Societal-Equity-Enhancing Criteria and Facility-Host Incentives Supporting Five Key Elements in the January 2012 Blue Ribbon Commission Report – 13015

Leif G. Eriksson*, George E. Dials**, and Critz H. George***
* Nuclear Waste Dispositions, 535 N. Interlachen Avenue, Unit 303, Winter Park, Florida 32789, USA, nukewastedisp@gmail.com
** B&W Conversion Services LLC, 1020 Monarch Road, Suite 300, Lexington, Kentucky 40513, USA, gedials@DUF6.com,
*** Retired DOE and Consultant, 1218 Countryside Lane, Albuquerque, New Mexico, 87114, USA, critz.george@gmail.com

ABSTRACT

In February 2009, the Obama Administration announced it would abandon USA's only candidate SNF/HLW-disposal facility since 1987. In 2010, all related activities were stopped and the Blue Ribbon Commission on America's Nuclear Future was established "to recommend a new strategy for managing the back end of the nuclear fuel cycle", which it did in January 2012, emphasizing eight key elements. However, Key Element 1, *"A new, consent-based approach to siting future nuclear facilities"*, is qualitative/indeterminate rather than quantitative/measurable. It is thus highly-susceptible to semantic permutations that could extend rather than, as intended, expedite the siting of future nuclear facilities unless it also defines: a) **Whose consent is needed?**; and b) **What constitutes consent**?

The following "generic", radiation-risk- and societal-equity-based criteria address these questions:

1. Identify areas affected by projected radiation and other health risks from:
    a. The proposed nuclear facility (***facility stakeholders***); and
    b. The related nuclear-materials-transportation routes (***transportation stakeholders***); then
2. Surround each ***stakeholder area*** with a *buffer zone* and **use this enlarged foot print to identify**:
    a. ***Stakeholder hosts***; and
    b. Areas not hosting any stakeholder category (***interested parties***).
3. Define ***"consent-based"*** as being at least 60 percent of the "population" in the respective ***stakeholder category*** and *apply this yardstick to both "in favor" and "against" votes*.

Although criteria 1 and 2 also need facility-based definitions to make Key Element 1 measurable, the described siting approach, augmented by related facility-host incentives, would expedite the schedule and reduce the cost for achieving Key Elements 4-6 and 8, politics permitting.

INTRODUCTION

At the end of 2012, the USA's policies for the safe and secure management of the back end of the nuclear fuel cycle were fragmented and many of the related programs were in a state of flux or at an impasse. The most promising master-keys for unlocking the future of the back end of the nuclear fuel cycle (Figure 1) were the findings and recommendations described in the Blue Ribbon Commission on America's Nuclear Future (BRC) 26 January 2012 report to the Secretary of Energy (the Secretary).[1] It was used herein as the starting point to design a transparent, *quantified*, approach for the siting (and development) of future nuclear facilities based on our more than 100 years of combined related experiences from nuclear waste management and disposal programs in the USA and abroad since the early 1970s [e.g., 2-7] that rationalizes the back end of the nuclear fuel cycle by applying the principles of **societal equity** and **scientific management.** Although the focus herein is on safe disposal of used and spent nuclear fuel (SNF) and high-level radioactive waste (HLW), *the described siting approach is **generic** pending facility-specific definitions and incentives*. It can therefore be adapted to a broad range of nuclear facilities.

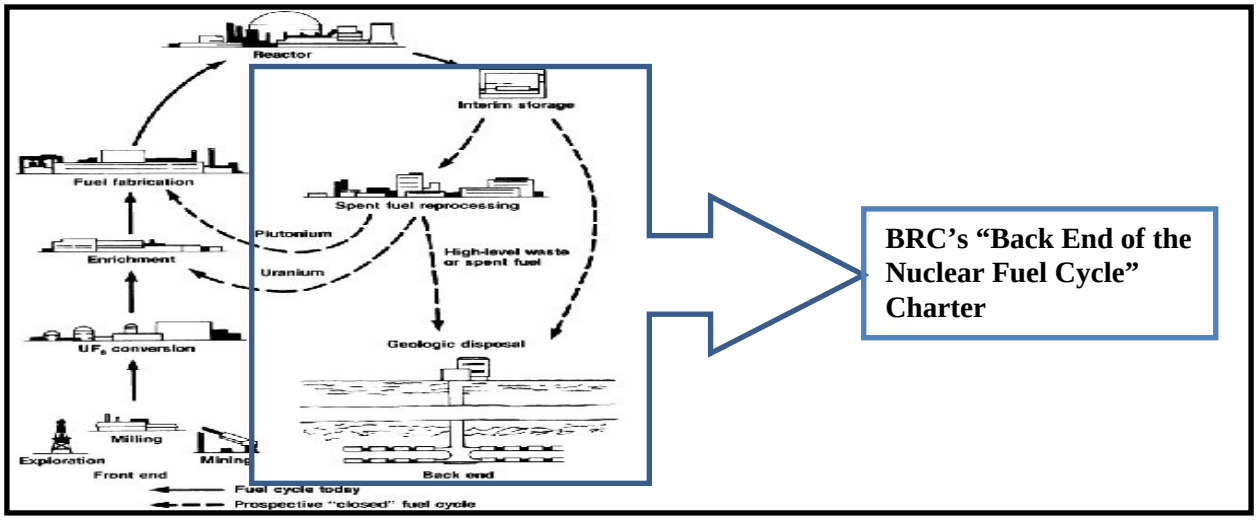

Fig. 1. Schematic illustration of main components of the nuclear fuel cycle and BRC's related charter (dashed and solid lines with arrow indicate transportation and, sometimes, treatment/packaging).

BACKGROUND

At the end of 2012, long-lived radioactive materials (LLRMs)[1] had been generated in the USA for more than 70 years and deep geological disposal of *solid-state* LLRMs had been the preferred (global) solution for more than 55 years.[8-10] Yet, in the USA, several LLRMs, including Class B and Class C LLW in 34 states, and all GTCC LLW, SNF, and HLW, still lacked "agreed-upon" disposition (= storage, reprocessing, and disposal on Figure 1) solutions; due in large part to differing and compartmentalized, federal and state laws, and the lack of Congressional action on LLRM laws with unmet schedules and/or objectives.[e.g., 5,7,11,12] For example, the still-legally-mandated opening date for the USA's first SNF repository failed on 1 February 1998.[12] In addition, the Executive Office announced in February 2009 [13] that the Obama Administration was abandoning the USA's only option since 1987 [14] for disposal of SNF and HLW at the YM site in Nevada (Figure 2). The YM site had been evaluated since 1978 and its repository-construction license had been reviewed by the NRC since June 2008. Pending the opening of an SNF- and/or a HLW-disposal solution, the more than 80,000 metric tons of heavy metals or an equivalent amount of uranium (MTU) of SNF and HLW already stored in the USA at more than 130 sites in 39 states (Figure 3) will continue to grow at least 2,000 MTU per year. Locations and rock types considered in the past for deep geological disposal of SNF and HLW in the USA are shown on Figure 2.

In 2010, the Secretary defunded the YM project, closed the DOE's Office of Civilian Radioactive Waste Management (OCRWM), assigned all its nuclear waste matters and staff to the DOE Office of Nuclear Energy (NE), and motioned to the NRC for withdrawal of the YM SNF/HLW-repository construction license application. At the direction of President Obama, he also established the BRC in January 2010 and chartered it *to conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel, high-level waste, and materials derived from nuclear activities* (Figure 1) *and to submit a final report within 24 months including a set of recommendations regarding policy and management, and any advisable changes in law*,[1, pp. 122-125] which it did on 26 January 2012. The NE prepared related draft responses for the White House in the fall of 2012, but they remain under wraps at the end of 2012.

[1] As used herein, the term "LLRM" typically refers to used and spent nuclear fuel (= SNF, herein), and other HLW, but it also occasionally includes other radioactive-waste categories containing long-lived radionuclides, such as Greater than Class C (GTCC) LLW, TRU waste (TRUW) and ILW (ILW-LL).

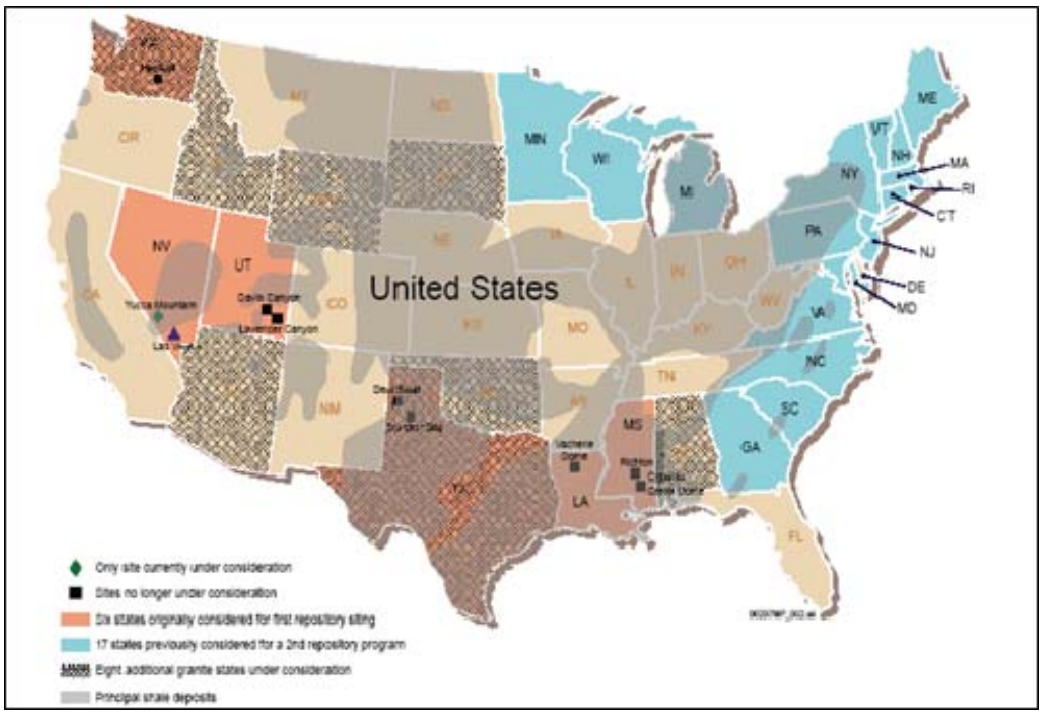

Fig. 2. Schematic illustration of locations, areas, states, and rock types considered in the contiguous USA during the hitherto more than 55-year-long, search for SNF and HLW repositories.

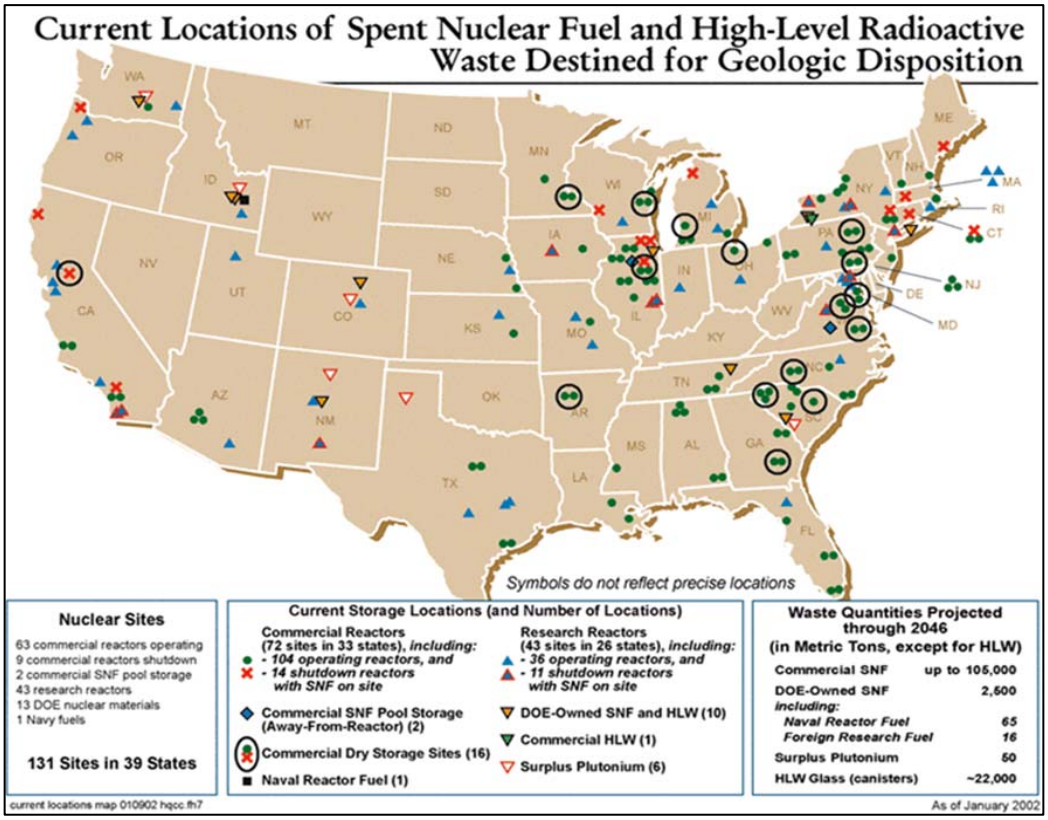

Fig. 3. Schematic illustration of 131 sites in 39 states containing SNF and HLW in January 2002.

DESCRIPTIONS

The strategy/plan for the back end of the nuclear fuel cycle (Figure 1) recommended by the BRC in its January 2012 final report [1] emphasized the following eight key elements:

1. A new, consent-based approach to siting future nuclear facilities.
2. A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
3. Access to the funds nuclear ratepayers are providing for the purpose of nuclear waste management.
4. Prompt efforts to develop one or more geologic disposal facilities.
5. Prompt efforts to develop one or more consolidated storage facilities.
6. Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
7. Support for continued US innovation in nuclear energy technology and for workforce development.
8. Active US leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.

While we agree with virtually all of BRC's recommendations, we believe *the intuitively-appealing qualitative term "consent-based" in Key Element 1 must be defined quantitatively.* Otherwise, its beauty will remain in the eye of the individual beholder and likely promote, rather than mitigate or minimize, the controversies, litigations and protracted delays that have plagued the US nuclear waste management and nuclear power programs, and eroded USA's international standings in the past. In addition to being indeterminate and nebulous, another fundamental shortcoming of the term "consent based" is that one simply cannot appease 100% of the population in any given county, state, Domestic Dependent Nation, or country considered for hosting a nuclear facility. In order for it to serve as a transparent, rational, starting point for the siting of any given nuclear facility, "consent-based" also must define:

1. Whose "consent" is needed?
2. How many of the related votes constitute "consent"?

Due to the fact that each nuclear facility, typically, is governed by federal and state requirements based on the type of nuclear activity and/or materials involved, *we chose Key Element 4 as the "upper bound" example for future applications of Key Element 1* because SNF and HLW: a) Pose the greatest and longest radiation risks; and b) Might urgently need domestic disposition solutions. Although Key Element 6 is integral to the successful implementation of Key Elements 1, 4, and 5, we did not elaborate upon it herein due to the fact that transportation of SNF and HLW, as well as many other LLRMs, has already been safely done in the USA and abroad for more than 40 years. We also chose to describe a set of ***facility host incentives*** (***FHIs***) already used successfully to plan, manage, and advance domestic and foreign programs for safe and secure deep geological disposal of LLRM at e.g., the WIPP site in New Mexico, USA (www.wipp.energy.ws), the Olkiluoto site at Eurajoki in Finland (www.posiva.fi),[15] the Meuse/Haute-Marne site in France (www.andra.fr), and the Forsmark and Oskarshamn sites in Sweden (www.skb.se) during the past 20 years. As follows, described and discussed herein are: ***one set of measurable, social-equity-enhancing, criteria*** (***SEECs***); and ***one set of already proven FHIs***. Whereas ***the SEECs*** *are hard-linked* ("fused"), ***the FHIs*** *can be can be selected or rejected on an individual basis by the host parties* shown in green on Figure 4. Furthermore, the described ***SEECs*** and ***FHIs*** are only considered *potential starting points for the siting of future nuclear facilities.* ***Integral to the proposed approach is that both the SEECs and the FHIs are defined on a facility-specific basis before being implemented and then re-evaluated periodically and updated, if required, during the nuclear-facility siting and development processes as more detailed data and information become available with time.***

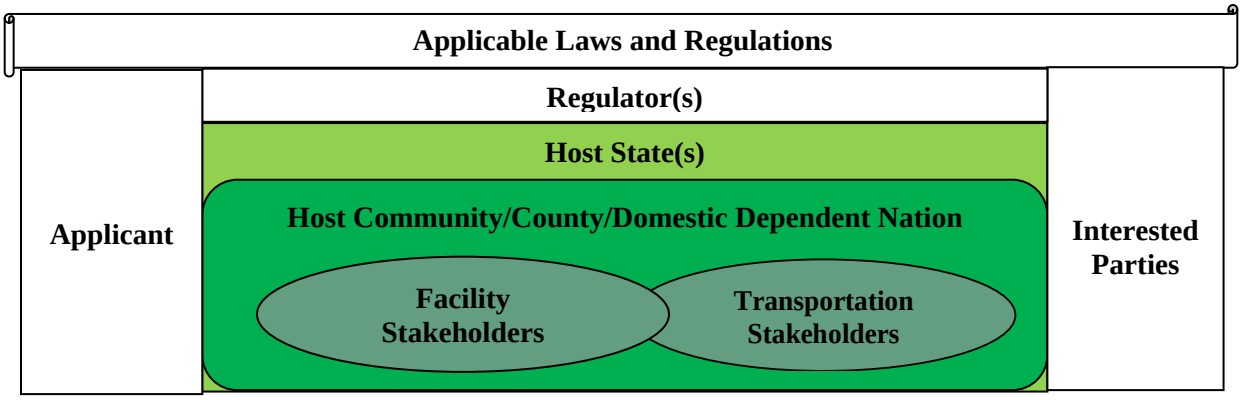

Fig. 4. Schematic illustration of the main *nuclear-facility-siting and -development building blocks* embodied in ***the SEECs*** proposed in this paper with the "voting groups" shown in green colors, but it does not show the interested parties' continuous access to the applicant ant the stakeholders.

Societal-Equity-Enhancing Criteria

The following, generic, ***SEECs*** were designed to provide simple, rational, defensible, tools for identifying and dealing with different population groups when siting a given nuclear facility in a societally-equitable manner. In other words, they were designed to ensure the voices and opinions of the people subjected to potential risks from a proposed nuclear facility and its waste-transportation routes are identified and prioritized from the outset, and timely informed of that fact and their substantial role in Federal policy.

1. *Geographically-based distinctions between people:*
    a. *Subjected to projected radiation and other health risks* from the proposed facility or residing within a given distance* from the proposed facility (**facility stakeholders**);*
    b. *Subjected to projected radiation and other health risks* from the proposed waste-transportation routes or residing within a given distance* from them (**transportation stakeholders**); and*
    c. *Not subjected to a projected radiation risk* or residing outside a given distance* from either the proposed facility or its proposed transportation routes, respectively (**interested parties****).*
2. *"Majority consent" is presented as a guiding principle with these parameters:*
    a. *Only required of **stakeholders**; and*
    b. *Defined as at least 60 percent (%) of the related **stakeholder group(s)** shown in green color on Figure 4 and applying to both votes "in favor" and "against".*

* Values remain to be determined (TBD) and then periodically updated.

The fundamental underpinnings of SEEC 1 are: 1) Radioactivity and its related health effects and risks are quantifiable; and 2) They decrease with time. Simply stated, they are functions of the *amount and characteristics* (e.g., age and half-life) *of the radioisotopes*, their respective *travel distance* to the radiation target, and the type and amount of *shielding* located between the radiation source and the radiation target. Although the "generic" information and models required for defensible calculations are already readily available, important site-specific parameters and their respective ranges that ultimately are required for this determination to be acceptable to the regulator(s) may not be available until well into the site characterization program. We thus referred to both the ***facility- and transportation-stakeholder areas*** and the related radiation-exposure/dose limits as TBD above. *The a-priori representation of radiation risk in the proposed **SEECs** is tied to an assumption that the applicable regulation(s) will be*

met, which adds confidence that the determining entity will be the EPA and NRC; not the facility advocate. Another fundamental underpinning is thus *that the definition of adequate public and environmental "protection/safety" in the legal and regulatory frameworks is not modified during the siting process. Such modification, however well-intentioned, can convey a notion that safety margins have been reduced* and, as illustrated at the YM site, can result in severe adverse effects on public and political confidence in the inherent natural barriers provided by the site. Similarly can a late design change introducing a $16 billion drip shield. ***The fundamental objectives of SEEC 2 are to: 1) Provide a transparent, quantitative, definition for "consent-based"; and 2) How it can be applied. The nexus for all proposed SEECs is logic based on risks that, in turn, identifies affected and non-affected parties.***

Facility-Host Incentives

The following ***six FHIs*** were mainly adopted from similar components used to successfully site and/or develop, and certify/license LLRM-disposal facilities in the USA, Finland, and Sweden:

1. *"Independent" facility-host subject-matter expert-groups.*[2]
2. *A multi-state organization made up by the Governors in states with waste-transportation routes.*[3]
3. *A comprehensive, forward-looking, fully-integrated, periodically-updated Facility Siting and Development Plan (FSDP) that also commits the facility-siting entity to issue a related status report at least every third year, that is available to* ***stakeholders****,* ***stakeholder hosts****, and* ***interested parties*** *and their respective elected representatives at county, Domestic Dependent Nation, state, and national levels (Figure 4).*[4]
4. *Several annual public meetings in which the* ***stakeholder groups*** *and* ***interested parties*** *have the opportunity to learn about the status of the program and to interact in real time with the implementing organization(s), key participating scientists, and the related regulators.*[5]
5. *Veto right by* ***stakeholder hosts*** *(Figure 4) until the license application to receive nuclear material has been docketed by the regulator(s).*[6]
6. *A standing national advisory board made up of representatives from academic disciplines that could contribute to the formation of a set of moral, ethical and scientific guidelines by which the problem of nuclear waste disposition is to be addressed and resolved.*[7]

The main common intended objective of the six proposed FHIs is to gain and maintain majority stakeholder acceptance and support. They embody the related, hitherto largely-neglected, fundamental ethical and moral obligations of ensuring that the risks the ***stakeholders and stakeholder hosts,*** **also** jointly referred to herein as **the affected parties,** may be exposed to from a proposed nuclear facility are understood, adequately safeguarded against, and can be irrevocably rejected by ***a majority of them*** until all information required for opening the facility had been subjected careful evaluation by all concerned.

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[2] Based upon but not limited to the now dissolved New Mexico Environmental Evaluation Group (EEG).

[3] Based upon but not limited to the Western Governors' Association (WGA), which still oversees TRUW shipments to the Waste Isolation Pilot Plant (WIPP) repository (Figure 5) (www.wipp.energy.ws).

[4] Based upon the Swedish Nuclear Fuel and Waste Management Company's (SKB's) (www.skb.se) Research, Development, and Demonstration Plans and SKB's, Posiva of Finland's (www.posiva.fi), and the US's Nuclear Waste Technical Review Board's (NWTRB's) Annual Reports (www.nwtrb.gov).

[5] Based on how WIPP communicate in a timely, transparent, interactive manner with ***stakeholders*** and other ***interested parties*** that enhanced public acceptance and support, and rate of progress. The nexus for this successful process was the 1994-1998 WIPP Disposal Decision Plan (DDP) shown on Figure 6.

[6] Based largely upon the Swedish approach (www.skb.se).

[7] We envision something like this growing out of the BRC beginnings but taking on the scale and scope of the Swedish National Council for Nuclear Waste (KASAM) in Sweden (www.karnavfallsradet.se), but it would have to have its remit coordinated with that of the NWTRB to avoid overlap.

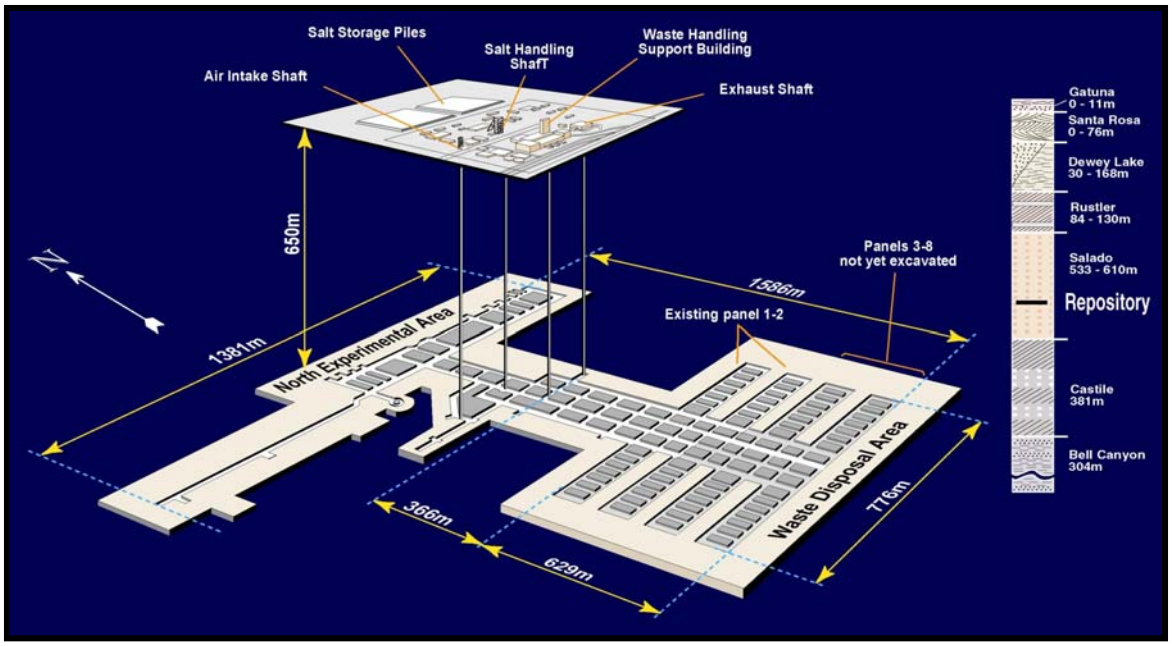

Fig. 5. Schematic illustration of surface and subsurface facilities and the stratigraphy at the WIPP site.

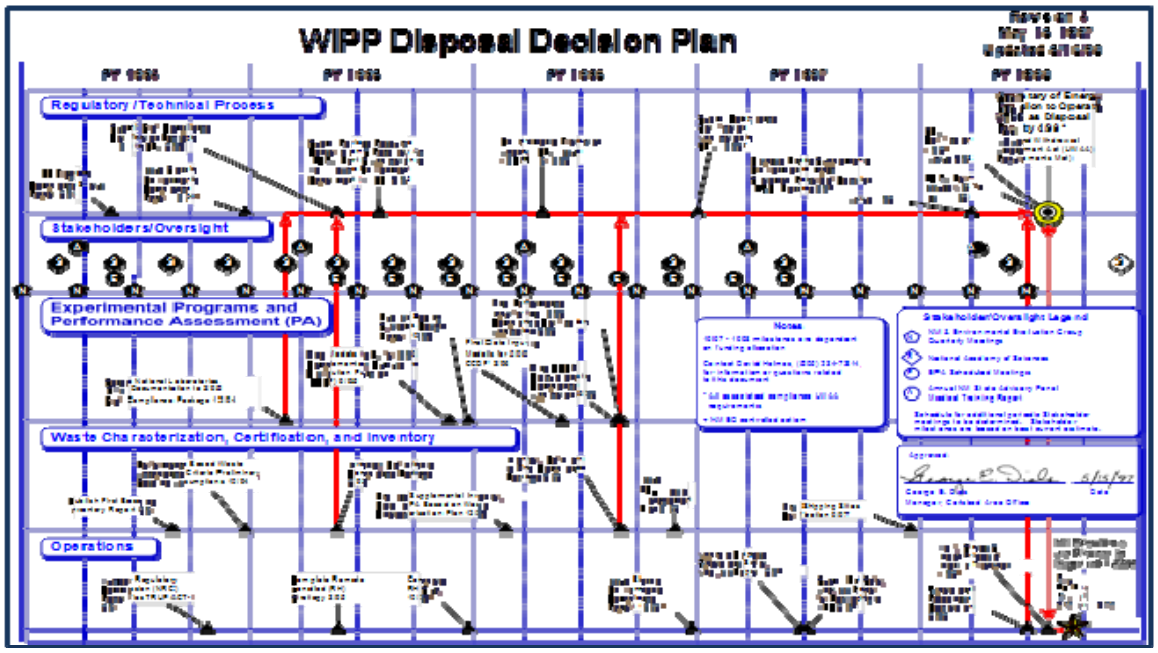

Fig. 6. The 1994-1998 WIPP Disposal Decision Plan.

DISCUSSIONS

Although ***the SEECs*** and ***the FHIs*** described above are "generic" and apply to a broad range of nuclear facilities, the subsequent discussions (and descriptions) focus on their respective applications in support of BRC Key Elements 1 and 4. Based on our related relevant experiences, in addition to recent actions by the Obama Administration and its sycophants, seven long-standing root causes for the opposition and the repeated delays to the siting of SNF- and HLW-disposal facilities in the USA during the past 30 years are:

1. The lack of a fully integrated national nuclear waste management policy.[e.g., 5]
2. No distinction is generally made as to whether the party expressing the concerns and/or objections would be exposed to a radiation or other health-risks from the proposed facility.
3. The lack of a balance between the risks posed by the proposed nuclear facility and its related societal needs, benefits, options, and consequences.
4. LLRM repositories, by their nature (centralized disposal at sites selected for uncommon safety), will be few in number and thus are vulnerable to complaints of "inequity." Fairness must be achieved by the balance of benefits and perceived risk among the population seeing itself as "affected".
5. The "incomprehensible" temporal and spatial scales, and the-state-of-the-art scientific and engineering concepts involved.
6. The long-standing lack of political will [12] to:
    a) Fund the OCRWM program as requested by the DOE; and
    b) Amend or replace the Nuclear Waste Policy Act of 1982 [12] after its disposal schedule failed on 1 February 1998 with no other SNF-disposition solution in sight for > 10 years.

As illustrated by Key Element 1, the BRC recommendations reflect a long-overdue increased domestic awareness of and attention to the critical importance of both early and sustained support by affected populace and units of government, like those successfully achieved for LLRM-storage and disposal facilities for TRUW in the USA, and for multiple ILW-LL, SNF and HLW storage and disposal facilities in Finland, France, and Sweden. However, again, Key Element 1 is indeterminate and its meaning thus remains in the eye of the beholder. Of particular concern is that the historical record shows that almost *all "ideological eyes" are rigidly myopic and all "political visions" change with time*. We thus concluded that the term "consent-based" must be defined to the point to where it would be logical, *measurable*, and compliant with the Constitution in order for it to serve as a viable, rational, politically-acceptable, starting point for Key Elements 4, 5, and 6. Select portions of the reasoning, logic, and justifications employed in support of the ***SEECs*** and ***FHIs*** described herein are elaborated upon in the subsequent text.

With respect to "consent" in Key Element 1, the BRC envisioned that communities might volunteer to be considered at the outset and that the facility developer might also approach communities hosting potentially favorable locations. Negotiated partnership agreements, including flexible and substantial incentives and meaningful consultative roles for affected parties, were cited by the BRC as a means toward stable "legally enforceable" commitments.[1] As follows, Key Element 1 is the BRC's intended common underpinning and starting point for Key Elements 4 and 5, both of which are directly linked to Key Element 6. This was another reason we deemed the six "proven" ***FHIs*** promising catalysts for attaining and sustaining ***stakeholder*** support before and during the siting and development of a proposed nuclear facility that, in turn, also would reduce both the timeline and the cost for the opening of the facility. The manner of implementation and the related acceptance and progress of Key Elements 4-6 were also deemed to govern the timeline for achieving and sustaining Key Element 8 abroad.

With regard to Key Element 8, the selection of a globally-unique SNF/HLW-repository host rock in 1987 [14] and the DOE's subsequent prompt termination of virtually all international "hands-on" repository-science-exchange involvements have adversely affected the USA's standings in the international nuclear waste management community. One related reason being, the US SNF/HLW-disposal program has had very little, if any, state-of-the-art repository science or engineering information of interest to offer other nations, since they all were targeting other geological settings. Another is the repeated delays and currently, politically-manipulated, uncertain status of the YM SNF/HLW repository program. Simply stated, USA's "leadership" status in the SNF/HLW-disposal area in the international radioactive waste management community has been eroding since 1987. One or more SNF/HLW-repository paradigms are thus promptly needed to restore and then maintain USA's "leadership" standings in the international radioactive waste management community, which the proposed S***EECs*** and ***FHIs*** could accomplish.

Societal-Equity-Enhancing Criteria

As illustrated on Figure 4, the proposed voting rights belong to **the affected parties**. It may not equally clearly illustrated that the intended concept/approach is that ***all interested parties*** would still be able to voice their concerns and opinions throughout the siting and facility-development processes to the regulator(s) and **all affected parties** and their respective elected representatives, and to take legal action at any time if not satisfied with the related response. The main related underpinnings in US law are:

1. All US citizens have the undeniable right to hold and express personal opinions.
2. All US citizens also have a right to seek adjudicated relief when one's rights are damaged or threatened by the actions of another. The concept of "standing" guarantees that those affected by a threat or experiencing a harm (that is, having cause to seek relief) will not have their case skewed or diluted by participants who are not affected.

Figure 4 also embodies the recognition that ***the stakeholders*** defined by radiological risk will not be the only voters to whom the Governor of the affected state is answerable because many of those who would not be a party to negotiated consent on any basis of risk exposure will in fact have a forceful presence due to the host-state Governor needing their vote. She/he will thus carry their proxy to the negotiating table, even if they are not there through another affected ***stakeholder-group*** or ***stakeholder-host*** representative.

The fundamental ethical, moral, and safety concerns governing the set of ***SEECs*** described above and schematically illustrated on Figure 4 are:

1. Historically, interest-groups opposing civilian and military applications of the atom have successfully opposed the development of the related LLRM-storage and, in particular, -disposal solutions regardless of the related adverse consequences on current and future generations. This indiscriminate, "constipate-nuclear-energy-to death-at-all-cost" strategy embodies grave societal injustices because it has prevented safer LLRM-disposition solutions from being developed Of particular concern are: a) *It is not necessarily representative of the majority opinion held by* ***the affected parties***; and b) *It unnecessarily extends the risks for the safe management and disposition of LLRMs to both more people and future generations.* One common key objective of the ***SEECs*** described herein is thus to provide quantitative yardsticks for "objectively" establishing the opinions held by ***the affected parties***; however, as mentioned in the preceding text, the proposed initial yardsticks in ***SEEC 1*** will require periodic re-evaluations and, likely, modifications with time as the related databases evolve from generic to site-specific.
2. As illustrated on Figure 3, the nation's stockpiles of SNF and HLW are large and dispersed all over the US. Furthermore, whereas some of this waste may be treated and the related volume requiring disposal may shrink, *there will still be a residual volume of LLRMs that will require safe and secure disposal*. However, several current SNF-storage facilities are almost filled to capacity and the NRC-licensed "Private Fuel Storage" facility in Utah pursued by eight nuclear utilities was cancelled in December 2012. *As follows, several LLRMs will require "new" storage and disposal solutions, and in some SNF-storage cases, time is of utmost importance.*

As mentioned above, the amount of radiation and its related health hazards from any given radioactive source are functions of time, shielding, and distance to the target. The "radiation-risk" zone for any given nuclear-disposal facility can therefore be defined numerically based on the intended radionuclide inventory, the proposed disposal concept, and the inherent and perceived future characteristics of the potential host rock for the repository. Although the site-specific ***facility-stakeholder*** area for a potential near-field radiation risk posed by a nuclear facility can be calculated at a very early stage, for SNF and HLW-disposal systems these calculations typically embody significant uncertainties pending the subsequent detailed definition of the radionuclide inventory, the initial and long-term characteristics of

the host rock(s), and the disposal concept. Simply stated, *the siting of an SNF and/or HLW repository is an iterative catch-22 endeavor*. We thus advocate surrounding each ***stakeholder area*** with a TBD "buffer zone" to ensure that subsequent radionuclide-inventory, site-conditions and design modifications would not extend the "***stakeholder***" area into an "***interested party***" area, because it would compromise and possibly void the preceding efforts. Applicable guidance can be found in the US Code of Federal Regulations, Title 10, Part 60 (10 CFR 60), "*Controlled area means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the outer boundary of the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure.*"[16]

A much simpler and faster, yet deemed conservative and empirically-defensible, siting approach would be to defer the radiation-risk-based *definition of the* ***facility-stakeholder area*** and instead using a 25-km-diameter circle centered at or near the potential facility location until a reasonable amount of *site-specific* demographic, hydro-geologic-chemical, waste-inventory, and design-specific data are available. This approach would provide an at least 10-km-wide buffer zone outside of the perimeter of any portion of the repository if the repository-layout foot print does not exceed 5 km in any given direction. If it does exceed 5 km and/or a wider buffer zone is deemed required, the shape of the siting foot print should be adjusted accordingly. Suffice it to mention here as empirical reference points that the *"controlled area"* at WIPP, which is certified to contain up to 175,584 m^3 of TRUW, is a square with 6.44-km-long sides and the related diagonal, which would be the equivalent to the 25-km diameter proposed above, is 9.11 km. Furthermore, the longest (diagonal) distance from perimeter to perimeter of the entire underground facility, i.e., the repository, the shaft pillar, and the adjoining URL on Figure 5, is 2.1 km.

Though both of the above initial area-definition approaches may require subsequent refinements, they would serve to conservatively identify the following three radiation-risk-based, nuclear-facility-related population domains, of which **the first two domains depict "affected parties" with voting rights**:

1. ***Facility Stakeholders***;
2. ***Stakeholder hosts***; and
3. ***Interested parties***.

These two domains could and should then also be prioritized during the pre-opening process. With regards to the aforementioned distinction between ***stakeholders, i.e.,*** **affected parties,** and ***interested parties***, and their proposed subsequent respective roles in a future nuclear-facility-siting process, the January 2012 BRC recommendations included a new "consent-based" process (Key Element 1) to be used for selecting and evaluating sites and licensing new nuclear facilities, including consolidated storage (Key Element 5) and disposal (Key Element 4) facilities,[1] but it did not define that process in administrative detail. The BRC did, however, suggest that *"all affected units of government, including the host state or tribe, regional and local authorities, and the host community, [be] willing to support or at least accept a facility"*,[1] which, in our opinion, embodies the following tacit understandings:

1. Not everyone is affected by the siting or operation of a nuclear-waste-disposition facility.
2. Not everyone should have equal access to the negotiated terms of consent, including the "flexible and substantial incentives" envisioned by the BRC.[1]

As elaborated upon in the subsequent examples, this language of "**affected parties**" parallels the concept of "standing" in civil courts. Any party that can show that there is significant possibility of future harm to him/her through the actions of others has "standing" before a civil law court and can seek injunctive (or equitable) relief. However, the future harm must be the loss of a recognized right (security of person or property, right of companionship, etc.). In other words, the harm or loss must be a real harm or loss, not a

hypothetical or fictitious harm or loss. As an example, assume a resident of New Mexico learns of someone in the Maine woods periodically firing a hunting rifle into the air, and he/she seeks an injunction to stop the shooter in Maine. Any court would tell the New Mexico resident that he did not have standing to bring the suit because "No hunting rifle can hurl a bullet 3,400 km (2,100 miles)". However, when it comes to the siting of disposal systems for SNF and/or HLW the USA, social-science research has found widespread a priori belief that risks extend for several hundreds if not thousands of kilometers.[e.g., 7,17] *Program outreach simply must put some semblance of reality ahead of such spurious opinion formation.*

The determination of a list of affected parties and the negotiation of the terms of consent agreements will be an administrative and not judicial process, but the concepts of standing are the same. This administrative process must be substantive, logical and fair or else it can be attacked as arbitrary and capricious in a judicial proceeding. We thus propose a means herein, i.e., ***SEEC 1***, consistent with these concepts of common law equity, to identify and bound the universe of affected parties to a number that can reasonably be served with due process. Our tool to do this is the best available estimate of the radiological and other health risks that might be imposed upon anyone in proximity to the proposed nuclear facility operations. As in the case of civil law, ***SEECs 1 and 2.a.*** seek to focus the attentions of the authorities on those who suffer some risk of harm, no matter how small, and to prevent their voices and interests from being diluted or overridden by distracting and specious claims from ***interested parties***.

SEEC 2.b. proposes the percentage of a given ***stakeholder group*** that would be required for a "consent-based" decision. Based on the premise it had to more than 50% and would never reach 100%, we looked at related data from the WIPP site in the US, the Oskarshamn site in Sweden, and the Olkiluoto site in Finland. We also solicited advices from esteemed US colleagues. Based on the related information, we concluded that 60% of the ***stakeholder*** votes would be less than those attained in Finland and Sweden the past 20 years at the aforementioned sites, but sufficient to be viewed as substantial majority. *Clearly, this number is arbitrary but it is not capricious*. The main paradigm embodied in ***SEEC 2.b.*** using the proposed or any other percentage for defining "consent" is that *it applies to both votes for and against*.

It is re-emphasized that ***the SEECs*** outlined herein will not lock out or eliminate the suggestions, concerns, issues, or objections expressed by ***interested parties***. In addition to the continuous access to the regulator(s) and **affected parties** shown in green on Figure 4, another integral component of the proposed siting approach is that all ***interested parties***, as well as all ***stakeholders***, would also have continuous access during and after the repository pre-opening period to other entities overseeing the siting, design, licensing, development, opening, and safe and secure operation of a new SNF- or HLW-disposal facility. These entities currently include the NWTRB, the NRC, and the EPA, as well as state agencies and multi-state political groups such as the WGA, all possessing subject-matter expertise in at least one relevant discipline. ***All interested parties, as well as all stakeholders,*** not satisfied with the response to or action on a given issue would also be able to file legal challenges both during and after the pre-opening period.

In summation, the integrated, majority-consent- and health-risk-based, *quantitative*, nuclear-facility-siting concept embodied in the proposed ***SEECs*** would ensure societal equity by requiring majority-consents in each ***stakeholder group*** (shown in green on Figure 4). It also includes the opportunity for ***all interested parties*** to express their concerns and opinions in periodic public meetings hosted and/or attended by representatives from the siting entity, the regulator(s), t***he stakeholder groups***, and the oversight entity(ies). Indeed, ***the SEECs*** described herein are only intended as a transparent, societally-equitable, starting point for the siting of nuclear facilities. The ***SEECs*** thus need to be periodically revisited and modified, as appropriate, based upon the additional information and experiences obtained with time.

Based on our experiences, the most common historical challenges to the siting and development of new nuclear facilities in the USA and abroad are: a) Wide-spread "fear of the unknown"; b) The "perceived" radiation and other risks posed by the proposed facility; and c) "Self-serving" opposition. With regards to

challenges a) and b), whereas the scientific and engineering experts directly involved in the siting, design, development, etc. of deep geological disposal systems for LLRMs understand some, but not necessarily all, of the involved concepts, components, and risks, conservatively estimated, less than < 1% of the general public and their elected representatives and their sycophants in the USA, as well as in any other nation for that matter, has the education and experience required to grasp all of the following key concepts of LLRM-repository science:

- The huge spatial and temporal scales;
- The scientific and technological/engineering concepts;
- The safety/risk-assessment codes, models, and methodologies involved in the siting, design, operation and decommissioning, and post-closure performance; or
- The health risk(s) posed by the projected radionuclide releases.

Clearly, members of the general public cannot be expected to understand or to accept carte blanch the risks of a proposed nuclear facility that forces them into very unfamiliar terrain. As history shows, their initial reaction is to oppose anything that sounds like it will present a threat to their health, their community's health, or their property values. The siting of LLRM-disposition systems has thus experienced broad-based, public, ideological, and political opposition resulting in repeated project delays and cost increases both in the USA and abroad during the past 30 years. This is a rational reaction when knowledge is limited. Communication of risk and LLRM-repository technology with members of the general public and their elected representatives will therefore need to respectfully, timely, and legibly deal with layers of misunderstanding that can be any of the following:

1. Things that are true which they reject.
2. Things that are true of which they are uncertain.
3. Things that are untrue of which they are uncertain.
4. Things that are untrue which they nonetheless believe.
5. Things that are untrue which they see as such.

As follows, in any given country, ***the acceptance of a LLRM repository is essentially based upon either trust in the "messenger(s)" or the perceived personal risks and/or benefits***.[7,11,15,17] This condition has provided and will likely continue to provide fertile ground for various interest groups to seed the public's minds with misinformation resulting in doubts and fears causing opposition requiring attention and adversely affecting the schedule and cost for the siting and development of nuclear facilities for safe and secure disposal of SNF and HLW. The related societal needs, domino effects, and adverse consequences are often not an integral part of the related evaluation and decision-making process. Furthermore, the indeterminate term "consent-based" in Key Element 1 may serve as an unintended catalyst for a new venue for time-consuming debates and legal challenges that may have very little to do with actual radiation- or health-risks, or public safety unless it is more precisely defined. Two integral components of the nuclear-facility-siting approach described herein are thus:

1. All s***takeholders***, ***stakeholder hosts***, and ***interested parties*** are provided *trustworthy* information and feed back in a timely manner; and
2. The scientists and administrators who undertake this daunting task must be able and willing to inform and engage the public and their elected representatives in the needed conversation on the path to consent in a manner the general public and the political community and its sycophants comprehend and/or trust.

Typically, considerable public and political trust is vested in the regulator(s) and/or in one or more "independent" subject-matter expert groups such as e.g., the NWTRB and the now dissolved EEG.

However, neither the regulator(s) nor the "out-of-state" independent review groups have historically had the manpower or financial resources required for a timely, inter-active, dialogue even with **the affected parties**. Furthermore, although the NWTRB has the pre-requisite subject-matter expertise, it is a politically-appointed, federally-funded, entity located in the District of Columbia chartered to advise Congress, which might raise independence and objectivity concerns (and reservations) among both **affected** and ***interested parties***. We thus provided other "independent" options in **the *FHIs***.

Facility-Host Incentives

Relative to past LLRM-repository-siting processes in the USA where everyone's opinion purportedly is treated equally, but the loudest and the politically-powerful voices typically get most attention, *the proposed **SEECs** embody the paradigm of prioritizing the **affected parties'** suggestions, concerns, issues, and objections and having **interested parties** funnel theirs through the respective **stakeholder group(s).*** This societal-equity- and health-risk-based streamlining of the nuclear-facility siting and development processes would, in turn, allow the implementing organization(s) to focus its resources on the task at hand rather than, as has been the case hitherto, having to divert significant time and resources in addressing non-health-risk-related suggestions, concerns, issues, and objections. However, in order for this concept to work, it is imperative that one or more of the host(s) for the proposed facility is(are) provided adequate financial resources to assemble and then maintain a core group of subject matter experts that may change in composition during the different stages of the historically, at least 25-year-long, pre-opening period for a deep geological repository for LLRMs in the USA.[7] It is also deemed imperative that all ***stakeholder hosts*** will receive benefits *similar to* those granted New Mexico for the WIPP TRUW repository and the host communities for Finland's and Sweden's candidate final SNF repository, with two modifications. A priori, the economic compensation to the facility-host(s) (FH) should neither be time- nor amount-limited as it was for WIPP. It should continue on a periodically-renegotiated milestone-achievement basis until the facility closes or is terminated. Pro secondo, to entice timely progress, milestone achievement bonuses should also be considered. Three such readily-identifiable SNF and HLW-repository milestones deemed to deserve special recognition are the FH's "formal" majority-consent acceptance of: 1) *Hosting the search for a new facility*; 2) *The proposed disposal concept*; and 3) *The licensing application(s)*. In both Sweden and Finland, an incentive/benefit approach was negotiated at the local level for the respective nation's first SNF repository and then used as part of the domestic siting processes. A related "Vuojoki Agreement" was signed in Finland in 1999 and an "Added Value Agreement" was signed in Sweden in 2009.[15] These agreements represent "locally-negotiated", *evolving*, incentive approaches.

The FHIs described herein would provide the ***affected parties*** significant long-term benefits in return for accepting the inherent and implied risks of hosting a nuclear facility. Their respective underpinnings are summarized in the foot notes on page 6. With regards to ***FHI 5***, clearly, the proposed irrevocable host-state authority to veto the "project" up to the point the license application to receive nuclear materials is docketed by the regulator(s) embodies significant financial and schedule risks. But, as demonstrated for more than two decades in Sweden, it can also serve to build and maintain a very knowledgeable "in-house" subject-matter stakeholder group that serves as: 1) A trustworthy information source for other ***stakeholders***; 2) An effective sieve for suggestions, concerns, issues, and objections raised by ***interested parties***; and 3) An effective bulwark against "self-serving" suggestions, concerns, issues, and objections. In addition, both prior to and after this veto point all US citizens, i.e., both ***stakeholders*** and ***interested parties***, can use their unalienable civic obligation and right to present and promote their suggestions, concerns, issues, and objections to the cognizant regulator(s) and their respective elected representatives or interest group, and to pursue legal action if unsatisfied with the response to their concerns.

With regards to ***FHI 6***, we envision this group to include theology, philosophy, psychology, and sociology, as well as the physical science disciplines. We also envision the group having the goal of fostering a national majority consensus on all of the issues that have been raised in the past to challenge

and derail nuclear facility siting and development attempts in the US thus far, and being given the funding and capacities to reach the population at large, to conduct public interactions of every sort and format, and to distribute consensus documents nationwide, particularly through electronic means. For example, *a relational database* explaining *in layman terms* the risks of leaving the TRUW where they were relative to disposing them more than 600 m below the ground surface in a 600-m-thick, virtually-impermeable, salt formation (Figure 5) was instrumental in gaining both public and political acceptance and support. From Swedish experience, we can say that this group should have the influence to insert public demands of notable merit into the siting, planning, design, and operation of disposal facilities. It would be the trusted third party mediating the social forces holding sway on the engineering project. This is a delegation of some project control over costs and schedule, but so is the acceptance of "consent" as a prime directive. We believe the ***FHI 6*** mechanism will strongly assist the building of necessary trust.

SUMMARY OF MAIN OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

At the end of 2012 the historical record either showed or indicated that the US:

1. Already had stockpiles of SNF and HLW exceeding 80,000 MTU that will continue to increase by more than 2,000 MTU per year until a large-capacity SNF-storage or -disposal facility opens.
2. Lacked an SNF-disposal solution acceptable to the Obama Administration despite more than 55 years of costly national efforts in compliance with applicable laws and regulations.[11]
3. At the very earliest may open its first SNF- and HLW-repository 8-12 years after the YM-repository project is re-started, provided the US Court of Appeals for the District of Columbia rules "favorably" on two current law suits; one not scheduled for ruling until 2014.
4. Would need at least one new SNF repository if either: a) The legal MTU capacity of the YM repository is not increased; or b) The YM repository is aborted.
5. May not open its first SNF-repository in another 25-40+ years in the event the YM SNF/HLW-repository project is terminated.
6. Had experienced repeated losses of public confidence in the current SNF/HLW disposal concept and its management that in turn has compromised and adversely affected public confidence in deep geological disposal of LLRMs both in the US and abroad, and will continue to do so until: a) The merits of the WIPP LLRM repository is better understood and appreciated in the USA and abroad; and/or b) Another ***pedigreed*** SNF- or HLW-disposal solution/concept is pursued.
7. Had experienced repeated losses of credibility in the international radioactive waste management community that in turn had eroded the foundation for the USA being considered a leader in this area. This erosional process will continue every time politics: a) Ignore, override, or suppress sound science and engineering; and b) Ignore or disregard existing laws or due process.

Accordingly, the BRC concluded in its 2012 report to the Secretary, that *"America's nuclear waste management program is at an impasse"* and recommended a new strategy for managing the back end of the nuclear fuel cycle.[1] Although the Obama Administration has not yet responded to the BRC report and has no legal obligation to do it, if national security and sound science prevail, future searches for one or more new SNF and/or HLW disposition sites will be based upon the 2012 BRC report. While we agree with and support virtually all of BRC's recommendations, based on our more than 100 years of combined involvement in and monitoring of nuclear waste management programs in the US and abroad since the early 1970s, we believe Key Element 1 must be promptly quantified to: a) Serve as a rational starting point for the siting of any given LLRM-disposition facility; b) Ensure/provide societal equity; c) Garner and maintain majority acceptance and sustained support by the parties affected by the proposed facility; d) Mitigate or minimize non-radiation-risk-related challenges; and e) Achieve Key Elements 4, 5, 6, and 8 in a defensible, timely, and cost-effective manner. We thus designed and described herein: 1) *A set of "fused" SEECs* quantitatively defining the term "consent" in Key Element 1 *based on radiation risks and societal equity that, in turn, identify areas and populaces affected by the proposed nuclear*

facility (and its related infrastructures), and those that/who are not; and 2) *A set of selective FHIs already used successfully at WIPP in the USA and abroad to garner and maintain public and political acceptance and support of nuclear facilities.* Provided they are timely implemented, adequately funded, shielded from spurious ideological, career, and political ambitions and agendas, and benefitting from trustworthy program/project governance, *the proposed SEECs and FHIs* would significantly reduce the time and effort required in the past by the implementing organization to address issues raised by individuals and parties not subjected to any identifiable radiation-related health-risk from the proposed nuclear facility or its infrastructures, i.e., **they would expedite the accomplishment of BRC Key Elements 4, 5, 6, and 8.**

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