7.4 Transportation Accidents

A description of the methodology used to analyze the environmental impacts associated with the transportation of radioactive materials, including accidents, is provided in Subsection 5.11.2. The NRC has analyzed the transportation of radioactive materials in its assessments of environmental impacts for the proposed ESP sites at North Anna, Clinton, and Grand Gulf (References 7.4-1, 7.4-2, and 7.4-3). STPNOC has reviewed the NRC analyses for guidance in assessing transportation impacts for the two proposed ABWR units at the STP site (Reference 7.4-1, 7.4-2, 7.4-3). As discussed in Subsection 5.11.1, transportation of radioactive waste is enveloped by the analyses in [WASH 1238 and NUREG-75/038] and no further analysis is required. STPNOC has prepared additional analyses of fuel transportation effects.

7.4.1 Transportation of Unirradiated Fuel

Accident risks are calculated as a product of frequency and consequence. Accident frequencies for transportation of fuel to future reactors are expected to be lower than those used in the analysis in WASH-1238 (Reference 7.4-4), which forms the basis for Table S-4 of 10 CFR 51.52, because of improvements in highway safety and security since that document was written. Traffic accident, injury, and fatality rates have fallen over the past 30 years. The consequences of accidents that are severe enough to result in a release of unirradiated particles to the environment from advanced light water reactors (LWR) fuels are projected to not be significantly different from those for current generation LWRs. The fuel form, cladding, and packaging are similar to those used in the LWRs analyzed in WASH-1238 (Reference 7.4-4). Consequently, as described in NUREG-1811 (Reference 7.4-1), NUREG-1815 (Reference 7.4-2), and NUREG-1817 (Reference 7.4-3), the risks of accidents during transportation of unirradiated fuel to STP 3 & 4 would be expected to be smaller than the reference LWR results listed in Table S-4.

7.4.2 Transportation of Spent Fuel

The RADTRAN 5 computer code was used to estimate impacts of transportation accidents involving spent fuel shipments. RADTRAN 5 considers a spectrum of potential transportation accidents, ranging from those with high frequencies and low consequences (i.e., “fender benders”) to those with low frequencies and high consequences (i.e., accidents in which the shipping container is exposed to severe mechanical and thermal conditions).

The radionuclide inventory for the ABWR spent fuel after five years of decay has been developed by GE. Previous NRC evaluations (References 7.4-1, 7.4-2, and 7.4-3) have identified the radionuclides that are the dominant contributors to transportation accident risks. The dominant radionuclides are similar regardless of the fuel type. Based on a review of the NRC analyses, it was determined that the screening results were appropriate to apply to the ABWR fuel inventory to simplify the RADTRAN 5 calculations. The spent fuel inventory used in this analysis for the ABWR is presented in Table 7.4-1.

Engineered shipping casks are used to transport spent fuel because of the radiation shielding and accident resistance required by 10 CFR 71, “Packaging and Transportation of Radioactive Material.” Spent fuel shipping casks must be certified as Type B packaging systems, meaning they must withstand a series of severe hypothetical accidents with essentially no loss of containment or shielding capability. According to NUREG/CR-6672, Volume 1 (Reference 7.4-5), the probability of encountering accident conditions that would lead to shipping cask failure is less than 0.01% (i.e., more than 99.99% of all accidents would result in no release of radioactive material from the shipping cask). This analysis assumed that shipping casks for advanced LWR spent fuels would provide mechanical and thermal protection of the spent fuel cargo that is equivalent to that for current generation spent fuel.

The RADTRAN 5 accident risk calculations were performed using radionuclide inventories per shipment for the spent fuel from the ABWR assuming 0.5 MTU per shipment. The resulting risk estimates were multiplied by the expected annual spent fuel shipments (MTU per year) to derive estimates of the annual accident risks associated with spent fuel shipments from the ABWR. The amount of spent fuel shipped per year was assumed to be equivalent to the annual discharge quantity: 42 MTU per year for an ABWR. (This discharge quantity has not been normalized to the reference LWR. The normalized value is presented in Table 7.4-2.)

The release fractions for current generation LWR fuels were used to approximate the impacts from the advanced LWR spent fuel shipments. This assumes that the fuel materials and containment systems for the ABWR (i.e., cladding, fuel coatings) behave similarly to current LWR fuel under applied mechanical and thermal conditions.

Using RADTRAN 5, the population dose from the released radioactive material was calculated for five possible exposure pathways:

(1) External dose from exposure to the passing cloud of radioactive material.

(2) External dose from the radionuclides deposited on the ground by the passing plume (the radiation exposure from this pathway was included even though the area surrounding a potential accidental release would be evacuated and decontaminated, thus preventing long-term exposures from this pathway).

(3) Internal dose from inhalation of airborne radioactive contaminants.

(4) Internal dose from resuspension of radioactive materials that were deposited on the ground (the radiation exposures from this pathway were included even though evacuation and decontamination of the area surrounding a potential accidental release would prevent long-term exposures).

(5) Internal dose from ingestion of contaminated food (the analysis assumed interdiction of foodstuffs and evacuation after an accident; no internal dose due to ingestion of contaminated foods was calculated).

A sixth pathway, external doses from increased radiation fields surrounding a shipping cask with damaged shielding, was considered but was not included in the analysis. It is possible that shielding materials incorporated into the cask structures could become damaged as a result of an accident. However, the loss of shielding events was not included in this analysis because their contribution to spent fuel transportation risk is much smaller than the dispersal accident risks from the five pathways listed above.

In addition, calculations were performed to assess the environmental consequences of transportation accidents when shipping spent fuel from the STP site to a spent fuel repository assumed to be at Yucca Mountain, Nevada. The shipping distances and population distribution information for the route were the same as those used for the "incident-free" transportation impacts analysis.

Table 7.4-2 presents unit (per MTU) accident risks associated with transportation of spent fuel from the STP site to the proposed Yucca Mountain repository. The accident risks are provided in the form of a collective population dose (i.e., person-rem over the shipping campaign). The table also presents estimates of accident risk per reactor year normalized to the reference reactor analyzed in WASH-1238 (Reference 7.4-4). The transportation accident impacts were also calculated for the alternative sites (Allens Creek, Limestone, Malakoff, and Parish) within the region of interest.

The risk to the public from radiation exposure was estimated using the nominal probability coefficient for total detriment [730 fatal cancers, nonfatal cancers, and severe hereditary effects per 1×10^6 person-rem from ICRP Publication 60 (Reference 7.4-6)] health effects per reference reactor year. These values are presented in Table 7.4-2. These estimated risks are quite small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that would be expected to occur annually in the same population from exposure to natural sources of radiation using the same linear, no-threshold dose response model. Therefore, there will be negligible increases in environmental risk effects as a result of accidents that may result from shipping spent fuel from the STP site to a spent fuel disposal repository.

7.4.3 Conclusion

Based on these analyses, STPNOC concludes that the overall transportation accident risks associated with spent fuel shipments from the proposed ABWR units at the STP site are SMALL. This is consistent with the NRC conclusion regarding the risks associated with transportation of spent fuel from current generation reactors presented in WASH-1238 (Reference 7.4-4) and in Table S-4 of 10 CFR 51.52.

7.4.4 References

7.4-1 “Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site, NUREG-1811,” December 2006.

7.4-2 “Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site, NUREG-1815,” July 2006.

7.4-3 “Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site, NUREG-1817,” April 2006.

7.4-4 “Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, WASH-1238,” December 1972.

7.4-5 “Reexamination of Spent Fuel Shipment Risk Estimates,” NUREG/CR-6672, Volume 1, March 2000.

7.4-6 “Recommendations of the International Commission on Radiological Protection, ICRP Publication 60,” ICRP (International Commission on Radiological Protection), 1991.

Table 7.4-1 Radionuclide Inventory Used in Transportation Accident Risk Calculations for the ABWR

Radionuclide	ABWR Inventory Ci/MTU
Co-60	3630
Am-241	1440
Am-242m	33.2
Am-243	59.5
Ce-144	1.32×10^4
Cm-242	62.2
Cm-243	61.7
Cm-244	1.35×10^4
Cm-245	2.25
Cs-134	7.76×10^4
Cs-137	1.58×10^5
Eu-154	1.56×10^4
Eu-155	8270
Pm-147	3.13×10^4
Pu-238	1.09×10^4
Pu-239	427
Pu-240	852
Pu-241	1.35×10^5
Pu-242	3.19
Ru-106	2.29×10^4
Sb-125	7,170
Sr-90	1.06×10^5
Y-90	1.06×10^5

Ci/MTU = curies per metric ton uranium

Table 7.4-2 Spent Fuel Transportation Accident Risks for the ABWR

Site	Unit Population Dose (Person-Rem per MTU) [1]	MTU per Reference Reactor Year	Population Dose (Person-Rem per Reference Reactor Year) [1]	Total Detrimental Health Effects per Reference Reactor Year
STP	5.15×10^{-8}	29	1.50×10^{-6}	1.09×10^{-9}
Allens Creek	5.05×10^{-8}	29	1.47×10^{-6}	1.07×10^{-9}
Limestone	5.32×10^{-8}	29	1.54×10^{-6}	1.13×10^{-9}
Malakoff	5.21×10^{-8}	29	1.51×10^{-6}	1.10×10^{-9}
Parish	5.75×10^{-8}	29	1.67×10^{-6}	1.22×10^{-9}

[1] Value presented is the product of probability and collective dose