C9 Engineered Containment Systems for Radioactive and Hazardous Wastes — Do Current Approaches Present Opportunities for Future Environmental Forensics?

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The goal of this presentation is to familiarize the audience with the current approach to long-term containment of wastes, the failure of which may require future forensic investigation.

This presentation will impact the forensic community and/or humanity by demonstrating the limitations of current containment systems, some of which may result in the need for future forensic investigations.

The field of environmental forensics has evolved largely as a result of past chemical and waste management practices that have resulted in large scale contamination of surface and subsurface environmental media (surface water and groundwater, soils and sediments). When it became known that these practices were affecting valuable environmental resources, steps were initiated to both restore the contaminated media to an appropriate degree, based on risk and future land use, and to adopt improved standards and practices for the ongoing management of wastes and cleanup residuals. As a result of major technical and economic limitations on implementing remediation, a large volume of these contaminated media will be contained in engineered systems either in situ, using surface and possibly subsurface barriers, or excavated and placed into new engineered containment systems (disposal cells). Given the lifetimes of the radioactive and hazardous constituents (hundreds or thousands of years to essentially forever for stable toxic metals), these engineered systems will have to be monitored and maintained, with ongoing access restrictions (institutional controls), for very long time horizons.

The primary function of an engineered containment system is to prevent radioactive and/or hazardous constituents from migrating to potential exposure points. Institutional controls are also needed insure ongoing monitoring and maintenance and to prevent direct contact with the contaminated media. The design approaches that have evolved rely on a primary barrier system whose main function is to keep infiltrating rainwater and possibly groundwater from contacting the contaminated materials and wastes that are being isolated and transporting constituents to the environment. This primary barrier, in a surface barrier system for example, typically consists of a compacted soil layer, sometimes augmented with bentonite, together with a synthetic membrane (geo-membrane) to keep the soil from desiccating and cracking and to provide an additional layer of protection. Over the years, as experience has been gained, additional layers have been added to protect the primary barrier system from the adverse impact of natural processes such as erosion and bio-intrusion that can compromise the performance of the primary barrier system. The current design approach typically contains several layers and is very expensive to construct (typically several hundred thousand dollars an acre). In some cases, where gases are of concern (e.g., methane, radon), gas barriers or collection systems are employed as well.

While our experience with the current state of the art approaches to system design is limited to a few decades at best, observations of system performance and data are beginning to emerge. These data and observations suggest that there is merit to re-evaluating our current approach. In particular, design approaches that can accommodate a certain degree of environmental change and that do not have to rely on resisting natural processes are generating a great deal of interest.

Also, progress has been hampered, to varying degrees, by the current regulations that call for prescriptive designs (that may not be the best in certain environments), i.e., requiring monitoring of the saturated zone and only thirty (30) years of post closure monitoring and maintenance for facilities regulated under the Resource Conservation and Recovery Act (RCRA). In many cases, particularly at the Department of Energy sites, extensive vadose zones are present that provide separations of hundreds of feet between the engineered containment system and the top of the saturated zone. Monitoring of both the vadose zone and the system itself could provide valuable early warning information concerning system performance.

The authors have spent many years working on both Superfund sites and the investigation and restoration of former nuclear weapons production facilities and are currently evaluating system design and monitoring approaches at a number of sites. The time appears appropriate to determine: the data needed to evaluate the performance of the sites over time; what tools are needed to collect the data; and what needs to be built into the design to help ensure the data are available. Examples will also be provided that illustrate the shortcomings of the current approach and alternative design and monitoring approaches that could provide improved and more cost effective protection over long time horizons.

Long Term Containment, Monitoring Needs, Design Needs