



**Final submission from
Ken Chaplin**

**Mémoire définitif de
Ken Chaplin**

In the Matter of the

À l'égard des

Canadian Nuclear Laboratories (CNL)

Laboratoires Nucléaires Canadiens (LNC)

Application from the CNL to amend its
Chalk River Laboratories site licence to
authorize the construction of a near surface
disposal facility

Demande des LNC visant à modifier le permis
du site des Laboratoires de Chalk River pour
autoriser la construction d'une installation de
gestion des déchets près de la surface

**Commission Public Hearing
Part 2**

**Audience publique de la Commission
Partie 2**

May and June 2022

Mai et juin 2022

This version of the submission from Mr. Ken Chaplin is to correct an error made by the Commission Registry.

Mr. Chaplin filed his final written submission on January 31, 2023. Additional comments were filed on April 21, 2023. The Registry inadvertently replaced the submission filed on January 31, 2023 with the additional comments sent on April 21, 2023, instead of adding them to the initial submission.

This corrected version includes the submission filed on January 31, 2023 and the additional comments sent on April 21, 2023.

Cette version du mémoire de M. Ken Chaplin vise à corriger une erreur commise par le greffe de la Commission.

M. Chaplin a déposé son mémoire définitif le 31 janvier 2023. Des commentaires supplémentaires ont été déposés le 21 avril 2023. Le greffe a remplacé par inadvertance le mémoire déposé le 31 janvier 2023 par les commentaires supplémentaires envoyés le 21 avril 2023, au lieu de les ajouter au mémoire initial.

Cette version corrigée inclut le mémoire déposé le 31 janvier 2023 et les commentaires supplémentaires envoyés le 21 avril 2023.

Filed on January 31, 2023

CNL's Near Surface Disposal Facility (NSDF) License Change (Final Submission 2023 Feb 2)

Ken Chaplin, Intervenor on behalf of license change to allow CNL to construct the NSDF.

The NSDF is an appropriate way to dispose of an immense volume of low-level waste. It presents no risk from the primary source of concern, radiation. In addition, it minimizes risks and pollution from larger, conventional concerns including transportation.

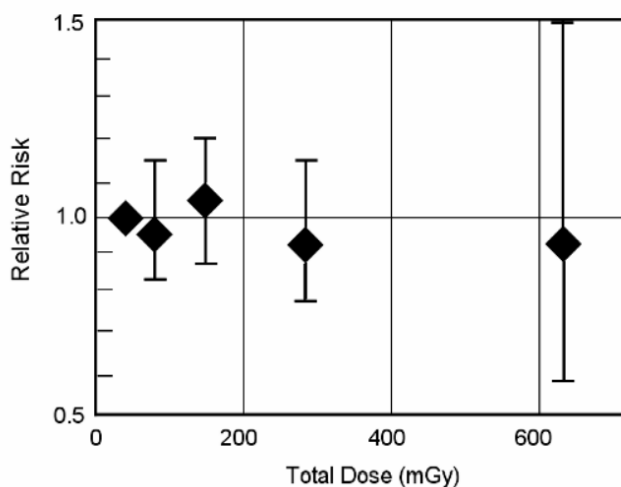
My comments will demonstrate that the NSDF is safe by showing that the Linear No Threshold theory (LNT) is wrong. LNT permeates the discussions of risk without being noticed. I listened to two verbal submissions in 2022 June while waiting to give my verbal submission and LNT was key, but unacknowledged, to the concerns raised by both intervenors. LNT causes fear of radiation and so the NSDF. First however some personal background that is presented to allay concerns that I am simply biased due to my work at AECL/CNL.

In 1970 while investigating air pollution I read that 50,000 Americans died annually due to the burning of fossil fuels. In 1975 I started work at Chalk River Labs during the OPEC oil crisis. These experiences led to my interests in conservation, renewable energy, and energies' environmental and strategic issues. I left AECL in 1979 to obtain a post graduate degree in Applied Mathematics from Waterloo. My thesis, some course work, and work terms were on solar energy. When I graduated, I worked in the environmental industry on air pollution and oil spill computer models. Eventually I realised that nuclear was the solution to many problems, so I returned to Chalk River Labs where I worked till retirement.

The benefits of nuclear technology were obvious to me, so I investigated the basis for opposition to reactors in general and radiation in particular. I have been investigating the risks of radiation for many years and have given several presentations on how the risks of radiation were over-estimated in the media and misunderstood by scientific studies.

During the Ban the Bomb movement scientific and regulatory bodies adopted the idea that radiation damage in people is not repaired and so any level of radiation is harmful. This idea is called LNT and it became a powerful argument to stop nuclear weapons testing. However, life evolved constantly exposed to radiation, and radiation levels over long geologic periods were much higher than now. Mechanisms evolved to repair damage from radiation. These repair mechanisms have been studied and confirmed experimentally. As a result of DNA repair and cell replacement, there is a threshold below which radiation does not cause damage. Currently, some regions of the world have 100 times more naturally occurring radiation than other regions without causing more cancer. Figure 1 is Slide 89 of the John Boice presentation on Radiation Epidemiology & Dosimetry Course to the National Cancer Institute. Note that John Boice was president of the National Council of Radiation Protection (NCRP), is presently its Director of Science, and he and the NCRP are advocates of LNT, at least for some situations. However, this example of a low dose rate that includes internal radiation, similar to the NSDF, does not show any increase in cancer as radiation increases. Note there is no increase in cancer in Figure 1 at many times the dose of the hypothetical NSDF subsistence farmer who gets 170 micro-Sieverts per year.

Relative Risk of All Cancer Excluding Leukemia by Cumulative Dose to High Background Radiation in Kerala



Nair et al. *Health Physics*, 2009;
Boice et al. *Radiation Research* 2010

Figure 1: Relative risk of solid cancer in a high background area. There is slightly less cancer in the highest dose ranges than the control group (John Boice slide).

Figure 1 shows no increase in cancer in high background areas. Figure 2 shows a decrease in cancer and increase in life expectancy with increased radiation for counties in the US: Background Radiation Impacts Human Longevity and Cancer Mortality: Reconsidering the Linear No-Threshold Paradigm. David, Wolfson, Fraifeld. *Biogerontology* (2021) <https://doi.org/10.1007/s10522-020-09909-4>. The health benefits were partially due to a statistically significant decrease in lung cancer in high dose areas. Figure 2 shows male data on the left and female data on the right; life expectancy is on the top and cancer mortality on the bottom. The horizontal axis of background radiation in Figure 2 is for external radiation (terrestrial and cosmic). Note that a follow-up study of the entire US population by the same authors found Life Expectancy to be positively correlated with background gamma radiation and radon.

Edward Calabrese, a professor of toxicology at the University of Massachusetts for decades and chief editor of the scientific journal *Dose Response*, has investigated the historical foundations of the LNT theory. He has written several publications on the historical development of LNT in peer-reviewed journals. Importantly, he has over 10 hours of interviews on the Health Physics Society web site, HPS.org and on the Health Physics youtube channel. Each of the 22 videos are introduced by the president of the Health Physics Society, John Cardarelli. Calabrese has documented how there was never any evidence supporting LNT and that LNT should never have been adopted. It is important to note that publishing these videos is acting against the self interest of the HPS because inevitably fewer people will work in health physics if LNT, and consequently ALARA (As Low As Reasonably Achievable), are rejected as these videos suggest.

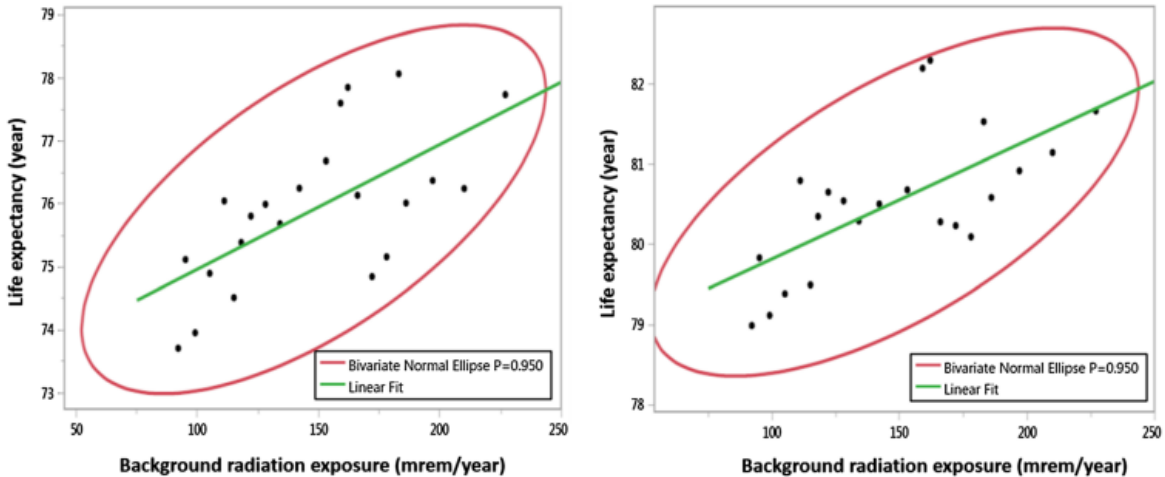


Fig. 1 The life expectancy was plotted against the average estimated radiation level of each exposure level. The regression equations for males (a) and females (b), respectively:

$LE = 0.02BRL + 73.0$ and $LE = 0.015BRL + 78.3$, where LE stands for life expectancy in years, and BRL stands for background radiation levels in mrem/year

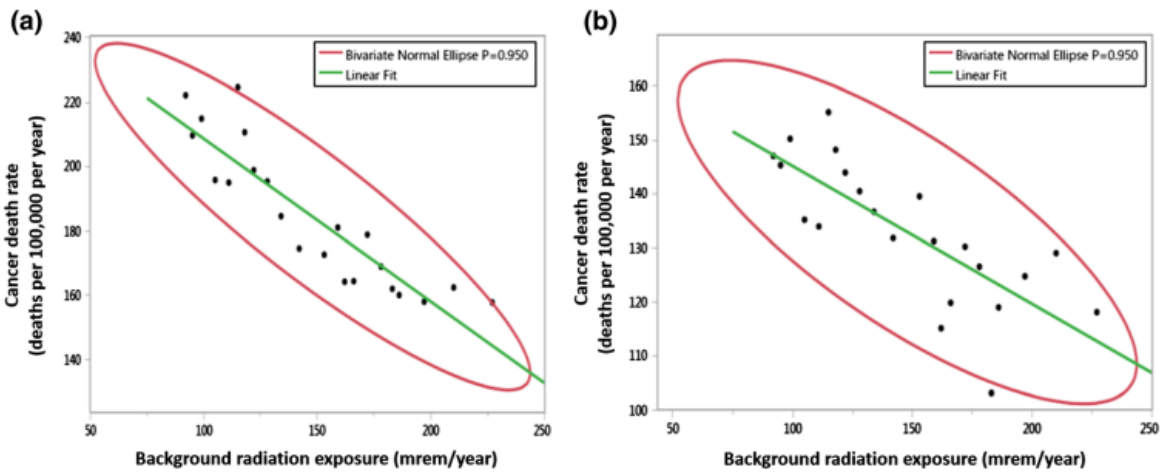


Figure 2: Increase in life expectancy and decrease in total cancer for high background radiation in the US

Cancer due to radiation is low even if LNT is accepted. This is demonstrated by a study of Hiroshima /Nagasaki (H/N) survivors that the NCRP said strongly supported LNT and was produced by the Radiation Effects Research Foundation, the official agency responsible for H/N studies that assumes LNT from the start of their studies. This study: “Solid Cancer Incidence among the Life Span Study of Atomic Bomb Survivors: 1958–2009, Grant et al., 2017, concluded that males had a 1% Excess Relative Risk of solid cancer incidence at 100 milli-Gray acute dose. This 100 milli-Gray exposure is the average for the 1000 most highly exposed Fukushima workers. Therefore, this study predicts 3 extra solid cancers due to radiation above the expected 300, based on a 30% cancer incidence. Of course, the number of cancers would actually vary between 270 and 330 due to random variability, which means a cancer increase due to radiation would not be detectable. This is what the WHO and UNSCEAR mean when they say no discernible increase from Fukushima is expected. If LNT were not assumed from the beginning, then this Grant study would likely have found no increase in cancer at 100 mill-Gray. The same would be true of leukemia.

LNT is not true because of DNA repair and cell death and replacement. The two figures above show that chronic doses that include both internal and external radiation, like the NSDF, are not harmful and may be beneficial. In addition, it is important to understand that hypothetical effects of LNT are extremely small as shown by the Grant et al. study in Radiation Research. There is no doubt that Fukushima was an enormous accident, but the UN and World Health Organization (WHO) concluded there will be no detectable increase in cancer, even to the workers, even though they assumed that no level of radiation is safe. This shows that estimated radiation risks are low, even for relatively large doses and even when risk is over-estimated by assuming LNT. Note that the hourly dose rates in the Grant et al. study for the 100 milli-Gray acute exposure are over a million times higher than the hypothetical NSDF subsistence farmer. Note also that very few people can live on and take food and water from the NSDF.

Opponents of the NSDF misunderstand risk because they have heard of a few tragic situations where huge doses and dose rates caused harm. I will provide some examples of their misunderstandings.

NSDF opponents have claimed that radiation from the NSDF would increase genetic damage. Not true. A report presented on the 35th anniversary of Chernobyl concluded there was no genetic damage (Yeager M, Machiela MJ, Kothiyal P, et al. Lack of transgenerational effects of ionizing radiation exposure from the Chernobyl accident. April 22, 2021. *Science*. DOI: 10.1126/science.abg2365). This reinforces studies showing no genetic, heritable, damage in H/N survivors. John Boice of the National Cancer Institute and president of the NCRP said: "intense study of 70,000 offspring of atomic bomb survivors has failed to identify an increase in congenital abnormalities, cancer, chromosome aberrations or mutational blood protein changes". Doses and dose rates from the NSDF are negligible compared to H/N and therefore will obviously not cause heritable genetic damage.

NSDF opponents have claimed that radiation from the NSDF would increase birth defects. Not true. H/N caused a small increase in birth defects for acute doses greater than 1 Gray (Neel, RERF). So, birth defects do not occur until the hourly dose rates are about 100,000,000 times higher than for the hypothetical NSDF subsistence farmer.

NSDF opponents have claimed that radiation from Cobalt-60 would give off intense radiation from the NSDF mound and workers are shielded as a result. Not true. Of course, workers will be shielded to lower their annual doses from all the radioactive materials they are directly working with. However, the contents and the many layers of the mound will shield the radiation. Cobalt-60 has a half life of just over 5 years, so 50 years after the end of the closure phase, radiation levels from the mound will drop from barely, or not, detectable by very sensitive equipment to less than 0.1% of that.

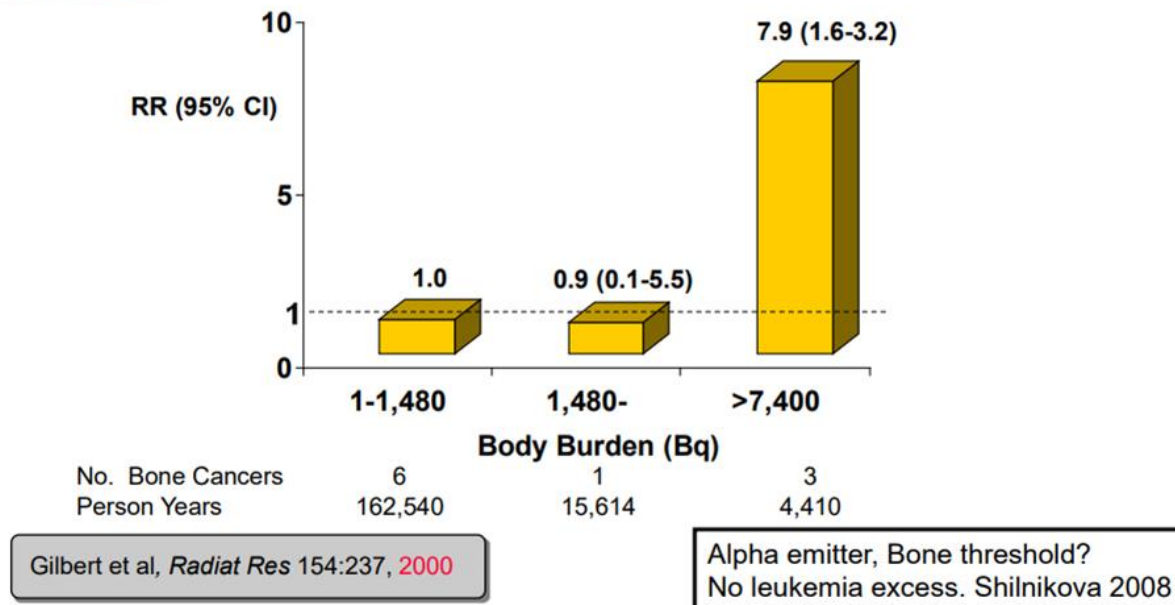
NSDF opponents have claimed that radiation from the NSDF could increase cancer. Not true. H/N caused cancer at high doses and exceptionally high dose rates. The 106 Chernobyl workers who had very high doses and suffered acute radiation syndrome but survived, had a handful of extra leukemia cases but not extra solid cancers. The most important study of cancer incidence (Grant et. al., discussed above) estimated a 1% relative increase of cancer incidence (30.3% instead of 30%) for people like the 1,000 most exposed Fukushima workers. Again, NSDF will cause insignificant doses and dose rates by comparison.

NSDF opponents have claimed that plutonium from waste sites is dangerous. Not true. American and Soviet workers were very heavily exposed to plutonium in the 1950's and 1960's, but even groups that ingested large amounts had very low levels of harm. For example, a large group of Soviet workers, who

worked in very risky conditions, only had three cases of bone cancer and no leukemia, Figure 3. This study also shows workers with less than a dose threshold of 7,400 Bq did not get cancer (Gilbert et. al., Radiation Research 2000 and John Boice "Radiation Epidemiology & Dosimetry Course, Radiation Studies and Concepts II" Slide 56, see below). Note that the NSDF does not typically lead to inhalation and so lung cancer is not a concern. The NSDF will not cause harm from plutonium.



Mayak - Plutonium - Bone



Sokolnikov et al, *Int J Ca* 2008— **update_bone, liver, lung – same bone picture**
 Sokolnikov et al, *PLoS One*, Feb 2015 – other than bone, liver, lung – low ERR/Sv
 Hunter et al, *Br J Ca PLoS One*, Oct 2013 – other than bone, liver, lung – no to low ERR/Sv

Figure 3: Studies of bone cancer in Russian Mayak workers with high plutonium exposure (John Boice slide)

It has been claimed that long lived radioisotopes other than plutonium are dangerous for long periods of time. Not true. Figure 4, UNSCEAR 2000, shows a very distinct threshold at 10 Gray annual dose. Long lived radioisotopes release radioactivity slowly. Radioactivity is much more dangerous when the dose rate is high. Long lived radioisotopes typically are alpha emitters that have thresholds as seen with Russian workers (Figure 3) and the radium dial painters (R.D. Evans), Figure 4. In addition, alpha emitters are big atoms with low solubility in water resulting in slow propagation in the environment. Compare John Boice's "practical threshold" 10 Gray in the bottom left of Figure 4; this is millions of times above alpha doses in the worst case scenario from the NSDF.

Bone Cancer in Radium Dial Painters (UNSCEAR 2000; Rowland Rad Res 1978)

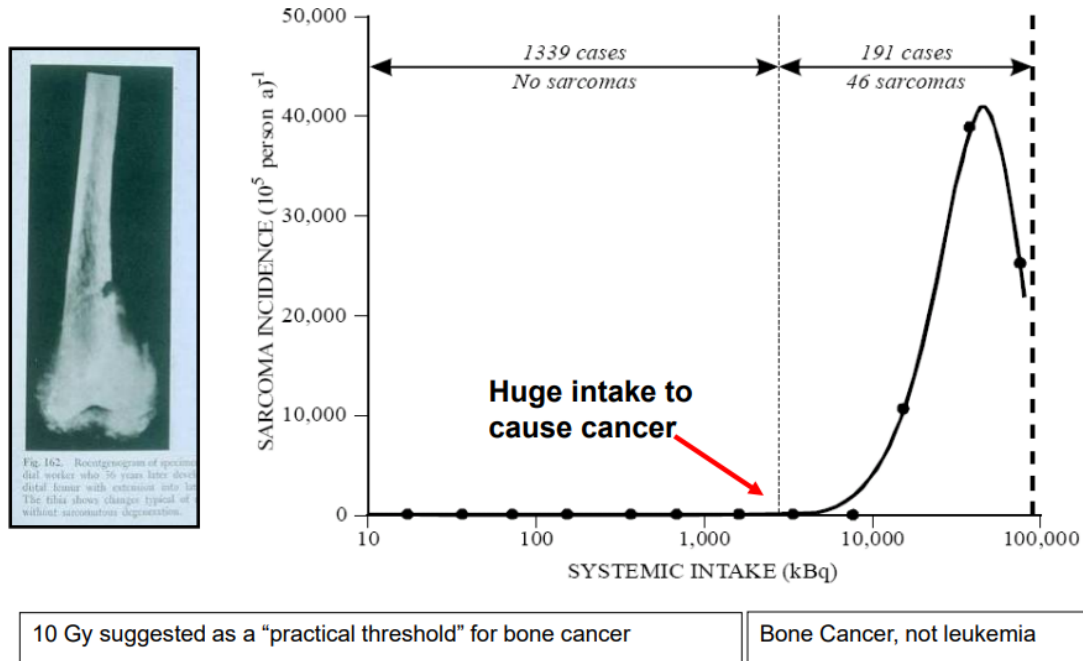


Figure 4: Bone cancer in radium dial painters; UNSCEAR 2000, Note the comment that "10 Gray suggested as a "practical threshold" for bone cancer" (John Boice slide)

Figures 1, 3, and 4 were lifted from Dr. Boice's presentations that are available on the internet and were presented to the National Cancer Institute. I also quoted Dr. Boice on the lack of genetic harm from Hiroshima/Nagasaki. Dr. Boice is Professor of Epidemiology at Vanderbilt University School of Medicine, Past President of NCRP (2012 to 2018) and currently its Director of Science, was awarded Doctor of Science in Epidemiology from Harvard University, and he developed the Radiation Epidemiology Branch in the National Cancer Institute. Dr. Boice is not just authoritative. As past president of the NCRP he is a spokesperson for LNT for use in radiation protection. I could have quoted other scientists who believe that low doses of radiation are beneficial.

The view of Dr. Boice and the NCRP is that LNT forms the most reasonable and practical basis for radiation protection regulations. That does not mean Dr. Boice believes the negligible doses from the NSDF would cause harm. In fact, he obviously believes internal alpha emitters have thresholds, Figures 3 and 4. He also shows evidence that chronic doses in high background areas are not harmful even though they are many times higher than doses for the hypothetical NSDF subsistence farmer, Figure 1. He also stated that the intense radiation from Hiroshima/Nagasaki did not cause heritable harm, above. NCRP support for LNT as a basis for regulation is largely for the external, acute doses common in medical applications.

LNT causes anxiety no matter how low the dose. In addition, LNT caused CNL to estimate committed dose to a hypothetical subsistence farmer by estimating the lifetime internal alpha dose, multiplying by 20, and adding it to external dose. CMD-22- H7 on page 94 says: “The enhanced erosion case results in an annual dose of 0.114 mSv, 7,650 years post-closure resulting from a resident farmer consuming locally grown foodstuffs (the dose is mainly due to Radium-228).” Figure 4 shows that there is absolutely no health impact from the radium dose and it should not be added to the external dose. Figure 3 shows the same is true with plutonium and even Dr. John Boice of the NCRP would agree.

As was earlier discussed, Calabrese has shown there was no evidence for LNT and it should not have been adopted in the 1950’s to 1970’s. It can be shown with a larger document that studies that the NCRP declared to strongly support LNT from external sources, do not: Estimating Risk and NCRP’s Commentary 27, Ken Chaplin, June 2021 CNS conference. Even supporters of LNT as a basis for regulation (Dr. Boice), accept:

- thresholds for internal alpha emitters,
- no evidence of harm from high background areas,
- no heritable genetic harm from radiation, and
- no evidence of harm for external acute doses at levels far above the NSDF.

An important consequence of there being no harm at dose levels thousands of times higher than the NSDF is that there is no reason to apply ALARA. Preventing doses below a threshold has no benefit. In fact, there have been serious repercussions from trying to prevent doses that are safe. In particular, the evacuation at Fukushima caused over 1,000 deaths and the Japanese and German shutdown of reactors caused even more deaths from air pollution. Opponents want significant changes to the direction of the NSDF. However, these opinions are not wise, and any design change would be much more difficult to implement than people could possibly imagine. We must not start another long design phase only to find out years from now that the current design was better or cheaper. The public and workers can rest assured they are not at risk from radiation.

Filed on April 21, 2023

Letter to the CNSC in support of immediate license change to allow the NSDF.

I felt compelled to add a comment to my written submission after the regrettable but inevitable 2023 April 15 news that Germany shut down its last reactors permanently. In 2019, Germany, due to shutting down most of its reactors, produced 10 times more greenhouse gas emissions per MWH than Ontario while producing electricity at three times the cost. Germany also helped finance the invasion of the Ukraine while doing so. Greenhouse gas emissions and costs have simply gotten worse since. There was another path for Germany, but opposition to nuclear prevented it.

License change to allow NSDF construction should be as soon as possible. There is no radiological risk from such a facility, nor is there from NPD entombment. I don't believe there is significant radiological risk from the current decommissioning of the site that is stalled because of the lack of the NSDF; however, there is always the risk of a fire or flood that makes the papers. Leaving waste in an intermediate state for long periods of time simply adds unnecessary risk. Getting the NSDF started is in everyone's interest.

At this point people have had a long time to comment on the NSDF. Comments suggesting radiological risk from NSDF or NPD entombment have been incorrect as my detailed submission indicates. On the other hand, worldwide opposition to all things nuclear has exacerbated: environmental, economic, and strategic problems. It is not surprising that James Hansen, a climate scientist, is an outspoken advocate of nuclear energy.

Please help facilitate project commencement.

Ken Chaplin