A Holistic, "Rapid-Deployment", Solution for Safe Used Nuclear Fuel Management in the United States of America

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ABSTRACT

Recent political initiatives and increased willingness in the United States of America (U.S. or USA) to consider federal storage and recycling of used nuclear fuel (UNF), augmented by expressed private interest in developing 31 new nuclear power plants, strongly suggest that the U.S. is on the brink of a nuclear-energy renaissance. Unfortunately, the related UNF-management and -disposition research, technology, and facility developments have been virtually dormant for 25 years. Fortunately, other countries have pursued safe UNF-management and -disposition solutions during this period that the U.S. now can take advantage of to develop the required UNF-management technologies and facilities in a timely and cost-effective manner.

The following criteria/concepts for the timely and cost-effective development of safe and secure nuclear facilities were applied to current and planned UNF-management in the U.S. to formulate a potential, holistic, "rapid-deployment" UNF-management solution at the Nevada Test Site (NTS), referred to as *the Nevada National Nuclear Fuel Management Cente*r (3NFMC):

- *Locate pending UNF-storage and -recycling facilities on the NTS* in the vicinity of the Nation's candidate deep geological disposal system (repository) for UNF and other high-level radioactive waste (HLW) at the Yucca Mountain (YM) site;
- *Locate all main UNF-management facilities underground*; and
- *Use best-available technology to site, design, and construct the pending facilities*.

Three main *challenges* to the timely and cost-effective development of the 3NFMC are: (1) Statutory restrictions preventing the UNF-storage and -disposal facilities from being co-located and co-developed by federal and civilian/private parties; (2) Long-standing, scientific, local-political, key-Congressional, and national-ideological opposition to the YM UNF/HLW repository; and (3) The discouraging track record, and the related lack of trust in, and credibility of the organization currently responsible for developing the UNF/HLW repository.

Homeland Security could be the *catalyst* for mitigating the first two challenges. Infusion of leadership from the nuclear utilities, active involvement by local residents and communities, performance incentives, and accountability in the implementing organization combined with the prompt adaptation of applicable existing domestic and foreign approaches, technologies, and facilities, i.e., leapfrogging, are promising catalysts for mitigating the third challenge.

The primary envisioned *attributes/benefits* embodied in the timely development of the 3NFMC are: (1) Enhanced Homeland Security, including (a) higher levels of control and safeguarding of highly-radioactive materials, and (b) Sustained nuclear renaissance; (2) Reduction in UNF/HLW

disposal "breach-of-contract" compensations to the nuclear utilities; (3) Minimization of public and environmental radiation risks; and (4) Intellectual and financial benefits to the host state.

INTRODUCTION

At the end of 2006, approximately 20 percent of the electricity produced in the United States of America (U.S.) was generated by 104 nuclear power plants (NPPs). Whereas 28 NPPs have been decommission, no new NPP has been built during the past 24 years. During the past couple of years, the U.S. Congress has approved and proposed nuclear-energy-related incentives, largely championed by Senator Domenici, designed to secure a nuclear-energy-based future. Private interests have responded with more than 30 proposed new NPPs. Although current key nuclear-energy-related vital signs strongly suggest that the U.S. is gradually awakening from its Cinderella sleep and is on the brink of a nuclear renaissance, *key components of the nuclear fuel cycle are missing and need to be developed*. Furthermore, *the order and pace in which they are developed are of utmost National importance* because they affect:

1. Homeland Security.
2. The pace of the nuclear renaissance and, thus, the cost of energy.
3. The number and amount of damage claims due to the nuclear utilities.

This paper outlines a potential "rapid-deployment" package-solution for safe, cost-effective, and timely management and disposition of UNF and other high-level radioactive waste (HLW) at the Nevada Test Site (NTS) in the State of Nevada (Nevada), referred to as *the Nevada National Nuclear Fuel Management Center* (3NFMC). The reference to "rapid deployment" is related to the potential for the U.S. Department of Energy (US DOE) of being able to taking title to utility-generated UNF at least five years ahead of the current schedule, which would save at least five billions U.S. dollars ($5B) plus the even larger reduction in "breach-of-contract" damages due to the nuclear utilities. The subsequent text is organized as follows:

- Description of the main 3NFMC components and concepts.
- Relevant background information, including basis and approach for the 3NFMC analysis.
- Discussion of the benefits and challenges embodied in the 3NFMC.
- Summary of recommendations and opinions, including potential "path-forward" options.
- A full listing of the references indicated by numbers in brackets in the main text ([1-11]).

For emphasis, key portions of the main text are highlighted in *italics*. However, the reader is advised that this text (a) is solely attributable to the author and (b) should be read and interpreted in the context of the following statements by the French philosopher Jean Jacques Rousseau (1712-1778) and the English poet William Shakespeare (1564-1616), respectively:

"No generalization is entirely true; not even this one", and
"The beauty is in the eye of the beholder".

MAIN 3NFMC COMPONENTS AND CONCEPTS

Following is a concise description of the main proposed components/concepts of the 3NFMC:

1. Continue the characterization and licensing efforts supporting the nation's only candidate UNF/HLW repository at the YM site (Fig. 1) because *neither recycling nor long-term storage negates/eliminates the need for a HLW repository.* However, the licensing and development schedule, and the facility design should be modified, as required, to ensure:
   a. A sufficient volume of UNF is readily available for uninterrupted recycling; and
   b. The isotopes resulting from recycling can be safely disposed of in the YM repository.
2. Promptly develop *underground* facilities for UNF-storage and -recycling adjacent to the YM site on "clean" portions of the 3,561-square-kilometer (km^2) NTS (Fig. 1) based on:
   a. The Swedish (Figs. 2 and 3 [www.skb.se]) and Finnish concepts of integrating/co-locating the UNF-generating, -storage and -disposal facilities, whenever possible;
   b. The Finnish "leapfrogging" approach that lead to cost-effective collaborations with the Swedish Nuclear Fuel and Waste Management Company (SKB); and
   c. The design and operating experience of SKB's UNF-storage facility (Clab) (Fig. 3).
3. Make the UNF-generating utilities, local residents and communities, and the host state integral partners in the organization responsible for the siting, developing, and securing operating licenses for future 3NFMC facilities, *including the UNF/HLW repository.*

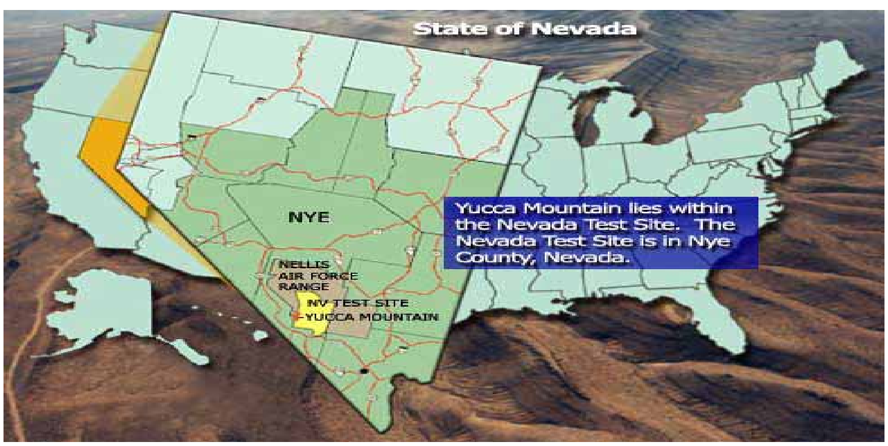
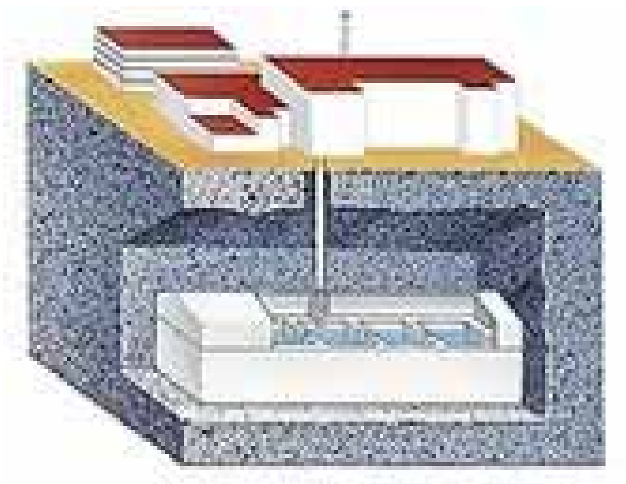


Fig. 1. Map showing the location of the Yucca Mountain candidate UNF/HLW-repository site and the Nevada Test Site. (Courtesy of the U.S. Department of Energy).

LEGEND:

1. Operating NPPs
2. Planned Encapsulation Facility
3. Operating Central UNF-Storage Facility (Clab)
4. Operating Hard Rock (International Underground UNF-Disposal Research) Laboratory at Äspö

Fig. 2. Illustration of the co-location of nuclear-fuel-cycle facilities in the Oskarshamn's community, Sweden (also hosting one of the two candidate UNF-repository sites).



When Opened	Phase 1: 1985 Phase 2: 2006
Storage Volume (9 water-filled basins + 1 in reserve)	Phase 1: 5,000 tons of Uranium (ToU) Phase 2: 3,000 ToU
Handling Capacity	300 ToU per year
Phases 1 and 2 Cavern Dimensions	Height = 27 m Width = 21 m Length = 120 m
Construction Cost	~$235M
Operations Cost	~$14M per year
Rock Cover	~25 m

Fig. 3. Schematic cross-section illustration of Phase 1 and fact sheet on the SKB's Clab facility.

BACKGROUND

The 3NFMC solution outlined in this paper is a potential, "rapid-deployment", management and -disposition solution for the tail-end of the nuclear fuel cycle. It is based on a combination of (1) the author's involvement in (a) subsurface developments since 1963 [e.g., 1,2] and (b) safe radioactive waste management solutions in the U.S. and abroad since 1978, [e.g., 3-5], and (2) currently considered components of the holistic approach shown in Fig. 4 [6] being applied to the current status of and future plans for UNF-management and -disposition in the U.S. and abroad.

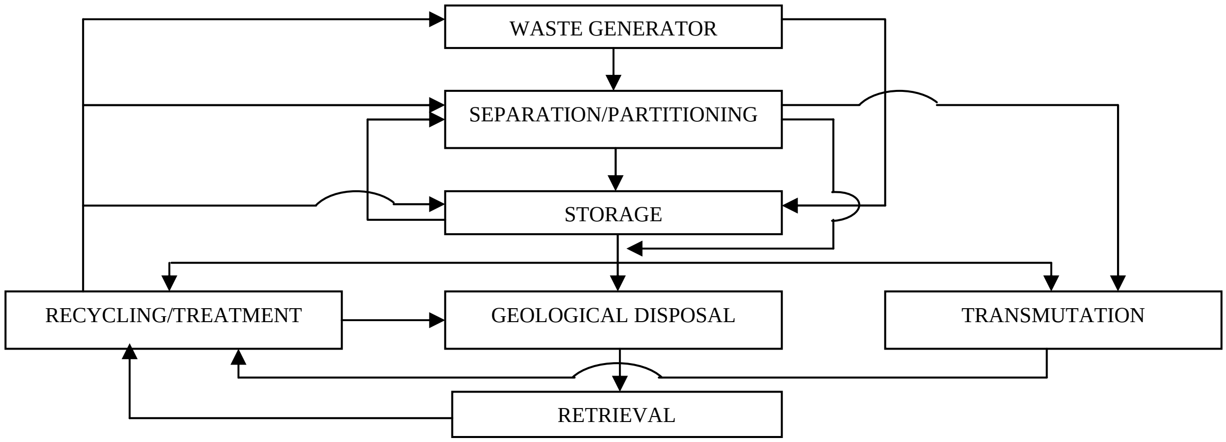


Fig. 4. Main components of the holistic approach for safe LLRM-management and -disposal.[6]

Following are the two boundary assumptions for the analysis supporting the 3NFMC solution:

1. The UNF-management and -disposition initiatives funded or proposed by the U.S. Congress at the end of 2006, e.g., *UNF-storage and -recycling*, will happen.
2. Regardless of any future UNF-treatment or -utilization process, there will be residual, long-lived radioactive wastes/materials (LLRMs) from current and future stockpiles of UNF and HLW that will require long-term containment and isolation in a repository.

The 3NFMC analysis also included the following major assumptions and considerations:

- UNF and HLW are the main current LLRM waste streams needing repository disposal;
- The Yucca Mountain (YM) site in Nevada was the starting point for the analysis;
- One or more additional LLRM-disposal (repository) sites may be needed; and
- Public and political acceptance of, and confidence and trust in the implementing organization(s) will govern the pace and cost of the 3NFMC and the nuclear renaissance.

The following aspects of the 3NFMC are addressed further below under separate headings:

1. Maturity of the proposed UNF and HLW-management and -disposition concepts.
2. Feasibility of accommodating the main 3NFMC facilities underground at the NTS.
3. Track record and credibility of and trust in the implementing organization.

Maturity of the UNF-Management and –Disposition Concepts Embodied in the 3NFMC

Please note that most of the subsequent text under this heading is excerpted from a paper presented at the 2003 Waste Management Conference (WM'03).[6] However, all references to literature sources and figures were deleted and clarifying and editorial updates were made.

Separation/partitioning of different radioactive (and chemical) components has been available on an industrial scale for more than 30 years. However, in many countries, separation and partitioning of LLRMs are not integral components of the national energy policy. Two main reasons for this policy appear to be:

- The absence of a holistic energy-management policy; and
- Lack of incentives or requirements for the nuclear utilities to pursue nuclear-fuel-conservation and waste-minimization/reduction measures.

Notwithstanding these constraints, *separation/partitioning* offers the benefit of strictly controlled waste streams and the generation of constituents that may be either directly used or used as feed for other LLRM-disposition solutions such as transmutation and recycling/reprocessing.

Recycling and treatment, including reprocessing, of LLRMs are common industrial processes. Indeed, reprocessing is an LLRM-disposition technology/solution that has been safely used on an industrial scale in France, England, and the U.S. for more than 30 years. Reprocessing essentially enhances the concentration of radioisotopes required for nuclear-energy and nuclear-weapons production; however, *it produces large quantities of waste*. Furthermore, recycling does very little, if anything, to relieve the rate and tax payers from current nuclear-utility claims based on the US DOE's inability to comply with the law.[7,8] *The urgently-needed, missing link to reducing current and future utility claims*, currently estimated to total between ~$12B and $300B contingent upon when the US DOE takes title to utility-generated UNF and the estimator, *is a long-term (20-100 years), federal storage facility for utility-generated UNF.*

In the U.S., federal/government-operated *LLRM-storage* facilities have been in safe use since the early 1940s and utility-managed/operated LLRM-storage facilities have been in safe use since the early 1950s. More than 30 nations are safely storing civilian-generated and some defense-generated LLRMs in surface and near-surface facilities with different levels of protection against malevolent actions. In terms of safeguards, the specially designed *underground facility* for long-term (30-50 years) UNF storage in Sweden, Clab (Fig. 3), is an excellent example of an environmentally robust, "terrorist-unfriendly", LLRM-storage facility because it provides strict ingress and egress control and virtually precludes the spread of any unplanned radionuclide release(s) beyond the underground facility.

In summation, *both the technology and operating experience required for safe storage of LLRMs are well proven around the world for a broad range of different LLRM-storage concepts*. The major current global challenge seems to be to find LLRM-storage sites with adequate local acceptance and support away from the sites where the LLRMs are generated, if needed. A related national/domestic challenge is that the operational life and productivity/efficiency of existing NPPs have continued to increase, which, in turn, results in more LLRMs that require more and, in some cases, earlier storage solutions due to the accelerated filling of available storage space. "As illustrated by recent international and national actions, e.g., in Russia and USA, respectively, the development of additional LLRM-storage solutions is a recognized need that, in our opinion, could benefit both in terms of cost and schedule reductions from collaborations among the LLRM generators, including the joint siting, development, and operation of LLRM-storage facilities, and other LLRM-disposition solutions."[6]

With regards to safe *disposal of LLRMs*, at the end of 2006, the Waste Isolation Pilot Plant (WIPP) repository is the only operating deep geological LLRM-disposal facility in the world. The U.S. Environmental Protection Agency (US EPA) certified in May 1998 that the WIPP disposal system complied with all regulatory compliance criteria for safe disposal of UNF, HLW, and transuranic radioactive waste (TRUW). On 11 September 2006, the WIPP repository safely received its 5,000 TRUW shipment.[http://wipp.energy.gov] When filled to its current statutory capacity, WIPP will contain 175,584 m^3 of TRUW. The world's next three LLRM repositories are currently scheduled to open in the U.S. (welded tuff) sometime between 2017 and 2020, in Sweden (crystalline/igneous rocks) in 2018, [www.skb.se] and in Finland (crystalline/ igneous rocks) in 2020 [www.posiva.fi]. The YM repository may contain up to 70,000 metric tons of uranium (MTU), of which ~62,000 MTU are scheduled to be UNF. Notwithstanding the current global scarcity of operating LLRM-disposal facilities, deep geological disposal of LLRMs has been pursued around the world for more than 45 years. It is presently by far the most scientifically and technologically mature, and internationally accepted LLRM-disposal solution. Pending the opening of the world's next UNF/HLW repository, WIPP provides an invaluable national solution that also serves as a global physical demonstration of:

- The feasibility of the deep geological disposal concept;
- Rock salt's excellent radionuclide containment and isolation characteristics; and
- The feasibility of safe long-distance (truck) transportation of LLRMs.

Feasibility of Accommodating the Main 3NFMC Facilities Underground on the NTS

The YM site is located within the 3,561-km^2 federally-owned and -operated NTS (Fig. 1). In turn, the NTS is located adjacent to another federally-owned and -operated 14,167-km^2 site. The NTS has been subjected to a broad range of underground characterization efforts and subsurface developments in a broad range of rock types for more than 50 years. For example, UNF-disposal-related activities include the YM URL in volcanic rocks and a predecessor URL in the Climax granite. A large number of defense-related research projects have also utilized these and other rock types for practical applications. Since the cavern-dimensions required for the main UNF-management and -disposal facilities discussed in this text are moderate by industry standards, there should be an abundance of rocks at the NTS that could host them. As follows, there is no apparent geologic or geographic constraint to locating the UNF-storage and -recycling facilities adjacent to the YM site on the NTS. The main author-perceived challenges are:

- To stay clear of areas already contaminated by or that would become contaminated by migrating radionuclides during the lifetime of the 3NFMC facilities.
- To obtain the required level of local support, including the required state permits.

Track Record and Credibility of and Trust in the Implementing Organization

This section focuses on the track record and credibility of, and trust in the implementing organization for the YM UNF/HLW repository because it is the only currently available organizational component of the 3NFMC with a long-standing track record (20+ years). The WIPP TRUW repository organization, which has a 33-year track record but is not a component of the 3NFMC, was used as a comparative U.S. yardstick. An overarching, biased, discussion of the importance of public and political acceptance precedes the organizational discussion.

Achieving the acceptance, and timely and cost-effective disposition, of LLRMs comprises one of the most daunting and multi-facetted societal challenges of this generation. As history shows, the development of even regulation-compliant LLRM-disposition solutions normally experience public, organizational, and political opposition, including legal challenges, causing significant delays and life-cycle-cost increases and, in some cases, project cancellation. Following are two author-perceived root causes for these challenges:

- The inherent intellectual challenges posed by the one or more of the long temporal and large spatial scales, and the related advanced, often state of the art, scientific concepts of an LLRM-disposition solution are typically beyond the comprehension of most humans, making the proposed solution susceptible to misconceptions and misrepresentations emanating from personal, ideological, and organizational agendas. *One major function of the implementing organizations is thus to make the complexities of the proposed LLRM-disposition solution understood and accepted by the general public because, if the concept is not understood, it will not be accepted by either the general public or, in turn, its elected representatives*.[9-11]
- However, *if one doesn’t trust the messenger, the message will not be believed.*[10,11] Another major function of the implementing organization, if being the messenger, is thus to earn public trust and credibility because, again, it will govern the pace and cost of the promoted/pursued LLRM-disposition solution.

Notwithstanding these formidable challenges, *this generation is ethically and morally obligated to timely find safe and cost-effective LLRM-disposition solutions that embody flexibility for future generations*. For example, *showcasing existing safe facilities, such as Clab and WIPP, may remove unjustified fears and enhance acceptance among objective members of the general public*. Indeed, it has been demonstrated both in the U.S. and abroad, e.g., France, Switzerland, and Sweden, during the past 25 years that *local acceptance can be gained even in “initially-hostile” areas and political regimes*. Indeed, the WIPP TRUW-repository program is an excellent U.S. example of how political support changed with time. In the 1970s and 1980s, some state politicians, including one Governor not to be named, opposed the development of the WIPP TRUW repository and instigated lawsuits and other political roadblocks hindering/ delaying its development. Notwithstanding this political opposition, strong, local, public and political support since the early 1970s, sound science since 1975, a dedicated, credible US DOE management organization, including a fully committed U.S. Secretary of Energy (Secretary), Mrs. Hazel O’Leary, carried the WIPP TRUW repository program through public hearings to a successful certification in May 1998. The various components and lessons learned at WIPP were relied upon in this text as the guiding light for the path forward for the 3NFMC.[e.g., 5,9-11]

As summarized in the “Time and Money” section below, the YM UNF/HLW repository program has faced strong political opposition since 1987 that, in combinations with scientific challenges, have contributed to repeated program delays, cost-increases, and successful nuclear-utility lawsuits. Although the implementing organization benefits from some of the best scientists and engineers in the world, and some of the events adversely affecting its track record were well beyond the implementing organizations control, the fact remains that, at the end of 2006, public confidence and trust in as well as the track record of the current implementing organization for the YM UNF/HLW repository is very low. The author’s perception of the related root causes for the aforementioned delays and cost increases were summarized and discussed in a 2004 member report to Commission Number 14 of the International Association of Engineering Geology (IAEG), as were potential "corrective actions" to identified problems and challenges.[9] Only some of these root causes and potential corrective actions are addressed in this paper.

One very positive condition to recognize in this paper is that, similar to the WIPP site, the local county designed to host the candidate YM UNF/HLW repository, i.e., Nye County (Fig. 1), supports it. Another positive condition is that the Science Advisor organization for WIPP now has the same role at the YM site. In other words, the very important ambers of local political and residential support, and good science, exist for starting a state and national brushfire supporting the YM UNF/HLW repository and, by extension, the 3NFMC and the nuclear renaissance.

In summation, the candidate YM UNF/HLW-repository site/program and, by association the implementing organization, currently suffers from strong political opposition that likely will continue to pose challenges to the timely and cost-effective development of a UNF/HLW repository at the YM site, as well as the 3NFMC, if current political conditions and policies remain unchanged. However, there may be the following two potential solutions to a more promising future for the YM UNF/HLW repository (and/or another repository on the NTS):

1. Offer Nevada the opportunity to host the 3NFMC. The related intellectual and financial benefits to local communities and the state would be of considerable duration and magnitude. It would also provide a vital service that would enhance National Security and sustain the nuclear renaissance.
2. Staff the implementing organization with residents and political representatives from the host state and nearby communities/counties. This would convey the message that it is concerned about the safety and safeguards of the population residing and to be residing around the NTS in the foreseeable future. The fact remains that, due to past research and underground tests on the NTS, it will not be inhabitable in the foreseeable future whether or not any additional LLRM-management and/or -disposition facility is hosted there. In addition, since credibility and trust can only be earned by actions/accomplishments,[9-11] the implementing organization should also include representatives from the nuclear utilities whom could inspire and fuel the sustenance of a work ethic focused on accomplishments, accountability, and pride, i.e., it happened on my watch.

In closing, this author is guardedly optimistic that the implementing organization can be structured and an LLRM-management and -disposition package that may even include disused radioactive sealed sources and greater than Class C low-level radioactive waste can be developed that would meet the approval and acceptance of local residents and their elected representatives.

DISCUSSION OF BENEFITS AND CHALLENGES EMBODIED IN THE 3NFMC

The following main categories of benefits that conceivably could be derived from the 3NFMC and their related challenges are concisely discussed below under separate headings:

1. Time and money.
2. Human and environmental safety.

3. Homeland Security.
4. Intellectual and financial diversity in the host state.

Time and Money

From logistics and financial perspectives, *the opening of a federally-managed UNF-storage facility is the critical path item for reducing the damage claims due to the nuclear utilities*. Furthermore, when it is operating, the schedules for recycling and disposal facilities become more flexible. Based on the Swedish schedule for the Clab facility (Fig. 3), a staged/phased underground UNF-storage facility on the NTS could be developed in stages/phases and be operational within five years. Although, the construction and operations costs for Clab may not be appropriate yardsticks for U.S. conditions, conceivably, the cost for developing and operating a much larger UNF-storage facility on the NTS would be well below the related reduction in damage claims due to the nuclear utilities for a more than five-year delay in taking title to utility-generated UNF described below.

An operating federal UNF-storage facility would also accommodate a relaxation of the schedule for the UNF/HLW repository. This, in turn, could allow a portion of the existing underground facilities and infrastructures at the YM site to be expeditiously converted and expanded for UNF storage within a few years, which could reduce the damage compensations due to the nuclear utilities further. Actually, the same facility could be used for both storage and disposal as shown in Fig. 5.[4] The primitive, “commingling”, concept of the MD Design may, however, be less waste-handling efficient than separate storage and disposal facilities. It could thus be more cost and waste-handling efficient to co-locate the 3NFMC-storage and -recycling facilities similar to the concept shown for the Swedish encapsulation and Clab facilities in Fig. 2.

The federal government has not complied with its statutory mandates of taking title to and beginning the safe *disposal of utility-generated UNF* by the 31st of January 1998.[7,8] In 2006, the Secretary announced a revised “best-case” scenario that delayed the opening of the YM UNF/HLW repository from 2010 to between 2017 and 2020.

In 2005, the US DOE estimated the additional program cost for the then projected 2010 opening of the YM UNF/HLW repository to be ~$1B per year. The nuclear utilities, on the other hand, estimated their <u>total</u> damage claims could reach ~$100B-~$300B, contingent upon when the US DOE would take title to their UNF. The lower estimate was based on the YM UNF/HLW repository opening in 2010.

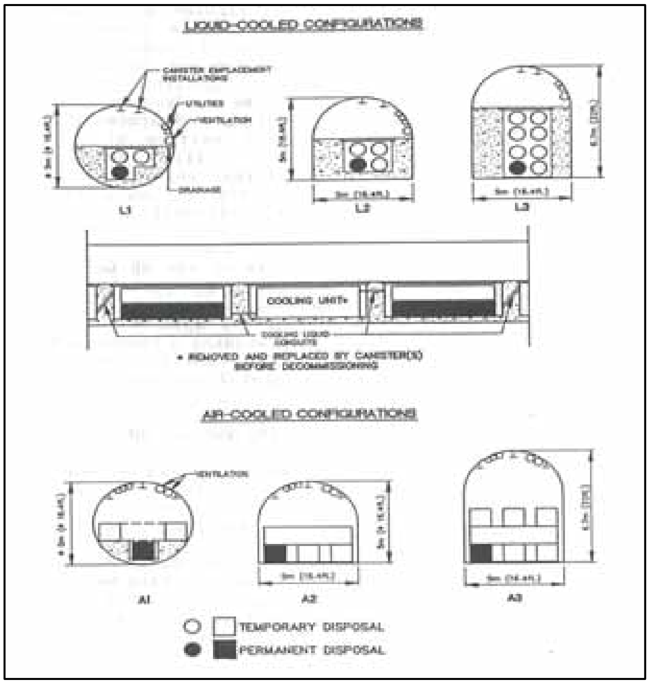


Fig. 5. The wet and dry concepts of the 1991 MD Design for the combined storage and disposal of HLW under different tunnel and canister-emplacement configurations.[4]

Whether the nation's first UNF-repository opens in 2017, 2020, or at some later date, the projected stockpiles of UNF in 2010 will be on the order of ~60,000 tons, which is very close to the current limit of ~62,000 tons for utility-generated UNF in the YM UNF/HLW repository. Furthermore, there are space and thermal constraints at the YM site that will limit the potential increase in disposed UNF. Also, Senator Domenici stated on the 3rd of August 2006, "May I repeat for those who don't think we need to address temporary storage: if everything goes perfectly, it will take over 30 years - longer than I have been in the Senate - to eliminate the existing backlog of spent fuel. As follows, there are already identified disposal-volume and transportation/storage-capacity challenges. The related "inescapable" conclusion is that the YM UNF/HLW repository *does not provide a long-term UNF-disposition solution as currently legislated and designed*. Furthermore, expanding the capacity of the YM UNF/HLW repository may not be possible due to prevailing legal, space, and/or thermal constraints.

In summation, the order and pace of developing the pending 3NFMC facilities are of significant financial consequences. In the author's opinion, again, the *development and opening of a federal storage facility is the current critical path item.* The search for one or more other repository sites is also a very high author priority. However, the high priority rating is based on the very-long lead time required for the siting, designing, constructing, and licensing of a UNF/HLW repository rather than a perceived imminent national need for a UNF/HLW repository, whether it is the nation's first or second UNF/HLW repository. Furthermore, unless the implementing organization for the YM UNF/HLW repository can establish and sustain adequate local residential and political support, and achieve its current milestones, the components of the nuclear renaissance it may be responsible for in an expanded playing field will most likely continue to suffer from delays and cost increases. Again, active participation of the nuclear utilities, local resident, host and adjacent communities/counties, and the state in the implementing organization is seen by this author as key to enhancing and sustaining the trustworthiness and credibility of the implementing organization for a scientifically, politically, and emotionally charged program, such as the YM UNF/HLW program, whether the program(s) is(are) implemented in Nevada or elsewhere in the U.S.

Human and Environmental Safety

Two apparent benefits of locating the 3NFMC on the NTS are (1) the reductions in transportation distances and (2) the related reductions in transportation risks relative to a geographically dispersed set of UNF-management and -disposition facilities. Furthermore, the NTS is a classified federal facility with a long-standing, high, safety culture and high-safeguards, including being restricted from public access. Although portions of the NTS are radioactively contaminated, such areas are known and easy to avoid.

As mentioned earlier, one of the most apparent benefits of locating the main UNF-management and -disposition facilities of the 3NFMC underground is the limited adverse human and environmental effects/impacts of any unplanned or malicious release(s) of radioactive isotopes, including terrorist-induced releases, since the resulting contamination would be contained within the underground facility. Another major benefit of locating the facilities underground is the ease of controlling and safeguarding against unauthorized human ingress and egress.

Homeland Security

As abhorrently demonstrated to the world on the 11th of September 2001, the administration, the armed forces, and the general public in the U.S. are and will remain the main targets for various terrorist activities. Two associated, long-standing, global concerns are the threats embodied in unauthorized access to UNF and HLW for (1) proliferation and (2) radiological disbursement device (RDD) purposes. As follows, one of the imperative global societal obligations and daunting challenges of this generation is thus to safely manage and dispose, i.e., control, the radioactive materials used in and generated by past and present nuclear applications.

Whereas many radioactive materials benefit from readily-available, safe, disposition solutions, UNF and HLW do not. The world’s first UNF repository is currently projected to open in 2017. In the meantime, UNF and HLW are stored by the generators and/or users in a broad range of facilities providing different levels of human and environmental protection and safeguards. Of particular societal concern is that both UNF and HLW contain long-lived, highly-radioactive isotopes that could be used with long-lasting, devastating effects in RDDs. It is thus imperative that access to UNF and HLW for malicious purposes/use is prevented. This can be accomplished by keeping all UNF and HLW inventories accounted for and kept highly safeguarded until being disposed of or treated, which, based on the historical record in the U.S., typically involves a period in excess of 10 years. In light of the long pre-disposal periods and the related potential liabilities involved, the federal government is the most suitable caretaker of the disposed UNF and HLW. Indeed, it already has established or is in the process of establishing policies and programs, such as the US DOE’s Off-Site Source Recovery Project for sealed sources and greater-than-Class-C (GTCC) low-level radioactive waste (LLW) and GTCC LLW-like materials, designed to minimize the potential for public exposures to unacceptable/harmful levels of radiation, including RDDs. The 3NFMC described in this paper provides a similar potential solution for controlled and highly safeguarded UNF-management and -disposition. It also provides for long-term access to source material for nuclear energy, which would reduce national dependence upon and sensitivity to fluctuations in access to foreign energy resources.

Intellectual and Financial Diversity in the Host State

The establishment of the 3NFMC at the NTS would enhance and diversify the intellectual talent at and the national standings of educational institutions, and state, community, and private organizations in Nevada. It would also provide a very-long-term stable source of employment and revenue to both the local communities and the state.

SUMMARY

In no order of perceived importance, the main perceived benefits of the 3NFMC solution relative to other currently discussed UNF-management and -disposition options in the U.S. are:

1. Increased National Security.
2. Enhanced public and environmental protection against any unauthorized radionuclide release, including terrorist activities.
3. Significant time- and cost-savings in that it provides for a rapid development of the required federal UNF-storage facility, which will accelerate the US DOE’s current schedule for taking title to utility-generated UNF and thereby reduce the related “breach-of-contract” damage reimbursements. It also optimizes the return on past and future financial and intellectual investments such as existing programs and facilities, and the vast existing databases on the YM site/NTS.
4. Increased intellectual and financial diversity in the host state.

There is no apparent new safety issue or concern associated with the 3NFMC solution. The main perceived challenges are essentially non-scientific, focused on the YM UNF/HLW repository, and largely fueled by (1) the long-standing political opposition in Nevada and that vested, by definition, in anti-nuclear “ideological” interest groups, and (2) the modifications of the current legal framework for UNF-management and -disposition required for (a) co-locating and (b) co-developing in time and by federal-government, state, community, and nuclear-utility representatives the UNF-storage and -disposal facilities. However, the National-Security and general-public benefits provided by the 3NFMC could serve as the catalyst for the required enabling legislation.

The opening of a federal storage facility for utility-generated UNF is deemed to be the key and critical path item for reducing the damage claims due to the nuclear utilities. Converting the candidate YM UNF/HLW repository to a long-term storage facility for UNF and HLW could drastically advance the date for when the federal government would be able to take title to utility-generated UNF. An operating federal UNF-storage facility would also provide more flexibility to the repository-development schedule, including the development of an alternate UNF/HLW repository, if needed. Furthermore, the development of another UNF/HLW repository in crystalline/igneous or argillaceous/clayish rock would allow the U.S. to take advantage of (leapfrog on) readily available international URLs and their related repository concepts, technologies and designs, and, likely, construction and operational experiences from two UNF-repositories in crystalline/igneous rocks. However, for all of this to happen in a timely and cost-effective manner, the Nation needs a related political will and the implementing organization needs an "***it happened on my watch!***" paradigm.

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