1. Summary

Public concern and increased cost of the disposal of low-level radioactive waste (LLRW) have led to a need to address the minimization of these wastes particularly as they pertain to research laboratories and other small users of radioactive materials. The information in this Report will prove valuable not only to the generator of this waste but to those organizations responsible for licensing and regulation.

Since risks associated with waste are related to the concentration of the hazardous material, the quantity and form of the waste, and the potential for dispersion in the environment, the generator's first priority should be the partial or total elimination of the source of the waste stream. Furthermore, waste that cannot be eliminated should be recycled in an environmentally safe manner. Next, waste that cannot be eliminated or recycled should, when feasible, be treated to reduce its hazards and to reduce the volume of the wastes. The final step is that of selecting a disposal method consistent with protection of the public health and the environment which is in compliance with federal and state laws and regulations.

An overview of applicable laws and regulations is essential in understanding the needs for a waste minimization program. The production and disposal of radioactive wastes are ultimately guided and controlled by federal laws beginning with the Atomic Energy Act of 1954 (AEA), as amended, and now include the following:

- Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)
- Hazardous and Solid Waste Amendments Act of 1984 (HSWA)
- Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA)
- Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA)
- Nuclear Waste Policy Act of 1982 (NWPA)
- Pollution Prevention Act of 1990 (PPA)
- Resource Conservation and Recovery Act of 1976 (RCRA), as amended
- Toxic Substances Control Act of 1976 (TSCA)

These laws and resulting regulations are discussed in detail in Section 2.

Regulations derived from these laws are usually administered and enforced by the U.S. Environmental Protection Agency (EPA), U.S. Nuclear Regulatory Commission (NRC), U.S. Department of Energy (DOE), U.S. Department of Defense (DOD), U.S. Department of Transportation (DOT), and the Occupational Safety and Health Administration (OSHA). The authority for implementing and enforcing many of EPA regulations is delegated to the states.

The decreasing trend in waste generation by nuclear power utilities has been driven by the increased cost of waste disposal and by increased emphasis on overall plant performance by industry groups such as the Institute for Nuclear Power Operations. For example, it appears that the volume of these wastes has decreased sharply while the total radioactivity has remained nearly constant indicating that, in general, costs of disposal of LLRW are volume based.

This reduction in utility waste is not seen in the small generators of waste, which suggests that waste minimization may be effective in reducing costs for them. Cost reduction for small generators can be a significant saving in overall project budgets. For the small generator, two sources of waste streams deserve particular mention. First, is the waste associated with analytical procedures, which has become a new source of wastes and can be expected to increase substantially with new activities such as decommissioning and environmental restoration. Second, is the large volume of scintillation fluids generated in research, academic and medical facilities. Currently these wastes in part are disposed into sanitary sewers without further regard to the radioactive materials content if they meet the requirements of 10 CFR Part 20.2003 (NRC, 2002a).

An effective waste minimization program is required for each facility generating waste. To be effective, it is essential that the program be supported at all levels of management. A single individual with direct access to senior facility management should have responsibility for organizing, planning and promotion of all waste minimization functions. Waste minimization and management should be an integral part of the project and institutional planning and budgeting process. Effective strategies need the attention of senior management.

Within this program an important element is the establishment of definitive and realistic goals. Employee awareness, incentives and training are essential to ensure that each individual involved in the program is an active participant in minimizing waste.

An important management tool is trend analysis which can assist not only in delineating the progress in meeting goals but the data can focus attention on where additional resources may be needed. Detailed guidance is given in Section 4.

Characterization of the individual sources of waste streams, which is required by regulations, can substantially aid in maximizing volume reduction and waste minimization. This characterization should include the chemical and radiological composition of the waste, information on input material, material usage, the generation process, applicable regulatory standards, minimization methods, and disposal costs.

Information exchange and technology transfer is of great importance in bringing innovative approaches to the waste minimization program. Section 5 contains a compendium of internet and other sources of information exchange.

The selection of waste minimization methods should begin with consideration of source reduction or elimination. This should then be followed by consideration of recycling the waste. The next step is treatment of the waste prior to disposal. Optimization of treatment and disposal should be evaluated from regulatory compliance and cost perspectives.

Although source reduction has been effective in manufacturing and other industrial applications, it is more difficult in the research and educational environment, particularly in medicine, where substitution of materials can be difficult. Section 5 provides general guidance on waste minimization.

Section 6 provides discussion and examples on the importance of attention to equipment, layout and process changes for minimizing waste. For example, introduction of microscale techniques. Examples of good operating practices are also discussed and examples given in this Section. Waste segregation in all its facets is the predominate issue: radioactive/nonradioactive, long/short half-life, radioactive/hazardous, etc.

Detailed discussion and examples for each technique of minimization are presented in Section 7 which deals primarily with biomedical applications of radioactive material. For example, it has been shown that savings obtained through bulk purchases can be lost in disposing of the unused material and short-lived radionuclides can often be substituted for long-lived radionuclides.

The last method discussed in Section 7 is treatment for storage or disposal. In the discussion and in the examples a number of approaches are given. For radioactive waste, the objectives are to reduce the radiotoxicity, the volume, and mobility of the contained

radioactive materials. Further it is important to meet transportation, processor and disposal site requirements for waste that needs to be sent elsewhere for management. For mixed and multihazardous waste, an objective is to eliminate one or more of the hazardous properties to allow disposal as a single waste type. For multihazardous waste it is important to inactivate pathogens and other characteristics of regulated medical wastes.

Section 8 provides specific guidance for the design of facilities with emphasis on the needs of the small user. Institutions handling radioactive material should incorporate pollution prevention and waste minimization considerations during the design of facilities. A primary issue during design is planning for a variety of waste handling areas such as satellite collection and assembly areas, temporary staging areas, central marshaling and processing areas, and treatment, storage and disposal areas. The objectives of good facility design will be met most effectively when the planners evaluate the complex interrelationships among the various processes, from construction to operation, decommissioning and demolition.

There are a number of unresolved issues that adversely impact waste minimization. These are identified in Section 9. Of particular note are regulatory barriers to effective waste minimization. This is exemplified by the inconsistent approach to these issues by various federal and state regulations. For the small user, there is an absence of a well defined and focused infrastructure for waste.