1 for California and Arizona. In Arizona all truck traffic except those which pass along

Figure 2. Average annual shipments from western reactors and from an MRS in Oak Ridge, TN, to a repository in Yucca Mountain, NV.

DOE/OCRWM/TRAN 2-M16

AVERAGE ANNUAL SHIPMENTS FROM WESTERN REACTORS AND FROM AN MRS IN OAK RIDGE, TN TO A REPOSITORY IN YUCCA MOUNTAIN, NV

(Nevada and vicinity)

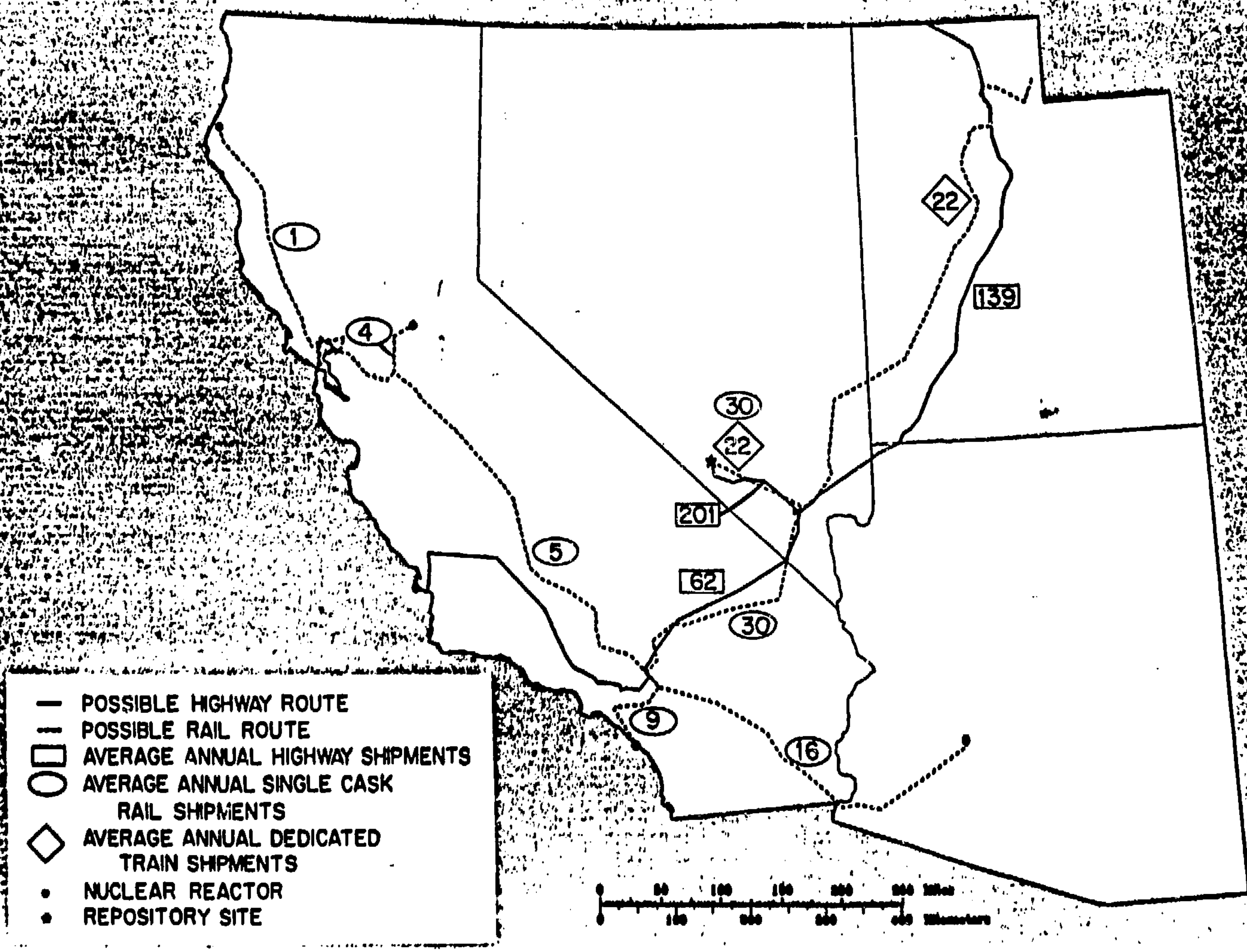


Table 1. Annual number of shipments and distance traveled when transporting spent fuel to a candidate repository site at Yucca Mountain, Nevada

State	Direct to repository: Shipments, Rail	Direct to repository: Shipments, Truck	Direct to repository: Distance, mi x 10^3, Rail	Direct to repository: Distance, mi x 10^3, Truck	MRS scenario: Shipments, Rail	MRS scenario: Shipments, Truck	MRS scenario: Distance, mi x 10^3, Rail	MRS scenario: Distance, mi x 10^3, Truck
AZ	28	933	7.1	153.8	16	139	2.2	4.0
CA	42	62	16.0	30.0	30	62	12.6	30.0
ID	0	139	0.0	38.2	0	139	0.0	38.2
NV	262	995	58.5	164.4	52*	201	9.6	33.8
OR	0	139	0.0	40.4	0	139	0.0	40.4
UT	220	573	82.7	221.3	22*	139	8.3	58.5

*Includes 22 dedicated trains between the MRS and repository.

I-15 between Utah and Nevada will be eliminated in the MRS scenario since the eastern reactors do not ship fuel directly to the repository. This will remove approximately 360 shipments per year from I-40. The number of rail shipments in Arizona will be reduced from 28/year to 16/year. These remaining shipments will be originating at the Palo Verde reactor.

As shown in Table 1, either scenario will produce the same transportation impact in the states of Idaho and Oregon. Shipments passing through these states are carrying fuel from reactors in Oregon and Washington. In either scenario, these shipments will be transported directly to the repository.

Transportation Patterns in the Vicinity of the MRS

The MRS resulted in a net decrease in the number of shipments in the vicinity of the repository. If all non-western reactors transport fuel assemblies to a MRS, there will be an increase in the shipments in the vicinity of the MRS. However, this increase is not as drastic as one would expect, and in some cases, spent fuel traffic in the east would actually decrease. In order to illustrate these trends, detailed traffic patterns within the state of Tennessee will be discussed in this section.

A significant number of spent fuel shipments is expected to pass through Tennessee in the various direct shipment scenarios. If a repository were located in Hanford, Washington, a southeast to northwest traffic pattern would be established. Shipments originating in Florida, Georgia, South Carolina, Alabama, and Mississippi would result in approximately 61 rail and 317 truck shipments passing through Tennessee annually. For the other two repository sites, a more east to west traffic pattern would be established. In addition to the shipments identified above, additional highway shipments will enter Tennessee from Virginia. The number of highway shipments increases to 360 per year for a repository at Yucca Mountain and to 412 per year for a repository at Deaf Smith County, Texas. The number of rail shipments is essentially independent of the repository location.

The number of highway and rail shipments which are expected to pass through the major Tennessee cities are summarized in Tables 2 and

Table 2. Average annual number of truck shipments passing through the state and major cities of Tennessee

Destination	Shipments through				
	Memphis	Nashville	Chattanooga	Knoxville	Tennessee
Hanford, WA	47	270	180	0	317
Yucca Mtn., NV	360	313	180	43	360
Deaf Smith, TX	412	365	180	95	412
Oak Ridge, TN	0	115	172	575	862

Table 3. Average annual number of rail shipments passing through the state and major cities of Tennessee

Destination	Shipments through				
	Memphis	Nashville	Chattanooga	Knoxville	Tennessee
Hanford, WA	25	3	3	7	61
Yucca Mtn., NV	3	12	22	7	61
Deaf Smith, TX	7	5	22	7	58
Oak Ridge, TN	24[a]	0	54[a]	56[a]	269

[a]Dedicated trains transporting consolidated fuel from the MRS to a repository do not pass through any of the major cities in Tennessee.

3, respectively. The Interstate highways passing through Tennessee cities are listed below:

1. Memphis — I-40 and I-55
2. Nashville — I-40, I-24, and I-65
3. Chattanooga — I-24 and I-75
4. Knoxville — I-40 and I-75.

It should be noted that any traffic flowing south along I-75 from Kentucky is considered to pass through Knoxville. However, any traffic flowing north along I-75 from Chattanooga to its junction with I-40 is not considered to pass through Knoxville.

The trend in highway shipments reflects the general transportation trend discussed above. More shipments will move across the state when the repository is located in Texas than when the repository is located in Washington. The rail shipments (see Table 3) show a sizable variation with repository location. Memphis will experience the most shipments when the repository is located in Hanford, Washington. The maximum number of rail shipments will pass through Nashville if a repository were sited at Yucca Mountain. Chattanooga will experience more shipments for repository sites in Texas and Nevada.

The effect of a MRS is also shown in Tables 2 and 3. The line in each table labeled Oak Ridge shows the number of shipments expected to pass through the major Tennessee cities in the MRS transportation scenario, where it was assumed that approximately 53,000 MTU of spent fuel will be transferred from the non-western reactors to the Oak

Ridge site over a 23-year period. While the total number of highway shipments would increase to 862 annually, the number of shipments passing through Memphis, Nashville, and Chattanooga would decreases. In fact, no highway shipments are expected to pass through the Memphis area. The number of shipments passing through Knoxville will increase as a result of fuel shipments originating at the reactors in the northeastern part of the country.

The number of rail shipments passing through Tennessee will increase from approximately 60 per year to about 270 per year for the MRS scenario. In the Memphis area, 24 rail shipments would be expected each year. These shipments will be carrying fuel from reactors located in Nebraska, Kansas, Arkansas, and Texas eastward to the MRS. The number of rail shipments to the MRS is approximately the same as the number of shipments when all fuel is shipped directly to Hanford, Washington (see Table 4). In the MRS scenario, no rail shipments are expected to pass through Nashville. The majority of rail shipments from the upper midwest would pass directly from Kentucky to the MRS site without going through either Nashville or Knoxville. A MRS will result in an increase in the number of rail shipments passing through Chattanooga and Knoxville every year, 54 and 56 annual shipments, respectively. However, even at these increased rates, only one shipment would pass through these areas each a week.

The dedicated trains transporting the consolidated fuel from the MRS to the repository are expected to travel directly north into Kentucky and would not pass through any of the major Tennessee cities.

While the MRS will increase the number of shipments within the state, it has been shown that in general the number of shipments in the western part of the state will actually decrease. The only sections of the state showing an increase in number of shipments is the northeastern portion and the vicinity of Oak Ridge. However, even with this increase, the number of truck shipments is expected to be between two and three per day. About five rail shipments are expected to arrive at the MRS each week.

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