U.S. Nuclear Regulatory Commission Research Needs
Relevant to Spent Nuclear Fuel Recycle

- Separation Factors—Knowledge of the split of each chemical species in each process step in the plant (the separation factors) constitutes information critical to determining the inventory and concentration of each species in each process, effluent, or waste stream. This inventory and concentration is the starting point for estimating routine releases and the consequences of accidents. Additional knowledge is needed about the radioelements iodine, technetium, and neptunium.

- Modeling—A model can be developed that simulates the interconnected equipment in a facility flowsheet using the separation factors to determine the radionuclide concentrations and inventory. Such models need to accommodate complexation, colloids, internal recycle streams, and important conditions in bulk fluids (e.g., temperature, acidity, radiolysis).

- Solvent Stability—Spent nuclear fuel (SNF) recycle flowsheets call for the use of multiple organic solvents for extracting various radionuclides, as well as ion exchange materials that are subject to degradation by radiation or aggressive chemicals such as nitric acid. The effects of degradation products can range from altered process behavior to the formation of chemicals that can cause explosions. The ability to understand the formation and behavior of these species is important to assessing safety.

- Cost-Benefit Analysis of Effluent Controls—At some point, it will be necessary to determine the fraction of volatile radionuclides that can be released from the reprocessing plant. This will involve balancing the capabilities of various technologies for removing radionuclides, the cost of removing various amounts of radionuclides, and the dose reduction achieved by removing each additional increment of a radionuclide. Work is required to understand and document the technical status and cost of effluent control technologies and to develop a methodology for performing the cost-benefit analysis.

- Novel Waste Forms—SNF recycle could produce a number of waste forms for which few data exist on long-term performance and degradation. Examples include krypton (gas cylinders, ion implantation in metal), iodine (barium iodate in cement, silver zeolite in cement), carbon (calcium carbonate in cement, organic compounds), technetium (compacted cladding, melted cladding), and cesium/strontium (an aluminosilicate mineral). An understanding is needed of the performance of these waste forms in likely storage and disposal environments.

- Behavior of Tritium and Cladding in Voloxidation—Voloxidation is a process in which segmented SNF is heated in air to disaggregate the SNF matrix to powder and release tritium from the matrix. However, a significant amount of tritium is expected to be in the cladding in the form of zirconium tritide. More information is needed on the effects of various voloxidation conditions on the fraction of tritium released.

- Residual Cladding Contamination—How much of the SNF remains with the cladding? Is the radionuclide distribution the same as the SNF, or are some elements preferentially associated with the cladding? This is somewhat important in a waste disposal situation but would be very important if U.S. Department of Energy proposals involving recycling the cladding material become reality.

- Institutional Controls and Cement—Storage time for a cesium/strontium waste until it decays to the Class C concentrations is about 300 years. During this period, it is to be stored in an actively managed engineered surface storage facility. Reviewing the acceptability of this concept and the specific technology proposed will require judgments on the reliability of institutional controls for this duration. A better understanding of the strengths, limitations, and historical performance of such controls is desirable to provide a basis for these judgments. Similarly, information on the amount of maintenance likely to be required during the institutional control period and the performance of the facility and the degradation rate of the facility after controls cease is important for assessing the performance of and potential releases from the facility.