Radionuclides need designation as Chemicals of Mutual Concern to accommodate NRC's regulatory system inadequacies and protect the Great Lakes

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Prepared for Canadian Environmental Law Association and Toxics Free Great Lakes Binational Network

March 2021

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Brief Biography

Cindy Folkers has a Master of Science in Environmental Sciences from Johns Hopkins University and has researched radiation and health issues since 1994. She has written extensively, including essays in two anthologies, and has given numerous presentations focused on radiation's disproportionate impact on women, children and pregnancy.

CELA publication number: 1473

Acknowledgements: Canadian Environmental Law Association would like to recognize the support of Canadian Environmental Law Foundation, Legal Aid Ontario and the Mott Foundation.

Disclaimer: The views, comments and recommendations provided in this report are those of the CELA and its author and not of its funders.

[1]Prepared for Canadian Environmental Law Association, and Toxics Free Great Lakes Binational Network

In March 2016, 110 advocacy groups submitted an application under the binational Great Lakes Water Quality Agreement to designate radionuclides as "Chemicals of Mutual Concern" (CMCs) under Annex 3 of that Agreement.[2] Environment and Climate Change Canada and the U.S. Environmental Protection Agency sent that application to each country's nuclear regulatory agency (U.S. Nuclear Regulatory Commission and the Canadian Nuclear Safety Commission) for comment.

Both countries' nuclear regulatory agencies reported back to the environment agencies for their country in 2017. Both nuclear regulatory agencies recommended that radionuclides not be designated as CMC's under the GLWQA.

We are disturbed that the USEPA and ECCC have not also commented on consideration of radionuclides as CMCs. EPA and ECCC have a much better understanding of the GLWQA and the prime responsibility for implementing that Agreement. They also have the most promising frameworks for meeting the GLWQA goals and have significant responsibility environmental contamination from these persistent pollutants - not only for their release, but also their remediation. Yet they appear to have ceded the comment responsibility to NRC and CNSC.

The groups who nominated radionuclides to become CMC's asked Cindy Folkers[+] to assess the adequacy of the NRC's regulatory system to protect the Great Lakes from radionuclides. The following are her findings on this topic.

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Radionuclides are persistent pollutants that must be designated as Chemicals of Mutual Concern in order to protect Great Lakes communities and environment

Summary

Designating radionuclides as Chemicals of Mutual Concern (CMCs) would benefit the Great Lakes. It would tighten the regulatory framework for radionuclides, increase the assessment of their presence and impacts in the Great Lakes, and encourage attempts to more effectively curtail exposure and damage.

The International Joint Commission (IJC) in its 1997 report[3] recognizes the Great Lakes as a large, freshwater environment with a closed ecosystem that often retains contaminants in a non-uniform way. Protection measures for the Great Lakes environment require special consideration of this unique ecosystem.

In its response letter resisting designation of radionuclides as CMCs, dated January 24, 2017, the U.S. Nuclear Regulatory Commission (NRC) defends its regulatory framework as adequate – even conservative. The reality is quite different. NRC's framework:

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[2] See application at [http://www.cela.ca/publications/radionuclides-chemical-mutual-concern-great-lakes-basin]

[+] Cindy Folkers has a Master of Science in Environmental Sciences from Johns Hopkins University and has researched radiation and health issues since 1994. She has written extensively, including essays in two anthologies, and has given numerous presentations focused on radiation's disproportionate impact on women, children and pregnancy.

[3] Inventory of Radionuclides for the Great Lakes. Nuclear Task Force. International Joint Commission, United States and Canada. December 1997

- allows release of radionuclides to the environment, but is not consistent or robust enough to fully characterize the releases

- is primarily based on principles of engineering, not health

- does not protect sensitive members of the public adequately

- does not accommodate cumulative doses, environmental cycling of radionuclides or bioaccumulation and biomagnification – all necessary for a full accounting of, and protection from, any impact to the Great Lakes

- inadequately protected residents from the unplanned and disastrous release of radiation from Three Mile Island, despite NRC's contrary claims

- has not been tested by conducting appropriate health studies around facilities. Therefore, NRC cannot claim it protects public health

- Is not adequate to support a state-of-the-art health study around NRC-licensed facilities

NRC suffers from scientific intransigence, refusing to recognize the abundance of scientific evidence demonstrating that even small doses of radiation pose a risk. It clings to old health assumptions, eschewing new studies and insightful examination methods.

NRC is not the only U.S. agency responsible for tracking and protecting against radiation released to the environment. Its perspective regarding a CMC designation is very limited, since its opportunity for control primarily stops at the licensee fence line because it relies on facility technical and engineering methods, and accurate licensee reporting. However, contamination from facilities extends further out in time and space, essentially becoming a problem for other agencies, the public and the environment.

Part 1. NRC existing regulatory programs are not comprehensive or fully adequate for protecting human and non-human animals, or the environment.

a. NRC bases protection standards on engineering principles primarily, not public health.

In its response letter regarding CMCs[4], NRC states that it constructs its regulatory framework to protect the public and the environment by using "established engineering principles for safe plant design and operation." Principles of public health appear nowhere in this list of framework components. Instead, NRC assumes that its "As Low As Reasonably Achievable" (ALARA) protocol (assured, NRC claims, through control and monitoring of releases) is protective of public health past its facility boundaries. Since ALARA appears to be based on only what is possible through engineering, not by what is necessary to protect public health, it might actually be causing health problems, particularly since even low doses carry risk.[5] Further, if regulatory goals overall are zero

[4] Nuclear Regulatory Commission. Basis for the U.S. Nuclear Regulatory Commission's Recommendation that Radionuclides Not Be Listed as Chemicals of Mutual Concern Under the Great Lakes Quality Agreement. Letter. January 24, 2017.

[5] Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. 2006. p 10.

release or pollution prevention, as required in the GLWQA, ALARA is not the framework to assure attainment of those goals.

b. The standards NRC claims it is meeting with its engineering-based (not health-based) ALARA principles are in themselves not protective enough.

NRC contends[6] that ALARA is protective of public health, but to what standard? The International Commission on Radiological Protection (ICRP) recommends radiation exposure limits that governments and industries often incorporate into their exposure standards. NRC says it "has incorporated the recommendations from the ICRP and set the public dose limit in its regulations at 1 mSv…"[7]

NRC sets this 1mSv (100mrem) limit as an annual dose to a member of the public. What does this limit mean for human health? "This translates − in the NRC's own published assessment − to a risk of fatal cancer over a 70-year span of 3.5 per 1000 people exposed (or 1 fatal cancer per 286 people exposed)"[8]. It is a 1 in 143 cancer incidence. This is not gender or pregnancy adjusted. Further, this is a per-facility exposure. What happens when members of a community might be getting exposures from *multiple* sites?This risk is also much higher than the Environmental Protection Agency (EPA) allows: 1 in 10,000 cancer incidence while trying to accomplish 1 in 1 million cancer incidence.[9]

NRC says it does a cost benefit analysis.[10] Cost benefit analysis assumes that some people will be sacrificed for the benefit of others; in this case "benefit" almost always means attaining or saving more money. Sacrificing the health and lives of people for money is a questionable practice and should not replace the necessary work of correcting the problem (in this case radioactive contamination). If NRC insists on using cost benefit analysis, it should at least keep up with the latest science and incorporate impacts on earnings potential. Research[11,12] in Nordic countries associates very low radiation doses with impaired neural development that causes subclinical impacts

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[6] NRC 2017.

[7] *Ibid*.

[8] Olson, M. Dose versus risk in US regulation of radiation exposure. Nuclear Monitor Issue: #788 10/07/2014

[9] "Acceptable Exposure Level: This is a legal term defined in the National Contingency Plan (NCP), which is the regulation that promulgates CERCLA… An acceptable exposure level is the "concentration level of a contaminant to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime..." For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent lifetime cancer risk to an individual of between 10-4 (1 in 10,000) and 10-6 (1 in 1,000,000) using information on the relationship between the dose and response. The 10-6 risk level shall be used as the point of departure for determining remediation goals for alternatives when Applicable or Relevant and Appropriate Requirements (ARARs) are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure." Sometimes this is referred to as the acceptable risk range (Source: National Oil and Hazardous Substances Pollution Contingency Plan). Sometimes "acceptable exposure level" is referred to as "acceptable risk." Alternative definition: An "acceptable" risk level (or range) of a contaminant, defined by law, that EPA uses to make cleanup decisions at Superfund sites. This is a risk level (or range) that people can be exposed to, including sensitive populations, without health problems. For carcinogens, the acceptable risk range is between 10-4 (1 in 10,000) and 10-6 (1 in 1,000,000). " from: https://semspub.epa.gov/work/HQ/174688.pdf

[10] Olson, M. Dose versus risk in US regulation of radiation exposure. Nuclear Monitor Issue: #788 10/07/2014.

[11] Almond, et al. Chernobyl's Subclinical Legacy: Prenatal Exposure to Radioactive Fallout and School Outcomes in Sweden. The Quarterly Journal of Economics (2009) 124 (4): 1729-1772.

[12] Heiervang, KS. The Chernobyl accident and cognitive functioning: a study of Norwegian adolescents exposed in utero. Dev Neuropsychol. 2010;35(6):643-55.

creating behavioral problems and underperformance in school. Impacts such as these, and others associated with low dose radiation exposure (lower IQ), can lower the earnings potential of a person. Estimating costs of these health impacts can be informed by work already underway for cost estimates of other toxic exposures, although this work might have to be adjusted for impacts unique to radionuclide exposures. For costs of subclinical and brain development impacts, Dr. Leonardo Trasande, Department of Pediatrics, New York University (NYU) School of Medicine, has provided good research[13] to start.

The data and assumptions underpinning ICRP recommendations also fall short of protecting health. ICRP fails to account for a number of radiation impacts including genetic impacts past the second generation of exposure[14]; impacts on the placenta,[15,16] which performs organ functions during pregnancy; impacts on certain blood forming cells during embryo and fetal development;[17,18] impacts on fetal and embryo organs which are forming from single cells.[19] Worse still, ICRP dismisses the ultimate impacts of some of these shortcomings by claiming that the detriment remains unknown.[20]

ICRP's math converting radioactivity to damage doesn't account for cumulative biological damage from continuing exposure to low doses.[21] Once a biological system has suffered damage, perfect repair is elusive and the same dose given again can result in greater damage than the previous time.

ICRP recognizes that both carbon 14 and tritium can collect in fetal tissue at twice the concentration in maternal tissue.[22] Since most exposure standards are based on an average of impacts on men, women and children (leaving out pregnancy altogether), this effect remains unaccounted for both within the ICRP recommendations and NRC's regulatory framework. In the case of tritium, the half-life is over 12 years, but the hazardous life can be 10-20 times that. Carbon 14 has a half-life of over 5,000 years. Stable forms of both are basic building blocks of all biological life. Radioactive forms will be incorporated into living tissue in the same way, but are dangerous. This becomes an even more pertinent issue for the Great Lakes region since toxic substances stay longer periods of time and accumulate. Both tritium and carbon 14 are recognized among the radionuclides of long-term concern by the 1997 IJC report[23]. EPA regulations (40 CFR

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[13] https://med.nyu.edu/faculty/leonardo-trasande

[14] The 2007 Recommendations of the International Commission on Radiological Protection ICRP Publication 103 Ann. ICRP 37 (2-4), 2007. pp 53-56.

[15] Basic Anatomical and Physiological Data for Use in Radiological Protection Reference Values. ICRP Publication 89. Ann. ICRP 32 (3-4), 2002. p. 231.

[16] Doses to the Embryo and Fetus from Intakes of Radionuclides by the Mother. ICRP Publication 88. Ann. ICRP 31 (1-3), 2001. Chapter 3.

[17] *Ibid.*

[18] Phipps, A.W. et al. SOME ASPECTS OF THE FETAL DOSES GIVEN IN ICRP PUBLICATION 88. Radiation Protection Dosimetry Vol. 105, Nos 1–4, pp. 279–284 (2003). p. 282.

[19] ICRP 88. pp. 27, 53,60-61.

[20] Phipps. p. 282.

[21] Personal communication. Eckerman. November 7, 2016.

[22] ICRP 88. pp 24-25.

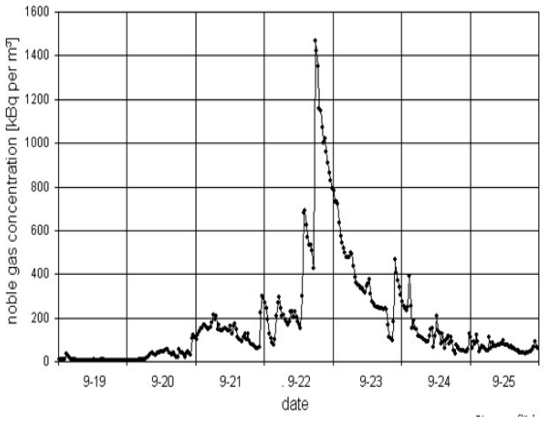
[23] In 1997, the IJC issued a report attempting to describe the cycling of radionuclides through Great Lakes biota in a systematic but limited way, using a material balance approach. The IJC concluded this examination was needed because radionuclide monitoring systems are used by regulatory bodies primarily to demonstrate compliance with discharge

190) specifically have NOT regulated tritium or carbon 14 from civilian nuclear reactors, claiming that these isotopes can't really be filtered or removed from the environment in any case.[24]

c. NRC does not have a robust regulatory regime for monitoring radioactive releases to the environment. NRC trusts that releases are properly measured by the licensees.

NRC's regulatory framework is unreliable first because it depends substantially on truthfulness of licensee reporting; second because release measurements are not consistent or reliable and in fact, the way they are reported can be deceptive.

The U.S. National Academy of Sciences panel to examine the cancer risks around NRC licensed facilities determined in their Phase I report that carbon 14 may be the largest dose to the public.[25] However, NRC has never required licensees to *measure* the carbon 14 released from nuclear reactors as radioactive carbon dioxide and methane. Only in 2010 did the NRC say that carbon 14 emissions had to be *estimated*.[26] Consequently, doses from this radionuclide with a half-life of almost 6,000 years, are largely unknown.



Even after facilities are closed and decommissioned, tritium still oozes[27] from any concrete, cement and metal left. The NRC does not continue monitoring at these dismantled sites and in fact, as the Big Rock example below illustrates, has no interest in following contamination pathways and bioaccumulation once offsite, even if it flows back on site.

Radiation is released routinely and in spikes. We know this thanks to the German Green Party who pressured local government officials to release actual real-time data, not averaged data, for a single power reactor. This graph shows a radionuclide spike approximately 500 times higher than normal reactor emissions, which are already regularly higher than background radiation.[28] Spikes could be higher, but this is difficult to know since releases are already averaged in publicly accessible U.S. documents. Since the emissions data in the U.S. are given as an average, these spikes would be smoothed out. German and U.S. nuclear technologies are similar so there is no reason to believe that reactors in the U.S. don't release in spikes as well, during refueling

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licenses and are not capable of assessing cycling of radionuclides through the environment. Further examination of this issue is needed, but in the 20 years since IJC issued its report, little progress has been made regarding its concerns.

[24] https://www.govinfo.gov/content/pkg/FR-2014-02-04/pdf/2014-02307.pdf p. 6519

[25] Analysis of Cancer Risks in Populations Near Nuclear Facilities. Phase 1. National Academy of Sciences. National Research Council of the National Academies, Nuclear Radiation and Studies Board. 2012. p. 5.

[26] Wahl, D. The Impact of Carbon-14 on Limerick's Gaseous Effluent Dose Model. Limerick Generating Station. Exelon Nuclear. 2010. Accessed 3/12/2021.

[27] McClenaghan et al. Submission to the CNSC on Draft Environmental Impact Statement Re: Nuclear Power Demonstration Closure Project (Ref No. 80121). Canadian Environmental Law Association. February 2018.

[28] Fairlie I. Hypothesis to explain childhood cancer near nuclear power plants. Int J Occup Environ Health. 2010 Jul-Sep;16(3):341-50.

outages or other maintenance, for example. Timing matters during pregnancy and the sensitive and unique developmental processes that are occurring, but NRC's regulatory framework does not account for timing of exposure.

The case[29] of the now shuttered Big Rock Point[30] (BRP) nuclear reactor in Charlevoix, MI is an instructive example of NRC licensees' inadequate monitoring. In 1998, six months after BRP had permanently shut down, radioactivity traveled back up a reactor discharge canal, causing radiation monitor alarms to sound. The culprit was believed to be algae that had bio-magnified radioactive isotopes suspended in Lake Michigan water. The NRC's response was to ignore the alarms and continue with the decommissioning, dismantling the radiation monitors along with the rest of the facility.[31]

If radiation monitors are inoperable for less than 30 days, BRP operators were under no obligation to report this outage. In these circumstances, licensees could have relied on much less dependable monitoring procedures, missing effluent. These same NRC requirements exist fleet wide[32], meaning that, at any number of licensee facilities, releases could exist that were not reported on and accounted for in public doses.

From 1984 until 2000 (BRP ceased operating in 1997), NRC licensee documents, reveal that the tritium contamination in groundwater at the site violated the EPA Safe Drinking Water Act maximum contamination level of 20,000 picocuries per liter numerous times.[33] Clearly contamination continues after a facility has closed and the NRC has ceased to require monitoring.

d. Scientific panel recognizes NRC regulatory framework shortcomings.

A U.S. National Academy of Sciences committee issued a 2014 report[34] investigating the technical feasibility of using NRC licensee data and methodologies to assess human cancer risk around their facilities. In doing so, NAS illuminated several areas that needed "consideration:"

- focus on doses from carbon 14 releases, which have *never* been measured. Only since 2010 has NRC forced licensees to estimate these releases. NAS claims exposure to carbon 14 could be a major concern in any health study, yet NRC has still not mandated adequate monitoring.
- develop new dose models for carbon 14 and consider altering all current dose and exposure models in order to, among other reasons, fit the specifics of each site,

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[29] Kamps, K. Say Yes to Michigan, Say No to the "Plutonium State Park": Backgrounder on Big Rock Nuclear Power Plant November 30, 2006.

[30] I choose Big Rock Point as a case study because it represents both an operating and closed reactor. It is on the U.S. side of Lake Michigan and represents NRC's handling of such a facility during and after its operation. BRP is also the subject of a thoroughly researched report, and also was one of NAS's pilot sites, making it the perfect representation of concerns and shortcomings for nuclear facilities on the GL.

[31] Consumers Energy report, "Radiological Event History" July 1, 2004 "License Termination Plan" (LTP, 3-98 incident report) referenced in Kamps 2006. p 22

[32] Lochbaum, D. Personal Communication. April 9, 2018.

[33] Consumers Energy report, "Radiological Event History" July 1, 2004 "License Termination Plan" (LTP, Page 2B-1) referenced in Kamps 2006. pp 11 & 33.

[34] Analysis of Cancer Risks in Populations Near Nuclear Facilities. Phase 2: Pilot Planning. National Research Council of the National Academies, Nuclear Radiation and Studies Board. 2014.

including local weather conditions.
- validate **"**releases and dose estimates by independent entities such as states and research organizations."
- explore other non-nuclear facility sources for meteorological data such as the National Center for Atmospheric Research Reanalysis Project.

In other words, NRC licensee effluent data and modeling may be good enough to demonstrate compliance with NRC's regulatory requirements, but data generated by this framework falls short when attempting to assess health and environmental impact.

e. NRC's use of the Three Mile Island nuclear disaster as an example of regulatory success is tragically incorrect.

Research shows increases in lung cancer and leukemia in the TMI plume pathways. Chromosome tests demonstrate, even 15 years after exposure, radiation damage was orders of magnitude higher than claimed by NRC[35]. These health outcomes seriously challenge NRC's competence in protection of health. Either NRC has severely underestimated doses from the TMI accident (claiming the highest dose received was under its 100 mrem per year dose, with the average being 1.4 mrem)[36] or even these small doses can create devastating health impacts. Either way, NRC's continued denial of impacts has proven it is unqualified to protect public and environmental health.

Part 2. NRC lacks the proper health and environmental knowledge and understanding to assert any conclusion regarding evidence of health or environmental harm to the Great Lakes.

a. NRC's contention that science shows a safe dose of radiation is incorrect.

The U.S. National Academy of Sciences set up an expert panel to explore this issue. This panel is commonly referred to as the BEIR (Biological Effects of Ionizing Radiation) VII panel. It rejected a threshold, concluding "that the preponderance of information indicates that there will be some risk, even at low doses" and "there is no compelling evidence to indicate a dose threshold below which the risk of tumor induction is zero."[37] Despite NRC's attempts to dissemble the truth of this statement, research since the BEIR VII report also shows low doses have negative health outcomes.[38]

b. Since no study has been performed, NRC cannot claim there are no health or environmental impacts from effluent flowing out of its facilities.

NRC claims that there is no need to list radionuclides as CMCs since NRC licensees don't release enough radioactivity to harm public health. In truth, there has never been independent analysis in the U.S. examining cancer and non-cancer health impacts

[35] Wing, S. A reevaluation of cancer incidence near the Three Mile Island nuclear plant: the collision of evidence and assumptions. Environ Health Perspect. 1997 Jan; 105(1): 52–57.

[36] Nuclear Regulatory Commission. January 24, 2017.

[37] Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2. 2006. p 10.

[38] see the companion piece for specific health references: CMCs radiation and health comments.docx

particularly in children. The one recent attempt[39] to investigate this issue was defunded by the NRC. The planned study was going to examine seven pilot sites before deciding the feasibility of studying all reactors in the U.S. One of these sites was to be BRP. The most recent study from the early 1990s examined cancer mortality around reactors, but failed to ask the proper questions in the correct way.

In fact, studies on child health have shown increases of childhood leukemia surrounding similar facilities.[40] Studies of background radiation, natural and manmade, also showed increased risk of childhood leukemia and central nervous system cancers.[41]

c. Lingering radioisotope contamination in Great Lakes areas poses a risk not considered by the regulatory framework of NRC.

In IJC's 1997 report, the Task Force concluded that NRC's framework is "not designed to look at environmental cycling of radionuclides." Unfortunately, this limitation doesn't keep NRC from claiming that lingering contamination is below permissible doses, a claim the NRC makes often for many of its licensees, including BRP.

d. NRC clings to old health assumptions, eschewing new, careful, insightful examination methods.

Radiation exposure can change our bodies in microscopic ways. These microscopic formations (biomarkers or bioindicators) can be malformations of cell components, proteins, etc. Studies assessing the impact of the Chernobyl and TMI disasters and the impact of regular operations around a German nuclear reactor, have incorporated biomarkers to help determine radiation exposure.[42] While NRC licensees attempt to monitor *environmental* contamination, NRC has never incorporated this kind of *biological* monitoring, which might prove useful after spike releases from various facility outages.

Part 3. Designating radionuclides as Chemicals of Mutual Concern (CMCs) would unquestionably benefit the Great Lakes.

a. NRC is not meeting GLWQA's goal of "virtual elimination" and "zero discharge"

The 1978 Great Lakes Water Quality Agreement introduced the goal of "virtual elimination" of persistent toxic substances and the technique of "zero discharge" as the method to achieve virtual elimination. Coming to the same conclusion as the NAS panel

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[39] Analysis of Cancer Risks in Populations Near Nuclear Facilities. Phase 1. National Research Council of the National Academies, Nuclear Radiation and Studies Board. 2012.

[40] Fairlie I. Hypothesis to explain childhood cancer near nuclear power plants. Int J Occup Environ Health. 2010 Jul-Sep;16(3):341-50.

[41] Kendall, GM. A record-based case-control study of natural background radiation and the incidence of childhood leukaemia and other cancers in Great Britain during 1980-2006. Leukemia. 2013 Jan;27(1):3-9. AND Spycher, BD. Background ionizing radiation and the risk of childhood cancer: a census-based nationwide cohort study. Environ Health Perspect. 2015 Jun;123(6):622-8.

[42] Wing, S. A reevaluation of cancer incidence near the Three Mile Island nuclear plant: the collision of evidence and assumptions. Environ Health Perspect. 1997 Jan; 105(1): 52–57. AND Schmitz-Feuerhake, I, et al. Leukemia in the Proximity of a German Boiling-water Nuclear Reactor: Evidence of Population Exposure by Chromosome Studies and Environmental Radioactivity. Environmental Health Perspectives - Vol 105, Supplement 6. December 1997. AND Livingston GK. Radiobiological evaluation of immigrants from the vicinity of Chernobyl. Int J Radiat Biol. 1997 Dec;72(6):703-13.

did regarding the inadequacy of NRC contaminant measurement for health assessment, the 1997 IJC report determined "it is not possible to tell if nuclear plant monitoring is satisfactory to assure meeting the goals and objectives of the Great Lakes Water Quality Agreement." Further, for radionuclides, IJC concludes "[a] revised monitoring and analytical protocol with emphasis on biouptake characteristics, physiological roles and impacts would greatly help in meeting the goals and objectives of the Great Lakes Water Quality Agreement…" IJC further points to a need for study of GL freshwater transfer factors for radionuclides.[43] Over two decades after the IJC report, NRC's framework still cannot meet any of these IJC determinations.

With NRC's ALARA principle in place for release of radioactivity to the environment, it is virtually *guaranteed* that NRC's regulatory framework is not adequate to meet the GLWQA. ALARA is as low as they say they can achieve. It is NOT "zero discharge" and therefore automatically does not meet, or even attempt to meet, a zero discharge standard. This is clearly shown in NRC's mixed fission and activation products (MFAP) graphs in their CMC letter, which show releases still in the billions of decays per second, annually, per facility, although releases have been decreasing over time. Further, it also does not account for environmental accumulation of persistent radionuclides, a limitation recognized by IJC. In fact, since ALARA is not a fixed standard, NRC can raise or lower ALARA whenever it likes to suit a licensee's particular request.

In 1996, the IJC recommended that radionuclides be addressed like other persistent toxic substances.[44] NRC appears to make no regulatory allowance for the *accumulation of* past releases of radionuclides in the environment, and seems to have no interest in considering zero release policy in the future. In the case of civilian nuclear reactors, NRC largely leaves monitoring of radioactive releases, and reporting of regulation breaches, to the licensee.[45] So while EPA sets regulations for civilian reactors, handing over implementation and enforcement to NRC, NRC, in turn, largely hands this responsibility over to the licensees.

Combined with NRC licensees' uneven effluent measurement, sporadic environmental monitoring, incomplete knowledge of release pathways, and unwillingness to conduct actual health assessments using the most up-to-date and independent techniques, it is clear that the Great Lakes region would benefit from listing radionuclides as CMCs. NRC's regulatory framework utterly fails to address continued exposures from past releases, which, shown on NRC's MFAP graphs, were orders of magnitude higher than today. .

b*. NRC is not the only agency maintaining control over facilities or processes that release radioisotopes.*

NRC is not the only U.S. agency responsible for tracking and protecting against radiation released to the environment. Therefore, its determination regarding a CMC designation is worth little, since its framework primarily relies on licensee self-monitoring and reporting to meet a regulatory standard that is not designed to meet a zero release goal,

[43] IJC 1997. pp 87, 90, overview page.

[44] Eighth Biennial Report Under the Great Lakes Water Quality Agreement, June 1996, p. 37. Quoted in Jackson, J. Radionuclides as a Chemical of Mutual Concern in the Great Lakes Basin. February 2016. p 12.

[45] https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/env-monitoring.html

and does not allow for accumulating radiological contamination into the surrounding environment and public.

Agencies such as Department of Energy, Environmental Protection Agency, Department of Transportation, Food and Drug Administration may maintain control over sites or activities within the Great Lakes watershed. These facilities could include reprocessing, waste, and some weapons-related facilities.

With the larger number of nuclear facilities ringing the Great Lakes, transport accidents are also a concern, particularly if moving radioactive waste across the lakes. "[R]elease of only a small fraction of shipping cask's contents would be sufficient to contaminate a 42 square mile area and cost over $620 million to cleanup."[46] This assumes the contaminated area could be cleaned up to its original condition, something that has yet to be accomplished at radioactively contaminated sites like Chernobyl, Fukushima and numerous weapons sites worldwide.

c*. USEPA is in a much clearer regulatory position to assess and comply with GLWQA stipulations, although even EPA needs to improve.*

Out of all of the agencies that regulate or create standards for radioactive materials, EPA, even with all of its flaws (and it has many — see companion piece Radionuclides vs chemicals), also has frameworks that can begin to accommodate GLWQA goals of zero release and virtual elimination. EPA has control over any site designated as Superfund. Remediation of contaminated sites such as these have a cleanup goal of 1 in 10 thousand to 1 in a million cancer incidence risk for both toxic and radiological hazards. This standard is much more protective than either NRC, or other EPA standards, for radiation. And while EPA regulation does allow release of radioactivity, and fails to account for all that is released[47], zero release concepts for toxics is at least acknowledged. In fact, there are a number of EPA frameworks for toxics, such as a Hazard Index that tracks non-cancer impacts, which should be used for radionuclides.

Even with EPA's future promise, radionuclides still need to be designated as CMCs now so that a full accounting of current contamination can begin. Additionally, under its current structure, EPA will not be able to fulfill the promise of some of its frameworks. An *immediate* CMC designation would benefit the Great Lakes because it would begin to address the radioactive pollution threat through an intense and strategic monitoring program used for other CMCs, but currently unavailable for radionuclides because they lack the CMC designation.

Conclusion

Protection measures for the Great Lakes environment require special consideration of its unique ecosystem, which is closed, and retains contaminants in non-uniform ways. The

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[46] Jackson, J. Radionuclides as a Chemical of Mutual Concern in the Great Lakes Basin. Canadian Environmental Law Association. February 2016, p. 9. Quoted from State of Nevada Nuclear Waste Project Office, "Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste to a Repository," May 20, 1999, p. 5

[47] In a major shortcoming, EPA 40 CFR 190 fails to account for tritium or carbon 14 releases at all. https://www.govinfo.gov/content/pkg/FR-2014-02-04/pdf/2014-02307.pdf

multiplicity of nuclear facilities in the GL means that compliance with regulatory standards that are set for a single facility are not protective enough. Therefore:

- contamination beyond the fence line needs to be properly measured and impacts assessed.

- Contamination needs to be counted from the first operation of the first facility that released it

- cumulative impacts of decades of releases need to be properly measured and impacts assessed, particularly bioaccumulation and biomagnification.

- In future, contamination must be prevented rather than controlled after it is released – a guiding principle of precaution

- Since the GL ecosystem is extremely diverse and unique, the ecosystem as a whole must be protected. Partial protection is not protective enough.

The NRC does not possess, nor do they show interest in accommodating, the frameworks necessary to meet the GLWQA goals of zero release and virtual elimination. The EPA possesses the most promising frameworks, but does not currently apply these frameworks in a robust way for radioactive pollution. Therefore, radionuclides MUST be listed as CMCs in order to gain clarity. Otherwise, these impacts are left unaddressed and the public and environment are left unprotected. CMC designation could realign and tighten the regulatory framework for radionuclides so that their presence can be discerned, and steps can be taken to limit exposure and begin to address any ongoing public and environmental health issues.