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Low-Level Radioactive Waste Disposal at a Humid Site

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Abstract

Waste management in humid environments poses a continuing challenge because of the potential contamination of groundwater in the long term. Short-term needs for waste disposal, regulatory uncertainty, and unique site and waste characteristics have led to the development of a site-specific waste classification and management system proposed for the Oak Ridge Reservation. The overlying principle of protection of public health and safety is used to define waste classes compatible with generated waste types, disposal sites and technologies, and treatment technologies.

KEY WORDS - Low-Level Radioactive Waste Disposal, Radioactive Waste Classification, Regulatory Compliance, Radioactive Waste Management.

Introduction

Satisfactory solutions to the problems of managing hazardous, radioactive, and mixed waste are increasingly difficult to obtain. Regulations governing waste management are voluminous and are constantly being revised, updated, amended, and interpreted. These changes often make management more difficult and expensive while reducing the available options for waste disposal. This is especially true for large waste generators that have unusual waste characteristics. Costly testing, monitoring, certification, and quality assurance programs are now commonplace. As the available disposal capacity dwindles, waste treatment and minimization become necessary parts of waste management and effective means for controlling costs. This paper presents an approach to effective waste management that can assist in resolving many of the complexities involved in waste management.

Many of the difficulties in waste management recall the environmental laws and regulations imposed on automobiles in the late 1960s and early 1970s. Automakers had not previously considered emissions when designing cars, but they were suddenly required to dramatically reduce emissions or have their products removed from the market. Design and manufacturing procedures, historically focused on performance first and emissions last, were altered to address emissions first and performance later. After large expenditures and dramatic increases in the cost of vehicles, emissions have been reduced to a

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fraction of previous levels and performance has been restored. In like manner, waste management is evolving to include more than simply providing a service for the disposition of excess materials produced by waste generating processes. The new role of waste management emphasizes the need to define an approach that is responsible, economical and acceptable. When coupled with the pressure to provide continued disposal services for waste generators, the responsibilities associated with waste management are being dramatically increased.

Background

The 14,800-ha Oak Ridge Reservation (ORR) owned by the U.S. Department of Energy (DOE) includes the Oak Ridge National Laboratory (ORNL), the Y-12 Plant, and the Oak Ridge Gaseous Diffusion Plant. The waste generation rate is approximately 100,000 m^3/year. The majority of the waste volume is sanitary waste. The second largest component of the wastes generated on the ORR is uranium-contaminated waste from the Y-12 Plant. The characteristics of the waste are summarized in Table 1.

The ORR is located in the Valley and Ridge Physiographic Province within the Appalachian Highland Physiographic Division. A geologic cross section of the ORR is shown in Fig. 1. The four major geologic units underlying the ORR have developed into a sequence of parallel ridges and valleys with a dip angle between 30 and 40°. Slopes are steep, with fairly flat parcels of land up to 40 ha located on ridge tops and in valleys. Groundwater is abundant and of good quality, typically close to the land surface, and with a preferential flow along strike. Precipitation averages 140 cm/year and is distributed nearly uniformly throughout the year. Springs and sinkholes are common features in several areas where limestone formations are present.

Waste disposal operations have been performed on the ORR since 1944. Historical disposal operations have resulted in releases of contamination to the environment. Existing waste disposal operations include a sanitary landfill for wastes with less than 120 pCi/g uranium and shallow land burial for wastes with higher levels of uranium activity. High-activity wastes generated at ORNL are disposed of in caissons in an existing burial ground. Low-activity, hazardous and mixed wastes are stored.

Waste disposal on the ORR is subject to regulation by DOE, the State of Tennessee, and the Environmental Protection Agency (EPA). Low-level radioactive waste disposal on the ORR is regulated by DOE. DOE orders regulating radioactive waste disposal are currently being revised and are expected to be much more prescriptive and restrictive. The EPA is preparing regulations that will affect radioactive waste disposal on the ORR at the site boundary. The U.S. Nuclear Regulatory Commission has promulgated regulations governing commercial low-level radioactive waste disposal. These regulations have not been interpreted in legal proceedings but represent the only comprehensive regulatory guidance for the disposal of low-level radioactive wastes generated in commercial processes.

Development of an Effective Waste Management System

Additional waste disposal facilities for the ORR are needed in the near future for operations to continue. Processes that generate wastes require disposal capacity to be available when needed; however, the costs of disposal must be kept as low as possible for the processes to remain competitive. Available sites for the disposal of waste on the ORR may not be acceptable because of the naturally complex geohydrologic conditions. The uncertain performance of existing disposal facilities mandates improved waste management operations. However, new technology for improved operations largely has not been significantly demonstrated. With the forthcoming changes in waste disposal regulations, the proper approach to waste management is not clear.

The approach taken has been to establish a unifying principle for effective waste management that will guide the development of future waste disposal facilities. The overlying principle of waste management on the ORR is to protect human health and safety both now and in the future. This principle must work in concert with the demands that disposal capacity be available when needed and costs be minimized. In order to mitigate potential conflicts involving considerations of safety, availability and cost, a waste classification system was developed that integrated the characteristics of the wastes and site with the potential doses to the public, both now and in the future. The waste classes developed allow for disposal strategies to be prepared, facilities to be designed, and assurances to be provided to the regulators that the objectives of the law--protection of the human health--are being accomplished. In essence, the need for the facility continues to push the system into action, but the overlying principle provides direction.

Waste classification for low-level radioactive waste on the ORR uses four waste classes that are defined in terms of the concentration of contaminants in the wastes. Sanitary wastes are classified as non-radioactive wastes to be disposed of without concern for their radioactive contents. Class I radioactive waste is composed of slightly contaminated materials that are disposed of using industrial waste disposal technology acceptable to the State of Tennessee. Class II wastes are those that will not pose a threat to health and safety at the end of the institutional control period. This class of wastes is largely composed of short half-lived radioactive wastes that are generated at ORNL. Class III wastes by definition will not pose a threat to health and safety at the end of institutional control, providing that the soluble portion of the wastes is removed prior to facility closure and intruder protection is provided. Class IV wastes are those wastes not suitable for disposal because they would pose a threat to public health and safety. Class IV wastes are to be treated for disposal as Class I, II, III wastes, stored for disposal at some later time, or shipped to an alternative site for disposal.

Each waste class was developed in conjunction with disposal sites, disposal technologies and treatment technologies. Class I wastes comprise the largest volume of waste generated on the ORR, and a large

percentage are unstable. Disposal of these wastes as industrial wastes is anticipated to require double containment liners with leachate collection monitoring and treatment. Sites on the ORR where soils are thick and groundwater is deep are considered to be the most suitable sites for Class I waste disposal. Class II waste disposal relies on the technology incorporated into treatment and disposal along with institutional control to ensure that any unexpected releases are acceptably low. Wastes are expected to be solidified in vaults and placed within an above-grade earth mounded vault. Zero release of contamination is the design objective, with monitoring facilities installed to ensure that any unexpected releases are acceptably low. Class III wastes, primarily uranium, pose a special problem to waste management because doses attributable to uranium increase with time, and uranium is naturally ubiquitous. Preliminary laboratory experiments indicate that 75% of the uranium in wastes is soluble within eight exchanges of water. If the soluble fraction of the contamination is removed during the institutional control period, the remaining waste can be stabilized in the disposal unit and intruder protection provided. Such a combination of technologies would protect water resources from contamination and minimize the risk to an inadvertent intruder. Class IV wastes are intended to be treated in such a way that the bulk of the wastes can be disposed of in one of the other waste classes. The residuals from the treatment of wastes would require storage or shipment prior to disposal.

Numerous issues were identified in the development of the waste classification system for the ORR. Some of these concerns have been resolved while others are continuing to be debated as part of the evolution of the waste disposal strategy. For the waste classes to be reflective of the wastes generated on the ORR, data describing the waste characteristics and their treatability were needed. As the waste technologies, site characteristics, and concentration limits for each waste class were defined, improvements in the process of defining the waste characteristics occurred. The purpose of this lengthy development process was to ensure that those involved in waste management activities on the ORR were considered in the development of the system. As a result, the system is representative of the various needs for waste management and satisfies the principle of effective waste management. Early in the development process, the limited area that could be considered for waste disposal facilities, the uncertain performance characteristics of the available sites, and the unsettled regulatory environment were identified as prominent issues to be addressed. The combination of these issues suggested the definition of performance requirements for the ORR that are more restrictive than existing regulations to provide reasonable assurances that public health and safety would be protected both now and in the future. The restricted performance level used for the purposes of design, performance assessment, and remedial actions (referred to as the trigger dose) was 10 mrem annual effective dose equivalent to an off-site individual at any time or to an inadvertent intruder at the time of the loss of institutional control over site access.

The development of new disposal facilities on the ORR depends on the resolution of several other issues. Issues of regulatory

importance include the definition and duration of the institutional control period, protection of water resources, the determination of the definition of radioactive waste that has levels of contamination below regulatory concern (BRC), and intruder protection. Institutional issues such as waste segregation, ALARA requirements, and waste storage and shipment are also important for the successful development of new facilities. Efforts are continuing to resolve these issues that are important to waste disposal on the ORR and across the United States.

Discussion

The efforts to develop an effective waste management system on the ORR have centered on protecting public health and safety both now and in the future. The resulting system has been developed as a site-specific response to the existing rules and regulations for the disposal of low-level radioactive waste. The need for a site-specific response is based on

- the unique characteristics of the wastes generated on the ORR that are not addressed comprehensively by existing rules and regulations;
- the unique site characteristics that include high precipitation rates, complex terrain and complex geohydrology; and
- the need for additional disposal capacity in the near future to allow for the continuance of operations.

While the site characteristics, waste characteristics, and operational requirements are all considered important factors in the formulation of the system, the principle of protecting the public health and safety guided the development of the system.

The advantage of formulating a waste management and waste classification system on a site-specific basis is that the facility design and operations can be defined to suit the existing environmental conditions, resulting in the overall facility performance being optimized. Facilities that are designed and operated according to generic rules can be prevented from taking advantage of favorable site conditions (e.g. absence of precipitation) because the generic waste classification system presumes the existence of an alternative condition. Additionally, sites that might be declared unsuitable for waste disposal by the generic rules could be made useful sites for waste disposal of some wastes and provide incentives for advancements in waste disposal technology. For the optimal utilization of resources, a site-specific waste management system is preferable, but at the expense of increased regulatory and institutional difficulties.

Conclusions

The experiences on the ORR in developing a site-specific waste management and classification system have shown that the most important step in making the system defensible is maintaining the principle of

protection of public health and safety both now and in the future. Emphasizing this principle has made resolution of institutional and regulatory issues possible.

Throughout the United States, the needs of waste management are likely to force the establishment of regulatory precedence and flexibility. A site-specific approach, based on waste and site characteristics as they affect public health and safety, can be an effective tool in dealing with the regulatory complexities that inhibit achievement of the goals dictated by the spirit of the regulations. Even for sites that would qualify for regulatory approval under generic rules, site-specific strategies could be expected to yield improvements in both performance and efficiency.

Table 1. Characteristics of low-level wastes on Oak Ridge Reservation

Oak Ridge National Laboratory (9/86 - 3/87)

Description	Volume (m^3)	Total Activity (Ci)
Uranium/Thorium	20.2	0.18
Fission Products	372.0	23100
Induced Activity	98.0	1620
Tritium	2.2	5.5
Other	22.9	0.0015
Landfill	33.5	0.0
Asbestos	0.5	0.0001
Non-Conforming Rejects	25.1	2.49

Y-12 Plant (9/85 - 9/86)

Description	Volume (m^3)	Activity (pCi/g)
Sanitary Trash	66000	<120
Low Level Trash	25500	120-1000
Clean Scrap Metal	6380	<120
Depleted Uranium	5320	450000
Classified Waste	1060	120-450000
Contaminated Metal	2120	120-30000
Hazardous Waste	<500	120-30000

Oak Ridge Gaseous Diffusion Plant

(All wastes generated shipped to Y-12 for disposal)

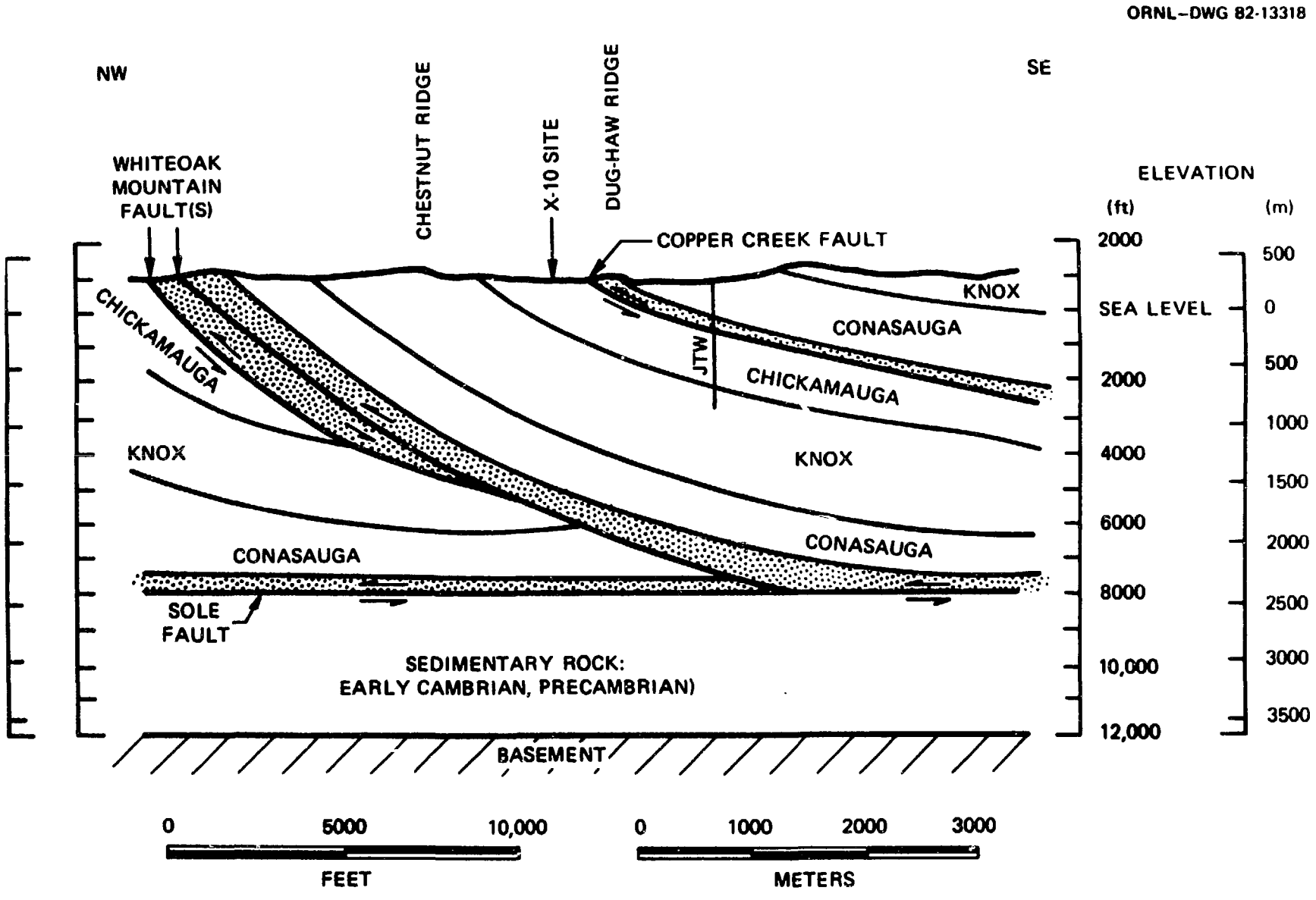

Fig. 1. Geologic cross section through the Oak Ridge Reservation.