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INNOVATIVE SOLUTIONS TO SOLVE COMPLEX RADIOACTIVE WASTE MANAGEMENT PROBLEMS IN THE U.S.

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ABSTRACT

Ever since Wilhelm Roentgen, Henri Becquerel, and Marie Curie discovered x-rays, radioactivity, and radium, respectively, at the turn of the nineteenth century, nuclear technologies have continued to evolve and significantly enrich the quality of life for mankind. The evolution of such technologies has enabled our society to diagnose medical illnesses without the need for invasive surgeries, treat cancers, conduct research, develop new kinds of pharmaceuticals, preserve our food supply, and generate over 20% of our nation's electricity from commercial nuclear power plants. While these life-changing technologies have significantly enriched our quality of life and advanced our understanding of the sciences, they also generate radioactive waste that must be managed responsibly in a manner that protects public health.

Over the past several decades, decision makers have developed a patchwork of policies to safely manage radioactive wastes−policies that are not necessarily based on the risk posed to public health, but more often on the origins of the waste and the manner in which they are defined in federal legislation. However, in the past several years, much progress has been made to better risk-inform the practices of managing Low-Level Radioactive Waste (LLW) in the United States. In 2012, the nation's first regional commercial facility for disposing of Class A, B, and C LLW since the U.S. Congress enacted the Low-Level Radioactive Waste Policy Act of 1980, as amended in 1985, was opened in Andrews County, Texas. Since then, other innovative LLW management solutions have emerged, ranging from cost-effective disposal options for wastes with very low levels of radioactivity to depleted uranium, and perhaps ultimately, for waste exceeding the concentration-based limits for Class C LLW (i.e., Greater Than Class C LLW) as specified in Title 10 of the Code of Federal Regulations (CFR), §61.55.

Most recently, a license application for a consolidated interim storage facility for Spent Nuclear Fuel (SNF) is currently under review by the U.S. Nuclear Regulatory Commission (NRC). Should the NRC approve the license application, SNF currently located at 12 shutdown and decommissioned nuclear reactors could be placed into interim storage in Texas. Approval of this license application would facilitate the complete decommissioning of nuclear power plants, returning them to greenfields, and allowing the local communities to repurpose the lands for further economic development.

Over the next decade, many of these waste management challenges that once seemed insurmountable may soon be transformed into a reality. As will be discussed at the award lecture, achieving such possibilities clearly aligns with the vision of creating innovative radioactive waste management solutions for our nation that were championed by the late physician and statesman, Dr. Richard S. Hodes.

INTRODUCTION

On September 30, 2004, the U.S. Senate's Committee on Energy and Natural Resources ("Committee") held a hearing of Low-Level Radioactive Waste Oversight in Washington, D.C. The hearing was held in part based on a report prepared by the Government Accountability Office (GAO) titled, *"Low-Level Radioactive, Disposal Availability Adequate in Short Term, but Oversight Needed to Identify any Future Shortfalls* (GAO-04-604) published in June 2004 [1]. Testimony was provided by the U.S. Department of Energy (DOE), California Radioactive Waste Management Forum (CAL RAD Forum), GAO, and the Health Physics Society (HPS). The focus of the hearing was geared towards ensuring available access would be provided to waste generators not belonging to the Atlantic Interstate Low-Level Radioactive Waste Management Compact[1] ("Atlantic Compact") to the disposal facility operated by Chem-Nuclear Systems located at Barnwell, South Carolina, after July 1, 2008.

The DOE shared information with the Committee regarding its disposal facilities and policies for Low-Level Radioactive Waste (LLW) it generated or owned. It also shared information regarding the plans and progress that had been made to secure and safeguard vulnerable disused sealed sources that could potentially be used for malevolent purposes.

Testimony provided by GAO, CAL RAD Forum, and the HPS [2] noted that deadline established for creating new disposal sites had consistently been missed as mandated by the Low-Level Radioactive Policy Act (LLWPA) of 1980, as amended in 1985. These organizations recognized that good efforts were currently underway in Texas, which could be promising in the future, but noted that not a single new regional disposal facility had been opened since Congress enacted the LLWPA. Each organization also acknowledged that adequate availability for disposal of Class A, B, and C LLW was currently available to waste generators across the country. However, access to facilities for disposal of Class B/C LLW for generators located in 36 states not belonging to the Atlantic Compact or the Northwest Interstate Compact on Low-Level Radioactive Waste[2] would no longer be available after July 1, 2008.

ENERGY POLICY ACT OF 2005

Soon after the terrorist attacks that occurred in our nation on September 11, 2001, the federal government undertook significant enhancements to protect nuclear installations and radioactive materials from potential malevolent acts. Orders were issued by the U.S. Nuclear Regulatory Commission (NRC) regarding the operations as well as both the transportation and storage of radioactive materials, including certain disused sealed sources.

Congress enacted the Energy Policy Act of 2005 (EPAct), which among other things, significantly strengthened the controls to protect disused sealed sources from being used in a Radiological Dispersal Device (RDD) or Radiological Exposure Device (RED). It required the NRC to establish a national database to track Category 1 and 2 disused sealed sources that have been effectively implemented. It also created the Interagency Radiation Source Protection and Security Task Force directed to evaluate and provide recommendations relating to the security of radiation sources in the U.S. from potential terrorist threats, including acts of sabotage, theft, or use of a radiation source in a RDD or RED.

Prior to enactment of the EPAct, President George W. Bush committed to pass legislation needed to implement the International Atomic Energy Agency's (IAEA) *Code of Conduct for the Safety and Security of Sealed Sources* (Code of Conduct) at the Eight-Industrial Countries (G-8) Summit in Evian, France. The Code of Conduct contained activity thresholds for Category 1 and 2 disused sources, including those for ^{226}Ra [3]. It specified additional controls for implementation that would be required by member nations.

Several professional, regulatory, and scientific organizations shared stakeholder views on actions and policies that should be considered to better safeguard certain radioactive materials and protect public health. The HPS

[1] Atlantic Interstate Low-Level Radioactive Waste Management Compact includes Connecticut, New Jersey, and South Carolina.

[2] Northwest Interstate Compact on Low-Level Radioactive Waste includes Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, and Wyoming. Disposal access is also provided to states belonging to the Rocky Mountain Low-Level Radioactive Waste Compact which includes Colorado, Nevada, and New Mexico, to the disposal facility located in Richland, Washington.

was especially interested in actions that would provide uniform federal controls related to the security of discrete sources of ^{226}Ra and other radionuclides that were outside of the scope of the Atomic Energy Act of 1954 (AEA), as amended. In early 2005, the HPS and the Organization of Agreement States (OAS) chartered a Working Group[3] of experts that prepared a position statement and legislative language which proposed amendments to the AEA that would bring certain Naturally Occurring and Accelerator-Produced Radioactive Material (NARM) under unified federal control and regulated by the NRC.

On January 14, 2005, the HPS and OAS issued a joint position statement titled *Congressional Action is Needed to Ensure Uniform Safety and Security Regulations for Certain Radioactive Materials* to members of Congress and select federal government agencies [4]. In its letter to Congress, the HPS and OAS stated that the events of September 11, 2001, underscored the importance of empowering federal agencies with the appropriate authority to carry out its charge of protecting our society from acts of terrorism [5]. They also stated that the primary federal responsibility for the control of commercial uses of most radioactive materials resided with the NRC. The radioactive materials, over which the NRC had authority for ensuring the common defense and security pursuant to the AEA, did not include NARM or a number of other radionuclides that are generally produced by particle accelerators. However, the IAEA had included some of these radionuclides on their list of potentially "dangerous" materials in its Code of Conduct, because they may be effectively used in a RDD or RED. One of the recommendations made by the HPS and OAS was the need for Congressional action to fill the statutory void by bringing ^{226}Ra, particle accelerator-produced materials, and other radioactive materials with comparable risks under a single federal authority, thereby ensuring the security of these radiological sources and furthering the protection of public health.

The principles outlined by the HPS and OAS would serve to establish a uniform regulatory framework, under the direction of the NRC, for securing these radiological sources needed to protect public health. The NRC was encouraged to work with the state regulatory agencies to develop supporting regulations consistent with the Suggested State Regulations established by the Conference of Radiation Control Program Directors.

The HPS-OAS position statement also recommended authorizing flexible waste disposal options that were safe, economical, and commensurate with the level of risk that these radioactive sources pose to public health−a recommendation that was applauded by the National Academy of Sciences as an important step toward making their control more uniform and consistent with their actual radiological properties and risks [6]. Such disposal options were needed to avoid the potential for generating orphan sources that would likely result from creating newly-defined AEA materials without providing appropriate disposal options. The legislation proposed by the HPS and OAS for discrete sources of ^{226}Ra and accelerator-produced radioactive materials would be defined as 11.e(3) and 11.e(4) byproduct materials under an amendment to the AEA, respectively. These two newly defined types of byproduct materials would also be excluded from the definition of LLW and authorized for disposal in a Subtitle C landfill regulated under the Resource Conservation and Recovery Act (RCRA) or a commercial disposal facility licensed under Title 10 of the Code of Federal Regulations (CFR) Part 61. The HPS and OAS recommended that the NRC would be required to promulgate a rulemaking[4] to implement such requirements within 18 months from the date of enactment of the statute.

The proposed changes to the AEA were originally incorporated into Senate Bill 2763 (SB 2763) titled, *Bill to Amend the Atomic Energy Act to Clarify the Treatment of Accelerator-produced and Other Radioactive Material as By-product Material,* sponsored by Senator Hillary Rodham Clinton (D-NY). This legislation gained bipartisan support

[3] Working Group was chaired by J. Scott Kirk. Other representatives included Ralph Andersen, Jim Tipodes, Barbara Hamrick, Mike Boyd, Anthony Thompson, J.D, and Christopher Pugsley, J.D. The HPS-OAS Position Statement was signed by HPS President Ray Guilmette and OAS Chair, Jared Thompson.

[4] A rulemaking titled, *The Expanded Definition of Byproduct Material.,* was subsequently promulgated by the NRC.

and was ultimately included in Section 651 of the EPAct sponsored by Senator Pete Domenici (R-NM) and Congressman Joe Barton (R-TX). On August 8, 2005, President George W. Bush signed this legislation into law and the U.S. became the first of 74 member states committing to implement the Code of Conduct, thus bringing ^{226}Ra and certain accelerator-produced radioactive materials under uniform federal control [7].

TEXAS LEADERSHIP SUPPORTS OPENING A NEW REGIONAL DISPOSAL FACILITY IN ANDREWS COUNTY, TEXAS

The geography in west Texas is arid, remote, and proven ideal for siting radioactive waste disposal facilities. The region receives less than 38 cm (15 in) of precipitation annually. Over the past 100 years, the local population in Andrews County has ranged from a few hundred to nearly 15,000. The community of Andrews County, had long relied on the vast natural oil and gas resources that had been developed from the Permian Basin in far west Texas to fuel its economy. Many large oil and gas exploration and development corporations had established engineering and geophysical services in Andrews County to support the industry. However, the Andrews County Economic Development Board sought to diversify its economic base as a hedge against the fluctuations in the price of crude oil. In the early 1990s, it welcomed Waste Control Specialists LLC (WCS) to construct a hazardous and radioactive waste disposal facility in the community, recognizing that the unique geology of the Permian Basin and scarcity of groundwater could be ideal for siting such a facility.

Local geologists that were familiar with developing, not only oil and gas reserves, but also available sources of potable water supplies in the region, were contacted regarding the location of land that could be suitable for siting a waste disposal facility. Several of these scientists suggested exploring approximately 14,000 acres of land located nearly 51 km (32 mi) west of Andrews, Texas, known as the "Flying W Ranch". It was well known to local geologists that the Dockum Formation, which was comprised of very low permeable clays, formed a ridge close to the ground surface at the ranch (Fig. 1). The Dockum Formation was estimated to be 183 to 244 m (600-800 ft) thick. The water table was also estimated to be located at depths ranging from 244 to 305 m (800-1,000 ft) below grade at the Flying W Ranch. Not long thereafter, WCS acquired the ranch and prepared a permit application for treating, storing, and disposing hazardous and mixed waste that was later approved by regulatory agencies in Texas in the late 1990s.

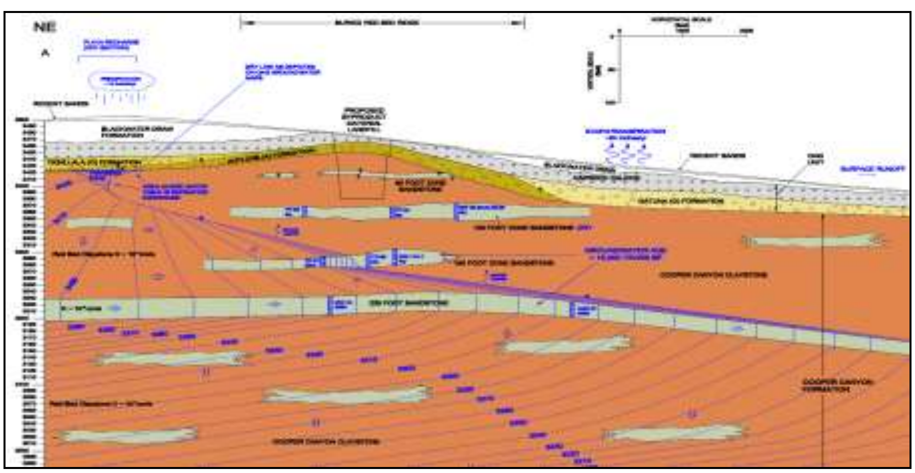

Fig. 1. Geologic Stratigraphic Cross-Section of Dockum Formation.

Regional Community Support

This region of the U.S. has long supported the use of nuclear technologies. The local communities of west Texas and southeast New Mexico strongly supported DOE's efforts to open the first and only deep geologic repository at the Waste Isolation Pilot Plant (WIPP) in the U.S. This facility is authorized to dispose of defense-related transuranic waste and is located near Carlsbad, New Mexico, and approximately 113 km (70 mi) west of WCS. Moreover, the National Enrichment Facility (NEF), owned by URENCO USA, shares a common border with WCS and is located near Eunice, New Mexico. The NEF was successfully licensed by the NRC in 2005. This region of west Texas and southeastern New Mexico is often referred to as the "nuclear energy corridor".

Difficulties with Siting Waste Previous Disposal Facilities

In the 1990s, Texas had sought to license a regional facility to dispose of Class A, B, and C LLW generated within the Texas Compact[5] near the community of Sierra Blanca, Texas. However, the local community near Sierra Blanca and the government of Mexico opposed siting the disposal facility near the Rio Grande River. In the late 1990s, the license application to construct and operate Sierra Blanca was denied by the Texas Natural Resource Conservation Commission, currently known as the Texas Commission on Environmental Quality (TCEQ).

In 1999, the GAO reported that ten sites across the country, including Sierra Blanca, had been unsuccessful in opening a regional disposal facility, at a cost of approximately $600 million, as mandated by the LLWPA of 1980 [8]. The reasons for these unsuccessful attempts were attributable mostly to lack of community and/or political support, but much less due to technical issues associated with these sites.

A Private/Public Partnership: A New Approach Taken in Texas

The Texas legislature enacted Senate Bill 1567 (S.B. 1567) seeking a new approach to open a successful regional disposal facility pursuant to the LLWPA of 1980. This approach would allow for the "privatization" of a commercial disposal facility for Class A, B, and C LLW. Pursuant to the Texas Radiation Control Act, one facility would be authorized for disposal of Class A, B, and C LLW generated by the commercial sector. A separate facility would also be authorized to dispose of "Federal Facility Waste" statutorily defined as LLW, which was the responsibility of the federal government as defined in the LWPAA of 1985. The legislation mandated that Class B/C LLW as well as "high dose-rate Class A LLW[6]" must be solidified within reinforced concrete canisters for disposal in a manner that would provide retrievable and assured isolation of the waste.

The statute would require the licensee to acquire 100% of the mineral rights underlying both facilities prior to waste disposal. It required Texas to take title of waste generated by the commercial sector prior to disposal. The DOE was also required to enter a written agreement with Texas to take title of the waste into perpetuity at the time of site closure. A requirement was also established to erect a monument over the disposal facilities to warn future generations of the presence of radioactive materials underground upon closure. These actions were considered important to ensure that continued ownership of the lands would be held by government agencies and intended to impede future habitation or intrusion into the waste disposal facilities.

Stringent siting criteria were also mandated under this legislation. The facility was required to be located in one of over 50 select counties in west Texas. The average rainfall was required to be less than 51 cm y^{-1} (20 in y^{-1}). It also could not be located in the headwaters of certain river basins and at least 100 km (62 mi) from any international border. In August 2004, WCS filed its license application with the TCEQ, along with the required fee of $500,000, as required under the S.B 1567.

[5] Texas Compact initially included Maine, Vermont, and Texas. Maine has since withdrawn from the Texas Compact leaving only Texas and Vermont.

[6] High dose-rate Class A LLW was subsequently defined in regulation as waste that does not exceed the limits for Class A as defined in 10 CFR 61.55 and which has a measured dose rate exceeding 0.1 mSv h^{-1} (100 mrem h^{-1}) at a distance of 30 cm from the surface of the package.

On September 9, 2009, TCEQ issued the license to WCS to construct and operate the first new regional disposal facility for Class A, B, and C LLW (Fig. 2) in the U.S. in over 40 years [9].

Fig. 2. Map Depicting the Location of WCS.

SOLUTIONS FOR WASTE STRANDED IN 36 STATES

At the time that the license was issued, Class B/C LLW was effectively stranded in 36 states by South Carolina's decision to restrict access to Barnwell on July 1, 2008. Accordingly, waste generators had limited options available, other than long-term storage until alternatives could be developed.

The NRC developed a list of activities planned to provide the licensed community with more flexibility approaches to the management of LLW in its *Strategic Assessment of Low-Level Radioactive Waste Regulatory Program* (SECY-07-0180) [10]. One option that was initiated by the NRC involved revisions to the *Concentration Averaging and Encapsulation Branch Technical Position* [11] that would provide flexibility to better classify LLW in a more risk-informed manner. The NRC proposed changes to the guidance that would allow for the intentional blending of Class B/C LLW with lower concentrations of Class A LLW, so that the final waste form could be disposed of as Class A LLW. This approach would eliminate large volumes, but not all types of Class B/C LLW, and allow for the disposal of reclassified blended Class A LLW in a near surface disposal, such as the one located in Clive, Utah.

However, the approach to reclassifying waste that had been intentionally blended was not authorized in Texas. The TCEQ had established regulations prohibiting reducing the concentration of radioactive constituents by dilution or blending, as a means to change the waste classification or alter disposal requirements. Radioactive material that had been diluted or blended would be subject to the disposal regulations that would have been in effect prior to dilution or blending, as specified in Title 30 of the Texas Administrative Code (TAC), Rule 336.229, *Prohibition of Dilution.*

A different solution was offered in Texas. Members of the Texas legislature introduced bills to authorize the importation of radioactive waste from non-regional generators for disposal in Andrews County. The TCEQ also established the rates for disposal of waste generated within the Texas Compact. During these deliberations, several stakeholders sought assurances that adequate disposal capacities would be set aside for waste generated in Texas and Vermont at the newly licensed disposal facility. Some stakeholders wanted assurances that the disposal rates established for imported waste would not cost less than the maximum rates charged to generators in the Texas Compact. The legislation would require TCEQ to conduct a study to evaluate whether or not the Texas Compact Waste Disposal Facility (CWF) would also have sufficient capacity to accommodate disposal of waste imported by non-regional generators. The law was intended to benefit Texas economically by requiring a 30% surcharge fee for waste imported into the state for disposal.

In 2011, Texas Governor Rick Perry approved legislation requiring the Texas Low-Level Radioactive Waste Disposal Compact Commission (Texas Compact Commission) to establish regulations governing the importation of up to 4,440 TBq y^{-1} (120,000 Ci y^{-1}) of Class A, B, and C LLW for disposal in Andrews County, Texas[7]. It also mandated that no more than 30% of the capacity volume of the CWF would be consumed from disposal of waste imported from generators outside the Texas Compact. Soon thereafter, the Texas Compact Commission promulgated implementing regulations establishing the framework for approving petitions to import Class B/C LLW from generators in 36 states that previously had no other disposal options available since July 1, 2008. This milestone marked a major contribution demonstrated by the leadership in Texas to the field of radioactive waste management that cannot be overstated.

INITIAL LICENSE

The land where the CWF and Federal Waste Disposal Facility (FWF) would be constructed was extensively characterized in support of preparing the initial license application. Over 600 borings and monitoring wells were required to determine the geotechnical and hydrogeological proprieties underlying the site. Additional meteorological and climate studies were used to estimate the levels of precipitation that could impact water infiltration into the disposal units well into the future. Water collected in a sandstone unit located approximately 66 m (225 ft) below grade was carbon-dated with an estimated age of 16,000 years. The data indicated that no hydrogeological recharge to the 225' sandstone unit had occurred since the time of the last ice age. This sandstone unit only produced approximately 0.4 L d^{-1} of non-potable water−volumes that are insufficient to supply a homestead with drinking/household water or for irrigation of crops.

Engineering Design & Site Characteristics

The engineering design for the disposal units included a multi-layered geotechnical membrane, with a 1 m (~3 ft) cover of low permeable compacted clay, overlain with an intruder resistant barrier that would be constructed at the time of site closure. The thickness of the cover system would range from 7.6 to 12.2 m (25-45 ft). The engineering design of the cover system would impede diffusion and the transport of mobile radionuclides through the environment.

Pursuant to the statutory requirements, Class B/C LLW and high dose-rate Class A LLW would be placed and grouted within reinforced concrete canisters (i.e., Modular Concrete Canisters (MCCs)) and emplaced at a depth of up nearly 36 m (120 ft) below grade. The dimensions of the MCCs are 3.05 by 2.13 m (10 by 7 ft), each weighing approximately 41 MT (90,000 lbs) at the time of disposal. Each MCC would be stacked one-on-top of another, up to seven and four high in the FWF and CWF, respectively. The disposal emplacement array, coupled with the depth of disposal, and robustness of the MCCs were intended to provide long term stability and designed to impede the likelihood of human intrusion as required under 30 TAC 336.725, *Protection of Individuals from Inadvertent Intrusion.*

[7] The legislation (2011 Texas Health and Safety Code, Chapter 401.207) authorized up to 8,140 TBq (220,000 Ci) of Class A, B, and C LLW in the first year.

Performance Assessment

The initial conceptual design was used to determine compliance with 30 TAC 336.723, *Performance Objectives*. The initial Performance Assessment (PA) was constructed using a variety of software codes, including RESRAD and MODFLOW to simulate the fate and transport radionuclides in the environment needed to demonstrate compliance with the performance objectives. The initial inventory of radionuclides analyzed included the short and long-lived radionuclides that were expected to be present in waste stream produced by generators belonging to the Texas Compact (Texas, Vermont, and Maine) in 1994. The inventory initially analyzed also included 10,000 m^3 of Depleted Uranium (DU).

While the initial PA concluded that the disposal inventory of radionuclides analyzed would comply with the performance objectives, additional constraints were included in the license issued in September 2009. The initial license placed restrictions on the disposal activities for ^{14}C, ^{99}Tc, and ^{129}I, and prohibited the disposal of DU with concentrations exceeding 10 nCi/g.

DISPOSAL OF LARGE QUANTITIES OF DEPLETED URANIUM

The regulatory history regarding the classification and disposal requirements regarding DU has been quite complex over the past several years. On December 27, 1982, the NRC promulgated regulations establishing a system for classifying Class A, B, and C LLW in 10 CFR Part 61, *Licensing Requirements for Land Disposal of Radioactive Was*te [12]. During the development of the technical basis supporting the waste classification system, the NRC only analyzed the typical waste streams that were known or expected to be encountered in the commercial sector in the Draft Environmental Impact Statement (DEIS) supporting the original 10 CFR 61 rulemaking [13]. Only small quantities of DU were generated in the commercial sector prior to 1982. As such, the NRC did not fully analyze the potential impacts to public health or the environment related to the disposal of large quantities of DU. Waste streams containing uranium, regardless of the level of enrichment, were classified as Class A LLW in 10 CFR §61.55.

In 2003, Louisiana Energy Services, L.P. (LES)[8] proposed constructing the NEF to be located near Eunice, New Mexico. The NEF, a commercial uranium enrichment facility, would process and separate natural uranium into enriched uranium for the purpose of fabricating fuel for nuclear reactors. Additionally, the NEF would generate large quantities of DU that would require disposal as Class A LLW in a facility licensed pursuant to 10 CFR 61.

On December 15, 2003, LES submitted an application, under 10 CFR Part 70, to construct the NEF. During the license proceedings, the NRC acknowledged that DU was properly classified as Class A LLW. However, the NRC Commissioners also accepted contentions raised during a hearing regarding whether or not DU had been properly classified at the time 10 CFR 61 was originally established in 1982. The contention raised correctly asserted that the hazard associated with DU was much greater than those posed by other types of LLW containing radionuclides other than uranium−that is, DU becomes more radioactive over time as a result of the ingrowth of ^{238}U progeny, whereas, typical waste streams disposed of in a facility licensed under Part 61, containing different radionuclides which decay to lesser levels of activity as depicted in Figure 3.

During these deliberations, the Commissioners reaffirmed that the Atomic Safety Licensing Board's decision that DU was properly classified as LLW. However, they deferred a ruling whether or not DU should be classified as Class A, B, C, or waste exceeding the Class C levels (referred to as Greater Than Class C (GTCC) LLW). The Commissioners also acknowledged that Class A, B, C and perhaps GTCC LLW, should be disposed of in a near surface disposal facility at depths of up to 30 m. However, they recognized that more

[8] Since renamed URENCO USA.

protective methods could also be used to land dispose certain LLW in a deeper facility equipped with special engineered barriers, often referred to as an "Intermediate Depth Waste Disposal Facility" [14].

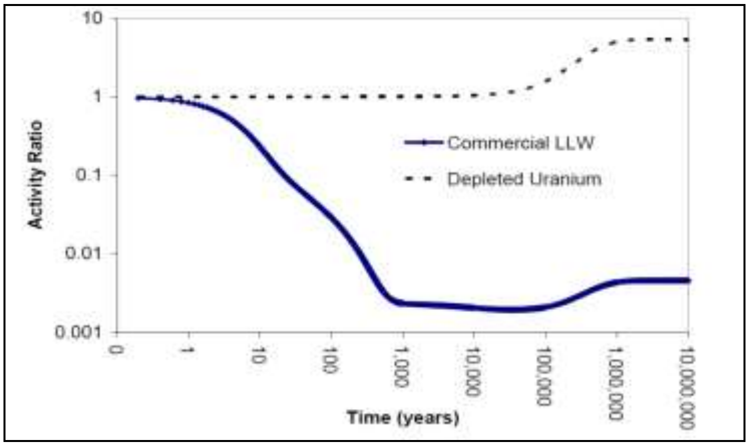

Fig. 3. Activity Ratios of DU and a Commercial LLW Disposal Facility. The activity ratios are defined as the initial activity to the activity at various points in time [15].

Site Specific Analysis Rulemaking and Guidance to Agreement States

On October 19, 2005, the Commissioners acknowledged that an inadequate environmental analysis had been performed in support of the initial rulemaking establishing the requirements in 10 CFR 61 (CLI-05-20) [16]. Soon thereafter, the Commissioners directed its staff (SECY-08-0147) to proceed with a rulemaking to specify requirements for a Site-Specific Analysis (SSA) for the disposal of large quantities of DU [17]. Its staff was also directed to develop a guidance document for public comment that would outline the parameters, assumptions, and technical analysis to be used in conducting a SSA.

The NRC began soliciting stakeholder involvement to gather information about the manner in which DU could be disposed of to protect public health. The NRC also issued guidance to Agreement States that would be relevant for reviewing a PA relating to the disposal of large quantities of DU on April, 13, 2010 [18]. The guidance suggested that Agreement States could evaluate a SSA submitted by a licensee to support disposal of large quantities of DU until such time that the NRC completed its SAA rulemaking. The guidance acknowledged that disposal of large quantities of DU may be appropriate in near surface disposal facilities under certain conditions, such as use of robust engineered barriers and disposal of waste at deeper depths. The guidance recommended limiting radiation doses to 5 mSv y^{-1} (500 mrem y^{-1}) for an inadvertent intruder after expiration of the 100-year institutional period. It also recommended a dose limit of 0.25 mSv y^{-1} (25 mrem y^{-1}) intended to protect the general public with a Period of Performance of 10,000 years, including evaluating the effects of potential climate changes following NUREG-1573 [19].

The NRC recognized that the performance objectives in Subpart C of 10 CFR 61 did not provide explicit requirements for radon and which different regulatory programs and different regulatory agencies had taken a variety of approaches to assess the impacts from radon. The NRC recommended evaluating such impacts using the update to the 10 CFR 61 impact analysis (NUREG/CR-4370) [20].

Texas Approves Major Amendment

WCS began to make significant enhancements to the PA as required by license conditions soon after the initial license was issued in September 2009 [21]. This effort required collection of additional site characterization data, minor modifications to the conceptual model, and reconstructing the PA using the GoldSim software over the next two years, which was performed by Neptune & Company and INTERA.

On August 5, 2013, after significant enhancements to the PA were completed, WCS submitted a major amendment to RML R04100 seeking to remove the disposal limits for ^{14}C, ^{99}Tc, and ^{129}I, as well authorization to dispose of large quantities of DU. The DU expected to be disposed of included deconverted U_3O_8 and DU with recycled uranium containing small quantities of actinides and long-lived mobile radionuclides. The TCEQ conducted its review of the license amendment request following the guidance developed by the NRC for Agreement States regarding the disposal of large quantities of DU. The PA analyzed the impacts to public health that could potentially result for a period of 1,000 years or peak dose, whichever is longer, pursuant to 30 TAC 336.709, *Technical and Environmental Analyses*. Accordingly, the impacts to public health were modeled out to one million years as part of the licensing review process−a time frame substantially longer than that suggested in the guidance to Agreement States.

During the license review, the entire inventory of DU (700,000 MTs) expected to be disposed of by the DOE over the next 30 years was assessed. A future climate change scenario was also analyzed for all assumed inventories of DU. Under this scenario, a climate study for Wichita, Kansas, that was used in the initial license application, was analyzed in the PA. By increasing the infiltration from zero to 0.27 mm y^{-1}, the effects of infiltration could be evaluated to determine compliance with the performance objectives. Additionally, 24-hour rainfall records collected since the 1950s were evaluated, assuming that the disposal facility's cover system had been degraded over time.

The results of the PA were most impressive and demonstrated that large quantities of DU could be safely disposed of at levels well below the 0.25 mSv y^{-1} (25 mrem y^{-1}) and 5 mSv y^{-1} (500 mrem y^{-1}) standards for members of the public and an inadvertent intruder, respectively. As shared with both the NRC Commissioners and the National Academy of Sciences, such analyses clearly demonstrated that a modern facility developed in an arid environment, with low permeability clays, and well above any potable water supplies can readily comply with the performance objectives proposed in the SSA rulemaking under 10 CFR 61 [22] [23].

PROGRESS TOWARDS PROVIDING A DISPOSAL OPTION FOR GTCC LLW

Significant strides have been made over the past few years in providing a potential disposal option for GTCC LLW in a land disposal facility licensed under 10 CFR 61. In December 2015, the NRC Commissioners directed its staff (SRM-15-0094) to prepare a regulatory analysis that would assess the quantities of GTCC LLW that may be suitable for land disposal in a near surface disposal facility within six months of issuing the final SSA rule [24]. Based on this analysis, NRC may develop technical criteria for the safe disposal of GTCC LLW. The NRC may determine whether or not it or an Agreement State should retain exclusive regulatory authority governing the disposal of such waste pursuant to the requirements of Section 274 of the AEA. The Commissioners also directed its staff to proceed with a rulemaking to resolve the discrepancy related to the exclusionary language for transuranic waste, defining "waste" in 10 CFR 61.2 consistently with the definition of LLW as specified in the LLWPAA of 1985.

Final Environmental Impact Statement

In February 2016, DOE[9] issued a Final Environmental Impact Statement (EIS) titled, *Disposal of Greater-Than Class C (GTCC) Low-Level Waste and GTCC-like Waste* (DOE/EIS-0375) pursuant to the EPAct of 2005 [25]. In its EIS, the DOE analyzed the environmental impacts attributable to disposal of such waste streams in a

[9] DOE selected a commercial disposal facility licensed under Part 61 and the WIPP as its Preferred Alternatives in the Final EIS. Pursuant to the EPAct of 2005, DOE is expected to issue its report to Congress on actions needed to fulfill its responsibility for the disposal of commercially generated GTCC LLW in the near future.

facility located in both an arid and a humid environment. During the NRC Commissioners' briefing on GTCC LLW (SECY-15-0094), DOE acknowledged its analysis concluded that disposal of GTCC and GTCC-like LLW in a facility located in a humid environment would cause significantly greater impacts as opposed to one located in an arid environment [26] [27].

The DOE also evaluated the performance of various facility designs that could be used to dispose of GTCC and GTCC-like LLW. The EIS concluded that disposal of this waste in a facility with features, such as robust engineered barriers, deeper depth of disposal, and enhanced waste packaging would further reduce the environmental impacts. The design of a near surface vault facility evaluated by DOE had features very similar in design of the WCS FWF (Fig.4).

DOE Enhanced Near Surface Vault Facility **WCS Enhanced Near Surface Vault Facility**

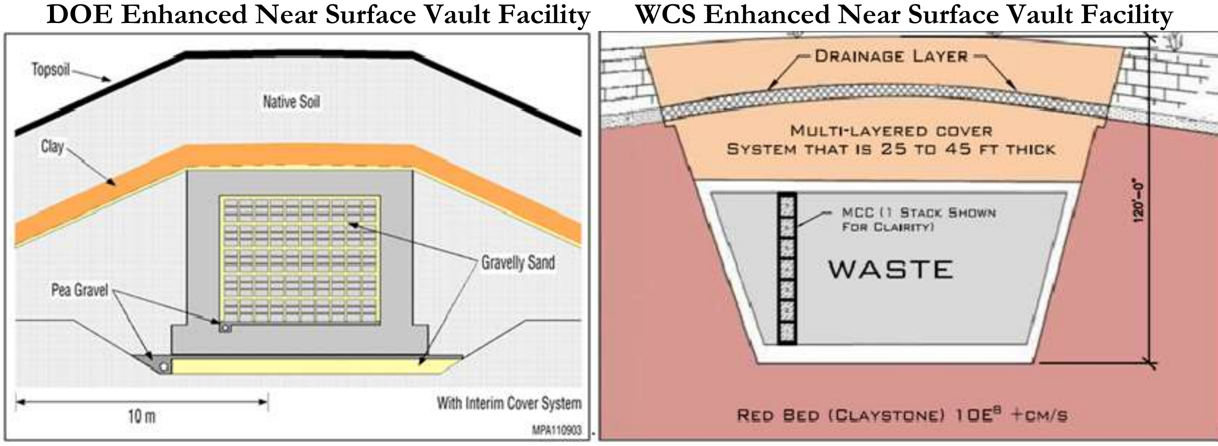

Fig. 4. A Comparison of Enhanced Near Surface Vault Facilities.

Regulatory Authority to Regulate the Disposal of GTCC LLW

As previously discussed, the NRC established regulations for land disposal of Class A, B, and C LLW in 1982. Waste exceeding the limits for Class C LLW were deemed generally not suitable for near surface disposal in a shallow landfill as designed and constructed at that time. While the NRC discouraged disposal of GTCC waste in such a disposal facility, it did not specifically prohibit it. The Commission provided licensees with the flexibility to request authorization to dispose of GTCC LLW in a near surface disposal facility on a case-by-case basis in 10 CFR 61.55.

At the time that the Commission was developing rules for the disposal of LLW, states were undertaking the task of developing new disposal facilities. This undertaking was spurred by the 1980 mandate that each state should be responsible for the disposal of waste generated in that state or enter into interstate compacts. Realizing that GTCC LLW was not likely to be disposed of in a state or compact disposal facility, Congress amended the law in 1985, to assign the responsibility of disposing commercially generated GTCC waste to the federal government, a task that was ultimately assigned to the DOE. The law also reserved the licensing "responsibility" [emphasis added] of such a facility to the NRC. The law did not grant the NRC the authority to regulate the disposal of radioactive waste generated or owned by the DOE, including waste in the possession of the DOE that is comparable in half-life and concentration to commercial GTCC LLW.

Petition for Rulemaking

On July 21, 2014, WCS filed a Petition for Rulemaking ("Petition") with the TCEQ requesting changes to 30 TAC 336 that would remove prohibitions for disposing of GTCC and GTCC-like LLW. As addressed in the

Petition, disposal of GTCC and GTCC-like[10] LLW was prohibited in 30 TAC 336, but was specifically authorized by Texas statute, as well as laws and regulations promulgated by the NRC in 10 CFR 61 [28].

At the agenda meeting with the TCEQ Commissioners [29], WCS stated that the definition of "Federal Facility Waste" specified in the Texas Radiation Control Act authorized disposal of waste that is the responsibility of the federal government pursuant to the LLWPAA of 1985. Federal Facility Waste includes Class A, B, C, and GTCC-like LLW generated or owned by the federal government. It also includes commercially generated GTCC LLW as specified in Section 3 of the LLWPAA of 1985. Such waste must be disposed of in the FWF that requires DOE to take title of it in perpetuity at the time of site closure.

WCS stated that the Petition requested changes to regulation established by the TCEQ to better align with the regulations promulgated by the NRC in 10 CFR 61. The TCEQ Commissioners unanimously approved the Petition, directing its staff reach out to its federal counterparts seeking clarification regarding the agency's authority and jurisdiction to regulate the disposal of GTCC, GTCC-like, and transuranic waste in Texas[11]. On January 30, 2015, TCEQ submitted such a letter requesting clarification from the NRC regarding their authority and jurisdiction to regulate the disposal of such waste in Andrews County[30].

The Petition filed by WCS and TCEQ's letter requesting such clarifications from the NRC started an important conversation that may ultimately provide a disposal pathway for waste that has been effectively stranded for decades.

Commissioners Briefing on GTCC LLW

On August 13, 2015, the NRC Commissioners deliberated on the legal merits, described in SECY-15-0094 [31], of whether or not an Agreement State could assume regulatory authority over the disposal of GTCC LLW. The NRC Office of General Counsel (OGC) shared its opinion that the Section 3 of LLWPAA of 1985 charged the Commission with the "responsibility" of licensing a facility for the disposal of commercial GTCC LLW. However, OGC stated that such statutory language did not preclude the NRC from granting an Agreement State with the "authority" over a program for which it had already assumed regulatory control over pursuant to Section 274 of the AEA.

As discussed by Kirk and Jacobi, specifically under Section 274.c(4) of the AEA, the commission may determine by regulation or order to retain the exclusive licensing authority governing the disposal of byproduct, source, or special nuclear material based on the hazard or potential hazard of disposal of such waste may pose to public health [32]. However, the Commission has currently not made such a determination by order or regulation and reiterated its policy (in SRM-15-0094) that disposal of GTCC LLW may currently be disposed of on a case-by-case basis in a facility licensed under 10 CFR 61.

At the Commissioners' briefing, staff also recommended a rulemaking to align the definition of "waste" specified in 10 CFR 61.2 with the Waste Classification Tables in 10 CFR 61.55 for the purpose of providing a regulatory disposal path for waste with certain transuranic radionuclides exceeding 100 nCi/g.

NRC staff recommended that Texas should be granted with the authority to regulate GTCC LLW consistent with the NRC's historical desire to allow States to regulate disposal of such waste. It stated that this approach would provide greater regulatory flexibility because Texas had acquired considerable experience in licensing

[10] GTCC-like LLW is waste with concentrations of radionuclides exceeding the Class A limits, but is owned or generated by DOE.

[11] The TCEQ Commissioners did not approve changes specific language in 30 TAC 336. A rulemaking must be completed removing the prohibitions currently in place before disposal of waste exceeding the limits for Class C LLW is may be authorized by TCEQ.

the facility for other types of LLW and would establish clear-cut Federal and State licensing pathways for disposal of GTCC LLW.

The Basis for Class C LLW: A Re-Examination

At the Commissioners' briefing, Kirk [33] stated that the original assumptions used to establish the Class C limits in 1982 should be examined to assess whether a well-sited, highly-engineered facility located in an arid region of the U.S. may be suitable for disposing of GTCC LLW The limits for Class C LLW were originally developed to ensure that an inadvertent intruder would not be exposed to a radiation dose in excess of 5 mSv y^{-1} (500 mrem y^{-1}) based on conservative assumptions. The exposure scenarios considered by the NRC at that time had assumed the disposal facility was located in a humid environment on the east coast of the U.S. This assumption was based on the belief that several nuclear power plants on the east coast would be decommissioned and the waste disposed at a facility similar in design and siting characteristics to the disposal facility in Barnwell, South Carolina [34].

The NRC had assumed that a future resident would unknowingly construct a dwelling over a waste disposal facility and install a drinking water well at the margins of the disposal units. Water used for drinking water and to irrigate food was assumed to be contaminated from the nearby radioactive waste disposal facility.

The NRC established the Class C limits requiring that waste be disposed of at a depth of at least 5 m below ground or require the use of engineered intruder barriers that could be relied upon for 500 years. Disposal at such depths or use of engineered barriers were assumed to be sufficient to prevent inadvertent intrusion into the waste. Kirk suggested that such requirements were conservatively established for Class C LLW should be reexamined, especially in light of the site characteristics and disposal practices currently used in a modern disposal facility, such as FWF−that is, use of multiple engineered intruder barriers, disposal at depths up to 36 m (120 ft) in an arid environment that is far removed from potable water supplies.

Staff Requirements Memorandum

The Commission Vote Record provided a range of opinions regarding the technical and legal matters that had been addressed during the deliberations on GTCC LLW. The Commissioners agreed that, among other things, a regulatory technical basis would be prepared to address the hazard that GTCC LLW posed and whether or not this waste could be safely disposed of in Andrews County, Texas. The results of the regulatory analysis would help determine whether or not the NRC should retain exclusive licensing authority of the disposal of GTCC LWW, or if this authority should reside with Texas pursuant to Section 274.c(4) of the AEA.

In Commissioner Jeffery Baran's concluding remarks he succinctly stated that:

> *"I have been impressed by the thoughtful, problem-solving approach that all of those involved have brought to this challenging matter. If resolving GTCC waste disposal issues were easy, we would not be here 30 years after the Amendments Act still pondering fundamental questions about which agency has the responsibility to license a GTCC waste disposal facility"* [35].

On December 22, 2015, the Commissioners directed their staff to complete the regulatory basis regarding disposal of GTCC LLW within six months of issuing the final SSA rule. Its staff issued the final SSA rulemaking (SECY-16-0106) to the Commissioners for consideration on September 15, 2016 [36].

DISPOSAL OPTIONS FOR WASTE WITH VERY LOW LEVELS OF RADIOACTIVITY

In 2013, WCS developed a framework to establish limits for waste with very low levels of radioactivity for disposal in its landfill permitted under RCRA. The framework was supported by NRC's process, allowing licensees to request authorization to dispose of such waste in RCRA landfills, provided that the annual radiation doses to members of the public would not exceed a few millirems, pursuant to 10 CFR 20.2002. The NRC's process has provided alternative and cost-effective disposal options to generators across the country, especially for high volumes of bulk waste and soils associated with the decommissioning of nuclear facilities. This practice has also conserved valuable disposal capacity for the disposal of waste with much higher levels of radioactivity in facilities licensed under 10 CFR 61.

The NRC assigned a compatibility category C when it promulgated 10 CFR 20.2002 and therefore, not all Agreement States had chosen to promulgate a similar regulation.Additionally, the NRC provided guidance to Agreement States regarding the process or procedures that should be considered if licensees requested an Agreement State to authorize disposal of waste with very low levels of radioactivity [37]. As stated in the guidance, Agreement States may authorize alternative approaches for disposal of waste with very low levels of radioactivity under Part 20.2002 or by an "exemption request" received from licensees.

The TCEQ did not choose to adopt a Part 20.2002-like regulation in 30 TAC 336. However, it published guidance [38] for licensees seeking to dispose of certain radioactive waste that was exempted by rule (e.g., waste with less the 0.05 wt. % of source material) or by an exemption under 30 TAC 336.5, *Exemptions*. Licensees requesting an exemption to dispose of radioactive materials are required to, among other things, demonstrate that the exemption is not prohibited by law and will not result in a significant risk to public health.

In May 2013, TCEQ approved an exemption request for disposing of waste with very low levels of radioactivity in a RCRA landfill operated by WCS. The disposal limits that were approved ensured that the maximum dose of radiation that a member of the public could receive would not exceed 0.01 mSv y^{-1} (1 mrem y^{-1}) over the next 1,000 years. The limits were established using the PA developed on the probabilistic GoldSim platform and based on the engineering design of the RCRA landfill. The cumulative impacts attributable to waste disposed in the RCRA landfill, and the adjacent LLW disposal facilities, must also be analyzed as part of the Annual Update to the PA required as a condition of the license.

The framework established by TCEQ provided greater flexibility to licensees than Part 20.2002. The latter is typically waste stream dependent, often requiring nine months or longer for the NRC to complete its licensing review under Part 20.2002. Waste with low-levels of radioactivity intended for disposal at the RCRA landfill are received at WCS as radioactive materials and subject to confirmatory measurements needed to demonstrate compliance with the approved disposal limits. Such waste does not require approval of an import petition by the Texas Compact Commission and is also not subject to the 30 % surcharge applied to Class A LLW disposed of at the CWF.

The framework established by WCS was designed to provide generators with both scheduling flexibility and cost-effective disposal options for waste at approximately 10% of the limits for Class A LLW. It also conserves valuable capacity for the disposal of Class A, B, and C LLW at both CWF and FWF. DOE also recently approved this process as Authorized Limits in accordance with Order 458.1, *Radiation Protection of the Public and the Environment* [39].

CONSOLIDATED INTERIM STORAGE OF SPENT NUCLEAR FUEL

On April 28, 2016, WCS filed its license application with the NRC requesting authorization to construct and operate a Consolidated Interim Storage Facility (CISF) for Spent Nuclear Fuel (SNF) in Andrews County, Texas [40]. In its license application, WCS requested storing up to 5,000 Metric Tons of Heavy Metal (MTHM) from 12 shutdown and decommissioned Nuclear Power Plants (NPPs) across the country in storage systems manufactured by AREVA and NAC International. Upon approval of the license application, future amendments could be filed with the NRC to expand the storage capacity at the CISF from 5,000 to 40,000 MTHM in eight phases.

The CISF would be located north of the FWF (Fig. 5). A major advantage that this facility offers is the extensive infrastructure that has already been developed in support of WCS' waste disposal operations. Such infrastructure includes support facilities, roads, and a Class 1 rail line developed by the Texas-New Mexico Railroad with easements leading from Monahans, Texas through Eunice, New Mexico. Such capabilities would allow for the transport of SNF from NPPs located across the country.

Fig. 5. Location and Artist Rendition of the CISF.

WCS has developed a state-of-the-art environmental monitoring program, RACER-DAT (Risk Analysis, Communication, Evaluation, and Reduction-Data Analysis Tool) to evaluate the impact at its disposal facilities that could be expanded to cover the CISF [41]. This tool was originally created to enhance the ability of Los Alamos National Laboratory (LANL) to effectively communicate the data and processes used to evaluate environmental risks to the public in 2003. The RACER project staff consisted of members of Risk Assessment Corporation, LANL, and the New Mexico Environment Department (NMED). RACER staff worked closely with members of the community, tribal governments, and others within NMED and LANL to create innovative tools that could provide information to regulators, LANL, and the community about the sources of public health risk and ecological impacts from operations at LANL [42]. The RACER-DAT provided the public with web-based access to environmental measurement data collected in and around the LANL site. Its effectiveness is readily capable of addressing any future, potential contentions regarding the cumulative impacts the CISF could pose to groundwater, environmental media, and other nearby sources of radiation present in the region triggered under 40 CFR 190, *Environmental Radiation Protection Standards for Nuclear Power Operations*.

Status of License Application

The license application submitted on April 28, 2016, included, among other things, a Safety Analysis Report (SAR), Environmental Report (ER), Physical Security Plan (PSP), Quality Assurance Program Description (QAPD), and an Emergency Plan (EP) pursuant to 10 CFR Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor- Related Greater Than Class C Waste*. The NRC recently docketed the license application and noticed an opportunity for hearings. It has announced the dates for public meetings that will be held to support the scoping process that will be conducted to prepare an EIS, as specified in 10 CFR Part 51, *Environmental Regulations for Domestic Licensing and Related Regulatory*

Functions [43]. WCS requested the NRC to complete its licensing review and issue a Final EIS within three years after docketing the license application. Upon issuance of the license application, SNF currently stored at 12 shutdown and decommissioned NPPs could be placed into interim storage and the former reactor sites returned to greenfields, allowing the lands to be repurposed by the local communities for further economic development.

Obligations Mandated by the Nuclear Waste Policy Act

Pursuant to the NWPA, DOE was required to take title of SNF generated from commercial nuclear power reactors across the country beginning in 1997. However, DOE has not fulfilled its legal responsibilities and SNF is scattered across the nation at 75 operating and decommissioned NPPs in 33 states. DOE is expected to pay over $27 billion of tax payer funds for failing to meet its legal obligations by 2021. To remedy this situation, DOE is taking a hard look at actions needed to site a permanent repository and a CISF to manage SNF generated over the past several decades following many of the recommendations from former President Barak Obama's Blue Ribbon Commission on America's Nuclear Future (BRC) [44].

Legislative Changes Needed

Electric utilities have paid fees into the Nuclear Waste Fund (NWF) for the expressed purpose of constructing a geologic repository for disposal of up to 70,000 MTHM of SNF over the past several decades. Fees collected to date total over $30 billion. Given the difficulties in opening the repository that would be located at Yucca Mountain, some members of Congress have supported changes to the NWPA which would allow a small portion of these fees to be used to construct and operate and CISF.

The Senate has been more in favor of supporting consolidated storage of SNF than attempting to open Yucca Mountain. However, others in the House of Representatives believe that completing the licensing review for Yucca Mountain is the law of the land and proposed funding allowing the NRC to proceed with completing its review of the licensing application [45]. Congressman Mike Conaway (R-TX) and Mick Mulvaney (R-SC) had introduced legislation to amend the NWPA, allowing the DOE to take title of the nuclear waste and contract with private companies to store SNF last year [46]. On January 12, 2017, similar legislation titled, *The Interim Consolidated Storage Act of 2017,* was also recently introduced by Congressmen, Mike Conway (R-TX) and Daryl Issa (R-CA) in the 115th Congress that would provide such an important interim solution, enabling DOE to fulfil its obligations under the NWPA.

A CISF is an interim solution that complements, but does not compete with the requirement of opening Yucca Mountain. It is widely acknowledged that the repository at Yucca Mountain will not be opened until as late as 2048. Therefore, Congress should enact legislation that funds both a pilot program for consolidated interim storage of SNF and funds the NRC licensing review for the repository at Yucca Mountain. Such an approach makes more sense because SNF could be consolidated from the shutdown decommissioned reactors, placed into interim storage, and one day be repackaged in a configuration that is suitable for disposal at a repository.

Model for Creating Private/Public Partnerships

Texas has demonstrated a strong willingness to creatively solve some of the nation's most difficult waste management challenges−from creating a private/public partnership to license the first new regional disposal facility of Class A, B, and C LLW in 40 years, to actions taken that may allow for the removal of SNF from

NPPs across the country. Ultimately, this approach would allow for the lands to be returned to greenfields and repurposed for the economic benefit by the communities that had been willing to host the reactor sites.

Policy makers should take a hard look at the successful approaches taken by the leadership in Texas in solving problems that once seemed almost insurmountable. On March 28, 2014, Texas Governor Rick Perry stated in a letter to Lieutenant Governor, David Dewhurst and Speaker of House, Joe Straus, that it was time for Texas to act and begin looking for a safe and secure solution for SNF and other High Level Waste in Texas [47]. Governor Perry enclosed a report that had charged the TCEQ with preparing a report on the challenges posed by SNF currently stored on-site at the six NPPs located in Texas.

The report prepared by the TCEQ recognized the challenges with licensing a CISF, encouraging decision makers to take into account currently licensed and constructed radioactive waste disposal facilities such as the Waste Isolation Pilot Plant in New Mexico and the Texas Low-Level Radioactive Waste Disposal Facility in Andrews County. In its report, TCEQ stated that if the methodology used for siting these two facilities is built upon, the siting and construction of a SNF storage facility is not only feasible but could be highly successful [48].

Shortly before WCS submitted its "Letter of Intent" [49] to file an application, the Andrews County Commissioners unanimously approved a resolution in support of hosting a CISF in their community on January 20, 2015 [50]. Such a commitment demonstrated Andrews County's willingness to host such a facility and to help solve a significant problem that faces our nation.

This year may mark a significant milestone in moving forward with developing solutions for both licensing a CISF in Texas and a permanent geologic repository in Nevada?

CONCLUSIONS

Many accomplishments have been made in the field of radioactive waste management over the past decade. Solutions emerged after access to the disposal facility in Barnwell, South Carolina was restricted to non-regional generators, ensuring that Class B/C LLW generated in 36 states would no longer be stranded. One such solution was the opening of the first regional disposal facility located in Andrews County in over 40 years. The robustness of this facility was again rigorously tested as part of the licensing review that led to authorization to dispose of large quantities of DU by the TCEQ. This review clearly demonstrated that long-lived alpha emitting radionuclides could be safely isolated from the biosphere for hundreds of thousands of years. Another examination regarding the capabilities of this facility will be performed and may provide a disposal pathway for transuranic, GTCC, and GTCC-like waste in the near future. However, an NRC rulemaking to revise 10 CFR 61 will be required. Such a rulemaking may be long and arduous to complete. Success will require stakeholder support and a commitment from both federal and state agencies. It may also require Congressional involvement, perhaps sometime after DOE provides it with a report on GTCC LLW as mandated in the EPAct of 2005. However, if a solution to solve this decades old problem were easy it would have been solved long ago as astutely stated during deliberations on this matter by NRC Commissioner, Jeffery Baran.

The issuance of a license to WCS offered waste generators accessible disposal options for Class A, B, and C LLW. Moreover, the ability to receive wastes with very low levels of radioactivity clearly helped change its competitive landscape. The framework established helped provide the nuclear industry with cost effective disposal options for a wide range of waste streams supporting the decommissioning and cleanup in both commercial and government sectors.

The many successes of WCS would likely not have materialized without the vision and strong support of the leadership in Texas and Andrews County. The private/public partnership forged has significantly contributed to the successes in Texas and could serve as a model in solving some of the nation's other complex waste management challenges. Most notably, the possible issuance of a license for a SNF interim storage facility, and perhaps a geologic repository, may provide the means for DOE to fulfill its obligations pursuant to the NWPA of 1982. Given the momentum demonstrated by members of Congress, a path forward for one or more of these challenges could be nearer than imagined.

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