trace metal in samples taken at Cumberland River RM 285.0, with the exception of manganese (drinking water standard of 0.05 milligrams per liter), are below primary and secondary standard concentrations specified for drinking water in 40 CFR 141 and 40 CFR 143. However, the concentrations of cadmium, copper, lead, and zinc are above those specified for the stricter Tennessee Water Quality Criteria for Fish and Aquatic Life as interpreted for the Oak Ridge site (Martin Marietta 1984). A summary of water quality parameters and water quality criteria is given in Table 5.35.

TABLE 5.35. Surface Water Quality Parameters and Standards for the Hartsville Site (TVA 1974a)[a]

Parameter[b]	Number of Observations	Observed Concentrations (mg/L) Maximum	Mean	Standard[c]	% of Standard
Temperature, °C	105	23.5	15.1		
Dissolved oxygen	99	11.9	9.13	5 minimum	
BOD (5-day, 20°C)	36	5	1.2		
COD	36	14	9.5		
pH	36	8	7.1	6.5 - 8.5	
Total alkalinity as $CaCO_3$	36	68	52		
Nitrite plus nitrate nitrogen as N	36	0.49	0.286	10	3
Phosphorous	36	0.27	0.099		
Chloride	3	6	5	250	2
Sulfate	36	20	17	250	7
Boron	36	0.2	0.107		
Cadmium	36	0.016	0.003	0.000025	120
Chromium	36	0.015	0.006	0.05	120
Copper	36	0.2	0.085	0.02	430
Iron (dissolved)	3	0.04	0.027	0.3[d]	9
Lead	36	0.12	0.033	0.0038	870
Manganese	36	0.2	0.082	0.05[d]	160
Nickel	36	0.5	0.084	0.1	85
Zinc	36	0.27	0.111	0.05	220
Fecal coliforms/100 mL	10	90	26	1,100	3

(a) Data collected monthly, January-December 1974, at Cumberland River RM 285.
(b) In mg/L unless specified.
(c) From Tennessee Water Quality Criteria for Domestic Water and Fish and Aquatic Life (taken from Martin Marietta 1984a); unless specified.
(d) Secondary drinking water standard from 40 CFR 143.

Ground Water. The Hartsville site is located near the northern edge of the Central Basin, which is underlain by nearly horizontal limestone strata. These limestone formations are generally poor water-bearing formations, largely because of the presence of shale beds, shale partings, and shaly limestone. Their ability to receive, store, and transmit water is low.

Ground water at the proposed Hartsville MRS site occurs at shallow depths under unconfined conditions in openings formed along fractures and bedding planes in the Hermitage and Carters Limestone formations. Some fractures have been enlarged by solutioning and can occur up to several feet along joints. Many of the solution cavities are partly or completely filled by residual clay.

Ground water at the Hartsville site is generally within 20 to 30 feet (6.1 to 9.2 m) of the surface. Water-level measurements made in the foundation exploration holes for the Hartsville Nuclear Power Plant show that water levels are variable across the site. Wells a few feet apart may show a difference of several feet in water depth. This is thought to be caused by the vertical permeability in the rock being less than the horizontal permeability. Inconsistent water levels are typical of rocks of low permeability. In general, however, the water table does conform to topographic configuration and has a gradient of about 0.05 from the site to Old Hickory Reservoir. Overburden thickness at the proposed site averages about 20 feet (6.1 m). The overburden has little effect on ground-water storage because, over most of the site area, the water table is below the top of bedrock. Above an elevation of 350 feet (110 m), the average bedrock porosity is estimated to be about 2%. Below this elevation, the porosity is lower. The well yield statistics for Trousdale County reflect the low permeability and transmissivity of the rocks.

Nearly everywhere, the water table is below the top of the bedrock at depths of 0 to 75 feet (0 to 23 m) below the land surface. The shallow, unconfined, ground-water flow is generally from recharge areas along topographic highs toward topographic lows. The gradient and flow is generally toward Old Hickory Lake and streams that flow into Old Hickory Lake.

Ground-Water Use. The ability of the limestone formations under the site to receive, store and transmit water is generally low. Wells near the site produce water at rates of only 8 to 50 gallons (30 to 190 L) per minute. Most of the wells near the site are for stock or have been abandoned. The remaining wells are for domestic use. The ground water in the region supplies about 530,000 gallons (2 million L) per day to 6,000 people.

Ground-Water Quality. The ground water in Smith and Trousdale Counties is hard-to-very-hard and is high in dissolved solids. Noticeable hydrogen sulfide occurs in 17% of the wells in Trousdale County. A summary of results of water quality analysis of samples collected from wells at the Hartsville site is shown in Table 5.36. The wells show good quality, except for generally elevated levels of manganese and some elevated levels of lead.

5.3.4 Ecology

The site has been used intensively for agricultural purposes for many years. Heavily fenced, it consists primarily of pasture, cropland, and understocked woodland. Human activity, particularly cultivation, has continually disrupted plant and animal communities, leaving little of the area in a relatively undisturbed state. This section describes the current ecological environment of the site and is taken from TVA (1974a).

5.3.4.1 Flora

The variety and complexity of herbaceous and woody plant associations of the region is an indication of its transitional nature. No distinct vegetation dominance is observable at the site, due to cultivation. Most of the region is being used for agriculture, and, therefore, dominance constantly shifts accommodating numerous accessory species of plants. Table 5.37 lists the scientific names of the plants mentioned below.

TABLE 5.36. Ground-Water Quality Data from Wells at the Hartsville Site (TVA 1974a)

Parameter	Observed Concentration (mg/L)		Drinking Water Standard[a]	% of Standard
	Maximum	Mean		
Total alkalinity	160	105	--	
Cadmium	0.002	<0.001	0.01	<10
Chromium	<0.005	<0.005	0.05	<10
Copper	0.19	0.06	1.0	6
Lead	0.19	0.07	0.05	140
Manganese	10	2.0	0.05	4,000
Total NO_2 + NO_3	0.79	0.2	10	2
Sulfate	30	10	250	4
Zinc	0.53	0.27	5.0	5
pH (pH units)	7.6 - 8.2	7.9	6.5 - 8.5	
TDS	240	130	500	26

(a) Drinking water standards from 40 CFR 141 and 40 CFR 143.

TABLE 5.37. Scientific Names for Plants Identified at the Hartsville Site

Common Name	Scientific Name
American Elm	*Ulmus americana* L.
Aster	*Aster pilosus* Willd.
Beech	*Fagus grandifolia* Ehrh.
Bitterweed	*Saturjea calimintha*
Black cherry	*Prunus americana*
Blackberry; Dewberry	*Rubus* sp.
Black Locust	*Robnia pseudo-acacia* L.
Black Oak	*Quercus velutina* Lain.
Black Willow	*Salix nigra* Marsh.
Broom Sedge	*Andropogon virginicus* L.
Box Elder	*Acer negundo* L.
Chinquapin Oak	*Quercus muehlenbergii* Engelm
Clover	*Trifolium* sp.
Common Ragweed	*Ambrosia artemisiifolia* L.
Coral-Berry	*Symphoricarpos orbiculatus* Moench.
Corn	*Zea* sp.
Cottonwood	*Populus deltoides* Marsh.
Daisy Fleabane	*Erigeron strigosus* Muhl.
Ebony Spleenwort	*Asplenium platyneuron* (L.) Oakes
Evening Primrose	*Oenothera laciniata* Hill.
False Buckwheat	*Polygonum scandens* L.
Fishing Cane	*Arundinaria gigantea* (Walt.) Muhl.
Four-O'clock	*Mirabilis jalapa* L.
Foxtail Grass	*Setaria geniculata* (Lam.) Beauv.
Giant Pigweed	*Amaranthus spinosus* L.
Giant Ragweed	*Ambrosia trifida* L.
Goldenrod	*Solidago altissima* L.
Hibiscus	*Hibiscu militaris* Czv.
Hickory	*Carva* sp.
Honeysuckle	*Lonicera japonica* Thunb.
Horse Nettle	*Solanum carolinense* L.
Ironweed	*Veronica altissima* Nult.
Jimson Weed	*Datura stramonium* L.
Lespedeza	*Lespedeza cuneata* (Dumont) G.D. Sericea
Maple	*Acer* sp.
Marsh Elder	*Iva xanthisolia* Nult.
Mississippi Horseweed	*Erigeron canadensis* L.
Mulberry	*Morus alba* L.
Mullein	*Verbascum thapsus* L.
Muscadine	*Vitis rotundifolia* Michx.

TABLE 5.37. (contd)

Common Name	Scientific Name
Okra	*Abelmoschus esculentus* (L.) Moench
Osage Orange	*Maclura pomifera* (Raf.) Schneid.
Panic grass	*Panicum* sp.
Partridge Pea	*Cassia fasciculata* Michx.
Passion Flower	*Passiflora incarnata* L.
Petunia	*Petunia hybrida* Vilm.
Poison Ivy	*Rhus radicans* L.
Poke	*Phytolacca americana* L.
Red Cedar	*Juniperus virginiana* L.
Shagbark Hickory	*Carya ovata* (Mill.) K. Koch.
Silver Maple	*Acer saccharinum* L.
Snow-on-the-Mountain	*Euphorbia marginata* Pursh.
Spurge	*Euphorbia presslii* Guss.
Sumac	*Rhus glabra* L.
Sycamore	*Platanus occidentalis* L.
Tobacco	*Nicotiana tabacum* L.
Tomato	*Lycopersicon esculentum* Mill
Tulip Tree	*Liriodendron tulipifera* L.
Turnip	*Brassica rapa* L.
Violet	*Viola* sp.
Winged Elm	*Ulmus alata* Michx.

The vegetation of the site has been tentatively categorized into seven arbitrary zones: 1) limestone knolls with mostly closed woods but occasional open spaces, 2) open woods and deciduous tree rows primarily occurring along property lines, 3) pastures, 4) old fields, 5) cultivated areas, 6) fence rows, and 7) riparian woodlands. These seven categories are described below:

1. Limestone knolls have gentle slopes. The lower slopes of these knolls have black cherry/shagbark hickory/osage orange associations, and ground vegetation has an abundance of bitterweeds and spurge. On higher slopes, red cedar with blackberry, winged elm, and occasionally chinquapin oaks are abundant. Here the ground vegetation consists mostly of grasses and wingstems, with a good mixture of red cedar, oak, and hickory saplings. Osage orange is uniformly distributed throughout the slopes. Colonies of blue-green algae and lichens are consistently found on exposed rocks, and xerophytic moss is found on the sides of rocks. One species of fern, Ebony spleenwort, has been identified, but many others have been recorded for

this type of physiographic region. On a single southwest-facing slope, a few old (100 years or older) beech trees occur, accompanied by a few giant chinquapin oaks. A rare plant, marbleseed (Onosmodium molls), was found growing in a localized area in and adjacent to a gas pipeline. Marbleseed is generally considered a cedar glade endemic, but it is also found in old fields in the region.

2. Open woods vegetation is found primarily along property lines and ditch corridors. Elm and maple are the most important woody species, being present in both seedlings and transgressive layers. Open woods areas are characterized by mature deciduous trees and a small number of shrubs and large herbs. The canopy is comprised mainly of American elm, black oak, box elder, silver maple, black locust, and an occasional osage orange. The ground vegetation consists of sparsely distributed blackberry, dewberry, sumac saplings, poison ivy, and various tree seedlings.

3. Pastures exhibit an abundance of panic grass, lespedeza, clover, and some broom sedge. Pure stands of broom sedge are found only in abandoned pastures. Fields that have not been brought under cultivation for one to three years (and not heavily grazed) exhibit the maximum number of species.

4. Old fields are abundant with common ragweed, giant ragweed, marsh elder, Mississippi horseweed, and false buckwheat. In addition to the above, daisy fleabane is a prominent species during early summer. In places closer to ditches and creeks, horse nettle and ironweed show uniform distribution. Giant pigweed and jimson weed are frequently found around barnyards and ditches rich in cattle manure. Areas that were not used for more than five years are dominated by golden rod, broom sedge, and aster in irregularly scattered clumps, along with some grasses.

5. Cultivated areas are used primarily for corn, tobacco, and home vegetable gardens. Many of these cultigens escape and persist in fields and creek banks and may be mistaken for naturalized weeds. Okra, tomato, and turnip are found in some of the one-year-old fields. In addition to native species, several introduced ornamentals, such as violet, petunia, four-o'clock, snow-on-the-mountain, and hibiscus occur.

6. Fence rows (barbed wire) are numerous in the area, and a variety of vegetation occurs there. Fence rows that have not been cleared of vegetation for many years exhibit only honeysuckle. Poke, passion flower, coral berry, evening primrose and, occasionally mullein are

the dominant species on many fence rows. Foxtail grass and false buckwheat, muscadine, black locust, and partridge peak were also abundant on roadside fence rows, along with mulberry and red cedar. Many of the fence posts also support a rich growth of lichens and liverwort.

7. Riparian Woodlands. The wooded areas on the banks of Dixon Creek and the Cumberland River are dominated by cottonwood, sycamore, and tulip trees and an abundant admixture of black willow saplings and fishing cane.

In general, only two areas of the Hartsville site afford some semblance of native vegetation. The largest area is the wooded knolls adjacent to and north of the site. The diversity of this area, although not documented, is expected to be low. The wooded shorelines of Dixon Creek, Dixon Island, and Cumberland River constitute the major portion of riparian habitat at the site. This vegetation category is considered the most important habitat type at the site because of its suitability for a large number of plant and animal species. A complete list of the plants considered by the State of Tennessee to be rare or endangered is provided in Appendix K. A similar list of species, in adjoining counties, is available upon request from the Department of Conservation in Nashville.

5.3.4.2 Fauna

The Hartsville site has no very unusual habitats, primarily due to the intense agricultural activities in the area. However, several bird, small-mammal, and reptile and amphibian habitats occur at the site.

Wooded knolls afford the largest terrestrial bird and small mammal habitats, although the diversity of such areas is typically not great. The riparian woodland areas along Dixon Creek, the Cumberland River, and Dixon Island constitute another important habitat type at the site. These areas are suitable for the greatest number of species. The riverbank of the Cumberland and the tributary streams are the most valuable wildlife habitat at the site.

Generally the wooded areas, although quite small in comparison with the entire site, support a myriad of songbirds, reptiles and amphibians, and small mammals. Fence rows and riparian areas also support a variety of wildlife species, with the shoreline wooded sections being the most important.

Fourteen species of mammals have been identified on the Hartsville site. Three additional species have been recorded as being present within the study area. Mice (Mus musculus, Peromyscus leucopus, Peromyscus maniculatus, Microtus ochrogaster) are more abundant than any other group. M. musculus is the most abundant of these species.

Sixteen members of the genus Sylvilagus have been observed. Positive identification to species has not been possible, but all are believed to be eastern cottontail rabbits (S. floridanus). White-tailed deer (Odocoileus virginianus) and least shrews (Cryptotis parva) have been observed. Field observations of opossums (Didelphis marsupialis) and red foxes (Vulpes fulva) have been made at night. Also identified on the site are the Norway rat (Rattus norvegicus), the woodchuck (Marmota monax), the gray squirrel (Sciurus carolinensis), and a fox squirrel (S. niger).

Game species such as quail, rabbit, and gray squirrel also occur onsite, although habitat conditions cannot support large populations of these species. Two species of breeding waterfowl are known to use the site: wood duck and greater Canada geese. Black vultures have been seen in large concentrations on the site--all on or near Dixon Island. Apparently these birds use Dixon Island as a staging area enroute to breeding territory nearby, as a feeding area during the breeding season, and as a loafing site, especially for nonbreeders.

Threatened or endangered birds, which are rarely seen on the site and almost certainly do not breed there, are the peregrine falcon, bald eagle, golden eagle (Aquila chrysaetos), osprey, and red-cockaded woodpecker (Picoides borealis). The only rare or endangered mammal occurring on the site is the gray bat (Myotis grisencens). This bat occurs most commonly in the caves of central Kentucky, southern Indiana, and Ohio, and in the Ozark Mountains. A complete list of the animals considered by the State of Tennessee to be rare or endangered is provided in Appendix K. A similar list of species, in adjoining counties, is available upon request from the Department of Conservation in Nashville.

A total of 14 species of amphibians and 12 species of reptiles have been collected and/or identified on the Hartsville site.

5.3.4.3 Aquatic Life

Sixty-one species of zooplankton have been collected (excluding Ostracoda and Tardigrada). Thirty-three species of Rotifera, 19 of Cladocera, and nine of Copepoda have been identified. Of the Rotifera, Keratella, Polyarthra, and Synchaeta were the most abundant genera.

The phytoplankton are dominated by the Bacillariophycea (diatoms). At times, as in March, the Pyrrophyta make up a significant quantity of the surface phytoplankton. This is also true of the Euglenophyta during certain months (July and August). The Chlorophyta is the next most abundant of the phytoplankton. The percentage of the Chlorophyta is highest during the warmer months (July, August, September) near the surface. Cyanophyta is highest during June, making up about 1.2% of the population. During the other months of the year, Cyanophyta make up less than 1%.

In the periphyton, Bacillariophycease are the most dominant taxa. Chlorophyta make up a significant portion of the periphyton community during June, July, and August, but never exceed 40% of the sample except in Dixon Creek. Cyanophyta make up a significant portion of the periphyton during July in the Cumberland River and Dixon Creek.

In the bottom fauna, Oligochaeta, Chironomidae, and Corbicula are consistently encountered in high numbers and represented the majority of the biomass. Populations in sand substratum generally have fewer individuals, fewer species, and smaller biomass than those of the mud substratum. Trichoptera, Ephemeroptera, and Diptera appear to be the predominant organisms in samples collected by artificial substrates.

Old Hickory Reservoir is located downstream of Center Hill, Dale Hollow, and Cordell Hull Reservoirs, all of which strongly influence Old Hickory Reservoir with cool water discharges and variable flows. Old Hickory has a rapid water-exchange rate and, at the site, appears as a slightly broadened river. Site assessments initiated in 1972 and 1973 indicate that the fish community is not typical of either a stream or a lake habitat and is dominated by gizzard shad, carp, and bluegill sunfish. Other abundant species include both black crappie (Pomoxis nigromaculatus) and white crappie (P. annularis), sauger, walleye, and freshwater drum (Aplodinotus grunniens). With 35 species represented in samples, the species complex of Dixon Creek differs considerably from fish communities found in the Cumberland River during the latter 19th century, prior to impoundment.

National Marine Fisheries Service records indicate that Old Hickory Reservoir supports an annual commercial fish harvest of about 4.4 pounds (2.0 kg) per acre, most of which are buffalo (Ictiobus sp.), carp (Cyprinus carpio), and catfish (Ictalurus sp.).

The only threatened or endangered aquatic species found near the Hartsville site is the federally listed endangered pink mucket pearly mussel (Lampsilis orbiculata). However, its occurrence in the Cumberland River near the site is rare. A complete list of the aquatic species considered by the State of Tennessee to be rare or endangered is provided in Appendix K. A similar list of species, in adjoining counties, is available upon request from the Department of Conservation in Nashville.

5.3.5 Land Use

The Hartsville site is located in central Tennessee on the banks of the Cumberland River in Smith and Trousdale counties. With the exception of relatively small, scattered communities and numerous crossroads settlements, the land surrounding the site is sparsely populated farmland and bottom land.

No cities with a population greater than 1,000 people are located within 5 miles (8 km) of the Hartsville site; however, The small towns of Dixon Springs and Riddleton are near the site. Dixon Springs is only 1.5 miles (2.4 km) east of the site. Two cities with a population over 1,000 are within a 10-mile (16-km) radius of the proposed location: Hartsville, which is 5 miles (8 km) to the northwest, and Carthage, which is 10 miles (16 km) to the southeast. This section describes the current uses of the land surrounding the Hartsville site.

5.3.5.1 Commercial, Industrial, and Residential Sites

Residential land is scarce around the site. Residences in the immediate vicinity consist mainly of farms and associated houses scattered along numerous small roads. This resident population around the site is projected to remain fairly constant. Future residential development is expected to be confined to the larger cities and urban areas (TVA 1974b).

No chemical plants or other industries processing hazardous material exist on or near the site. There are no missile silos or military bases in the region (TVA 1976). Industrial activity within a 10-mile (16-km) radius of the Hartsville site is found almost exclusively within or immediately adjacent to the cities of Hartsville and Carthage. Several manufacturing plants are located in the city of Hartsville. These industries produce apparel, footwear, and other fabricated products (TVA 1976). Trousdale County supports one industrial park - the Trousdale County Industrial Park, which consists of 66 acres (27 ha) (Tennessee Division of Community Development 1983). Numerous other small industrial parks are located throughout the primary impact area.

While no commercial activity is currently taking place on the site, it was cleared, graded, and modified for industrial use before the TVA abandoned the construction of its nuclear plants. Present TVA activity at the site consists of disposal of surplus equipment, storage of reserve material, and storage of parts and electric cable. Unrelated to the TVA is a natural gas pipeline, [22 inches (56 cm) in diameter], which crosses the northern portion of the Hartsville site. The line owned and operated by the East Tennessee Natural Gas Company, was constructed in the 1950s, and 1.67 miles (2.7 km) of it are within the Hartsville site's boundary (TVA 1974b).

5.3.5.2 Agricultural Activities

Most of the region surrounding the Hartsville site can be characterized as rural, and farming is the predominant land use. Active agricultural production accounts for 52% of all of the land use in Smith and Trousdale counties. This overshadows urban and industrial development, which accounts for only 3% of total land use (TVA 1975). As of 1982, there were 1,800 farms in the two counties totaling 215,000 acres (University of Tennessee 1985). Most of this land is used as pasture or for hay production. Corn and tobacco are other major crops. In 1973, within 5 miles (8 km) of the site 500 acres (203 ha) of land was devoted to tobacco, 400 to corn, and 300 to soybeans (TVA 1975). In this same area, 25 to 30 irrigation systems drew upon surface water mainly in support of tobacco crops. It was estimated that 75% of the families living in the immediate vicinity of the site had home gardens. The average size of these plots was about a 0.25 acres (0.1 ha) (TVA 1974a).

The site has a history of agricultural activity. Its soil is classified as good for both crop and pasture land. Before the initiation of the TVA project, 1,750 of the total 1,940 acres (710 of 790 ha) was cleared for agricultural activity. Pasture and hay crops accounted for 1,575 acres (640 ha) on this cleared land. The remainder of it consisted of corn, soybeans, tobacco, and vegetable gardens (TVA 1974a).

5.3.5.3 Grazing Area

Livestock is a major source of income and a major user of land in middle Tennessee. The bottom land soil of the Hartsville site is ideally suited for the maintenance of both beef and dairy cattle. Prior to the aborted TVA nuclear project, much of the land was heavily cultivated and extensively fenced for cattle (TVA 1974b). In 1973 an agricultural survey found that within a 5-mile (8-km) radius of the Hartsville site, 10,000 acres (4,100 ha) of pasture land supported 10,900 head of livestock. This figure was comprised of 5,900 cattle, 4,000 hogs, and 1,000 sheep (TVA 1974b). Of the 5,900 cattle, 5,000 were beef cattle. Dairy production, however, is also important to the region. Several farms near site keep cows to produce milk for both domestic and commercial consumption. In 1983, Smith County had 1,100 dairy cattle, and Trousdale County had 550 (Tennessee Department of Agriculture 1984).

5.3.5.4 Minerals, Forests, and Natural Resources

Mining and mineral extraction is not a major form of land use in the region. Small amounts of coal are present in White and Overton Counties, which are east of the site within a 50-mile (80-km) radius, but no production is on record (Keystone Coal Industry Manual 1980). Coal is not as important to this part of Tennessee as it is to parts of eastern Tennessee and neighboring Kentucky. Natural resources, such as limestone, crushed stone, and phosphate rocks, are common in the area. Limestone quarries exist in two groups west of Hartsville along SR-25 approximately 6.2 and 9.3 miles (10 and 15 km) from the site.

Forest land is common in this mostly rural section of Tennessee. In 1980, 35% of the total land area in Smith and Trousdale counties was covered with commercial forests (University of Tennessee 1983). Most of the forests are comprised of different species of hardwood trees. Much of the area is understocked because it has been used intensely by humans for many years. Prior to TVA activity, 190 acres (77 ha) of forested land existed at the site.

5.3.5.5 Utilities

The Bull Run-Wilson 500 kV transmission line is located approximately 16 miles south of the Hartsville site, and the Gallatin-Cordell Hull 161-kV line is located approximately 6 miles south of the site. The Gallatin-Lafayette 161-kV line is located about 8 miles (13 km) northwest of the site.

A 22-inch (56-cm) natural gas pipeline belonging to the East Tennessee Natural Gas Company passes through the northern part of the Hartsville site (TVA 1974a). The pipeline crosses the site boundary near the northwest corner, enters a compressor substation north-northeast of the Hartsville nuclear plants, and leaves the site at the northeast site boundary (Figure 5.21).

5.3.5.6 Parks and Recreation

The Hartsville region supports numerous outdoor activities such as swimming, boating, camping, and fishing. Most of these activities are connected with the Cumberland River and its associated waterways, such as the Old Hickory Reservoir.

Thirteen recreation areas are located within 10 miles (16 km) of the Hartsville site. It is estimated that during peak hours these areas are utilized by about 1,250 persons. Within a 5-mile (8-km) radius of the site, peak-hour usage is estimated to be about 240 persons (TVA 1975). No recreational areas are located within 2 miles (3.2 km) of the Hartsville site. Only one recreation area exists in the 2- to 3-mile (3.2-km to 4.8-km) range (TVA 1974b). The Green Hill Country Club is located 3 miles (4.8 km) from the site on SR-25. The 27,778-acre (11,000-ha) Old Hickory Wildlife Management Area is located along the Cumberland River, downstream within 10 miles (16 km) of the Hartsville site (TVA 1974c).

5.3.6 Socioeconomics

The Hartsville site is located in Trousdale County, in northcentral Tennessee, at the abandoned Hartsville Nuclear Power Plant site. An MRS

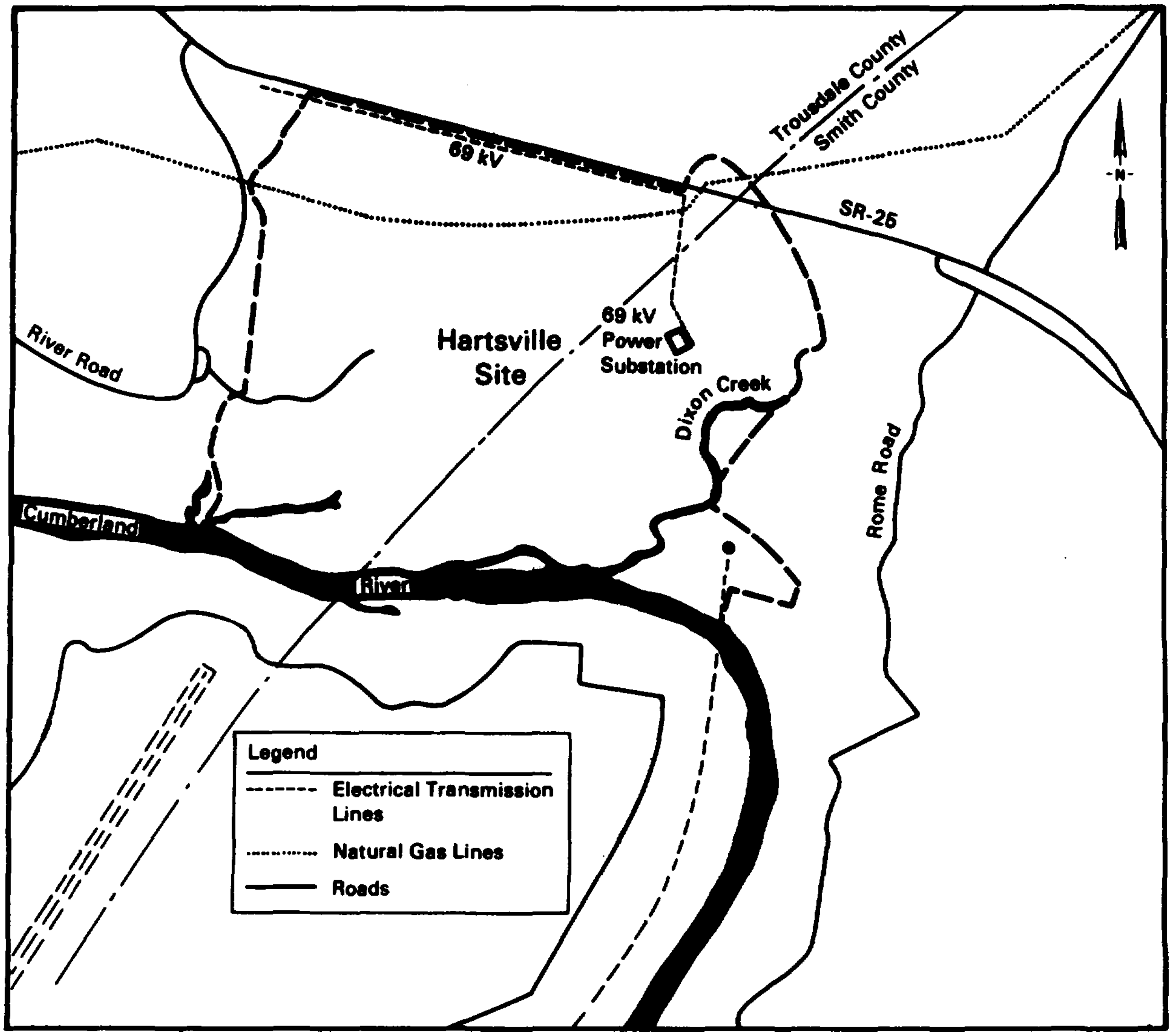

FIGURE 5.21. Existing Utilities at Hartsville Site

Facility at the Hartsville site would most likely affect the same five counties as did the TVA construction program: Trousdale, Smith, Macon, Sumner and Wilson counties. These five counties compose the primary impact area. Data will also be reported for a wider 50-mile (80-km) radius impact area, shown in Figure 5.22 The primary impact area and principal towns and cities within it are shown in Figure 5.23. The 50-mile impact area consists of 20 Tennessee counties and eight Kentucky counties.

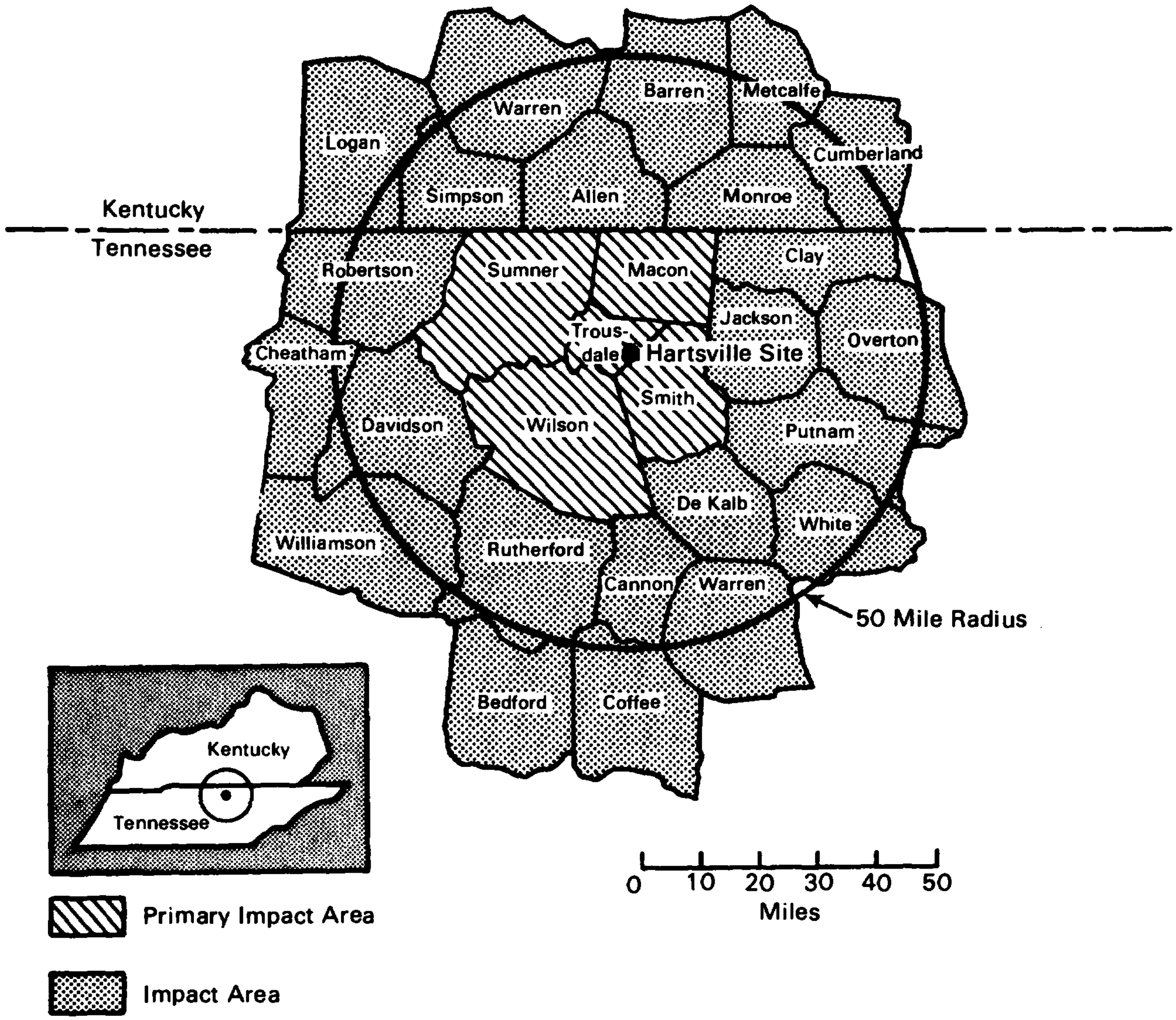

FIGURE 5.22. Socioeconomic Impact Area for the Hartsville Site

5.3.6.1 Historical and Sociocultural Background

The Hartsville area was settled by the English who immigrated into the area during the 1700s. Germans also moved into the Hartsville region in the 1800s. The primary economic activities at that time were agriculture and mining.

More recently, the Hartsville area has seen the effects of major nuclear power plant construction by the TVA. The socioeconomic effect of power plant construction was less than was anticipated. The TVA made a major effort to

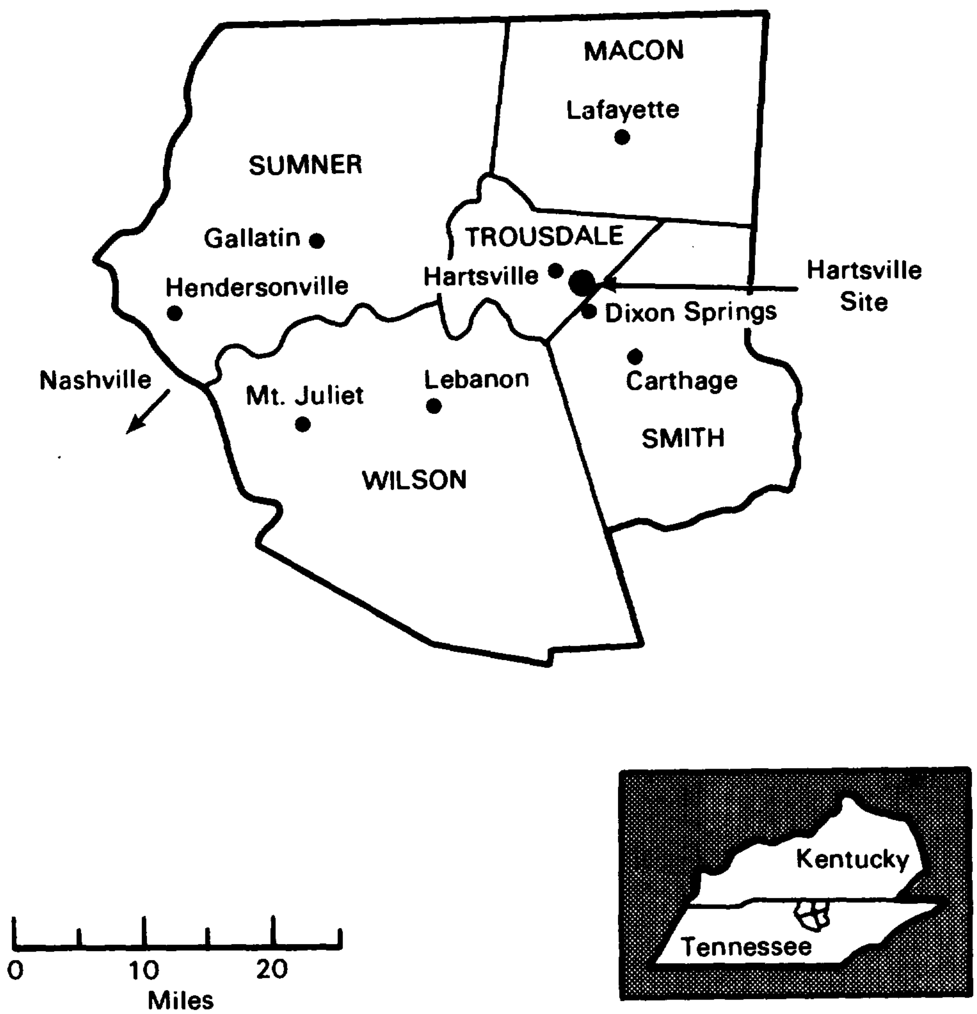

FIGURE 5.23. Principal Cities Within the Primary Impact Area for the Hartsville Site

recruit local labor, and in the peak year of construction activity (1979), about 34% of the project work force (2,200) was from the five-county primary impact area. Other cities of noteworthy size around Hartsville include Lebanon, Cookeville, and Gallatin. Other cities that supplied more than 100 workers during peak TVA construction were Hendersonville, Lafayette, Smithville, Madison, and Mount Juliet (TVA 1979).

Table 5.38 gives the population and a breakdown of population density for the 50-mile (80-km) radius impact counties.

The primary impact area counties had a combined 1980 population of 178,626, while the surrounding impact counties numbered 1,091,125. Total population for the 50-mile impact area was 1,269,751 in 1980. The respective

TABLE 5.38. 1980 Population and 1984 Estimated Population for the Hartsville Site Impact Area (University of Tennessee 1985; U.S. Department of Commerce 1985b; 1983)

Counties	Population 1980	Population 1984	Land Area (mi^2)	1980 Average Population Density	1980 Population by Age (yrs) <5	5-17	18-64	>65
Primary Impact Area:								
Trousdale County	6,137	5,600	114	54	466	1,184	3,695	792
Smith County	14,935	14,600	313	48	1,031	3,077	8,632	2,195
Macon County	15,700	15,700	307	51	1,130	3,344	9,106	2,120
Sumner County	85,790	90,800	529	162	6,520	20,675	51,045	7,550
Wilson County	56,064	60,300	570	98	4,093	13,119	33,302	5,550
Subtotal	178,626	187,000	1,833	97	13,240	41,399	105,780	18,207
Davidson County (Nashville)	477,811	485,000	501	953	31,536	87,917	305,321	53,037
Other Tennessee Counties[a]	425,412	483,900	5,558	77	30,857	92,816	253,707	48,032
Kentucky Counties[b]	187,902	200,300	3,086	61	13,671	38,203	112,155	23,873
TOTAL Impact Area	1,269,751	1,326,600	10,978	116	89,304	260,335	776,963	143,149

(a) Bedford, Cannon, Cheatham, Clay, Coffee, DeKalb, Jackson, Overton, Putnam, Robertson, Rutherford, Warren, White, Williamson.
(b) Allen, Barren, Cumberland, Logan, Metcalfe, Monroe, Simpson, Warren.

estimated 1984 populations are 187,000 for the primary impact area, and 1,326,600 for the 50-mile impact area.

Economic growth in the area drew in construction workers, skilled technicians and professionals from throughout the United States. Thus, cancellation of the project was an economic shock to the area. Through these economic fluctuations, the population in the primary impact area increased by 12% (17,400 people) during the three-year period ending in March 1979. Although population has continued to grow through the present, TVA-project-related population declined after 1979 (TVA 1982a).

Limited construction on the Hartsville Nuclear Plant two-unit project began in April 1976, with employment reaching a peak of approximately 7,000 by May 1979. At that time, TVA made the decision to defer construction on Hartsville Plant "B" on the basis of staff projections of a continued downward trend in load forecasts. This resulted in the layoff of 2,000 workers, reducing those employed on the project to a total of 5,000. After reviewing the 1981 load forecast, which reduced projections still further, TVA decided to stretch out the construction on the remaining Hartsville Plant "A". This further reduced the project work force by 2,000 down to a level of 3,000 workers by December 1981. An "option paper" prepared by TVA staff and presented to the TVA Board of Directors in January 1982, re-examined earlier projections of power demand and construction on the Hartsville Nuclear Project, and with the updated information, the Board of Directors chose to stop construction on the projects.

As a result, all the primary impact counties suffered significant payroll losses. Macon and Trousdale counties both experienced an absolute decline in local-option sales tax receipts, and some convenience stores near the plant suffered losses in sales volume (Mid-Cumberland 1983).

According to TVA estimates in the 1975 EIS, during peak employment, the housing demand for new population would total about 2,200 dwelling units (1,700 for workers with families plus 500 for single workers rooming together). The EIS indicated that although conventional housing still tended to be the preferred type of dwelling, mobile homes were being used increasingly by construction workers where other housing was not available, reaching 45% at TVA's most recent projects. Based on this projection, mobile homes were expected to total 1,000 at peak, with the remaining 1,200 dwelling units comprising houses, apartments and sleeping rooms.

TVA's estimate placed the greatest demand for housing in areas close to the plant site in Macon, Trousdale, and Smith counties. Since conventional housing was not available in these counties, TVA encouraged the development of mobile home parks. Two parks were developed based on the projections made by TVA.

The impact of population moves and the demand for housing that was estimated by TVA did not materialize. A major reason for why the expected distribution of population moves did not occur was that the highly successful bus and van pool program created by the TVA made it unnecessary for many workers to change residences to work at the project. Another reason was unavailable rental housing in close proximity to the plant site. Although the TVA had helped with the planning and development of two hundred and fifty spaces for mobile homes, Hartsville Nuclear Power Plant workers chose to locate or remain in neighborhoods in Sumner, Wilson and Davidson Counties.

The decision by the TVA to close the Hartsville Nuclear Project had its greatest impact on the developers of the mobile home parks in the Hartsville area. The developers had purchased mobile homes based on the assumption that plant construction would create a need for housing in the area for eight to ten years; with the total shutdown of plant construction developers lost several hundred thousand dollars on their investments (Mid-Cumberland 1983).

Homes were purchased by several construction workers who assumed, like the mobile home park developers, that plant construction would continue for several years. Figures are not available as to the number of TVA workers who bought homes in the impact area with the expectation of living and working there from eight to 10 years. The number of workers that bought homes in the area and subsequently had problems in paying their mortgage as a result of plant closure is known to exist, but has not been documented.

As with housing needs, the anticipated water and sewer needs as projected in the EIS did not materialize. The projected need was based on an estimate of the number of construction workers expected to relocate in the impact area. Since the actual influx was considerably less, the demand for additional water and sewer hookups did not materialize. The TVA spent several hundred thousand dollars helping to upgrade water and sewer systems. Since the expected water and sewer demand did not materialize, the mitigation efforts by the TVA worked as an advantage for the local governments that received funds. The improvements made with the help of the TVA would aid in future growth and development of the area.

5.3.6.2 Demographics

The major population center near the Hartsville site is Nashville, 39 miles (63 km) to the west. Nashville, with a 1980 population of 455,651, is substantially more diversified than the smaller communities in the primary impact area.

Table 5.38 also provides a breakdown of the population by age group. The three significant age groupings are 5-17, 18-64, and 65 and over. In 1980, the primary impact area counties had a total of 105,780 people in the 18-64 age bracket. Together with Davidson County, these counties had a total of 411,101 in the 18-64 age group. The 1980 area total for the 18 to 64 age group is 776,963 people. This age group is significant because it represents the potential labor force available locally.[a]

The second largest population group is the 5-17 age bracket, with 41,399 persons in the primary impact counties and 218,936 persons in the remainder of the impact area. The 1980 area total for the 5-17 age group was 260,335 persons. This age group represents the potential demand for primary and secondary education services.

The next largest population age category is the over-65 group. In 1980, the primary impact area counties had 18,207 in this age group, while the remainder of the impact area had 124,942 persons, totalling 143,149 for the entire impact area. This age bracket is significant because it represents the principal source of potential demand for nursing home care and extensive medical care. The under-5 age group, the smallest group shown, is included in the table for completeness.

All of these age groups are in the same approximate proportion as the United States as a whole; the Hartsville region is not unique in this regard.

Geographic Distribution. For the five-county primary impact area, approximately 74% of the population live in Sumner and Wilson counties. Nashville (Davidson County) is the major population center near the Hartsville site. Nashville is west of Hartsville about 39 miles (63 km). Nashville's 1980 population was 455,651 persons (Tennessee Division of Community Development 1983). The next largest cities are Gallatin in Sumner County (17,191 in 1980), Hendersonville in Sumner County (25,561 in 1980), and Lebanon in Wilson County (11,872 in 1980). These cities lie to the west of the Hartsville site. The population density in the Hartsville region is about 116 persons per square mile.

Baseline Forecasts. Table 5.39 contains the baseline forecasts, by age group, for the total area for the years 1980, 1991, 2010, and 2030. The baseline forecast assumes the MRS facility has not been constructed. The baseline forecast years have been selected for the purpose of comparing population growth in the absence of MRS to population growth in key years in its development, assuming it were built.

For all age groups, the total population for the Hartsville area increases at an annual rate of 2.0% between 1980 and 1991. Between 1991 and 2010, population growth is 1.5% per year; and between 2010 and 2030, population increases

(a) As noted before, labor force participation rates and skill mix also influence the size of available labor force.

TABLE 5.39. Baseline Population Forecasts by Age Group for the Hartsville 50-Mile Impact Area[(a)]

Age Groups	Year 1980	1991	2010	2030
Combined Age Groups (Total Population)	1,270,000	1,575,000 (2.0)	2,105,000 (1.5)	2,330,000 (0.5) (1.2)
<5	89,000	105,000 (1.5)	125,000 (0.9)	125,000 (0.0) (0.7)
5-17	260,000	285,000 (0.8)	335,000 (0.9)	345,000 (0.1) (0.6)
18-64	777,000	1,005,000 (2.4)	1,405,000 (1.8)	1,455,000 (0.2) (1.3)
>65	144,000	180,000 (2.0)	240,000 (1.5)	405,000 (2.6) (2.1)

(a) From PNL's MASTER Model. First number in parentheses is the annual average percent growth over previous period. Second number in parentheses in the last column is the annual average percent growth over the entire period.

at a rate of 0.5% per year. When the population forecast is broken down into age categories, more revealing results are found. For example, the highest growth in the 5-17 age group (the group to examine for forecasting primary and secondary education demand) is between 1991 and 2010 when it grows at a 0.9% annual rate over the previous period. However, the potential labor force population, 18-64, grows at an annual rate of 2.4% per year between 1980 and 1991. This growth is not likely to be significant when compared to the potential demand for labor because the number of jobs actually is forecast to grow at a slower rate, reducing the number of workers who will need to migrate into the Hartsville area. Finally, the 65-and-older age group increases most significantly between 2010 and 2030, reflecting the aging of the "baby-boom" generation. In this period, the demand for health care would be particularly high.

Comparing the the Hartsville area population forecasts provided by PNL's MASTER model to population forecasts for the entire United States from Data Resources, Inc. (DRI 1985), it is readily apparent that the Hartsville 50-mile impact area population will grow at a relatively faster rate than the nation as a whole (1.2% per year versus 0.8% per year). This is largely due to continued, rapid immigration into the Nashville area.

5.3.6.3 Employment

This section provides a detailed examination of employment near the Hartsville site. The 1984 civilian labor force numbers, total employment figures, and unemployment rate are presented, and baseline forecasts are provided for years relevant to the MRS project.

Data on the 1984 labor force, employment, and unemployment of the Hartsville impact area is presented in Table 5.40 and compared with Tennessee and United States data. The total civilian labor force for the five-county primary impact area, estimated by the Bureau of Labor Statistics (BLS) for 1984 was 98,311 workers, over 80% of whom lived in Sumner and Wilson Counties (University of Tennessee 1985). The total civilian labor force in the rest of the impact-area counties was over 585,000. Davidson County, which includes Nashville, the largest city in the 28 impact counties, had a 1984 total civilian labor force of 261,040 workers. Nashville lies about 46 miles (74 km) southwest of the Hartsville site.

The unemployment rate varies widely throughout the five-county primary impact area. Based on 1984 BLS figures, it ranges from a high of 12.1% in Trousdale County to a low of 7.3% in Sumner County. Except for Sumner and Wilson Counties, the entire five-county primary impact area has a higher unemployment rate than the state of Tennessee. Generally the rural counties in the primary impact area have slowly growing or declining economies with higher unemployment rates than the Nashville area or the United States as a whole. The suburban Nashville area, on the other hand, grew quite rapidly between 1970 and 1980 and is expected to be further influenced by General Motors' proposed Saturn plant in Spring Hill, Tennessee, south of Nashville.

The wide disparity in unemployment rates among the counties indicates the difficult economic conditions Trousdale and Macon Counties have been experiencing. These counties have a very weak industrial base. Only 3% of the land in Trousdale and Smith Counties is used for industrial or urban activities. Most of the land is devoted to agriculture (89% in Trousdale County, 66.8% in Macon County). The cancellation of the TVA's nuclear project at Hartsville also contributed to the stagnation of the local economy.

TABLE 5.40. Employment and Labor Force Data for the Hartsville Impact Area, Compared with Tennessee and the United States, 1984 (University of Tennessee 1985; U.S. Department of Labor 1985)

Counties	Total Labor Force	Total Employment	Total Unemployment	Unemployment Rate (%)
Primary Impact Area:				
Macon County	6,700	5,920	780	11.6
Smith County	7,590	6,740	850	11.2
Sumner County	49,660	46,050	3,610	7.3
Trousdale County	2,570	2,260	310	12.1
Wilson County	31,810	29,710	2,100	6.6
Subtotal	98,330	90,680	7,650	7.8
Davidson County (Nashville)	261,040	248,640	12,400	4.8
Other Tennessee Counties	227,300	209,600	17,700	7.8
Kentucky Counties	97,309	86,968	10,377	10.7
TOTAL Impact Area	683,979	635,888	48,127	7.0
Tennessee	2,223,000	2,033,000	190,000	8.5
United States	113,544,000	106,702,000	8,539,000	7.5

Even though the MRS facility would not begin construction until 1991, these unemployment figures identify the approximate size of the idle work force and provide an idea as to how much additional economic activity the region can absorb. In some regards, however, these figures can be misleading. The unemployment rate only identifies the quantity of workers without jobs; it reveals nothing about their skills or abilities. Distribution of skills is better seen by examining the industries and occupations of the employed workforce, which serves as a proxy for the skill mix of the labor force as a whole.

The employment data presented in Table 5.41 provides additional understanding of the aggregate statistics. In 1983, according to the Tennessee Department of Employment Security, 16% of the Smith County labor force worked in manufacturing, 5% in wholesale and retail trade, 2% in professional or

TABLE 5.41. Labor Force and Distribution in Major Economic Sectors of the Hartsville Primary Impact Area and Nashville MSA, 1983 (Tennessee Department of Employment Security 1984)

County	Civilian Labor Force (1983)	% of Total Labor Force Employed in: Manufacturing	Wholesale/ Retail	Services	Government
Macon	7,000	26	3	6	6
Smith	7,870	16	5	2	6
Sumner[(a)]	NA	26	22	15	18
Trousdale	2,570	39	7	7	10
Wilson[(a)]	NA	29	20	15	10
Nashville MSA[(b)]	450,700	18	20	18	14

(a) Data not available separately for the 1983 labor force and its distribution in Sumner and Wilson Counties, since they are reported as part of the Nashville MSA. Percentages shown are for 1980 from the U.S. Department of Commerce (1983).

(b) Includes Cheatham, Davidson, Dickson, Robertson, Rutherford, Sumner, Williamson, and Wilson Counties. Dickson County is not in the 50-mile impact area.

NA = Not available.

service jobs, and 6% in government. In Trousdale County, 39% of the labor force worked in manufacturing, 7% worked in wholesale and retail trade, 7% in professional or service jobs, and 10% in government. It is apparent from Table 5.41 that the counties nearest the site have a much less developed service sector than does the city of Nashville. The Nashville MSA percentages are as follows: 18% of all workers were in manufacturing, 20% of all jobs were in wholesale and retail trade, 18% of all workers had professional or service jobs, and 14% of all workers were in government.

Substantial manufacturing activity took place in the counties that form the Nashville MSA (Cheatham, Davidson, Dickson, Robertson, Rutherford, Sumner, Williamson, and Wilson). For the entire 50-mile (80-km) impact area, the manufacturing of metals and machinery was an important activity that employed a large number of workers. Other influential industries included those involved with the production of apparel and other finished textiles, printing, publishing and allied industries, the production of transportation equipment, the manufacturing of leather and leather products, and the production of furniture and fixtures.

Table 5.42 summarizes the occupational mix of the employed labor force in the primary impact area and Davidson County (including the city of Nashville) at the time of the 1980 census. Although the skill mix is expected to change in the future as the economy develops, and although the presence of Hartsville Nuclear Power Plant construction workers in 1980 probably distorted the occupational structure of the counties reported, Table 5.42 gives some idea of the skills available in the region. As can be seen from the table, Davidson County in 1980 had a large number of executives, managers, skilled professionals, and service workers, while the primary impact area had more farm operators and workers and more crafts and transportation workers (Davidson County had a higher absolute number). About 22,400 construction workers were working in the Nashville MSA in 1984 (University of Tennessee 1985).

Another factor affecting the degree of socioeconomic impact of MRS is the degree to which the overall baseline economy in the Hartsville area will have grown between the present and the mid 1990s. Table 5.43 shows baseline economic forecasts for the 50-mile impact area surrounding the Hartsville site. Total employment, based on a moderate economic growth scenario for the United States, is forecasted to be about 1.6% per year between 1982 and 1991, the first year of MRS construction. Baseline employment is forecasted to grow 2.3% per year before the year 2010, and another 1.0% per year between 2010 and 2030.

5.3.6.4 Income

The income level of any community is one of the key determinants of the wealth of the community, which in turn influences the variety and quality of products purchased, and the ability of the community to pay for community services such as parks, sewage disposal systems, and local road maintenance. This section defines the present income levels of the counties within the Hartsville site primary impact area and presents a baseline forecast of income for the 50-mile impact area. Although impacts of an MRS would be felt wherever payroll dollars and direct purchases are made, the most likely areas for such purchases would be the primary impact counties and Nashville. In Nashville, however, the impact of MRS is likely to be small relative to activity already occurring.

Table 5.44 details 1983 data for the Hartsville primary impact counties, Nashville, and the state of Tennessee regarding the level of total personal income and per capita income. Per capita income is more revealing than personal income, as it can be used to compare income levels across counties. Of the primary impact counties, Sumner County is the wealthiest while Smith County is the poorest. Of the primary impact counties, only Sumner and Wilson counties show incomes higher than the state average. Davidson County is considerably above the state average.

TABLE 5.42. Employment Distribution for the Hartsville Primary Impact Area and Davidson County, 1980 (University of Tennessee 1983)

Category	County					Primary Impact Area	Davidson (Including Nashville)
	Macon	Smith	Sumner	Trousdale	Wilson		
Total Employed	7,701	7,198	42,032	3,294	28,606	88,831	249,906
Executive, Administrative, Managerial							
Number	229	336	4,011	158	2,452	7,186	27,673
Percent	3.0	4.7	9.5	4.8	8.6	8.1	11.1
Number	363	424	3,942	262	2,280	7,271	32,538
Percent	4.7	5.9	9.4	8.0	8.0	8.2	13.0
Technicians and Related Support							
Number	94	142	1,043	58	647	1,984	8,671
Percent	1.2	2.0	2.5	1.8	2.3	2.2	3.5
Sales							
Number	355	413	4,666	210	2,393	8,037	25,450
Percent	4.6	5.7	11.1	6.4	8.4	9.0	10.2
Administrative Support, Clerical							
Number	737	641	5,859	334	4,208	11,779	49,598
Percent	9.6	8.9	13.9	10.1	14.7	13.3	19.8
Private Household							
Number	7	26	314	21	171	539	2,005
Percent	0.1	0.4	0.7	0.6	0.6	0.6	0.8
Protective Services							
Number	45	79	374	18	232	748	4,259
Percent	0.6	0.1	0.9	0.5	0.8	0.8	1.7
Services, Except Protective and Household							
Number	481	495	3,212	216	2,405	6,809	25,710
Percent	6.2	6.9	7.6	6.6	8.4	7.7	10.3
Farming, Forestry, Fishing							
Number	531	349	906	180	467	2,433	1,591
Percent	6.9	4.8	2.2	5.5	1.6	2.7	0.6
Precision Production, Craft, and Repair							
Number	1,093	1,166	6,478	559	3,888	13,184	24,468
Percent	14.2	16.2	15.4	17.0	13.6	14.8	9.8
Machine Operations, Assemblers, Inspectors							
Number	2,379	1.737	6,728	761	5,467	17,072	22,048
Percent	30.9	24.1	16.0	23.1	19.1	19.2	8.8
Transportation and Material Moving							
Number	498	565	1,793	185	1,419	4,460	9,510
Percent	6.5	7.8	4.3	5.6	5.0	5.0	3.8
Handlers, Cleaners, Helpers, and Laborers							
Number	889	825	2,706	332	2,577	7,329	16,385
Percent	11.5	11.5	6.4	10.1	9.0	8.2	6.6

TABLE 5.43. Baseline Employment Forecasts by Sector for the Hartsville Site 50-Mile Impact Area[(a)]

Employment Sector	1984	1991	2010	2030
Agriculture	7,100	6,900	6,200	5,300
Agricultural Services, Forestry, and Fisheries	2,000	1,900	2,200	2,800
Mining	900	1,000	1,300	1,400
Construction	30,600	37,500	62,900	89,400
Nondurable Manufacturing	78,500	92,600	130,900	137,200
Durable Manufacturing	78,500	101,600	172,800	175,600
Public Utilities	22,500	24,000	29,000	35,500
Wholesale Trade	44,500	56,100	89,600	85,900
Retail Trade	92,300	114,600	186,000	233,900
Finance, Insurance, and Real Estate	34,300	41,900	62,500	71,100
Services	112,800	133,500	215,400	330,100
Government	94,700	104,800	138,000	184,200
TOTAL	598,700	716,400	1,096,800	1,352,400

(a) From PNL's MASTER Model (see Appendix H).

Table 5.45 presents baseline personal income for the Hartsville area for selected years. Table 5.45 shows that estimated real personal income will change, from $20,200 million in 1991, the proposed initial year of MRS facility construction, to $43,200 million in 2030, the final forecast year.

In 1983 the total level of personal income in 1985 dollars for the Hartsville primary impact counties totaled $1,864 million, while the total personal income level for the remaining counties within 50 miles (80 km) was $12,396 million, for a total area personal income level of $14,260 million in 1985

TABLE 5.44. Personal Income Data for the Hartsville Site Primary Impact Area, Nashville, and State of Tennessee, 1983 (U.S. Department of Commerce 1985a)

County or Area	Total Personal Income (million of $)	Per Capita Personal Income (1983 $)
Macon County	$125	$7,784
Smith County	112	7,622
Sumner County	878	9,867
Trousdale County	52	9,203
Wilson County	559	9,590
TOTAL, Primary Impact Area	$1,726	$9,396[a]
Davidson County (Nashville)	$5,815	$11,997
Tennessee	$44,580	$9,515

(a) Based on 1983 Bureau of Census estimated population.

TABLE 5.45. Baseline Forecasts of Personal Income for the Hartsville 50-Mile Impact Area[a]

Year	Personal Income (million 1985 $)	Annual Average Change Over Previous Period (%)	Per Capita Income (1985$)	Annual Average Change Over Previous Period (%)
1983	14,300	---	10,400	---
1991	20,200	4.4	12,800	2.6
2010	33,200	2.6	15,800	1.1
2030	43,200	1.3	18,500	0.8

(a) MASTER model baseline forecast.

dollars. Adjusting for the effects of inflation, these changes are a useful predictor (in part) of the demand for income-influenced goods and services over time, such as the demand for transportation and medical services.

5.3.6.5 Housing Characteristics

By examining an area's total housing stock, including vacancy rates, structure types (multifamily, single-family, mobile home), and unit status ("rented" or "occupant-owned"), it is possible to assess to some extent the wealth of the occupants, the degree of transience of the local population, and the demand for housing.

Table 5.46 describes the housing situation in 1980 in the five counties comprising the potential primary impact area of the Hartsville MRS site. Even though nuclear construction was proceeding at the time, the five counties showed a total of 4,058 vacant units, or 6.3% of the stock. This would house a substantial influx of new population if these conditions were to prevail until MRS construction began in 1991.[a] There was considerable variation among the counties. Relatively urbanized Sumner and Wilson counties showed higher housing prices and lower vacancy rates than did the more rural counties closer to the site. Trousdale showed above-average rents, reflecting a tight rental market in the area of Hartsville. Several mobile home parks were developed or added to (with TVA help) during construction of the Hartsville Nuclear Power Plants. At that time, 243 mobile home spaces were added (TVA 1979). Some of these would likely be available during the MRS construction phase.

Of the total year-round housing stock, 83% was single-family, 8.7% mobile homes, and 8.5% multifamily in the five county primary impact area. This single-family and multifamily distinction is relevant for ascertaining, among other factors, the level of infrastructure demand for items like roads, telephone lines and sewage lines, since individuals in single-family residences may require more of these than the same number of individuals residing in multifamily residences.

It is also useful to distinguish between the percentages of residents who rent and those who own their dwellings. A high degree of home ownership generally reflects a more permanent degree of commitment to a community by its citizens. In addition, renters are charged different taxes and purchase different goods than do owners. Temporary employees, such as construction workers, are also likelier to rent. About 78% of the housing stock was owner-occupied in 1980 in the primary impact area, much higher than the averages for Tennessee (68.6%) or the United States (64.4%).

(a) A portion of the MRS employees would likely already be local residents and would not require additional housing.

TABLE 5.46. Summary Housing Data for the Hartsville Primary Impact Area, 1980 (University of Tennessee 1983)[a]

Item	County					Primary Impact Area
	Macon	Smith	Sumner	Trousdale	Wilson	
Total Year-Round Units (number)	6,078	6,032	30,107	2,481	20,044	64,742
Number Vacant	433	640	1,550	254	1,181	4,058
% Vacant	7.1	10.6	5.1	10.2	5.9	6.3
Occupied Units (number)	5,645	5,392	28,557	2,227	18,863	60,684
% Owner-Occupied	81.3	77.1	77.5	69.3	79.7	78.2
Number of Structures:						
1-unit structures	5,163	5,124	24,863	1,889	16,888	53,927
Structures of 2 or more units	326	316	3,001	242	1,649	5,534
Mobile homes	589	592	2,243	350	1,507	5,281
Median Value ($) of Owner-Occupied Units	$27,800	$31,200	$46,800	$30,100	$48,000	$42,500
Median Value as a % of Tennessee's Median Value	78.1	87.6	131.5	84.6	134.8	119.2
Median Rent ($/mo) of Rental Units	$108	$106	$193	$149	$155	$165
Median Rent as a % of Tennessee's Median Rent	73.0	71.6	130.4	100.7	104.7	111.4

(a) From 1980 Census of Housing. Does not show Davidson County, which had 9,602 vacant units.

5.3.6.6 Fiscal Characteristics

This section contains a fiscal profile of the Hartsville primary impact area. Total revenues are described by source. Public service expenditures are described by function. Comparing revenues to expenditures gives some idea of the financial health of the area and may reveal the area's ability to weather economic "shocks" such as recessions and booms. Expenditure categories by function indicate how the "financial pie" is divided and reflect what things the community values. This section also discusses the county and city taxes and debts.

Counties. Table 5.47 shows a number of measures of local government fiscal health for the five county governments in the Hartsville primary impact area for recent years. Each of the counties supplied between one-half and one-third of its total operating revenue from its own sources. Between two-thirds and four-fifths of this locally supplied revenue came from property taxes and county sales taxes. Property tax revenues ranged from a low of $80 per capita (Smith County) to a high of $133 per capita (Sumner County). Total tax effort (collections per capita) from property and sales taxes combined) ranged from $102 per capita in Macon County to $159 per capita in Summer County.

Table 5.47 also shows operating expenditures by function for the county governments. In half the cases, operating expenditures were less than operating revenues, with most of the difference accounted for by capital projects and transfers to other governments. Macon and Wilson Counties had slight surpluses in fiscal year 1983, while Summer, Smith, and Trousdale Counties had deficits. Schools accounted for between 56% (Trousdale) and 70% (Sumner) of total operating expenditures of county governments.

Finally, Table 5.47 shows a breakdown of assessed value and effective tax rates (that is, taking into account assessment ratios) for various classes of property. Assessed value per capita ranged from $2,300 in Macon County to $4,800 in Trousdale County. In the rural counties of Macon and Smith assessed value per capita, assessed value as a percent of market value, effective tax rates, and revenues per capita collections were all lower than for the more urbanized Sumner and Wilson Counties. Trousdale was an exception to this rural-urban split because of its relatively high assessed value per capita. None of the counties appears to have unusual financial difficulties, although Trousdale County has a relatively high ratio of bonded debt to property tax base compared with the other counties shown.

TABLE 5.47. Selected Local Government Fiscal Data for the Hartsville Site Primary Impact Area Counties (University of Tennessee 1983; Tennessee Division of Community Development 1985a-1985m)

	County				
	Macon	Smith	Sumner	Trousdale	Wilson
Operating Revenue, Fiscal Year Ended June 30, 1983 (thousand 1983 $)					
Total[a]	$5,923	$6,382	$35,872	$2,850	$20,244
Local Sources:	2,328	3,046	19,862	1,147	11,829
Property Tax	1,291	1,203	11,426	598	7,256
Sales Tax	309	687	2,240	178	1,318
State Sources	2,837	2,525	13,795	1,377	7,352
Federal Sources	758	811	2,214	326	1,063
Revenue Per Capita,[b] Major Sources, Fiscal Year Ended June 30, 1983 (1983 $)					
Local Sources:					
Property Tax	$82	$80	$133	$97	$129
Sales Tax	20	46	26	29	24
State Sources	181	169	160	224	131
Federal Sources	48	54	26	53	19
Operating Expenditures by Function, Fiscal Year Ended June 30, 1983 (thousand 1983 $)					
Total[a]	$5,885	$6,448	$37,746	$2,905	$20,156
General Purpose	961	1,173	3,748	652	2,857
Schools	3,829	4,022	26,352	1,616	12,379
Highways	758	663	2,171	535	2,056
Debt Service	338	589	5,476	102	2,862
Assessed Value, 1983 (million 1983 $)					
Estimated Actual Value	$267,978	$266,379	$1,836,986	$106,424	$1,158,610
Total Assessed Value	36,627	40,082	277,311	29,607	167,786
Assessed Value per Capita (dollars)[b]	2,383	2,683	3,232	4,823	2,993
Residential and Farm	25,370	23,601	178,252	12,006	114,950
Public Utilities	7,526	4,566	17,320	5,534	14,648
Commercial and Industrial	4,329	8,741	58,717	4,823	29,372
Personal Tangible	2,403	3,173	21,466	880	8,816
Effective Tax Rate by Class of Property, 1983 ($ per $100)					
Commercial and Industrial, Real Property	$ 0.75	$ 0.66	$ 0.90	$ 1.23	$ 1.10
Residential, Real Property	0.47	0.41	0.56	0.77	0.69
Average, All Property	0.55	0.48	0.64	0.86	0.73

(a) Total includes items not shown separately in source.
(b) Based on 1980 census population.

Cities. Table 5.48 presents selected financial data for some of the key city governments in the primary impact area. Effective local property tax rates varied from a combined rate of $0.51 per hundred dollars of estimated market value in Lafayette to $1.21 in Lebanon. As discussed in Section 5.1.1.6, the effective tax rate is the best available index of relative tax effort. Part of the difference is accounted for by the varying local sales tax rates (shown in the table). The difference in effective rates is not accounted for by the differences among cities in assessed valuation per capita. Those cities having higher assessed valuation do not necessarily have lower nominal tax rates. The cities and counties also varied in debt burden. The average dollar of assessed value in Hendersonville bore only 8.1 cents in combined city and county debt; in Lebanon, 31.8 cents. Of the cities examined, Carthage and Lebanon appear to be least able and Lafayette and Hendersonville appear to be the best able to finance new public facilities, should these become necessary.

5.3.6.7 Community Services and Infrastructure

This section discusses the current capacities of many of the community service functions offered in the Hartsville primary impact area. Current capacity and demand is expected to change before the mid-1990s, when an MRS facility is proposed to be built; however, current data will at least provide an indication of potential service capacity problems in the Hartsville area.

Public Education. Table 5.49 summarizes public education operations for the six school systems in the Hartsville primary impact area. For perspective, Table 5.49 also shows the number of additional plant-related students each school system received at peak construction of the Hartsville Nuclear Power Plants in 1979. However, this project had several times the projected workforce of the proposed MRS facility and likely had a larger impact than the proposed facility. The largest absolute impact in 1979 was in Sumner County (336 students); the largest relative impact in new enrollment was in Trousdale County (8.3% of enrollment).

Public Welfare. Table 5.50 summarizes selected social services data (public welfare) for the Hartsville site primary impact area. These statistics are determined by demography (e.g., the number of households headed by females), the state of economy (especially household income), and the eligibility requirements and funding levels of the various programs. These statistics can be expected to change before the mid-1990s; however, they do provide some indication of the relative demand for social services in the primary impact counties.

TABLE 5.48. Selected Local Government Fiscal Data for the Hartsville Site Primary Impact Area Cities (Tennessee Department of Economic and Community Development 1983; Tennessee Taxpayers Association 1984)

	Lafayette (Macon) (6/83)	Carthage (Smith) (6/83)	Gallatin (Sumner) (9/83)	Hendersonville (Sumner) (6/83)	Hartsville (Trousdale) (6/83)	Lebanon (Wilson) (6/83)
Property Tax Rates ($ per $100)[a]						
City	$1.85	$2.20	$2.10	$0.90	$0.30	$1.21
County	3.73	3.22	4.23	4.23	2.86	5.38
School	0	0	0	0	0	0.70
Total Nominal Rate	$5.58	$5.42	$6.33	$5.13	$3.16	$7.29
Average Effective Rate	$0.51	$0.87	$1.04	$0.77	$0.87	$1.21
Local Option Sales Tax Rate (%)[a]						
City	0	0	0	0	0	0
County	2.25	2.0	2.25	2.25	2.25	1.5
City-Assessed Valuation[b]						
Total (million $)	$10.1	$6.5	$53.6	$101.9	$11.0	$39.1
Per Capita ($)[c]	$2,657	$2,431	$3,116	$3,838	$4,122	$3,290
Ratio of Bonded Debt to Assessed Valuation (%)[b]						
City	13.8	19.0	11.6	4.3	26.1	16.8
County	1.9	11.5	12.0	3.8	1.8	15.0
TOTAL	15.7	30.5	23.6	8.1	27.9	31.8

(a) From Tennessee Taxpayers Association (1984). Effective rate equals the nominal rate times the ratio of appraised value to market value, times the ratio of assessed value to appraised value because property is assessed at less than appraised value in Tennessee.
(b) From Tennessee Division of Community Development (1983).
(c) Based on 1980 census population.

TABLE 5.49. Public Education Statistics, Hartsville Primary Impact Area School Systems, Scholastic Year 1983-84 (Tennessee Department of Education 1984; TVA 1979)

School District	Total Enrollment	Average Daily Attendance (ADA)	Students Per Teacher[a]	Expenditures Per Pupil in ADA	Plant-Related Enrollment Peak Hartsville Nuclear Plant Construction (1979)
Macon County	2,931	2,725	19.1	$1,347	122
Smith County	2,637	2,468	17.1	1,484	21
Sumner County	18,593	17,115	18.5	1,598	336
Trousdale County	1,042	966	16.9	1,620	86
Wilson County	9,105	8,321	19.4	1,351	58
Lebanon	2,325	2,173	16.6	1,537	71

(a) Includes all instructional staff.

TABLE 5.50. Selected Social Services Data for the Hartsville Site Primary Impact Area (University of Tennessee 1985)

	Macon County	Smith County	Sumner County	Trousdale County	Wilson County	Tennessee
Total Families, 1979	4,661	4,383	24,114	1,836	15,819	4,476,000
Families with Incomes Less than Poverty Level, 1979						
Number	654	482	2,007	131	1,313	736,000
Percent of total families	14.0	11.0	8.3	7.1	8.3	16.4
Total Transfer Payment per Capita, 1983						
	$1,323	$1,511	$1,183	$1,505	$1,213	$ 1,526
Families Receiving Aid to Families with Dependent Children, FY 1983						
Children	169	163	786	80	606	103,425
Payment per child	$ 755	$ 780	$ 821	$ 764	$ 797	$ 781
Food Stamps, FY 1983						
Persons Participating	1,647	1,512	5,176	797	3,690	598,192
Value per person	$ 525	$ 501	$ 556	$ 445	$ 554	$ 538
Caseload for Medical Assistance, June 1983						
Aged (including Medicaid)	54	31	168	44	136	14,463
Women and Children	3	6	25	4	31	3,478
Others	12	6	18	3	27	2,718

For the most part, past case loads are small. Total transfer payments per capita tended to be below average for Tennessee, while both aid to families with dependent children and food stamps tended to be about average for the state. Poverty tended to be less prevalent in the primary impact area in 1979 than in the state as a whole. However, this situation may have changed somewhat since the cancellation of the Hartsville Nuclear Plant in 1980-82 and layoffs in durable-goods manufacturing firms in the five-county area (Mid-Cumberland 1983).

Health Care. For the Hartsville Nuclear Power Plants, the TVA provided its own ambulance service to the construction site, assisted in establishing an emergency ambulance service in Trousdale and Smith Counties, and provided funds for an environmentalist, nurse-clinician, and maternal and child-health nurse. Most TVA workers lived in more densely-settled counties (Sumner, Wilson, Davidson) where existing health care services could handle the population increase. The existing capacity is expected to remain in place and expand with normal population growth. Table 5.51 shows existing health care facilities and capabilities in the primary impact area. In addition, Nashville facilities and specialists would be available for specialized treatment. The primary impact area shows a lower ratio of hospital beds, physicians, and dentists to population than the nation as a whole. However, this is fairly typical of rural areas and small towns and does not necessarily mean the primary impact area is

TABLE 5.51. Health Care Facilities and Capabilities for the Hartsville Site Primary Impact Area (University of Tennessee 1983, Statistical Abstract of the U.S. 1985)

Available Facilities/Specialists	County				
	Macon	Smith	Sumner	Trousdale	Wilson
Hospital beds, 1983					
Number	43	95	278	34	284
Per 1,000[a]	2.67	6.46	3.13	5.97	4.87
National Average per 1,000	5.9	5.9	5.9	5.9	5.9
Physicians, 1984					
Number	3	8	79	2	42
Per 1,000	0.19	0.55	0.87	0.36	0.70
National Average per 1,000 (1981)	1.85	1.85	1.85	1.85	1.85
Dentists, 1984					
Number	3	3	34	2	20
per 1,000	0.19	0.21	0.37	0.36	0.33
National Average per 1,000 (1982)	0.55	0.55	0.55	0.55	0.55

(a) Per 1,000 population.

underserved. For most of the counties, the number of hospital beds per 1,000 population is above the rural area standard of 3.3 (Branch et al. 1982). Davidson County has 5,558 staffed hospital beds, 1,679 physicians, and 359 dentists that could also serve the primary impact area counties.

Parks and Recreation. The city of Hartsville and other nearby cities have several parks and recreational facilities such as golf courses and country clubs. Popular outdoor activities include hunting, fishing, boating, and hiking. These activities usually take place at nearby state parks and TVA lakes (see Table 5.52). Municipal outdoor recreational facilities, such as soccer fields and baseball diamonds, are abundant. During the TVA construction period, TVA helped implement park improvements in the cities of Hartsville, Lebanon, and Gallatin and in Trousdale, Smith, and Macon Counties, spending over $200 thousand (TVA 1981).

Because of the nature of the MRS facility as a nuclear materials handling and storage site, local citizens are concerned that there is a potential for disruption of the tourism and outdoor recreation industries. The DOE is unable to confirm or refute this concern. There is some evidence that when potential or actual threats to public health or safety are publicized, disruption to tourism can occur (see Section 6.2.6.5). Recreationists might choose to avoid any area containing nuclear waste because they may believe the area is not safe. Chapter 6 further discusses these potential avoidance responses. Table 5.52 shows selected recreation facilities whose use might be at risk if avoidance of the area occurred.

Law Enforcement and Fire Protection. An MRS facility at the Hartsville site, near SR-25, would be expected to affect law enforcement and fire protection in much the same way (although to a lesser degree) as did construction of the TVA nuclear plants. The plant area is within the jurisdiction of the Trousdale County Sheriff's Department, whose workload doubled during the peak construction period. Increased traffic required the City of Gallatin to hire three part-time traffic monitors and the City of Hartsville to hire two part-time traffic monitors. No major increase in crime was noted (Mid-Cumberland 1983).

Table 5.53 summarizes police and fire protection services available in the Hartsville site primary impact area. The primary impact area appears to be adequately served at present.

TABLE 5.52. Outdoor Parks and Recreation and Tourist Facilities for the the Hartsville Site Primary Impact Area (Tennessee Division of Community Development 1983; University of Tennessee 1985)

County/Location	Facility	Comments
Macon County		
Lafayette	2 hotels (30 rooms) golf course, country club, 2 parks	No major tourist facilities
Smith County		
Carthage	1 hotel (30 rooms), golf course; Cordell Hull Lake and Marina, park	Some water-based recreation
Sumner County		
Bledsoe Creek Camping Park	State park	Visitors/yr: 46,300
Gallatin	3 hotels (100 rooms), 2 golf courses, country club, 3 parks	Some facilities
Hendersonville	2 hotels (58 rooms), 5 parks, House of Cash Museum, Twitty City (tourist attraction)	Some tourism related to music industry
Trousdale County		
Hartsville	1 hotel (30 rooms), golf course, country club, park, Cordell Hull Lake, Old Hickory Reservoir	Water-based recreation available
Wilson County		
Cedars of Lebanon	State park	Visitors/yr: 578,000
Lebanon	8 hotels (400+ rooms), 2 golf courses, country club, 4 parks, 3 campgrounds	400 camping sites available
Mt. Juliet	3 hotels (120 rooms), 4 parks	Some facilities

TABLE 5.53. Police and Fire Protection Resources for the Hartsville Site Primary Impact Area, 1983 (Tennessee Division of Community Development 1983)

County/City	Police Protection Staff	Police Protection Vehicles	Fire Protection Full-Time Firefighters	Fire Protection Volunteers	Fire Protection Trucks
Macon County					
Lafayette					
Number	9	7	5	22	4
Per 1,000[a]	2.36	1.84	1.31	5.78	1.05
Smith County					
Carthage					
Number	7	2	2	18	2
Per 1,000	2.62	0.75	0.75	6.74	0.75
Sumner County					
Gallatin					
Number	27	13	33	9	6
Per 1,000	1.57	0.78	1.92	0.52	0.35
Hendersonville					
Number	33	21	21	6	6
Per 1,000	1.24	0.79	0.79	0.23	0.23
Trousdale County					
Hartsville					
Number	7	3	0	25	2
Per 1,000	2.61	1.12	0	9.35	0.75
Wilson County					
Lebanon					
Number	27	9	26	10	5
Per 1,000	2.27	0.76	2.19	0.84	0.42
Mt. Juliet					
Number	5	4	2	14	4
Per 1,000	0.62	0.50	0.25	1.75	0.30
Standard					
Per 1,000	1.5(b)	0.7(c)	2(b)	NA(b)	0.33(c)

(a) Per 1,000 people, based on 1980 census population.
(b) From Stenehjem and Metzger (1976). No figures are available for number of volunteer firefighters required for towns of the size shown.
(c) Branch et al. (1982). See also Appendix H.

5.3.6.8 Utilities

In determining the ability of the site's utility systems to support current and future demands, three factors must be considered: existing and planned resource or capacity estimates, existing and projected consumption rates, and existing and planned delivery/storage capacities. It is assumed that electrical and gas system capacity will increase to meet population increase as required; therefore, the utilities considered in this report are water and sewage.

During Hartsville Nuclear Power Plant construction, one new water line was laid at the Hartsville site and the Cities of Hartsville and Carthage upgraded their waste water treatment systems. Table 5.54 summarizes water and sewage systems for key communities in the Hartsville site primary impact area. Most systems have sufficient capacity to accommodate current needs and additional population growth.

5.3.6.9 Economic Development Plans and Capabilities

At the closure of construction at the Hartsville Nuclear Power Plants in March, 1982, a number of suggestions were made to help the five Hartsville

TABLE 5.54. Water and Sewage System Capacity in Selected Communities of the Hartsville Site Primary Impact Area, 1983 (gal/day) (Tennessee Division of Community Development 1983)

County/City	Water Supply		Sewage Treatment	
	Capacity	Current Use	Capacity	Current Use
Macon County				
Lafayette	2,000,000	600,000	2,000,000	900,000
Smith County				
Carthage	NA	NA	NA	NA
Sumner County				
Gallatin	4,000,000	2,100,000	2,000,000	1,900,000
Hendersonville(a)	3,500,000	2,300,000	5,000,000	850,000
Trousdale County				
Hartsville	1,000,000	515,000	750,000	300,000
Wilson County				
Lebanon	6,000,000	4,200,000	2,000,000	2,500,000
Mt. Juliet	4,000,000	1,700,000	300,000	150,000

(a) New plant planned with a capacity of 5 million gallons (19,000,000 L) per day.

NA = Not available.

primary impact area counties make up for TVA employment and payrolls lost to the economic base of the area. In August 1981, TVA made funds available to Macon, Smith, and Trousdale Counties for assistance in job and industrial development. Most of the funds were allocated for capital improvements at two industrial parks. In March 1982, the TVA also set aside $1.6 million in power program funds to fund up to 50% of eligible high-probability industrial development projects and to provide technical assistance. Programs for retraining continued mitigation funding of local government, and aid in industrial recruitment were also part of the program (Mid-Cumberland 1983).

The economic recovery proposals for the Hartsville site area reflect a heavy emphasis on improving industrial development opportunities by pooling local, state, TVA, and other federal resources. In addition to existing facilities, several industrial parks have been proposed for Trousdale County, Sumner County, and Macon County. One of the potential sites for a regional industrial park is at the Hartsville Nuclear Power Plant site. It is particularly well-suited for large, water-using industries requiring less-expensive water transportation. Other potential industrial sites in the five-county area are either smaller or less developed, or both.

5.3.7 Archaeological and Historical Sites

Archaeological sites identified at the Hartsville site date from Early Archaic through Woodland and Mississippian (TVA 1974a). Fifteen sites have been identified as occurring in the vicinity of the site; these are described in Table 5.55.

No known historical sites have been identified as occurring within the area likely to be disturbed, although such sites have been identified in the nearby region.

No sites are presently listed under the National Historic Preservation Act.

5.3.8 Aesthetic Characteristic

This section describes these aesthetic characteristics of the site to establish a baseline. Residents and others within sight of the project area could potentially be concerned about noise levels, particularly during construction, and the visual qualities of the Hartsville MRS site. This section describes these aesthetic characteristics of the site to establish a baseline.

TABLE 5.55. Archaeological Sites Within the Area of Disturbance at the Hartsville Site[a]

Archaeological Number	Description
40SM27	Archaic and Woodland site
40SM28	Intermediate cultural affiliation
40SM31	Archaic and Woodland site; now destroyed
40TR33	Indeterminate cultural affiliation
40TR34	No information available
40TR36	Middle Woodland occupation area; partially destroyed by previous construction activities
40SM39	Archaic site now covered by rip-rap
40SM43	Mississippian ceremonial center and village (this site is the most likely to qualify under the National Historic Preservation Act)
40SM51	Hunting or butchering station
40SM53	Flint-knapping, wood- and/or skin-working, and hunting site
40SM55 40SM108	Late Archaic "base camp"
40SM62	Late Archaic to early Woodland site
40TS4	Middle to late Archaic seasonal or otherwise specialized encampment
S.I.8	Middle to late Archaic site (minor site)
S.I.9	Middle to late Archaic hunting and butchering station

(a) From Fielder, G. F., Jr., Tennessee Department of Conservation. Letter to C. E. Cushing, Pacific Northwest Laboratory October 7, 1985.

5.3.8.1 Noise Levels

The acoustic setting near the Hartsville site consists of a typically quiet rural background interspersed with sounds from activities conducted at the Hartsville Nuclear Power Plant. Receptors of noise include about 20 to 40 residents located within 2,000 feet (610 m) of the site on all sides of the project boundary. Wind, which affects the propagation of noise, is typically along the west-southwest/east-northeast axis.

No studies of background noise have been conducted at the Hartsville site. However, vehicles passing by on SR-25 appear to be the greatest contributor to the ambient noise environment. Heavy trucks produce the greatest noise levels on this high-speed road, particularly noticeable at residences along the highway north of the site.

5.3.8.2 Visual Qualities

The Hartsville site is located in a region of very gently rolling terrain, with local hills north, west, and southwest of the site. Much of the site is devoid of vegetation. The majority of the site has been cleared, graded, and modified for industrial uses. Only a thin line of undisturbed area parallels the Cumberland River to the south, Dixon Springs to the east, and along the farming areas on the west boundary of the site.

No systematic visual analyses of the site have been done. However, the site might be classified as "distinctive" - the site appearance is unusual in relation to the surrounding area.

The site is visible at a distance from approaches from the east (SR-25), west (SR-141), and from county roads from the south (see Figure 5.24). It is estimated that 40 to 50 homes have visible access to the site. From the Cumberland River (Old Hickory Lake) several short views of the site through the vegetation can be seen.

No objectives for management of visual quality have been defined for the Hartsville site. However, the TVA estimates that most viewers of the site favor restoring the scenic qualities that existed prior to site development.

5.3.9 Transportation Conditions

The Hartsville site is located near Hartsville, Tennessee. The site is approximately 15 miles (24 km) north of the nearest Interstate Highway and 3 miles (5 km) north of the navigable Cumberland River. The site is adjacent

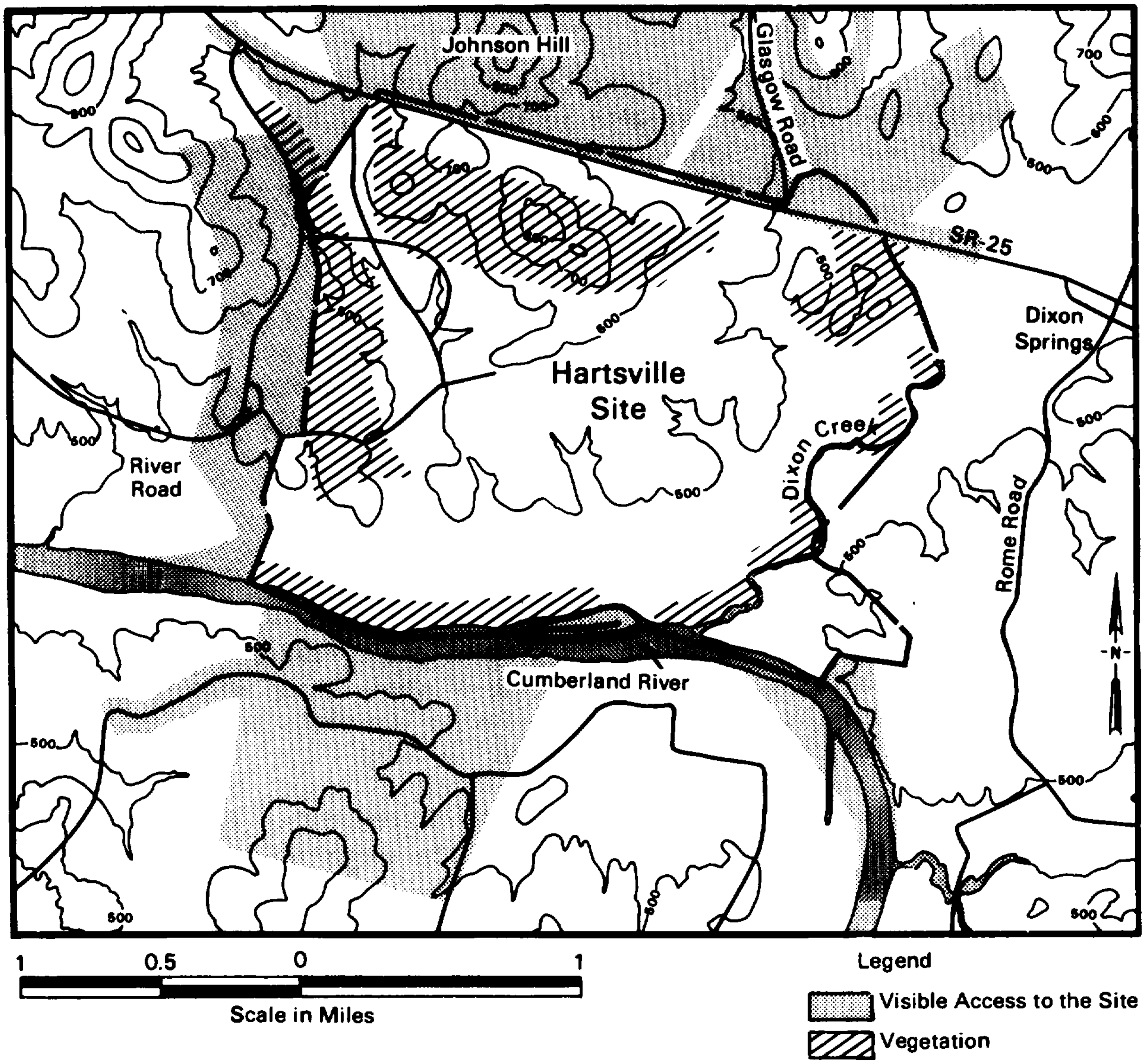

FIGURE 5.24. Viewing Points to the Hartsville Site

to SR-25 with access to both a north-south and an east-west Interstate, as shown in Figure 5.25. The nearest main rail line is located about 15 miles (24 km) northwest of the site.

5.3.9.1 Highways

Major highway routes providing access to the Hartsville site are I-40, which extends east-west and connects Nashville to Memphis and Knoxville; I-65, which extends north-south and connects Nashville to Louisville, Kentucky,

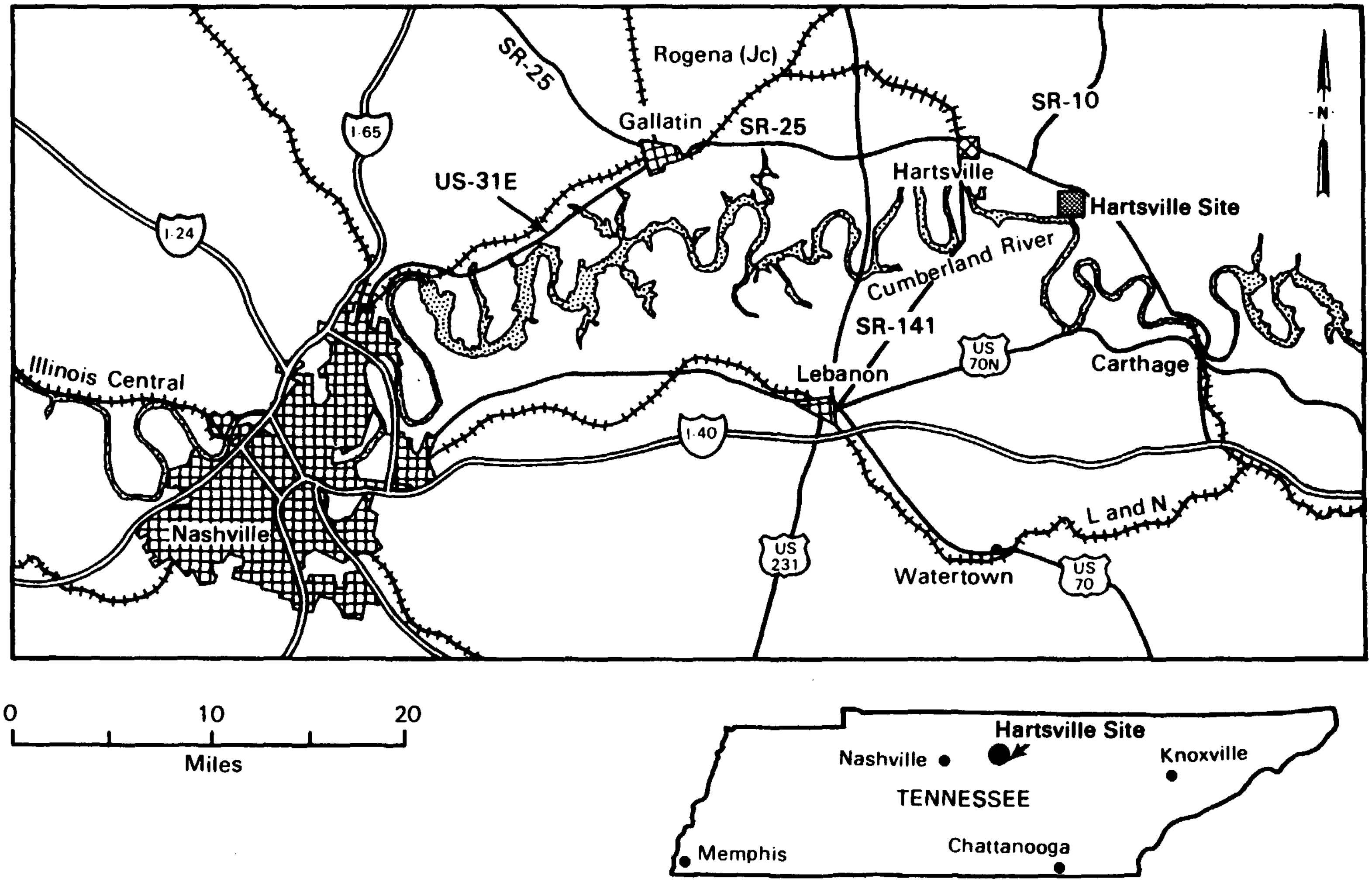

FIGURE 5.25. Hartsville Site Transportation System

and Huntsville, Alabama; and I-24, which extends northwest-southeast and connects Nashville to Paducah and Chattanooga. These Interstates converge in Nashville's downtown area.

Primary access routes from these Interstates to the proposed site includes US-231, which extends north-south, parallel to and about 25 miles (40 km) east of I-65. SR-25 extends east-west and is immediately adjacent to the project site. SR-10, which is the same as US-231 south of SR-25, and SR-141 provide additional north-south access to the site, particularly for local commuters, as shown in Figure 5.25. The average daily traffic of roads providing access to the Hartsville site is given in Table 5.56.

5.3.9.2 Railroads

There are no main rail lines within a 5-mile (8-km) radius of the site. However, an abandoned Louisville and Nashville Railway System track connects the city of Hartsville, about 5 miles (8 km) from the site, with to Rogena, about 10 miles (16 km) northwest of Hartsville (Golder 1985). Rogena is approximately 10 miles (16 km) from Gallatin, from which access to Nashville and Louisville, Kentucky, is available, as shown in Figure 5.25.

TABLE 5.56. Average Daily Traffic of Roads Providing Access to the Proposed Hartsville Site (DOT 1984)

Route Segment	Annual Average Daily Traffic (Both Directions)
SR-25, east of SR-10	2,350
SR-25, west of SR-10	5,180
SR-10, north of SR-25	3,590
SR-10 SR/25, east of SR-141	6,650
SR-10 SR/25, west of SR-141	5,420
SR-141, north of SR-10/SR-25	1,380
SR-141, south of SR-10/SR-25	6,200
SR-10/SR-25, east of US-231	4,740
SR-10/SR-25, west of US-231	4,830
US-231, north of SR-10/SR-25	1,600
US-231, south of SR-10/SR-25	3,010

5.3.9.3 Airports

No airports are located within 15 miles (24 km) of the Hartsville site. Two small airports are within 15 to 20 miles (24 to 32 km) of the site - one in Lebanon, 17 miles (27 km) southwest, and one in Gallatin, about 18 miles (29 km) west (TVA 1974b). Both of these small airports are used primarily by light aircraft.

The nearest large commercial airport is located in Nashville, about 38 miles (61 km) southwest of the site. This airport is serviced by several major carriers and has over 200 flights available daily (TVA 1976; Tennessee Division of Community Development 1983).

5.3.9.4 Waterways

The nearest barge terminal is located approximately 3 miles (5 km) south of the site (Golder 1985). No rail line from the site to the barge dock exists.

Cumberland River barge traffic does not occur past the Hartsville site (TVA 1976). The TVA proposed to load railcars on barges at the Gallatin Steam Plant and unload them at the barge dock for the TVA nuclear plant project; however, this has not been implemented because the project was canceled in about 1979.

5.4 REFERENCES

Adams, R. C., et al. 1983. The Metropolitan and State Economic Regions (MASTER) Model - Model Documentation. PNL-4698, Pacific Northwest Laboratory, Richland, Washington.

Auxier, J. A., et al. 1973. Contribution of Natural Terrestrial Sources to the Total Radiation Dose to Man. ORNL-TM-4323, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Boyle, J. W., et al. 1982. Environmental Analysis of the Operation of Oak Ridge National Laboratory. ORNL-5870, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Branch, K., et al. 1982. Guide to Social Assessment. BLM-YA-PT-82-007-1606. Mt. West Research, North, Inc., Billings, Montana.

Braun, E. L. 1950. Deciduous Forests of Eastern North America. Hafner Press, New York.

City of Oak Ridge. 1983. The Case for Continued Federal Payments in Lieu of Taxes to the City of Oak Ridge. Oak Ridge, Tennessee.

Data Resources, Inc. (DRI). 1985. U.S. Long Term Review, Summer 1985. Data Resources, Inc., New York, New York.

Exxon Nuclear Company, Inc. (Exxon). 1977. Nuclear Fuel Recovery and Recycling Center, Environmental Report. XN-FR-33, Rev. 1, Docket 50-564, Exxon Nuclear Company, Inc., Richland, Washington.

Fitzpatrick, F. C. 1982. Oak Ridge National Laboratory Site Data for Safety-Analyses Report. ORNL/ENG/TM-19, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Folz, D. 1984. Oak Ridge Housing Strategies Report. City of Oak Ridge, Oak Ridge, Tennessee.

Freeman, T. A., E. C. Harvey, T. R. Lyman and D. G. Ousterhout. 1984. Analysis of Annual Assistance Issues: City of Oak Ridge, Anderson and Roane Counties, Tennessee. DOE/OR/2134-T2, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee.

Geraghty and Miller, Inc. 1985. Remedial Action Alternatives for the Bear Creek Valley Waste Disposal Area. Y/SUB/85-00206C/3, Geraghty and Miller, Inc. Tampa, Florida.

Gilmore, J. S., D. Hammond, K. D. Moore and J. F. Johnson. 1982. Socio-economic Impacts of Power Plants. EA-2228, Electric Power Research Institute, Palo Alto, California.

Golder Associates, Inc., et al. 1985. Monitored Retrievable Storage Facility Site Screening and Evaluation Report. U.S. Department of Energy, Richland Operations, Richland, Washington.

Holzworth, G. C. 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. AP-101. Environmental Protection Agency, Research Triangle Park, North Carolina.

Jolley, R. L. 1982. Archaeological Investigations in the Clinch River Breeder Reactor Project Area 1981-82. Building Conservation Technology, Inc., Nashville, Tennessee.

Keystone Coal Industry Manual. 1980. McGraw-Hill Mining Publications, Mining Information Services, New York, New York.

Klement, A. W., Jr., C. R. Miller, R. P. Minx, and B. Shleien. 1972. Estimates of Ionizing Radiation Doses in the United States 1960-2000. ORP/CSD 72-1, U.S. Environmental Protection Agency, Office of Radiation Programs, Rockville, Maryland.

Leholm et al. 1976. Profile of North Dakota's Electric Power Plant Construction Workforce. Statistical Series No. 22, North Dakota Agricultural Experiment Station, Fargo, North Dakota.

Levin, S. G., R. K. Stoms, E. Kuerze and W. Huskisson. 1968. "Summary of National Environmental Gamma Radiation Using a Calibrated Portable Scintillation Counter." Radiological Health Data and Reports. 9(11):679-695.

Martin Marietta Energy Systems, Inc. 1984a. Environmental Monitoring Report. Y/UB-19, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

Martin Marietta Energy Systems, Inc. 1984b. ORGDP Site Development and Facilities Utilization Plan, KD-5514, prepared for the U.S. Department of Energy.

Martin Marietta Energy Systems, Inc. 1985. Appendices: Remedial Alternatives for Bear Creek Waste Disposal Area. Y/TS-109, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee.

Mid-Cumberland Council of Governments and Development District (Mid-Cumberland). 1983. Hartsville Project Impact Study. Mid-Cumberland Council of Governments and Development District, Nashville, Tennessee.

Murdock, S. H. and R. R. Hamm. 1983. "Assessing the Demographic and Public Service Impacts of Repository Siting." Nuclear Waste: Socioeconomic Dimensions of Long-Term Storage. Westview Press, Boulder Colorado.

Myrick, T. E., B. A. Berven and F. F. Haywood. 1981. State Background Radiation Levels: Results of Measurements Taken During 1975-1979. ORNL/TM-7343, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

National Academy of Sciences. 1965. Highway Capacity Manual. Special Report 87, Publication 1328, National Academy of Sciences, Highway Research Board.

National Council on Radiation Protection and Measurements (NCRP). 1975. Natural Background Radiation in the United States. Handbook 45, National Council on Radiation Protection and Measurements, Washington, D.C.

Oak Ridge National Laboratory (ORNL). 1982. Environmental Analysis of Operations at the X-10 Site. ORNL-5870, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Oak Ridge National Laboratory (ORNL). 1984. Resource Management Plan for the Oak Ridge Reservation. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Oakes, T. W., K. E. Shank and C. E. Easterly. 1976. "Natural and Man-Made Radionuclide Concentrations in Tennessee Soil." In Proceedings of the Health Physics Society Tenth Midyear Topical Symposium. Rensselaer Polytechnic Institute, Troy, New York.

Oakely, D. T. 1972. Natural Radiation Exposure in the United States. ORP/SID 72-1, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, D.C.

Pierre, J. L., and R. G. Wallace. 1983. Preconstruction Radioactivity Levels in the Vicinity of the Proposed Clinch River Breeder Reactor Project, 1982. Tennessee Valley Authority, Radiological Health Group, Knoxville, Tennessee.

Pierre, J. L., and R. G. Wallace. 1984. Preconstruction Radioactivity Levels in the Vicinity of the Proposed Clinch River Breeder Reactor Project, 1983. Tennessee Valley Authority, Radiological Health Group, Knoxville, Tennessee.

Popper, J. 1985. "The Environmentalist and the Lulu." Environment. March 27, 1985. pp 7-40.

Project Management Corporation (PMC). 1975. Clinch River Breeder Reactor Plant Environmental Report, Vol. I-II (Amendments III-XIII through 1982). Docket 50537.2, U.S. Nuclear Regulatory Commission, Washington, D.C.

Project Management Corporation (PMC). 1982. License Application, PSAR, Amendment 68, U.S. Nuclear Regulatory Commission, Washington, D.C.

Ralph M. Parsons Company (Parsons). 1985. Conceptual Design Report, Integral Monitored Retrievable Storage (MRS) Facility, Vol. 1. Ralph M. Parsons Company, Pasadena, California.

Rand McNally and Company. 1982. Road Atlas: United States/Canada/Mexico. Rand McNally and Company, Chicago, Illinois.

Rainey, R. S., and L. M. Mills. 1983. "Environmental Sound Survey--Clinch River Breeder Reactor Project." Tennessee Valley Authority, Industrial Hygiene Branch (Muscle Shoals, Alabama); Nuclear Licensing Branch (Chattanooga, Tennessee).

Stenehjem, E. J., and J. E. Metzger. 1976. A Framework for Projecting Employment and Population Changes Accompanying Energy Development, Vol. I. ANL/AA-14, Argonne National Laboratories, Argonne, Illinois.

Tennessee Department of Agriculture (TDA). 1984. Tennessee Agricultural Statistics: 1984 Annual Bulletin. Tennessee Crop Reporting Service Bulletin T-21, Tennessee Department of Agriculture, Nashville, Tennessee.

Tennessee Department of Education. 1984. Annual Statistical Report of the Department of Education for the Scholastic Year Ending June 30, 1984. State of Tennessee Department of Education, Nashville, Tennessee.

Tennessee Department of Employment Security. 1984. Annual Averages: Tennessee Labor Force Estimates 1979-1983. Nashville, Tennessee.

Tennessee Department of Health and Environmental Air Pollution Control Division. 1984. Air Quality Report. Nashville, Tennessee.

Tennessee Department of Transportation (DOT). 1984. Oak Ridge and Roane County Traffic Maps.

Tennessee Division of Community Development. 1982. Tennessee Community Data. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1983. Tennessee Community Data. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1984. Tennessee Community Data. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985a. Anderson County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985b. Loudon County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985c. Roane County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985d. Meigs County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985e. Rhea County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985f. Knox County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985g. Morgan County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985h. Davidson County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985i. Macon County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985j. Smith County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985k. Sumner County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985l. Trousdale County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Division of Community Development. 1985m. Wilson County Profile. Tennessee Department of Economic and Community Development, Nashville, Tennessee.

Tennessee Taxpayers Association. 1984. The 1984 Annual Survey of State and Local Government in Tennessee. Tennessee Manufacturers and Taxpayers Association, Nashville, Tennessee.

Tennessee Valley Authority (TVA). 1974a. Hartsville Nuclear Plants Environmental Reports, Vol. 1-4. 50518-3, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1974b. License Application PSAR, Vol. 1. Docket STN-50518-16, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1974c. License Application Environmental Report, Vol. 1. Docket STN-50518-3, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1974d. AEC Draft Environmental Statement. Docket STN-50518-22, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1975. Final Environmental Statement. Docket STN-50518-59, Knoxville, Tennessee

Tennessee Valley Authority (TVA). 1976. Nuclear Regulatory Commission's Safety Evaluation Report. Docket STN-50518-111, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1979. Hartsville Nuclear Plants Socio-economic Monitoring and Mitigation Report. HNP-SMR-6, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1981. Hartsville Nuclear Plants Socio-economic Monitoring and Mitigation Report. HNP-SMR-9, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1982a. Hartsville Nuclear Plants Socio-economic Monitoring and Mitigation Report. HNP-SMR-10, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1982b. Supplement to Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant. Docket No. 50-537, NUREG-0139, prepared for the Nuclear Regulatory Commission, Washington, D.C.

Tennessee Valley Authority (TVA). 1985. Cultural Resource Program. Tennessee Valley Authority, Norris, Tennessee.

Thornton, C. C. 1978. Baseline Noise Data for the Summertime Period at the Clinch River Breeder Reactor Plant Site. Tennessee Valley Authority Memorandum to R. S. Rainey, Industrial Hygiene Branch.

University of Tennessee. 1983. Tennessee Statistical Abstract 1983/84. Center for Business and Economic Research, University of Tennessee, Knoxville, Tennessee.

University of Tennessee. 1985. Tennessee Statistical Abstract 1985/86. Center for Business and Economic Research, University of Tennessee, Knoxville, Tennessee.

U.S. Code of Federal Regulations, Title 40, Part 50 (40 CFR 50). "National Primary and Secondary Ambient Air Quality Standards."

U.S. Code of Federal Regulations, Title 40, Part 51 (40 CFR 51). "Requirements for Preparation, Adoption and Submittal of Implementation Plans."

U.S. Code of Federal Regulations, Title 40, Part 141 (40 CFR 141). "National Primary Drinking Water Regulations."

U.S. Code of Federal Regulations, Title 40, Part 143 (40 CFR 143). "National Secondary Drinking Water Regulations."

U.S. Department of Commerce. 1983. County and City Data Book. Bureau of the Census.

U.S. Department of Commerce. 1985. Statistical Abstracts of the United States. U.S. Printing Office, Washington, D.C.

U.S. Department of Commerce. 1985a. "County and Metropolitan Area Personal Income, 1981-1983." Survey of Current Business. 65(5):41-99.

U.S. Department of Commerce, Bureau of the Census. 1985b. "Provisional Estimates of County Populations, July 1, 1984." Current Population Reports. Series P-26, 84-52C.

U.S. Department of Energy (DOE). 1980. Oak Ridge Reservation Land Use Plan, DOE/ORO-748, Rev. 1. Oak Ridge, Tennessee, March.

U.S. Department of Energy (DOE). 1985a. Screening and Identification of Sites for a Proposed Monitored Retrievable Storage Facility. DOE/RW-0023, Washington, D.C.

U.S. Department of Energy (DOE). 1985b. Socioeconomic Assessment: Partial Closure of the Oak Ridge Uranium Enrichment Facility. DOE/OR/20837-T7, Oak Ridge, Tennessee.

U.S. Department of Labor. 1985. Monthly Labor Review. 10(8).

U.S. Environmental Protection Agency (EPA). 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. EPA-550/9-74-004, Arlington, Virginia.

U.S. Nuclear Regulatory Commission. 1982. Draft Supplement to Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant. NUREG-0139, Office of Nuclear Reactor Regulation, Washington, D.C.

Water Quality Criteria; Corrections, 46 Fed. Reg. 40919(August 13, 1981).

Wood, H. O., and F. Newman. 1931. "Modified Mercalli Intensity Scale of 1931." Seis. Soc. Am. Bull. 53(5):979-987.

6.0 ENVIRONMENTAL IMPACTS

This chapter presents the projected environmental impacts of construction, operation, and decommissioning of an MRS facility at the three alternative sites described in Chapter 5 (the Clinch River site, the Oak Ridge site, and the Hartsville site). Impacts are addressed in terms of the following environmental characteristics: radiological, air and water quality, ecological, land use, socioeconomic, and aesthetic. Resource requirements and transportation impacts are also discussed.

Impacts of the MRS facility are estimated for a design maximum throughput rate of 3,600 MTU per year. This was done to bound the environmental impacts. Other assumptions used to estimate impacts are listed on pages 4.1 and 4.2 of Chapter 4.

Environmental impacts that are common to all three sites are presented first, followed by a discussion of the impacts for each of the three sites.

6.1 IMPACTS COMMON TO ALL SITES

The environmental impacts common to all three alternative MRS sites are discussed in this section for the MRS activities and designs described in Chapter 4. Impacts unique to the Clinch River, Oak Ridge, and Hartsville sites are presented in Sections 6.2, 6.3, and 6.4, respectively.

6.1.1 Radiological Impacts

The potential radiological impacts, including cumulative effects, have been considered for preconstruction, construction, operation, decommissioning, and transportation activities for the six site-design combinations. Radiological consequences are estimated on the basis of one year of operation at the design throughput rate of 3,600 MTU per year. This represents a conservative, bounding case. Assuming a uniform throughput for the 26-year facility lifetime, the cumulative radiological consequences would be approximately 26 times the annual values presented here.

For the radionuclides contributing to the public radiation dose, the multiplication of the 50-year commitment by 26 to get the cumulative dose from 26 years of operation at a constant rate is very nearly correct. The dose commitment from tritium and ^{129}I is received almost entirely in the first year of exposure for inhalation and ingestion. The one exposure pathway where the approximation is not exact is for ingestion of crops grown in subsequent years that become contaminated from residual activity. The dose from ingestion pathways is largely from milk and above-ground vegetables. This dose is highest in the first year, because activity is deposited directly onto edible surfaces (grass in the case of the milk pathway) and much is transferred to man. During subsequent years the uptake is through plant roots, which results in less contamination reaching the edible product.

The following sections discuss the basis for the radiological impact analysis. The estimated impacts are presented in later sections for each site, as mentioned above.

6.1.1.1 Preconstruction and Construction

During preconstruction and construction small amounts of naturally occurring radon will be released during soil excavation. Preliminary analysis shows that these releases would result in radiation doses that are orders of magnitude below regulatory limits. Therefore, the radiological impacts from preconstruction and construction activities are not detailed in this report.

6.1.1.2 Operation

This section presents the potential radiological releases from normal operation of an MRS facility for all site-design combinations. Results of the impact analysis are presented later in this chapter in the sections for each site.

The postulated releases of radioactivity during normal operations are based on an analysis of the MRS facility processes and potential accidents and minor process upsets (Parsons 1985). Three sources for release were identified: 1) venting of shipping casks, 2) fuel rod damage during consolidation, and 3) a fuel assembly drop accident. The first two events are expected to occur fairly frequently and result in minor releases of fission gases. The fuel assembly drop accident is expected to occur no more than once per year. The postulated releases from these events are believed to give a reasonably conservative estimate for normal operation releases.

Under normal operating conditions, releases to the atmosphere are expected to result from venting of spent-fuel shipping casks and consolidation of spent fuel.[a] Handling of other waste types is not expected to result in significant releases because only spent fuel contains the volatile radionuclides ^{3}H, ^{85}Kr, and ^{129}I. Shipping-cask venting and consolidation of spent fuel would be

(a) Other wastes handled and packaged at the MRS facility will be HLW, RHTRU, and CHTRU generated during the packaging and handling of spent fuel. For simplicity, spent fuel and its associated wastes are collectively referred to as spent fuel.

performed in hot cells in the R&H building, where all releases pass through the air filtration system. These operations are common to all site-design combinations. In addition to releases from normal operations, the release from one fuel assembly drop accident per year is included in the annual release estimate. A complete description of this postulated accident is provided in the following section (6.1.1.3 Operating Accidents).

As part of normal operations, the spent-fuel shipping cask atmosphere is vented to the ventilation system before removal of the cask head. It is assumed that 0.01% of the fuel rods will be damaged in shipment, and portions of their radionuclide inventories will be released to the interior of the cask during normal operations (DOE 1978).

To consolidate the fuel rods, the fuel-rod bundles will be disassembled in the hot cells. Disassembly involves cutting the ends off the fuel-rod bundles, a process that does not involve the fuel directly but might cause suspension of built-up reactor corrosion products (crud). Radioactive release for this operation is calculated by estimating crud composition and by incorporating data on laser cutting operations. The airborne material from crud and structural steel components is passed through an in-cell filter (90% efficiency) and three high-efficiency particulate air (HEPA) filters (each tested to 99.97% efficiency) prior to release to the environment. A conservative estimate of the filter system efficiency is represented by a transmission factor for particulate material of 2×10^{-9}. This factor is applied to the cell concentration to estimate the amount of material reaching the atmosphere. Removal of radioactive material on the heating, ventilating, and air conditioning duct surfaces is not considered in these calculations. The ^{85}Kr, ^{129}I, and ^{3}H releases are not reduced by filtration.

Fuel rods tend to swell in the harsh environment of a reactor core, and 0.1% to 0.3% of the rods may become bound in the spacers of the fuel rod bundles (Funk and Jacobson 1979). Some of these fuel rods may then rupture during fuel rod consolidation, allowing for release of volatile radionuclides. In this analysis, a conservative assumption is made that 0.3% of the rods become bound[a] and that 50% of these are ruptured during fuel rod consolidations. This rate corresponds to one rod rupture per every three PWR assemblies or one per every 11 BWR assemblies.

In estimating the release of radionuclides from fuel the fraction of fission gas available for release must be known. An analysis has been performed based on an American Nuclear Society Standard (ANS 1982) to estimate the available release fractions for PWR and BWR fuel irradiated to 33,000 MWD per MTU

(a) According to German experience, this assumption is very conservative (Huppert 1978).

and 55,000 MWD per MTU. Results of the analysis indicate small releases for the 33,000 MWD per MTU fuel with larger fractions for the 55,000 MWD per MTU fuel. Based on this analysis, fission gas release fractions for the 33,000 MWD per MTU fuel were assumed to be 30% for krypton and 10% for tritium and iodine, as recommended by Regulatory Guide 1.25 (NRC 1972). The predicted release fractions for fuel irradiated to 55,000 MWD per MTU were 40% for PWR fuel and 57% for BWR fuel. These fractions apply to krypton, tritium and iodine. That is, for high burnup (55,000 MWD per MTU), release fractions for BWR fuel are assumed to increase by a factor of two for krypton and by a factor of six for tritium and iodine.

The release estimate for normal operations is based on receipt of 90% fuel at 33,000 MWD per MTU (10 years out of reactor) and 10% fuel at 55,000 MWD per MTU (10 years out of reactor). Also, 40% of the fuel is assumed to be from BWRs and 60% from PWRs.

For a processing rate of 3,600 MTU per year, the curies released per year as the result of normal receiving and handling activities plus one fuel assembly drop event are given in Table 6.1. These releases are to the atmosphere via the R&H building stack after they pass through the filter system. The releases are assumed to occur at a uniform rate throughout the year.

The radiological consequences from normal releases are presented in the respective sections for each site.

6.1.1.3 Operating Accidents

Preliminary assessment of potential abnormal occurrences for the MRS facility has been completed. This analysis, the conceptual design, and an accident analysis (Parsons 1985) have been used as the basis for the current accident evaluation. Four "design event" classifications are used to describe the events at an MRS that may result in release of radionuclides beyond the controlled area. The characteristic of each "design event" class is given in Table 6.2.

TABLE 6.1. Annual Atmospheric Release of Radionuclides from Routine Operations at an MRS facility

Radionuclide	Annual Release (Ci/yr)
^{3}H	2.9×10^{2}
^{85}Kr	9.6×10^{3}
^{129}I	3.0×10^{-2}

TABLE 6.2. Design Event Classes

Design Event Class	Class Description/Initiating Event
I	Operational events that occur frequently with minor releases (not considered accidents)
II	Events with a reasonable likelihood of occurring once during a typical year of MRS operation
III	Infrequent events that could occur during the MRS design lifetime
IV	Events that are initiated by natural phenomena or that are caused by human error, and which are unlikely to occur during the MRS design lifetime but require consideration

Events of Class I include intentional cask venting and expected release of volatiles during fuel rod consolidation. Releases from these events have been included in the routine-release source terms and will not be considered further.

Events of Class II, III, and IV represent off-normal events and accidents and are considered in the present analysis. The purpose of the present analysis is to provide a bound of potential radiological impacts for the MRS facility. Assumptions used in the analyses were selected to: 1) maximize the fuel involved in the accidents, 2) maximize the release during the accident, and 3) represent the highest possible exposure situation. The maximum amount of fuel handled as a unit during operations is one canister containing consolidated fuel (three PWR assemblies or seven BWR assemblies). Prior to disassembly the maximum amount of fuel handled is one PWR assembly. Releases are based on conservative estimates of fission gas released from fuel. The fuel assumed to be involved in the accidents is selected based on the highest inventory of fission gas radionuclides. This is either PWR or BWR fuel irradiated to 55,000 MWD per MTU. The maximally exposed individual is assumed to be at the point of nearest approach to the security fence for the duration of the accidental release and is exposed to the entire released activity. The wind is also assumed to be blowing in the direction of the individual for the duration of the accident. Further details of the exposure assessment analysis are presented in Appendix G.

Events of Class II are initiated by mechanical failures, operator error, or electrical power failure and have little potential for release of radionuclides beyond the confined area in which the accident occurs. The Class II event considered in the present analysis, caused by failure of the lifting and handling systems or operator error, involves dropping of a fuel assembly in the R&H building hot cell. For the design throughput rate of 3,600 MTU per year, about two fuel assembly drops per year would be expected based on observed events in other facilities performing similar fuel handling operations (Bailey 1983). However, only one fuel assembly drop event (out of 34 total) has ever been observed to release radioactive material from the fuel rods (and that was a minor release). Therefore, the frequency of fuel assembly drops that result in release of radionuclides is expected to be less than one per year. For this EA, the frequency is assumed to be one per year and one fuel assembly drop accident that releases radionuclides has been included in the annual normal operation source term.

The events of Class III are less likely to occur than the Class II events. A Class III event, in the present analysis, is considered to be that of a shipping cask drop in the receiving and inspection area.

Events of Class IV are initiated by low probability events (such as severe natural phenomena, events caused by human error, or severe mechanical failure) and are highly unlikely to occur. The facility is designed to withstand earthquakes and tornadoes without loss of containment capabilities. Therefore, releases of radionuclides from these events are improbable if not impossible. For the present analysis, an earthquake or tornado is assumed to be a contributory cause to accidents in the storage area during emplacement or retrieval operations. The postulated accident in the storage area is dependent on the storage design. For the sealed storage cask design, the accident involves dropping or overturning a storage cask. For the field drywell design, the accident involves shearing a canister during emplacement in a drywell. Although a detailed safety analysis of the MRS facility has not been conducted, the most severe accidents presented here represent the accidents that have been hypothesized.

All areas of the MRS facility where fissionable material is handled or stored have been designed to prevent nuclear criticality in accordance with 10 CFR 72.73 (by restrictions on spacing of fissionable material). In addition, criticality is only possible, even with favorable geometry, when a moderator is present, such as water. The design of the shielded process cell in the R&H building precludes the presence of a moderator, either in the cell or in the canister after consolidation. Moderators are also absent in the onsite storage mode (cask or drywell). Because the storage units are seal-welded and a second barrier (cask or drywell liner) is present, the potential for water entering the annular space around the canisters is very low. The design analysis indicated that even if one canister were to be filled with water, criticality would not occur. The criticality analysis for the MRS was based on unirradiated fuel with a relatively high enrichment (highest potential for criticality). Because of these design features, a nuclear criticality is not considered possible and is not included in the accident analysis.

The release of radionuclides for each accident is based on the handling of spent fuel having the highest activity considered for the MRS. Based on the inventory shown in Table 6.3, this is fuel exposed to 55,000 MWD per MTU and are then stored 10 years out of the reactor. The accident and impact analyses are performed for accidents involving handling of this spent fuel. While other waste types may be handled at the MRS facility, spent fuel bounds the consequences because the most likely radionuclides to be released are those of the more volatile elements (i.e., H, I, and Kr). Spent fuel has the largest inventory of these volatile radionuclides.

The radionuclide inventories given in Table 6.3 represent the activity in spent fuel based on 1 MTU initially loaded into a reactor. To determine activities released from fuel during an accident, it is only necessary to estimate the equivalent weight of fuel involved in the accident and apply appropriate release factors. For example, if a PWR fuel assembly [containing 0.462 metric tons of heavy metal (MTHM)] has 2% of its fuel rods damaged, then 0.02 x 0.462, or 0.00924, is the equivalent amount of fuel from which activity may be released. For fuel at 55,000 MWD per MTU and 10 years old, this could involve 0.00924 x 490 or 4.5 Ci of ^{3}H. This method is used in the following accident scenario descriptions in determining activities released to the atmosphere.

Offsite impacts from these accidents vary by site and are present in respective site sections: Clinch River - Section 6.2.1; Oak Ridge - Section 6.3.1; and Hartsville - Section 6.4.1. Details of each accident scenario and the postulated source terms are provided in the discussions below. The impacts presented are based on the assumption that the accident occurs; the probability of the event is not factored into the impact calculation.

TABLE 6.3. Inventory of Selected Radionuclides in Spent Fuel

Radionuclide	Activity (Ci/MTHM) 33,000 MWD/MTU (5 yr)	33,000 MWD/MTU (10 yr)	55,000 MWD/MTU (10 yr)
^{3}H	4.1×10^{2}	3.1×10^{2}	4.9×10^{2}
^{129}I	3.2×10^{-2}	3.2×10^{-2}	5.0×10^{-2}
^{85}Kr	6.7×10^{3}	4.9×10^{3}	7.4×10^{3}

Fuel Assembly Drop. Removal of fuel assemblies from the transportation cask involves lifting the assemblies vertically from the cask into the R&H building hot cell. During this operation, it is assumed that failure of the lifting and handling system, failure of the lifting bail, or operator error results in dropping one PWR fuel assembly (PWR assemblies contain more activity than BWR assemblies). Operating procedures and equipment are designed to minimize the potential for this type of accident. As mentioned on page 6.5, the frequency of a fuel drop accident with release of radionuclides is assumed to be one per year (i.e., one-half of the fuel assembly drops result in the estimated release described below). The assembly is assumed to fall at an angle against the cask rim or other structure resulting in breakage of all fuel rods in the dropped assembly. This is assumed to result in release of volatile fission products to the hot-cell interior and to the atmosphere via the HEPA filtration system and the facility stack. Applying the release fraction of 40% results in a release of 1,400 curies of ^{85}Kr, 91 curies of ^{3}H, and 0.0092 curies of ^{129}I. This scenario is applicable to both storage concepts.

Shipping Cask Drop. This accident involves dropping a shipping cask during transfer from the transport vehicle (truck or railcar) at the R&H building. Currently licensed shipping casks must be lifted from the carrier and placed on a cask cart to allow for mating with the hot-cell inlet. During the lifting operation, the shipping cask could be dropped: this is unlikely because of the design of the lifting equipment. All overhead cranes will have retainers to prevent derailment, and lifting yokes will be structurally overdesigned.

The United States Code of Federal Regulations (49 CFR 173.398) specifies that the licensed cask must survive a 30-foot (~9 m) drop onto a flat, unyielding surface followed by a puncture test, exposure to a temperature of 1,475°F (801°C) for 30 minutes, and a water immersion test; after these tests, the cask is allowed to leak a maximum of 1,000 curies of ^{85}Kr and 10 curies (~3 m) each of ^{3}H and ^{129}I. The carrier unloading facility will be designed so that a cask will not be lifted more than 10 feet in the air. The cask drop scenario is much less severe than the tests and the cask is assumed to remain intact. However, for the present analysis it is assumed that 1% of the fuel rods are damaged in the drop (100 times the failure rate for normal shipping operations). Based on the fission gas release study described in Section 6.1.1.2, it is assumed that 57% of the krypton, tritium and iodine in the broken fuel rods are released to the cask interior (for BWR fuel irradiated to 55,000 MWD per MTU). Upon venting of the cask, the volatile radionuclides are released through the ventilation system to the atmosphere. Any particulate material would be captured in the HEPA filtration system. Assuming the accident involves a rail cask with 36 BWR fuel assemblies (maximum release), the total release to the atmosphere (through the facility stack) would be 280 curies of ^{85}Kr, 19 curies of ^{3}H, and 1.9×10^{-3} curies of ^{129}I. This scenario is applicable to both storage concepts.

Storage Cask Drop (Sealed Storage Cask Concept). This accident is postulated to occur during emplacement of a sealed storage cask. A tracked vehicle is used to transport a cask to the storage site, and a mobile crane lifts the cask from the transporter and places it on a storage pad. During the transport/emplacement operation, the cask could be dropped or tipped over. Because of engineered safety features, structural overdesign, and safe operating procedures, the probability of this accident is very small. A seismic event is assumed to be a prime cause of this accident.

The lifting height from the transporter to the storage pad is minimized by prudent operating procedures. If a cask were dropped, the concrete shield and inner metal liner should remain intact. The canisters have been designed to withstand the postulated drop for this scenario without loss of containment. Thus, no release of radionuclides to the atmosphere is expected. It is assumed that the cask is returned to the R&H building for repackaging of the fuel as a precautionary measure. It is hypothesized that 5% of the fuel rods in one of the 12 canisters in the cask are ruptured and radioactivity is released to the interior of the canister. Normally the canister would be overpacked without opening, in which case there would be no release to the environment. If the canister is opened, the volatile fission products from the 5% failed fuel rods will be released to the hot cell and to the atmosphere via the HEPA filtration system. As for the shipping cask drop accident, it is assumed that 57% of the krypton, tritium and iodine are released from the damaged fuel rods to the atmosphere. For a BWR canister [seven fuel assemblies with a total of 1.3 metric tons of heavy metal (MTHM)], the release would be 280 curies of ^{85}Kr, 18 curies of ^{3}H, and 1.9×10^{-3} curies of ^{129}I.

Canister Shearing (Field Drywell Concept). When a field drywell canister is being placed into or retrieved from its drywell, it would be subject to shearing if the transport vehicle moved. Safety features of the transport vehicle prohibit vehicle movement during emplacement or retrieval so that the probability of a canister shearing accident, as postulated, is very small. However, for the present analysis, a major seismic event is assumed to be the prime cause of vehicle movement. The amount of canister damage from the shearing action depends on the force behind the vehicle movement. Action strong enough to completely shear the canister into two pieces is very unlikely. For the present analysis, it is assumed that the shearing accident results in tearing of the canister shell and that all of the fuel rods are damaged enough to release a fraction of their volatile fission products to the atmosphere. As before, it is assumed that 57% of the krypton, tritium and iodine are released from the damaged fuel rods. The fuel rods are not assumed to be damaged sufficiently to cause airborne release of a significant amount of particulate material. For a BWR canister (seven fuel assemblies with a total of 1.3 MTHM), the total release of volatile fission products would be 5,500 curies of ^{85}Kr, 360 curies of ^{3}H, and 3.7×10^{-2} curies of ^{129}I.

6.1.1.4 Decommissioning Activities

The MRS facility is designed to facilitate decontamination/decommissioning of structures and equipment and to minimize exposure of the public and workers. Decommissioning of the storage areas begins during retrieval operations. Final decommissioning of all facilities will be performed after all spent fuel and waste packages have been removed from the site and after removal, decontamination, and disposal of major equipment. The decommissioning will be completed upon removal of all radioactive material down to residual levels that are acceptable for release of the property for unrestricted use (10 CFR 20.105). Upon completion of decommissioning, the R&H building will be in a safe shutdown mode, and the storage area for the sealed storage cask design will remain with decontaminated casks in place. The field drywell area will be covered with topsoil.

During the storage period, the cask and drywell monitoring system will detect any leakage from failed canisters. If failure is detected, the cask or drywell canister will be returned to the R&H building for transfer of waste to new storage units. The sealed storage casks will be decontaminated for re-use or destroyed (if decontamination efforts are not effective). Drywells will be decontaminated in-place.

During the storage period, the spent fuel emits a low-level neutron flux. This flux will cause formation of small amounts of radioactive material through neutron activation of stable soil elements. An analysis of neutron activation for the field drywell storage design indicates that within a few days of removal of the spent fuel, the dose rate from the soil (0.0008 mrem per year) is much less than the dose rate from naturally occurring radioactive potassium (^{40}K) present in the soil (27 mrem per year).

Decommissioning involves a relatively small amount of residual radioactivity. Because of the precautionary measures taken in handling this small amount of radioactive material during decommissioning, no significant offsite releases are anticipated for normal decommissioning operations of the MRS facility.

6.1.2 Air Quality Impacts

This analysis of air quality impacts identifies effluents present during each MRS phase and their sources, emission rates, and compliance with standards of regulated pollutants. Sources and emission rates of unregulated pollutants are also given.

National Ambient Air Quality Standards (NAAQS) set allowable concentrations of total suspended particulates (TSP), nitrogen oxides (NO_x), sulfur oxides (SO_x), hydrocarbons (HC), and carbon monoxide (CO) (40 CFR 50). A proposed change would replace the TSP standard with a standard for PM_{10}, particles with an aerodynamic diameter less than 10 microns (Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter 1984). "Significant" amounts of these pollutants, for the purposes of prevention of significant deterioration (PSD) and allowable incremental concentrations of pollutants, are specified in 40 CFR 51. Pollutants with projected emissions equal to or greater than the significant amounts are modeled to estimate incremental concentration. These concentrations are compared with NAAQS and PSD increments, if applicable, in evaluating impacts. Air quality impacts specific to each site are discussed in Sections 6.2.2, 6.3.2, and 6.4.2.

Because activities at the site may vary widely over time, emissions are based on "worst case," or maximum impact, for each phase of operations at the site. Emissions during construction are postulated for maximum earth moving and area disruption. Emissions from operations are based on facility loading conditions. Emissions from decommissioning are based on maximum site disruption.

6.1.2.1 Preconstruction and Construction

Preconstruction activities, outlined in Section 4.1, would have minimal impact on air quality of the local area. Emissions from site characterization activities are estimated to be less than "significant" amounts.

The impact of building an MRS facility will be similar to that of any large construction project.

Construction activities are expected to temporarily affect ambient air quality in the immediate vicinity of the site. TSP, the current indicator for the particulate matter standards, includes particulate matter up to a nominal 30 microns. This is the size considered in emission factors for fugitive dust.

Fugitive dust from earth moving and heavy traffic will be the most significant air pollutant related to construction of the R&H building and storage area. Intermittent operations that will generate suspended particles include blasting and rock crushing. The concrete batch plant and aggregate materials stored at the site will be another source of fugitive dust. However, it is estimated that the rate of emissions from concrete batching and aggregate storage will be less than 15% of the maximum fugitive-dust emission rate.

The estimated emission of fugitive dust during the peak period of construction (>50 ton per yr) is greater than EPA's regulatory significant level for TSP emissions in 40 CFR 51. Other pollutants from construction will include combustion products from mobile sources. Emissions are projected to result in airborne concentrations within regulatory limits.

Emissions from an MRS facility are based on an active construction site of 100 acres (40 ha) during the period of maximum impact. EPA emission factors (EPA 1983) are used, corrected for the wet climate and site watering or stabilization measures. Dust emissions may vary greatly from day to day depending on the level of activity, specific operations, and the prevailing weather. Emissions of combustion products are based on consumption rates of fuels and EPA emission factors for heavy equipment.

Incremental concentrations of pollutants and local dispersion characteristics for the three sites are given in Sections 6.2, 6.3, and 6.4. In these sections, ambient air concentrations are compared with NAAQS and PSD increments for a Class II region. Emissions resulting from construction, such as fugitive dust, are usually excluded from PSD increment consumption. Details of the calculation methods are given in Appendix G.

To determine the concentration of a pollutant in ambient air, a release rate is multiplied by a meteorological dispersion factor, which is specific to the site. Impacts from airborne releases are discussed in Sections 6.2.2, 6.3.2 and 6.4.2.

Air quality regulations are based on levels that protect public health within an adequate margin of safety. Health effects from short-term exposure to TSP may be manifested in sensitive individuals at levels of about 250 micrograms per cubic meter, or about the level at which 24-hour concentration standards are set. Long-term effects may be manifested at levels of about 110-180 TSP, about twice the annual primary standard. Resultant airborne concentrations are given for each site, for comparison with these standards.

6.1.2.2 Operation

The major stationary sources of atmospheric emissions during operation of an MRS facility are oil-fired steam boilers. The cask manufacturing plant adjacent to the cask-type MRS facility will also emit particles. Vehicles also contribute a small quantity of additional emissions (see Appendix G).

Emissions are estimated from fuel use rate and concrete manufacturing rate. Projected fuel use rates are given in Section 6.1.7. Table 6.4, which compares emissions from an MRS facility with regulatory significant levels of emissions from stationary sources, shows that all emissions from operations are projected to be less than these regulatory levels. Concentrations resulting from emissions are given for each individual site in Sections 6.2, 6.3, and 6.4, where they are compared with NAAQS and PSD Class II increments.

TABLE 6.4. EPA Regulatory Significant Levels for Emission (40 CFR 51) and Annual Estimated Emissions from Operation of an MRS Facility (tons/yr)[a]

Pollutant	Significant Level	Estimated Emissions	
		Cask	Drywell
TSP (concrete production)	25	<5[b]	<1
NO_x	40	18	9
SO_x	40	28	15
CO	100	5	3

(a) Estimated emissions are calculated for stationary sources.
(b) Includes TSP from the concrete-batch plant adjacent to the MRS facility.

Some nonregulated chemicals may be emitted from the MRS facility. Potential pollutants and their sources are described below.

A mixture of helium and argon, both inert gases, is to be used in the hot cells for welding operations. The anticipated use rate is 30,700 standard cubic feet (scf) (870 m^3) per month of argon and 3,400 scf (96 m^3) per month of helium. Inert gases, being nontoxic but asphixiants, are of concern for reasons of industrial safety rather than for environmental reasons.

The sealed storage canisters in the hot cells will be cleaned and decontaminated using Freon®[a] (trichlorotrifluroethane), also known as Refrigerant 113 (R-113). Freon®, a nonflammable fluorinated hydrocarbon, will be recycled in the process. Less than 1/2% loss per cycle, or 936 scf (26 m^3) per month or about 4000 pounds (1800 kg) per year is assumed. This release rate would result in an 8-hour average air concentration at the fenceline of less than 0.01 ppm, which is well below the occupational standard of 1,000 ppm (NIOSH 1982). The total production rate of halogenated hydrocarbons (including R-113) during 1984 was reported to be about 1.1 billion lb (0.5 billion kg) (USITC 1985). Normally, all Freon® in a system such as household systems and restaurant-type walk-in freezers will eventually be released to the atmosphere over a several year period. No adverse environmental effects are expected from the small incremental release of fluorocarbons from the MRS facility.

(a) Freon® is a registered trademark of Du Pont Nemours and Company, Inc.

Potential impacts from operation of a cooling tower include plume formation, ground fog and ice, and drift.

The longest plumes will occur at 100% relative humidity and under stable atmospheric conditions. These conditions are most likely to occur during the winter between midnight and early morning. Visual impact of plumes is generally reduced by cloud cover when it exists, by terrain features at the Clinch River and Oak Ridge sites, and by low population density.

Fogging may be caused by the initial high turbulence of the plume and low buoyancy during periods of 100% relative humidity and unstable atmospheric conditions. Ground fog and icing are important environmental concerns at sensitive areas such as highways, bridges, and building complexes. Such sensitive areas are located at a distance from the cooling tower of about 1.2 mi (2 km) at the Clinch River site, 1.7 mi (2.7 km) at the Oak Ridge site, and 0.8 mi (1.2 km) at the Hartsville site. Additional fogging was not considered a significant environmental concern for the proposed CRBR at the CR site (PMC 1975, Amendment VI). The cooling tower for the MRS facility is roughly 3% of the capacity of the mechanical draft cooling towers designed for the CRBR (25 MW vs 776 MW).

Drift deposition will be limited to the immediate plant area, and does not pose a significant environmental concern. The MRS cooling tower is expected to cause no significant environmental effects.

Waste Heat. Waste heat from radioactive decay of the spent fuel is dissipated into the local environment. The above-ground sealed storage cask design concept was used to calculate the dissipation rate of heat to the atmosphere because the field drywell dissipates more heat to the ground, and less to the atmosphere. The heat generation rate is assumed to be 1,650 watts (W) per PWR canister and 1,260 W per BWR canister. Spent fuel accounts for most of the 22 megawatts (MW) generated by 15,000 MTU of spent fuel.

Two other major heat dissipating systems exist in the facility: lag storage and the cooling tower. Heat dissipated by the in-building lag storage area (capacity of 1,000 MTU) is about 1.3 MW. The MRS facility cooling tower is rated at 85.9 x 10^6 BTU per hour, or 25.2 MW.

For comparison, the primary aluminum smelter located near Knoxville generates an estimated 50 to 60 MW of waste heat.

The heat dissipation rate from the sealed storage cask facility is about 182 W per square meter, or about one-half of the 370 W per square meter of natural heat output from the surface of the earth.

Potential effects of a surface-level heat dissipation system include raising the ambient temperature, forming an unstable atmospheric layer next to the ground, influencing large-scale meteorological conditions, and changing the terrestrial environment downwind.

Thermally produced convection, which depends strongly on surface heating and vertical temperature distribution, produces vertical eddy currents. These convection currents mix air of different characteristics. Mixing depth increases with increased heating of the ground.

Small-scale turbulence can gradually change large-scale conditions, especially those close to the ground. Site-induced turbulence warms the air by bringing up heat from the surface. Such turbulence causes surface winds, increases moisture, and may slow the average wind by mixing it with the slower-moving air from lower levels.

The effect of waste heat is that it establishes an unstable layer in the otherwise stable air close to the ground. An inversion layer generally covers the entire region at an elevation of 1,100 to 1,800 ft (350 to 550 m) in the mornings, and 3,300 to 5,900 ft (1,000 to 1,800 m) in the afternoons. Waste heat from the storage area will tend to establish a new mixing depth over the site from the surface to the inversion layer.

In the areas surrounding the site, surface temperatures will be lower than at the site. The storage-area heat island produces a shallow, mixed layer. Although heat generated from the storage area will tend to weaken local stagnation, accumulation of warmer air still raises the ambient air temperature, which may affect the heat-transfer rate. Any changes in the surrounding downwind environment would probably be subtle, long-term, and extremely difficult to detect. Therefore, no discernable impacts are expected.

6.1.2.3 Decommissioning

The decommissioning plan calls for decontamination of structures to acceptable levels, without complete restoration of the site. This indicates a minimal amount of demolition and earthwork, thus little airborne particulate matter. Radiological concerns will dictate careful decontamination and dismantling of MRS-related facilities and equipment. Potentially contaminated dust will be filtered from the air.

6.1.3 Water Quality and Use Impacts

Water quality impacts common to all sites are evaluated in this section. For each MRS phase (preconstruction through decommissioning), routine effluents that could potentially affect water quality and use are considered.

In the event of a flood, the MRS facility would not affect water quality because all components of the facility would be at an elevation well above the probable maximum flood level for each site.

6.1.3.1 Preconstruction and Construction

The primary use of water during construction is for dust control (greater than 90%) and for concrete production. The use rate during construction is estimated to be 200,000 to 300,000 gallons (760,000 to 1.1 million L) per day (0.3-0.5 cfs).

During construction, ditches divert overland flow around the site. Temporary degradation of water quality will be mitigated by the settling of suspended solids in runoff ponds before discharge into surface waters.

6.1.3.2 Operation

The maximum water requirement for the MRS facility is 365,000 gallons (1.4 million L) per day, at summer cooling rates. Cooling-tower make-up (73%) and boiler-feedwater make-up (19%) account for most of the plant water requirement. Most of the cooling water is used to remove heat from the R&H building. Spent-fuel assemblies and canisters will never come in direct contact with cooling water. Cask-forming operations at the sealed storage cask manufacturing facility adjacent to the MRS require about 7,500 gallons (28,000 L) per day, or about 2% of the potable water use.

A drainage system will be employed to drain and collect all surface water that could cause damage to the facilities, property, or adjoining land. The drainage system will include grading, pavement, ditches, culverts, storm drains, and catch basins. Intruder-proof barriers will be provided on all culverts that pass through security fences, and incepter ditches will divert overland flow around the site (Parsons 1985).

The MRS facility is designed so that no radioactive waterborne effluents are discharged.[a] Waterborne contaminants resulting from spills within the R&H building would be contained within the building drain/sump system. Contaminated water would be processed through the radioactive waste treatment system.

The amount of nonradioactive process water treated at the facility is 22,500 gallons (85,000 L) per day. Two major sources of effluent water include

(a) Design calls for monitoring potentially radioactive streams and diverting the radwaste treatment processing, where the volume of radioactive waste water is reduced by evaporation, and consolidated into a solid waste form.

cooling tower blowdown (60%) and steam boiler blowdown (14%). The sanitary sewer system treats about 14,000 gallons (53,000 L) per day.

Waste water from operations is neutralized, as necessary, and a polymer solution is added to flocculate the mixture (coagulate suspended particles) into a sludge. The effluent from the flocculation tank is clarified and pressure-filtered before discharge. Effluent from the pressure filter contains approximately three parts per million of suspended solids and trace chemical constituents. Filter effluent meets the State of Tennessee and EPA standards for industrial waste water disposal. The dewatered sludge is disposed of at an offsite landfill designated as appropriate for the chemical content of the sludge.

Sanitary sewage is screened, comminuted, aerated, and clarified. Effluent from the clarifier is further treated by the filter system. Pressure filter effluent is disinfected with chlorine before discharge. This effluent meets the State of Tennessee and EPA standards for municipal and domestic waste-water disposal. Sludge from the clarifier is aerated to prevent it from becoming septic prior to offsite disposal.

6.1.3.3 Decommissioning

Water use during decommissioning is projected to be less than during operation of the facility. Regrading, which has been identified as a decommissioning activity for the drywell concept, may cause increased runoff. This will be mitigated by the use of runoff ponds. Stabilization will ultimately reduce silt in the runoff from the decommissioned site.

6.1.4 Ecological Impacts

This section addresses the ecological impacts of an MRS facility for preconstruction, construction, operation, and decommissioning phases. Only impacts common to all three alternative sites are discussed here. For a more detailed discussion of impacts unique to the Clinch River, Oak Ridge, and Hartsville sites, refer to Sections 6.2, 6.3, and 6.4, respectively.

6.1.4.1 Preconstruction and Construction

Removal of natural vegetation from the site will result in the loss of the area's associated primary production to higher trophic levels, either directly as forage or indirectly through loss of minerals normally produced in decomposition. Loss of habitat will also be associated with the removal of both the natural vegetation and soil. These losses could include nesting sites for birds, ground cover for small mammals and reptiles, and burrowing habitat for small mammals, reptiles, and insects. However, the disposal of the removed overburden could produce new habitat once it has stabilized; but this could be at the expense of what it covers. Revegetation of spoils may be enhanced by using fertilizers or other methods to promote plant growth.

During construction, noise and activity may deter wildlife from using the site. In addition, increased traffic will probably heighten the incidence of road-kill loss of wildlife; however, this cannot be quantified at the time.

6.1.4.2 Operation

Water withdrawal from natural water bodies (rivers) will adversely impact any entrained biota, but this should not result in a significant impact to the aquatic ecosystem since the water removal will be quite small--less than about 0.01% of the total flow of the Clinch or Cumberland Rivers. At this small percentage, even complete destruction of all entrained biota would not adversely impact the ecosystems.

Noise and movement from operations of the facility will deter wildlife from using the area. Losses of wildlife from road kill will occur, but the magnitude of this loss cannot be quantified at this time.

Liquid process waste and sanitary wastes will be treated and discharged directly into the surface waters adjoining the sites (Clinch River, Bear Creek, and Cumberland River). These waste waters are not expected to adversely impact the aquatic ecosystems since discharge levels are within both state and federal standards for waste-water disposal.

6.1.4.3 Decommissioning

Decommissioning of the facility will result in few additional ecological impacts. Losses of wildlife from road kill could occur.

6.1.5 Land Use Impacts

This section addresses the land use impacts of an MRS facility for preconstruction, construction, operation, and decommissioning phases. Only impacts common to all three alternative sites are discussed here. For a detailed discussion of impacts unique to the Clinch River, Oak Ridge, and Hartsville sites, refer to Sections 6.2, 6.3, and 6.4, respectively.

Commitment of the site to storage of nuclear materials will render natural resources on or near the site unavailable. Construction of an MRS facility requires that up to 320 acres (130 ha) of land for sealed storage cask or up to 465 acres (190 ha) for field drywell be committed to the facility for its operating lifetime.

6.1.5.1 Preconstruction and Construction

Preconstruction and construction activities will include site characterization, site preparation, and facility construction. Site characterization will have no substantial effect on land use at any of the sites.

Site preparation will consist of clearing, leveling, and filling the land. At the Clinch River and Hartsville sites, preconstruction and construction activities associated with previous projects have disturbed a significant portion of the land. Some further site preparation will be needed, however (see Sections 6.2. and 6.4).

Disposal of overburden from site preparation will have potential positive and negative impacts, depending on the disposal location and method. When stabilized, the disposed overburden could provide new habitat for wildlife and plants; however, it will destroy the existing habitat that it covers. Present plans call for removing and disposing of minimal overburden, with most of it being used onsite for leveling or other purposes. The site area not covered with buildings, asphalt, crushed rock, or other materials related to operations, will be landscaped and seeded with grass to minimize erosion and other adverse impacts.

Care will be taken to preserve archaeological or historical sites encountered. Once a site has been selected, it will require additional archaeological and historical investigations in accordance with federal preservation regulations (36 CFR 800). At this time, if any sites are determined eligible for inclusion in the National Register of Historic Places and such sites determined to be affected by construction, operations, decommissioning, or future changes in land use, then a plan will be negotiated between the DOE, the Tennessee State Historic Preservation Officer, and the Federal Advisory Council on Historic Preservation. This is usually carried out during the Draft EIS phase and implemented prior to construction.[a]

For site preparation and facility construction, temporary utilities will be installed. Some utilities that can be utilized already exist at or near all of the sites. These are site-specific and are discussed in Sections 6.2, 6.3, and 6.4 for the Clinch River, Oak Ridge, and Hartsville sites, respectively.

Some new transportation routes will be constructed for employee road access and truck and rail access to the site for waste shipment. These new roads and railways will impact some natural habitat. New transportation systems are discussed in greater detail in Sections 6.2.9, 6.3.9, and 6.4.9.

(a) Letter from G. F. Fielder, Jr., Tennessee Department of Conservation, to Dr. C. E. Cushing, Pacific Northwest Laboratory.

6.1.5.2 Operation

Operation of the facility should produce very little additional impact on land use over the impacts from construction.

6.1.5.3 Decommissioning

Decommissioning of the facility should result in little, if any, additional impacts. After decommissioning, the site will be available for unrestricted use, which will impact land use.

6.1.6 Socioeconomic Impacts

The MRS facility, similar to any other industrial facility of substantial size, creates both direct and indirect local demands for human and natural resources, public services, and community infrastructure. If these demands are large enough relative to the local supply of these resources, they will noticeably affect local level and distribution of population and income, as well as housing availability, unemployment rates, demand for social services, and the revenues and expenditures of state and local government. These effects are one class of potential socioeconomic impacts of the MRS facility. For this analysis, these effects are referred to as "standard" socioeconomic effects.

Standard socioeconomic effects are discussed for each of the three alternative MRS sites in Sections 6.2.6 (for the Clinch River and Oak Ridge sites) and 6.4.6 (for the Hartsville site).

There are also two types of nonstandard socioeconomic effects associated with an MRS facility. The first of these might best be characterized as a "federal industry" effect.

Locating a federal facility in any community creates unique problems for the community because its facilities are not taxable. In the case of an MRS, the foregone taxes are substantial. In the absence of offsetting financial compensation, any demands the facility or its employees create on public services would have to be met out of the general tax base. This can result in higher local tax rates and can discourage private economic development, which is a priority of the city of Oak Ridge. Similar to many large private industrial developments subject to policy changes or uncertain markets, large federal facilities can also preempt available industrial sites; they can affect the entire local wage structure through their wage policies; they can create a climate of business uncertainty by changes in their operating levels; and as a result, they can adversely affect the image of the area as a potential location for business investment. This, in turn, can also discourage economic development. These effects are common to all three MRS sites. In the case of the

Clinch River and Oak Ridge sites, this general "federal industry" effect is exacerbated because the city of Oak Ridge and Anderson and Roane counties are already heavily dependent on the federal government (e.g., 77% of total employment in the city is accounted for by the federal government) (Freeman et al. 1984). Federal industry effects on the Clinch River and Oak Ridge sites are discussed in Section 6.2.6. The effects at the Hartsville site are discussed in Section 6.4.6.

The other type of potential nonstandard socioeconomic effect of an MRS arises out of the facility's perceived characteristics as a site where dangerous materials are handled and temporarily stored. Regardless of whether there are any actual health risks from radiation exposure, the MRS facility may still generate socioeconomic impacts because of behavioral reactions by the public to the perceived risk. Risk perception is a complex judgmental process that is influenced by factors such as familiarity and ability to conceptualize the risk, existence and distribution of offsetting benefits, degree of individual control over the level of risk, and apparent severity of potential consequences (Otway and Winterfeldt 1982).

Some members of the public might choose to avoid perceived risk by avoiding particular products and locations. If this were to occur with an MRS, this could lead to local economic losses because of consumer avoidance of agricultural products grown near the MRS site, loss of tourism, or loss of outdoor recreation dollars from the economy. In addition, if the public sees the MRS facility as imposing an unacceptable environmental risk on the community, whether or not such perceptions are accurate, the community may find it more difficult to attract and keep industries, since the people who work in these industries may not wish to live in the vicinity of the MRS facility. Such negative effects on recruiting would most likely occur with industries that are not tied to a particular location by transportation and raw materials considerations and that have requirements for a highly skilled labor force that must be assembled from a national labor market. Such "footloose" industries would tend to be attracted to locations offering the most amenities to the workforce. The overall socioeconomic effects of perception and risk-avoidance behavior described above will be called special socioeconomic effects because they would depend on the public perception that a nuclear waste facility imposes environmental risk. Potential special socioeconomic effects at the Clinch River and Oak Ridge sites are discussed in Section 6.2.6. The potential special effects at Hartsville are discussed in Section 6.4.6.

6.1.7 Resource Requirements

Resources required to build the MRS facility include fuel, concrete, and steel. The quantities required are discussed for each MRS activity and storage design concept.

6.1.7.1 Preconstruction/Construction

During construction of the facility, energy in the form of fuel and electricity is used in earth-moving and construction activities, building materials are used, and water is used both in construction and in dust control. Projected resource requirements for construction of a 3,600 MTU per year MRS facility, for both the sealed storage cask and field drywell, are given in Table 6.5. Some major features of the facility, such as the receiving and handling operations, are nearly identical for either design concept. Energy use for both construction and operation is considered to be the same for either design concept. No adverse impacts have been identified relating to resources required for construction. In addition to the land required for the MRS facility, up to 43 acres (17 ha) will be required for access roads.

TABLE 6.5. Resource Requirements for Construction of an MRS Facility[a]

Resource	Sealed Storage Cask	Field Drywell
Land (to fenceline)	up to 320 acres	up to 465 acres
Energy		
Fuel oil	63,000 gal/yr	63,000 gal/yr
Diesel	210,000 gal/yr	210,000 gal/yr
Gasoline	315,000 gal/yr	315,000 gal/yr
Electricity	5,040 MW-hr/yr	5,040 MW-hr/yr
Concrete	210,000 yd^3	200,000 yd^3
Steel	23,000 tons	22,000 tons
Water		
Concrete (storage only)	7.0 mgy	0.2 mgy
Dust control[b]	78 mgy	107 mgy

(a) Energy, concrete, steel, and water used on an annual basis during loading operation for 3,600 MTU/yr throughput rate.
(b) Dust control for 0.1 gallons per square foot per working day--rain or wet days, assuming one third of the site is being disturbed.

6.1.7.2 Operation

Major resources required for operation of an MRS facility include fuel for steam boilers and vehicles, and concrete and steel for casks, or steel for drywells. Resource requirements for facility operation are summarized in Table 6.6. These consist of energy and water to operate the facility and concrete to construct storage modules. These quantities can be supplied without any problem.

6.1.8 Aesthetic Impacts

Aesthetic impacts of an MRS facility that are common to all three site locations are discussed in this section. For site-specific impacts, see Sections 6.2.8, 6.3.8, and 6.4.8 for the Clinch River, Oak Ridge, and Hartsville sites, respectively.

TABLE 6.6. Resource Requirements for Operation of MRS Facility[a]

Resource	Sealed Storage Cask	Field Drywell
Land (to fenceline)	up to 320 acres	up to 465 acres
Energy		
Fuel oil	952,000 gal	952,000 gal
Diesel	110,000 gal	110,000 gal
Gasoline	75,000 gal	75,000 gal
Electricity	144,000 MW-hr/yr	144,000 MW-hr/yr
Concrete		
Storage modules	33,900 yd^3	5,500 yd^3
Steel		
Storage modules	10,300 tons	4,500 tons
Water		
Concrete (storage only)	1.4 mgy	0.2 mgy
Sanitary/process	133 mgy	130 mgy

(a) Energy, concrete, steel, and water used on an annual basis, during processing operations, are calculated for 3,600 MTU/yr.

6.1.8.1 Noise Levels

The Environmental Protection Agency, deriving authority from the Noise Control Act of 1972, identified noise levels on the basis of protecting "the public health and welfare with an adequate margin of safety." An equivalent sound level to avoid hearing loss has been identified as $L_{eq(24)}$ less than or equal to 70 dB. (See Section 5.0 for a definition of terms.) For outdoor activity, sound levels that are acceptable in areas where quiet is the norm are identified as L_{dn} less than or equal to 55 dB. In outdoor areas where people spend limited amounts of time, $L_{eq(24)}$ less than or equal to 55 dB is identified as acceptable (EPA 1974).

Noise levels are expected to be highest during the site preparation phase of construction. Construction is expected to require two work shifts, totaling 16 hours per day, five days per week. Important sources of noise during that time will be operation of heavy, diesel-power construction equipment and blasting during site leveling. Intermittent blasting will occur over a period of about one to two years. The resulting noise will be noticeable to residents within a few miles of the site and could reach a level of annoyance for residents within one mile of the site. The noise impact for blasting operations may be reduced by using small multiple charges for blasting, and scheduling this activity for the late afternoon, as planned for the CRBR project (NRC 1982).

During operation of the MRS facility important sources of noise include the cooling tower, R&H building exhaust fans, compressors, and onsite vehicles. An additional source of noise adjacent to the sealed storage cask facility will be the mixing of concrete for cask production. Operation of the concrete-production facility will be eight hours per day, with no concrete mixing occurring during the night shift. No detailed studies of noise have been conducted for this facility. Based on reported noise emissions from equipment to be used at an MRS facility (EEI 1978), an analysis shows that noise levels during operation will not exceed L_{dn} of 55 dB at nearby residences (Appendix G).

6.1.8.2 Visual Impacts

Visual impacts of an MRS are site-specific and are treated in Sections 6.2.8.2, 6.3.8.2, and 6.4.8.2.

Figure 6.1 is a conceptual drawing of the MRS facility. The largest building at the facility is the R&H building, a concrete structure, 118 feet (36 m) high. The main stack, 165 feet (50 m) above grade level, is on the R&H building. Other visible features include administration and maintenance buildings, fuel and water storage tanks, and truck and train facilities.

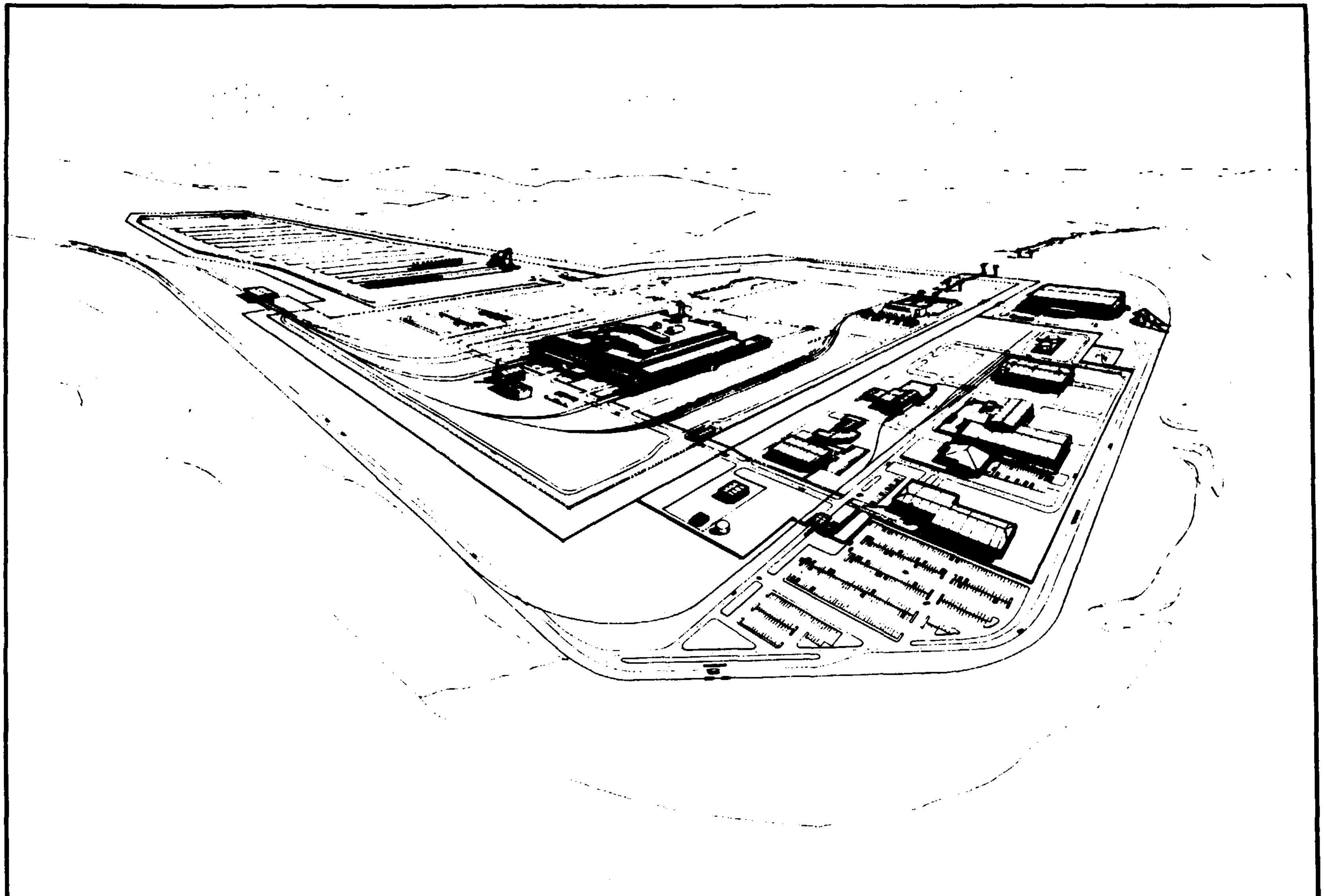

FIGURE 6.1. Conceptual Drawing of the MRS Facility (Sealed Storage Cask Design)

The sealed storage cask facility will have a concrete batch and cask-manufacturing plant adjacent to the site. The storage area of such a facility will consist of an array of concrete casks, which are about 22 feet (6.7 m) tall.

A field drywell facility will not have a cask manufacturing facility. The storage area will be larger than that of the sealed storage cask facility but will not have visible above-ground structures.

6.1.9 Transportation Impacts

Potential transportation impacts to members of the public (nonoccupational) that are common to all three candidate MRS sites are discussed briefly in this section. The primary transportation impacts are those associated with 1) the movement of spent fuel from individual reactor sites to the MRS, 2) the shipment of consolidated fuel rods and associated waste products from the MRS to a repository, and 3) the increase in average daily traffic that results from spent fuel shipments and commuting to the MRS site. Impacts associated with the movement of spent fuel are represented in this section by cost, radiological effects, and nonradiological effects. Except for effects on local traffic, transportation impacts are similar to those that would occur in the currently authorized waste management system (i.e., spent fuel is shipped directly from reactors to a repository). Local traffic impacts are discussed in more detail in Sections 6.2.9, 6.3.9, and 6.4.9 for the Clinch River, Oak Ridge, and Hartsville sites, respectively.

Shipments of spent fuel from reactors to the MRS facility are assumed to be either 100% rail or 30% truck/70% rail. Transport from the MRS facility to the repository is always assumed to be by dedicated train (train transports only radioactive material). The total impacts presented in this section bound the potential environmental consequences for the 26-year operational period.

6.1.9.1 Traffic Impacts

Traffic impacts result from 1) the shipment of spent fuel and associated waste to and from the MRS, 2) the shipment of materials to the MRS site during construction and operation, and 3) the commuting labor force. These traffic impacts are represented by the estimated increase in the average daily traffic flow over major roads or rail lines. The peak traffic impacts from spent-fuel shipments were calculated for the 30% truck/70% rail case and are based on an annual throughput of 3,600 MTU. This flow of spent fuel would increase the daily traffic by eight trucks (four arriving and four leaving), and three trains. The annual number of rail shipments from the MRS facility to a repository would be about 30. Estimates of increases in average daily commuter traffic are higher than increases from spent-fuel shipments, as shown in Table 6.7.

TABLE 6.7. Projected Peak Increases in Average Daily Traffic (ADT) Flow (vehicle trips/day)[a]

MRS Site	Trains[b]	Trucks[b]	Passenger Cars[c]
Clinch River	3	8	1,000
Oak Ridge	3	8	1,000
Hartsville	3	8	1,000

(a) Daily averages are double the number of vehicles arriving at MRS (e.g., 500 ingoing plus 500 outgoing vehicles equals 1,000 passenger cars per day).
(b) Increases in average daily traffic are not significantly different for the three MRS sites and are based on peak shipments of 3,600 MTU/year.
(c) Commuter traffic impacts are for the peak construction year and are expected to decrease to about 650 cars per day during normal operating years. (325 ingoing plus 325 out-going vehicles equals 650 cars per day.)

The traffic impacts at the three candidate MRS sites will depend on current daily traffic conditions and local transportation systems. The current average daily traffic conditions on major roads serving each site (see Sections 5.1.9, 5.2.9, and 5.3.9) are evaluated, and traffic impacts are described in Sections 6.2.9.2, 6.3.9.2, and 6.4.9.2 for the Clinch River, Oak Ridge, and Hartsville sites, respectively. Traffic impacts are calculated based on two people per car.

6.1.9.2 Cost Impacts

The total costs associated with shipping spent fuel from reactor sites to MRS sites and then to potential repository sites are discussed briefly in this section. Total costs are based on 1985 constant dollars and include capital, maintenance, and shipping costs for the 26-year lifetime of the MRS facility. Not included in the total transportation costs are site-specific costs such as construction costs for building roads, rail-line spurs, and shipping and receiving facilities.

Total shipping costs were examined for two conceptual spent-fuel rail casks. A small rail cask with a loaded weight capacity of 100-ton (91 t) resulted in the highest total shipping cost for the MRS-to-repository transportation leg when compared to a larger, more efficient, 150-ton rail cask design. For a given transportation scenario, the overall transportation costs are not significantly different for the three candidate MRS sites. In addition, the costs are not significantly different for either 30% truck/70% rail or 100% rail shipments from reactor sites to MRS sites. The total cost impacts would be dependent on the spent-fuel cask capacity and the location of the potential repository site, but are expected to be bounded by the total costs shown in Table 6.8.

6.1.9.3 Radiological Impacts

Radiological impacts to the public from transportation include both exposure to radiation emitted by the radioactive package (shielded by the shipping cask) during normal transportation, and a potential exposure to radiation emitted by radionuclides that might be released from the radioactive package if the shipment is involved in an accident. The accident component of the radiological impact is based on a risk assessment of potential transportation-related accidents and associated radioactive releases.[a] The accident risk assessment considers 1) the probability of a shipment being involved in an accident, 2) the response of the package to the specified accident conditions, and 3) if a release is predicted, the consequences of a release of radioactive material from the package. Radiological impacts are determined for rural, suburban, and urban population groups (see Appendix F).

The total radiological doses are higher for truck shipments than rail shipments, as shown in Table 6.9. However, for a given transportation scenario, the total radiological doses are essentially the same for each of the three alternative MRS sites. Also, the total radiological doses are essentially the same for the nine potential repository sites that were included in the analysis, because the reactor-to-MRS transportation leg dominates the risk assessment results, as shown in Table 6.9.

The dose to the maximally exposed individual for normal operations from transportation is not expected to exceed 0.005 rem from each prolonged exposure event (see Tables F.28 and F.29, Appendix F). The maximum 50-year dose to a hypothetical individual living near the scene of the most severe accident is around 10 to 60 mrem, depending on the cask loading; i.e., the cask could contain between 14 and 84 BWR fuel assemblies. This individual is assumed to live about 230 feet (70 m) from the accident scene for a period of 50 years. If a firefighter were to be present at the time of a release of radionuclides from the cask and did not use protective breathing equipment, then it is expected that the firefighter could receive a maximum dose of 10 to 60 mrem. The probability of the most severe accident that could result in these doses is about one in every million transportation accidents involving spent fuel (see Table F.30, Appendix F).

(a) From Cashwell, J. W., K. S. Neuhauser and P. C. Reardon. 1986. Transportation Impacts of the Commercial Radioactive Waste Management Program (Draft). SAND85-2715, Sandia National Laboratory, Albuquerque, New Mexico.

TABLE 6.8. Overall Costs[a] for Spent-Fuel Shipments (million 1985 $)

Shipment to MRS[b]	Rail Shipment from MRS to Repository[c] 100-ton Cask	150-ton Cask
30% truck/70% rail	$1,600	$1,200
100% rail	$1,600	$1,200

(a) Overall costs are estimated for 26-year lifetime of the MRS facility and include capital, maintenance, and shipping costs from all reactor sites to the MRS and then to the Yucca Mountain repository site.
(b) Overall costs are not significantly different for the three MRS candidate sites (Oak Ridge, Clinch River, and Hartsville).
(c) It is assumed that all reactor spent fuel is shipped from the MRS to the Yucca Mountain repository in either a 100-ton or 150-ton cask.

TABLE 6.9. Radiological Dose Resulting from Spent-Fuel Transport (person-rem)[a]

Destination/Transportation Scenario	26-Year Exposure Routine Transport	Accident Risk	Subtotals[b]
All reactors to MRS			
100% rail	600	80	680
30% truck/70% rail	5,800	89	5,900
MRS-to-repository[c]			
100-ton cask	230	160	390
150-ton cask	97	150	250

(a) Impacts are not significantly different for the three alternative MRS sites and are bounded by the results presented in this table.
(b) Subtotals are rounded to two significant figures. Total radiological impacts for a given transportation scenario are the sum of routine and accident risk components for both the reactor-to-MRS and MRS-to-repository transportation legs.
(c) The Yucca Mountain repository site was assumed.

6.1.9.4 Nonradiological Impacts

Nonradiological transportation impacts (health effects) include fatalities from pollutants generated by burning diesel fuel needed to move the shipments, and traumatic deaths and nonfatal injuries from traffic accidents involving spent-fuel shipments. These nonradiological impacts are estimated in Table 6.10. The estimated numbers of traumatic deaths and nonfatal injuries are based on accident statistics evaluated for truck/trailer vehicles similar to those that will be used to transport spent fuel to the MRS site (Smith and Wilmot 1982). The rail transport accident rate is based on statistics for all rail accidents involving all types of freight (DOT 1977-1981). Occupational (transportation worker) nonradiological impacts are included in the total impact estimates presented in Table 6.10.

Nonradiological impacts are significantly higher for 30% truck/70% rail shipments than 100% rail shipments, as shown in Table 6.10. However, for either truck or rail transport, the total nonradiological impacts are essentially the same for each of the three alternative MRS sites, due to their geographic proximity. Total impacts for a given transportation scenario are obtained by combining the reactor-to-MRS and MRS-to-repository shipments

TABLE 6.10. Nonradiological Injuries and Fatalities Resulting from Spent-Fuel Transport[a]

Destination/Transportation Scenario	26-Year Operation	
	Nonfatal Injuries	Fatalities[b]
All Reactors to MRS		
100% rail	8.5	1.0
30% truck/70% rail	43	3.4
MRS-to-Repository[c]		
100-ton cask	266	26
150-ton cask	106	10

(a) Impacts are not significantly different for the three alternative MRS sites and are bounded by the results presented in this table.
(b) Fatalities includes health effects (deaths) from both pollutants and accidents.
(c) The Yucca Mountain repository site was assumed.

for the 26-year operating period. The total impacts (115 to 310 injuries; 11 to 30 fatalities) are small when compared to the total number of injuries and fatalities (97,000) that are expected to result from all United States commercial truck and rail shipments during the same 26-year period.

6.2 IMPACTS UNIQUE TO THE CLINCH RIVER SITE

This section presents the environmental impacts of an MRS facility at the Clinch River site. Impacts are projected for each MRS phase, as applicable. Figures 6.2 and 6.3 show the planned site layout at the Clinch River site for the sealed storage cask and field drywell design concepts, respectively. Differences in impacts for field drywell or sealed storage cask concepts are noted.

6.2.1 Radiological Impacts

The radiological consequences of normal operation releases from MRS operations at the Clinch River site are shown in Table 6.11. These results are based on the estimated annual releases described in Section 6.1.1.2. Details of analysis methods are presented in Appendix G, including meteorological assumptions.

The dose commitment to the maximally exposed individual is small compared with the annual limits of 75 mrem to thyroid or 25 mrem to total body and other organs (10 CFR 72). The exposures to the maximally exposed individual and to the population are very small compared with the annual dose from background radiation. The calculated doses are not expected to result in any distinguishable impacts.

The majority of the radiological doses are due to ^{3}H, ^{85}Kr, and ^{129}I.

Offsite doses from postulated operating accidents (as defined in Section 6.1.1.3) are presented in Table 6.12 for cask storage and in Table 6.13 for drywell storage. The doses presented in these tables are based on the assumption that the accident does occur; the probability of the event is not factored into the impact calculation. The doses presented are well below the regulatory limit of 5 rem for potential accidents (10 CFR 72). The population dose is well below the dose received from background radiation and is not expected to result in any statistically discernable health effects.

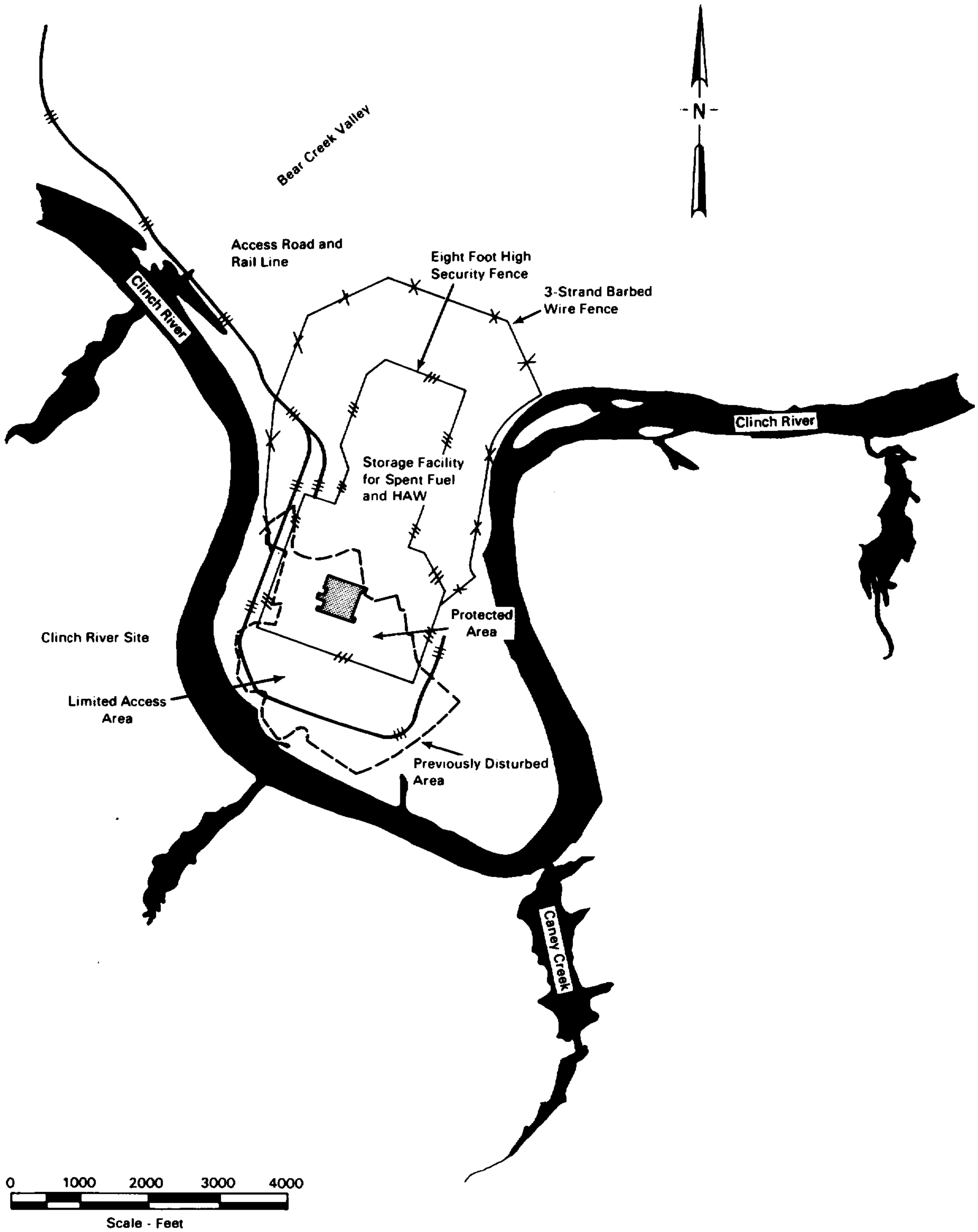

FIGURE 6.2. Layout of the Clinch River Site - Sealed Storage Cask Design

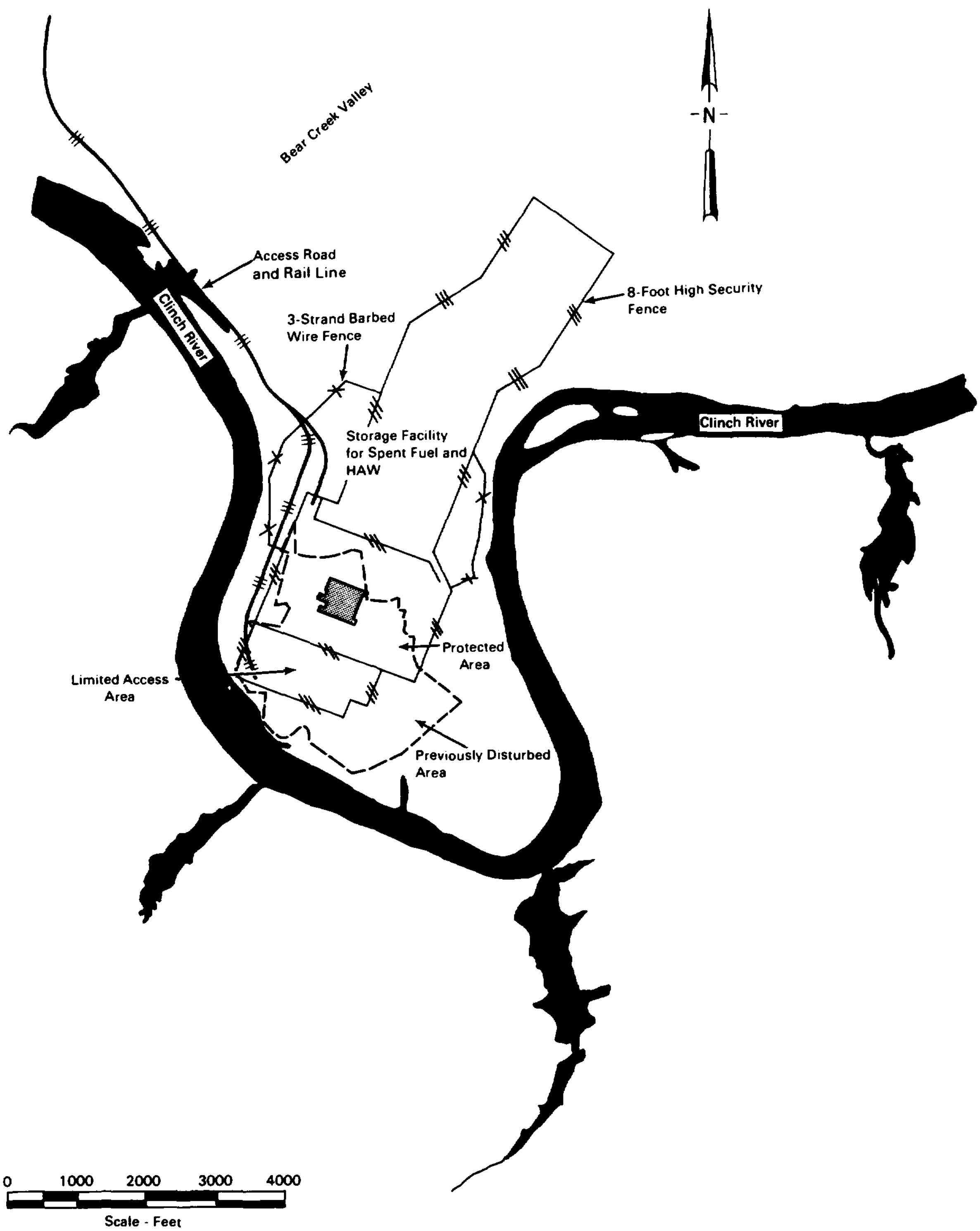

FIGURE 6.3. Layout of the Clinch River Site - Field Drywell Design

TABLE 6.11. Radiological Impacts[a] of MRS from Normal Operations at the Clinch River Site

Pathway and Location in the Body	50-Year Dose Commitment from Annual Release: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Air Submersion		
Total Body	1.7×10^{-7}	6×10^{-2}
Inhalation		
Total Body	2.4×10^{-7}	7×10^{-2}
Bone	6.3×10^{-10}	2×10^{-4}
Lungs	2.5×10^{-7}	7×10^{-2}
Thyroid	1.6×10^{-6}	5×10^{-1}
Ingestion		
Total Body	2.4×10^{-4}	2×10^{1}
Bone	2.8×10^{-6}	4×10^{-2}
Lungs	2.4×10^{-4}	2×10^{1}
Thyroid	1.3×10^{-3}	1×10^{2}
Total for all Exposure Pathways		
Total Body	2.4×10^{-4}	2×10^{1}
Bone	3.0×10^{-6}	1×10^{-1}
Lungs	2.4×10^{-4}	2×10^{1}
Thyroid	1.3×10^{-3}	1×10^{2}

(a) Impacts may be compared to the regulatory limit of 75 mrem to thyroid and 25 mrem to total body for the maximally exposed individual and to a background dose of 1.6×10^{5} person-rem for the population (based on an individual background dose of 150 mrem/yr for the Clinch River site).

(b) The maximally exposed individual is assumed to live at the location of the nearest resident and to eat locally grown food.

(c) Population dose commitments are calculated for the population within 50 miles of the site plus all people exposed to agricultural products grown within 50 miles (80 km) of the site.

TABLE 6.12. Radiological Impacts[a] of Potential MRS Facility Accidents for Sealed Storage Cask at the Clinch River Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Fuel Assembly Drop	Total Body	4.4×10^{-3}	3×10^{-2}
	Bone	1.4×10^{-4}	7×10^{-3}
	Lungs	4.6×10^{-3}	3×10^{-2}
	Thyroid	2.9×10^{-2}	2×10^{-1}
Shipping Cask Drop	Total Body	9.1×10^{-4}	6×10^{-3}
	Bone	3.0×10^{-5}	1×10^{-3}
	Lungs	9.6×10^{-4}	6×10^{-3}
	Thyroid	6.0×10^{-3}	3×10^{-2}
Storage Cask Drop	Total Body	8.9×10^{-4}	6×10^{-3}
	Bone	2.9×10^{-5}	1×10^{-3}
	Lungs	9.3×10^{-4}	6×10^{-3}
	Thyroid	5.9×10^{-3}	3×10^{-2}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a background dose of 1.6×10^5 person-rem/yr for the population (based on an individual background dose of 150 person-rem/yr for the Clinch River site).
(b) The maximally exposed individual is assumed to be at the nearest approach at the security fence for the duration of the accidental release. This location varies by accident and site.
(c) The population dose commitments are calculated for the population within 50 miles (80 km) of the site.

6.2.2 Air Quality Impacts

This air quality analysis for the Clinch River site uses source terms defined in Section 6.1. The basic assumptions and methods for estimating emissions are the same for all sites. Differences in concentrations of pollutants in the ambient air are a consequence of different dispersion characteristics at each site.

TABLE 6.13. Radiological Impacts[a] of Potential MRS Facility Accidents for Field Drywell at the Clinch River Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Fuel Assembly Drop	Total Body	4.8×10^{-3}	3×10^{-2}
	Bone	1.5×10^{-4}	7×10^{-3}
	Lungs	5.1×10^{-3}	3×10^{-2}
	Thyroid	3.2×10^{-2}	2×10^{-1}
Shipping Cask Drop	Total Body	1.0×10^{-3}	6×10^{-3}
	Bone	3.1×10^{-5}	1×10^{-3}
	Lungs	1.0×10^{-3}	6×10^{-3}
	Thyroid	6.7×10^{-3}	3×10^{-2}
Canister Shearing	Total Body	1.7×10^{-1}	5×10^{-1}
	Bone	1.9×10^{-3}	1×10^{-1}
	Lungs	1.8×10^{-1}	5×10^{-1}
	Thyroid	1.2×10^{0}	3×10^{0}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a background dose of 1.6×10^{5} person-rem/yr for the population (based on an individual background dose of 150 person-rem/yr for the Clinch River site).
(b) The maximally exposed individual is assumed to be at the nearest approach at the security fence for the duration of the accidental release. This location-varies by accident and site.
(c) The population dose commitments are calculated for the population within 50 miles (80 km) of the site.

6.2.2.1 Preconstruction and Construction

Preconstruction and site characterization activities would have minimal impact on air quality at the Clinch River site because little soil disruption or vehicle activity will occur. Emissions from site characterization activities are expected to be minimal.

Construction activities are expected to degrade, temporarily, the ambient air quality in the immediate vicinity of the site. Fugitive dust from land disturbance and heavy vehicle traffic is the most significant air pollutant related to construction of the R&H building and storage area. Interim blasting and rock crushing are also sources of suspended particles. Emissions are expected to be similar for the three sites, and are therefore given in Section 6.1.

Incremental concentrations of pollutants from both stationary and mobile sources are compared with NAAQS and are shown in Table 6.14. These concentrations for a location at the fenceline in the sector with the highest concentration.

Temporary emissions resulting from construction at the site are usually excluded from the restrictions on incremental pollutant concentrations set in 40 CFR 51 (PSD). Details of the calculation methods are given in Appendix G.

Table 6.14 shows that short-term TSP standards may be exceeded at the fenceline. A more detailed study may be required to assess area sources with more certainty. Air quality regulations are based on levels that protect sensitive individuals with an adequate margin of safety. The nearest residence is 4,000 ft (1.2 km) from the center of activity where concentrations of TSP are expected to be less than half the fenceline concentration. Combustion of fossil fuels will result in very small increases of atmospheric pollutants. Thus, few or no impacts to the public should occur.

6.2.2.2 Operation

The largest stationary sources of atmospheric emissions during operation of the MRS facility are oil-fired steam boilers. For the analysis, emissions from the cask manufacturing plant located adjacent to the cask-type facility are also included. Table 6.15 shows that concentrations resulting from emissions from stationary sources are below NAAQS. The annual average TSP

TABLE 6.14. Estimated Ambient Air Concentrations of Pollutant Emissions During MRS Construction of the Clinch River Site and Ambient Air Quality Standards ($\mu g/m^3$)[a]

Pollutant	NAAQS	Concentration at 100 m
Annual Average		
TSP	75	24
NO_x	100	2
24-hour Maximum		
TSP	260	330
8-hour Maximum		
CO	10,000	190

(a) Includes mobile sources.

TABLE 6.15. Estimated Ambient Air Concentrations of Pollutant Emissions During MRS Operation at the Clinch River Site and Ambient Air Quality Standards ($\mu g/m^3$)[a]

Pollutant	NAAQS	Concentration at Site Boundary $\mu g/m^3$ Cask	Drywell	PSD[b] Class II Increment
Annual Average				
TSP (concrete)	75	4		19
NO_x	100	0.03	0.03	
24-hour Maximum				
TSP	260	~60		37

(a) Stationary sources only.
(b) PSD = Prevention of Significant Deterioration, from 40 CFR 51.

concentration resulting from a cask manufacturing plant adjacent to a cask-type facility is well below the PSD increment for a Class II area. The 24-hour TSP concentration, although above the Class II increments, would be below the Class II increment at the closest residence. Vehicles at the facility will also emit small quantities of combustion products (Appendix G).

Concentrations from emissions resulting from operation of an MRS are very low, compared with NAAQS. No discernible impacts are expected.

6.2.2.3 Decommissioning

A decommissioning activity that could potentially generate airborne pollutants regrading the drywell field. Concern for radiological emissions will necessitate careful decontamination and dismantling of MRS-related facilities and equipment. Potentially contaminated dust will be filtered from the air before exhaust is vented up the stack. Impacts from these decommissioning activities will be minimal.

6.2.3 Water Quality and Use Impacts

Water quality impacts for the Clinch River site are evaluated in this section. Features unique to the Clinch River site are the water source and the receiving waters for the effluent stream. The ORGDP treatment facility on the Clinch River will be the source of water used by the facility.

6.2.3.1 Preconstruction and Construction

Water use rate during preconstruction should have very little impact on the water resources available from the Clinch River. Water use during construction will primarily be for dust control and concrete production. The use rate during construction is estimated to be 200,000 to 300,000 gallons (760,000 to 1.1 million L) per day (0.3 to 0.5 cfs, <0.01 m^3/sec), which is negligible in relation to the average flow of the Clinch River at the site (5,380 cfs, or 150 m^3/sec). Compared with that of other nearby industrial users, this use will have an imperceptible impact on the river.

Temporary degradation of water quality from high suspended solids content in runoff will be mitigated by settling solids in runoff ponds prior to discharge into the Clinch River. Three existing ponds will be used, and three additional ponds will be constructed.

6.2.3.2 Operation

The water use rate is expected to be 365,000 gallons (1.4 million L) per day (~0.6 cfs) during MRS operation. This is small compared with the flow rate of the river (5,380 cfs, 150 m^3/sec) and with withdrawals from the river by municipalities and industries [8 million gallons (30 million L) per day or 12.4 cfs below Melton Hill Dam, upstream of the proposed site]. The Clinch River is adequate to supply the needs of the facility without affecting other users.

No radioactive waterborne effluents will be released from the MRS facility. The waste treatment processes are designed so that the treated waste water meets all EPA and Tennessee effluent standards. These treatment processes are discussed in Section 6.1. Treated operations waste water [22,500 gallons (85,000 L) per day] and sanitary waste water [14,000 gallons (53,000 L) per day] are to be released into the Clinch River. Waste water from cask-forming operations at the sealed storage cask facility amounts to about 2% of the total waste water flow rate.

The impact of waste water disposal on surface water will be very small considering the volume of waste water (0.06 cfs or 0.0015 m^3/sec) and the chemical purity of the water, and the average river flow (5380 cfs or 150 m^3/sec). Ground water will not be affected by the disposal of waste water.

Runoff of storm water from the site will be mitigated by settling ponds, as during the construction phase.

6.2.3.3 Decommissioning

Water use during decommissioning is projected to be less than during operation of the facility. Regrading, which has been identified as a decommissioning activity for the field drywell concept, will necessitate use of water for dust control. Increased runoff and suspended solids from regraded areas will be mitigated by the use of runoff ponds. Stabilization will ultimately reduce silt in runoff from the decommissioned site.

6.2.4 Ecological Impacts

Three rare or endangered plants are known to occur on the Clinch River site. However, given the planned boundaries for both the sealed storage cask and field drywell concepts, neither the black snakeroot or Carey's saxifrage (two of the three) is expected to be adversely impacted by construction and operation of the facility. This assumption is based on a comparison of their known occurrence and maps of the proposed site. Potential impacts to ginseng, the third rare or endangered plant, is unknown. The site boundaries may possibly overlap the distribution of ginseng. Appropriate mitigation measures in accordance with the Endangered Species Act will be adopted as necessary.

6.2.5 Land Use Impacts

At the Clinch River site, facility layouts would require 303 acres for the sealed storage cask design, or 465 acres (190 ha) for the field drywell design. Preconstruction activities associated with previous site development have removed 131 acres (53 ha) (43%) of the 303 acres (120 ha) needed for the sealed storage cask design. An additional 172 acres (70 ha) will be disturbed with essentially total elimination of flora and fauna. For the field drywell design, 101 acres (41 ha) (22%) of the 465 acres (170 ha) needed have already been disturbed; an additional 364 acres (150 ha) of the site will be cleared. Twenty acres of land will be permanently disturbed for construction of access routes to the site. Because the field drywell facility requires more land area, land use impacts are greater than for the sealed storage cask facility.

6.2.5.1 Resources

No valuable mineral resources, such as fossil fuels, exist on the Clinch River site. In addition, the land is not considered to be valuable potential farmland. Therefore, no loss of farmland or resource availability is expected from location of an MRS facility at the Clinch River site.

The Clinch River site is considered by local and state officials to be a prime industrial location and efforts have been under way since termination of the Clinch River Breeder Reactor project to market the property as part of the community's industrial development program.

6.2.5.2 Archaeological and Historical Sites

The following archaeological sites are located within the fenced area (3-strand or 8-foot fence, as depicted in Figure 6.3) and will be impacted by construction of the field drywell facility: 40RE108, 40RE158, 40RE157, 40RE156, 40RE159*, 40RE154*, and 40RE153 (see Table 5.24 for description). [An asterisk (*) denotes those sites that have already been impacted by previous construction activities.] The following sites occur outside of this fenced area, but will probably be impacted by construction activities: 40RE163, 40RE152*, 40RE106, 40RE105, and 40RE165. These sites may also be impacted by construction of the sealed storage cask facility, except for site 40RE154, which would occur outside of the fenced boundaries. However, this site and sites 40RE152 and 40RE165 will be impacted by a new railroad spur.

6.2.6 Socioeconomic Impacts

This section discusses the standard socioeconomic impacts of an MRS facility at the Clinch River and Oak Ridge sites, including impacts on employment, income, population, housing, fiscal conditions, community services, and infrastructure. It also addresses nonstandard impacts relating to the siting of a DOE facility in a community already heavily dependent on the federal government. These two sites are discussed jointly because their socioeconomic impacts are the same due to geographic proximity [i.e., boundaries are about 3 miles (5 km) apart]. A current and projected baseline for these impacts was established in Section 5.1.6.

The location of the MRS facility at either the Clinch River or Oak Ridge site could reinforce the perception and the reality of the city of Oak Ridge as a federal one-company town. Preempting a scarce industrial site with an MRS facility precludes its potential use by other tax-paying industry. Because the MRS facility is not taxable under current law, the cost of public services supplied to the MRS facility and plant-related population would not be mitigated by property taxes ordinarily paid by a normal taxable facility of the same size. In addition, some companies that otherwise might have located in Oak Ridge may view the continuation of Oak Ridge as a one-company town as incompatible with their business and may decline to locate there, further reducing the potential tax base (Freeman et al. 1984). No quantitative analysis was performed on these intangible effects, however, because no data are available on the industries that might have located in Oak Ridge in the absence of an MRS facility. It is not clear at this time how to appraise the market value of the land, buildings, and equipment of this unique facility for property tax purposes.

Because it would perpetuate the company-town aspects of Oak Ridge, the location of the MRS facility at either the Clinch River or Oak Ridge site could also cause negative, largely unquantifiable, social impacts on the city's citizens. The city has a clear goal to diversify its economic base away from almost-exclusive dependence on federal government spending at the Oak Ridge Reservation. To accept an MRS facility, which would perpetuate such dependence, the citizens of Oak Ridge may have to give up a measure of control over their economic base, with accompanying feelings of loss of financial independence. In addition, the citizens could lose potential business services since new service firms may be reluctant to invest in a community whose principal economic base is perceived as almost exclusively dependent upon federal energy policy decisions affecting local purchases and payrolls (Freeman et al. 1984).

There does appear to be some potential for MRS-related development of ancillary firms specializing in remote handling, robotics applications in harsh environments, high-level equipment quality assurance, monitoring and survey instruments, remote heavy loading, and transport cask maintenance. It is not clear that these firms would necessarily locate near the MRS site.

6.2.6.1 Employment and Income

Many of the standard socioeconomic impacts associated with an MRS facility stem directly or indirectly from the project's demands for labor, materials, equipment, and business services. If labor, materials, equipment, and business services were all to be provided locally by suppliers in the 50-mile impact area, payments by the DOE for these goods and services would tend to be spent locally, generating demand for additional goods and services, and creating additional local jobs and income. If goods and services required by the MRS facility are imported into the impact area, the standard socioeconomic impact will be smaller. For purposes of this analysis, it is assumed that purchases of specialized instrumentation and equipment required by the MRS facility would be shared among local (Clinch River/Oak Ridge area) and national suppliers, that construction steel would be purchased on national markets, and that lumber, concrete, and miscellaneous equipment would be purchased within the impact area. It is assumed that labor for both construction and highly specialized operations would principally come from the primary impact area (including Knoxville). Because of the nuclear industry background of many workers in the area, it should be possible to staff the MRS facility largely from local sources. This would tend to minimize the standard socioeconomic impacts related to population growth. On the other hand, because little commuting would happen from outside the 50-mile impact area, socioeconomic impacts induced by spending of incomes earned at the facility would be relatively high.

Figure 6.4 shows the schedule and direct and total employment impacts of MRS construction, operations, and decommissioning at the Clinch River/Oak Ridge sites for the sealed storage cask design. Between 3.0 and 3.4 additional indirect and induced jobs per direct MRS job would be created in the 50-mile impact area, depending on the stage of life of the facility.[a] The additional jobs are created by the MRS facility purchases and the spending and respending of MRS-related incomes in the local economy. The peak impact year is 1994, with 4,500 more jobs available in the 50-mile impact area (2,750 in the primary impact area) than without an MRS facility. The cask manufacturing facility will employ about 120 people during the period 1995-2001, for total direct employment of 850 at the facility, including the DOE and state of Tennessee personnel. The total increase in regional employment will be 2,500. A steady level of inloading and outloading operations is achieved by the year 2003 and a constant level of about 650 people is employed at the facility from 2003 through 2017, when the last shipment is received. Total employment in the region stays about 1,900 persons higher than it would be without MRS during this period. Decontamination and decommissioning of casks begins in 2018 after shipments are no longer being accepted, while full-scale decommissioning of the facility begins in the mid-year 2021 after the last shipment is sent to the repository. During most of full-scale decommissioning, about 200 to 250 people are employed at the MRS facility. Total employment impact declines in two stages: first, to about 1,200 as receiving operations are shut down; second, to about 800 as operations and maintenance cease and only decommissioning activities are continued. A small, permanent, employment increase of about 150 persons will occur after 2026, the last year of decommissioning.[b]

Figure 6.5 shows that the impact on employment can be expected to be similar for the drywell case. Peak employment will occur in 1994.

Table 6.16 also shows, by city, that the sealed storage cask facility is expected to add, directly and indirectly, $127 million extra to the Clinch River/Oak Ridge 50-mile impact area's economy in 1994, the peak year of construction activity. During facility operating years, the impact on regional income will average about $66 million, and during decommissioning, about $26 million.

(a) Indirect jobs are jobs created as a result of purchases of goods and services, other than labor, by the MRS facility and supplying industries. Induced jobs are created by the purchases of the household sector out of incomes earned directly or indirectly as a result of MRS. Between 0.8 and 1.7 of these additional jobs would be generated within the primary impact area, including Knox County.

(b) This increase in employment is due to a dynamic growth effect on the trade and services sectors, which continue to employ about 140 people more than they would have if MRS never occurred.

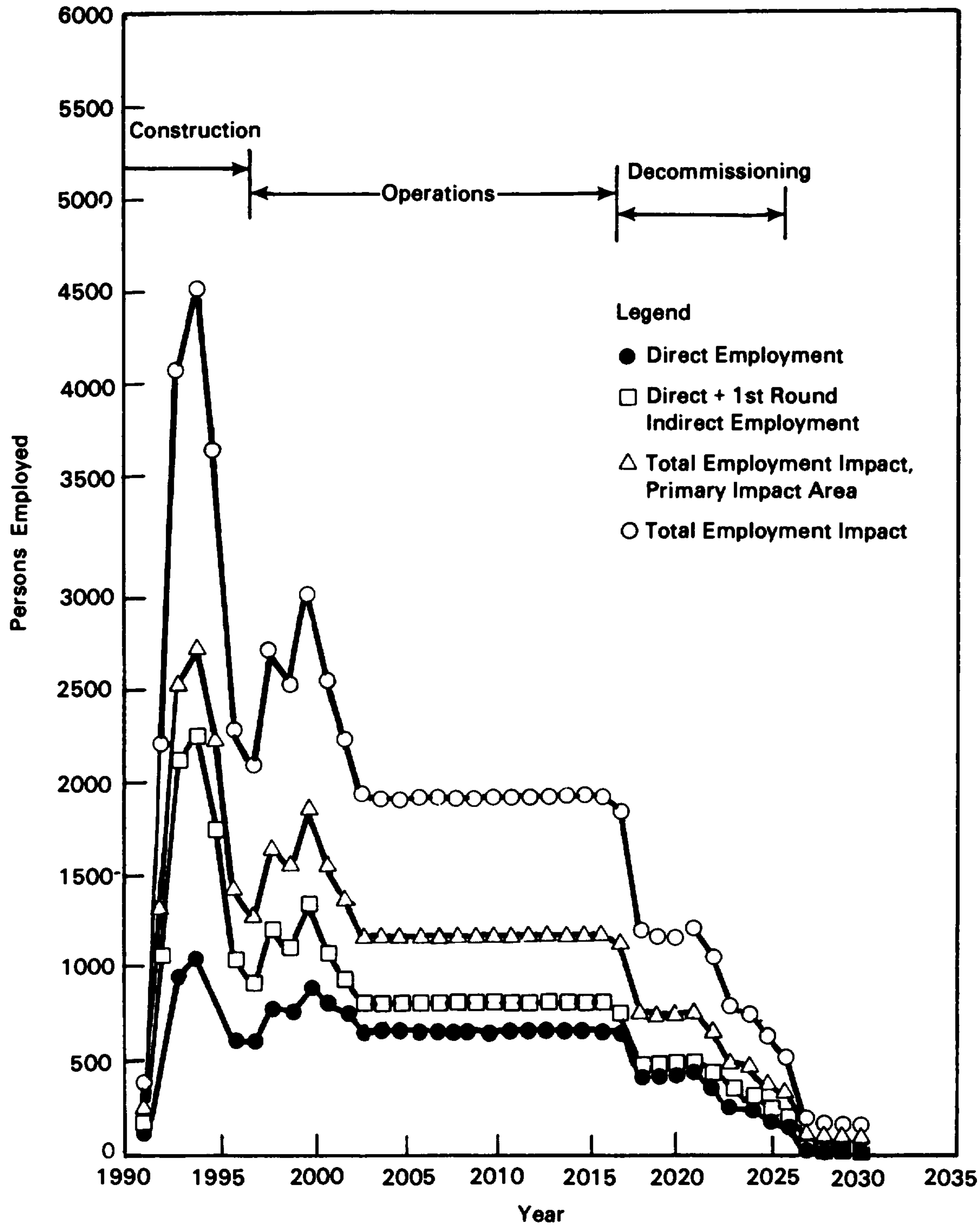

FIGURE 6.4. Employment Impacts of a Sealed Storage Cask Facility at the Clinch River/Oak Ridge Site

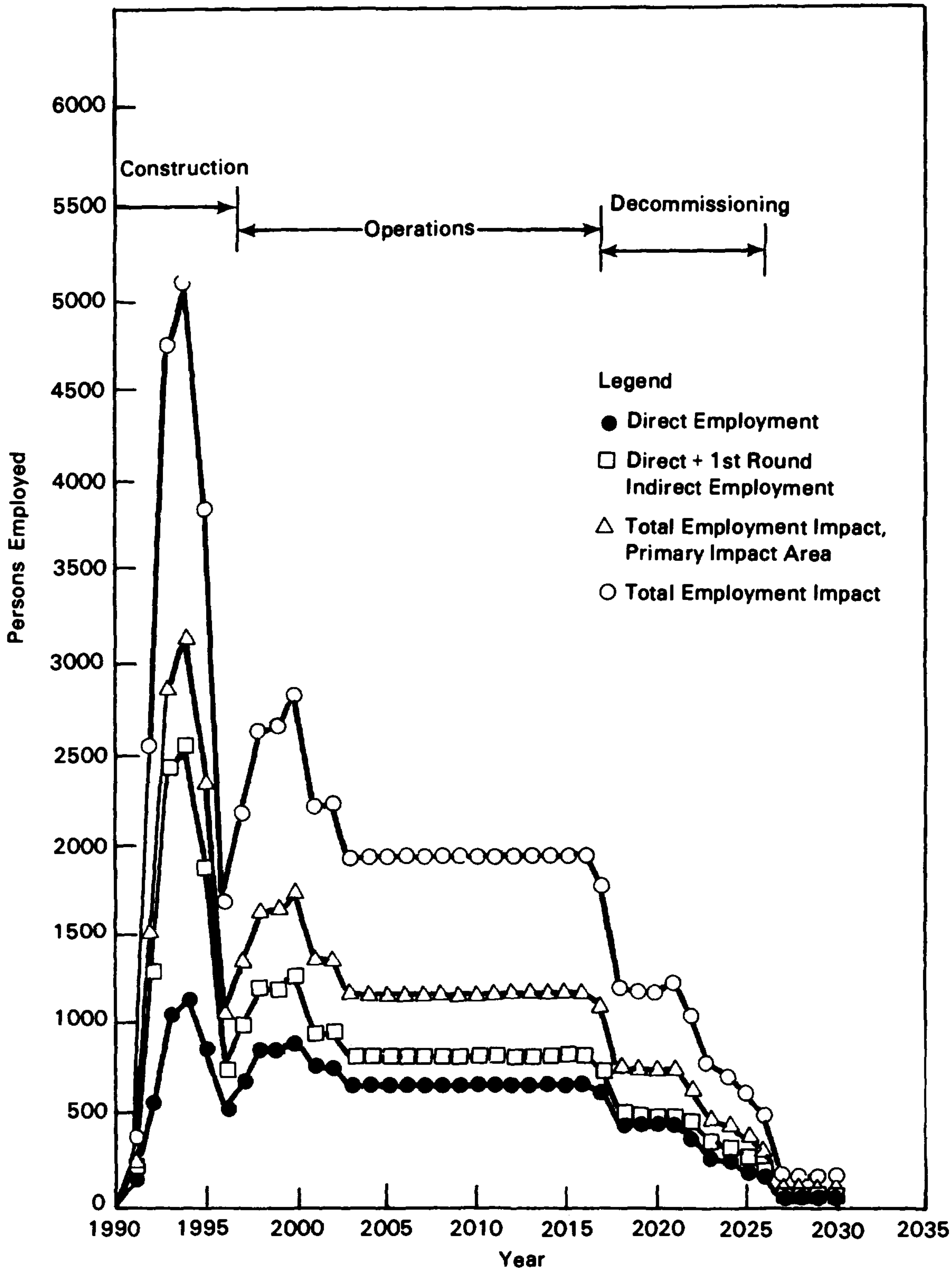

FIGURE 6.5. Employment Impacts of a Field Drywell MRS Facility at the Clinch River/Oak Ridge Site

TABLE 6.16. Employment and Income Impacts of a Sealed Storage Cask MRS Facility at Selected Communities in the Clinch River/Oak Ridge Primary Impact Area

County/City	Construction[(a)] Peak Year Employment Impact	Construction[(a)] Peak Year Real Income Impact (million 1985 $)	Operation[(b)] Average Year Employment Impact	Operation[(b)] Average Year Real Income Impact (million 1985 $)	Decommissioning[(c)] Average Year Employment Impact	Decommissioning[(c)] Average Year Real Income Impact (million 1985 $)
Anderson						
Oak Ridge	451	$12.7	192	$6.6	79	$2.6
Clinton	47	1.3	20	0.7	8	0.3
Oliver Springs	44	1.2	19	0.6	8	0.3
Norris	8	0.2	4	0.1	1	<0.1
Loudon						
Lenoir City	127	3.6	54	1.8	22	0.7
Loudon	52	1.5	22	0.8	9	0.3
Morgan						
Wartburg	6	0.2	2	0.1	1	<0.1
Roane						
Harriman	110	3.1	47	1.6	19	0.6
Rockwood	72	2.0	30	1.0	13	0.4
Kingston	105	3.0	44	1.5	18	0.6
Knox						
Knoxville/ Farragut	1676	47.3	712	24.4	294	9.8

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations excluding cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).

Much of the economic activity in the Clinch River/Oak Ridge impact area would be centered on a subset of the primary impact counties nearest the site. Included are Anderson, Roane, Morgan, Loudon, and Knox counties.[a] These counties house most of the people who work on the Oak Ridge reservation and contain most of the towns and cities in which incomes earned at the facility are likely to be spent.[b] The estimates presented in Table 6.16 are based on the relative population and distance of the communities from the Clinch River site as described in Appendix H (Oak Ridge can be expected to have about the same distribution). In each case, the increase in employment or income is assumed to take place at the larger communities in the county, although people may actually choose to live and work in the unincorporated areas of the respective counties or in some of the smaller towns. Only in the city of Oak Ridge and in Loudon and Anderson Counties is the peak effect of the plant more than about 1% of the existing (1984) employment and income base. The effect is expected to be noticeable but small in Oak Ridge (about 3%).

Table 6.17 indicates that the effects of a drywell MRS facility on the local economy are quite similar to those of the sealed storage cask design.

6.2.6.2 Population and Housing

Both the general and specialized skills required to build and operate the MRS facility are readily available in the Clinch River/Oak Ridge impact area and even within the primary impact area. It is unlikely that significant immigration would be required to work on the MRS facility itself. However, to the extent that the individuals involved already hold jobs, they would have to be replaced if they went to work on MRS by previously unemployed workers or by immigrants. The analysis in this section assumes, conservatively, that the propensity of the MRS-related employment to attract net migration is the same as for the average increase in employment in the region. In other words, while some of the net increase in jobs related to MRS is assumed to be filled from the ranks of the unemployed, this is assumed to be no more or less likely than for any other increase in employment. An alternative assumption is that the unemployed workers in the primary impact area fill all the MRS-related jobs, so that unemployment is reduced, no migration would be caused by MRS, and there would be no population-related impacts on housing or infrastructure. Since the MRS facility is relatively small, it is likely that it can be absorbed in the economy simply by reducing the overall unemployment rate or by increasing labor

(a) Meigs and Rhea counties are expected to be the residence of few workers at Clinch River or Oak Ridge.
(b) MRS material and equipment purchases may be made at greater distances away from the site, particularly for items requiring special construction and little ongoing service after the sale. Money spent on these purchases would likely leave the Clinch River/Oak Ridge impact area.

TABLE 6.17. Employment and Income Impacts of a Field Drywell MRS Facility at Selected Communities in the Clinch River/Oak Ridge Primary Impact Area

County/City	Construction[a]		Operations[b]		Decommissioning[c]	
	Peak Year Employment Impact	Peak Year Real Income Impact (million 1985 $)	Average Year Employment Impact	Average Year Real Income Impact (million 1985 $)	Average Year Employment Impact	Average Year Real Income Impact (million 1985 $)
Anderson						
Oak Ridge	510	$14.4	191	$6.6	77	$2.6
Clinton	53	1.5	20	0.7	8	0.3
Oliver Springs	50	1.4	19	0.6	8	0.2
Norris	9	0.3	3	0.1	1	<0.1
Loudon						
Lenoir City	143	4.0	54	1.8	21	0.7
Loudon	59	1.7	22	0.8	9	0.3
Morgan						
Wartburg	6	0.2	2	0.1	1	<0.1
Roane						
Harriman	124	3.5	47	1.6	19	0.6
Rockwood	81	2.3	30	1.0	12	0.4
Kingston	118	3.3	44	1.5	18	0.6
Knox						
Knoxville	1895	53.4	710	24.4	286	9.5

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations excluding cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).

force participation, with no effect on migration. By assuming that new MRS-related jobs have associated with them the average propensity to draw migrants to the area, the analysis may overstate growth-related "boom-bust" effects of migration on community services and infrastructure.[a]

Table 6.18 shows the expected upper-bound impact of MRS-related economic activity on local population and on housing demand in the primary impact area. The table assumes that 1980 average household sizes would continue to prevail and that the population in the base case without MRS is housed adequately. Thus, the increase in housing demanded over the base case (increase in households) would represent the potential extra demand for units. Although some potential exists at the local level for spot housing shortages, at the county level the increase is well within the number of vacant housing units existing in 1980. In addition, because the area economy is expected to be growing without MRS, the housing stock would be increasing and could be adequate to absorb the MRS-related population increase when it appears. Table 6.18 reports only the impacts in the primary impact area. The impacts in the remainder of the 50-mile impact area are considered to be too widely distributed to be noticeable. At the completion of construction and again at the end of operations a small number of units would be released on the local housing markets, possibly depressing housing values slightly. Because of the small number of units involved, it is unlikely that the effect would be noticeable. The impact of a drywell design MRS is virtually identical, so no table is shown for that concept.

6.2.6.3 Fiscal Conditions

Some impact may be expected on local government fiscal conditions from the MRS facility project. Although, currently, the MRS facility itself is not taxable,[b] the general increase in economic activity projected for MRS can be expected to result in increases in property, income, and sales taxes collections. Similarly, the increase in population may result in some increases in local government expenditures. These effects are unlikely to be large enough to be noticed in communities outside the primary impact area. Table 6.19 shows the projected impact on state and local revenues and expenditures for the primary impact area, based on the following assumptions for state and local government, which are explained further in Appendix H:

(a) This assumes that the new jobs--direct, indirect, and induced--are filled in the historical proportions in each industry from a combination of previously unemployed, employed persons switching jobs, persons previously not in the labor force, commuters, and new migrants.

(b) The DOE has proposed that payments equivalent to taxes be made to local government at the MRS site. The details of this arrangement have not been worked out.

TABLE 6.18. Maximum Population and Housing Impact of a Sealed Storage Cask MRS Facility at the Clinch River/Oak Ridge Primary Impact Area

County/City	Construction[a]		Operations[b]		Decommissioning[c]		County 1980 Housing Vacancies[e] (units)
	Peak Year Population Impact (persons)	Peak Year Housing Demand Impact (units)[d]	Average Year Population Impact (persons)	Average Year Housing Demand Impact (units)[d]	Average Year Population Impact (persons)	Average Year Housing Demand Impact (units)[d]	
Anderson	980	183	400	140	239	84	1,213
Oak Ridge	804	122	328	115	197	69	---
Clinton	83	29	34	12	19	7	---
Oliver Springs	78	27	32	11	19	7	---
Norris	15	5	6	2	4	1	---
Loudon	318	111	130	45	78	27	525
Lenoir City	225	79	92	32	55	19	---
Loudon	93	32	38	13	23	8	---
Morgan	10	4	4	1	2	1	504
Wartburg	10	4	4	1	2	1	---
Roane	509	178	208	73	125	44	1,448
Harriman	196	69	80	28	48	17	---
Rockwood	127	44	52	18	31	11	---
Kingston	186	65	76	27	46	16	---
Knox	3,072	1,075	1,254	439	752	263	7,826
Knoxville	2,984	1,044	1,218	426	730	255	---

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations excluding cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).
(d) At 1980 occupied units per capita, or 0.35 (2.8 persons per household) from 1980 census for the primary impact area.
(e) See Table 5.15.

TABLE 6.19. Major Source State and Local Revenue and Operating Expenditure Impacts for a Sealed Storage Cask MRS Facility at the Clinch River/Oak Ridge Primary Impact Area

Jurisdiction	Construction		Operations		Decommissioning	
	Peak Year Revenue Impact (thousand 1985 $)[a]	Peak Year Operating Expenditure Impact (thousand 1985 $)[b]	Average Year Revenue Impact (thousand 1985 $)[a]	Average Year Operating Expenditure Impact (thousand 1985 $)[b]	Average Year Revenue Impact (thousand 1985 $)[a]	Average Year Operating Expenditure Impact (thousand 1985 $)[b]
Anderson County	$ 230	$ 126	$ 101	$ 55	$ 54	$ 31
Oak Ridge	562	556	226	217	129	105
Clinton	50	49	20	20	10	10
Oliver Springs	8	NA	3	NA	2	NA
Norris	1	NA	<1	NA	<1	NA
Loudon County	86	67	38	27	19	15
Lenoir City	150	115	65	45	35	24
Loudon	35	45	14	18	9	11
Morgan County	5	4	3	3	3	3
Wartburg	<1	NA	<1	NA	<1	NA
Roane County	155	133	68	50	32	25
Harriman	113	110	45	43	25	22
Rockwood	35	35	14	14	9	9
Kingston	39	37	16	16	10	9
Knox County	927	470	429	192	209	114
Knoxville	2,262	2,572	915	1,027	526	552
Tennessee	7,000	6,400	3,600	2,500	1,400	1,500

(a) For counties and cities, revenues includes all local and state sources. The totals exclude some minor taxes, user fees, and intergovernmental transfers for education. Years are the same as previous tables.
(b) For all levels of government, expenditures include all general government functions except debt service. School districts are combined with their respective county or city governments.
NA = data not available to compute.

- unchanged real assessed value per capita
- constant ratio of retail sales and other income-related taxes to real income
- constant per capita population-related shared revenue
- constant real operating expenditures per capita for all expenditure categories.

It is possible that some or all of the above assumed relationships will actually change over time. For example, it is possible that MRS would not involve much of an increase in local assessed value even though the population increases or real per capita expenditures would either increase or decrease. However, such changes would involve a combination of future economic circumstances and political decisions by local government too complex to predict. Therefore, the revenue and expenditure forecasts in this section were made under the assumption that today's fiscal conditions would continue to prevail. To the extent that future local government dollars of revenues per capita or per incremental dollar of income are higher than today's average, the local governments would be likelier to show a fiscal surplus. To the extent local government dollars of revenue are lower for new population and income, the local governments would be likelier to show a deficit. The opposite applies for higher and lower spending for incremental population.

Table 6.19 indicates the impacts in the peak year of construction, average operating year, and average decommissioning year for the period 1991-2030. The totals do not include special planning, monitoring, and emergency response costs of the State of Tennessee and the local governments. Because of transportation considerations, some of these costs will likely extend to governments beyond the primary impact area.

The field drywell MRS concept has very similar impacts on state and local government revenues and expenditures to those of a sealed storage cask MRS facility, so they are not shown in detail. As can be seen from Table 6.19, the population-related operating expenditure impacts on state and local government are expected to be relatively small in comparison with the initial cost of the facility itself (approximately $1 billion). While transfers for monitoring, emergency planning, selected capital investments and infrastructure can be expected to increase the total to some degree, the total would still be small compared to the cost of the facility.

Privately owned industrial facilities in Tennessee are subject to real and personal property taxes. Were the MRS a privately owned facility it would be similarly taxed on the value of land, plant improvements, and equipment. A privately owned MRS would also be subject to local and state sales and business taxes. The dollar value could be substantial.

For example, the socioeconomic working group of the Clinch River Task Force has estimated the potential property taxes that would be received by the city of Oak Ridge if the MRS facility were taxable.[a] Using a market value of $500 million (lowest case) and $1 billion for the facility (highest case), the Task Force computed an assessed value of between $175 million and $297.5 million. This range of values could lower the property tax rate, since the facility would significantly increase the city's total assessed value. Based on lowered tax rates of $2.56 per hundred dollars of assessed value and $1.92 per hundred dollars of assessed value, respectively, the Task Force estimated potential city property tax revenues due to taxation of the MRS facility at $4.5 million (lowest case) to $5.7 million (highest case). Roane county would receive a similar amount. The actual basis for determining payments equivalent to taxes might be different. However, it is clear from the Clinch River Task Force analysis that the nontaxability of the MRS facility under current law represents a potential significant loss of income to local government.

A related problem considered by the local community as particularly troublesome is economic uncertainty associated with the current tax base. The potential cessation of federal financial assistance payments has brought with it the possibility of substantial local property tax increases. This has, in the opinion of community leaders, acted against efforts to recruit new industry into the area. The loss of potential large projects that never materialized (i.e., the Clinch River Breeder Reactor, a nuclear fuel reprocessing plant, the DOE centrifuge plant, and a coal to gas synthetic fuels plant), the downturn in employment at the existing DOE facilities, and the termination of fuel enrichment programs have contributed to the sense of economic uncertainty. A nontaxable MRS facility is seen locally as perpetuating this situation.

6.2.6.4 Community Services and Infrastructure

This section discusses the impact of MRS-related population growth on community services and infrastructure. Much of the infrastructure transferred to the city of Oak Ridge at the time of incorporation in 1959 is now over forty years old. The city's Comprehensive Plan notes the need to make significant improvements to the utility and street systems over the next several years, to repair outdoor recreation facilities, and improve and expand the park system. The increases in population in most of the primary impact area related to MRS facility are expected to be minimal; therefore, it is unlikely that major capital expenditures other than road improvements will be required. Similarly,

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(a) Clinch River Task Force. "Estimation of Taxes on MRS Facility (City of Oak Ridge Only)." August 26, 1985.

it is unlikely that there will be significant increases in social service programs such as Aid to Families with Dependent Children, food stamps, or medical assistance. Parks and recreation facilities, utilities, and fire protection should be adequate for the expected increase in population.

An example of the level of impacts that can be expected is provided in Table 6.20, which is concerned with increases in potential school enrollment and expenditures over a baseline situation that does not include MRS facilities. As can be seen by the table, the projected increase in school-age population is small enough that new investments are not likely to be required. In every case except Oak Ridge, the projected peak increase is less than 2% of the 1984 enrollment. In the case of Oak Ridge, it is 2.8%. Similarly, the reduction in enrollments at the end of the life of the MRS facility can be expected to be small, not burdening the local districts with significant overcapacity.

6.2.6.5 Special Socioeconomic Effects

There is some possibility of adverse socioeconomic effects in the Clinch River/Oak Ridge area due to perceived environmental risk. As was discussed in the introductory paragraphs of Section 6.2, perceived nuclear-related risk may have some negative effects on agriculture, tourism, outdoor recreation, and the ability of the Clinch River/Oak Ridge region to attract industry. Consumer avoidance may or may not occur. A search of the socioeconomic impact literature and risk analysis literature turned up no studies of long-term psychological impact or of avoidance of areas believed to be at risk from environmental hazards. Most of the available data on past instances of consumer avoidance are incomplete and relate to actual pollution incidents rather than the presence of facilities that the public believes to be environmentally risky. However, public reactions to past instances of environmental pollution may improve understanding of behavioral reactions to actual or perceived environmental hazards. No extrapolation to the MRS facility is possible at this time. The cases involve acute instances of perceived or actual hazard. None of the cases apply to the introduction of a new facility.

None of the accidents believed to be credible for the MRS facility will result in significant release (based on regulatory guidelines) of radioactive gases to the environment. For a description of credible accidents, see Section 6.1.1.3. In each of the historical cases discussed there was a highly publicized pollution incident (with actual health effects in some of the cases). As discussed in Sections 6.2.1, 6.3.1, and 6.4.1 accidents believed to be credible at an MRS result in radiation doses to the population well below regulatory limits and background radiation. A number of facilities (e.g., ORNL, ORGDP, Y-12) at the Department of Energy's Oak Ridge Reservation routinely handle radioactive material. Publicity concerning routine MRS

TABLE 6.20. Impact of a Sealed Storage Cask MRS Facility on Enrollment and Expenditures in Clinch River/Oak Ridge Primary Impact Area Schools

School District[a]	Construction: Peak Year Enrollment Impact (number of pupils)[b]	Construction: Peak Year Expenditures Impact (thousand 1985 $)[c]	Operations: Average Year Enrollment Impact (number of pupils)[b]	Operations: Average Year Expenditures Impact (thousand 1985 $)[c]	Decommissioning: Average Year Enrollment Impact (number of pupils)[b]	Decommissioning: Average Year Expenditures Impact (thousand 1985 $)[c]
Anderson County	16	$ 38	6	$ 14	3	$ 7
Clinton	14	23	5	8	2	3
Oak Ridge	138	402	53	154	23	67
Loudon County	16	28	6	11	3	5
Lenoir City	39	66	15	25	7	12
Morgan County	2	3	1	2	1	2
Roane County	54	88	20	32	9	14
Harriman	34	59	13	22	6	10
Knox County	15	25	6	10	3	5
Knoxville	511	1,029	197	397	87	175

(a) County enrollment and expenditures are for cities not listed separately.
(b) Assumes 100% of school-age population 5 to 17 years of age is enrolled in school.
(c) Assumes constant expenditures per pupil in 1985 dollars, adjusted for average daily attendance, then converted from 1984 dollars.

operations is expected to be no greater than for existing Oak Ridge facilities. Impacts discussed below are not likely impacts of MRS. Any special scenarios are believed to be invariant to the MRS concept selected because operating procedures for the two concepts are virtually identical and the storage systems very similar.

Agriculture. Two cases of past consumer avoidance of milk and meat products are well documented. In 1973, a warehouse shipping mix-up in Michigan resulted in the contamination of animal feeds in the state with PBB (polybrominated biphenyls), a fire retardant known to cause neurological and liver damage and suspected as a cause of cancer. Millions of farm animals had to be destroyed, and an unsuccessful effort was made to remove contaminated products from the Michigan market. In spite of the seriousness of health effects in farm animals, a survey of Michigan residents at the height of media coverage found that only about 1% of the population reported reduced milk consumption due to concern about contamination. Over 7% of the respondents indicated the same reason for reduced use of beef (United Dairy Industry Association 1977).

In 1979, in the Three Mile Island nuclear plant incident there was concern among public officials and the public that milk from local counties in south Pennsylvania might be contaminated by radioactivity. Extensive surveys were carried out by the Pennsylvania Department of Agriculture and none of the milk was found to be unsafe for consumption (Pennsylvania Department of Agriculture 1980). While no significant contamination of milk was found, some farmers experienced significant losses of sales. During the first month after the accident, some large dairies within 25 miles (40 km) of the TMI site experienced sales declines of as much as 30% (Pennsylvania Governor's Office 1979). Some of this loss may have been due to evacuation of a substantial portion of the population-within 15 miles of Three Mile Island. After the first four to five weeks, only milk juggers and fresh produce sellers within 15 miles of Three Mile Island reported continuing sales effects. A small sample of milk juggers reported a 10% decline in sales for six months following the accident. This is consistent with Houts et al. (1980), who found that 8.3% of the population within 5 miles (8 km) of Three Mile Island had switched their milk purchases away from local sources. Total losses estimated by the Pennsylvania Governor's Office at Three Mile Island were between $250,000 and $500,000.

Studies of health scares involving tuna (Griswold 1972) and tuna, whitefish, and cranberries (Daugherty 1964) indicate that consumption quickly returns to normal if there is no [apparent] actual health risk.

An accident such as the one that occurred at Three Mile Island is not possible at the MRS, due to the nature of the fuel stored and the subcritical storage mode (see Section 6.5.1, and Section 6.1.1.2 for details). Nonetheless, some avoidance effect on agriculture might be felt. The magnitude or duration cannot be predicted but is likely to be small.

Table 6.21 shows the value of 1983 crop production in the Clinch River/Oak Ridge primary impact counties, both in terms of value produced from selected major crops and livestock and in terms of cash receipts from marketing all crops and livestock. Differences in totals can be ascribed to the fact that not all crops are included in the selected crop figure, but that it does account for on-farm consumption. It is unlikely that soybeans, tobacco, wheat, and corn sales would be substantially affected by consumer avoidance since they are stored prior to sale and are sold on international, national, or regional markets where it would be difficult for consumers to make their concerns about environmental risk felt. A temporary loss of local milk, beef, and pork sales could occur.

Outdoor Recreation. A second potential form of consumer avoidance is reduction in recreational fishing and/or hunting and other forms of outdoor recreation on land and waters surrounding the MRS facility. Some consumer avoidance of environmental hazards has been detected in actual environmental pollution cases, such as the 1975 contamination of the James River in Virginia with kepone, an insecticide. In that case, Frye (1976) found (unquantified) losses to Chesapeake Bay seafood restaurants and retailers and to charter boat rentals. In this case, kepone was detected in some bluefish, and a commercial fisheries ban was extended to the area.

In the case of Three Mile Island, Hickey (1981) performed a detailed study of the effect of the accident on directly adjacent York Haven Pond during the 1979 fishing season and found that the number of hours fished and the number of anglers was essentially normal (i.e., within historical ranges of variation for pre-accident years). A release of "slightly radioactive" water occurred in late July 1979. Fishermen kept an unusually low number of fish in August. In addition, there were some undocumented indications of a decline in boating and summer cottage use on islands in York Haven Pond.

In the case involving a complete ban on consumption of sportfish harvested from the Shenandoah River due to mercury contamination, fishing activity initially declined 74%, then returned to normal within a one-year period, with the ban continuing in effect (Kauffman 1980). Kauffman estimated the one-year loss to local communities at $432,000. Martin (1978) found a similar 70% decline in Lake Ontario fishing activity for two months after "catch and release" fishing restrictions were imposed following discovery of mirex, a carcinogenic pesticide, in several sport fish species. Information was not available on duration of the response in the Lake Ontario case.

Information such as that outlined above suggests that environmental concerns that result from accidents can result in reduced recreation participation in the short term, but the effect is transitory even if the originally

TABLE 6.21. Value of Selected Major Crops Produced in the Clinch River/Oak Ridge Primary Impact Area in 1985 (thousand 1983 $)[a] (Tennessee Department of Agriculture 1984)

Crop	County: Anderson	Loudon	Meigs	Morgan	Rhea	Roane	Subtotal	Knox County	Total
Soybeans	$ 797.9	$ 225.1	$ 331.8	$ 284.4	$ 382.4	$ 31.6	$ 2,053.2	$ 312.8	$ 2,366.0
Tobacco	775.3	2,149.2	919.2	233.0	158.6	1,041.4	5,276.7	2,522.3	7,799.0
Wheat	--	190.7	112.2	--	103.0	--	405.9	44.9	450.8
Corn	51.1	456.2	341.3	357.7	642.4	180.7	2,029.4	355.9	2,385.3
Milk[b]	1,035.4	6,952.2	2,070.9	961.5	1,627.1	1,331.3	13,978.4	2,218.8	16,197.2
Beef[c]	1,650.7	4,264.2	1,788.9	1,238.0	1,788.2	2,338.5	13,067.8	5,089.6	18,157.4
Hogs and Pigs[d]	526.2	256.0	56.9	227.6	796.4	327.1	2,190.2	284.5	2,474.7
Subtotal	$4,836.6	$14,493.6	$5,620.5	$3,302.2	$5,498.1	$5,250.6	$39,001.6	$10,828.8	$49,830.4
Cash Receipts from Farm Marketings, 1982	$6,870	$16,031	$7,032	$6,219	$9,661	$6,337	$52,150	$19,583	$71,733
Crops	$4,054	$ 5,465	$2,642	$3,118	$4,909	$1,816	$22,004	$ 8,766	$30,770
Livestock	$2,816	$10,566	$4,390	$3,101	$4,752	$4,521	$30,146	$10,817	$40,963

(a) Estimated from production and season average price, except where shown.
(b) Estimated from number of cows, average production per cow, and gross farm income per pound of milk produced ($0.136 per pound of milk and milkfat).
(c) Estimated from statewide ratio of head of cattle and calves sold or consumed on farms to number of cattle and calves, ratio of gross income from marketings and farm marketings and farm consumption to total production of cattle and calves, and total head by county.
(d) Same as (c) for hogs and pigs.

perceived environmental risk is not. In the case of MRS, where the link between the facility and downstream fisheries is more tenuous, only smaller short-term effects appear possible.

Tourism. Perceived environmental risks have been seen to lessen an area's attractiveness as a recreation site and adversely affect the level of tourism for short periods after highly publicized accident or other acute conditions. For example, in the 30 days following the March 1979 Three Mile Island accident, reported losses at 10 major convention and lodging sites totaled approximately $2 million. Although the sample was not representative, the Pennsylvania Department of Commerce (PDC 1979b) estimated that total tourism losses approached $5 million (less than 1% of annual tourist expenditures in the area). A telephone survey of potential tourists, taken two weeks after the accident, indicated that 2% of families with pre-teenage children planning a trip in the following six months would avoid traveling to Pennsylvania because of fears related to Three Mile Island (PDC 1979a). This 2% is within the normal year-to-year variation. Tourism recovered in 1980 and no further study was done of long-term effects (PDC 1980).

Lower level perceived risks may or may not affect tourism. For example, in July 1980 the PDC noted no effect on tourism in the Three Mile Island area although radioactive krypton was being vented at the time. There was no drop-off in visits to the Three Mile Island Visitors' Center or to the two nearest Pennsylvania Visitors' Information Centers in Cumberland and York counties in 1980.

Based on this information, it appears possible that a decline in tourism-related expenditures might occur in the short term if the operation of the MRS site were accompanied by extensive adverse publicity.[a] Even so, a small decline might not be noticed against the background of recent year-to-year fluctuations in local tourism expenditures in the vicinity of the Clinch River/Oak Ridge site (U.S. Travel Data Center 1985). On the other hand, a recently completed survey of potential tourists to Tennessee conducted for the State of Tennessee indicated that up to 47% of tourists would alter travel plans to avoid the area within 10 miles of an MRS site and that 13% would drive

(a) A recent report by Science Applications International Corporation reviews a number of past studies of startups of nuclear power plants, hazardous waste problems, nuclear tests, and hotel fires. Although reduced tourism was sometimes found, the reduction was typically slight and hard to attribute to any one cause. See SAIC, High Level Nuclear Waste Transport and Storage Assessment: Assessment of Potential Impacts on Tourism in the Las Vegas Area, Interim Progress Report (Draft). Science Applications International Corporation, Las Vegas, Nevada, October 1984.

an hour out of their way to avoid passing within 5 miles of an MRS facility.[a] It is not clear what number of tourists would actually behave this way or for how long. Table 6.21a shows tourism-related expenditures and jobs in the local economy. However, based on the above evidence it is not clear that there would be any long-term adverse impacts on tourism as a result of MRS.

Economic Development. Economic development plans for the Clinch River/Oak Ridge area are concentrated on improving the economic diversification of Oak Ridge, particularly knowledge-intensive industries that can start up or be attracted to the area's skilled labor force and nearby universities. While no quantitative information is currently available on the effect of perceived environmental problems on industrial recruitment and retention in the Clinch River/Oak Ridge area, there is concern among local officials that the MRS site would give the locality that accepts it a negative image as a "waste dump." There is also concern that, unlike the front end of the fuel cycle, the nuclear waste business would generate few ancillary industries and would, prior to construction of the MRS discourage the siting of industries that do have many ancillary industries, such as aerospace or "high tech." Results of a recently completed survey of business leaders in Tennessee show that about 20% of these leaders would not choose to locate in a county with an MRS facility and that a minority of these--8% of the total sample--consider the business climate to be

TABLE 6.21a. Tourism-Related Expenditures and Employment in the Clinch River/Oak Ridge Primary Impact Area (U.S. Travel Data Center 1985)

County	1984 Travel-Related Expenditures (thousand 1984 $)	1984 Travel-Related Employment (Jobs)
Anderson	18,922	456
Loudon	6,591	163
Meigs	93	1
Morgan	582	12
Rhea	4,538	102
Roane	11,158	267
Subtotal	41,884	1,001
Knox	223,784	163
TOTAL	265,668	1,164

(a) Telephone conversation, Dr. William Fox, University of Tennessee Center for Business and Economic Research to Dr. Michael Scott, Pacific Northwest Laboratory, December 10, 1985.

much less desirable as a result of MRS, even if it resulted in a 40% decrease in the property tax. How they would actually respond to MRS is unknown.[a]

Psychological Stress Impacts

There is some possibility of psychological stress impacts from an MRS facility at the Clinch River/Oak Ridge site. Depending on local attitudes toward the MRS facility and the type of publicity the facility receives, the presence of such a facility in the Clinch River/Oak Ridge area may cause psychological stress in some individuals. According to authorities on the subject, stress is defined as the appraisal or perception of an event or situation as threatening some kind of danger, harm, or loss. The perception of danger is a more important factor than actual danger. The appraisal of threat sets off physiological and psychological reactions (increased adrenalin, elevated heart rate, increased blood pressure) and a search for ways to cope with the perceived threat (Baum et al. 1980).

If the perceived threat can be reduced by coping or by learning that the perceived threat is not severe, then stress is reduced. This is expected to be the case with MRS. However, if the individuals involved see the perceived threat as something inevitable, inescapable, and chronic, then physiological and psychological symptoms may result. Such symptoms were observed in the acutely stressful psychological environment surrounding the Three-Mile Island accident in 1979 and 1980 (Houts 1980). Additionally, individuals vary greatly in their capacity to adapt to stressful situations and in the degree of threat they perceive. In the case of the Three Mile Island incident, for example, mothers were among the groups exhibiting the most stress (Baum et al. 1980). Other researchers have observed that stress reactions vary with such factors as degree of knowledge concerning the threat, previous experience with the threat, age, income, economic ties (job or house) and other factors, such as community cohesiveness (Hansson et al. 1982; Preston et al. 1983; Goldhaber et al. 1983).

Researchers have distinguished reactions to stress-causing hazards such as floods, earthquakes, tornadoes and other recurrent natural threats from technological hazards (Baum et al. 1983) and low-level, "ambient" stress-causing situations such as noise or chronic air pollution from acute stress situations such as a fire, flood, or accident (Campbell 1983; Preston et al. 1983).

In the case of an MRS facility, it appears that stress reactions, if any, will likely be of the type related to long-term, low-level chronic stress rather than the acute type, such as was observed at Three Mile Island. Some

(a) Telephone conversation, Dr. William Fox, University of Tennessee Center for Business and Economic Research to Dr. Michael Scott, Pacific Northwest Laboratory, December 10, 1985.

researchers have observed that persons exposed to such hazards may not adjust to the problem by learning to adapt to it and may consider moving out or taking political action (Preston et al. 1983). Some persons may seek to leave the area. After the Three Mile Island incident, 17% of household heads living within five miles of the plant said that someone in their household had "considered" moving, and 6% had "definitely decided" to move. Between 1% and 2% actually did so within the first year, but this group tended to have demographic characteristics that associate them with groups that would move under normal conditions. The general moving rate for the area remained about constant. Supporting studies did not show unusual house-selling problems (Goldhaber et al. 1983). Movers were generally replaced with people more optimistic about the facility and positively disposed toward the technology involved. A similar phenomenon may be observed with any facility that produces stress reactions in a community.

Although the Clinch River/Oak Ridge site has a community more familiar with and knowledgeable about nuclear waste than Hartsville, there appears to be no reason to predict either higher or lower incidence of stress reactions for one site over the other, because the reaction is based on perception as much as actual knowledge.

6.2.7 Resource Requirements

Two powerlines would be rerouted around the Clinch River site, resulting in about 4 miles (6.4 km) of additional right-of-way along the river bank across from the facility. For the powerlines, trees would be removed and a maintenance road constructed. This would result in about 60 acres (24 ha) of lost forest habitat. However, edge habitat would be created by the new right-of-way.

A natural gas pipeline is located to the east of the site, along the boundary for about 200 feet (61 m). Site access to the pipeline would be possible, if required.

Existing water pumping and treatment facilities, which currently supply water to the ORGDP and Clinch River Industrial Park, would supply water to an MRS facility (usage of 365,000 gallons or 1.1 million L per day). The water supply facility (rated at 5 million gallons or 19 million L per day) is described in Section 5.1.3.2, under surface water use. Sufficient excess water (about 2.5 million gallons or 9.5 million L per day) is available from this water supply to meet the needs of the MRS facility.

Additional resource requirements for construction, operation, and decommissioning of an MRS facility are essentially the same for all three sites, differing only by storage design; these are addressed in Section 6.1, Impacts Common to All Sites.

6.2.8 Aesthetic Impacts

Aesthetic impacts of an MRS facility at the Clinch River site are discussed in this section.

6.2.8.1 Noise Levels

Background noise levels at the Clinch River site before the start of the CRBR project were about 31 to 51 dBA, during daytime, and 31 to 45 dBA, at night (Thornton 1978). A limited number of measurements made during site preparation of the CRBR project indicated that noise levels, day and night, were about 50 to 57 dBA around the perimeter of the site (Rainey and Mills 1983).

Disturbance from blasting can be mitigated by using small, multiple charges and by scheduling in late afternoon. Construction noise will probably be similar to that for CRBR construction. During site preparation and excavation, activity interference could occur for residents within about 1 mile (1.6 km) of the site (NRC 1982).

Although no detailed studies of noise levels during operation have been conducted, the operation phase is expected to generate much lower noise levels than construction.

The distance to the nearest resident at the Clinch River site is about 4,000 feet (1,200 m) from the acoustic center of the facility. At this distance, noise from operation of the facility should be less than 44 dBA, which is within the noise level recommended for residential areas.

6.2.8.2 Visual Impacts

During construction and operation of the MRS facility, buildings and equipment will be visible from some locations (see Figure 5.12). These viewing locations and the probable impact on the viewer are discussed in this section.

The site will be visible from I-40 for a short segment in the Caney Creek area. The existing vegetation would allow the traveler to see the tops of industrial facilities at the site. The site is also visible for a short distance along SR-58, from Gallaher Bridge. The cleared site is screened by vegetation, although structures will be visible. Unlike I-40, which carries large volumes of interstate truck and automobile traffic, SR-58 is used largely by people who work at ORNL. Such users are not expected to find the view of the site a major concern.

The site is also visible from Watts Bar Reservoir. Much of the cleared area of the site is visible from the river south and west of the site. When developed, it is estimated that many of the reservoir viewers would have a major concern for the scenic qualities of the area (TVA 1985). Preservation of the tight vegetation screen could substantially reduce this impact.

The site is visible from about 20 to 30 homes from the south, to the west (Dug Ridge to Bear Creek Valley). It is estimated that the majority of the viewers in these homes are also concerned about the scenic qualities of the site.

About 10 to 20 residents have views of the site from Caney Creek northward along Hood Ridge. A new subdivision, Buttermilk Shores, is under development with several homes already occupied and approximately 20 additional lots plotted. It is estimated that the majority of these viewers would have a major concern for scenic qualities. If the trees and knolls on the east side of the peninsula are preserved, these views of the MRS facilities, including views from near the crest of Hood Ridge, would be limited to just the tops of structures. The impact of the MRS, however, would differ little from many other forms of industry that could be developed on the site.

6.2.9 Transportation Impacts

The primary transportation impacts associated with the Clinch River MRS site may be divided into two distinct categories. The first category of impacts results from shipment of spent fuel from reactor sites to the MRS facility and then the shipment of consolidated spent fuel and associated wastes from the MRS to a repository. The second category of impacts results from the commuting labor force and from delivery of materials to the MRS site during its construction and operation. Impacts associated with the movement of spent fuel are represented in this section by cost, radiological effects, and nonradiological effects. Local traffic impacts from spent-fuel shipments are represented in Section 6.2.9.1 by the estimated increase in the average daily traffic flow. Estimates of commuter-traffic impacts at the Clinch River site are presented in Section 6.2.9.2.

6.2.9.1 Traffic Impacts from Spent-Fuel Shipments

Peak traffic impacts from spent-fuel shipments were estimated for a 30% truck/70% rail combination and 3,600 MTU per year fuel throughput. This bounding case assumes that reactors currently having the capability to ship by rail will do so, and only those reactors without this capability will ship by truck. This flow of spent fuel would increase the daily traffic by eight trucks (four arriving and four leaving), and three trains. The annual number of rail shipments required to transport consolidated fuel rods from the MRS to a repository would be approximately 30, depending on the shipping cask loading capacity and the number of fuel rods in each canister.

These traffic impacts are conservative because the actual projected schedule would result in a smaller spent-fuel throughput of 2,550-3,000 MTU per year rather than 3,600 MTU per year (see Table F.1).

The increase in traffic from spent-fuel shipments is a small fraction of the current daily traffic on primary transportation routes that serve the Clinch River site. (See Section 5.1.9 for a description of current transportation conditions at the Clinch River site.)

The actual truck and rail routes from the reactor sites to the Clinch River site will be in place before spent-fuel shipping commences. Truck shipments to the MRS facility will follow interstate highways to the maximum extent possible to comply with DOT regulations for routing of large quantity shipments of radioactive materials. Because of the extensive interstate highway system in the eastern part of the country, truck shipments can be made almost entirely over the interstate highways except for local access from the reactor to the interstate and from the interstate to the MRS. For local access onto the Clinch River site, a new rail line for spent-fuel transport and a new access road for both spent-fuel transport and commuter traffic would be constructed. These are shown in Figure 6.6. A number of alternative routes could be used for shipments; however, the maximum increase in traffic from spent-fuel shipments along any route is assumed to be less than 8 trucks per day.

6.2.9.2 Traffic Impacts from MRS Construction, Operation, and Decommissioning

Local traffic to the Clinch River site can be expected to increase during MRS construction, operation, and decommissioning. The greatest impact is expected during 1994, the peak year of construction, when about 1,000 workers would be commuting onto the site in two shifts. The likeliest routes onto the site appear to be SR-58, SR-95, and SR-162 from I-40 north (see Figure 6.6). Based on the forecasted distribution of workers around the site, no new roads, and an assumed two workers per vehicle, Table 6.22 shows the distribution of increased traffic on roads surrounding the site. The annual average daily traffic and level of service is shown for these routes. Bear Creek Road can also expect substantial volume increases over the segment south of SR-95.

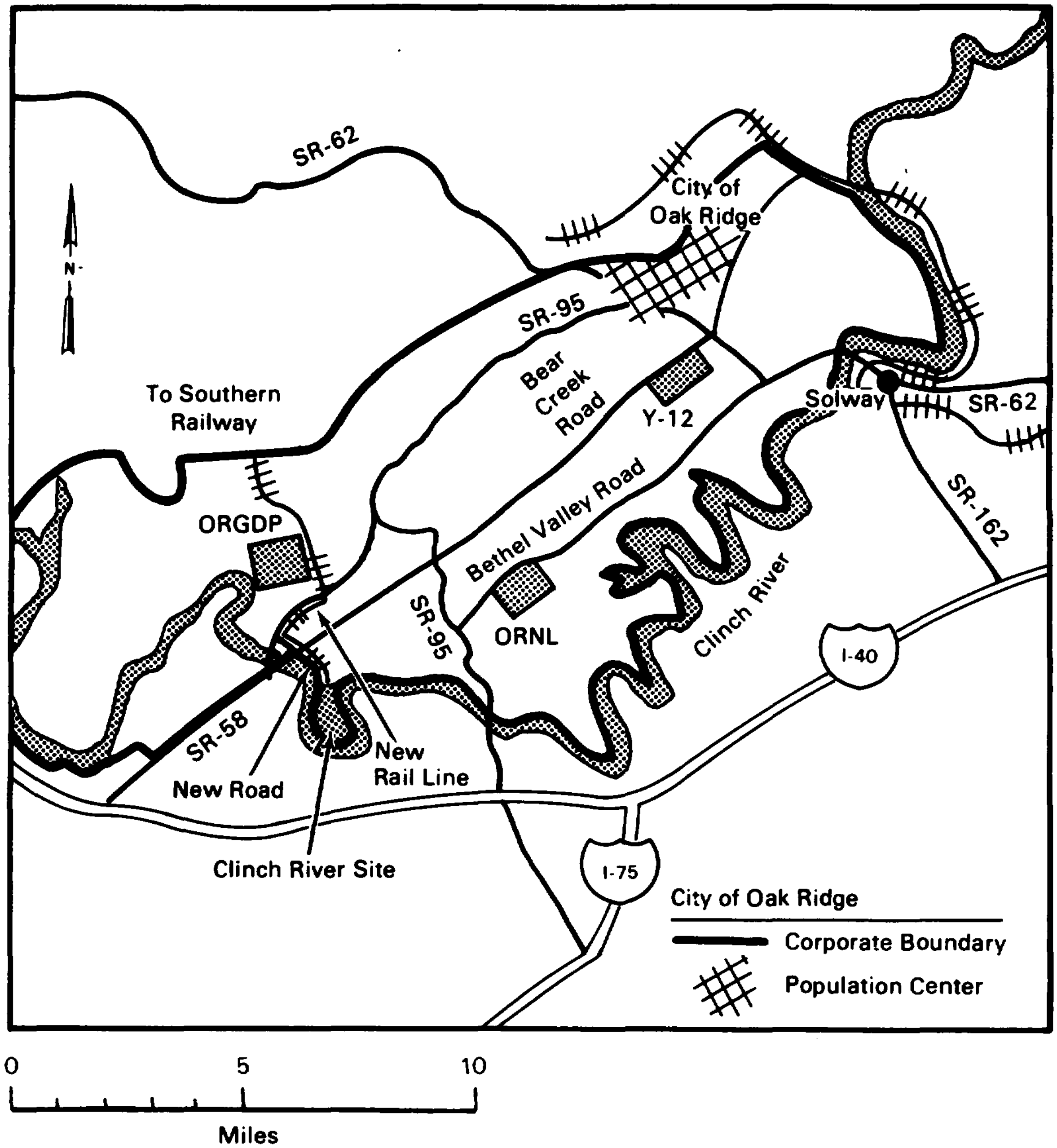

FIGURE 6.6. Transportation Routes to be Constructed for Access to the Clinch River Site

It is possible that improvements will be required to SR-58 and SR-95 if they are designated as primary routes for transportation of spent fuel from the interstate to the MRS site, since both are two-lane roads subject to congestion (see Section 5.1.9.1).

TABLE 6.22. Distribution of Projected and Existing Local Traffic for the Clinch River Site (PMC 1975; DOT 1984)

Highway Segment	Additional Vehicles: Average Daily Traffic, 1994[(a)]	Present Annual Average Daily Traffic (both directions)[(b)]	Existing Peak-Hour Level of Service[(c)]
SR-58, North of I-40, South of Bear Creek Road	110	7,910	D
SR-58, North of Bear Creek Road, South of ORGDP	110	7,910	D
SR-58, North of ORGDP, South of White Wing Road (SR-95)	222	8,790	D
SR-95, North of White Wing Road to Oak Ridge	222	7,700	E
SR-95 (White Wing Road), North of I-40, South of Bear Creek Road	66	4,920	E
Bethel Valley Road, West of South Illinois Avenue	624	4,200	NA

(a) Workers from Oak Ridge, Powell, Clinton, Norris, and Oliver Springs are assumed to approach the site along SR-58 from Oak Ridge. Workers from Loudon County are assumed to take I-40 and SR-95. Knoxville and Farragut workers are assumed to take the Pellissippi Parkway (SR-162) and Bethel Valley Road. Roane and Morgan County workers are assumed to use SR-58 through Kingston. The scenario assumes two workers per vehicle. Average daily traffic is twice the number of vehicles arriving at the MRS site per day (e.g., 500 vehicles inbound plus 500 vehicles outbound equals 1000 increase in traffic).

(b) See Table 5.26, Chapter 5.

(c) See Table 5.27 and 5.28, Chapter 5. Level D service (81% to 90% of capacity) is approaching unstable flow, with tolerable speeds but affected by high volume. Level E service (91% to 100% of capacity) is characterized by volumes at or near capacity with unstable flows and possible momentary blockages.

NA = Not available.

It appears from Table 6.22 that SR-95 south of Bear Creek Road has the potential for traffic problems since that segment is at or near capacity already. Considerable traffic would also be added to the Bethel Valley route into the site. In addition to commuter traffic, these routes would be used by several construction vehicles daily.

Traffic problems could persist during MRS operation because the traffic on many of the road segments through the ORR is already at or near capacity, and total employment at the site during operation would remain about 650 workers. Upgrading of roads could help alleviate this difficulty. During decommissioning, total employment will drop below 300; therefore, traffic is expected to be less affected by the facility.

If van pools or buses are utilized, traffic problems may be much reduced. During construction of the Hartsville Nuclear Power Plant, the day-shift average vehicle occupancy was 4.5 persons per vehicle going west from the site toward Nashville, compared to an average of 1.7 persons per vehicle at other TVA construction sites (TVA 1978).

6.2.9.3 Cost Impacts

The total costs associated with shipping spent fuel from reactor sites to the Clinch River site and then to potential repository sites are for the 26-year MRS operational lifetime. These total costs are based on constant 1985 dollars and include capital, maintenance, and shipping costs. However, these costs do not include potential costs of constructing new railways and upgrading existing rail lines and access roads in the vicinity of the Clinch River site. For purposes of obtaining bounding cost impacts, it is assumed that all spent fuel is shipped to the Clinch River site using either 100% rail or 30% truck/70% rail. Additional cost information was generated for cases assuming that only spent fuel from eastern reactors would be shipped to the MRS. If only eastern reactors ship waste to the MRS facility, spent fuel from western reactors would be shipped directly to one of the nine potential repository sites. Transport from the MRS site to the repository is assumed to be by dedicated train (train transports only radioactive material). The train is assumed to consist of five cask cars containing spent fuel and a maximum of five waste cars containing associated radioactive waste.

Shipping costs were examined for two conceptual spent-fuel casks. A small cask with a loaded weight capacity of 100 tons (91 t) resulted in the highest total shipping cost for the MRS-to-repository transportation leg when compared to a larger, more efficient, 150-ton cask design. The total costs are identical for either 30% truck/70% rail or 100% rail shipments from reactor sites to the Clinch River site and are more dependent on the capacity of the cask and the location of the potential repository site, as shown in Tables 6.23

TABLE 6.23. Total 26-Year Transportation Costs for Shipping Spent Fuel from all Reactors to the Clinch River Site and then to a Repository (million 1985 $)

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	1,600	1,200	1,600	1,200
Hanford	1,500	1,000	1,500	1,000
Deaf Smith and Swisher	1,400	940	1,400	940
Davis and Lavendar	1,500	980	1,500	980
Richton and Cypress Creek	1,100	840	1,100	840
Vacherie	1,200	870	1,200	870

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

and 6.24. Total costs are reduced by about 10% if western reactor spent fuel is shipped directly to the western most repository sites (Yucca Mountain, Hanford, Deaf Smith, or Davis) but are about the same if western reactor spent fuel is shipped directly to an eastern most repository site (Vacherie or Richton).

6.2.9.4 Radiological Impacts

Radiological impacts to the public and the transportation work force include: 1) a potential exposure to radiation emitted by the radioactive package (shielded by the shipping container) as the shipment passes by, and 2) a potential exposure to radiation emitted by radionuclides that might be released from the radioactive package if the shipment is involved in an accident. The accident risk assessment is based on potential transportation-related accidents and associated radioactive releases.[a] The accident risk assessment considers the probability of a shipment being involved in an accident, the response of the package to the statistically specified accident conditions, and, if a release is predicted, the consequences of a release of

(a) From Cashwell, J. W., K. S. Newhauser and P. C. Reardon. 1986. Transportation Impacts of the Commercial Radioactive Waste Management Program (Draft). SAND85-2715, Sandia National Laboratory, Albuquerque, New Mexico.

TABLE 6.24. Total 26-Year Transportation Costs for Shipping Spent Fuel from Only Eastern Reactors to the Clinch River Site and then All Spent Fuel to a Repository (million 1985 $)[a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	1400	1000	1400	1000
Hanford	1300	940	1300	940
Deaf Smith and Swisher	1300	900	1300	890
Davis and Lavender	1400	910	1400	900
Richton and Cypress Creek	1100	850	1100	860
Vacherie	1100	860	1100	870

(a) Western reactor spent fuel is assumed to be shipped directly to a repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

radioactive material from the package. Radiological impacts are determined for rural, suburban, and urban population groups (see Appendix F).

The total radiological impacts to members of the public and transportation workforce are presented in Tables 6.25 and 6.26. Table 6.25 presents the total 26-year radiological impacts for shipping all reactor spent fuel to the Clinch River site and then to a repository. Table 6.26 presents the total 26-year radiological impacts for shipping only eastern reactor spent fuel to the Clinch River site and then all spent fuel, including western reactor fuel, to a repository. Radiological impacts to the transportation work force are about 20% of the total impacts presented in Tables 6.25 and 6.26. The population dose is estimated to be less than 0.1% of the natural background radiation dose that would be received during the same 26-year period.

The total dose impacts do not differ significantly by repository location because most of the impacts occur along the reactor-to-MRS route. However, total dose impacts are a factor of 6 higher for 30% trucks/70% rail than 100% rail shipments as shown in Tables 6.25 and 6.26, because of the influence of the large number of truck shipments (21,000) required.

TABLE 6.25. Total 26-Year Radiological Impacts from Shipping Spent Fuel from all Reactors to Clinch River Site and then to a Repository (person-rem)

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	1.1×10^3	9.6×10^2	6.3×10^3	6.1×10^3
Hanford	1.0×10^3	9.0×10^2	6.2×10^3	6.1×10^3
Deaf Smith and Swisher	1.0×10^3	8.6×10^2	6.2×10^3	6.0×10^3
Davis and Lavender	1.0×10^3	8.8×10^2	6.2×10^3	6.1×10^3
Richton and Cypress Creek	8.6×10^2	7.7×10^2	6.0×10^3	6.0×10^3
Vacherie	1.0×10^3	8.6×10^2	6.2×10^3	6.1×10^3

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

TABLE 6.26. Total 26-Year Radiological Impacts from Shipping Spent Fuel from Eastern Reactors to Clinch River Site and then all Spent Fuel to a Repository (person-rem)[a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	9.9×10^2	8.7×10^2	5.5×10^3	5.4×10^3
Hanford	9.6×10^2	8.4×10^2	5.6×10^3	5.5×10^3
Deaf Smith and Swisher	9.3×10^2	8.1×10^2	5.8×10^3	5.7×10^3
Davis and Lavender	9.5×10^2	8.3×10^2	5.5×10^3	5.4×10^3
Richton and Cypress Creek	8.8×10^2	8.1×10^2	6.8×10^3	6.7×10^3
Vacherie	9.8×10^2	8.5×10^2	6.4×10^3	6.3×10^3

(a) Western reactor spent fuel is assumed to be shipped directly to a repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS-to-repository.

6.2.9.5 Nonradiological Impacts

Nonradiological transportation impacts (health effects) include fatalities from pollutants generated by burning diesel fuel needed to move the shipments, and traumatic deaths and nonfatal injuries resulting from traffic accidents that involve spent fuel shipments. These nonradiological risks are given in Tables 6.27 and 6.28. Table 6.27 presents the total 26-year nonradiological impacts for shipping all reactor spent fuel to the Clinch River site and then to a repository. Table 6.28 presents the total 26-year nonradiological impacts for shipping only eastern reactor spent fuel to the Clinch River site and then all spent fuel, including western reactor fuel, to a repository. The number of traumatic deaths and nonfatal injuries are based on accident statistics evaluated for truck and trailer vehicles similar to those that would be used to transport spent fuel to an MRS site (Smith and Wilmot 1982). Occupational nonradiological impacts are included in the total impact estimates presented in the tables.

The total nonradiological impacts are higher for 30% truck/70% rail shipments than 100% rail shipments, as shown in Tables 6.27 and 6.28. Total impacts are about 10% lower if western reactor spent fuel is shipped directly to a repository, as shown in Table 6.28. The number of fatalities over 26 years of operation ranges from four to 29 for 30% truck/70% rail, and from two to 27 for 100% rail shipments. The number of nonfatal injuries ranges from 45 to 310 for 30% truck/70% rail, and from 22 to 280 for 100% rail shipments.

TABLE 6.27. Total 26-Year Nonradiological Impacts from Shipping Spent Fuel from all Reactors to Clinch River Site and then to a Repository [fatalities (injuries)]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	27 (280)	11 (110)	29 (310)	13 (150)
Hanford	23 (240)	7.1 (64)	25 (270)	9.5 (98)
Deaf Smith and Swisher	16 (160)	4.7 (49)	18 (200)	7.1 (83)
Davis and Lavender	21 (220)	6.2 (64)	23 (260)	8.6 (98)
Richton and Cypress Creek	6.3 (66)	2.4 (24)	8.7 (100)	4.8 (58)
Vacherie	11 (110)	3.6 (37)	15 (150)	6.0 (71)

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from MRS to repository.

TABLE 6.28. Total 26-Year Nonradiological Impacts from Shipping Spent Fuel from Eastern Reactors to Clinch River Site and then all Spent Fuel to a Repository [fatalities (injuries)][a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	22 (240)	9.3 (99)	24 (260)	11 (120)
Hanford	20 (210)	5.9 (64)	22 (240)	7.7 (87)
Deaf Smith and Swisher	14 (140)	4.0 (42)	16 (170)	5.8 (66)
Davis and Lavender	18 (190)	5.3 (55)	20 (210)	7.1 (79)
Richton and Cypress Creek	5.5 (58)	2.1 (22)	7.3 (81)	3.9 (45)
Vacherie	9.3 (99)	3.1 (32)	11 (120)	4.9 (56)

(a) Western reactor spent fuel is assumed to be shipped directly to a repository.

(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from MRS to repository.

6.3 IMPACTS UNIQUE TO THE OAK RIDGE SITE

This section presents the environmental impacts of an MRS facility at the Oak Ridge site. Impacts are projected for each MRS phase, as applicable. Figures 6.7 and 6.8 show the planned site layout at the Oak Ridge site for the sealed storage cask and field drywell design concepts, respectively.

6.3.1 Radiological Impacts

The radiological consequences of normal operation releases at the Oak Ridge site are shown in Table 6.29. These results are based on the estimated annual releases described in Section 6.3.2. Details of analysis methods are presented in Appendix G.

The dose commitment to the maximally exposed individual is small compared with the annual limits of 75 mrem to thyroid or 25 mrem to total body and other organs (10 CFR 72). Exposures to the maximally exposed individual and to the population are very small compared with the annual dose from background radiation (see Table 6.55). The calculated doses are not expected to result in any discernible impacts.

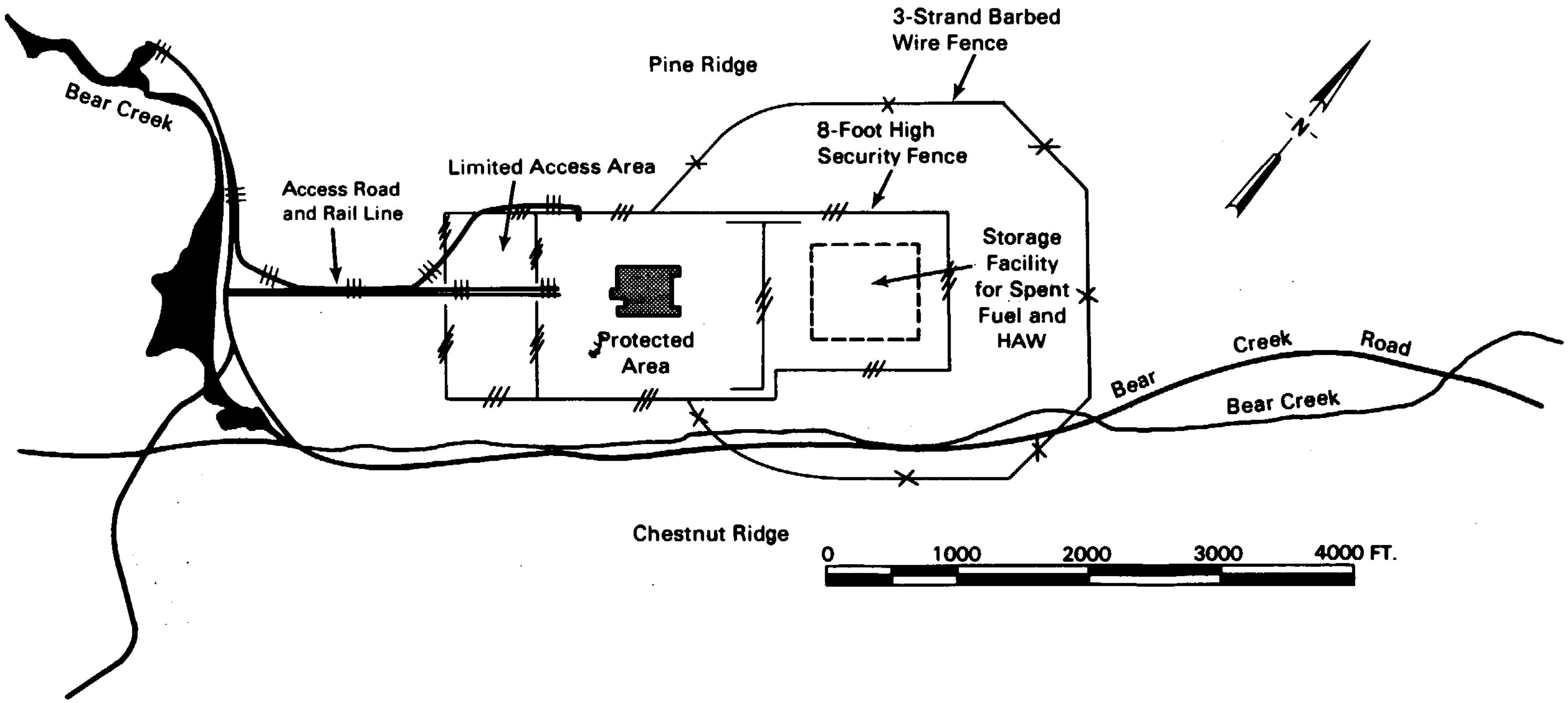

FIGURE 6.7. Layout of the Oak Ridge Site - Sealed Storage Cask Design

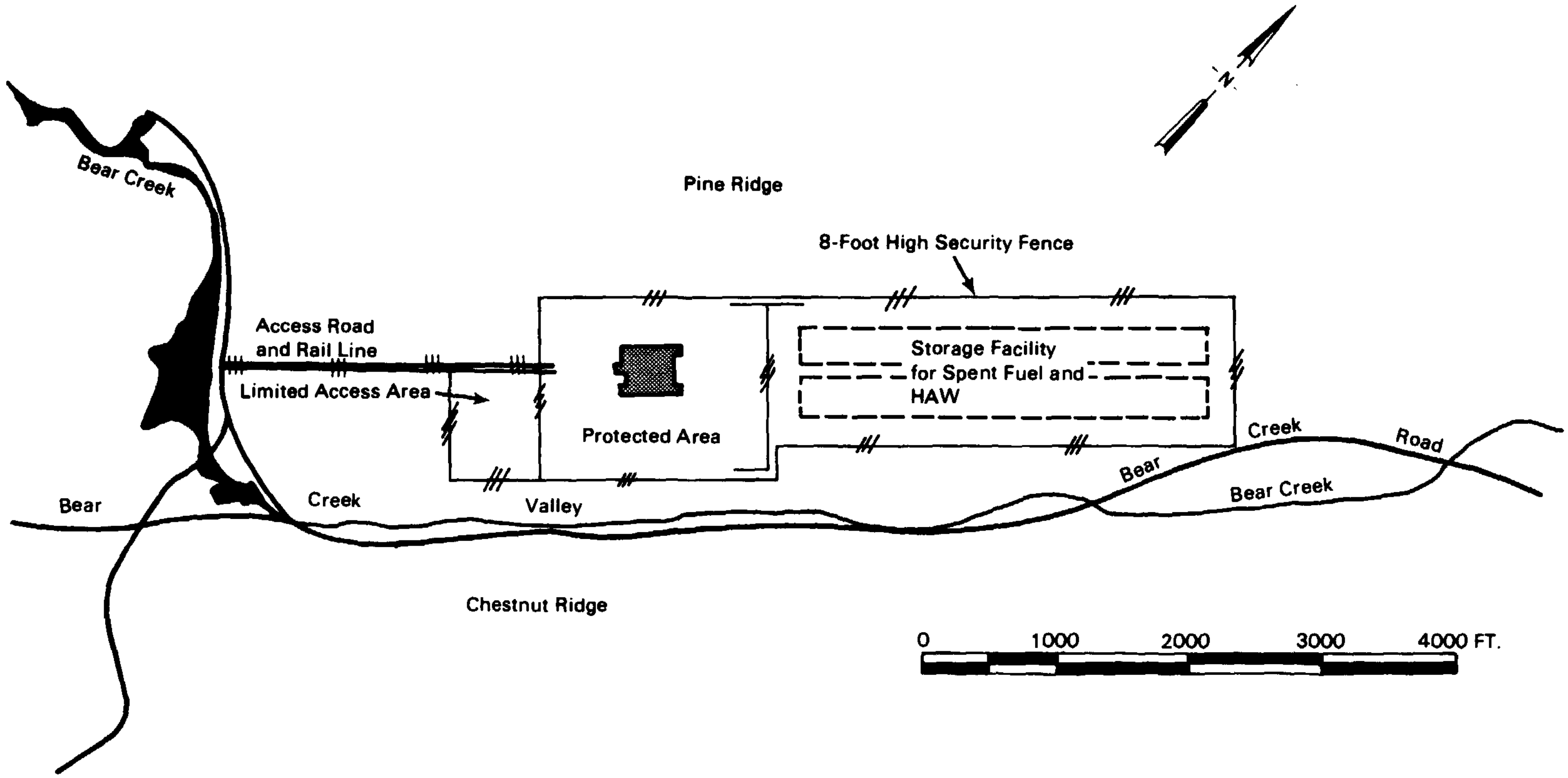

FIGURE 6.8. Layout of the Oak Ridge Site - Field Drywell Design

TABLE 6.29. Radiological Impacts[a] from MRS Facility of Normal Operations at the Oak Ridge Site

Pathway and Location in the Body	50-Year Dose Commitment from Annual Release: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Air Submersion		
Total Body	2.9×10^{-7}	6×10^{-2}
Inhalation		
Total Body	3.8×10^{-7}	7×10^{-2}
Bone	1.0×10^{-9}	2×10^{-4}
Lungs	4.0×10^{-7}	8×10^{-2}
Thyroid	2.6×10^{-6}	6×10^{-1}
Ingestion		
Total Body	4.1×10^{-4}	2×10^{1}
Bone	4.5×10^{-6}	4×10^{-2}
Lungs	4.0×10^{-4}	2×10^{1}
Thyroid	1.9×10^{-3}	1×10^{2}
Total for all Exposure Pathways		
Total Body	4.1×10^{-4}	2×10^{1}
Bone	4.8×10^{-6}	1×10^{-1}
Lungs	4.1×10^{-4}	2×10^{1}
Thyroid	1.9×10^{-3}	1×10^{2}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a background dose of 1.6×10^{5} person-rem for the population (based on an individual background dose of 150 mrem/yr for the Oak Ridge site).

(b) The maximally exposed individual is assumed to be at the nearest approach to the security fence for the duration of the accidental release. This location varies by accident and site.

(c) Population dose commitments are calculated for the population within 50 miles (80 km) of the site plus all people exposed to agricultural products within 50 miles of the site.

Offsite impacts of potential operating accidents (as defined in Section 6.1.1) are presented in Table 6.30 for cask storage, and in Table 6.31 for drywell storage. The impacts presented in these tables are based on the assumption that the accident does occur; the probability of the event is not factored into the impact calculation. The doses presented are well below the regulatory limit of 5 rem for design basis accidents (10 CFR 72). The population doses are well below the dose received from background radiation and are not expected to result in any discernible impacts.

TABLE 6.30. Radiological Impacts[a] of Potential MRS Facility Accidents for Sealed Storage Cask at the Oak Ridge Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	50-Year Dose Commitment to the Public: Population (person-rem)[c]
Fuel Assembly Drop	Total Body	2.2×10^{-2}	3×10^{-2}
	Bone	4.3×10^{-4}	7×10^{-3}
	Lungs	2.3×10^{-2}	3×10^{-2}
	Thyroid	1.5×10^{-1}	2×10^{-1}
Shipping Cask Drop	Total Body	4.6×10^{-3}	7×10^{-3}
	Bone	9.0×10^{-5}	1×10^{-3}
	Lungs	4.8×10^{-3}	7×10^{-3}
	Thyroid	3.1×10^{-2}	4×10^{-2}
Storage Cask Drop	Total Body	4.5×10^{-3}	6×10^{-3}
	Bone	8.4×10^{-5}	1×10^{-3}
	Lungs	4.7×10^{-3}	7×10^{-3}
	Thyroid	3.0×10^{-2}	4×10^{-2}

(a) Impacts may be compared to the regulatory limit of 5 rem to the total body for the maximally exposed individual and to a background dose of 1.6×10^5 person-rem for the population (based on an individual background dose of 150 mrem/yr for the Oak Ridge site).
(b) The maximally exposed individual is assumed to be at the nearest approach to the security fence for the duration of the accidental release. This location varies by accident and site.
(c) The population dose commitments are calculated for the population within 50 miles (80 km) of the site.

TABLE 6.31. Radiological Impacts(a) of Potential MRS Facility Accidents for Field Drywell at the Oak Ridge Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Fuel Assembly Drop	Total Body	1.7×10^{-2}	3×10^{-2}
	Bone	3.9×10^{-4}	7×10^{-3}
	Lungs	1.8×10^{-2}	3×10^{-2}
	Thyroid	1.1×10^{-1}	2×10^{-1}
Shipping Cask Drop	Total Body	3.6×10^{-3}	7×10^{-3}
	Bone	1.1×10^{-3}	1×10^{-3}
	Lungs	3.8×10^{-3}	7×10^{-3}
	Thyroid	2.4×10^{-2}	4×10^{-2}
Canister Shearing	Total Body	2.9×10^{-1}	6×10^{-1}
	Bone	3.1×10^{-3}	1×10^{-1}
	Lungs	3.0×10^{-1}	7×10^{-1}
	Thyroid	2.0×10^{0}	4×10^{0}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a background dose of 1.6×10^{5} person-rem for the population (based on an individual background dose of 150 mrem/yr for the Oak Ridge site).

(b) The maximally exposed individual is assumed to be at the nearest approach to the security fence for the duration of the accidental release. This location varies by accident and site.

(c) The population dose commitments are calculated for the population with 50 miles (80 km) of the site.

6.3.2 Air Quality Impacts

Differences in estimated concentrations of pollutants in the ambient air are a consequence of the dispersion characteristics at the site. Regulated pollutants for the Oak Ridge site are examined in this section. Many source terms are the same for all site locations; these are given in Section 6.1. Methods for estimating emissions are also described in Section 6.1.

6.3.2.1 Preconstruction and Construction

Preconstruction activities will have minimal impact on the air quality at the Oak Ridge site. Emissions from site characterization activities are estimated to be minimal. However, site preparation at the Oak Ridge site will involve the clearing of forested area. Thus, site preparation activities, along with construction activities, are expected to temporarily degrade the ambient air quality in the immediate vicinity of the site. Estimates of particulate emissions generated during construction are given in Table 6.32.

Incremental concentrations of pollutants from both stationary and mobile sources can be compared with NAAQS in Table 6.32. These concentrations are predicted to be at the fenceline in the area with the highest concentration. Distance and the surrounding terrain (forested) area give additional dispersion and aid in particle settling.

According to this analysis, short-term TSP standards may be exceeded at the fenceline. The maximum 24-hour concentration of TSP experienced by the nearest residents is expected to be much less than half the fenceline (330 ft or 100 m) concentration. A more detailed study may assess area sources of fugitive dust with more certainty.

TABLE 6.32. Projected Ambient Air Concentrations of Pollutant Emissions During MRS Construction at the Oak Ridge Site and National Ambient Air Quality Standards ($\mu g/m^3$)[a]

Pollutant	NAAQS	Concentration at 100 m
Annual average		
TSP	75	27
NO_x	100	3
24-hr maximum		
TSP	260	390
8-hr maximum		
CO	10,000	220

(a) Includes mobile sources.

The Oak Ridge site is 30 miles (50 km) from a Class I area. Activities at the site are not expected to have measurable effects on this or any Class I area.

Concentrations of products of combustion will result in small increases in ambient concentrations of NO_x and other combustion products. No significant effects are anticipated from increased concentrations.

Temporary emissions resulting from construction are usually excluded from PSD increment consumption. Details of the calculation methods are given in Appendix G.

6.3.2.2 Operation

Airborne emissions from MRS operations are less than the defined regulatory limits (Table 6.4). Concentrations of regulated pollutants resulting from emissions are well below ambient standards and are not expected to have any impact.

6.3.2.3 Decommissioning

Decommissioning activities that have potential to generate airborne pollutants are essentially the same for all sites, as discussed in Section 6.1.2.3. A low level of airborne emissions are anticipated; however, impacts from these activities will be minimal.

6.3.3 Water Quality and Use Impacts

Water quality impacts of an MRS facility at the Oak Ridge site are evaluated in this section. Water consumption and routine effluents are common to all three sites and are discussed in Section 6.1. Features unique to the Oak Ridge site include the water source and the receiving waters for the effluent stream.

6.3.3.1 Preconstruction and Construction

The existing water intake and treatment plant near the ORGDP will be the water source for the Oak Ridge site. Water use during preconstruction is expected to be slight. Water use during construction, outlined in Section 6.1, is small compared with water availability. Projected water use for both preconstruction and construction will have a negligible impact on the river.

The Oak Ridge site is located in Bear Creek Valley, downstream from Y-12 and associated waste disposal areas. Although sediments from Bear Creek upstream of the site are contaminated with uranium and other metals, the Oak

Ridge site, itself, is not shown to be contaminated. Site work for the MRS, which will temporarily increase the silt content of runoff, is not expected to spread significant amounts of contamination. Temporary degradation of water quality from a high suspended-solids content in runoff will be mitigated by settling solids in runoff ponds prior to discharge into Bear Creek. Settling ponds will be constructed to reduce the silt in runoff.

6.3.3.2 Operation

Existing surface water and treatment facilities at ORGDP are adequate to meet the needs of the facility during MRS operation without affecting other users. The expected water use rate of 365,000 gallons (1.4 million L) per day is small compared with the flow rate of the Clinch River and the capacity of the treatment plant [5 million gallons (19 million L) per day].

The MRS facility is designed so that there are no radioactive waterborne effluents. Water treatment processes are discussed in Section 6.1. Waste water is to be disposed of into Bear Creek. Both operations waste water and sanitary waste water will meet EPA and State of Tennessee effluent regulations. The impact of waste water disposal on surface water will be small considering the volume of waste water and the chemical purity of the water.

Runoff of storm water from the site will be mitigated by settling ponds, as during the construction phase. The 36,500 gallons (140,000 L) per day treated water from the MRS facility may contribute substantially to the flow rate of Bear Creek during the late summer, when the flow rate may be as low as 65,000 gallons (250,000 L) per day. No adverse impacts are anticipated from the increased flow rate.

6.3.3.3 Decommissioning

Water use during MRS decommissioning is projected to be less than during operation of the facility. Increased water use will be required for dust control during regrading the drywell field at a drywell type facility.

6.3.4 Ecological Impacts

An MRS facility at the Oak Ridge site will result in the greatest loss of natural habitat since no previous construction work has been done. This will entail loss of both primary production and biomass of other organisms inhabiting the site. Recolonization is not likely to occur during the lifetime of the MRS facility.

6.3.5 Land Use Impacts

No substantial preconstruction activities have occurred at the Oak Ridge site. Construction of a sealed storage cask facility at Oak Ridge will require that 320 acres (130 ha) of natural vegetation be removed; construction of a field drywell facility at Oak Ridge will require that 415 acres (170 ha) be cleared.

6.3.5.1 Resources

No valuable mineral resources, such as fossil fuels, exist on the site. However, 320 acres (130 ha) of timber (for sealed storage cask) or 415 acres (170 ha) (for field drywell) will be removed from the site to prepare for construction.

6.3.5.2 Archaeological and Historical Sites

Since archaeological surveys have not been done on the Oak Ridge site, impacts cannot be predicted. Prior to construction of the MRS facility, a detailed archaeological study would need to be conducted so that impacts can be projected.

6.3.6 Socioeconomic Impacts

Because of their geographic proximity, socioeconomic impacts for the Oak Ridge site are essentially the same as for the Clinch River site. Therefore, the two sites are discussed jointly in Section 6.2.6.

6.3.7 Resource Requirements

A 161 kV powerline would be rerouted to the south of the Oak Ridge site, resulting in about 3 miles (5 km) of additional right-of-way in Bear Creek Valley (see Figure 5.8). For the powerline, trees will be cut down and a maintenance road constructed. This will result in about 35 acres (14 ha) of lost habitat.

A natural gas pipeline is located to the south and west of the Oak Ridge site. To supply the facility with gas, an additional pipeline may be required.

The existing water pumping and treatment facilities that supply water to the ORGDP and Clinch River Industrial Park would serve the Oak Ridge site as well. The water plant is sized to handle 5 million gallons (19 million L) per day and is adequate to handle the 365,000 gallons (1.4 million L) per day required by the MRS facility. The pumping station and water filtration plant are located at Clinch River RM 14.5.

Additional resources required to build and operate an MRS facility are essentially the same for all three sites, differing only by storage design. These are given in Section 6.1, Impacts Common to All Sites.

6.3.8 Aesthetic Impacts

The aesthetic impacts of an MRS facility at the Oak Ridge site are presented in this section. Definitions of terminology associated with noise levels and a map showing visual access to the site are found in Chapter 5.

6.3.8.1 Noise Levels

Sources of noise from the MRS facility are common for all sites and are discussed in Section 6.1.

The nearest receptors of noise are within about 5,000 feet (1,200 m) of the acoustic center of the facility in the community of Country Club Estates. The distance alone would reduce the noise level to less than 42 dBA. These homes are separated from the site by Pine Ridge, which would reduce noise levels an additional 20 to 25 dBA or more at the nearest residential receptors. This should result in noise levels that may be indistinguishable from background noise. No adverse impact is expected.

6.3.8.2 Visual Impacts

MRS equipment and buildings will be visible from various locations (see Figure 5.17). Locations from which the facility can be viewed and the probable impacts to the viewer are discussed in this section.

The site is visible from only a very short segment of a state route from the south and from a controlled perimeter road on the east. Both roads are used primarily by employees of the ORNL. It is assumed that few of these viewers will have a major concern for the visual quality of the site. However, edge vegetation [some trees in excess of 80 feet (24 m) tall] should be maintained to "soften" the industrially developed portions of the site. No recreation or residential areas have visual access to the site.

It is predicted that the viewers of the Oak Ridge site will expect some retention of vegetation to screen views of the site. However, since the Y-12 plant has no barriers, it is expected that those viewers who will pass by the Oak Ridge site along Bear Creek Valley Road may not be extremely sensitive to the sight of industrial facilities.

6.3.9 Transportation Impacts

The primary transportation impacts associated with the Oak Ridge site may be divided into two distinct categories. The first category of impacts results from the shipment of spent fuel from reactor sites to the MRS facility and consolidated spent fuel and associated wastes from the MRS to a repository. The second category of impacts results from the commuting labor force and from delivery of materials to the MRS site during its construction and operation. Impacts associated with the movement of spent fuel are represented in this section by cost, radiological effects, and nonradiological effects. Local traffic impacts from spent fuel shipments are represented in Section 6.3.9.1 by the estimated increase in the average daily traffic flow. Estimates of commuter traffic impacts at the Oak Ridge site are presented in Section 6.3.9.2.

6.3.9.1 Traffic Impacts from Spent-Fuel Shipments

Traffic impacts from spent-fuel shipments are essentially the same for all three candidate MRS sites. (See Section 6.2.9.1 for a description of impacts at the Clinch River site.) For local access onto the Oak Ridge site, a new rail line for spent fuel transport would be constructed, as shown in Figure 6.9. A number of alternate shipment routes could be used; however, the maximum increase in daily traffic along any route is assumed to be less than eight trucks per day.

6.3.9.2 Traffic Impacts from MRS Construction, Operation, and Decommissioning

Local traffic to the Oak Ridge site (especially along Bear Creek Road) can be expected to increase during all phases of MRS activity. The largest impact would be expected in 1994, the peak construction year, when about 1,000 workers are expected to be employed at the construction site. The likeliest routes onto the site are along SR-95 (Oak Ridge Turnpike) from Oak Ridge, SR-58 and Bear Creek Road from Kingston, SR-95 (White Wing Road) north from I-40, and Pellissippi Parkway/Bethel Valley Road from the West Knox County area (Farragut) (see Figure 6.9). Bear Creek Road from Oak Ridge is closed to through traffic. Based on an assumption of no new roads, the forecasted distribution of workers around the site and an assumed two workers per vehicle, Table 6.33 shows the distribution of increased traffic on roads near the site contrasted with existing conditions.

A potential traffic problem exists along SR-95 and Bethel Valley Road during the construction period, since SR-95 is nearly at capacity and Bethel Valley Road would see a significant increase in commuter traffic. Besides commuter traffic, vehicles bringing construction materials to the site may be expected to use these same routes.

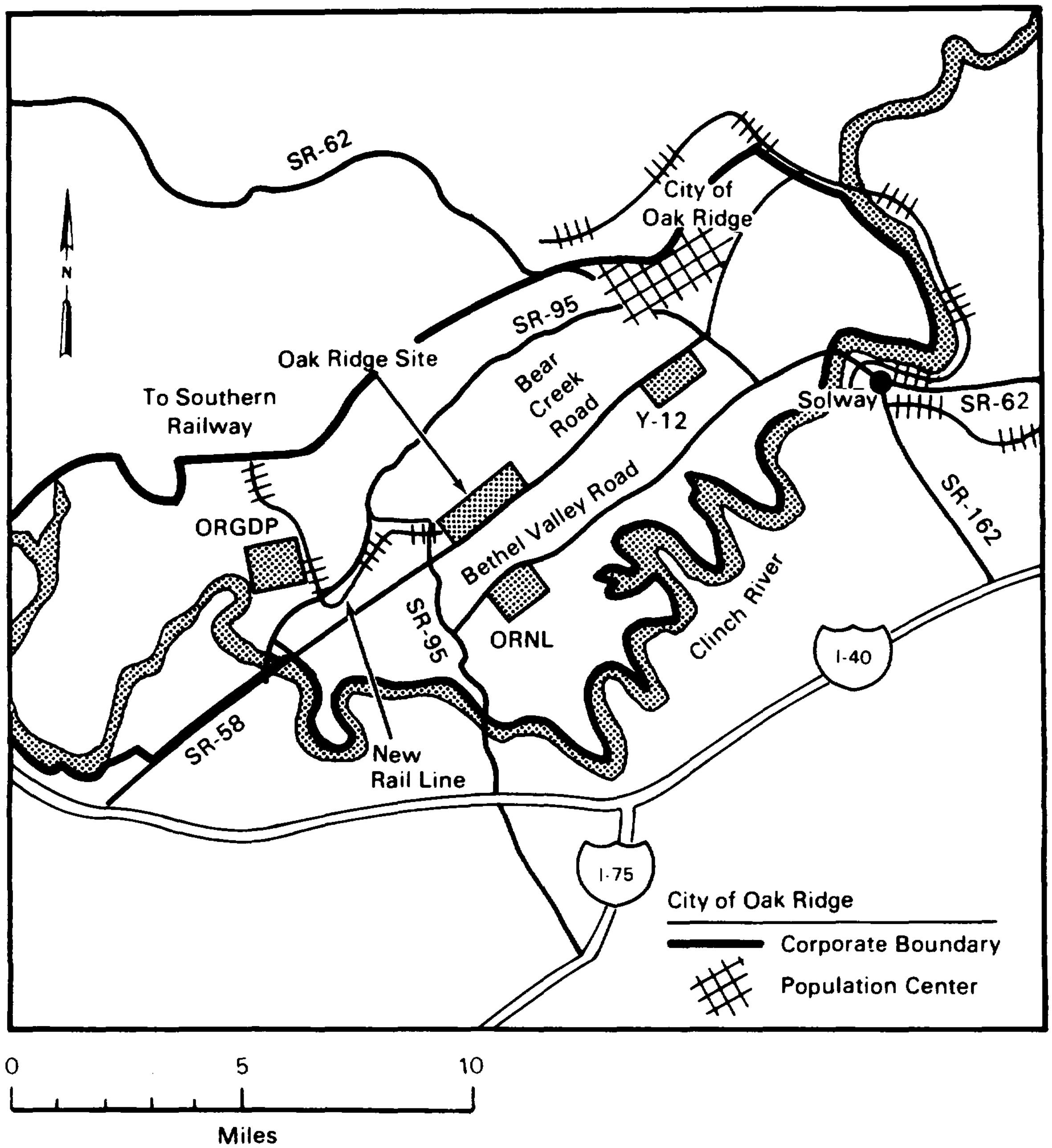

FIGURE 6.9. Transportation Routes to be Constructed for Access to the Oak Ridge Site

Traffic problems may persist during operation and decommissioning along SR-95, particularly because the route is nearly filled to capacity under current conditions near Bear Creek Road. However, due to lower employment during decommissioning, impacts would be smaller.

TABLE 6.33. Distribution of Projected and Existing Local Traffic for the Oak Ridge Site

Highway Segment	Projected Additional Vehicles in Average Daily Traffic, 1994[a]	Present Annual Average Daily Traffic (both directions)[b]	Existing Peak-Hour Level of Service[c]
SR-58, South of White Wing Road (SR-95)	110	8,790	D
SR-95, North of White Wing Road (SR-95)	222	7,700	E
White Wing Road, South of SR-58/SR-95 (Oak Ridge Turnpike)	288	4,920	E
Bethel Valley Road, West of South Illinois Avenue (SR-62)	624	4,200	NA

(a) Workers from Oak Ridge, Powell, Clinton, Norris, and Oliver Springs are assumed to approach the site along the Oak Ridge Turnpike to Bear Creek Road. Workers from Knoxville and Farragut are assumed to use the Pellissippi Parkway (SR-162) and Bethel Valley Road. Workers from Loudon County are assumed to use SR-95. Roane and Morgan County workers are assumed to take SR-58 through Kingston. Traffic impacts are based on two workers per vehicle. Average daily traffic increase equals twice the number of vehicles arriving at the site.
(b) See Tables 5.26 and 5.32, Chapter 5.
(c) See Tables 5.27 and 5.28, Chapter 5.
NA = Not available.

As described in Section 6.2.9.2, traffic impacts could be much reduced through busing and van pooling and/or through upgrading of roads.

6.3.9.3 Cost Impacts

The total costs associated with shipping spent fuel from reactor sites to the Oak Ridge site and then to potential repository sites are the same as those described for the Clinch River site in Section 6.2.9.3.

6.3.9.4 Radiological Impacts

Radiological impacts to the public and the transportation work force are presented in Tables 6.34 and 6.35. The transportation radiological impacts for the Oak Ridge site are the same as those described in Section 6.2.9.4 for the Clinch River site.

TABLE 6.34. Total 26-Year Radiological Impacts from Shipping Spent Fuel from All Reactors to the Oak Ridge Site and then to a Repository (person-rem)

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	1.1×10^3	9.4×10^2	6.3×10^3	6.1×10^3
Hanford	1.0×10^3	8.8×10^2	6.2×10^3	6.1×10^3
Deaf Smith and Swisher	1.0×10^3	8.6×10^2	6.2×10^3	6.0×10^3
Davis and Lavender	1.0×10^3	8.8×10^2	6.2×10^3	6.1×10^3
Richton and Cypress Creek	8.6×10^2	7.7×10^2	6.2×10^3	6.0×10^3
Vacherie	1.0×10^3	8.6×10^2	6.2×10^3	6.1×10^3

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from MRS-to-repository.

TABLE 6.35. Total 26-Year Radiological Impacts from Shipping Spent Fuel from Eastern Reactors to the Oak Ridge Site and then All Spent Fuel to a Repository (person-rem)[a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	9.9×10^2	8.7×10^2	5.5×10^3	5.4×10^3
Hanford	9.6×10^2	8.4×10^2	5.6×10^3	5.5×10^3
Deaf Smith and Swisher	9.3×10^2	8.1×10^2	5.8×10^3	5.7×10^3
Davis and Lavender	9.5×10^2	8.3×10^2	5.5×10^3	5.4×10^3
Richton and Cypress Creek	8.8×10^2	8.1×10^2	6.8×10^3	6.7×10^3
Vacherie	9.8×10^2	8.5×10^2	6.4×10^3	6.3×10^3

(a) Western reactor spent fuel is assumed to be shipped directly to repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from MRS to a repository.

6.3.9.5 Nonradiological Impacts

Nonradiological transportation impacts (health effects) for the Oak Ridge site are the same as those described for the Clinch River site (see Section 6.2.9.5).

6.4 IMPACTS UNIQUE TO THE HARTSVILLE SITE

This section presents the environmental impacts of an MRS facility at the Hartsville site. Impacts are projected for each MRS phase, as applicable. Figures 6.10 and 6.11 show the planned site layout at the Hartsville site for the sealed storage cask and field drywell design concepts, respectively. Differences in impacts for field drywell or sealed storage cask concepts are noted.

6.4.1 Radiological Impacts

The radiological consequences of normal operation releases from cask venting and fuel consolidation at the Hartsville site are shown in Table 6.36.

The dose commitment to the maximally exposed individual is small compared with the annual limits of 75 mrem to thyroid or 25 mrem to total body and other organs (10 CFR 72). Exposures to the maximally exposed individual and to the population are very small compared with the annual dose from background radiation of 120 mrem per year at the Hartsville site. The calculated doses are not expected to result in any statistically discernible health effects.

Offsite releases from potential operating accidents (as defined in Section 6.1.1.3) are presented in Table 6.37 for cask storage, and in Table 6.38 for drywell storage. The releases presented in these tables are based on the assumption that the accident does occur; the probability of the event is not factored into the calculation. The doses presented are well below the regulatory limit of 5 rem for design basis accidents (10 CFR 72). The population doses are well below the dose received from background radiation and no health effects are expected. These results are based on the estimated annual releases described in Section 6.1.1.2. Details of analysis methods are presented in Appendix G.

6.4.2 Air Quality Impacts

This air quality analysis for the Hartsville site examines regulated pollutants. Many source terms are the same for all locations. These and the methods for estimating emissions are covered in Section 6.1. Concentrations of pollutants in the ambient air may be different for each site as a consequence of the site's unique dispersion characteristics.

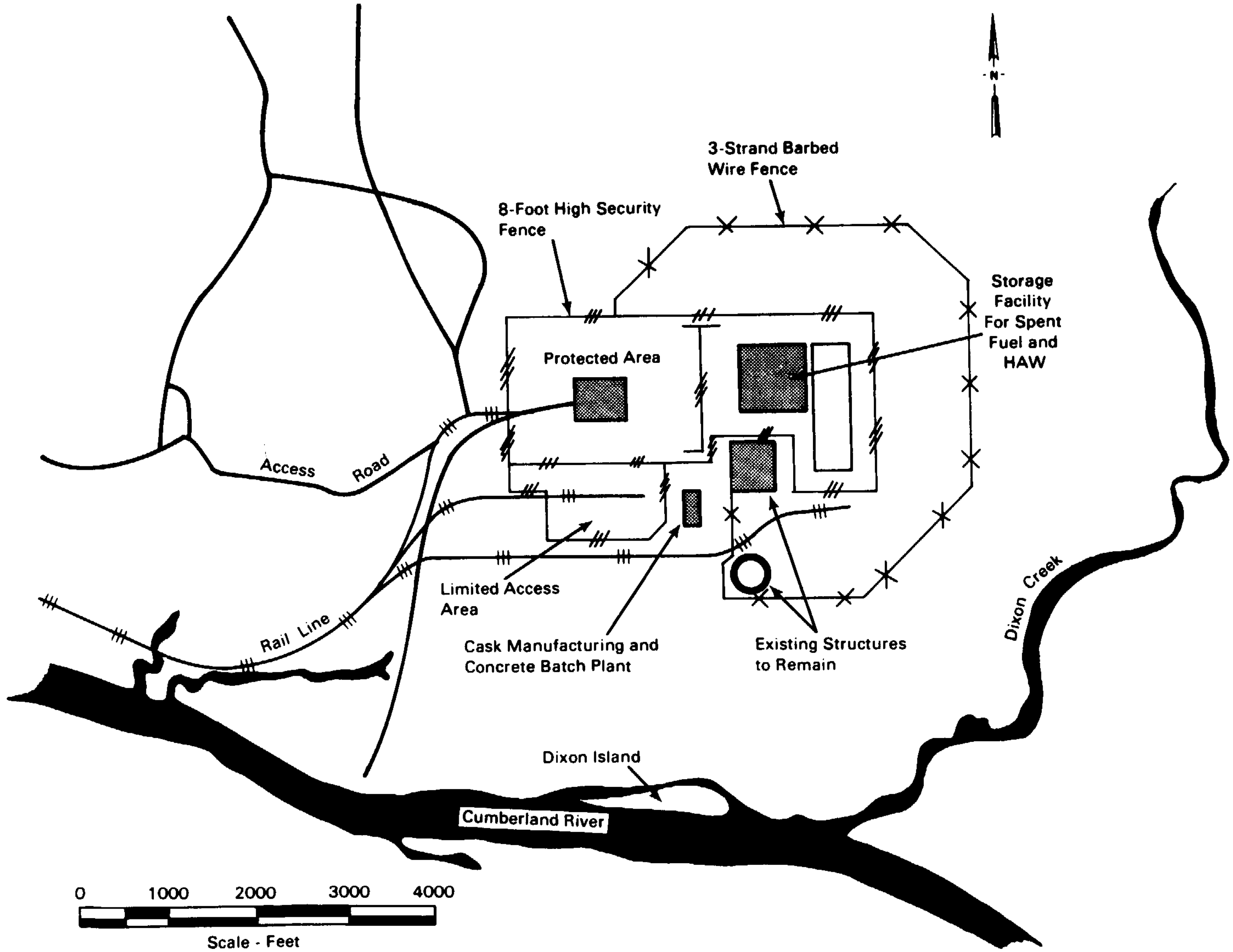

FIGURE 6.10. Layout of the Hartsville Site - Sealed Storage Cask Design

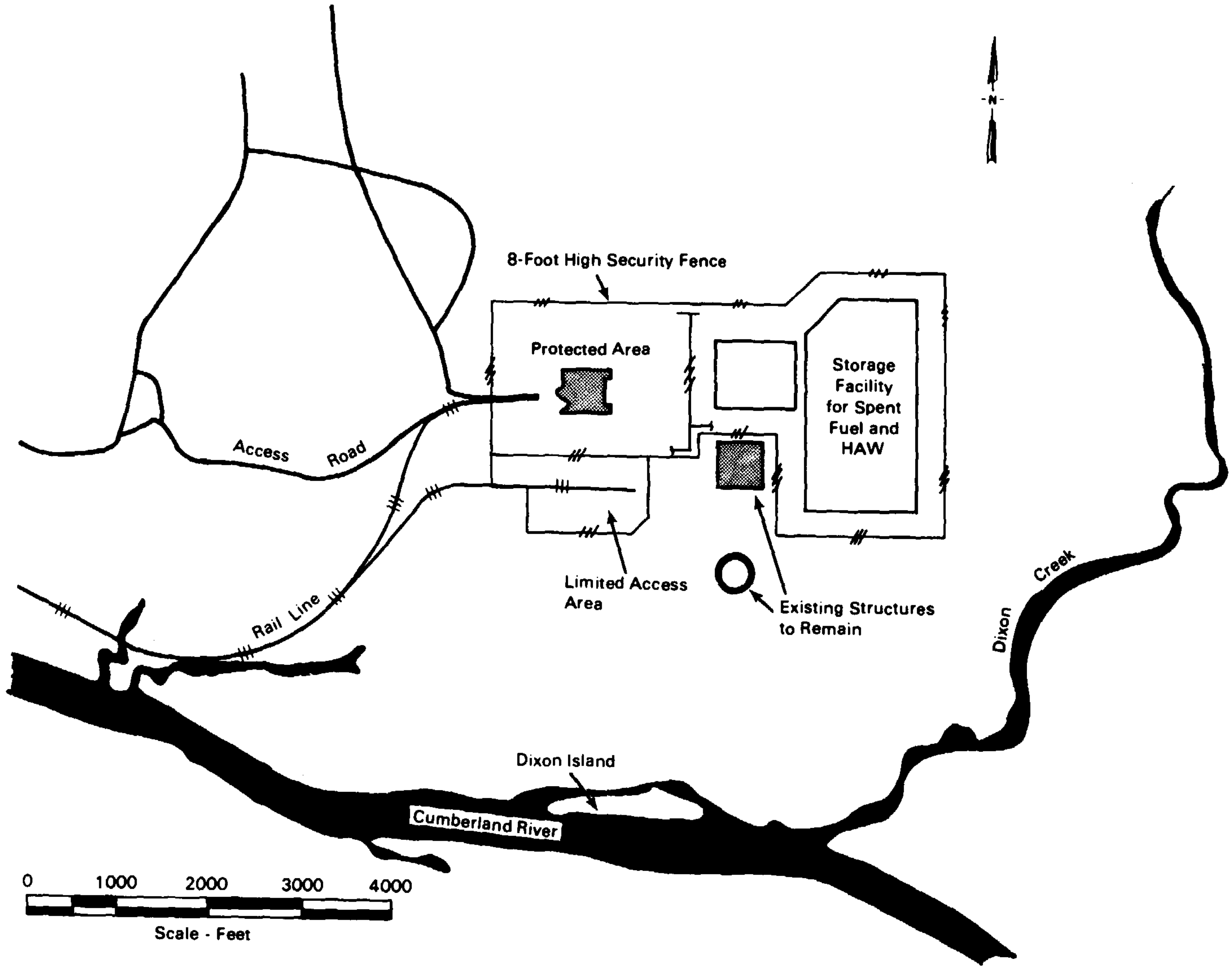

FIGURE 6.11. Layout of the Hartsville Site - Field Drywell Design

TABLE 6.36. Radiological Impacts[a] from MRS of Normal Operations at the Hartsville Site

Pathway and Location in the Body	50-Year Dose Commitment from Annual Release: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Air Submersion		
Total Body	2.5×10^{-7}	6×10^{-2}
Inhalation		
Total Body	3.4×10^{-7}	9×10^{-2}
Bone	9.4×10^{-10}	3×10^{-4}
Lungs	3.7×10^{-7}	9×10^{-2}
Thyroid	2.4×10^{-6}	6×10^{-1}
Ingestion		
Total Body	3.7×10^{-4}	2×10^{1}
Bone	4.1×10^{-6}	4×10^{-2}
Lungs	3.6×10^{-4}	2×10^{1}
Thyroid	1.7×10^{-3}	1×10^{2}
Total for all Exposure Pathways		
Total Body	3.7×10^{-4}	2×10^{1}
Bone	4.3×10^{-6}	1×10^{-1}
Lungs	3.7×10^{-4}	2×10^{1}
Thyroid	1.7×10^{-3}	1×10^{2}

(a) Impacts may be compared to the regulatory limit of 75 mrem to thyroid and 25 mrem to total body for the maximally exposed individual and to a background dose of 1×10^{5} person-rem for the population (based on an individual background dose of 120 mrem/yr for the site).
(b) The maximally exposed individual is assumed to live at the location of nearest resident and to eat locally grown food.
(c) Population dose commitments are calculated for the population within 50 miles (80 km) of the site plus for all people exposed to agricultural products grown within 50 miles of the site.

TABLE 6.37. Radiological Impacts[a] of Potential MRS Facility Accidents for Sealed Storage Cask at the Hartsville Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Fuel Assembly Drop	Total Body	2.7×10^{-3}	3×10^{-2}
	Bone	7.6×10^{-5}	8×10^{-3}
	Lungs	2.8×10^{-3}	4×10^{-2}
	Thyroid	1.8×10^{-2}	2×10^{-1}
Shipping Cask Drop	Total Body	5.5×10^{-4}	7×10^{-3}
	Bone	1.5×10^{-5}	2×10^{-3}
	Lungs	5.8×10^{-4}	7×10^{-3}
	Thyroid	3.7×10^{-3}	4×10^{-2}
Storage Cask Drop	Total Body	5.3×10^{-4}	7×10^{-3}
	Bone	1.5×10^{-5}	2×10^{-3}
	Lungs	5.6×10^{-4}	7×10^{-3}
	Thyroid	3.6×10^{-3}	4×10^{-2}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a background dose of 1×10^5 person-rem for the population (based on an individual background dose of 120 mrem/yr for the site).
(b) The maximally exposed individual is assumed to be at the nearest approach from the security fence for the duration of the accidental release. This location varies by accident and site.
(c) The population dose commitments are calculated for the population within 50 miles (80 km) of the site.

6.4.2.1 Preconstruction and Construction

Emissions from preconstruction and site characterization activities are estimated to be minimal. Site preparation at the Hartsville site will include demolishing some structures from the partially constructed Hartsville Nuclear Power Plant. Thus, site preparation and construction activities are expected to temporarily degrade the ambient air quality in the immediate vicinity of the site. Particulate emissions generated during construction are about the same for all site locations and are given in Section 6.1.2.

TABLE 6.38. Radiological Impacts[a] of Potential MRS Facility Accidents for Field Drywell at the Hartsville Site

Accident	Location in the Body	50-Year Dose Commitment to the Public: Maximally Exposed Individual (rem)[b]	Population (person-rem)[c]
Fuel Assembly Drop	Total Body	2.7×10^{-3}	3×10^{-2}
	Bone	7.6×10^{-5}	8×10^{-3}
	Lungs	2.8×10^{-3}	4×10^{-2}
	Thyroid	1.8×10^{-2}	2×10^{-1}
Shipping Cask Drop	Total Body	5.5×10^{-4}	7×10^{-3}
	Bone	1.5×10^{-5}	2×10^{-3}
	Lungs	5.8×10^{-4}	7×10^{-3}
	Thyroid	3.7×10^{-3}	4×10^{-2}
Canister Shearing	Total Body	7.5×10^{-2}	5×10^{-1}
	Bone	8.1×10^{-4}	1×10^{-1}
	Lungs	7.9×10^{-2}	5×10^{-1}
	Thyroid	5.1×10^{-1}	3×10^{0}

(a) Impacts may be compared to the regulatory limit of 5 rem to total body for the maximally exposed individual and to a individual background dose of 1×10^{5} person-rem for the population (based on an individual background dose of 120 mrem/yr for the site).
(b) The maximally exposed individual is assumed to be at the nearest approach from the security fence for the duration of the accidental release. This location varies by accident and site.
(c) The population dose commitments are calculated for the population within 50 miles (80 km) of the site.

For comparison, incremental concentrations of pollutants from both mobile and stationary sources are compared with NAAQS in Table 6.39. These concentrations are projected for the fenceline in the area with the highest concentration. A detailed explanation of the calculation methods used is given in Appendix G.

None of the pollutant concentrations shown in Table 6.39 exceed NAAQS. However, a more detailed study of area sources may assess these concentrations with more certainty.

TABLE 6.39. Projected Ambient Air Concentrations of Pollutant Emissions During MRS Construction at the Hartsville Site and NAAQS ($\mu g/m^3$)

Pollutant	NAAQS	Concentration at 100 m
Annual average		
TSP	75	30
NO_x	100	3
24-hr maximum		
TSP	260	200
8-hr maximum		
CO	10,000	210

The Hartsville site is 135 miles (220 km) from a Class I area. MRS facility construction is not expected to have measurable effects on this or any Class I area.

6.4.2.2 Operation

Sources of emission rates of atmospheric pollutants for MRS operation are the same for all site locations are given in Section 6.1. Emissions from operation are projected to be less than regulatory limits; therefore, concentrations are not computed. However, representative concentrations are given for the Clinch River site in Section 6.2.2.

6.4.2.3 Decommissioning

Decommissioning activities that could potentially generate airborne pollutants are approximately the same at all sites and are described in Section 6.1. Impacts of these activities will be minimal.

6.4.3 Water Quality and Use Impacts

Water quality impacts at the Hartsville site are evaluated in this section. Water consumption and routine effluents are common to all three sites and are discussed in Section 6.1. Features unique to the Hartsville site include the water source, effluent stream effects, and waste water treatment effects.

6.4.3.1 Preconstruction and Construction

The Hartsville site is located on the Cumberland River, which would be the water source for the site. Water use during the preconstruction phase of the project should have a negligible impact on the water resources available. Water use during construction is estimated to be about 7 million gallons (26 million L) per year for concrete production and related activities, plus 77 million to 100 million gallons (290 million to 380 million L) per year, or about 0.5 cubic feet per minute, for dust control. This use rate, equivalent to 200,000 to 300,000 gallons (760,000 to 1.1 million L) per day, is negligible compared with the average flow of the Cumberland River at Hartsville of 17,000 cfs (11 billion gallons, or 40 billion L, per day).

Temporary degradation of water quality from a high suspended solids content in runoff will be mitigated by solids settling in runoff ponds prior to discharge. Settling ponds will be constructed to reduce the silt content in the runoff.

6.4.3.2 Operation

Water use during MRS operation is expected to be about 365,000 gallons (1.4 million L) per day. This use rate is small compared with water availability.

The MRS facility is designed so that no radioactive waterborne effluents will originate from processing. The treatment of waste water from processing is discussed in Section 6.1. The water treatment systems are designed so that all effluent water meets both EPA and State of Tennessee water quality standards. Treated process waste water and treated sanitary waste are to be disposed of in the Cumberland River. The impact of waste-water disposal on surface water will be very small considering that the volume of waste water is only three-millionths of the flow of the receiving waters. Sludge from water treatment will be disposed of offsite.

Runoff of storm water from the site will be mitigated by ditches and settling ponds, as during the construction phase.

6.4.3.3 Decommissioning

Water use during decommissioning is projected to be less than during operation of the facility; therefore, no impacts are expected.

6.4.4 Ecological Impacts

No unique ecological impacts are expected for the Hartsville site. Should the endangered gray bat (*Myotis grisencens*) be encountered, provisions will be made for its protection and preservation.

6.4.5 Land Use Impacts

At the Hartsville site, 320 acres (130 ha) would be required for the sealed storage cask design and 410 acres (170 ha) for the field drywell design. Preconstruction activities associated with previous site development have resulted in the clearing of 247 acres (100 ha) (77%) of the 320 acres (130 ha) needed for the sealed storage cask facility. An additional 73 acres (30 ha) will be disturbed with essentially complete elimination of flora and fauna from natural ecosystems. For the field drywell facility, 337 acres (136 ha) (82%) of the 410 acres (170 ha) needed have already been disturbed; an additional 73 acres (30 ha) will be cleared of natural vegetation and wildlife. An additional 43 acres (17 ha) of land will be cleared for construction of access routes to the site.

6.4.5.1 Resources

No valuable mineral resources, such as fossil fuels, exist on the site. This former farmland was taken out of production for construction of the now-canceled Hartsville Nuclear Power Plants. Because MRS construction resource requirements depend on facility type and not location, these resources are discussed in Section 6.1.

6.4.5.2 Archaeological and Historical Sites

The following archaeological sites occur within the area of disturbance for the sealed storage cask design concept: 40SM51, 40SM53, 40TS4, S.I.8, and S.I.9 (see Table 5.55 for description). All except 40SM53 are also located within the area of disturbance for the field drywell design. However, all of these sites have already been impacted by previous construction. The remaining sites in Table 5.55 are located just outside the Hartsville site boundary, but would likely be impacted by construction activities due to their proximity. One of these sites, 40SM27, would be impacted by construction of the new rail spur; however, this site has already been partially disturbed by previous construction activity.

6.4.6 Socioeconomic Impacts

Socioeconomic impacts of an MRS facility at the Hartsville site are addressed in this section. A current and projected baseline for these impacts was established in Section 5.3.6.

The location of an MRS facility at the Hartsville site could preempt the site's use for other industrial development, which would pay taxes. It also could result in the cessation of TVA in-lieu-of-tax payments to local government in the area. Under current law, the cost of public services supplied to the MRS facility and plant-related population would not be mitigated by property and sales taxes ordinarily paid by a normal taxable facility of the same size. In addition, some companies that might otherwise have located in the Hartsville area may view the MRS facility as incompatible with their business, reducing the potential tax base. TVA currently makes substantial in-lieu-of-tax payments to the State of Tennessee based on the value of property represented by the partially-completed Hartsville Nuclear Power Plant. Transfer of the property for use as an MRS site would result in the loss of the Hartsville Nuclear Power Plant as "power" property and could result in the loss of payments. Fiscal year 1983 in-lieu-of-tax payments in the Hartsville primary impact area (excluding Davidson County) were $911 thousand (Mid-Cumberland 1983).

6.4.6.1 Employment and Income

The socioeconomic impacts of an MRS facility are largely dependent on the extent to which labor, materials, equipment and business services for the facility are supplied locally, as described in Section 6.2. Construction labor, some with nuclear plant experience, should be abundant in the Hartsville primary impact area or in Nashville. The Hartsville site is less likely to have specialized operations labor available locally than the Clinch River and Oak Ridge site because fewer of the workers in the area have the necessary nuclear background. Materials, equipment, and business services will be supplied in the same way as at the Clinch River site (national/local split--see Section 6.2.6), but a higher percentage may be local due to the larger economy in the Nashville area.

Figure 6.12 shows the MRS schedule and direct and total employment impacts of construction, operation, and decommissioning for the sealed storage cask concept. Between 3.9 and 4.3 indirect and induced jobs per direct MRS job would be created in the 50-mile impact area, depending on the MRS phase. This is higher than at the Clinch River/Oak Ridge site and reflects the larger

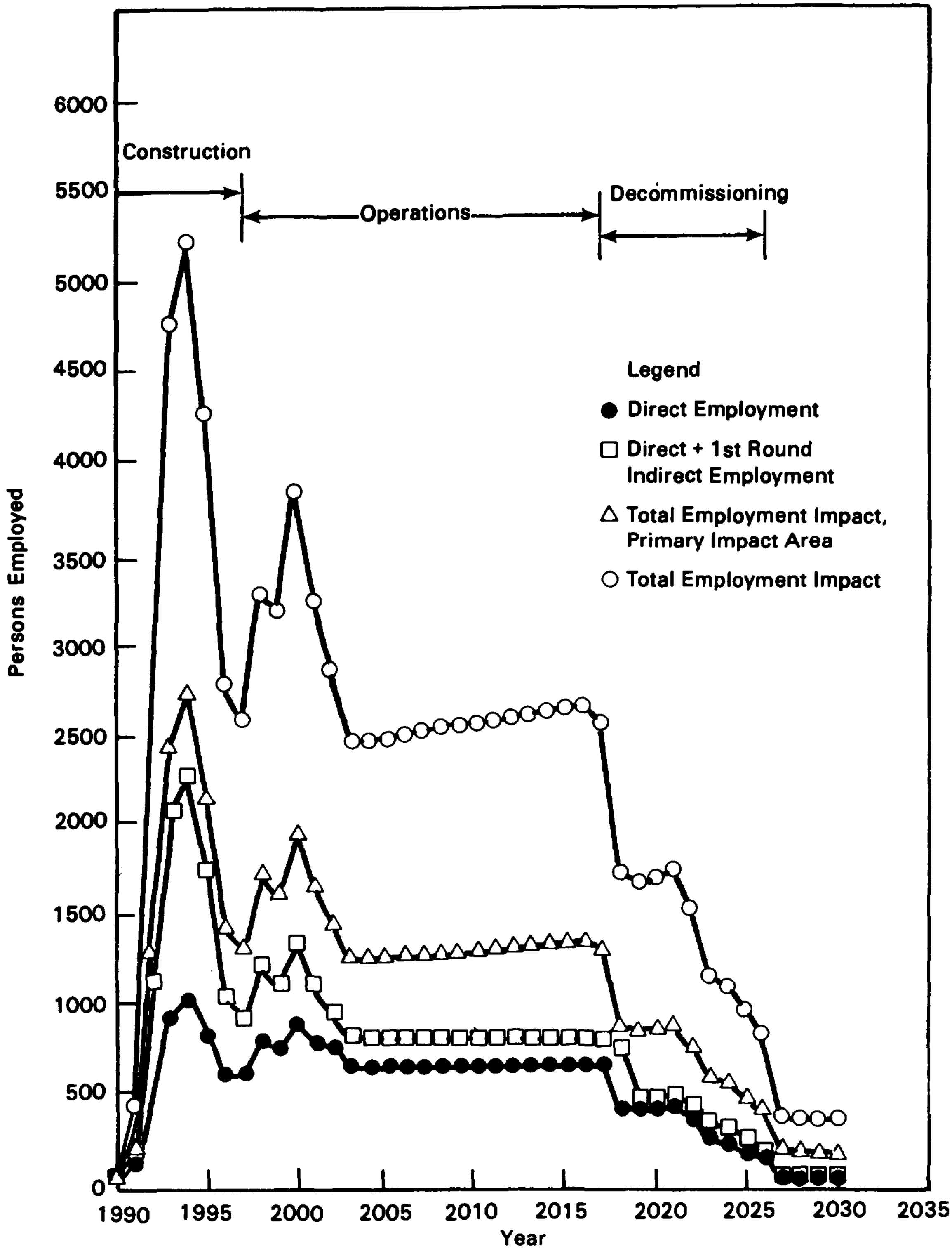

FIGURE 6.12. Employment Impacts of a Sealed Storage Cask MRS Facility at the Hartsville Site

Nashville area economy.[a] Indirect and induced jobs are created by MRS facility purchases and the spending and respending of MRS-related incomes in the local economy. The peak employment impact year is 1994, with 5,400 more jobs available in the 50-mile impact area (2,700 in the primary impact area) than without an MRS facility. The cask-manufacturing facility employs about 100 people during the period 1995-2001, for a total employment of about 850 people at the facility and a total increase in regional employment of 3,300. Steady inloading and outloading is achieved by the year 2003, requiring a constant level of about 650 people employed at the facility from 2003 through 2017, when the last shipment is received. During this period, total employment in the region is about 2,500 persons higher than it would be without the MRS facility.

Decontamination and decommissioning is scheduled to begin in 2018, after shipments are no longer being accepted. Full-scale decommissioning will begin in mid-year 2021, after the last shipment is sent to the repository. During full-scale decommissioning, about 200 to 250 people will be employed at the MRS facility. Total regional MRS employment impact will decline in two stages: stage 1) employment will decline to 1,700 as receiving operations are shut down; and stage 2) employment will decline to about 1,000 as operations and maintenance cease and only decommissioning activities are continued. A small, permanent, employment increase of about 330 employees persists after 2026, the last year of decommissioning.[b]

Figure 6.13 shows the impact on employment at a field drywell facility. This impact can be expected to be similar to the sealed storage cask impact. Peak employment will occur in 1994, with 6,100 additional people employed in the 50-mile impact area. Table 6.40 shows both the expected local share of employment impacts in the Hartsville primary impact area and the resulting effect on primary impact area incomes. Counties included in the table are

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(a) Between 1.0 and 1.7 of these jobs would appear in the primary impact area, including Davidson County (Nashville). A larger economy (other things equal) offers a broader array of goods and services than does a smaller one and, thus, tends to capture a larger proportion of total project-related spending on goods and services. This occurs both for direct expenditures by the project and for purchases by supplier firms and households.

(b) The persistence of higher employment in the Hartsville area appears to be due to a permanent dynamic growth effect of about 300 extra persons employed in services and trade, most likely business services.

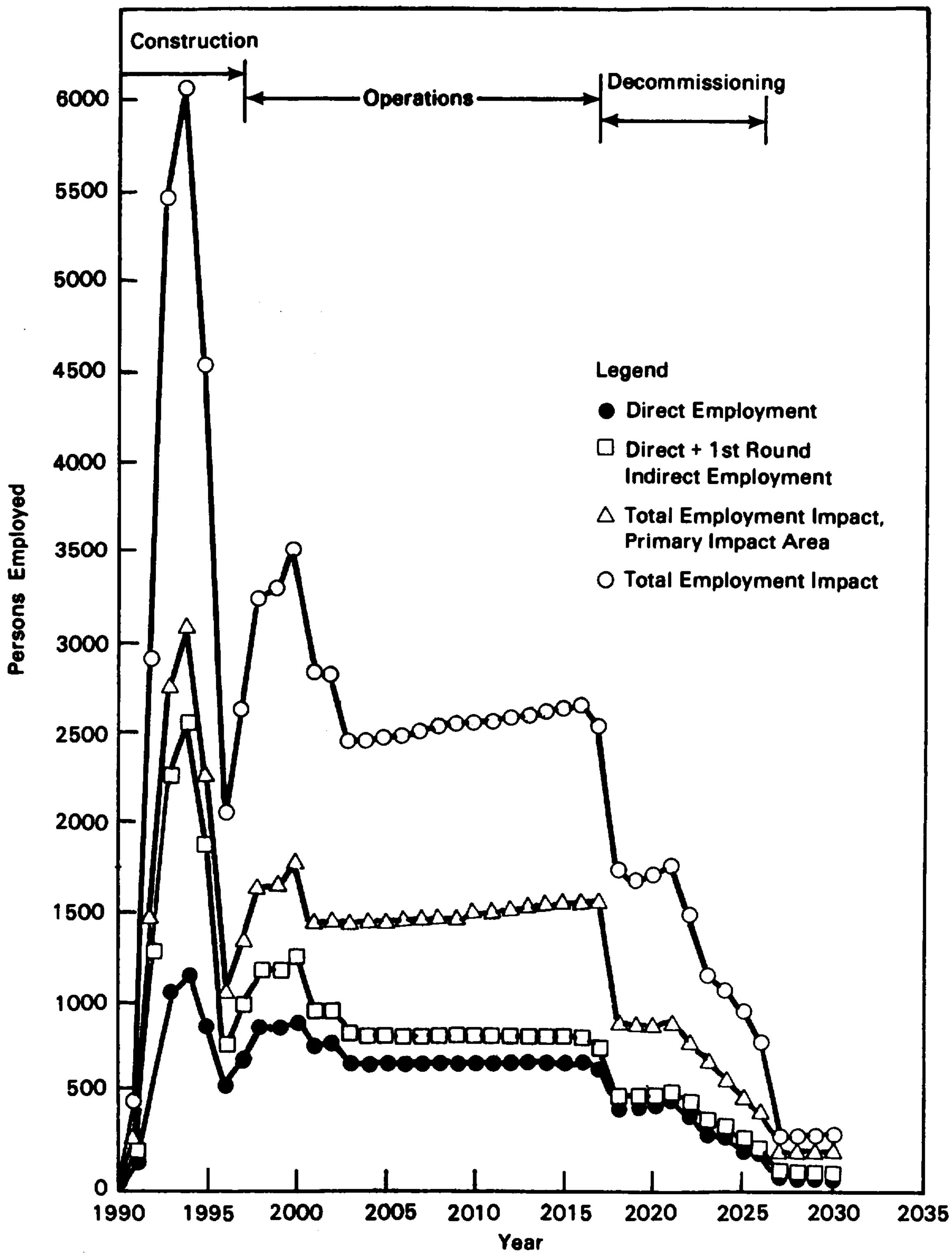

FIGURE 6.13. Employment Impacts of a Field Drywell MRS Facility at the Hartsville Site

TABLE 6.40. Employment and Income Impacts of a Sealed Storage Cask MRS Facility at Selected Communities in the Hartsville Primary Impact Area

County/City	Construction[a] Employment Impact	Construction[a] Real Income Impact (million 1985 $)	Operations[b] Employment Impact	Operations[b] Real Income Impact (million 1985 $)	Decommissioning[c] Employment Impact	Decommissioning[c] Real Income Impact (million 1985 $)
Macon						
Lafayette	38	$ 1.1	18	$ 0.6	8	$ 0.3
Smith						
Carthage	40	1.1	19	0.6	9	0.3
Sumner						
Gallatin	136	3.8	64	2.1	30	0.9
Hendersonville	125	3.5	59	1.9	27	0.9
Trousdale						
Hartsville	106	3.0	50	1.6	23	0.7
Wilson						
Lebanon	136	3.8	64	2.1	30	0.9
Mount Juliet	19	0.5	9	0.3	4	0.1
Davidson						
Nashville	2,122	59.0	1,005	32.8	462	14.4

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations excluding cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).

Macon, Smith, Sumner, Trousdale, Wilson and part of Davidson (Nashville).[a] Effects may be felt outside this six-county area, but would likely be too small to be significant to the local economy.

The facility is expected to directly and indirectly add about $150 million (1985 dollars) in personal income to the impact area's economy in 1994, the peak year of construction. During operating years, the impact on the 50-mile region would average $83 million, and during decommissioning, $37 million.

As shown in Table 6.40, much of the impact on income is concentrated in the primary impact counties or Nashville, where most of the economic activity is expected to occur. The estimates presented in Table 6.40 are based on the relative population and distance of the communities from the Hartsville site, as described in Appendix H. In each case, the increase in employment or income is assumed to take place at the larger communities in the county, even though people may actually live in the unincorporated areas of the respective counties or in some of the smaller towns.

Table 6.41 indicates that the effects of a field drywell MRS facility on the local economy are quite similar to those of a sealed storage cask facility.

6.4.6.2 Population and Housing

Workers with the skills required to build an MRS facility are available in the Hartsville impact area, and even within the primary impact area. For operations, however, it is less likely that workers with appropriate skills are available. Therefore, MRS operations will probably draw in-migrants into the Hartsville area. If the MRS facility replicates the experience with commuting that occurred with the Hartsville Nuclear Power Plants, a high percentage of the construction workforce would commute from Nashville rather than locate in the more rural primary impact counties.

It is assumed that the propensity of MRS-related employment to attract net in-migration is the same as for the average increase in employment in the region. Some of the net increase in jobs related to MRS is assumed to be filled from unemployed persons, but this is assumed to be no more likely than for any other increase in employment. Because of the small number of workers needed for the MRS project, the Hartsville site impact area will likely be able

(a) MRS materials and equipment may be purchased outside of the 50-mile impact area, particularly special items needed for construction that would require little ongoing service after the sale. Money earned on these sales would likely not affect the Hartsville site impact area.

TABLE 6.41. Employment and Income Impacts of a Field Drywell MRS Facility at Selected Communities in the Hartsville Primary Impact Area

County/City	Construction[a]		Operations[b]		Decommissioning[c]	
	Employment Impact	Real Income Impact (million 1985 $)	Employment Impact	Real Income Impact (million 1985 $)	Employment Impact	Real Income Impact (million 1985 $)
Macon						
Lafayette	43	$ 1.2	18	$ 0.6	8	$ 0.3
Smith						
Carthage	46	1.3	19	0.6	9	0.3
Sumner						
Gallatin	154	4.3	64	2.1	29	0.9
Hendersonville	141	3.9	59	1.9	26	0.8
Trousdale						
Hartsville	120	3.3	50	1.6	22	0.7
Wilson						
Lebanon	154	4.3	64	2.1	29	0.9
Mount Juliet	22	0.6	9	0.3	4	0.1
Davidson						
Nashville	2,400	66.7	1,002	32.8	449	14.0

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations excluding cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).

to absorb this employment impact through a reduction in the unemployment rate and minor in-migration. Thus, any estimated increases in employment are likely overstated.[a]

Table 6.42 shows the expected upper-bound impacts of MRS-related economic activity on local population and housing demand in the primary impact area. (The impacts for both storage concepts are approximately the same and, therefore, are not distinguished for this table.) The table assumes that the 1980 average household sizes will continue to prevail and that the baseline population without MRS is housed adequately. Thus, the increase in housing demanded over the baseline (equal to the increase in the number of households) represents the potential extra demand for additional units of housing. It is unlikely that this could result in a net shortage in housing units because of the small size of the increase relative to the (current) vacant stock. In addition, because the area economy is expected to be growing even without MRS, the housing stock will be increasing and could be adequate to absorb the MRS-related population increase.

Table 6.42 reports only the impacts in the primary impact area. The impacts in the remainder of the 50-mile impact area are considered to be too widely distributed to be noticeable. At the completion of construction and again at the cessation of operations, a small number of units will be released on the local housing markets. This could depress housing values slightly. Because of the small number of units involved, however, it is unlikely that the effect will be noticeable. The impact of the field drywell facility is virtually identical.

6.4.6.3 Fiscal Conditions

Although the MRS facility is not taxable,[b] local and state government may expect some revenue impacts as a result of the increase in MRS-related economic activity. In addition, population increases should result in some increases in government expenditures. These effects are not likely to be large enough to be noticed in communities outside the primary impact area. Table 6.43 shows the projected impact on state and local revenues for the

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(a) One exception to these forecasts applies. General Motors has announced plans to build and operate a major automotive assembly plant at Spring Hill (south of Nashville in Maury County), which may cause some temporary hindrance in the supply of some types of laborers in the Nashville labor market. Such potential shortages should be of short duration, but might cause relatively high migration per job created.

(b) The DOE has proposed that payments equivalent to taxes be made to local government. The details of this arrangement have not been established.

TABLE 6.42. Population and Housing Impacts of an MRS Facility at the Hartsville Primary Impact Area

County/City	Construction[a] Population Impact (persons)	Construction[a] Housing Demand Impact[d] (units)	Operations[b] Population Impact (persons)	Operations[b] Housing Demand Impact[d] (units)	Decommissioning[c] Housing Population Impact (persons)	Decommissioning[c] Housing Demand Impact[d] (units)	County 1980 Housing Vacancies[e] (units)
Macon County	59	20	27	9	14	5	433
Lafayette	59	20	27	9	14	5	--
Smith County	63	21	28	10	15	5	640
Carthage	63	21	28	10	15	5	--
Sumner County	403	137	182	62	96	33	1,550
Gallatin	210	71	95	32	50	17	--
Hendersonville	193	66	87	30	46	16	--
Trousdale County	164	56	74	25	39	13	254
Hartsville	164	56	74	25	39	13	--
Wilson County	239	81	108	36	57	19	1,181
Lebanon	210	71	95	32	50	17	--
Mt. Juliet	29	10	13	4	7	2	--
Davidson County	3,276	1,114	1,482	504	780	265	9,602
Nashville	3,276	1,114	1,482	504	780	265	--

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations without sealed storage cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).
(d) At 1980 occupied units per capita, or 0.34 (2.9 persons per household) from 1980 census for the primary impact area.
(e) See Table 5.46.

TABLE 6.43. Major-Source State and Local Revenue and Operating Expenditure Impacts at the Hartsville Primary Impact Area (thousand 1985 $)

County/City	Construction		Operation		Decommissioning	
	Peak Year Revenue Impact[(a)]	Peak Year Operating Expenditure Impact[(b)]	Average Year Revenue Impact[(a)]	Average Year Operating Expenditure Impact[(b)]	Average Year Revenue Impact[(a)]	Average Year Operating Expenditure Impact[(b)]
Macon County	$ 20	$ 21	$ 9	$ 8	$ 5	$ 5
Lafayette	14	19	7	9	3	5
Smith County	26	26	14	12	6	5
Carthage	14	14	6	6	3	3
Sumner County	157	130	74	58	34	23
Gallatin	59	59	27	27	14	14
Hendersonville	34	35	15	16	8	8
Trousdale County	73	82	34	36	17	17
Hartsville	13	NA	6	NA	3	NA
Wilson County	74	29	35	13	18	6
Lebanon	75	107	34	49	16	19
Mt. Juliet	1	NA	1	NA	<1	NA
Davidson County	1,999	2,684	995	1,202	454	548
Nashville	465	468	210	212	111	112
Tennessee	8,200	6,500	4,600	3,000	2,000	1,600

(a) For counties and cities, revenue includes all local and state revenue. The total excludes some minor taxes, user fees, and intergovernmental transfers. Years are the same as previous tables.

(b) For all levels of government, expenditure includes all general government functions except debt service. School districts are combined with their respective county or city governments.

primary impact area. The following assumptions are made in estimating these impacts and are explained further in Appendix H:

- a constant real assessed value per capita
- a constant ratio of retail sales taxes and other income-related taxes to real income
- constant per capita population-related shared taxes
- a constant real operating expenditures per capita for all expenditure categories.

As described in Section 6.2.6.3, actual future conditions could be different than these but would be the result of conditions too complex to predict. To the extent that local government revenues per incremental person in the local population or incremental dollar of local income are higher than shown, the local governments would be more likely to have a fiscal surplus; to the extent that the revenues are lower, the local governments would be more likely to have a deficit. The opposite conclusions would apply to higher and lower local government expenditures per incremental person in the population or in the school system.

Table 6.43 indicates the impacts during the peak construction year and the average operating and decommissioning years. The totals do not include special planning, monitoring, and emergency response preparedness costs to the State of Tennessee and the local governments. Because of transportation considerations, governments along transportation routes outside the primary impact area will also have some costs associated with planning, monitoring, and emergency response preparedness.

The field drywell facility creates impacts on state and local governments similar to those of a sealed storage cask MRS facility; therefore, so the revenues and costs for field drywell are not shown in detail.

As can be seen from Table 6.43, the impacts of population-related operating expenditure on state and local government are relatively small compared to the cost of the facility (about $1 billion). While transfers for monitoring, emergency planning, selected capital investments, and infrastructure can be expected to increase the total to some degree, the total would still be small compared to the cost of the facility.

No computation of potential foregone taxes similar to that for the city of Oak Ridge in Section 6.2.6.3 has been performed for the Hartsville site. A $1 billion MRS facility, if it were a normal taxable facility, would increase the estimated actual value of taxable property in Trousdale County 10 times over--from $106 million (Tennessee Taxpayers Association 1984) to $1.1 billion. Under those conditions it is not all clear what would happen to the level of government services provided, although it is likely that they would increase while tax rates would be reduced. Although DOE has proposed that payments equivalent to taxes be made to local governments, the basis for computing such payments has not been developed.

6.4.6.4 Community Services and Infrastructure

This section discusses the impacts of MRS-related population growth on community services and infrastructure. The increases in population throughout most of the primary impact area are expected to be minimal; therefore, it is unlikely that major capital expenditures will be required. Similarly, it is unlikely that there will be significant increases in social services such as Aid to Families with Dependent Children, food stamps, or medical assistance. Utility investments are not expected to be needed. Parks and recreation and fire protection should also be adequate for the projected increases in population.

As an example of the level of impacts that can be expected, Table 6.44, presents predicted enrollment and expenditure impacts for schools in the primary impact area. As can be seen in the table, the projected increase in school-age population is small enough in most areas that new investments would not likely be required. Nashville is a possible exception to this, depending upon how concentrated in particular schools the projected enrollment increases are. Similarly, the reduction in enrollments at the end of the life of the MRS facility can be expected to be small.

6.4.6.5 Special Socioeconomic Effects

As was discussed in greater detail with respect to the Clinch River and Oak Ridge sites, perceived MRS-related environmental risk might have negative effects on Hartsville area industries such as agriculture, tourism, and outdoor recreation, and on the Hartsville area's ability to attract new industry. The potential impacts of consumer avoidance at the Hartsville site are described in this section, following guidance from the studies cited in Section 6.2.6.5. While the Oak Ridge area is more familiar with nuclear facilities, such knowledge does not necessarily imply more local acceptance. Also, it is not likely that non-residents would view MRS any differently at the two sites. It is assumed for purposes of this analysis that negative consumer-avoidance impacts are equally as likely at Hartsville as at Clinch River and Oak Ridge because they depend upon public perception of the safety of the facility and because there is no basis to assume a difference in perception at the two sites.

TABLE 6.44. Impacts of a Sealed Storage Cask MRS Facility on Enrollment and Expenditures in Hartsville Primary Impact Area School Districts

School District	Construction[a] Enrollment Impact (number of pupils)	Construction[a] Expenditures Impact (thousand 1985 $)	Operations[b] Enrollment Impact (number of pupils)	Operations[b] Expenditures Impact (thousand 1985 $)	Decommissioning[c] Enrollment Impact (number of pupils)	Decommissioning[c] Expenditures Impact (thousand 1985 $)
Macon County	10	$ 14	4	$ 5	2	$ 3
Smith County	11	17	5	8	2	3
Sumner County	68	101	30	45	11	16
Trousdale County	28	45	12	19	5	8
Wilson County	5	7	2	3	1	1
Lebanon	35	54	16	25	6	9
Davidson County	553	1,298	245	575	93	218

(a) For peak construction year 1994.
(b) Average for years 2003 through 2016 (normal operations without sealed storage cask manufacturing).
(c) Average for years 2022 through 2025 (full-scale decommissioning).

Agriculture. Table 6.45 shows the estimated value of major crops produced in the Hartsville primary impact area in 1983, as well as the value of all crops and livestock sold in 1982 for these counties. Impacts, if any, would most likely be on milk, beef, and hogs. It is unlikely that avoidance effects, if any, would persist long enough for losses to be very large.

Outdoor Recreation. As described in Section 6.2.6.5, recreationists may avoid areas where environmental hazards are thought to be present, especially if fish and game are believed to be contaminated. The effect can be intense but is usually temporary, with recreation participation returning to normal levels within one year. Without detailed expenditure and participation data, estimating the economic impact of such avoidance is difficult; past studies (Kauffman 1980) suggest that losses to the local economy, if any, would be slight.

Tourism. Perceived environmental risk may reduce the Hartsville primary impact area's attractiveness as a recreation site. Past studies (see Section 6.2.6.5) have shown that impacts can occur if environmental risks appear to be potentially severe yet highly uncertain. Also, a recent State of Tennessee survey found significant concern over the MRS facility among tourists. Losses in the past generally have been temporary, even if the potential risk is not. A maximum one-year reduction (less than recent year-to-year fluctuations in total tourism expenditures) occurred at Three Mile Island during a highly publicized nuclear incident. Table 6.46 shows the size of annual travel-related expenditures and employment in the Hartsville primary impact area (U.S. Travel Data Center 1985).

Economic Development. As noted in Section 5.3.6, the local governments in the vicinity of the Hartsville site have been concerned with economic recovery after the cancellation of the Hartsville Nuclear Power Plants. A key feature of their recovery program is industrial recruitment. If the MRS facility should give the region the image of an environmentally hazardous area, this could impede industrial recruitment. A recent State of Tennessee study discussed in Section 6.2.6.5 indicates significant industrial concern over an MRS facility. As with the Clinch River/Oak Ridge sites, ancillary firms may also be drawn to the Hartsville area by the location of the MRS facility in the area.

Psychological Impact. There is some possibility of psychological impact from an MRS facility at Hartsville, but this is a function of perceptions of the facility that are hard-to-quantify. A more detailed discussion is contained in Section 6.2.6.5.

TABLE 6.45. Value of Selected Major Crops Produced in the Hartsville Primary Impact Area in 1983 (thousand 1983 \$)[a] (Tennessee Department of Agriculture 1984)

Crop	County					Subtotal	Davidson County	Total
	Macon	Smith	Sumner	Trousdale	Wilson			
Soybeans	\$ 829.5	\$ 213.3	\$ 2,022.4	\$ 142.2	\$ 355.5	\$ 3,562.9	\$ 711.0	\$ 4,273.9
Tobacco	6,367.5	5,981.2	8,106.0	2,985.2	2,716.1	26,156.0	434.4	26,590.4
Wheat	396.0	41.2	640.2	107.2	326.7	1,511.3	153.1	1,664.4
Corn	919.8	730.0	1,679.0	233.6	244.5	3,806.9	215.3	4,022.2
Milk[b]	3,845.9	1,627.1	4,881.3	887.5	4,585.5	15,827.3	1,109.4	16,936.7
Beef[c]	3,576.5	5,227.1	8,390.9	2,063.3	8,666.6	27,924.4	2,613.6	30,538.0
Hogs and Pigs[d]	1,137.8	1,052.4	1,706.8	256.0	1,166.3	5,319.3	256.0	5,575.3
Subtotal	\$17,073.0	\$14,872.3	\$27,426.6	\$ 6,675.0	\$18,061.2	\$ 84,108.1	\$ 5,471.7	\$ 86,600.9
Total 1982	\$18,811	\$19,429	\$43,133	\$10,321	\$26,799	\$118,493	\$19,432	\$137,925
Crops	\$12,623	\$ 9,639	\$22,802	\$ 6,499	\$ 8,432	\$ 59,995	\$ 9,180	\$ 69,175
Livestock	\$ 6,188	\$ 9,790	\$20,331	\$ 3,822	\$18,367	\$ 58,498	\$10,252	\$ 68,750

(a) Estimated from production and season average price, except where shown.
(b) Estimated from number of cows, average production per cow, and gross farm income per pound of milk produced (\$0.136 per pound of milk and milkfat).
(c) Estimated from statewide ratio of head of cattle and calves sold or consumed on farms to number of cattle and calves, ratio of gross income from marketings and farm marketings and farm consumption to total production of cattle and calves, and total head by county.
(d) Same as (c) for hogs and pigs.

TABLE 6.46. Tourism-Related Expenditures and Employment in the Hartsville Primary Impact Area (U.S. Travel Data Center 1985)

County	1984 Travel-Related Expenditures (thousand 1984 $)	1984 Travel-Related Employment (Jobs)
Macon	$ 595	11
Smith	720	12
Sumner	6,949	150
Trousdale	239	3
Wilson	13,388	312
SUBTOTAL	$ 21,891	488
Davidson	$1,028,068	24,320
TOTAL	$1,049,959	24,808

6.4.7 Resource Requirements

A natural gas pipeline passes through the northern section of the Hartsville site. This pipeline could be tapped for use at the site, as necessary.

Water pumping and treatment facilities located on the Cumberland River would serve the Hartsville site. A 1-million-gallon (3.8-million-L) per day pumping station and water filtration plant are located upstream from the site. Since only 60 to 70% of the plant capacity is being used, the existing water supply system may be able to provide water to the MRS facility.[a]

Additional resources required to build and operate the MRS facility are essentially the same for all three sites, differing only by storage design. These are given in Section 6.1, Impacts Common to All Sites.

6.4.8 Aesthetic Impacts

This section evaluates the aesthetic impacts of an MRS facility at the Hartsville site. Definitions of noise-level terminology and maps identifying visual access to the site are contained in Chapter 5.

(a) Communication between C. E. George of Ralph M. Parsons Co., and J. Merryman, Water Superintendent of Trousdale County Utility District,

6.4.8.1 Noise Levels

Noise levels are expected to be greatest during the construction phase. Sources of noise from the MRS facility are common to all sites and are discussed in Section 6.1.8.

The nearest resident at the Hartsville site lives at least 4,000 feet (1,200 m) from the acoustic center of the facility. During construction, intermittent noise and vibration from blasting could disturb residents within about 1 mile (1.6 km) of the site. Although no detailed studies of noise have been conducted, operation of the MRS facility is expected to produce noise levels of less than 44 dB at the nearest residences. Thus, estimated noise levels are clearly within the acceptable limit of L_{dn} = 55 dBA.

6.4.8.2 Visual Impacts

During construction and operation of the MRS facility, buildings and equipment will be visible offsite from various locations.

The site is visible from long distances as approached from the east on SR-25, the west on SR-25, the southwest on SR-141, and from the south on county roads. The concern of these viewers is not known. It is predicted that a significant number of local travelers will consider the site an intrusion into the agricultural landscape, but also as a source of economic benefits to the local economy. Therefore, the site's visual impact to local travelers is expected to be slight.

Forty to 50 homes have visual access to the site. These residents are likely to view the site as a disruption of the rural setting.

Viewers from the Cumberland River (Old Hickory Lake) will have several screened views of portions of the site through vegetation and full views of tall structures throughout most of the site. Recreationists on the river can be expected to find the view objectionable.

Objectives for management of the visual qualities of the Hartsville site have not been defined. However, it is estimated that most viewers of the site favor rehabilitation efforts aimed toward restoring the scenic qualities that existed prior to site development.

6.4.9 Transportation Impacts

The primary transportation impacts associated with the Hartsville MRS site may be divided into two distinct categories. The first category of impacts results from the shipment of spent fuel from reactor sites to the MRS facility and the shipment of spent fuel and associated wastes from the MRS to a repository. The second category of impacts results from the commuting labor force and from delivery of materials to the MRS site during its construction and operation. Impacts associated with the movement of spent fuel are represented in this section by cost, radiological impacts, and nonradiological impacts. Local traffic impacts from spent fuel shipments are represented in Section 6.4.9.1 by the estimated increase in the average daily traffic flow. Estimates of commuter traffic impacts at the Hartsville site are presented in Section 6.4.9.2.

6.4.9.1 Traffic Impacts from Spent Fuel Shipments

Traffic impacts from spent-fuel shipments are essentially the same for all three candidate MRS sites (see Section 6.2.9.1 for a description of these impacts). For local access onto the Hartsville site, two new rail lines would be constructed and an existing line would be upgraded for spent fuel transport. These rail lines are shown in Figure 6.14. A number of alternate shipment routes could be used; however, the maximum traffic from spent-fuel shipments along any route is expected to be less than eight trucks per day.

6.4.9.2 Traffic Impacts from MRS Construction, Operation, and Decommissioning

Local traffic to the Hartsville site can be expected to increase during all phases of MRS facility life. The largest impact on traffic would occur during the peak year of construction, 1994.

Two routes lead onto the site along SR-25. One route comes onto the site from the west via Hartsville, with traffic feeding in from Gallatin and other cities west of the site along US-31E, from Lebanon and other cities south of the site along US-231, and from Lafayette and other cities north along SR-10. The other route is from the east through Dixon Springs and Carthage. Based on the forecasted distribution of workers around the site and an assumed two workers per vehicle, Table 6.47 shows the distribution of increased traffic on roads near the site contrasted with existing conditions, assuming no new roads are constructed.

Table 6.47 indicates that there may be some commuting traffic problems along SR-25 to the west of the Hartsville site during peak construction. These problems would not be as severe as those experienced during construction of the Hartsville Nuclear Power Plant because the peak workforce would be much smaller (1,000 for MRS versus 6,600 for Hartsville Nuclear Power Plant). The level of impact would be highly dependent on the utilization of van pools and buses, as during the Hartsville Nuclear Power Plant construction period. The effect will

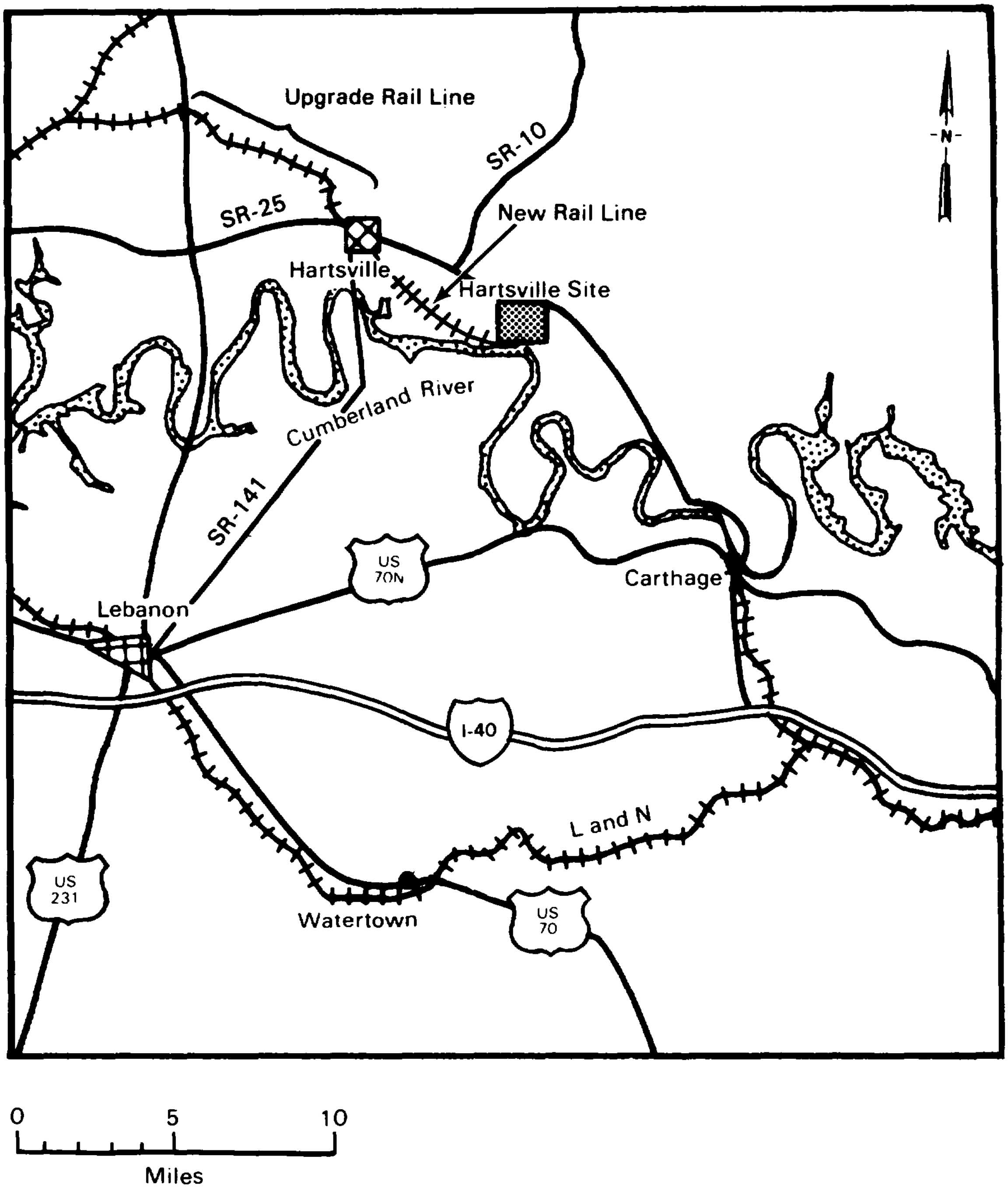

FIGURE 6.14. Transportation Routes to be Constructed and Upgraded for Access to the Hartsville Site

TABLE 6.47. Distribution of Projected and Existing Local Traffic for the Hartsville Site

Highway Segment	Additional Vehicles: Average Daily Traffic, 1994[a]	Present Annual Average Daily Traffic (both directions)[b]	Existing Peak-Hour Level of Service[c]
SR-25, east of SR-10	16	2,350	NA
SR-25, west of SR-10	1,000	5,180	NA
SR-10, north of SR-25	14	3,590	NA
SR-10/SR-25, east of SR-141	1,000	6,650	NA
SR-10/SR-25, west of SR-141	908	5,420	NA
SR-141, south of SR-10/SR-25	52	6,200	NA
SR-10/SR-25, east of US-231	908	4,740	NA
SR-10/SR-25, west of US-231	500	4,830	NA
US-231, south of SR-10/SR-25	408	3,010	NA

(a) One-half of the workers from Nashville, plus all workers from Hendersonville, and Gallatin are assumed to approach the site along US-31E and SR-25 from the west. Workers from Mt. Juliet and one-half of the Nashville workers are assumed to use US-231 and SR-25. Workers from Lebanon are assumed to use SR-141. Lafayette workers are assumed to use SR-10, while Hartsville and Carthage workers would likely use SR-25 from the west and east, respectively. The scenario assumes two workers per vehicle. Average traffic is twice the number of vehicles arriving at the MRS site.

(b) See Table 5.56, Chapter 5.

(c) Detailed service data were not available in the references cited. However, TVA (1982) reports that all segments were in at least Class D service at the end of construction of the Hartsville Nuclear Power Plants.

NA = Not available.

also be compounded by trucks carrying construction materials to the site. This was also a problem during Hartsville Nuclear Power Plant construction.

The traffic impacts may still be present during MRS operation if there is a concentrated number of commuters west of the site, but the smaller number of decommissioning workers is unlikely to have much effect. Hartsville Nuclear Power Plant construction caused marginal traffic congestion in 1977 with 3,450 employees and 4.5 workers per vehicle (this average vehicle occupancy was high due to heavy utilization of van pools) (TVA 1978).

6.4.9.3 Cost Impacts

The total costs associated with shipping spent fuel from reactors to the Hartsville site and then to potential repository sites are presented in Tables 6.48 and 6.49. The cost impacts for the Hartsville site are essentially the same as those described in Section 6.2.9.3 for the Clinch River site.

6.4.9.4 Radiological Impacts

Radiological impacts to the public and transportation work force are presented in Tables 6.50 and 6.51. The transportation radiological impacts for the Hartsville site are essentially the same as those described in Section 6.2.9.4 for the Clinch River site.

6.4.9.5 Nonradiological Impacts

Nonradiological transportation impacts (health effects) include fatalities from pollutants generated by burning diesel fuel needed to move the shipments, and traumatic deaths and nonfatal injuries from traffic accidents involving spent-fuel shipments. The number of traumatic deaths and nonfatal injuries are based on accident statistics evaluated for truck and trailer vehicles similar

TABLE 6.48. Total 26-Year Transportation Costs for Shipping Spent Fuel from All Reactors to the Hartsville Site and then to a Repository (million 1985 $)

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	1,600	1,200	1,600	1,200
Hanford	1,500	1,000	1,500	1,000
Deaf Smith and Swisher	1,300	930	1,300	930
Davis and Lavender	1,400	970	1,400	970
Richton and Cypress Creek	1,100	840	1,100	840
Vacherie	1,100	860	1,100	860

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

TABLE 6.49. Total 26-Year Transportation Costs for Shipping Spent Fuel from Only Eastern Reactors to the Hartsville Site and then all Spent Fuel to a Repository (million 1985 $)[a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	1,400	1,000	1,400	1,000
Hanford	1,300	940	1,300	940
Deaf Smith and Swisher	1,200	890	1,200	890
Davis and Lavender	1,300	900	1,300	900
Richton and Cypress Creek	1,100	840	1,100	860
Vacherie	1,100	860	1,100	860

(a) Western reactor spent fuel is assumed to be shipped directly to repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

TABLE 6.50. Total 26-Year Radiological Impacts from Shipping Spent Fuel from all Reactors to the Hartsville Site and then to a Repository (person-rem)

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	1.1×10^3	9.4×10^2	6.5×10^3	6.4×10^3
Hanford	1.1×10^3	9.1×10^2	7.4×10^3	7.3×10^3
Deaf Smith and Swisher	9.7×10^2	8.4×10^2	6.2×10^3	6.0×10^3
Davis and Lavender	1.0×10^3	8.5×10^2	6.2×10^3	6.0×10^3
Richton and Cypress Creek	8.6×10^2	7.7×10^2	6.1×10^3	6.0×10^3
Vacherie	8.4×10^3	7.7×10^2	6.0×10^3	6.0×10^3

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

TABLE 6.51. Total 26-Year Radiological Impacts from Shipping Spent Fuel from Only Eastern Reactors to the Hartsville Site and then All Spent Fuel to a Repository (person-rem)[a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	9.8×10^2	8.6×10^2	5.5×10^3	5.4×10^3
Hanford	1.0×10^3	8.6×10^2	5.7×10^3	5.5×10^3
Deaf Smith and Swisher	9.1×10^2	8.0×10^2	5.9×10^3	5.8×10^3
Davis and Lavender	9.3×10^2	8.1×10^2	5.5×10^3	5.4×10^3
Richton and Cypress Creek	8.8×10^2	8.1×10^2	6.8×10^3	6.7×10^3
Vacherie	8.4×10^2	7.8×10^2	6.3×10^3	6.3×10^3

(a) Western reactor spent fuel is assumed to be shipped directly to a repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

to those that would be used to transport spent fuel to an MRS site (Smith and Wilmot 1982). Occupational nonradiological impacts are included in the total impact estimates presented in Tables 6.52 and 6.53. The total 26-year impacts are lower for the Hartsville site than for corresponding nonradiological impacts described in Section 6.2.9.5 for the Clinch River and Oak Ridge sites.

The total number of fatalities over 26 years of operation ranges from four to 27 for 30% truck/70% rail and from two to 26 for 100% rail shipments. The number of nonfatal injuries to members of the public is in the range of 48 to 280 for 30% truck/70% rail and 23 to 250 for 100% rail shipments.

TABLE 6.52. Total 26-Year Nonradiological Impacts from Shipping Spent Fuel from All Reactors to the Hartsville Site and then to a Repository [fatalities (injuries)]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[a]	150-Ton Cask[a]	100-Ton Cask[a]	150-Ton Cask[a]
Yucca Mountain	26(250)	10(110)	27(280)	12(140)
Hanford	22(230)	6.6(68)	23(260)	8.2(100)
Deaf Smith and Swisher	14(140)	4.1(42)	15(180)	5.7(77)
Davis and Lavender	19(190)	5.5(56)	20(220)	7.1(91)
Richton and Cypress Creek	6.8(71)	2.4(25)	8.4(110)	4.0(60)
Vacherie	6.8(71)	2.4(25)	8.4(110)	4.0(60)

(a) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from MRS to repository.

TABLE 6.53. Total 26-Year Nonradiological Impacts from Shipping Spent Fuel from Only Eastern Reactors to the Hartsville Site and All Spent Fuel to a Repository [fatalities (injuries)][a]

Repository Site	100% Rail to MRS		30% Truck/ 70% Rail to MRS	
	100-Ton Cask[b]	150-Ton Cask[b]	100-Ton Cask[b]	150-Ton Cask[b]
Yucca Mountain	20(210)	8.5(90)	22(240)	10(120)
Hanford	19(200)	5.6(59)	21(220)	7.5(84)
Deaf Smith and Swisher	12(120)	3.5(37)	14(140)	5.4(62)
Davis and Lavender	16(160)	4.8(49)	18(190)	6.7(74)
Richton and Cypress Creek	5.9(63)	2.2(24)	7.8(88)	4.1(48)
Vacherie	5.9(62)	2.2(23)	7.8(87)	4.1(48)

(a) Western reactor spent fuel is assumed to be shipped directly to a repository.
(b) 100-ton and 150-ton casks are conceptual rail casks for shipping consolidated fuel rods and associated waste from the MRS to a repository.

6.5 SUMMARY OF IMPACTS ASSOCIATED WITH SITE-DESIGN COMBINATIONS

The three sites that have been identified by DOE as candidate sites for an MRS facility (all in Tennessee) are at the Clinch River Breeder Reactor site, (Clinch River site) the DOE Oak Ridge Reservation (Oak Ridge site), and the Tennessee Valley Authority's (TVA's) Hartsville Nuclear Power Plant site (Hartsville site).

The two proposed facility designs examined in this report differ in the mode of storage. In the sealed storage cask design, canisters of spent fuel are stored in large concrete cylinders placed upright on concrete pads. In the field drywell design, each canister of spent fuel is stored in an in-ground sealed, metal enclosure.

The following discussion summarizes and compares the projected environmental impacts of constructing, operating, and decommissioning an MRS facility for the six-design combinations. These incremental impacts are estimated for a bounding annual throughput of up to 3,600 MTU. Since the planned throughput is about 2,500 MTU per year, use of the design throughput of 3,600 MTU per year yields conservative results. In addition, transportation impacts are estimated for a total 26-year throughput of 62,000 MTU. Most impacts vary only slightly among the three candidate sites and two storage designs; exceptions to this are noted, and relative advantages and disadvantages are identified.

6.5.1 Radiological Impacts

The radiological impacts for the six site-design combinations are compared here for operation and transportation activities related to the MRS. Decommissioning activities are not included because no radioactive releases could be identified. During construction, small amounts of naturally occurring radon will be released during soil excavation. Preliminary analysis shows that these releases would result in radiation doses that are orders of magnitude below regulatory limits. Therefore, radiological impacts from construction are not detailed in this report.

Table 6.54 presents a summary of radiological impacts to the public for normal operation, postulated operational accidents, and transportation for the six site-design combinations. The doses to an individual are below annual regulatory limits [0.025 rem annually to the maximally exposed individual for normal operations and 5 rem for any design basis accident (10 CFR 72)]. For normal operations, the dose to the maximally exposed individual for normal operations from transportation is not expected to exceed 0.005 rem from each prolonged exposure event (see Appendix F, Tables F.28 and F.29).

TABLE 6.54. Summary of Radiological Impacts Associated with an MRS Facility as Compared with Natural Background Radiation

	Sealed Storage Cask			Field Drywell		
Activity/Population Group	Clinch River	Oak Ridge	Hartsville	Clinch River	Oak Ridge	Hartsville
Normal Operations (Annual Dose)						
Maximally exposed individual (rem)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Population (person-rem)	20	20	20	20	20	20
Natural Background at the Site (person-rem)[a]	160,000	160,000	120,000	160,000	160,000	120,000
Operational Accident[b]						
Maximally exposed individual (rem)	0.0044	0.022	0.0027	0.17	0.29	0.075
Population (person-rem)	0.03	0.03	0.03	0.5	0.6	0.5
Transportation (Annual Dose)[c]						
Population (person-rem)	200	200	200	200	200	200
Natural Background Along Transportation Route (person-rem)[d]	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Transportation Accident[e]						
Maximally exposed individual (rem)	60	60	60	60	60	60

(a) Values reported for background represent the annual dose received by the local population (within 50 miles) from natural sources. Population values represent the dose received from one year of normal operation by the same population group. The individual doses represent the dose received by the maximally exposed individual (usually the nearest resident).

(b) The worst operational accident for the sealed storage cask design is a fuel assembly drop in the R&H building. For the field drywell design, the worst operational accident is a canister shearing incident. (See Section 6.1.1.3 for a description of these and other accidents).

(c) The transportation impacts result from spent fuel shipments to the MRS site and then to a geologic repository site. The impacts are from routine exposure estimates for a bounding scenario (3600 MTU/year by 30% truck/70% rail).

(d) Values reported for background represents the annual dose received by the population located within 800 m (0.5 miles) of the projected truck and rail spent-fuel shipment routes. The estimated population is 10-15 million and the average background radiation dose is 0.1 rem/person-year (i.e., 10 million people multiplied times 0.1 rem/person-year equals 1 million person-rem).

(e) This severe transportation accident has a probability of about one in one million accidents (Wilmot et al. 1983). It is assumed that the cask contains 84 PWR fuel assemblies (150-ton cask).

The estimated doses from postulated accidents indicate the nature of the waste being handled and the operations being performed at the MRS. The spent fuel and high-level waste are not involved in any operations that require the use of or the production of high levels of energy. Therefore, no activities would initiate or contribute to large releases of radionuclides to the environment.

Radiological transportation impacts from transportation would occur for the currently authorized waste management system (i.e., spent fuel is shipped directly from the reactors to a repository). In all cases, the population doses are less than 0.1% of the dose received by the indicated population group from background radiation.

Individuals are exposed daily from a variety of natural and human-induced radiation sources. Table 6.55 lists some of these sources and the approximate annual dose received by the public (NCRP 1977).

6.5.2 Air Quality Impacts

Air quality impacts are based on emissions from "worst case," or maximum impact, for each phase of activity at the site.

Preconstruction and construction activities are expected to degrade, temporarily, the ambient air quality in the immediate vicinity of the site. A preliminary assessment indicates that short-term total suspended particulate (TSP) standards may be exceeded at the fenceline at all three sites due to fugitive dust from land disturbance and heavy vehicle traffic. During the preparation of the site, extensive blasting, rock crushing, and earth-moving activities may lead to an exceeding of the 24-hour TSP concentration standard on numerous occasions. A summary of emission rates from construction and

TABLE 6.55. Radiation Exposure from Various Sources (NCRP 1977)

Average Annual Source	Dose (rem)	Number of People Exposed
Television receivers (color, pre-1970 sets)	0.0002 - 0.0015	100 million
Airport inspection systems	0.000022	10 million
Transcontinental airline flight	0.0025/flight	
Building materials	0.007	100 million

operation of an MRS facility is given in Table 6.56. Combustion products produced by mobile sources (construction vehicles) cause concentrations in air which are projected to be within regulatory limits (see Appendix G).

Table 6.56 shows that during operation of the MRS facility, no significant quantities (defined in 40 CFR 51) of emissions are anticipated for any stationary source.

Waste heat generated by the facility is expected to include about 22 MW from the storage area and 25 MW (rated capacity) from the cooling tower. This is less than the waste heat generated by the primary aluminum smelter plant located near Knoxville. Environmental effects from waste heat are difficult to predict. No perceptible changes in the downwind environment are anticipated.

Decommissioning activities do not include major demolition. Regrading will be necessary only on the drywell field. Therefore, potential air quality impacts from postulated decommissioning activities are greater for the field drywell design.

6.5.3 Water Quality and Use Impacts

Water from surface sources used during the MRS preconstruction phase is a negligible fraction of the surface water resources available from the Clinch and Cumberland Rivers.

Water use during construction is primarily for dust control (90%) and concrete production. The use rate during construction is estimated to be less than 0.5 cfs (0.01 m^3/sec). This is a small fraction of the mean flow rates of the Clinch and Cumberland rivers, which are 5,380 cfs (150 m^3/sec) and

TABLE 6.56. Estimated Emissions from Construction and Operation and EPA's "Significant" Levels for Emission from 40 CFR 51 (ton/yr)

Pollutant	Annual Emissions: Construction[(a)]	Annual Emissions: Operation[(b)]	Significant Level
TSP	>50	<5	25
NO_x	--	9	40
SO_x	--	15	40
CO	--	3	100

(a) Mobile sources are not included.
(b) Includes boiler emissions and TSP from adjacent cask manufacturing plant.

17,000 cfs (480 m^3/sec), respectively. The flow rates of these rivers are variable, controlled by TVA dams. During construction, water quality could be temporarily degraded from high suspended-solids content of the runoff. This will be mitigated by settling solids in runoff ponds prior to discharging the water to surface waters.

During operation of the MRS facility, the maximum water requirement will be 365,000 gallons (1.4 million L) per day at summer cooling rates. Cooling tower make-up (73%) and boiler feedwater make-up (19%) account for most of the plant water requirement.

The MRS facility is designed so that there are no radioactive waterborne effluents. (All radioactive waste water generated onsite will be evaporated and the residue incorporated into a solid waste form for disposal offsite.) Nonradioactive water from operations [22,500 gallons (85,000 L) per day] and sanitary sewage water [14,000 gallons (53,000 L) per day] will be treated and discharged offsite and released to surface water.

Effluents from waste water treatment will meet the State of Tennessee and United States EPA standards for industrial waste-water disposal and municipal and domestic waste-water disposal. Because all waste-water streams are to meet all applicable standards, effluents are expected to have minimal impact on surface water or ground water quality.

Water use during decommissioning is projected to be less than that used during operation of the facility. Water use would be greater for the field drywell facility, which would use water for dust control during regrading of the drywell field.

6.5.4 Ecological Impacts

The largest ecological impact at any of the three sites will be the clearing of land and subsequent loss of this land to production and ecological processes. At both the Clinch River and Hartsville sites, significant portions of the area have already been impacted by previous construction; thus, the loss of natural habitat will be less at these sites than if the facility were sited at Oak Ridge.

The MRS facility should cause little impact on the archaeological resources of the sites. Many archaeological sites have already been disturbed by earlier construction activities at Clinch River and Hartsville. Those sites that have not been disturbed previously but which might be impacted by an MRS will be studied prior to construction.

There should be little impact to rare or endangered species. Such species occurring at the site include: at the Clinch River site, the plants black snakeroot (Cimicifuga rubifolia Kearney), ginseng (Panax quinquifolius Linnacus), and Carey's saxifrage (Saxifraga careyana Gray); and at the Hartsville site, the gray bat (Myotis grisencens). No complete survey for the occurrence of rare and endangered species at the Oak Ridge site has been conducted; such a survey will be needed. Should any of the rare species be encountered, provisions will be made for their protection and preservation.

6.5.5 Land Use Impacts

Construction of a sealed storage cask facility will require 303 to 320 acres (123 to 130 ha) of land, and a field drywell facility will require 410 to 465 acres (170 to 190 ha). Commitment of a site will render natural resources on or near the site unavailable for other purposes for the lifetime of the facility. No valuable or rare mineral resources are known to exist at any of the three sites.

6.5.6 Socioeconomic Impacts

The socioeconomic impacts of an MRS facility include standard socioeconomic effects common to all industrial development projects and two types of nonstandard socioeconomic effects that depend on the unusual nature of the facility. Standard socioeconomic impacts occur because of direct employment at the facility and expenditure by the facility for goods and services. The employment created by the demand for goods and services, and their indirect and induced effects on the local economy result in net immigration and create additional demands on housing and other community services. Nonstandard socioeconomic impacts occur because of unusual characteristics of the MRS facility. The first type of non-standard socioeconomic effect is the "federal industry" effect. Although the DOE has proposed that payments equivalent to taxes be made to local government, under current law a federal MRS facility would not be taxable and would not directly contribute revenues to local government to offset local government expenditures caused by project-related population in contrast to private-sector industrial facility of the same size. Moreover, the MRS facility may preempt some types of private economic development due to its adverse impact on the local tax base and its occupancy of a prime industrial site. The second type of nonstandard socioeconomic effect is the potential for a nuclear facility to be perceived as less environmentally acceptable to the public than other industry. This perception, accurate or not, might cause avoidance of the local area's crops, tourist facilities, and outdoor recreation opportunities and may make economic development more difficult because of reduced environmental amenities to the labor force.

Table 6.57 summarizes some of the key standard socioeconomic effects of the sealed storage cask MRS facility on the two primary impact areas. The impacts of a field drywell facility would be similar. Standard socioeconomic

TABLE 6.57. Summary of Standard Socioeconomic Effects of a Sealed Storage Cask MRS Facility[a]

Impact Area/ Socioeconomic Factor	Peak Construction Year Impact	Average Operating Year Impact	Average Decommissioning Year Impact
Clinch River/Oak Ridge primary impact area (including Knox County)			
Employment	2,800	1,200	480
Income (million 1985 $)	$78	$40	$16
Population	5,100	2,000	1,200
School enrollment	840	320	140
Local government revenues (million 1985 $)	$4.7	$2.0	$1.1
Local government expenditures (million 1985 $)	$4.3	$1.7	$0.9
Hartsville primary impact area (including Davidson County)			
Employment	2,700	1,300	600
Income (million 1985 $)	$76	$42	$18
Population	4,200	1,900	1,000
School enrollment	710	310	120
Local government revenues (million 1985 $)	$3.0	$1.5	$0.7
Local government expenditures (million 1985 $)	$3.7	$1.6	$0.8

(a) Includes all direct, indirect, and induced effects. Values are rounded to two significant figures.

effects outside primary impact areas are expected to be too diffused to be noticeable. As can be seen from the table, peak construction year employment impacts in the primary impact area would be about 2,700 to 2,800 people, about 1,000 of whom would be directly employed at the facility. During operations, the average impact would be about 1,200 to 1,300 jobs, of which 650 would be directly employed. If the proposed project were to draw migrants into the area in the same manner as previous projects, the peak increase in population would be about 5,100 in the five-county primary impact area surrounding the Clinch

River/Oak Ridge site (Anderson, Roane, Morgan, Loudon, and Knox Counties) and 4,200 in the Hartsville primary impact area (Macon, Smith, Sumner, Trousdale, and Davidson Counties). During operations, the respective differences would be 2,000 and 1,900 persons. These population increases are expected to be drawn toward the regional economic centers of Knoxville and Nashville. In most cases even the peak population impact on individual cities is expected to be only about 1% of today's population. About one-half the impact is due to the facility's purchases of goods and services. If, contrary to the assumptions made in this analysis, these purchases are mostly made outside the area or even out-of-state, the impacts would be correspondingly smaller.

Table 6.57 also shows the impacts of the facility on personal income, school enrollments, and local government revenues and expenditures. These impacts are also expected to be concentrated on Knoxville and Nashville, respectively.

The government revenue impacts of MRS assume current law, under which the MRS facility is not taxable. At the Clinch River/Oak Ridge site in particular, continued and expanded reliance on the federal government as the primary employer has negative implications for the tax base of the City of Oak Ridge and for Roane County. A non-taxable MRS facility would preempt a scarce industrial site, narrowing the city's already-narrow property tax base and potentially undermining its ability to provide high-quality public services. The local government's Clinch River MRS Task Force has computed annual foregone tax revenue to the city alone of $4.5 to 5.7 million (counting county taxes, about $10 million). This is only the direct effect. Because an industrial site is preempted and additional government services may have to be provided without offsetting government revenue, local tax rates might have to be increased, further indirectly reducing the city's ability to attract new private economic development.

Similar foregone tax and development data is not available for Trousdale County, the local government jurisdiction containing the Hartsville site. However, the value of the facility, if taxable, would increase Trousdale County's existing property tax base over 10 times. The MRS facility could preempt the Hartsville site as TVA power property, jeopardizing annual in-lieu-of-tax payments totalling $0.9 million per year to primary impact area governments. No data are available to compute the extent of indirectly lost economic development resulting from "federal industry" effects for either MRS site.

Special socioeconomic impacts of MRS, if they occur at all, are expected to be small and temporary. Existing literature relates mainly to the effects of accidents having potential adverse health effects rather than routine operations without accidents. However, the tone and extent of publicity regarding the MRS facility would be a significant intervening factor. The available literature suggests that any economic losses due to risk avoidance by tourists, recreationists, and consumers of agricultural products are temporary, lasting up to a year (Pennsylvania Governor's Office 1979; Griswold 1972; Kauffman 1980; PDC 1979b, 1980).

Local concerns over the effects of an MRS facility on tourism and industrial recruitment have support in the results of two surveys recently completed on behalf of the state of Tennessee (see Section 6.2.6.5). In those surveys, a significant number of potential tourists indicated a desire to avoid the MRS site, and several business leaders indicated that they would not locate in a county having an MRS facility, even with compensation. What their actual behavior would be is unknown; however, in the case of business investment the negative effect of lost recruitment, if any, could occur before MRS facility construction.

There is potential for attracting ancillary firms specializing in remote handling, robotics applications in harsh environments, high-level equipment quality assurance, monitoring and survey instruments, remote heavy loading, and transport cask maintenance. The location of these firms is unknown; not all of them would necessarily be near the MRS site.

6.5.7 Resource Impacts

Resources required to build the facility include fuel, concrete, and steel. The quantities required are similar to any large construction project. Resource requirements for construction and operation of a sealed storage cask facility and for a field drywell facility are summarized in Table 6.58. These resources would be obtained from both local and national markets and are expected to have a positive economic impact.

Water and power sources already exist near all of the sites. The Clinch River and Oak Ridge sites would be able to access necessary water from the ORGDP and the Hartsville Site would obtain water from an existing pumping station. Transmission lines and natural gas lines near all of the sites could be tapped.

6.5.8 Aesthetic Impacts

Aesthetic impacts of the MRS site are discussed in terms of projected noise levels and visual impacts.

6.5.8.1 Noise

The EPA, deriving authority from the Noise Control Act of 1972, identified noise levels on the basis of protecting "the public health and welfare within

TABLE 6.58. Resource Requirements for Construction and Operation of an MRS Facility

Resource	Sealed Storage Cask Construction	Sealed Storage Cask Operation[a]	Field Drywell Construction	Field Drywell Operation[a]
Land (to fenceline)	303 to 320 ac	--	410 to 465 ac	--
Energy[b]				
Fuel oil	63,000 gal/yr	952,000 gal/yr	63,000 gal/yr	952,000 gal/yr
Diesel	210,000 gal/yr	110,000 gal/yr	210,000 gal/yr	110,000 gal/yr
Gasoline	325,000 gal/yr	75,000 gal/yr	325,000 gal/yr	75,000 gal/yr
Electricity	5,000 MW-hr/yr	144,000 MW-hr/yr	5,000 MW-hr/yr	144,000 MW-hr/yr
Concrete	200,000 yd^3	33,900 yd^3	200,000 yd^3	5,000 yd^3
Steel	23,000 tons/yr	10,300 tons/yr	22,000 tons/yr	4,500 tons/yr
Water	85 mgy	134 mgy	107 mgy	130 mgy

(a) Resources used during loading operation for 3,600 MTU/yr.
(b) No additional steel and concrete and little additional energy and water are used during storage without receiving and handling functions.

an adequate margin of safety" (EPA 1974). Noises originating at each site would be attenuated by distance and natural barriers. Although no studies of noise from the facility have been performed, levels at nearby residences are generally not expected to exceed a day/night sound level of 55 dB, a level designed to protect from interference and annoyance during operation and most of the construction period. However, during site preparation, these levels may be exceeded during extensive blasting and rock-crushing operations. Intermittent noise during periods of blasting may cause annoyance to nearby residents within 1 mile (1.6 km) of the site.

6.5.8.2 Visual

The largest building at the facility will be the R&H building, a concrete structure, 97 feet (30 m; about 9 stories) high. (See Figure 4.1 for the conceptual appearance of an MRS facility at Clinch River.) The main stack, which is 165 feet (50 m) above ground level, is on top of the R&H building. The 36-acre (14 ha) storage area of this facility will consist of an array of concrete casks about 22 feet (6.7 m) tall.

A field drywell facility will have buildings similar to a sealed storage cask facility. The storage area, although larger than that of the cask facility [about 93 acres (38 ha)], will have no visible structures.

An MRS facility at the Clinch River site will be visible from the Clinch River, some sections of highway, and several residences. A facility located at the Oak Ridge site would be visible from roads, mainly for commuters to the ORNL. A facility at Hartsville would be visible from several locations, including roads and residences around the site and from the Cumberland River.

6.5.9 Transportation Impacts

Transportation impacts were assessed in terms of total costs, traffic, radiological exposures, and nonradiological impacts. For "bounding case" analyses, shipments to the MRS were assumed to be either 100% rail or a split of 30% truck and 70% rail. All shipments from the MRS to a repository will be by dedicated trains. Transportation impacts include both reactors-to-MRS and MRS-to-repository.

6.5.9.1 Costs

Shipping, maintenance, and capital equipment costs were examined for transporting spent fuel to candidate MRS sites and then to a repository. For shipment from the reactors to the MRS site, costs are nearly identical for either truck or rail shipments. The total costs will be higher by 30% to 50% if rail shipments to the repository are accomplished with 100-ton (loaded weight) casks rather than 150-ton casks. For a given repository location, the total costs (about $1.6 billion over the 26-year operating period) are essentially the same for all three candidate MRS sites because of their geographic proximity. However, MRS-to-repository shipping costs depend on both the rail cask capacity and distance to the repository.

6.5.9.2 Traffic Impacts

A maximum of either 550 trains for 100% rail or 1,100 trucks and 400 trains for the 30% truck/70% rail split would be received at the MRS facility each year at a bounding receipt rate of up to 3,600 MTU per year. The annual number of rail shipments required to transport consolidated spent fuel to a repository will be approximately 30, depending mostly on the shipping cask capacity. Up to 500 additional commuter vehicles per day may utilize some roads near the sites during peak construction.

6.5.9.3 Radiological Impacts

Radiological impacts to the public include both exposure to radiation from the package as the shipment is in transport and a potential exposure to radiation emitted by radionuclides that might be released from the radioactive package if the shipment is involved in an accident.

Total radiological impacts are significantly higher for the mixed 30% truck/70% rail shipments than rail shipments. However, for either the truck or rail mode of transport, the total radiological impacts are essentially the same for each of the three alternative MRS sites, due to the geographic proximity of the three sites. Also, the total radiological impacts are essentially the same for the nine potential repository sites that were included in the analysis, because the reactor-to-MRS transportation leg dominates the results of the analysis.

6.5.9.4 Nonradiological Impacts

Nonradiological transportation impacts (health effects) include fatalities from pollutants generated by diesel fuel burned in the transport of shipments, and traumatic deaths and nonfatal injuries from traffic accidents involving spent fuel shipments.

The total nonradiological impacts are 10% higher for the mixed 30% truck/70% rail shipments than for 100% rail shipments. However, for either the truck or rail mode of transportation, the total nonradiological impacts are essentially the same for the three sites because of their geographic proximity.

6.5.10 Relative Advantages and Disadvantages of the Six Site-Design Combinations

The relative advantages and disadvantages of each of the six alternative site design combinations are discussed below.

The sealed storage cask and the field drywell designs each produce similar effects for most of the variables examined in this EA. In general, relative advantages and disadvantages are evident only among the three sites. For example, the Clinch River and Hartsville sites have an advantage in that they are more well characterized than the Oak Ridge site (PMC 1975; TVA 1974).

In addition, the projected impacts for all site-design combinations were found by the DOE to be environmentally acceptable (i.e., each complies with applicable regulations). No single site-design combination emerged as being noticeably better or worse than others, based on total environmental impacts.

6.5.10.1 Radiological Factors

The total estimated radiological impacts (to the population) from the MRS facility are consistently less than 1% of natural background radiation. The doses to an individual are below annual regulatory limits. Therefore, the DOE determined that radiological impacts for each site-design combination did not exhibit an advantage over any other site-design combination.

6.5.10.2 Air Quality Factors

Calculations for the six site-design combinations show that, with the exception of total suspended particulates during construction, each would meet federal air quality standards. For TSP, the 24-hour maximum may be exceeded during the construction phase for all site-design combinations.

The air quality impacts for the various combinations of sites and concepts are mainly a function of air dispersion factors for each site. Since these dispersion factors do not differ significantly among the three sites, the DOE determined that no site-design combination exhibited an advantage over the other site-design combinations regarding air quality.

6.5.10.3 Water Quality and Use Factors

Only nonradioactive liquid effluents (operations waste water and sanitary waste water) will be discharged from the MRS facility. Since these effluents are treated to comply with federal and state standards, they are considered safe and would be similar for all site-design combinations.

6.5.10.4 Geotechnical Factors

The ground-water level at all sites is above or very near the depth required for the drywell at various locations on the sites. However, it is estimated from available information on ground-water depth and hydrogeologic conditions at the Clinch River and Hartsville sites that areas with depth to ground water greater than 30 feet (9.1 m) that are large enough to accommodate the current site layout of the field drywell design can be found. Hydrogeologic investigations at the Oak Ridge site have not been carried out to the extent that they have for the Clinch River and Hartsville sites. Therefore, areas with depth to ground water of greater than 30 feet (9.1 m) cannot be delineated without further characterization of the site.

6.5.10.5 Ecological Impacts and Land Use

The Clinch River site appears to have a relative ecological and land use advantage in that some of the site is already disrupted from previous construction activities. The area already disrupted constitutes about half of the 303 acres (123 ha) required for the sealed storage cask design, and about one-fourth of the 465 acres (188 ha) required for the field drywell design. A relative disadvantage is that this site is closest to known populations of endangered and threatened plants.

No relative ecological advantage was identified for the Oak Ridge site. A relative disadvantage is that this is the only site considered that does not have previously disrupted land. From 320 to 415 acres (130 to 168 ha) of land would have to be cleared.

The relative advantage of the Hartsville Site is that the land has previously been disrupted, and the disrupted land covers more area than the Clinch River site. Three-fourths of the 320 acres (130 ha) that would be required for the sealed storage cask design have already been cleared. Of the 410 acres (166 ha) required for the field drywell design, over 80% has already been cleared. No relative ecological disadvantages were identified.

6.5.10.6 Socioeconomic Impacts

For the purpose of assessing socioeconomic impacts, the Oak Ridge and Clinch River sites were considered as one area because of their proximity to each other [about 6 miles (9.6 km)]. Many of the standard socioeconomic impacts (e.g., population increase) described can be interpreted as either advantages or disadvantages. These impacts are virtually the same for all design concepts and sites.

The Clinch River/Oak Ridge region may have a greater technical labor force available locally, while the Hartsville site may have a greater construction labor force (if Nashville is included in the comparison).

The Hartsville area has a lower assessed value per capita, more pupils per teacher, lower expenditures per pupil, and fewer medical staff per capita. In addition, some nearby cities have sewage systems already near capacity.

Both the Hartsville and the Clinch River/Oak Ridge areas would benefit from the increased employment generated by an MRS facility.

Because of its history as a federal town, the City of Oak Ridge has particular difficulty in developing a conventional industrial base and may require special mitigative measures. In the case of Hartsville, it may be necessary to replace TVA in-lieu-of-tax payments.

The issues associated with siting of a nuclear facility, particularly one that will handle significant quantities of spent fuel, are basically common to all sites. However, there exists a more extensive history of local issues and interactions for the Clinch River and Oak Ridge sites than for the Hartsville site.

6.5.10.7 Aesthetic Impacts

The Oak Ridge site may be relatively advantageous because nearby residential areas are protected from view and noise by trees and hills. The Clinch River and Hartsville sites are visible from offsite residential and recreational vantage points.

6.5.10.8 Transportation Impacts

For the impacts assessed in this report (radiological, nonradiological, cost, and traffic impacts), no net advantages or disadvantages are evident among the six site-design combinations.

Each of the sites would require a few miles of new railroad, and each site could experience traffic congestion if the existing roads are not improved.

6.6 REFERENCES

American National Standards (ANS). 1982. American National Standard Method for Calculating the Release of Fission Products from Oxide Fuel. ANSI/ANS-5.4, American Nuclear Society.

Bailey, W. J. 1983. "Experience with Fuel Damage Caused by Abnormal Conditions in Handling and Transporting Operations." In *Proceedings of the Seventh International Symposium on Packaging and Transportation of Radioactive Materials*, Vol. I. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Baum, A., et al. 1980. *Psychological Stress for Alternatives of Decontamination of TMI-2 Reactor Building Atmosphere*. NUREG/CR-1584, U.S. Nuclear Regulatory Commission, Washington, D.C.

Baum, A., R. Fleming and L. M. Davidson. 1983. "Natural Disaster and Technological Catastrophe." *Environment and Behavior*. 15(3):333-354.

Campbell, J. M. 1983. "Ambient Stressors." *Environment and Behavior*. 15(3):355-380.

Daugherty, L. E. 1964. "Tuna's Time of Trouble." *Food Business*. January 1964, pp. 28-34.

Edison Electric Institute (EEI). 1978. *Electric Power Plant Environmental Noise Guide*. New York, New York.

Freeman, T. A., E. C. Harvey, T. R. Lyman and D. G. Ousterhout. 1984. *Analysis of Annual Assistance Issues: City of Oak Ridge, Anderson and Roane Counties, Tennessee*. DOE/OR/2134--T2, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee.

Frye, J. 1976. "Virginia Industry is Likely Victim of Kepone." *National Fisherman*. October 1976, p. 15-A.

Funk, C. W., and L. D. Jacobson. 1979. *Inventory and Characterization of Spent LWR Fuel*. HEDL-TME 77-82, Hanford Engineering Development Laboratory, Richland, Washington.

Goldhaber, M. K., P. S. Houts and R. DiSabella. 1983. "Moving After the Crisis: A Prospective Study of Three Mile Island Area Population Mobility." *Environment and Behavior* 15(1):93-120.

Griswold, D., ed. 1972. "Combatting Alleged Danger of a Product." *Public Relations News* 18(21), May 22, 1972.

Hannson, R. O., D. Noulles and S. J. Bellovich. 1982. "Knowledge, Warning, and Stress: A Study of Comparative Role in an Urban Floodplain." *Environment and Behavior* 14(2):171-185.

Hickey. 1981. Impact of the 1979 Accident at Three-Mile Island Nuclear Station on Recreational Fishing in the Susquehanna River. NUREG-0754, U.S. Nuclear Regulatory Commission, Washington, D.C.

Houts, P. S., et al. 1980. Health-Related Behavioral Impact of the Three Mile Island Nuclear Incident. Part I. Pennsylvania Department of Health, Harrisburg, Pennsylvania.

Huppert, K. L. 1978. "Spent Fuel Storage--Philosophies and Experience." In Proceedings of the Nuclear Energy Agency Seminar. Organisation for Economic Cooperation and Development, Madrid, Spain.

Kauffman, J. 1980. "Effect of a Mercury-Induced Consumption Ban on Angling Pressure." Fisheries 5(1):10-12.

Martin, R. G. 1978. "Impacts of Aquatic Contaminants on Angling." SFI Bulletin. No. 293. Sport Fishing Institute, Washington, D.C.

Mid-Cumberland Council of Governments and Development District (Mid-Cumberland). 1983. Hartsville Project Impact Study. Mid-Cumberland Council of Governments and Development District, Nashville, Tennessee.

National Council on Radiation Protection and Measurements (NCRP). 1977. Radiation Exposure from Consumer Products and Miscellaneous Sources. NCRP Report No. 56, Washington, D.C.

National Institute for Occupational Safety and Health. 1982. Registry of Toxic Effects of Chemical Substances, 1980 Edition. U.S. Department of Health and Human Services (DHHS), Washington, D.C.

Noise Control Act of 1972. Public Law 92-574.

Otway, H. J., and D. Von Winterfeldt. 1982. "Beyond Acceptable Risk: On the Social Acceptability of Technologies." Policy Sciences 14:247-256.

Michigan Milk Messenger. "PBB Coverage Has Slight Effect on Attitudes Toward Milk, UDIA Survey Shows." June 1977.

Pennsylvania Department of Agriculture. 1980. Three Mile Island Socioeconomic Impact Study: A Final Report on Work Element 3. Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania.

Pennsylvania Department of Commerce (PDC). 1979a. Three Mile Island Socio-Economic Study, Work Element 4: Identification and Measurement of Impacts on Tourism Industry. June 1979, Pennsylvania Department of Commerce, Harrisburg, Pennsylvania.

Pennsylvania Department of Commerce (PDC). 1979b. Three Mile Island Socio-Economic Study, Work Element 4: Identification and Measurement of Impacts on Tourism Industry. November 1979, Pennsylvania Department of Commerce, Harrisburg, Pennsylvania.

Pennsylvania Department of Commerce (PDC). 1980. Three Mile Island Socio-Economic Study. Harrisburg, Pennsylvania.

Pennsylvania Governor's Office of Policy and Planning. 1979. Three Mile Island Socioeconomic Impact Study. Harrisburg, Pennsylvania.

Preston, V., S. M. Taylor and D. C. Hodge. 1983. "Adjustment to Natural and Technological Hazards: A Study of an Urban Residential Community." Environment and Behavior 15(2):143-144.

Project Management Corporation (PMC). 1975. Clinch River Breeder Reactor Plant Environmental Report, Amendments III-XIII through 1982). Docket 50537.2, U.S. Nuclear Regulatory Commission, Washington, D.C.

Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter, 40 Fed. Reg. 55:10408-30 (March 20, 1984).

Rainey, R. S., and L. M. Mills. 1983. "Environmental Sound Survey--Clinch River Breeder Reactor Project." Tennessee Valley Authority, Industrial Hygiene Branch (Muscle Shoals, Alabama); Nuclear Licensing Branch (Chattanooga, Tennessee).

Ralph M. Parsons Company (Parsons). 1985. Conceptual Design Report, Integral Monitored Retrievable Storage (MRS) Facility. Vol. 1, Ralph M. Parsons Company, Pasadena, California.

Smith, R. W., and E. L. Wilmot. 1982. Truck Accident and Fatality Rates Calculated from California Highway Accident Statistics for 1980 and 1982. SAND 82-7006, Sandia National Laboratories, Albuquerque, New Mexico.

Tennessee Department of Agriculture (TDA). 1984. Tennessee Agricultural Statistics: 1984 Annual Bulletin. Tennessee Crop Reporting Service Bulletin T-21, Tennessee Department of Agriculture, Nashville, Tennessee.

Tennessee Taxpayers Association. 1984. The 1984 Annual Survey of State and Local Government in Tennessee. Tennessee Manufacturers and Taxpayers Association, Nashville, Tennessee.

Tennessee Valley Authority (TVA). 1974. Hartsville Nuclear Plants Environmental Reports, Vol. 1-4. Docket 50518-3, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1978. Hartsville Nuclear Plants Socioeconomic Monitoring and Mitigation Report, September 30, 1977. Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1982. Hartsville Nuclear Plants Socioeconomic Monitoring and Mitigation Report, March 31, 1981. HNP-SMR-10, Tennessee Valley Authority, Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 1985. Cultural Resource Program. Tennessee Valley Authority, Norris, Tennessee.

Thornton, C. C. 1978. Baseline Noise Data for the Summertime Period at the Clinch River Breeder Reactor Plant Site. Tennessee Valley Authority Memorandum to R. S. Rainey, Industrial Hygiene Branch.

United Dairy Industry Association. 1977. Consumer Reaction to PBB in Michigan. Marketing and Research Division, American Dairy Association of Michigan, Lansing, Michigan.

U.S. Code of Federal Regulations, Title 10, Part 20.105 (10 CFR 20.105). "Permissible Levels of Radiation in Unrestricted Areas."

U.S. Code of Federal Regulations, Title 10, Part 72 (10 CFR 72). "Licensing Requirements for the Independent Storage of Spent Fuel and High-Level Radioactive Waste."

U.S. Code of Federal Regulations, Title 36, Part 800 (36 CFR 800). "Protection of Historic and Cultural Properties."

U.S. Code of Federal Regulations, Title 40, Part 50 (40 CFR 50). "National Primary and Secondary Ambient Air Quality Standards."

U.S. Code of Federal Regulations, Title 40, Part 51 (40 CFR 51). "Requirements for Preparation, Adoption and Submittal of Implementation Plans."

U.S. Code of Federal Regulations, Title 49, Part 173 (49 CFR 173). "Shippers--General Requirements for Shipments and Packaging."

U.S. Department of Energy (DOE). 1978. Analytical Methodology and Facility Description of Spent Fuel Policy. DOE-ET-0054, Washington, D.C.

U.S. Department of Energy (DOE). 1975. Mission Plan for the Civilian Radioactive Waste Management Program. Vol. 1, DOE/RW-0005, Washington, D.C.

U.S. Department of Transportation (DOT). 1981. Accident/Incident Bulletin. Federal Railroad Administration, 1977-1981.

U.S. Department of Transportation (DOT). 1979. Accident of Motor Carriers of Property. Federal Highway Administration, 1978-1979.

U.S. Environmental Protection Agency (EPA). 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With An Adequate Margin of Safety. EPA 55019-74-004, Arlington, Virginia.

U.S. Environmental Protection Agency (EPA). 1983. "Fugitive Dust Sources." In Compilation of Air Pollutant Emission Factors. 3rd ed. (Including Supplements 1-15, 1984), Chapt. 11.2. Research Triangle Park, North Carolina.

U.S. International Trade Commission (USITC). 1985. Synthetic Organic Chemicals: United States Production and Sales, 1984. USITC Publication 1705, U.S. Government Printing Office, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1972. Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors. NRC Regulatory Guide 1.25, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1982. Draft Supplement to Final Environmental Statement Related to Construction and Operation of Clinch River Breeder Reactor Plant. NUREG-0139, Office of Nuclear Reactor Regulation, Washington, D.C.

U.S. Travel Data Center. 1985. The Economic Impact of Travel on Tennessee Counties, 1984. A Study Prepared for Tennessee Tourist Development. State of Tennessee Central Printing Division, Nashville, Tennessee.

Wilmot, E. L., M. M. Madsen and J. W. Cashwell. 1983. A Preliminary Analysis of the Cost and Risk of Transporting Nuclear Waste to Potential Candidate Commercial Repository Sites. SAND83-0867 (TTC-0434), Sandia National Laboratories, Albuquerque, New Mexico.

LIST OF AGENCIES CONTACTED

The following agencies provided information or review during preparation of this Environmental Assessment:

Advisory Council on Historic Preservation

City of Oak Ridge

Roane County Government
- Office of County Executive

State of Illinois
- Department of Nuclear Safety

State of Tennessee
- Department of Commerce
  - Division of Industrial Development
- Department of Conservation
  - Division of Archaeology
  - Division of Geology
  - Ecological Services
  - Legal Services
  - Planning and Evaluation
- Department of Health and Environment
  - Division of Radiological Health
    - Air Pollution Control
    - Division of Groundwater Protection
    - Solid Waste Management
    - Water Pollution Control
    - Water Supply
- Department of Tourism Development
- Department of Transportation
  - Emergency Services Coordinator
- East Tennessee Development District
- Technology Foundation
- Tennessee Attorney General's Office

Tennessee Emergency Management Agency

Trousdale County Government
- Office of County Executive

U.S. Environmental Protection Agency
    Office of Federal Activities
    Office of Radiation Programs

U.S. General Accounting Office

U.S. Geological Survey

U.S. Nuclear Regulatory Commission

University of Tennessee
    Center for Business Research

Vanderbilt University
    Civil Engineering Department

Definition of Terms

DEFINITIONS OF TERMS

ABBREVIATIONS

α	alpha radiation
ac	acre
ACGIH	American Conference of Governmental Industrial Hygienists
ADT	average daily traffic
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
β	beta radiation
BLS	Bureau of Labor Statistics
BOD	biological oxygen demand
BWR	boiling water reactor
°C	degrees Celsius
CFR	U.S. Code of Federal Regulations
cfs	cubic feet per second
CH	contact handled
CHLW	commercial high-level waste
CHTRU	contact-handled transuranic (waste)
Ci	curie
cm	centimeter
cm^3	cubic centimeter
CRBR	Clinch River Breeder Reactor
dBA	decibels (A - weighted)
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
EA	environmental assessment
ED	environmental document
EDTA	ethylenediaminetetraacetic acid
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
ft^2	square feet
γ	gamma radiation
g	gram
G	gravitational acceleration (normally notated as "g")
gal	gallon
gpd	gallons per day
gpm	gallons per minute
HEPA	high-efficiency particulate air (filter)
HLW	high-level waste

hr	hour
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
kg	kilogram
km	kilometer
kW	kilowatt
kWh	kilowatt hour
kV	kilovolts
L	liter
lb	pound
LLW	low-level waste
μ	micron
μCi	microcurie (1 x 10-6 Ci)
m	meter
m^2	square meter
m^3	cubic meter
MeV	million electron volts
mg	milligram
mgd	million gallons per day
mgy	million gallons per year
mi	mile
min	minute
mL	milliliter
MMI	Modified Mercalli Intensity
mo	month
mph	miles per hour
mrad	millirad
MRS	monitored retrievable storage
MSA	metropolitan statistical area
MSL	mean sea level
MTHM	metric ton of heavy metal
MTU	metric ton of uranium
MW	megawatt
MWD	megawatt days
NAAQS	National Ambient Air Quality Standard
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act (of 1982), Public Law 97-425
%	percent
ORR	Oak Ridge Reservation
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
pCi	picocurie (1 x 10^{-12} Ci)

Pm_{10}	particle with an aerodynamic diameter of smaller than or equal to a nominal 10 micrometers
PMC	Project Management Corporation
PNL	Pacific Northwest Laboratory
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
PWR	pressurized water reactor
R	roentgen
RAD	Regulatory Assessment Document
RCRA	Resource Conservation and Recovery Act, Public Law 94-580
R&H	receiving and handling (building)
RH	remote handled
RHTRU	remote-handled transuranic (waste)
RM	river mile
scf	standard cubic foot
SAIC	Science Applications International Corporation
sec	second
SIC	Standard Industrial Classification
t	metric ton; 2,205 pounds (1,000 kilograms)
TLD	thermoluminescent dosimeter
TLV	threshold limit value
TMI	Three Mile Island
TRU	transuranic (waste)
TSP	total suspended particulates
TTC	Transportation Technology Center
TVA	Tennessee Valley Authority
U	uranium
W	watt
W/m°K	watts per meter per degree Kelvin
yr	year

CONVERSION TABLE

ac x 43,500 = ft^2	in. x 2.54 = cm
ac x 4,047 = m^2	kg x 2.205 = lb
ac x 0.405 = ha	km x 0.621 = mi
(°C x 9/5) + 32 = °F	km^2 x 0.386 = mi^2
cm x 0.394 = in.	L x 0.264 = gal
cm^2 x 0.155 = $in.^2$	lb x 0.454 = kg
cm^3 x 0.061 = $in.^3$	m x 3.281 = ft
(°F - 32) x 5/9 = °C	m^2 x 10.76 = ft^2
ft x 0.305 = m	m^3 x 35.31 = ft^3
ft^2 x 0.093 = m^2	mi x 1.609 = km
ft^3 x 0.028 = m^3	mi^2 x 2.59 = km^2
gal x 3.785 = L	ton x 0.91 = t
ha x 2.471 = ac	t x 1.1 = ton

GLOSSARY

background radiation - the level of radioactivity from naturally occurring sources; principally radiation from cosmogenic (solar) and primordial (mineral/gaseous) radionuclides

backup MRS concept - the concept whereby an MRS facility would provide temporary storage of spent fuel and certain other wastes only to the extent needed (in terms of total stored quantities and storage times) to accommodate a delay in the start-up of repository facilities

biota - the animal and plant life of a particular region

blowdown - the water that is purged from a water-circulating system and is replaced with fresh water to prevent the buildup of chemicals in the system

canister - the first material envelope surrounding a waste form (e.g., spent fuel rods) to provide containment for storage and handling purposes

cask - a container designed for transporting and/or storing radioactive materials; design usually includes special shielding, handling, and sealing features to provide positive containment and minimize personnel exposure

Code of Federal Regulations (CFR) - a documentation of the regulations of federal executive departments and agencies, which is divided into 50 titles representing broad areas subject to federal regulation; each title is divided into chapters, which are further subdivided into parts

contact-handled (CH) waste - transuranic waste, usually packaged in some form, which emits low enough radiation levels (less than 200 mR/hr) to permit close and unshielded manipulation by workers

contamination (contaminated material) - the deposition, solvation, or infiltration of radionuclides on or into an object, material, or area; the presence of unwanted radioactive materials or their deposition, particularly where it might be harmful

controlled area - any specific region of a site into which entry by personnel is regulated by physical barrier and/or procedure

curie (Ci) - the basic unit used to define the rate of radioactive decay in an object or quantity of material. One curie equals 37 billion (3.7×10^{10}) disintegrations per second decay, radioactive - a spontaneous nuclear transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide by emission of particles and/or photons

decay heat - heat generated by radioactive decay in spent fuel or activated non-fuel components

decay products - the immediate product of radioactive decay of an element; also called radioactive decay products

decommissioning - the removal from service (at the end of its useful life) of an MRS facility and its related components in accordance with regulatory requirements and environmental policies

decontamination - the removal of radioactive material from an MRS facility, its surrounding soils, and equipment by washing, chemical action, mechanical cleaning, or other techniques

design basis accident - a postulated accident believed to have the most severe expected impacts on a facility; used as the basis for structural design of a facility and for safety analyses

disintegrations per minute (dpm) - the number of radioactive decay events occurring per unit time in a given amount of material

dispersion - phenomenon by which a material placed in a flowing medium gradually spreads and occupies an ever-increasing portion of the flow domain

disposal - the disposition of radioactive wastes (or other appropriate wastes) in a manner considered permanent so that there is no provision for recovery (i.e., in a repository)

dose commitment - the integrated dose which results from an intake of radioactive material when the dose is evaluated from the beginning of intake to a later time (usually 50 to 70 years); also used for the long-term integrated dose to which people are considered committed because radioactive material has been released to the environment

dose equivalent - a means of expressing dose (in rem) that provides a consistent estimate of dose effectiveness regardless of the rate, quantity, source, or quality of the radiation (often referred to simply as dose)

dose rate - the radiation dose delivered per unit time; measured, for instance, in rems per hour dosimeter - a device, such as film, thermoluminescent material, or ionization chamber, that measures radiation dose over a given period; these devices are worn or carried on a person's body to record radiation dose

drum - a metal cylindrical container used for the transportation, storage, and disposal of waste materials

drywell - see field drywell

ecology - that branch of biological science that deals with the study of relationships between organisms and their environment

ecosystem - an assemblage of biota and habitat

engineered barrier - an addition to a disposal site that is designed to retard or preclude radionuclide transport and/or to preserve the integrity of the disposal site

exposure - the condition of being made subject to the action of radiation; a measure, in roentgens, of the ionization produced in air by x-ray or gamma radiation

field drywell - an individual, stationary, inground, metal-lined cavity for storing one or more canisters or drums containing high-level waste or spent nuclear fuel. Shielding is provided by the surrounding earth and a shield plug. Heat dissipation is by conduction through the plug and earth to the atmosphere and also by thermal radiation.

food chain - a linear sequence of successive utilizations of nutrient energy by a series of species

food web - the concept of nutrient energy transfers (including decomposition) between species in an ecosystem

fuel assembly - a group of fuel rods, pins, plates, etc., held together by structural components; also called fuel bundle, fuel rod cluster, and fuel element

fuel rod - a basic component of nuclear fuel, such as a tube, element or other form, into which nuclear fuel is fabricated for use in a reactor; also called fuel pin

ground water - water that exists or flows below the surface (within the zones of saturation) grout - a fluid mixture of cement, water, fly ash and clay that sets up as a solid mass and is used for waste fixation or immobilization

habitat - the characteristics of the place where biota live

hazardous waste - usually means nonradioactive chemical toxins or otherwise potentially dangerous materials such as sodium, heavy metals, beryllium, and some organics

HEPA - high-efficiency particulate air (filter); material (usually a paper or fiber sheet pleated to increase surface area) that captures entrained particles from an air stream, usually with efficiencies of 99.95% and above

high-activity waste (HAW) - high specific-activity material that may exceed Class C specifications for low-level waste and may or may not contain some quantity of transuranic material

high-level waste (HLW) - the highly radioactive waste material that results from reprocessing spent nuclear fuel, including liquid waste produced directly in the first processing cycle in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; also, other highly radioactive material that the NRC determines requires permanent isolation

hot cell - a facility to handle, process, and/or investigate radioactive material; provides confinement, radiation shielding, remote handling and viewing

inadvertent intrusion - human activity such as home excavation, resource mining, and well digging that accidentally breaches a waste site

integral MRS concept - the concept whereby an MRS facility would receive, process, package, store and ship to the repositories all spent fuel and certain other wastes requiring permanent disposal, and thus serve as an "integral" part of the federal waste management system. In this role, sufficient storage would be provided to accommodate disruptions in operations.

interim storage - storage of radioactive material such that: isolation, monitoring, protection of humans, and human control are provided; and subsequent action involving treatment, transportation, and disposal or reprocessing is expected lag storage - temporary storage for spent fuel to accommodate fluctuations between process steps

low-level waste (LLW) - waste material containing relatively low quantities of radionuclides and requiring only near-surface burial to shield the environment from its radiation after disposal. Generally, this waste contains less than 100 nanocuries of transuranic material per gram of waste.

make-up - fresh water that is added to the process stream in a circulating system to compensate for evaporation and to prevent chemical buildup

maximum (or maximally exposed) individual - a hypothetical member of the public whose habits tend to maximize radiation dose to a given organ; for the case where exposures from airborne radionuclides result in the highest contribution to dose, this individual is assumed to reside continuously at the location of highest airborne radionuclide concentration and to eat food grown there

metric ton (or tonne) - 1,000 kilograms; 2,205 pounds

near surface - a location designation for waste not disposed of in deep geologic repositories

nuclear radiation - particles and electromagnetic energy given off by transformations occurring in the nucleus of an atom

offsite - any place outside a site boundary

overpack - a thin-walled secondary canister applied over a primary canister if it is found to be defective; also, a secondary (or additional) sealed external container fabricated to repository specifications for long-term containment of nuclear waste

package - the act of preparing spent nuclear fuel for storage, shipment, and/or final disposal. Includes disassembly and consolidation of spent fuel, placement of the consolidated spent fuel in canisters, and placement of the canisters into disposal containers.

packaging - assembly of radioactive material in one or more containers

particulate - generally refers to particles in an aerosol stream; usually can be removed by filtration

person-rem - the product of the dose equivalent in rem and the number of people receiving that dose, a collective population dose pH - a measure of acidity and alkalinity, neutrality being at pH 7; pH under 7 indicates an acid solution and pH over 7 indicates an alkaline solution; log reciprocal of the hydrogen ion concentration

PM_{10} - particle with an aerodynamic diameter of smaller than or equal to a nominal 10 micrometers

population dose (population exposure) - summation of individual radiation dose received by all those exposed to the source or event being considered

rad - unit of absorbed dose equal to 0.01 joules per kilogram in any medium

radiation (ionizing) - particles and electromagnetic energy emitted by nuclear transformations that are capable of producing ions when interacting with matter

radiation monitoring - a term covering application of a field of knowledge including determination of dose rates, surveys of personnel and equipment for contamination control, air sampling, exposure control, etc.

radiation survey - evaluation of an area or object with instruments in order to detect, identify and quantify radioactive materials and radiation fields present

radioactive waste - solid, liquid, or gaseous material of negligible economic value that contains radionuclides

radioactivity - the property of certain nuclides of emitting particles or electromagnetic radiation while undergoing nuclear transformations

radwaste - see radioactive waste

rem - a unit used in radiation protection to express the effective dose (i.e., the effects on human tissue) caused by a radiation field that is equivalent to the dose from one roentgen of gamma radiation

remote-handled (RH) waste - transuranic waste having a surface dose rate greater than 200 mR/hr and requiring shielding from and distance between it and human manipulators

repository - a facility consisting primarily of mined cavities in a deep geologic medium and associated support facilities for the permanent disposal of spent fuel and high-level waste rod consolidation - the disassembly and packaging (reconfiguration into a close-packed array) of spent fuel rods to achieve volume reduction, thereby limiting the space required for storage or disposal

roentgen - a unit of measure of ionizing electromagnetic radiation (exposure) (x-rays and gamma rays); one roentgen corresponds to the release by ionization of 83.8 ergs of energy per gram of air

shielding - walls or other constructions used to absorb radiation in order to protect personnel or equipment

shipping cask (transport cask) - a cask with a protective covering that contains and shields radioactive materials, dissipates heat, prevents damage to the contents, and prevents criticality during normal shipment and accident conditions

siting - the testing, evaluation, and institutional activities associated with the process of screening, recommending, and approving a site for evaluation or development

solid waste (radioactive) - either solid radioactive material or solid objects that contain radioactive material or bear radioactive surface contamination

spent nuclear fuel - irradiated nuclear fuel that has reached the end of its useful life

storage - retention of radioactive waste in a retrievable manner that requires surveillance and institutional control

surveillance - those activities to ensure that stored radioactive material remains safe (including inspection and monitoring of the site, maintenance of access barriers to radioactive material left on the site, and prevention of activities on the site that might impair these barriers)

throughput - average rate at which an MRS facility can receive, inspect, consolidate and package spent fuel

transportable storage cask - a container for transporting and storing canisters or fuel assemblies; design includes shielding, handling, and sealing features to provide positive containment and minimize personnel exposure consistent with requirements established for both storage and transport functions

transporter - a vehicle to move sealed storage casks or waste canisters at an MRS facility transuranic (TRU) waste - any waste material measured or assumed to contain more than a specified concentration (i.e., 100 nanocuries) of alpha emitters per gram of waste

water table - upper boundary of an unconfined aquifer surface below which saturated groundwater occurs; defined by the levels at which water stands in wells that barely penetrate the aquifer

Appendices

APPENDIX A

OPTIONS FOR IMPROVING THE NO-MRS SYSTEM

APPENDIX A

OPTIONS FOR IMPROVING THE NO-MRS SYSTEM

In Part I of this Environmental Assessment, the system performance of a no-MRS system and an MRS system are compared. This appendix examines a set of possible improvements to a no-MRS system and describes the advantages and disadvantages of implementing each improvement relative to the MRS system.

The following improvements in the no-MRS system were evaluated:

- expanded lag storage at the repository to provide a buffer between waste acceptance and waste emplacement
- expanded storage at reactor sites, either by adding modular dry storage or in-pool consolidation of spent fuel, to provide contingency storage if repository operations were delayed
- use of larger shipping casks and multi-cask shipments, thereby increasing the tonnage per shipment and reducing the number of discrete shipments.

These improvements were evaluated using existing information and engineering judgment because detailed designs and operational experience are limited for most of the options considered. However, because these options are conceptually similar to those presently being evaluated by the DOE as part of a broad Program Research and Development Announcement (PRDA) initiated in 1984, the evaluations were enhanced by the availability of draft results from the PRDA activities. The intent of the PRDA studies is to identify various concepts that would enhance the overall performance of the waste management system. These concepts include various configurations for spent-fuel canisters, the system-wide use of extra-large shipping casks, a mobile spent-fuel consolidation system for at-reactor consolidation, and metallic cask systems for storage, transportation and disposal. When the final results of the studies are available in early 1986, those concepts having sufficient merit will be considered for further development and possible application in the waste management system.

Postulated improvements to the no-MRS system in the three areas mentioned previously were evaluated over the same parameters that were used to compare the MRS and no-MRS systems in Chapters 2 and 3: system development, system operations (including transportation effects and storage requirements), system cost, radiation dose effects, and feasibility. Because designs and plans for many of the improvements considered in this appendix have not been developed to the same degree as the comparable components in the MRS or no-MRS systems, there are greater uncertainties in their advantages, disadvantages, costs and feasibility. Thus, the comparisons are necessarily more qualitative than those in Chapters 2 and 3. The comparisons also focus on the amount of "MRS-like" benefits that each option provides; for example, expansion of at-reactor storage is compared to the contingency storage that could be provided at the MRS facility.

A.1 SUMMARY AND CONCLUSIONS

The three types of potential improvements to the no-MRS system have been evaluated in terms of how they can achieve similar effects to the MRS system. The effects on system performance of the postulated improvements in the no-MRS system are compared with those of an MRS system in Table A.1.

The improvements that have been evaluated could potentially improve individual aspects of the no-MRS waste management system and could provide some of the same benefits as the MRS facility, but no single improvement or combination of improvements provides the same total system performance improvements as does deploying an MRS facility. The most significant aspects of each of the three types of postulated improvements to the no-MRS system are summarized briefly below and described more fully in the remainder of the appendix.

Expansion of lag storage at the repository would provide the operational decoupling that the MRS facility provides, i.e., it would allow independent operation of acceptance and emplacement and would thus improve the reliability and efficiency of the system. It would not, however, separate the development of the waste acceptance, transportation, and packaging functions from the repository development process (site selection, characterization, licensing, and construction) since all of the repository facilities are subject to a common (10 CFR 60) license. Consequently, this option would not allow the early and increased spent-fuel receipt that the MRS facility provides. The cost of adding storage at the repository site is assumed to be identical to the cost of adding storage at the MRS site. This option would not, by itself, provide any benefits to the transportation function.

Expanded at-reactor storage to provide a system contingency in case of changes in the scheduled startup of the repository is a viable improvement. There are two general ways that at-reactor storage can be expanded: by providing dry storage; or by consolidating the spent fuel to increase the capacity of the existing storage pool. The former is the more costly. The latter would

TABLE A.1. Summary of Improvements to the No-MRS System and Comparison with Effects of the MRS System

PRIMARY EFFECTS OF THE MRS SYSTEM

System Development	System Operations	System Cost	System Risk	Feasibility
Makes it easier to develop system functions by simplifying decisions and applying more certain information. Provides focal point for integrating all pre-emplacement functions.	Improves efficiency and reliability of the system since acceptance and emplacement could operate independently. Allows earlier and higher initial spent-fuel receipt. Improves control over transportation.	Facility costs increase $1.6-$2.0 billion. Transportation costs decline by as much as $0.2 billion. Storage cost avoided ranged from $150-$450 million with on-time repository.	Decreases in public dose from transportation. Occupational dose would increase some with the additional functions at the MRS facility.	Uses current technology. Licensable in a timely fashion. Could reach full-scale operation within 10 years of approval.

COMPARISON OF THE IMPROVED NO-MRS SYSTEM WITH THE INTEGRAL MRS SYSTEM

Improvements to No-MRS System	System Development	System Operations	System Cost	System Risk	Feasibility
LAG STORAGE AT REPOSITORY					
Expansion of storage at the repository to accelerate initial receipt and to decouple acceptance and emplacement operations.	Probably could not begin receiving much before start of emplacement, i.e., would not decouple development of acceptance and emplacement.	Would provide same operational decoupling between acceptance and emplacement as MRS system. Would have later and lower initial waste receipt than the MRS system--smaller effect on AR storage. Would not provide MRS transportation benefits.	Cost per storage unit would be the same as at the MRS facility. MRS system would cost $1.2 to $1.6 billion more than this version of the no-MRS system.	No effect on public dose. Some reduction in occupational dose compared to the MRS system since there would be fewer operations.	Technically feasible. Startup prior to emplacement could be difficult. Early start or large capacity could complicate licensing.
AT-REACTOR STORAGE EXPANSION					
- Modular Dry Storage					
Expansion of storage at reactor sites to provide a contingency in case of delays in repository startup.	Does not decouple development of acceptance and emplacement.	Utilities would store all spent fuel prior to repository receipt. Would increase utility storage compared to the MRS system.	Costs would be $110/kg or more depending upon storage method used, compared to $35-40/kg at the MRS facility. Total cost depends on timing of the repository.	No discernable effect.	Feasible to license and implement.
- In-Pool Consolidation					
Consolidation of spent fuel to increase capacity of pools and to reduce transportation requirements.	Allows early definition and conduct of preparation and packaging but does not decouple development of acceptance and emplacement.	Difficult to consistently control operations at many locations. Possible interference with reactor operations. Would reduce cask miles and provide similar transportation benefits to the MRS system.	Per unit cost about equal to MRS cost. Total cost impact depends upon fraction of reactors that consolidate.	Higher exposure at reactors. Uncertain change in public dose compared to MRS system.	Technically feasible, but operationally and institutionally difficult.
IMPROVED TRANSPORTATION					
More MTUs/shipment, fewer discrete shipments. - Greater use of rail - Extra-large rail casks - Multicask shipments - Overweight truck casks	Does not decouple development of acceptance and emplacement.	Large reductions in shipment miles are possible with similar improvements in control and impact reduction to those of the MRS system.	Insufficient information to assess net cost impact of modifications. Most changes would increase cost from the no-MRS system. Some changes would require utility investments.	Would reduce public dose similar to MRS reduction. Could increase occupational dose since there would be more handling at reactors but uncertain comparison to MRS system.	Questionable feasibility of some new technology. Reactor handling upgrades may not be cost effective.

necessitate the development and execution of contractual agreements between the DOE and each participating utility that would encompass such areas as responsibilities, liabilities, licensing, facilities, staffing, and costs. There is no assurance that any utilities will be interested or willing to participate in such arrangements. Unit costs for at-reactor storage (for fuel storage in other than high-density racks) are estimated to range from $40 to $110/kgU. Incremental unit storage costs at an MRS facility are estimated to range from $35 to $40/kgU.

Improvements in the transportation system, i.e., using larger casks and multi-cask shipments, could be implemented, which would result in fewer cross-country shipments and lower overall transportation impacts because of the reduced number of shipment miles. However, implementing some of these options would necessitate upgrading facilities and equipment at many reactors. The cost of these improvements cannot be assessed at this time because of the site-specific character of the at-reactor upgrading, and because some institutional interactions would be required for most of the improvements. Implementing multi-cask shipments from reactors would generally increase scheduling difficulties and transportation cost due to the increase in non-transport time for the casks.

A.2 EXPANDED LAG STORAGE AT THE REPOSITORY

The MRS facility provides 15,000 MTU of spent-fuel storage capacity. This capacity serves three important functions:

- It permits an increased spent-fuel receipt rate in the initial years of system operation thus reducing the need for many utilities (perhaps 20 to 25 reactor units) to supplement their spent-fuel storage capacity.
- It provides buffer storage between the waste acceptance and waste emplacement functions, which allows each function to be performed in the manner to best meet system performance needs.
- It provides limited contingency storage in case of changes in the repository startup schedule or in case of stoppages of emplacement operations, and could reduce the need for supplemental storage at reactor sites.

These functions could be provided in several ways. This section discusses the ability of an expanded lag storage at the repository to increase the initial spent-fuel receipt rate, to provide a buffer to meet operational needs, and to provide contingency storage.

Lag storage capability could be added to the first repository to provide some of the same benefits that are provided by the MRS system. For example, the waste acceptance process could be insulated from disruptions in repository emplacement. If the storage capability were licensed separately from the underground portion of the repository, spent fuel could also be received earlier and contingency storage could be provided in case of some types of delays in repository startup or diminished emplacement capability. Present repository surface facility designs include a three-month operational buffer (750 MTU) which is sufficient to ensure smooth functioning during normal emplacement operations, to unload the transportation system during slowdowns or brief stoppages in emplacement activities, and to maintain emplacement operations during brief disruptions of the transportation system.

To accelerate the initial fuel acceptance rates in the no-MRS system, expanded lag (buffer) storage at the repository could be provided. The spent-fuel acceptance rate at the repository during the initial five years of operation is controlled by the rate at which the underground emplacement excavations and operations progress following NRC licensing. (Completion of repository surface facilities also affects the lower acceptance rate but to a lesser degree.) The amount of storage that could be provided to accelerate acceptance of spent fuel while not impeding repository construction cannot be predicted at this time. The licensibility of such storage prior to repository operating approval could also be a major obstacle to its implementation, considering the constraints incorporated into the NWPA. If such storage were incorporated into the system, it could slowly be depleted and used as a contingency against emplacement disruptions when the repository reached full operation after five years.

If this buffer storage were deployed at the repository, the no-MRS system costs could be lower than those of the MRS system because services would have to be provided at only one site. Table A.2 compares estimated life-cycle costs for a no-MRS system with 12,000 MTU buffer storage at the repository to the relevant portions of the MRS system. These two systems are shown schematically in Figure A.1. The costs are based on information presented in Appendix C of this volume. The cost of adding buffer storage to the repository is assumed to be the same as for the MRS site because the same type of equipment and operations are required at either location.

As shown in the table, the life-cycle cost of the no-MRS system would be about $1.2 to $1.6 billion less than that for the MRS system when both have comparable amounts of storage. Transportation costs were not considered in this comparison because the net transportation cost effect of the MRS facility may be either positive or negative (as shown in Section 2.3) depending on

TABLE A.2. Estimated Life-Cycle Costs for an MRS Facility and for a Repository Surface Facility with Buffer Storage[a] (see Table C.10)

Waste Management System with Integral MRS Facility		No-MRS Waste Management System	
Facility	$ (billions)	Facility	$ (billions)
MRS	2.7	Repository	3.5 - 4.6
Repository	2.8 - 3.5	Storage Buffer	0.4
Total (Range)	5.5 - 6.2	Total (Range)	3.9 - 5.0

(a) The buffer storage for the MRS facility and the repository is assumed to be 12,000 MTU.

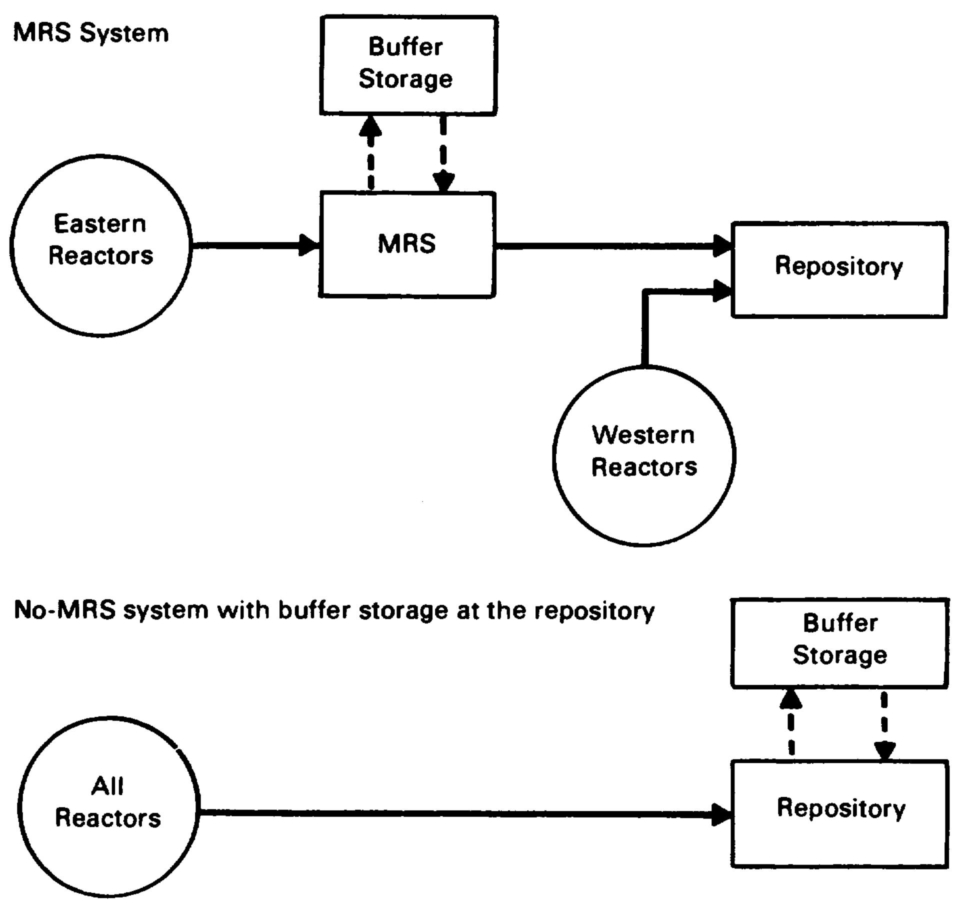

FIGURE A.1. Alternative Systems for Providing Buffer Storage of Spent Fuel the repository location and assumptions used for the MRS to repository transportation leg. The advantages and disadvantages of expanded lag storage at the repository relative to the MRS system are listed below.

Advantages

- The need to develop a separate site for a packaging and storage facility would be eliminated. Having one site would result in lower facility and site support costs than in the MRS system and would eliminate the partial duplication of the receiving functions that would exist in the MRS system.

Disadvantages

- It is doubtful that authorization to construct and operate a storage capability at the repository could be obtained in advance of repository licensing. A significant storage capacity could be viewed as attempting to implement MRS capability at the repository, which is prohibited by the NWPA. Construction of storage at the repository site could be viewed by the NRC as an investment in the site that would prejudice the review of the site license application. Consequently, this option would be more difficult to implement in a timely manner than the MRS system.

- If the storage portion of the facility could not be sited and construction initiated until the total repository is licensed, the initial receipt rate at the repository would be constrained by the schedule for constructing and operating the surface facilities. As a result, the initial system receipt rate would not likely be as high as in the MRS system.

A.3 EXPANDED STORAGE AT REACTOR SITES

Expanding storage capacity at reactor sites could provide the contingency storage that would be needed if the repository is delayed. Three methods for expanding storage capacity at reactors are available: reracking for high density storage, fuel consolidation, and dry storage. The first two involve expanding in-pool capacity, while the last requires storage outside of the pool. For this analysis, it is assumed that all reactors have been reracked to the maximum extent possible. Consequently, this option will not be discussed further.

The unit cost for at-reactor storage varies with the storage method used, the amount of fuel that requires storage, and the length of time that the fuel must be stored (discussed in Appendix D). Because of these considerations, a range of $40/kgU to $110/kgU was selected to represent the cost for providing at-reactor contingency storage. The low end of this range corresponds to storage costs when in-pool fuel consolidation and storage is used and the high end of the range corresponds to various dry storage options (see Appendix D). By comparison, the unit costs for contingency storage at an MRS facility range from $35/kgU to $40/kgU (see Appendix C). The lower unit cost of storage at the MRS facility results from economies of scale, and the narrower range of cost arises from the use of a single-storage method.

The relative cost of providing contingency storage in the MRS and no-MRS systems varies significantly with the assumptions that are made concerning the storage methods used for at-reactor storage and the amount of supplemental at-reactor storage that is displaced by the MRS facility. If all 15,000 MTU of storage at the MRS facility displaces dry storage at reactors costing $110/kgU, then about $1.7 billion in utility storage costs would be avoided for a cost at the MRS facility of $0.6 billion. If all 15,000 MTU of storage at the MRS facility displaces the need for an equivalent amount of storage space provided by in-pool spent-fuel consolidation, then about $0.6 billion in utility costs would be displaced by about $0.6 billion in costs at the MRS facility. In actuality, utility costs would fall somewhere within this range since not all utilities would be willing or able to consolidate their spent fuel.

A.3.1 Modular Dry Storage

Spent fuel that exceeds in-pool capacity could be stored in dry storage modules that are kept at the reactor site. Dry storage methods include metal casks, drywells, silos, and vaults. These methods are described in Appendix D together with their relative costs. Typically, dry-storage methods at reactors are more costly on a per-kilogram of contained uranium (kgU) basis than in-pool consolidation. The advantages and disadvantages relative to the MRS system of adding modular dry storage are listed below.

Advantages

- Total system costs would be lower than the MRS system for limited storage durations.

Disadvantages

- Dry storage methods have higher unit costs than incremental storage at the MRS facility--up to $110/kgU compared with $35/kgU to $40/kgU for incremental storage at the MRS facility.

- Dry storage would require a license for each reactor site under 10 CFR 72, while the MRS facility would require a single license.

A.3.2 Spent-Fuel Consolidation and Canistering

Spent-fuel consolidation is the process of separating the fuel-bearing components (spent-fuel rods) from the nonfuel-bearing components (assembly hardware) and placing the rods into a canister in a more compact array, thus reducing the space required to store spent-fuel rods by about one-half. Rod consolidation has been successfully accomplished on a demonstration scale at several reactor sites (Bailey 1985). Consolidation can also be used to provide a more compact waste form for dry storage (e.g., casks) as well. At-reactor consolidation is generally considered as a means to alleviate the spent-fuel storage problem at reactor sites; however, it has also been suggested as an alternative to consolidation in the federal portion of the waste management system. Three alternatives for accomplishing at-reactor consolidation and canistering are:

- at-reactor consolidation into a utility-selected canister
- at-reactor consolidation into a repository-specific canister
- at-reactor consolidation into a canister compatible with the repository-specific disposal container.

The utility-selected canister could, and likely would, be different in size from reactor to reactor, resulting in a variety of canisters that would not fit together well within the repository-specific disposal container. The repository-specific canister may not be identified until after a significant amount of spent fuel will have been consolidated to meet storage needs. This material might then have to be recanistered. Only the third alternative would actually permit canistering activities to proceed without the risk of the produced canisters being incompatible with the final repository-specific disposal container.

Each of the alternatives requires the utilities to perform the initial preparation and packaging of spent fuel, a responsibility assigned to the DOE by the NWPA. The DOE could contract with utilities to perform this function, which could include some arrangement to appropriately reimburse the utilities. The reimbursement should be related to the costs avoided by the DOE when the utility provides canisters of consolidated spent fuel instead of intact fuel assemblies. The maximum avoided cost would occur when all utilities perform the consolidation function, thus eliminating the need for such a facility at the repository. However, there is no assurance that all utilities would be willing or able to perform this function.

Each of the alternatives for consolidating spent fuel at reactor sites would shift the location of this spent-fuel preparation step from the federal government site (either the MRS facility or the repository) to the utility sites. This shift creates several important tradeoffs that are common to each of the above alternatives. The general advantages and disadvantages of at-reactor consolidation relative to the MRS system are discussed below.

Advantages

- A decentralized approach to spent-fuel consolidation would not require a new site. Existing reactor facilities, including rad-waste treatment capabilities, could be used to consolidate spent fuel and could lead to some cost savings since only incremental costs would apply.

- At-reactor fuel consolidation activities would be decoupled from the potentially lengthy site selection and facility development activities that may be required for either the MRS facility or the repository. Thus, if the consolidation canisters are sufficiently compatible with planned repository disposal containers, at-reactor consolidation activities could proceed at their own pace.

- Consolidating spent fuel at reactor sites would improve the efficiency of the subsequent waste management steps, especially storage and transportation. These improvements would result because of the more compact waste form, and if multiple assemblies were combined in a single canister, it would lessen the number of individual canisters that would require handling. Consequently, there could be a slight reduction in transportation impacts (e.g., total cask-miles) relative to the MRS system that consolidates fuel at a location close to the reactors.

Disadvantages

- Shifting the location for the principal spent-fuel preparation function to the utility sites would complicate the control and management of this function because consolidation and canistering of spent fuel would be performed at many locations and by many different groups and individuals.

- If the DOE were to perform the consolidation or were to contract with the utilities to do so, uncertain responsibilities and liabilities would result, especially for off-normal situations.

- These services could be funded through contracts between the DOE and the individual utilities; however, issues of equity could arise if Nuclear Waste Fund monies were used to pay for benefits (e.g., reduced storage requirements) gained by specific utilities.

- Consolidation carried out at a reactor facility would compete with normal utility activities for available resources such as personnel, equipment, or supplies. The operating license of the reactor would have to be amended to permit large-scale consolidation and storage of consolidated fuel.

- Total occupational dose would likely be higher on a decentralized basis because a central facility could more readily make use of remote-handling and heavy shielding to protect workers.

- Utility reluctance to participate could be encountered. The licensing of this activity at a number of reactors could be time consuming as the only license application to NRC, to date, for large-scale consolidation by a utility was withdrawn after a 3-year effort (Garrity 1984).

Each of the alternatives for at-reactor consolidation and canistering are discussed in more detail in the following sections.

A.3.2.1 At-Reactor Consolidation into Utility-Selected Canister

Utilities would most likely select a canister for consolidated fuel that would be compatible with their existing pool storage racks. Typically, each canister would hold the equivalent of two intact assemblies but would fit into the same rack space as a single intact assembly. The hardware from the disassembly process would most likely be compacted into a similarly-sized canister and also stored in the pool racks. Thus, a variety of reactor-specific canisters would be created which would not necessarily fit well together within the repository's disposal container. In addition, these canisters would probably not be sealed and inerted because systems capable of evacuating, backfilling with an inert gas, and seal-welding canisters underwater in the storage pools have not yet been demonstrated. These latter functions would probably have to be performed at the repository or the canister removed and discarded. Working over storage pools, consolidation workers would receive higher radiation doses than would be received at an MRS facility because of higher radiation levels over the pools. The advantages and disadvantages of this option relative to other at-reactor consolidation options are listed below.

Advantages

- Canisters would be compatible with the utility's existing pool storage racks and normal in-pool handling operations.

- Consolidation of spent fuel could proceed at the utility's pace, unrelated to repository waste package design and operating schedules.

Disadvantages

- Canisters would probably require further preparation (e.g., inerting, welding) at the repository to ready them for insertion into the disposal container.

- Canisters from one reactor may not fit together well with canisters from another reactor. The variation could present problems in assembling the contents for the disposal containers at the repository and could result in inefficient use of the container volumes.

A.3.2.2 At-Reactor Consolidation into a Repository-Specific Canister

In this alternative, the utilities would have to load the consolidated fuel rods into a repository-specific canister, which would be designed to fit efficiently into the repository's disposal container. The dimensions of the canister and the internal loading arrangements will be governed by the nature of the disposal medium and, therefore, may not be defined sufficiently early for the utility to provide an appropriate canister. An incorrect choice could result in the early-design canisters having to be repackaged. In addition, a repository-specific canister could be much larger in dimension and in total weight than would be a canister that fits within the pool storage racks. As a result, some new racks specifically designed for the canisters would have to be installed in the pool, and additional procedures and equipment would have to be put in place to ensure the safe handling and criticality safety of the large canisters. The advantages and disadvantages of this option relative to other at-reactor consolidation options are listed below.

Advantages

- Canisters would be compatible with the disposal container (by design).

- Total number of canisters to be processed and handled would be reduced.

Disadvantages

- Canister configuration may not be defined in time for the utilities to use these canisters in solving their near-term storage problems, given its dependency upon repository site characteristics and upon site-selection decisions.

- Larger, heavier canisters would require special procedures and handling equipment.

- Larger canisters would require special racks installed in the storage pool for storage of the canisters before they are shipped, or the use of onsite dry storage units which are more costly than pool storage.

- Incorrect early choice of canister configuration could necessitate subsequent repackaging into different canisters.

- Canisters would probably require further preparation (e.g., inerting, welding) at the repository to ready them for insertion into the disposal container.

A.3.2.3 At-Reactor Consolidation into a Canister Compatible with Repository Specific Disposal Containers

With this alternative, the utilities would consolidate fuel rods into canisters that are compatible with proposed repository disposal containers. The canister sizes also would allow the disposal package characteristics to be changed without requiring repackaging as knowledge of the disposal medium improves and requires such changes. One such canister concept considered for this alternative is the square/half-square configuration as proposed by NUS Corporation in their PRDA studies, where two assemblies are consolidated into a full-square canister and one assembly is consolidated into a half-square canister. One canister size would be used for pressurized water reactor (PWR) assemblies and a smaller canister size would be used for boiling water reactor (BWR) assemblies. Two half-square canisters would occupy approximately the same space as a single full-square canister, permitting a variety of geometric arrangements and improving the packing efficiency of the canisters within the repository disposal container.

A second arrangement is possible for this alternative, wherein a single square canister size would encompass all types of fuel assemblies. In this second arrangement, PWR assemblies would be canistered as described in the first arrangement, two in a full-square canister and one in a half-square canister. However, BWR assemblies would be consolidated with five assemblies in a full-square canister, and no half-square BWR canisters would be produced to avoid placing rods from a single assembly into two different canisters. The advantages and disadvantages of this option relative to other at-reactor consolidation options are listed below.

Advantages

- Canisters could be compatible with existing pool storage racks and cask shipping baskets, simplifying in-pool handling.

- Canisters would be small, permitting various arrangements of canisters to best fill the disposal container at the repository, even if the container design were changed as repository design proceeds.

Disadvantages

- For the PWR- and BWR-specific canisters, two different sizes of canister would have to be handled in shipment and in disposal canister loading.

- For the single-size canister, the canister would not fit within existing racks at BWRs and could also require special racks at PWRs.

- Both types of canisters would probably require further preparation (inerting, welding) at the repository prior to placement into a disposal container.

A.4 TRANSPORTATION IMPROVEMENTS IN THE NO-MRS SYSTEM

A series of changes to the transportation system were evaluated that would provide benefits similar to the MRS system by reducing the number of discrete shipments moving through the system. This reduction would be achieved by 1) using larger casks, and 2) combining casks into multi-cask shipments. The primary effect of these improvements would be to improve the degree of control that could be exercised over the transportation system, i.e., by reducing the number of cross-country shipments to the repository. The specific options considered included:

- increased use of rail transport
- use of extra-large rail casks
- multi-cask shipments
- use of overweight truck casks.

In addition, cask payloads (both truck and rail) could be increased if spent fuel is consolidated at the reactor sites before it is shipped.

Implementing these improvements could reduce the total shipment-miles in the no-MRS system. These improvements will generally require use of new cask or handling technology, facilities such as marshalling yards, investments at utilities to improve existing reactor facilities, and some additional handling of spent fuel outside of contained areas. The total cost implications of these options have not been evaluated at this time, as most have not yet been designed in detail.

The estimated cost of spent-fuel transportation is relatively insensitive to whether or not an MRS facility is included in the waste management system and could either increase or decrease slightly depending on repository location and cask capacity for shipments from the MRS facility to the repository (see Appendix F).

All of these improvements to the transportation system could be implemented in the MRS system and could lead to further reductions in transportation impacts for that system as well as the no-MRS system.

Each of the improvements is described below, along with preliminary information on the potential feasibility and reductions in transportation impacts (cask-miles and shipment-miles), costs, and radiation dose effects. The relative advantages and disadvantages of each option, as compared to the reference no-MRS transportation system, is also provided.

A.4.1 Increased Use of Rail Transport

Recent studies of cask-handling capability at existing reactors (Daling et al. 1985) have shown that many reactors are limited in their ability to handle large rail casks. These limitations stem from such factors as inadequate crane lifting capacity, lack of a rail spur onto the site or into the reactor building, and structural limitations of the storage pool. For the reactors of interest in this study and for the comparison between the no-MRS and MRS systems in Chapter 2, it was assumed that approximately 30% by weight of the spent fuel would be shipped by truck. The remaining spent fuel would be shipped in rail casks, which typically hold about 7 times as many spent-fuel assemblies as do truck casks. Daling et al. (1985) found that for 127 reactors studied, 41 could not presently ship by rail.

As the fraction of spent fuel shipped by rail (rather than by truck) increases, the total number of cask-miles within the system declines. In the no-MRS system, the 30% of spent fuel that moves by truck accounts for about 75% of the total cask-miles and 75% of the total shipments. Consequently, reducing the amount of shipping by truck would reduce the number of discrete shipments and the total cask-miles. Figure A.2 shows total cask-miles for the no-MRS and MRS systems as the assumed fraction of shipments by truck originating from reactors falls from 30% to 0%. Significant reductions in cask-miles could be achieved in both the no-MRS and the MRS systems from an increase in the fraction of fuel shipped by rail.

Two methods for increasing the use of rail transport for shipments originating from reactors are discussed in this section:

- upgrade reactor facilities to provide direct rail access, e.g., by adding rail spurs and modifying crane capacity
- transfer spent fuel to large rail casks outside of the pool using smaller transfer casks loaded in the storage pool, and if necessary, transport the large casks by truck ("heavy-haul") to the nearest rail access point.

Of these alternatives, the first can be accomplished without new technology development or application. Upgrading reactor-handling capabilities would require retrofitting or recertifying present equipment to handle heavier rail casks. Also, reactors that do not have rail service into the reactor site would need that service. The second alternative would require dry-cask transfer methods to be developed and certified. This technology is currently being investigated, especially for its use as a method to load storage units that could be used at reactor sites. The cost, risk, and feasibility of this alternative are uncertain at this time. "Heavy-haul" has been used many times to move heavy components such as reactor vessels onto sites without rail access, but has not yet been used for spent-fuel shipments. Each alternative is discussed in more detail below.

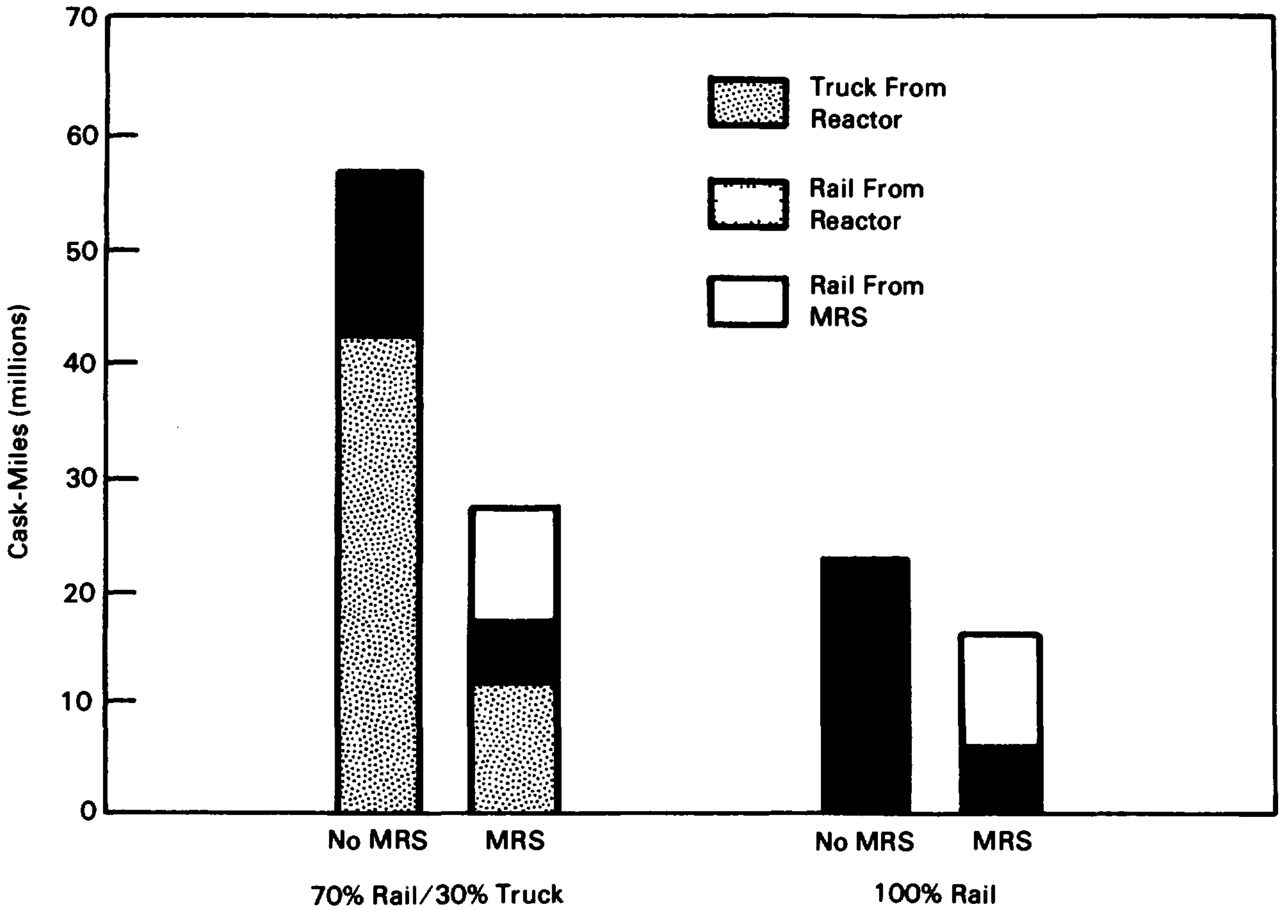

FIGURE A.2. Cask-Mile Reduction From Increased Rail Transport[a]

Upgrade Reactor Sites to Provide Direct Rail Access

A recent study (Daling et al. 1985) has estimated that 41 of 127 reactors do not have active rail lines or do not have the capability to receive, handle, and load a rail cask. Of these 41 plants, 12 plants would require extensive structural modifications within the reactor or fuel-handling buildings to upgrade rail capability. The remaining 29 reactors are limited to truck shipping because they are not provided with rail access to the site. These plants would require rail spurs to be built between the reactor site and the nearest rail point, distances ranging from 1 to 50 miles. Seventeen of these reactors were judged to be the most likely candidates for upgrades because they would require less than 10 miles of new rail spur construction and have no known

(a) Yucca Mountain repository is assumed, for illustrative purposes, to be the final destination in the calculations illustrated in this figure.

requirements for constructing bridges or tunnels. In many of these cases, additional studies would be required to assess the structural sufficiency of the pools, cranes and cask-handling areas before the first rail-cask handling sequence could commence.

Transport savings ranging from 10 to 35.5 million cask-miles for the MRS and no-MRS systems, respectively, would be achieved by providing direct rail access capabilities at all reactors. Figure A.2 shows the relationship for these bounding cases. As explained above, the likelihood and ease of providing direct rail service at these reactors varies. As a result, the actual cask-mile savings for these systems would be proportional to the percent of reactors to which rail access would be provided. The advantages and disadvantages of upgrading reactor sites to provide direct rail access relative to the reference no-MRS transportion system are listed below.

Advantages

- Cask-miles would be reduced because of the use of higher-capacity rail casks and the resulting reduction in the number of shipments.

- Transportation costs would be reduced because the unit cost for rail transport is less than the unit cost for truck transport, for long shipments.

Disadvantages

- Either utility funds would have to be expended for the improvements, which are of limited direct value to the utility, or Nuclear Waste Fund monies would have to be spent at specific sites, which could lead to equity questions.

- If the DOE were to fund on-site improvements, DOE's responsibilities for transport activities would be extended into reactor sites, and the DOE could become involved in licensing-related aspects of these improvements.

- In specific cases, the improvements might not be feasible because of right-of-way and rail access problems.

- Upgrading of the reactor fuel handling system might require extensive utility analyses prior to operational certification.

Dry-Cask Transfer and Heavy-Haul Methods

This alternative involves the transfer of spent fuel between casks in a dry environment and/or transfers of loaded spent-fuel casks between transport vehicles. Spent fuel from reactors not having rail cask receiving and loading capability could be loaded into a transfer cask (about the size of a truck cask) in the reactor pool using conventional methods. This loaded transfer cask would be removed from the reactor building and the spent fuel could be transferred directly (in a dry environment) to a large rail cask. Several transfer cask loads would be required to fill the rail cask. If there is no rail access at the reactor site, this rail cask would be heavy-hauled by truck to a nearby rail access point where it would be transferred onto a rail car. Some reactors could load the rail casks in their existing pool, but may not have onsite rail access. For these reactors, the rail transport cask would be heavy-hauled by special truck to a nearby rail access point where it would be transferred into a rail car.

The overall result of this alternative would be a shift from truck to rail transport. This shift would decrease the number of shipments and cask-miles, but require additional spent-fuel handling and transfer activities at or near the reactor facility. The advantages and disadvantages of dry-cask transfer and heavy-haul methods relative to the reference no-MRS transportation system are listed below.

Advantages

- Transportation system cask-miles and related transportation impacts such as public dose would be reduced.

- The DOE could use the largest practical rail cask, and a degree of independence from cask handling limitations at reactors (by use of a transfer cask) would be provided.

Disadvantages

- Transportation-related costs would increase significantly because of added handling activities, costs of transfer casks, and heavy-haul costs.

- Additional spent-fuel and hands-on cask handling steps would be involved that would increase occupational dose.

- Dry transfer technology is not currently licensed.

A.4.2 Use of Extra-Large Rail Casks

The use of extra-large rail casks (150 tons loaded) in the no-MRS system would significantly reduce the total cask-miles traveled as well as the total number of shipments required. The actual percentage reduction that may be obtained in cask-miles and in the number of shipments is directly proportional to the relative cask capacities. An extra-large rail cask (150 tons) could carry two to three times the spent-fuel payload of a 100-ton rail cask. This capacity increase would reduce the number of shipments and cask-miles by factors of two to three from those expected for the smaller cask.

The use of these large rail casks would require the implementation of dry-cask transfers at most of the reactors currently in operation in the U.S. The majority of reactors that are currently listed as having rail-cask-handling capabilities can handle rail casks having a loaded weight between 100 and 125 tons (Daling et al. 1985). This option, with its dry-transfer component, presents the same general advantages and disadvantages as described previously in Section A.4.1.

A.4.3 Multi-Cask Shipments

The total number of shipments and shipment-miles within the waste management system can be reduced by combining single-cask shipments into larger multi-cask shipments. The overall reduction in shipment-miles occurring in both the MRS and no-MRS systems by the use of multi-cask shipments is illustrated in Figure A.3. This figure shows the total shipment-miles resulting from 1, 3 and 5 casks per train shipment from individual reactors. The bounding case of all reactors shipping by rail was assumed in the calculations illustrated in the figure.

Several alternatives for combination of shipments were considered:

- use of truck convoys
- combining rail shipments at marshalling yards
- scheduling multi-cask shipments from reactors.

Inherent in each of these options is the added amount of non-transport time that occurs for individual casks. This increased non-transport time is incurred either at the reactor, where loaded casks are idle while awaiting the loading of subsequent casks, or at the marshalling yards, where early-arriving casks remain idle while awaiting the arrival of other casks to be added to the shipment. This increased non-transport time lengthens the average total time

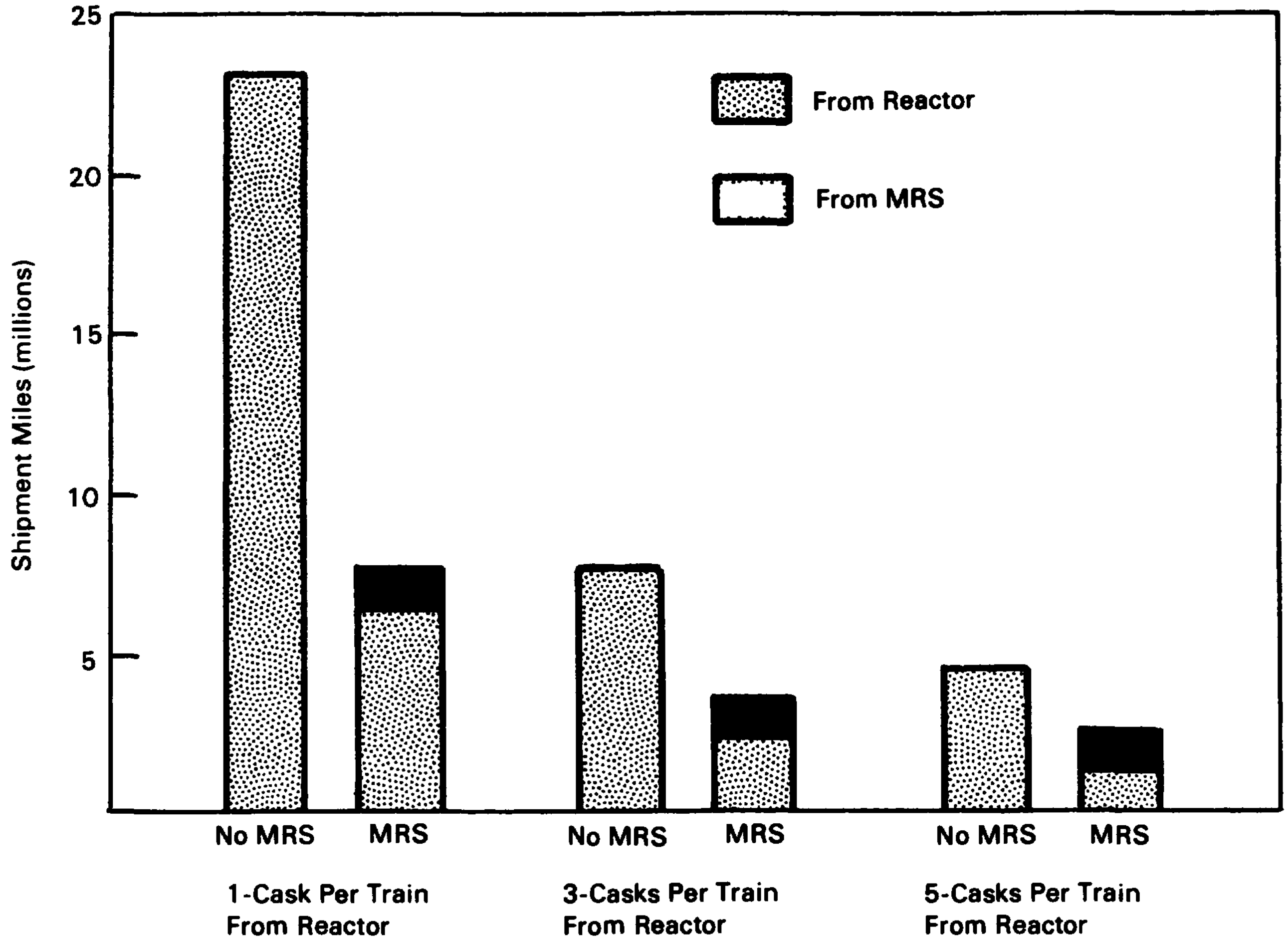

FIGURE A.3. Shipment-Miles as a Function of the Number of Casks in Multi-Cask Shipments[a]

required for a trip for casks and requires that more casks be added to the cask fleet to ship the same amount of spent fuel in an equivalent time period. These extra casks will add to the overall cost (capital and maintenance) of shipping the spent fuel.

Alternatives that consider the use of multi-cask shipments from individual reactors may impact the requirements for additional "at-reactor" storage within the reactor system. This increased requirement could result from the smaller number of reactors that would be serviced during a single year (fewer number of reactors, with larger amount of fuel taken from each reactor). Reactors not serviced during a given year will need an additional 1 to 2 years increased storage capacity and, in certain instances, may require additional out-of-pool storage.

(a) Yucca Mountain repository is assumed, for illustrative purposes, to be the final destination in the calculations illustrated in this figure.

All of these alternatives require differing degrees of planning, scheduling and control of operational parameters. No new technology is required for the implementation of any of these options. Each of the alternatives are discussed below.

Truck Convoys

This method of combining shipments would require individual truck shipments of spent fuel to be marshalled at either individual reactors or a centralized yard. The combined shipments would then travel as a convoy to the repository. This marshalling of truck shipments would, in effect, reduce the number of separate shipments of spent fuel on the highways. The advantages and disadvantages of this option relative to the reference no-MRS transportation system are discussed below.

Advantages

- Truck convoys would provide easier control and monitoring and would provide economies of scale for safeguards, security and emergency response functions.

Disadvantages

- Casks waiting to be formed into convoys would experience greater amounts of non-transport time.
- Logistical planning and scheduling would be more complicated.
- Occupational radiation exposure may be increased due to proximity to the waiting loaded casks.

Combine Rail Shipments at Marshalling Yards

Individual rail shipments from reactors could be combined into fewer, larger shipments to the repository by coordinating shipments from reactors near centralized marshalling yards. This would allow an opportunity for combining individual shipments into a single train and would minimize the total waiting time of casks at the marshalling yard.

The total number of shipment-miles that may be saved by the use of marshalling yards may be estimated by the use of Figure A.3. This figure represents the limiting case where each individual reactor would serve as a marshalling yard prior to multi-cask shipments of spent fuel. The actual savings would be somewhat less than that which is illustrated due to the transport legs from individual reactors to the marshalling yard. The advantages and disadvantages of this option relative to the reference no-MRS transportation system are listed below.

Advantages

- Management and monitoring capability would be more efficient, and the opportunity to share resources for safeguards, security and emergency response would be available.
- Switching operations at rail yards, where accidents are more likely to occur, would be decreased (Daling et al. 1985).

Disadvantages

- Holding, queuing and safeguarding of loaded rail-cask cars at public or private locations may be involved where local approvals may be required.
- Casks waiting to be formed into shipments to the repository would experience greater amounts of non-transport time.
- A larger queue would be created at the receiving facility, which would lengthen cask turnaround times and increase the required fleet size.
- Occupational radiation exposure may be increased due to proximity to the waiting loaded casks.

Scheduling Multi-Cask Shipments from Reactors

By scheduling to receive more than one cask of spent fuel at a time from each reactor and by combining the multiple casks in a single shipment, the number of separate shipments could be reduced. The advantages and disadvantages of this option relative to the reference no-MRS transportation system are listed below.

Advantages

- Training and retraining activities for handling crews at the reactor would be reduced because of fewer, but longer periods of loading operations.

- The number of individual shipments would decrease.

- Management and monitoring of shipments would be more efficient.

Disadvantages

- Casks sitting in queue for loading or unloading would experience longer non-transport times, which can increase the required fleet size and lead to increased occupational exposure.

A.4.4 Use of Overweight Truck Shipments

The capacities of truck casks are generally limited by the gross vehicle weight limits rather than by physical volume constraints. Thus, the size of truck shipments could be increased, with corresponding reductions in the number of such shipments, by using overweight rather than legal-weight shipments.

One complication with this alternative is that the regulations and statutes governing overweight truck shipments are not consistent throughout the U.S., but vary from state to state. This results in more complex scheduling and interactions to ensure that the overweight shipments are consistent with the regulations of the various states along the routes. Overweight shipments might also be constrained to operate only during certain times of the day or at reduced speeds, resulting in a net reduction in shipment speed. Some states also do not allow overweight truck shipments during the winter months because of possible damage to highways. The DOE is continuing to investigate and refine the scheduling and regulatory compliance issues associated with this option. The advantages and disadvantages of this option relative to the reference no-MRS transportation system are listed below.

Advantages

- The number of shipments would be reduced in direct proportion to the increased capacity of the truck casks and the fraction of overweight truck shipments.

- The transport cost would be slightly lower due to increased payload per shipment.

Disadvantages

- Route selection and timing of shipments would be less flexible.

- States could impose operational restrictions.

- Administrative costs would be increased by the cost of additional state permits.

- Modifications to handling equipment at reactors might be required.

A.5 REFERENCES

Bailey, W. J. 1985. Status of Rod Consolidation. PNL-5122, Pacific Northwest Laboratory, Richland, Washington.

Daling, P. M., et al. 1985. Spent Fuel Shipping Cask Handling Capabilities of Commercial Light Water Reactors. PNL-5384, Pacific Northwest Laboratory, Richland, Washington.

Garrity, J. H. 1984. "Review of Technical and Institutional Problems in Implementing a Spent Fuel Consolidation Program." Seminar on Spent Fuel Storage, Institute of Nuclear Materials Management, Washington, D.C.

U.S. Code of Federal Regulations, Title 10, Part 72 (10 CFR 72). "Licensing Requirements for the Independent Storage of Spent Fuel and High-Level Radioactive Waste."

U.S. Department of Energy. 1984. Draft Mission Plan for the Civilian Radioactive Waste Management Program. DOE/RW-0005, U.S. Department of Energy, Washington, D.C.

APPENDIX B

ALTERNATIVE DISTRIBUTION OF PACKAGING FUNCTIONS IN AN MRS SYSTEM

APPENDIX B

ALTERNATIVE DISTRIBUTION OF PACKAGING FUNCTIONS IN AN MRS SYSTEM

The need for monitored retrievable storage (MRS) was analyzed in Chapter 2, Part 1, of this Environmental Assessment. For that analysis, the MRS facility was assumed to handle only spent fuel and to service only the first repository. The preferred arrangement called for the MRS facility to receive and consolidate spent fuel from eastern reactors only and for the repository to prepare the final disposal container. Many other arrangements for the integral MRS facility are possible, however, and have been considered in arriving at the preferred configuration. This appendix presents an evaluation of these alternative arrangements and related issues concerning the deployment of the MRS facility.

Specifically, this appendix addresses the following issues and supports the findings that are listed under each set of issues:

1. Distribution of spent-fuel preparation functions. These functions include the disassembly and consolidation of spent-fuel assemblies; placement of fuel rods into canisters to facilitate handling, storage and retrieval operations; and placement of fuel rods or canisters into the final disposal container. In addition, the DOE has also considered options for handling fuel from western reactors in an MRS system. Findings for this issue are:

    - Consolidation should be performed at the MRS facility.
    - Final packaging for disposal should be performed at the repository.
    - Canistering and packaging of western fuel assemblies at the repository reduces transportation impacts to most sites (cask-miles, cost, and risk) with little or no increase in system cost.

2. Interactions between MRS deployment decisions and other waste management system design and integration issues. The DOE has considered the implications of the possible strategies for handling defense high-level waste (DHLW) on the deployment of the MRS facility. Also, the possible interactions of the MRS facility with the second repository (not presently authorized by Congress) have been considered. Findings for this issue are:

- Accepting DHLW at the repository would strengthen the motivation to place the spent fuel into a disposal container at the repository if that placement is required for DHLW and has not been done at the defense facilities. The DHLW will be shipped directly to the repository and the MRS facility will not handle DHLW.

- The current MRS design could serve two repositories at the receipt rate specified in the Mission Plan (DOE 1985a) if the second repository is increasing its receipt rate, while the first repository is decreasing its receipt rate in anticipation of closure. Alternatively, this MRS facility design could accommodate two repositories simultaneously, but at lower individual receipt rates.

- Use of a single MRS facility to supply two repositories would result in a lower average cost per MTU (metric ton of uranium) emplaced without a significant increase in public risk or radiation exposure, as compared with having two or more MRS facilities.

3. Configuration of the transportation leg between the MRS facility and the repository. Several options exist for configuring this transportation segment. The MRS facility would provide the opportunity to use dedicated train shipments and high-capacity rail casks for shipment to the repository, but multicask shipments using general rail commerce could also be used. The finding for this issue is:

   - Compared with general commerce, the use of dedicated trains would reduce transport time, would reduce the number of shipments required, and would increase the degree of control that can be exercised over the cross-country shipment of spent fuel, even though it could increase system cost due to higher shipping costs.

The analyses and discussions that led to the above conclusions are contained in the following sections of this appendix.

B.1 DISTRIBUTION OF SPENT-FUEL PREPARATION FUNCTIONS

This section discusses the possible effects on the waste management system of 1) consolidating the spent-fuel assemblies at either the MRS facility or the repository, 2) applying the final disposal container at either the MRS facility or the repository, and 3) sending the fuel from western reactors either through the MRS facility or directly to the repository.

B.1.1 Fuel-Assembly Consolidation

Consolidation of fuel assemblies into compact packages of rods reduces the volume occupied by the spent fuel and can benefit storage, transportation and disposal processes. By reducing the volume, more material can be stored in the same space. Similarly, since more fuel can be placed in a given cask, the number of cask shipments required to transport a given amount of fuel from the MRS facility could be reduced, thereby reducing the expected number of transportation accidents and the public radiation exposure due to cask shipments. And finally, if consolidation were done at the MRS facility, there would most likely be both worker exposure and cost reductions at the repository. Exposure and costs would most likely be reduced because, for a given amount of fuel, fewer casks would be received, fewer disposal packages would be prepared and emplaced, and fewer boreholes would be required to emplace the material.

The MRS facility is designed to perform consolidation of spent-fuel assemblies and to place the rods into sealed canisters for near-term storage when necessary and for eventual enclosure in a repository-specific disposal container. The facility is designed to consolidate the spent fuel from eastern reactors that is destined for the first repository. Transport of the fuel, consolidated and sealed in canisters, from the MRS facility to the repository would be accomplished in large rail casks. A 150-ton rail cask could carry two to three times as much consolidated canistered fuel as intact canistered fuel. Compared to using a 100-ton cask, using the 150-ton rail casks to carry canisters of consolidated fuel would reduce the number of shipments and the cost of transport between the MRS facility and the repository, thereby reducing the expected number of transportation accidents and the potential for radiation exposure to the public.

In the no-MRS system, consolidation of spent fuel at the repository would be accomplished using essentially the same type of facilities as are planned for the MRS facility. Occupational radiation doses accumulated from consolidation and canisterization would be essentially the same as at an MRS facility, and the direct cost of performing the work would also be essentially the same. Some reductions in the cost of support services would be expected, since the subsurface repository operations would share in the cost of providing those services.

At-repository consolidation has two principal disadvantages. Those disadvantages are that the cask-miles and other transportation effects would be markedly increased compared with consolidation at a point closer to the reactors (e.g., at an MRS facility), and that the facility could serve only the one repository cost effectively. An advantage of consolidation at an MRS facility is the earlier operation of the consolidation system, which would provide assurance that startup of the pre-emplacement packaging system would not detract from initial repository operation. The centrally located MRS facility could also provide an option for preparing fuel for the second repository, if determined desirable.

The principal parameters of interest are compared in Table B.1, for consolidation either at the MRS facility or at the repository. These data are compared graphically in Figures B.1 and B.2. From consideration of these data and the foregoing discussion, it is concluded that some system advantages would result from performing consolidation of spent fuel at the MRS facility.

The preceding discussion was based on the assumption that consolidation of spent fuel would be performed somewhere within the waste management system. However, it has not yet been determined whether consolidation will be a required part of the system. While there appear to be some system benefits resulting from consolidation at an MRS facility, the principal system benefit provided by an MRS facility would be the decoupling of the receipt of spent fuel into the system from the disposal of spent fuel at the repository, a benefit that would continue whether or not spent fuel is consolidated.

TABLE B.1. Effect of Fuel Consolidation on MRS-to-Repository Cask-Miles and Transport Costs[(a)]

Consolidation at	Cask-Miles[(b)] (millions)	Transport Costs (millions $)
Basalt		
MRS	9.5[(c)]	430.9[(c)]
Repository	9.9	577.6
Salt		
MRS	5.4[(c)]	343.9[(c)]
Repository	5.4	423.8
Tuff		
MRS	12.4[(c)]	569.3[(c)]
Repository	9.0	547.6

(a) 62,000 MTU throughput; all fuel passes through the MRS facility.
(b) 150-ton rail cask; capacity 22 to 38 MTU consolidated, 16.5 MTU intact.
(c) Based on repository-specific canisters not optimized for transport.

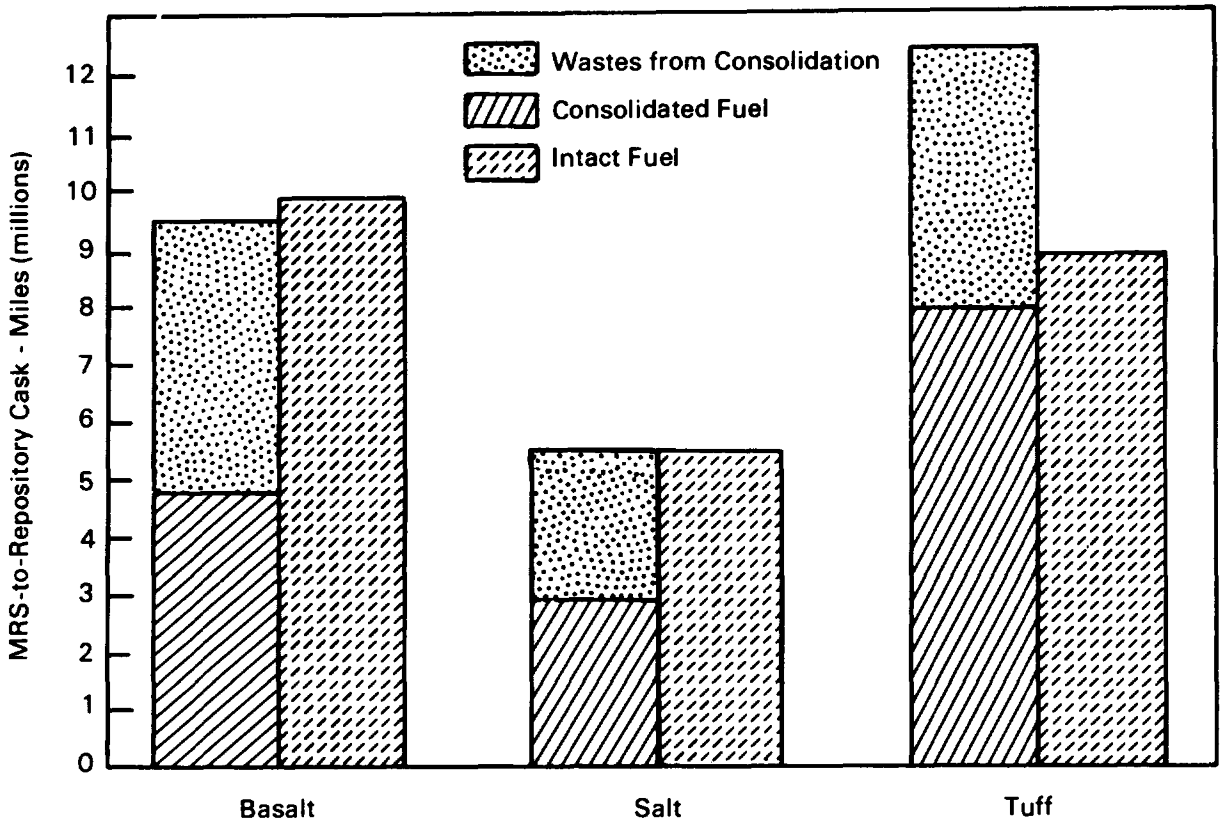

FIGURE B.1. Comparison of MRS-to-Repository Cask-Miles with Consolidation at Either MRS or Repository

B.1.2 Application of Disposal Container

The alternatives for application of a final disposal container, if one is required, are shown in Figure B.3. The final disposal container could be applied at either the MRS facility or the repository with little effect on system capital or facility operating cost, as shown by the results from the MRS/Repository Interface Task Force (DOE 1986). Among the disadvantages of final packaging at the MRS facility would be the increased quality assurance requirements that could arise at the repository for containers that have undergone long distance transport. The geologic medium into which the container would be emplaced can have an impact on where to prepare the final container. For the heavy-walled containers required in salt and basalt, the increased number of cask shipments between the MRS facility and the repository required to carry the large containers would be a cost disadvantage. Recent analyses have suggested that, for a salt repository container, the capacity of a 150-ton rail cask would be reduced from five containers to three, thus increasing the number of shipments and the cost of transport by a similar ratio (i.e., a factor of nearly 1.7). The thinner-walled containers planned for use

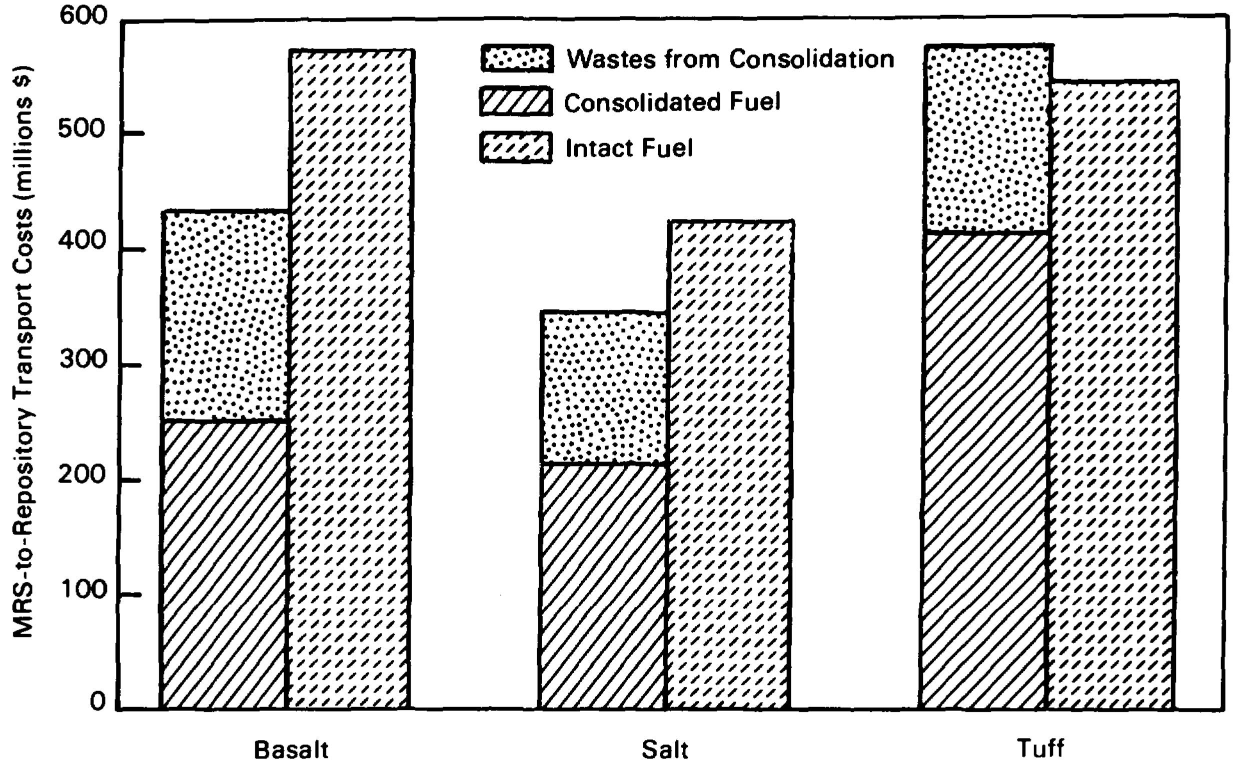

FIGURE B.2. Comparison of MRS-to-Repository Transport Costs with Consolidation at Either MRS or Repository

in the tuff repository would cause little or no impact on the transportation system. DHLW canisters in the waste stream would present the same disadvantages for final packaging at the MRS facility as do the canisters of spent fuel, in terms of transport costs and quality assurance/quality control (QA/QC) requirements.

Preparing the final disposal container at the repository has several advantages and no major disadvantages. The empty containers would be shipped to the repository by ordinary freight since they would be clean and nonradioactive, thus reducing that transport cost compared with shipping containers when filled with spent fuel. Spent-fuel canisters would be shipped to the repository from the MRS facility in casks that have higher payload capabilities for canisters than if the canisters were inserted in the thicker-walled disposal containers. Producing the final closure and performing the appropriate QA/QC tests on the container would be done in the repository hot cell just prior to emplacement. The loaded final container would not have undergone

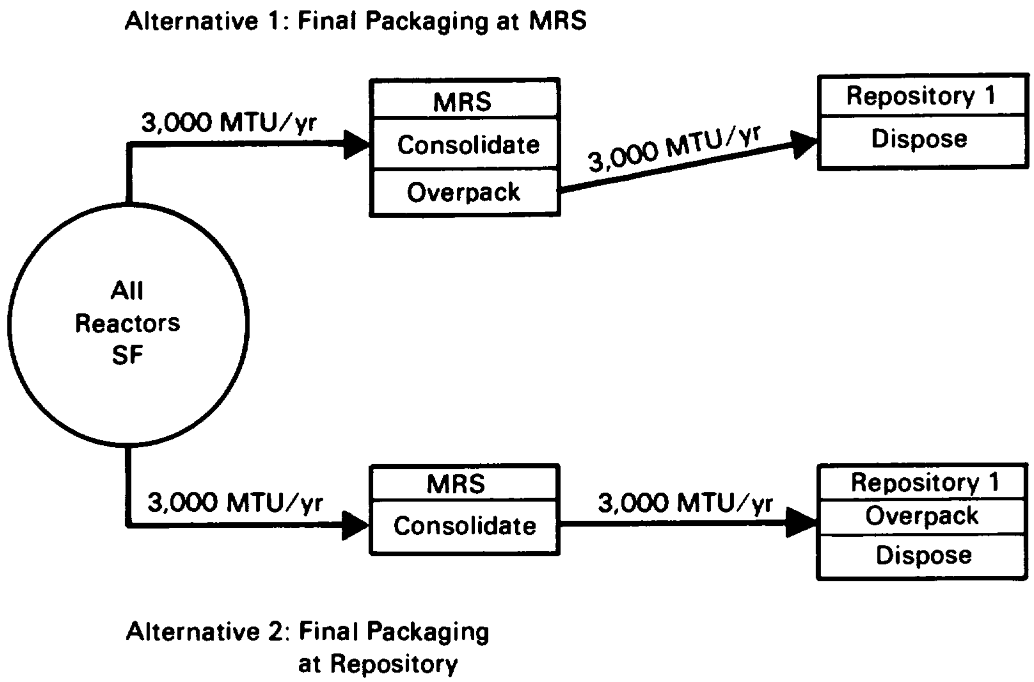

FIGURE B.3. Alternatives for Applying the Final Disposal Package

extensive transport in a rail cask prior to emplacement. The only obvious disadvantage to having this function at the repository would be the very slight increase in the size of the already-required receiving hot cell to accommodate the packaging functions.

The principal tradeoffs for applying the final disposal container at either the MRS facility or at the repository are shown in Table B.2. From consideration of these data and the foregoing discussion, the currently preferred location for applying the disposal container is the repository.

B.1.3 Treatment of Western Fuel

The alternatives for preparing and packaging spent fuel from western reactors are shown in Figure B.4. Since most of the repository sites presently under consideration are in the western part of the U.S., and the proposed sites for the MRS facility are all in the south-central part of the country, the treatment of the spent fuel from the western reactors should be addressed. In the MRS system, the spent fuel from western reactors could be 1) shipped directly to the MRS facility in conventional truck or rail casks to join the main spent-fuel flow for normal consolidation and canisterization, or 2) shipped intact directly to the repository in conventional truck or rail casks for consolidation, packaging, and disposal. The incremental changes in

TABLE B.2. Effect of Packaging Location on Cask-Miles and Transportation Costs[a]

Disposal Containers Applied At	Cask-Miles (millions)	MRS-to-Repository Transportation Costs (millions $)[b]
Basalt		
MRS	9.9	502.7
Repository	4.8	247.9
Salt		
MRS	4.5	314.3
Repository	2.9	211.9
Tuff		
MRS	9.2	495.9
Repository	7.6	411.7

(a) Based on: 62,000 MTU throughput; all fuel consolidated at the MRS facility; repository-specific canisters and disposal containers not optimized for transport; 150-ton cask with capacity 18.5 to 22.0 MTU in repository-specific disposal containers, 22 to 38 MTU in repository-specific canisters; cask-miles and transportation cost are assumed to vary linearly with capacity.
(b) Costs based on shipment of fuel only, not including consolidation wastes.

system cask-miles and in system costs for implementing strategy (2) above, compared to strategy (1), are given in Table B.3. Each of these strategies has some advantages and disadvantages, as discussed below.

The principal advantage of shipping western spent fuel directly to the repository is the reduction in cask-miles and associated transportation effects (see Section 2.3). As shown in Table B.3, total cask-miles for transporting all 62,000 MTU of spent fuel to the repository would be reduced by 1.8 to 5.3 million miles. This corresponds to a reduction of 7% to 17% for the three repository sites considered. Although not shown in Table B.3, there would be a significant decrease in cross-country shipments with the western fuel shipped

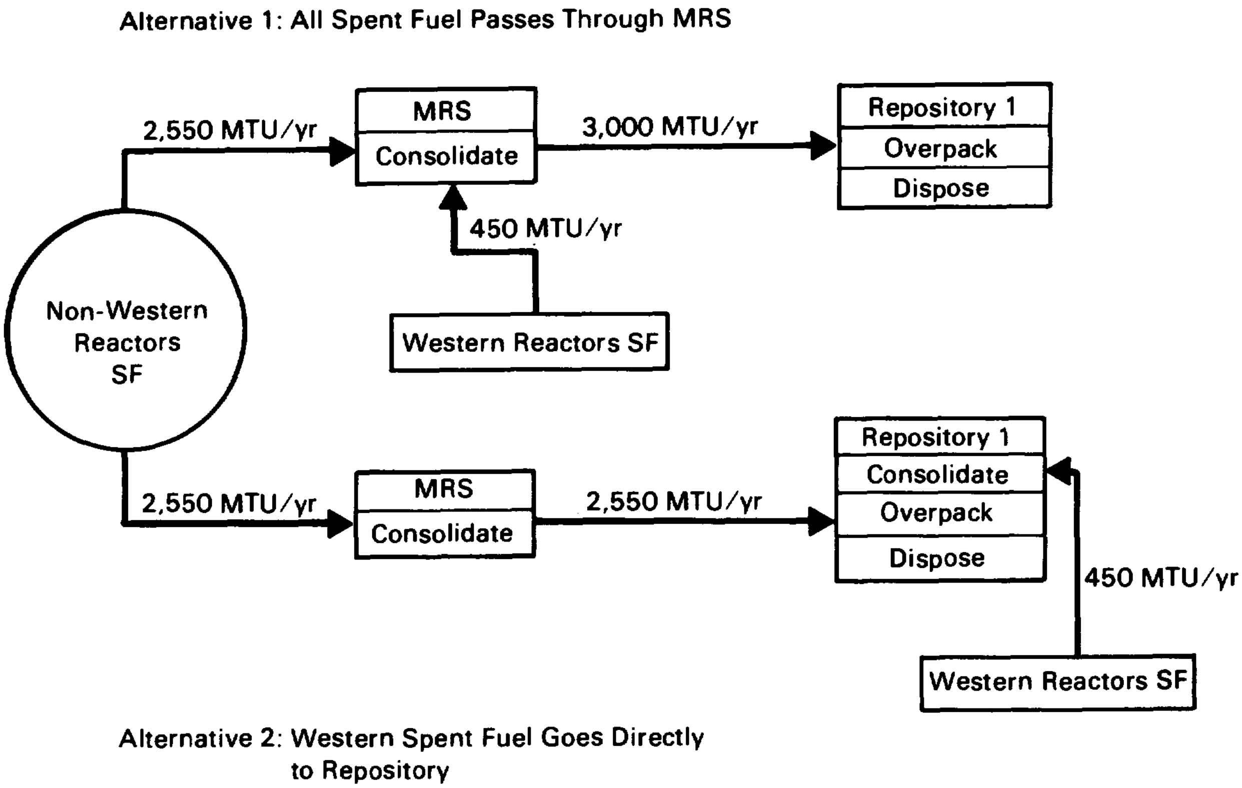

FIGURE B.4. Alternatives for Preparing and Packaging Western Spent Fuel

directly to the repository. With that decrease, the management and control of the transportation function would be simplified (see Section 2.3).

Transportation costs would be reduced by roughly $100 million if the western fuel were to be shipped directly to the repository, for a net change in system cost ranging from zero to an increase of about $100 million, depending on repository location.

With all spent fuel passing through an MRS facility, material received at the repository would normally be in sealed, clean canisters. Thus, the hot-cell capability and operations at the repository would be limited to receiving clean canisters and inserting them in disposal containers. The hot cells would remain essentially uncontaminated.

Receiving spent-fuel assemblies from the western reactors would require additional hot cell capability at the repository. In addition, facilities would have to be added to treat the radioactive by-products and contamination associated with handling of bare spent fuel. The MRS/Repository Interface Task

TABLE B.3. Effects of Implementing Western Fuel Strategies[a]

Parameter	(All Fuel Through MRS) Strategy 1			(Western Reactor Fuel Direct to Repository) Strategy 2			Incremental Effect		
	Basalt	Salt	Tuff	Basalt	Salt	Tuff	Basalt	Salt	Tuff
Cask-Miles[b] (millions)	29.6	25.6	32.1	25.5	23.8	26.8	-4.1	-1.8	-5.3
Transport Costs[c] (billions)	1.0	0.9	1.2	0.9	0.9	1.1	-0.1	0.0	-0.1
MRS Facility and Repository Costs[c] (billions)	6.1	5.9	5.4	6.2	6.0	5.5	0.1	0.1	0.1
System Cost (billions)	7.1	6.8	6.6	7.1	6.9	6.6	0.0	0.1	0.0

(a) 9000 MTU of western fuel to the repository.
(b) 30% truck/70% rail, reactor to MRS; 100% rail in 150-ton casks, MRS to repository (see Tables F.6-F.10).
(c) Data from Table C.10.

Force report (DOE 1986) indicates that the repository life-cycle costs (not including transportation) would be increased by about $300 million and the MRS facility costs reduced by $200 million if the western fuel were to be consolidated at the repository, instead of being shipped directly to the MRS facility for consolidation. Detailed acceptance scheduling to be completed by 1991 may show, however, that exceptions are warranted to accommodate western reactors' schedules early on or under unusual circumstances. In no case would western fuel be precluded from shipment to the MRS facility should schedule or circumstances warrant, i.e., if necessary for the DOE to meet contractual obligations for acceptance.

Selection of Strategy 2 (western fuel direct to repository) has an additional aspect that must be considered. The western fuel could not be received at the repository until it opens for operation, presently planned for 1998, compared with the planned initial receipt of spent fuel at an MRS facility some 15 months earlier. A review of the projections of spent-fuel storage requirements (DOE 1985b) shows, however, that only one western reactor would likely have a storage problem during that time interval.

B.2 MRS DEPLOYMENT AND FUTURE SYSTEM DECISIONS

This section discusses where the disposal container should be applied to defense high-level waste and whether the MRS facility could and/or should service more than the first repository.

B.2.1 Packaging of Defense High-Level Waste

The defense high-level wastes (DHLW) are expected to be mixed with glass and cast into a canister that is sealed and decontaminated at the waste production site. The principal issue related to DHLW is where in the system a final disposal container, if required, should be applied.

The same considerations discussed in Section B.1.2 on where to apply the disposal container to the spent-fuel canisters are relevant to this issue. Since the canisters would be clean and acceptable for transport without further packaging, there would seem to be no incentive to apply the final container prior to receipt at the repository. Application of the container at the production site would increase the number of cask shipments and the transport cost relative to application at the repository. Application of the container at the MRS facility would also increase the number of cask shipments and the transport cost. Application of the container at the repository would minimize the number of cask shipments and the transport costs, and would facilitate container quality assurance. Thus, performing the final packaging for DHLW at the repository would provide a further incentive for preparing the spent-fuel disposal container at the repository since many of the facilities and resources could be shared.

B.2.2 Servicing a Second Repository

A waste management system without an MRS facility would require construction and operation of a complete fuel consolidation and packaging facility at each disposal site, thus duplicating expensive facilities. The MRS facility would provide an option for packaging for the second repository that could result in improved waste system efficiency. This option will be evaluated as the second repository becomes more definitive.

B.3 MRS TO REPOSITORY TRANSPORTATION CONFIGURATION

Two alternative configurations for transportation between an MRS facility and the repository have been compared. The two configurations are: 1) transport by general-freight commodity service; and 2) transport by dedicated (single-use) service. The assumptions used in these analyses and the results are discussed below.

B.3.1 General-Freight Service

The analyses performed for transport of spent fuel (and associated waste products) between the MRS facility and a repository by general-freight service assumed that the spent fuel would be handled as a general commerce commodity. The spent fuel was assumed to be shipped on a one cask-car or five cask-cars per train basis at an average speed of approximately 200 miles per day. This average speed accounts for delays at various classification and switching yards that general commerce commodity shipments encounter during routine transit. Each individual shipment of spent fuel is assumed to be accompanied by an escort service riding on the train.

In addition to the round-trip transit time for routine shipping, an additional 1.5 days turnaround time for loading each of the spent-fuel casks at the MRS facility and 1.5 days for unloading each of the casks at the repository was assumed.

B.3.2 Dedicated Service

The use of dedicated train service for transport of spent fuel (and associated waste products) between the MRS facility and the repository assumes that spent fuel would be the only commodity transported on the train. The dedicated train was assumed to consist of five to ten cask-cars and operate at an average speed of 1.5 times the speed assumed for general freight service. The increase in average speed is primarily due to much shorter times spent in switching or classification yards due to the single-use feature of the train; the train does not travel at a higher speed. Escort service is supplied for each train-load of spent fuel.

The cumulative turnaround time at each end of the trip for loading or unloading the casks of spent fuel was assumed to vary between 4.5 days and 7.5 days for 5 and 10 casks per train, respectively.

B.3.3 Cost and Risk Comparison

Analyses of the comparative costs and risks associated with general freight service and with dedicated train service are presented in the following subsections.