Following the Path Backward

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*a critique of the Draft Study Report
of the Nuclear Waste Management Organization*

entitled

Choosing a Way Forward

released in May 2005

September 2005

Introduction
Following the Path Backward

Irradiated nuclear fuel has been produced in Canada since 1945. Once created, this highly radioactive material remains dangerous for millions of years. It cannot be destroyed or made harmless by any available method. It can only be stored and guarded in perpetuity. Failure of containment can have catastrophic results.

For thirty years – from 1945 until 1975 – the nuclear industry made no effort to alert Canadians to the problems of safeguarding this extraordinarily toxic material in perpetuity. That has changed. The industry now sees the long-term management of irradiated nuclear fuel as a serious problem – not on a technical level, but in the sphere of public relations. For if nuclear wastes are perceived to be an unsolved problem, opposition to nuclear power will grow, and the nuclear industry's future will be in jeopardy.

In the spring of 2005, a group created by the nuclear industry issued a draft report on the long-term management of Canada's irradiated nuclear fuel. This group, the Nuclear Waste Management Organization (NWMO), called their report "Choosing a Way Forward." The "choosing" referred to is not their own, they claim, but the Canadian public's; for NWMO maintains its conclusions and recommendations are crafted from what ordinary Canadians think they would like to see happen with irradiated nuclear fuel. NWMO bases its claim on how selected people responded to NWMO presentations at meetings arranged by NWMO.

Our critique is entitled "Following the Path Backward" because we believe the NWMO process has not been designed to stimulate informed choice through genuine consultation, but to manoeuvre people into accepting an agenda first laid down by the nuclear industry over twenty-five years ago.

The industry's agenda is not to eliminate nuclear fuel wastes but to make the continued production of these wastes publicly acceptable. To achieve this, the industry needs to convince the public that irradiated nuclear fuel can be safely disposed of once and for all, even though industry plans point in the opposite direction: the continued accumulation and accelerated production of these long-lived toxic materials.

Accordingly, NWMO avoided asking people whether Canada should continue producing irradiated nuclear fuel; people were asked simply where they think the existing and anticipated wastes should be stored. Would people like to (a) leave the irradiated fuel wastes where they are now, or (b) move them to one central site, or (c) bury them deep underground in rock formations?

When pressured to select one of these three options, or to formulate an entirely new strategy for storing nuclear fuel wastes somewhere else, people are understandably puzzled. Why are agents of the industry asking ordinary Canadians, who know little about the subject, what should be done with the industry's most toxic waste byproducts? Doesn't the industry have a plan? And if so, what exactly is the point of this exercise?

As the NWMO Report reveals, the three options offered to Canadians are in fact merely three phases of a single option, and that option is the strategy selected by the nuclear industry over thirty years ago: burial of irradiated fuel deep underground. On-site storage is the status quo. It is inescapable for a period of time in any event. Centralized storage is the next phase. It is needed in preparation for the third phase: deep burial.

No matter which phase of the deep burial strategy is chosen by Canadians, the industry scores a major public relations victory by making it seem that people are willing to accept nuclear power provided the wastes are handled in a specified manner. Choosing one of NWMO's options can easily be misconstrued as a vote of approval for nuclear power. The industry can then expand and do what it wants with the waste, claiming that it is simply carrying out the public's will.

But is there in fact a proven safe method for storing irradiated fuel for millions of years? Do Canadians really want to continue producing these wastes? Were Canadians lied to by the industry when told that nuclear power is "clean energy"? These questions of policy choice and accountability are marginalized and trivialized by the NWMO process.

The lessons of the past have not been learned. The 1977 Hare Report laid out the geologic disposal concept of Atomic Energy of Canada Ltd. (AECL), but emphasized that the safety of this concept has to be "validated". The 1978 Report of the Ontario Royal Commission on Electric Power Planning, *A Race Against Time* , recommended a moratorium on nuclear power unless at least one safe method of waste storage for millennia can be demonstrated. The 1998 Seaborn Panel Report found that geologic disposal should be studied further. but that it should not now be accepted as Canada's policy because it is not publicly acceptable and the safety of the concept is not established in all respects.

The concept remains unproven. Science cannot predict long-term futures.

The Ontario Royal Commission on Electric Power Planning warned that the industry insistence on centralized storage is inextricably linked with industry plans for advanced fuel cycles based on plutonium recycling.

The warning has gone unheeded. NWMO obscures the issue entirely.

Most importantly, recommendations to create an agency "at arm's length" (i.e. independent) from the industry have been totally disregarded. The Board Members of NWMO are the corporations that produce the waste.

The call for independence has been denied. The industry remains in charge.

Montréal, September, 2005

Summary
Following the Path Backward

- NWMO is to be commended for adopting the "polluter pays" principle, in this case requiring the polluters to amass an amount of $24.4 billion – the estimated costs of long-term management of irradiated nuclear fuel. In accordance with historic nuclear cost over-runs, this amount should be tripled or quadrupled, however, and contributions adjusted accordingly.

- To its credit, NWMO does not minimize the magnitude of the long-term nuclear waste management problem. However, it provides little or no information on the history of this problem, despite receiving frequent questions from participants: "How did we get into this mess?"

- The fact that NWMO is a creation of the nuclear industry compromises its usefulness and muddies the waters. Many participants at meetings were under the false impression that NWMO represents government.

- The history of AECL's geologic disposal concept, and of the various investigations that have been carried out on this concept, is not clearly indicated by NWMO. Consequently, Canadians are left in the dark over how we got to where we are now and what deficiencies in the geologic disposal concept have been identified in past inquiries.

- In particular, NWMO nowhere discusses or reveals that AECL originally regarded geologic disposal as intimately connected with plutonium recycling ("reprocessing"). Nor does NWMO communicate the fact that the Ontario Royal Commission on Electric Power Planning expressly opposed the centralized storage of irradiated nuclear fuel because they had concluded that the construction of such a facility would "presuppose" reprocessing.

- NWMO claims to be advancing a new concept, called "Adaptive Phased Management", but there is little to distinguish it from AECL's "geologic disposal" concept, except for the time frame of implementation. With "Adaptive Phased Management", it becomes clear that the three options previously advertized by NWMO are simply three different phases of this one option, formulated by the industry 30 years ago.

- The primary stated objective of NWMO is "safety – to protect people and the environment." Yet their document gives no information on the health effects of radiation, or on the fundamental aspects of radio-ecology – e.g. the transmission of radioactive materials through food chains, the dispersal of radioactive gases and dust over land areas, or the mobility of soluble and insoluble radioactive materials in water.

- A pro-industry bias is evidenced by NWMO's brief mention of the discredited notion of "hormesis" – the fanciful theory that very low-level exposures to ionizing radiation may be beneficial rather than harmful. The US National

Academy of Sciences recently published a report firmly repudiating the "hormesis" theory as having no scientific merit, and reinforcing earlier studies that show the opposite: every dose of radiation, no matter how small, will cause an increase in harmful effects such as cancer provided a large enough population is exposed. These important findings and principles are nowhere explained by NWMO.

- Nor does NWMO cite any human data – even data that has been gathered in Canada on uranium miners exposed to radiation on the job who have shown significant increases in radiation-induced cancer rates. Such data is relevant, since NWMO claims that, after one million years of storage, irradiated nuclear fuel is no more dangerous than a high-grade uranium ore deposit. The claim makes little sense if people are unaware of the health hazards associated with high-grade uranium ore deposits.

- NWMO does not mention the special problems related to tritium releases from CANDU reactors. Tritium is a weakly-radioactive form of hydrogen that is given off into the environment in large quantities from Canadian reactors. It is no hazard when it is outside the body, but it is hazardous when it is inside the body. It is known to be a carcinogen (cancer-causing substance), a teratogen (causing malformed foetuses), and a mutagen (provoking changes to the genes and chromosomes that determine hereditary traits),

- Tritium is a good example of an internal emitter that poses no external hazard. Irradiated nuclear fuel contains many such internal emitters that do not pose external hazards, most of them more dangerous than tritium. This is particularly true of the "alpha emitters" such as radium, thorium, curium, and plutonium. NWMO says virtually nothing about them.

- One of NWMO's biggest failures lies in its refusal to study the rates of production of irradiated nuclear fuel. Even a cursory analysis shows that the radioactivity of the irradiated fuel that must continue to be stored on-site at a nuclear station (i.e. in the spent fuel bay) is far greater than the total radio-activity found in all of the older fuel that is able to be moved off-site. In practical terns, this means that any transportation of spent fuel off-site has only a very small impact on the total catastrophe potential due to the on-site wastes.

- Moreover, if nuclear power is allowed to expand through the building of new reactors, the amount of unburied waste at the surface will also expand at the same rate, despite all efforts to transport the waste off-site and bury it as quickly as possible. In practice, this means that NWMO's primary safety objective can never be met as long as new irradiated fuel is being produced at a constant or expanding rate. Only a complete phase-out of nuclear power would make it even theoretically possible to relocate all, or even the most dangerous portion, of the irradiated fuel to a single site, whether above-ground or below-ground.

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1.1 Financial Guarantees for the Management of Irradiated Fuel

In its draft final report, "Choosing A Way Forward" (May 2005), the Nuclear Waste Management Organization (NWMO) estimates that managing irradiated nuclear fuel from Canada's nuclear reactors will cost more than $20 billion, regardless of which management approach is adopted by the Government of Canada.

For those who have difficulty in envisaging what twenty billion dollars represents, it is equivalent to one million dollars per year, every year, for twenty thousand years; or, if you prefer, a hundred million dollars a year, every year, for two centuries.

The NWMO is to be commended for adhering to the "polluter pays" principle, and for its emphasis on ensuring that

> "... adequate resources are available, now and in the future, to pay the costs of the selected approach...." *[Choosing a Way Forward , p. 11]*

In accordance with these principles, and in conformity with the Nuclear Fuel Waste Act of 2002, those corporations whose nuclear reactors have produced irradiated fuel are obliged to put money aside in an interest-earning trust fund in order to amass the large sums that will be required to manage the irradiated fuel in perpetuity.

We applaud these financial initiatives, but we are concerned that the cost estimates may prove to be substantially incorrect. If the actual long-term management costs are double or triple those put forward by NWMO, the trust fund will not be adequate to get the job done and the "polluter pays" principle will be violated.

In the context of the Canadian nuclear industry, cost estimates are often too low. Construction costs for the Point Lepreau reactor in New Brunswick and the Gentilly-2 reactor in Quebec were originally estimated at $400 million apiece, but the actual construction costs were three times greater. Each reactor cost about $1,200 million.

The Darlington nuclear station in Ontario was originally estimated to cost about $2.5 billion to build, but it ended up costing $14 billion – more than a five-fold increase.

More recently, Pickering "A" Unit 4 was restarted at a cost of $1.2 billion, even though the initial cost estimate was $300 million – that's a four-fold increase. In a December 2002 report, the estimated cost of restarting all four Pickering "A" reactors had ballooned from $780 million to $3 to $4 billion – that's much more than a three-fold increase. In fact it probably represents a four-fold or five-fold increase.

Given this track record, prudence dictates that we assume, from the outset, that the estimated costs associated with the long-term management of irradiated nuclear fuel may well undergo a four-fold increase (or worse). Thus we recommend that the corporations now producing irradiated nuclear fuel be required to amass a sum of at least $80 billion through the trust fund mechanism already laid out in the Act, but without extending the time frame for contributions into the trust fund.

1.2 Some Notable Aspects of the NWMO Report

The Nuclear Waste Management Organization (NWMO) has done Canadians a service by confirming once and for all that the perpetual safe management of irradiated nuclear fuel is an unresolved problem of gigantic proportions.

In its recent report, entitled "Choosing a Way Forward" *[CAWF]* , the NWMO has confirmed that nuclear fuel, after being used in a nuclear reactor, will remain extremely dangerous for an extraordinarily long period of time, and that this material cannot be eliminated or rendered harmless by any method currently known to science:

> "... used fuel will remain a potential health risk for a very long period, likely hundreds of thousands of years or longer." *[CAWF, p. 9]*
>
> "A technical method cannot be practically demonstrated over thousands of years prior to implementation." *[CAWF, p. 11]*
>
> "... we must not ... pretend we have all the answers for all time." *[CAWF, p. 12]*
>
> "... no one of the management approaches ... perfectly addresses all of the objectives." *[CAWF, p. 19]*

But the industry-led organization has done Canadians a disservice by failing to report accurately and fully on the history of the irradiated nuclear fuel issue in Canada. At many of the NWMO dialogue sessions, participants asked how Canada got into the business of producing this incredibly toxic radioactive waste material. Did the decision-makers know at the outset how dangerous the stuff is? Or were they misled? Did the reactor owners know from the beginning how difficult and costly the waste would be to manage? Or were they simply unaware?

The NWMO report is silent on these vitally important questions of accountability. Yet they cut to the heart of the larger question of trust. If Canadians have been deceived before on this issue, deliberately or not, surely they must beware of being deceived once again – perhaps by the same parties.

The NWMO has also failed to study two historically significant approaches to the management of irradiated nuclear fuel waste: (1) the phase-out of nuclear power, and (2) the reprocessing of irradiated nuclear fuel to recover plutonium. Both approaches were raised explicitly during NWMO dialogue sessions, both are mentioned briefly in the NWMO report, both have been formally considered on previous occasions in the Canadian context, but neither is studied by the NWMO as an option.

In our opinion, these NWMO failures and oversights are not accidental, but are the consequences of entrusting a public policy question of enormous importance to a body which is owned by the industry that created the problem in the first place. Ultimately, the fault is with an ill-considered aspect of the Nuclear Fuel Waste Act, passed by the Chrétien government in 2002. which creates a powerful Nuclear Waste Organization that is owned by the nuclear industry. We recommend that this Act be repealed and replaced by one which puts the nuclear waste issue into the hands of an organization at arm's length from the industry and from the government, as was recommended vigorously by the Seaborn Environmental Assessment Panel in 1998.

1.3 The Need for Independence

In politics, as in life, whoever controls the information can often control the agenda. Until the mid-1970s, the Canadian nuclear industry was an impenetrable monolith. Secrecy was its hallmark, and the information willingly provided by the industry to the public was carefully crafted to reinforce the message that nuclear power is good.

In those days, as in these, most of the civil servants advising Ministers on matters of nuclear policy were drawn from the nuclear industry itself. With such ready access to the ears of the decision-makers by nuclear advocates , a favorable impression towards nuclear power was cultivated and constantly reinforced at the highest levels of government. Meanwhile, on most technical matters, mystification prevailed,

Things began changing in the mid-1970s. The 1974 detonation of India's first atomic bomb using technology freely provided by Canada and the USA, shocked the world. It provoked a profound public re-examination of nuclear power in several countries. In Canada, the 1975 revelations of radioactive contamination of homes and schools in Port Hope through the mismanagement of nuclear wastes added fuel to the fire.

The 1976 Flowers Report, "Nuclear Energy and the Environment", was published by the UK Royal Commission on the Environment. It raised a host of nuclear issues publicly for the first time ever. The report warned against any commitment to a large nuclear power program because of weapons proliferation concerns and the unresolved problems of nuclear waste management. The report was written by Sir Brian Flowers, a prominent nuclear physicist; it provided a wealth of information.

> "We have explained our reasons for thinking that nuclear development raises long-term issues of unusual range and difficulty which are political and ethical, as well as technical, in character.... More is needed here than bland, unsubstantiated official assurance that the environmental impact of nuclear power has been fully taken into account." *[Nuclear Energy and the Environmenty, para. 521]*

The 1978 Porter Commission Report "A Race Against Time", by the Ontario Royal Commission on Electric Power Planning, was the first independent investigation of the Canadian nuclear power industry ever to be made available to the Canadian public. It was an eye-opener. In many cases, industry assertions – even on some highly technical safety-related matters – did not stand up to independent scrutiny.

> "Governments must recognize that decisions about nuclear power are fundamentally political in the widest sense of the word; they relate to quality of life and quality of the environment; they cannot be left to the utility alone." *[A Race Against Time, Major Findings and Conclusions, p. xviii]*

> "Nuclear energy should no longer receive the major portion of energy research funding. There should be much greater expenditure on the development, demonstration and commercialization of energy storage, energy-efficiency (co-generation and fluidized bed combustion) and renewable technologies which are compatible with Ontario's energy needs." *[A Race Against Time, Major Findings and Conclusions, p. xvii]*

The House of Commons Public Accounts Committee also published a report in 1978 documenting the loss of $130 million on the sale of a CANDU reactor to Argentina and the unaccountable transfer of tens of millions of dollars into numbered Swiss bank accounts by Atomic Energy of Canada Limited, probably earmarked for bribes.

Then came the Three Mile Island meltdown in 1979. Following more than a year of public hearings, the Select Committee on Ontario Hydro Affairs published three reports in 1980: "The Safety of Ontario's Nuclear Reactors", "The Management of Nuclear Fuel Waste", and "Mining, Milling and Refining of Uranium in Ontario". All of them warned against accepting industry claims without independent scrutiny:

> "The AECB [Atomic Energy Control Board] should commission a study to analyze the likelihood and consequences of a catastrophic accident in a CANDU reactor. The study should be directed by recognized experts outside the AECB, AECL [Atomic Energy of Canada Ltd.] and Ontario Hydro. "
>
> [The Safety of Ontario's Nuclear Reactors, p. 37]

> "One of the major problems AECL [Atomic Energy of Canada Ltd.] must overcome is the public's perception that its entire program – from basic research to public information – is biased by its commitment to nuclear power and consequent desire to show that waste disposal is not an insuperable problem. The Committee's view is that AECL has compounded its credibility problem by its one-sided, overly positive and broadly pro-nuclear presentation of information."
>
> [The Management of Nuclear Fuel Waste, p. 26]

> "All citizens should:
>
> - have the right to be fully informed about the exact nature of the waste disposal program including any and all risks associated with it;
> - have an opportunity to ask questions on a regular basis of responsible officials relating to any aspect of the entire program;
> - have the right to express points of view to an independent decision-making body responsible for protecting public health and safety."
>
> [The Management of Nuclear Fuel Waste, p. 26]

> "A Council should be formed by the government of Ontario with ... representation from within and outside the nuclear establishment to ... focus on concerns about radiation problems in Ontario. The Council should review particular problems of radiation associated with operating or planned reactors independent of Ontario Hydro and the Government."
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> [The Safety of Ontario's Nuclear Reactors, Recommendation III]

Although these reports were written 25 to 30 years ago, they are all valuable resources. They represent a small handful of independent and authoritative assessments of the nuclear waste management problem and the industry that spawned that problem, carried out by bodies operating at arm's length from the industry. They are as compelling today as when they were written. They have stood the test of time, both scientifically and philosophically. They provide us with an independent point of view.

2.1 History of Irradiated Nuclear Fuel

Canada began producing irradiated nuclear fuel in 1945, just one month after the dropping of the world's first atomic bombs on the cities of Hiroshima and Nagasaki.

The war-time decision to build nuclear reactors at Chalk River, Ontario, was made in Washington D.C. by a tripartite committee in 1944. The Canadian research efforts were part of the World War II Atomic Bomb project – involving the USA, UK and Canada – as stated on a bronze plaque displayed at the Chalk River Visitor's Centre:

> "A nuclear chain reaction was first initiated in Canada on September 5, 1945, when the ZEEP reactor went into operation here at Chalk River. Originally part of an effort to produce plutonium for nuclear weapons, the reactor was designed by a team of Canadian, British, and French scientists and engineers assembled in Montreal and in Ottawa in 1942-43."

By 1975 – thirty years into the nuclear age – there were a dozen reactors operating in Canada, seven of them electricity-producing power reactors, all mass-producing irradiated nuclear fuel. Yet it wasn't until 1977, with the publication of the Hare Report ("The Management of Canada's Nuclear Wastes") that the Government of Canada first acknowledged the nature of the long-term hazard. Of the three authors, only A. Aikin, an ex-Vice-President of AECL, was knowledgeable on nuclear wastes.

The Hare report recommended burying irradiated nuclear fuel in the Canadian Shield and abandoning it there – an AECL plan later known as "geologic disposal".

One year later, in 1978, the Ontario Royal Commission on Electric Power Planning published its Report on Nuclear Power, entitled "A Race Against Time". The Commission observed that there is no scientific proof that geologic disposal will provide the necessary degree of protection to future generations. The Commission recommended that unless such proof could be provided by 1985, there should be a moratorium on the building of any new reactors in Ontario.

There have, in fact, been no new power reactors ordered since 1978, either in Canada or in the USA. Thus all of the nuclear power reactors in Canada today – eight at Pickering , nine at Bruce (including Douglas Point), four at Darlington, one at Rolphton (NPD), two in Quebec (Gentilly-1 and Gentilly-2), and one in New Brunswick (Point Lepreau) – were ordered at a time when neither the public nor their elected members had any idea of the scope of the nuclear waste problem.

Had they been properly informed of the hazardous nature of irradiated fuel at the outset, we believe that Canadians would never have accepted nuclear power. The fact that Canadians are now willing to shoulder responsibility for those nuclear wastes that have already been produced in no way justifies the continued production of such wastes in the future. Should we persist in manufacturing these wastes? It's a question NWMO never really asks, although many Canadians raised it with them.

2.2 History of AECL's Geologic Disposal Concept

In the mid 1970's, nuclear spokesmen generally portrayed nuclear power as safe and clean, a virtually trouble-free technology. Some stated in public that severe nuclear accidents were not really possible and that the long-term management of nuclear wastes was simply a public relations problem, not a serious technical problem.

Following the publication of the Hare Report in 1977, the Standing Committee on National Resources and Public Works held hearings into the nuclear fuel waste issue. During the 1977-78 session, the Committee received over 300 briefs, mostly critical of the Canadian nuclear industry's unproven claims and perceived conflict of interest.

Robert Uffen, Dean of Engineering at Queen's University and ex-Vice Chairman of Ontario Hydro, urged the Committee to recommend a halt to the building of new reactors until the waste problem is satisfactorily resolved. The Canadian Geological Council told the Committee that research into geologic disposal should not be left in the hands of the nuclear industry. This seems self-evident; if the nuclear industry views the waste issue as primarily a PR problem, how can it be trusted to give an objective, unbiased scientific appraisal of its own proposed geologic disposal program?

Meanwhile, the Ontario Royal Commission on Electric Power Planning was conducting public hearings into the entire spectrum of nuclear issues, from uranium mining residues to the potential for catastrophic reactor accidents to the long-term management of nuclear fuel and the possibility of plutonium recycling. The Commission was formulating similarly stringent recommendations.

Abruptly, in June 1978, without even waiting to hear from either the Parliamentary Committee or the Royal Commission, the Government of Canada signed an agreement with the Government of Ontario to authorize an extensive research program, under the direction of Atomic Energy of Canada Limited and Ontario Hydro, to "validate" the geologic disposal concept mentioned in the Hare Report.

Fifteen years and seven hundred million dollars later, AECL produced in 1994 a multi-volume Environmental Impact Statement on its Geologic Disposal Concept. The Environmental Assessment Panel that was appointed to evaluate the EIS was chaired by Blair Seaborn, and so it came to be known as the Seaborn Panel.

The Seaborn Panel concluded that the geologic disposal concept had not been demonstrated to be adequately safe in all respects, and that it was not considered a socially acceptable approach in the eyes of the Canadian public for a host of reasons.

The Seaborn Panel unanimously recommended that an independent Nuclear Fuel Waste Agency be formed, "at arm's length" from both government and the nuclear industry, to advise the government on a strategy for the long-term management of irradiated nuclear fuel. Instead, the Chrétien government created the NWMO, whose Board of Directors has as its sole members only those corporations that mass-produce irradiated nuclear fuel: Ontario Power Generation, NB Power, and Hydro-Québec.

2.3 History of the Three Management Methods

Therefore the Nuclear Fuel Waste Act (NFWA) of 2002 requires the corporations that produce irradiated fuel to create a non-profit body, the Nuclear Waste Management Organization (NWMO) , to elaborate a number of proposed approaches for the management of irradiated nuclear fuel. By law, the NWMO must recommend one or more of these approaches to the Government, and – by law – must study (among others) approaches that are based solely on one of the following three methods:

> Option 1 : deep geological disposal in the Canadian Shield;
>
> Option 2 : storage at nuclear reactor sites ["on-site storage"] , and
>
> Option 3 : centralized storage, either above or below ground.

Option 2 is, of course, the status quo. When first removed from the reactor, an irradiated CANDU fuel bundle (about the size of a fireplace log) is so radioactive that it would kill any unprotected human being standing a metre away from it for more than 20 seconds. Freshly discharged irradiated fuel generates a great deal of heat – so much that it must be cooled in a deep pool of slowly circulating water for at least seven years to prevent it from over-heating and releasing radioactive gases. After that time, the irradiated fuel can be transferred into heavily-shielded dry storage containers, each with its own cooling system, located close to the nuclear reactor site.

Option 1 is clearly the AECL concept of geologic disposal, first mentioned in the Hare Report of 1977. In 1998, the Seaborn Panel had concluded [see Exec. Sum.] that

> "The concept in its current form does not have the required level of acceptability to be adopted as Canada's approach for managing nuclear waste."

Among other things, the Panel was concerned about the safety of geologic disposal:

> "From a social perspective, safety of the AECL concept has not been adequately demonstrated for a conceptual stage of development." [Ch. 5.2.2.1]

Nevertheless, the Seaborn Panel did not reject the geologic disposal concept outright saying that further study would be needed to resolve a host of unanswered questions.

Option 3 was first considered and flatly rejected by the Ontario Royal Commission on Electric Power Planning, which concluded in its 1978 report:

> "there is no need for a central interim storage facility for spent fuel. All spent fuel should be stored at nuclear generating station sites, either in circulating water storage bays or in 'dry storage' if this proves feasible."
> *(A Race Against Time, Major Findings and Conclusions, p. xii)*

The Royal Commission was concerned about the risks of moving irradiated fuel:

> "The hazards associated with transportation, in particular the possibility of accidents and the threat of hijacking, are real possibilities. Hence, the minimization of handling and transporting spent fuel is a desirable objective." *(A Race Against Time, p. 91)*

Indeed, why move irradiated fuel from point A to point B if it's no safer at point B ?

2.4 NWMO's Option 4 : "Adaptive Phased Management"

In its May 2005 report, "Choosing a Way Forward", the NWMO claims to have developed a fourth option that combines aspects of the three options specified in the Nuclear Fuel Waste Act. The fourth option is called by NWMO, in a masterpiece of bureaucratese, "Adaptive Phased Management". The idea is to store the irradiated fuel at the reactor site for a certain period of time, then to move it to a centralized storage site for a while, and then to bury it deep in a stable rock formation forever.

As anyone can see, this is just Option 1 – deep geological disposal. In fact, the three options can be seen not as different options, but merely different phases of the one option that was foreshadowed back in 1977 by the Hare Report. In order to achieve deep geological disposal, one must have on-site storage to begin with, then transportation to a centralized site at a later time, and finally, burial in a deep rock formation.

Here's how the NWMO describes Option 1 *[CAWF, p. 51]* :

> "The management approach is:
>
> • Long-term management of used nuclear fuel through containment and isolation in a deep geologic repository;
>
> • Used nuclear fuel is transported from the nuclear reactor sites to a central location for long-term management;
>
> • Following an interim period of monitoring, the repository is closed, without the intent to retrieve the used fuel."

And here's how the NWMO describes Option 4 *[CAWF. p. 10]* ; it is

> "A risk management approach with the following characteristics:
>
> • Centralized containment and isolation of the used fuel in a deep geologic repository ... ;
>
> • Provision for ... shallow underground storage of used fuel at the central site, prior to final placement in a deep repository;
>
> • Potential for retrievability of the used fuel ... until ... final closure."

It is a mystery why the NWMO insists on calling this a fourth option. Perhaps it is too embarrassed to confess that its two-and-a-half years of study and dialogue have produced so little that is new. The NWMO maintains that this particular approach has "emerged from a process of collaborative development with citizens" *[CAWF, p. 11]* without acknowledging that it is also a public policy prescription written by nuclear advocates almost thirty years ago. If NWMO had stated openly that it was choosing Option 1 , it might have felt compelled to call its report "Following the Path Backward" rather than "Choosing a Way Forward".

To us, the NWMO "dialogue" process has the earmarks of an elaborate public relations marketing campaign rather than a democratic consensus-building process. The use of "focus groups", for example, was originally developed as a marketing tool, not as an instrument for conducting serious social science research. Was it perhaps a foregone conclusion that the dialogues would result in AECL's prior and preferred approach?

3.1 NWMO's Primary Stated Objective: Safety

The NWMO emphasizes that its primary objective is safety:

> "Our primary motivation is safety – to protect people and the environment from highly radioactive waste. We are not confused or conflicted about this objective and common vision." [CAWF. p. 11]

Strangely, however, there is no useful information in the document on the subject of human health, environmental integrity, or the biological effects of atomic radiation.

Why does human health have to be protected from irradiated nuclear fuel? Is it because high doses of radiation from used fuel will cause radiation sickness and possibly death? Is it because chronic exposure to low levels of radiation from used fuel can cause cancers of all kinds, as well as genetic damage that can affect future generations? Is it because exposure of a foetus to radiation can cause a host of developmental abnormalities, including spontaneous abortions, behavioural disabilities, mild-to-gross malformations and subsequent mental retardation? From the NWMO draft report, you would never know that these things are of concern.

Nor is there any discussion of how the hundreds of different radioactive materials in irradiated nuclear fuel can behave once they have escaped into the environment, or how they can affect biological organisms. The NWMO doesn't even give a list of these materials. There is no discussion of how some of the radioactive poisons in used nuclear fuel can concentrate in specific food chains, or how they accumulate in specific organs such as the lungs, the gonads, the thyroid, the liver, or the skeleton.

Others have done better. In 1980, the Select Committee on Ontario Hydro Affairs issued a report entitled "The Safety of Ontario's Nuclear Reactors" in which we read:

> "It is not right to say that a catastrophic accident is impossible . . . . The worst possible accident . . . could involve the spread of radioactive poisons over large areas, killing thousands immediately, killing others through increasing susceptibility to cancer, risking genetic defects that could affect future generations, and possibly contaminating large land areas for future habitation or cultivation. " *[Safety, pp. 9-10]*

Here's what the Royal Commission on Electric Power Planning had to say:

> "By definition, a major reactor accident would lead to the severe overheating, and subsequent melting, of the nuclear fuel, which would give rise to a substantial quantity of radioactive material escaping, after breaching several formidable barriers, into the environment.
>
> "The major health and environmental threat would be due to the escape of the fission products to the atmosphere. The most important of these are caesium, ruthenium, tellurium and the fission gases, iodine, krypton and xenon.
>
> "It is generally agreed that the greatest threat to health in the event of a major reactor accident is the considerable quantity of the radio-isotope iodine-131... which would be released to the atmosphere.

> "It is well known ... that iodine-131, after ingestion or inhalation, concentrates in the thyroid gland and may cause ... thyroid cancer. The threat to children in such circumstances is particularly serious because the iodine-131 could be ingested in the form of contaminated milk....
>
> "Because of its half-life of about 8 days, iodine-131 remains highly radioactive for a few weeks. Subsequently, the major contributor to the radiation field is caesium-134 with a half-life of two years. The radioactivity arising from this isotope would persist for many years.
>
> "Apart from the direct radiation to which individuals might be exposed in consequence of the released radioactivity, there would also be a threat to the public in the immediate vicinity of the affected nuclear power station, from radioactively contaminated food and water....
>
> "When we talk about the safety of a nuclear reactor, we are referring essentially to how effectively the fantastic amount of radioactivity contained in the reactor core can be prevented from escaping into the ground and atmosphere in the event of major malfunctions.
>
> "Clearly, if a major release of this accumulated radioactivity occurred ... the consequences would be extremely serious and could involve several thousand immediate fatalities and many more delayed fatalities."
>
> *[A Race Against Time, pp. 73-76]*

These radioactive poisons, released during a catastrophic nuclear accident, are those contained in freshly irradiated nuclear fuel. In older irradiated fuel, the isotopes of concern are different, but it is still important to know what they are and what they do

The failure of the NWMO to provide any meaningful discussion of health and safety is apparent in Appendix 2 of the report entitled "The Nature of the Hazard" *[CAWF, pp. 240-246]* In this appendix, nothing is said about specific biological hazards. The word "cancer" is never mentioned, nor are genetic or teratogenic effects alluded to. The discussion is quite dry, using language, concepts and units of measurement which are likely to be baffling and mystifying to the untutored lay person.

One section of the appendix deals with an absurd scenario of someone standing beside a million-year old used fuel bundle for 110 hours, yielding an external dose of radiation about equal to the annual regulatory limit for a member of the public. Yet only one sentence is devoted to the far more significant internal risk: "... this material is a potential internal exposure health risk for more than a million years." *[CAWF, p. 242]*

In fact, the principal radiological hazard of very old irradiated fuel is due to the extreme toxicity of alpha radiation. Alpha radiation is not an external hazard, but it is a very grave hazard inside the body. It is about 20 times more damaging (per unit dose) than the more penetrating gamma radiation. None of this is explained or even mentioned by NWMO. No attempt is made to calculate the number of fatal doses that could be administered through internal contamination by radioactive poisons contained in a single million-year old fuel bundle. The entire discussion is focused on measurements related to the physical sciences, not on health effects related to the biomedical sciences.

3.2 What is a Safe Dose of Radiation?

NWMO invokes human safety and environmental integrity, yet says nothing about either. What NWMO describes is engineering technology and radiation standards:

> "... exposure to the public is expected to be well within Canadian regulatory standards and norms." *[CAWF, pp.79, 80, 81, 82]*

But nowhere does NWMO address the question of whether the radiation standards adequately protect humans or the environment. We believe experience has shown that they do not. Many Canadians have died of radiation exposures well within those standards, and major radioactive pollution has resulted despite regulatory standards.

Science teaches us that all material things are made up of tiny particles called atoms. In nature, there are 92 different kinds of atoms, ranging from the lightest (hydrogen) to the heaviest (uranium). Everything we see around us – the rocks, the water, the plants and animals – are made up of various combinations of these 92 types of atoms.

Most atoms are stable. They never change, they just enter into different combinations. But some atoms are unstable; such atoms are said to be radioactive. At a particular moment, without warning, such an unstable atom will violently disintegrate. When this happens, the atom throws off a piece of itself – an alpha particle or a beta particle – and instantly changes into a different type of atom altogether. In addition, there is sometimes a burst of pure energy given off, called a gamma ray or a gamma "photon".

The emissions from disintegrating radioactive atoms are harmful to living things. Alpha particles, beta particles, and gamma rays are extremely energetic; so much so that they can randomly break the bonds that tie atoms together into molecules. (For this reason, they are collectively referred to as "ionizing radiation", along with X-rays.)

When this happens inside a living cell, the genetic instructions of the cell may be damaged. Such a damaged cell can then begin reproducing in an abnormal fashion, eventually resulting in a serious, possibly life-threatening illness. In particular, exposure to atomic radiation has been shown to cause cancerous growths of all kinds.

For this reason, atomic radiation is said to be carcinogenic (that is, cancer-causing). If an unborn child is exposed to atomic radiation in the womb, it may develop abnormally. Consequently, atomic radiation is said to be teratogenic (that is, causing abnormal development of a fetus). The most important teratogenic effects so far identified include physical malformations, behavioural abnormalities, and mental retardation in children exposed as foetuses during the formation of their brains.

If a man's sperm cells or a woman's egg cells are damaged by atomic radiation, their children or grand-children or great-grand-children may inherit defective genes. So atomic radiation is also mutagenic (that is, it causes damage to the genes).

The most prestigious independent scientific studies on biological effects of radiation have reported that there's no evidence to support the idea of a "safe" dose of radiation. They have concluded that every radiation dose, if administered to a large enough population, will cause proportional increases in cancer incidence and genetic disorders.

The nuclear industry knows that the regulatory standards do not protect individuals against the threat of cancer. In November 1981, two atomic workers at Chalk River, Ontario, were granted full pensions because of cancers which they had contracted as a result of radiation exposure on the job. "We acknowledge that it was probable that their cancers were caused by working here," said a statement by Chalk River Nuclear Laboratories, despite the fact that neither of the men had ever been over-exposed to radiation.

Robert Potvin, a spokesman for the Atomic Energy Control Board (AECB), which regulated the Canadian nuclear industry at that time, said that the two cases of compensation have "no implications" from the safety standpoint. They "simply confirm the long-standing expectation" that nuclear workers run a higher-than-usual risk of cancer due to years of exposure to low-level radiation, he said.

According to the best scientific evidence, the number of radiation-induced cancers and genetic defects occurring in a given population is proportional to the total dose of radiation received by that entire population – it's called the "population dose". If the population dose doubles, then the number of radiation-induced cancers and genetic defects will also double. If the population dose is cut in half, the number of radiation-induced cancers and genetic defects is likewise reduced by fifty percent.

This means that radiation standards cannot reduce the number of detrimental effects (e.g. cancers) to zero, but only to some number that is considered "acceptable". Which raises the question, "acceptable to whom?" Presumably, not to those individuals who get the radiation-induced cancers! Who makes the decision as to what is acceptable?

The radiation standards are set and administered by agencies having little expertise in the biological field. The Canadian Nuclear Safety Commission, for example, does not even have a Health division or a Medical division. Most CNSC staff members have expertise in the physical sciences or in engineering – not in medicine or ecology.

In 1980, in a chapter entitled "Atomic Energy Control Board: Unfit to Regulate", the British Columbia Medical Association noted that:

> "The Manager of the Radiation Protection Division of the AECB is Mr. Bush, who has a degree in Chemical Engineering (1955). He worked for Atomic Energy of Canada Limited (AECL) in Chalk River from 1957 to 1969, and subsequently with the AECB from 1969 to the present. One notes that Mr. Bush is responsible for developing radiation protection guidelines and regulations. Mr. Bush admitted, 'I'm not a medical doctor. I'm not an epidemiologist." *[Health Dangers of Uranium Mining, BCMA]*

In 1989, the Atomic Energy Control Board begged the Government for more resources to do its job better. In its presentation to the Treasury Board, AECB stated:

> "The AECB has a very small staff which is responsible for reviewing world-wide evidence of the effects of radiation on the human body, and for developing appropriate standards for radiation protection... Standards for radiation protection are controversial. The AECB must be up-to-date and be able to modify and defend its standards. It cannot do so with existing resources, which are about one-tenth of those used in the UK and the USA."

3.3 Radiation Standards: The Case of Radon in Mines

Let us consider the occupational standard for radon exposures in uranium mines. Radon is a radioactive gas which disintegrates within hours to produce a host of solid radioactive byproducts called "radon progeny" (once known as "radon daughters"). Every atom of radon comes from an atom of uranium, through a natural process of "radioactive decay". Thus radon levels are especially high in uranium mines.

Statistics have demonstrated that every uranium mining population around the world, including those in Canada, has shown a significant increase in lung cancer deaths due to the chronic inhalation of radon gas and the deposition of solid radioactive byproducts in the delicate lung tissues. Radiation standards have helped to limit the damage, but they have not prevented it. Mining deaths from radon continue to occur.

In 1980 the British Columbia Medical Association [BCMA] published a 470-page report, "The Health Hazards of Uranium Mining", expressing alarm at the elevated lung cancer risk assciated with a "permissible" level of occupational exposure to radon:

> "The AECB [Atomic Energy Control Board] is unfit to regulate uranium mining.... Despite AECB claims to the contrary, the [cancer] risks from radiation in uranium mining far exceed those of a 'safe' industry."
> *[Health Dangers of Uranium Mining, BCMA 1980]*

As in the case of cigarette smoking, excess radon-induced lung cancers do not occur right away. There is a period of time, called the "latency period", in which no increase is observable; then the increase in cancers becomes more and more apparent year after year. For lung cancer caused by radon exposure, the latency period is about 20 years:

> "Risk of lung cancer from radiation, although beginning after several years of employment, continues many years past termination of employment; thus a gradually flowering crop of cancers grows larger each year."
> *[Health Dangers of Uranium Mining, BCMA 1980]*

Displeased with BCMA's criticisms, AECB hired an independent expert to examine the evidence on radon. Drawing on cancer statistics in uranium mines world-wide, Dr. Duncan Thomas reported that the AECB's radon standard could lead to a quadrupling of lung cancer incidence: instead of 54 men out of 1000 dying of lung cancer, the rate could go as high as 110 to 300 lung cancer deaths for each 1000 men exposed, without exceeding AECB radon exposure limits. [AECB Research Report *INFO-0081, Sept. 1982]*

As recently as April 2003, miners in Northern Saskatchewan were sent into an area of the McArthur River mine where the levels of radon in the air were hundreds of times greater than the maximum permissible concentration. For 48 hours they were forced to work without the benefit of respirators which would have protected their lungs from unnecessary exposure to radon and its radioactive progeny. Following a protracted investigation, the Canadian Nuclear Safety Commission published a report on the incident which talked about engineering failures, management inadequacies, geological errors, radon measurements, and environmental effluents, but said not a word about human health or the increased risks to workers who had been so needlessly exposed.

3.4 Radiation Standards: The Case of Radon in Homes

The US Surgeon General has now declared radon exposure in homes to be the second leading cause of lung cancer, after smoking. The Governments of the USA and of Sweden have declared radon-induced lung cancer from residential exposure to be a major public health concern. In both countries, public service announcements urge homeowners to test their homes for radon and take corrective measures if needed.

Canadian authorities have downplayed the domestic radon hazard, and have set a standard for the allowable levels of radon in Canadian homes that is five times more permissive than in the USA or Sweden. The Canadian standard is 800 becquerels per cubic metre compared with the USA / Sweden standard of 160 becquerels per cubic metre.

A becquerel is a measurement of radioactivity. It indicates one radioactive disintegration per second. The Canadian radon standard says that it is acceptable to have 800 alpha particles emitted each second in each cubic metre of air in a home. That's 48,000 alpha particles per minute, or 2,880,000 alpha particles per hour, in each cubic metre of air.

In 1999, the US National Academy of Sciences estimated that a lifetime exposure to indoor radon at the Canadian standard would result in a seven-fold increase in lung cancer among smokers, and a three-and-a-half-fold increase in lung cancer among non-smokers. *[Health Effects of Exposure to Radon: BEIR VI, Table ES-1, p.12]*

For Canadian smokers, this would mean an increase in lung cancer deaths from 50 to 350 for each 1000 males so exposed. For Canadian non-smokers, lung cancer deaths would increase from 4 to 14 for each 1000 males exposed. That's a lot of extra deaths.

The USA / Sweden standard is not safe either; it's just not as brutal as the Canadian standard. The US NRC Report cited above indicates that a lifetime indoor radon exposure at the US standard would double lung cancer deaths among smokers, and increase lung cancer deaths among non-smokers by fifty percent. The report estimates that 15,000 to 21,000 people die of radon-induced lung cancer every year in the USA.

Based on these facts and figures, it is clearly not true that the radiation standards set by Canadian authorities serve to protect people from radiation-induced death. As the British Columbia Medical Association's 1980 Report stated:

> "Canadian regulations lag far behind countries which are more conscious and concerned about occupational and public health and safety."
>
> *[Health Dangers of Uranium Mining, Summary of Major Points, BCMA 1980]*

The 1999 US NRC Report [BEIR-VI] is the most authoritative independent scientific review of radon carcinogenesis available. It endorses the view universally adopted by all nuclear regulatory bodies in the world: there is no reason to suppose that any level of radon exposure is safe; in fact, there is good scientific evidence that the number of deaths caused by radon is proportional to the total dose received by the population.

3.5 Radiation Standards: The Case of Tritium from CANDU Reactors

Hydrogen is the lightest of all atoms. It is perfectly stable. Ordinary water is H2O : two atoms of hydrogen (H) combined with one atom of oxygen (O) makes a single water molecule. Water is present in all living things, and so, therefore, is hydrogen.

Tritium (T) is a radioactive form of hydrogen. A tritium atom is three times heavier than an ordinary hydrogen atom, but – except for the fact that it is radioactive – it behaves exactly the same as ordinary hydrogen. A water molecule made with tritium instead of with ordinary hydrogen is called a "tritiated" water molecule: T_2O or HTO.

During normal operation, CANDU reactors produce a lot of tritium – much more than any other kind of nuclear reactor. Although most of this tritium is contained inside the reactor, large quantities also escape into the environment around the plant – some of it in the form of radioactive steam (made up of tritiated water molecules), some of it in the form of radioactive ("tritated") liquid effluents.

Since tritiated water behaves just like ordinary water, the radioactivity cannot be filtered out or removed from the water in any easy way. So the tritium escapes into the environment and enters into drinking water, food, and (of course) the human body. Like all radioactive materials, tritium is a cancer-causing agent. It is also a mutagen and a teratogen – it causes damage to the genes and it provokes abnormalities in foetuses.

Less than ten years after the first CANDU reactors began operations, the tritium levels in the Great Lakes were found to be measurably increasing. While there are many American reactors on the shores of these lakes, almost all of the tritium in the lake water came from the Canadian plants. Tritium levels in the drinking water of communities near the Canadian reactors were also measurably increasing.

The regulatory limit for tritium in drinking water is much more lax in Canada than in other countries, perhaps because the tritium emissions from CANDUs are difficult to stop and the regulatory agency doesn't want to cause the industry too much trouble. After many passionate complaints by citizens about tritium in their drinking water, the Ontario Government asked the Advisory Council on Environmental Standards (ACES) to study the regulatory standards for tritium in drinking water to see if they were OK.

By comparing the toxicity of tritium to the toxicity of various chemicals, the ACES scientists ruled that the existing permissible levels for tritium were much too lax. They recommended that the permissible level for tritium in drinking water be sharply reduced from 10,000 becquerels per litre of water to 20 becquerels per liter within 5 years. That recommendation represents a reduction by a factor of 500 in the levels of tritium that were previously considered acceptable by Canada's regulatory agency.

Ontario set the drinking water standard for tritium at 7,000 becquerels per litre – 350 times higher than that recommended by the advisory panel based on medical science. In Canada, regulatory limits for tritium in drinking water have clearly been inadequate to protect public health or to preserve the environmental integrity of the Great Lakes.

3.6 NWMO's Safety Objection – Conclusion

The NWMO report offers the following remarkable boast:

> "The physical, chemical, and radiological characteristics of used nuclear fuel, and their hazards, are well understood." *[CAWF, p. 77]*

Insofar as the hazards are concerned, we do not believe this statement to be credible. In a 1989 AECL publication 211 different radioactive poisons are identified, all of them present in a 10-year old irradiated nuclear fuel bundle discharged from a CANDU reactor. The AECL authors state that their list is by no means complete.

Are we to believe that the Canadian nuclear industry or that the Canadian nuclear regulatory agency fully understands how each of these 211 substances will behave in the food chain, how they may concentrate in various organs, what dose of radiation they may deliver to exposed individuals, and what the precise consequences of those radiation exposures might be? Such a claim cannot be credited. Canadian nuclear agencies are dominated by physical scientists and engineers, and exhibit a dearth of biomedical or environmental scientists; they simply do not possess the expertise.

In 1984, the US Environmental Protection Agency (US EPA) and the US Nuclear Regulatory Commission (US NRC) asked the US National Academy of Sciences (US NAS) to provide "a comprehensive assessment of available knowledge of the risks associated with internally-deposited alpha-emitters". Here's what is stated in their final report, the 1988 US National Research Council Report entitled "Health Risks of Radon and Other Internally Deposited Alpha Emitters: BEIR-IV":

> "Radiation effects depend not only on the physical properties of emitted radiation, but also on the physiology and biochemistry of the exposed person and the physical and chemical characteristics of the radio-nuclides, which control their deposition, transport, metabolism, excretion, and reuse in the body....
>
> "Human data on cancer induction by alpha-particle irradiation are sparse.... All of the epidemiological surveys are presently in progress, none is completed ... so that the lifetime carcinogenic risks of alpha-radiation exposure remain uncertain. Sufficient human data are not available for assessing the late health effects of the transuranic elements, e.g. plutonium-239 ... so dependence must be placed on animal experiments....
>
> "Finally, the committee notes that it assumes no responsibility to address the subject of regulatory guidance on exposure levels or societal cost-benefit issues that involve the radionuclides of concern. Clearly, such issues are beyond the scope of the committee's task and beyond its expertise." *[NRC BEIR-IV, pp. 2-4]*

There is still an enormous amount that is unknown about the health effects of all these radioactive poisons. A 2004 UK Report by the Committee Examining Radiation Risks of Internal Emitters [CERRIE] points out there are great uncertainties in the risk estimates associated with radioactive materials that are incorporated into the body.

We believe that an organization having safety as its first objective should publish top-notch educational materials, written in simple English, documenting the spectrum of detrimental health effects associated with human exposures to at least 20 or 30 of the hundreds of radioactive materials (radionuclides) contained in irradiated nuclear fuel.

Such an organization should also explain in simple terms the ecological principals of bio-accumulation, concentration in the food chain, and relative biological effectiveness, combined with case studies of lessons learned in environmental contamination after episodes such as atmospheric bomb-testing in the 40s and 50s, the explosion of a tank of liquid high-level radioactive wastes in the Ural mountains in 1974, or the Chernobyl accident in the Ukraine in 1987, all involving the dissemination of fission products,

Instead, NWMO simply states that radiation exposures will be below regulatory limits, without even stating what corrective actions will be taken if radiation exposures turn out not to be below those regulatory limits. Will deeply buried wastes be dug up again? And if so, will it make any difference, since the damage will have been done already?

The NWMO is evidently accepting unscientific assurances, perhaps from its Board of Directors, on the state of our knowledge base regarding the health effects of radioactive exposures. Only from an industry-led organization would one expect this sentence:

> "There is also on-going debate on the potential benefits from low doses of radiation (hormesis)...." *[CAWF, p. 142]*

The self-serving hypothesis that low doses of atomic radiation could be harmless or even beneficial below a certain "threshold" of exposure {dubbed "hormesis") has been zealously advanced by nuclear advocates, and repeatedly discounted by every independent scientific body of stature since the 1950's. Yet the nuclear industry continues to mislead the public and their own workers by suggesting that radiation exposures below some arbitrarily-established regulatory limits are in fact "safe".

On June 29 2005, a committee of the US National Academy of Sciences published its findings on this precise question. The Seventh Committee on the Biological Effects of Ionizing Radiation (BEIR-VII) concluded, as had all the previous BEIR committees, that even very low doses of radiation pose a risk of cancer over a person's lifetime. It flatly rejected claims that tiny doses are harmless or may in fact be beneficial.

The Chairman of the Committee, Richard R. Monson, is a professor of epidemiology at Harvard's School of Public Health. At a press conference, he told the media:

> "The scientific research base shows that there is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial." *[Associated Press, June 29 2005]*

Back in 1977, the United Nations Scientific Committee on the Effects of Atomic Radiation [UNSCEAR] had stated as its guiding principle for radiation protection::

> "All radiation exposures should be avoided unless there is a clear benefit."

The use of fluorocarbons was phased out worldwide to protect the ozone layer. Quebec phased out the use of PCB's after a mammoth 1988 fire in a PCB warehouse at St-Basile-le-grand. Perhaps it is now time for Canada to stop producing irradiated nuclear fuel.

4.1 The Nuclear Phase-Out Option

As long as nuclear reactors continue to operate in Canada, there is a fresh supply of highly radioactive used fuel being mass-produced on a daily basis. For seven to ten years, this irradiated fuel is literally too hot to be transported away from the reactor site. Thus, there will always be seven-to-ten-years worth of irradiated nuclear fuel at the site of each operating reactor, no matter what is done with the older used fuel.

The catastrophe potential at a reactor site depends mainly on the irradiated fuel that is inside the reactor core and in the water-filled spent fuel bay. These two locations account for well over 90 percent of the total radioactivity on-site, even if all of the older irradiated fuel is maintained in dry storage containers right on-site or close by.

The reason for this is that a "fresh" irradiated fuel bundle – one just removed from the reactor core – is 1000 times more radioactive than one which is ten years old, even though the latter remains one of the most deadly radioactive objects on earth.

Thus, as long as nuclear reactors continue to operate, the risk to public health and to the environment around the reactor sites is only marginally diminished, regardless of what option is adopted by the NWMO or the Government for the long-term management of used fuel. There will always be 7–10 years worth of the hottest stuff left on-site.

Moreover, transporting irradiated nuclear fuel to a central repository only exacerbates the problem as long as the reactors themselves continue to operate. For, instead of having seven sites where irradiated nuclear fuel is stored, as is the case at present, we will have eight sites: the seven reactor sites plus the centralized repository. And there is the added danger of transportation exposures, accidents and highjackings.

A similar consideration applies to deep geologic disposal. As long as the reactors continue to operate, the catastrophe potential is virtually unchanged at the reactor sites, but the never-ending transports of irradiated fuel and the temporary central storage of irradiated fuel will simply add new risks to the existing ones.

Moreover, the deep geologic repository will not likely be closed and sealed as long as reactors are continuing to produce more and more irradiated nuclear fuel. Indeed, it is difficult to see how the repository could be sealed until the very last nuclear reactor has been shut down for at least seven-to-ten years, and probably much longer.

Despite the logic of these observations, the NWMO refuses to endorse a "nuclear phase-out" scenario. Since the organization is motivated by safety – protecting human health and preserving environmental integrity – how can it fail to realize that the safety objective is impossible to achieve without a nuclear phase-out?

We believe that until Canada stops producing this highly toxic material, transporting it over highways or rail lines or rivers or lakes is analogous to rearranging the deck chairs on the Titanic – there is no way that shuffling the used fuel can prevent a catastrophe from happening. It is disappointing that an organization committed to safety will not study the option of stopping the production of the toxic material that poses the threat.

4.2 The Case for a Nuclear Phase-Out

In its glossary, the NWMO report says this about the precautionary principle:

> "... in decision-making, greater benefit of the doubt will be granted to the environment and to public health than to the activities that may be held to threaten these things.... The absence of full scientific certainty shall not be used as a reason for postponing decisions where there is risk of serious or irreversible harm" *[CAWF, p. 294]*

Nuclear power is the only civilian technology that produces new unstable elements that did not exist in nature before. Since elements are the basic building blocks of all material things, the harmful effects of these unstable elements cannot be neutralized by any practical method known; they clearly pose a risk of serious and irreversible harm.

A nuclear power reactor is designed to boil water. The resulting steam is used to turn turbines, thereby generating electricity exactly as in a coal-fired, oil-fired, natural-gas-fired, or wood-burning plant. The "nuclear fire" is just another kind of water-boiler. But the "ashes" of that nuclear fire are sufficiently poisonous to cause billions of human cancers, and so long-lived that they must be forcefully kept out of the environment for periods of time that dwarf the imagination. According to the precautionary principle, nuclear power should be phased out. There is no reason for postponing that decision.

The NWMO promised in its first discussion document that "… where the NWMO feels that assumptions around future energy scenarios are critical to the assessment, this will be reported." [Asking the Right Questions, p. 20] But in its draft study report, the NWMO has not identified any of the problems that continued waste production will have on building a socially acceptable waste management option.

For example, the NWMO report states that if all nuclear reactors are refurbished and new reactors are built [Continuing CANDU Nuclear Program, p. 292] used nuclear fuel would be transported to the central management site for a period of 250 years at a rate of about 120,000 bundles a year. [CAWF, p. 292] If on the other hand, nuclear power is phased out following NWMO’s timetable (all reactors shut down by 2012) the transportation period for used fuel would only be 20 years [CAWF, p. 291] .

A nuclear phase-out is of critical importance for all parties, especially for communities along the transportation routes. Without a phase-out, the catastrophe potential at all reactor sites will remain enormous, a new and growing catastrophe potential will be created at the central repository, and shipments of irradiated nuclear fuel by road, rail, or water, will be unremitting. How can this be called a solution to the waste problem?

Yet the prospect for a nuclear phase-out is not on the table, politically speaking. In November 2005, NWMO's final report goes to the Minister of Natural Resources. On March 9 2005, the current Minister, Mr Efford, told the Canadian Nuclear Association:

> "We are on the threshold of a new age for nuclear energy..... Please be assured that we will continue to support the industry so that it continues to grow and remain competitive and viable for the long term."

4.3 Stifling Debate on a Nuclear Phase-Out

As previously noted, in 1978 the governments of Canada and Ontario directed AECL to examine the concept of deep geologic disposal of irradiated nuclear fuel in the stable rock of the Canadian Shield. Ten years later, the federal Energy Minister, Jake Epp (now Chairman of Ontario Power Generation) referred the AECL concept to the Environment Minister, Lucien Bouchard, for public review by a panel under FEARO (The Federal Environmental Assessment and Review Office).

Mr. Epp's proposed terms of reference explicitly forbade the panel to study the option of stopping the production of irradiated nuclear fuel by shutting down nuclear reactors. Mr. Bouchard objected to this, saying that the principle of "reduction at source" must be an essential aspect of any waste management strategy. Mr. Epp finally compromised, promising that the government of Canada would hold parallel public hearings on the subject of nuclear energy. This evolved into a promise for a set of public hearings on Canadian energy policy, which would include nuclear energy as one component.

When the panel began holding public hearings, Mr. Blair Seaborn, the Panel's Chairman, repeatedly assured the public that there would be a parallel set of public hearings to address the question of whether Canada should continue to produce irradiated nuclear fuel. Such hearings were promised and would take place, he said.

But the government reneged on its promise. The parallel hearings never took place. A chastened Mr. Seaborn had to publicly apologize for his previous assurances, saying that he did not understand why the government had decided not to keep its promise.

The Seaborn Panel delivered its report in 1998, and the government of Canada passed the Nuclear Fuel Waste Act in 2002, requiring the creation of the NWMO. From the beginning, NWMO representatives stated that it was "not within their mandate" to discuss the question of stopping the production of nuclear wastes. They were not allowed to raise this question, although they could report that they heard others say it.

It appears that either the government of Canada or the Board of Directors of the NWMO did not want to allow for a truly open discussion of all the relevant options. As a result, NWMO has not studied any approaches that are predicated on a nuclear phase-out. This is legally significant, because according to the Nuclear Fuel Waste Act, the government will choose one of the approaches that NWMO has studied.

Once again, the idea of a nuclear phase-out is simply not on the table. It seems that government and industry have no intention of discontinuing the production of irradiated nuclear fuel. In fact the "management options" discussed by NWMO are just that: options for endlessly producing, transporting, and managing these wastes, with no end in sight. It's not really a question of getting rid of these wastes once and for all, but simply "clearing the decks" in order to make room for more.

The NWMO report states that some participants in the dialogues questioned the continued production of nuclear electricity. In fact, they were questioning not the electricity, but the risk of catastrophe and the continued production of nuclear waste.

4.4 The Kyoto Accord and the Nuclear Phase-Out Option

Nuclear advocates often argue that nuclear power is needed to replace fossil fuels. How else will we reduce greenhouse gas emissions and meet our Kyoto obligations?

But solar energy, wind power, ocean thermal energy, and a host of other renewable energy sources are also free of greenhouse gas emissions. Moreover, studies show that each dollar invested in energy efficiency will, on average, displace seven times as much greenhouse gas than if that same dollar were invested in nuclear power.

In 1993, the Royal Society of Canada published its COGGER report ("Canadian Options for Greenhouse Gas Emissions Reduction"). No mention is made of nuclear power as an alternative energy source because, when considering the priorities for reducing greenhouse gas emissions. nuclear is just too far down the list to be interesting.

Nevertheless, the Government of Canada has spent 17 billions of taxpayers' dollars promoting nuclear power, and it can't seem to bear the idea of phasing it out. In fact, Ottawa tried very hard to have nuclear power treated as a "green" energy alternative for the purpose of satisfying the Kyoto Accord on the reduction of greenhouse gas emissions, only to be turned down flat by the European Union and other countries.

The Minister of Environment for Norway, addressing Ottawa's proposal, stated "The position of Canada just replaces one problem with another." The British Minister of Environment, Micheal Meacher, called the Canadian proposal "very controversial".

Germany declared that it completrely rejected the idea of using nuclear in the context of the Kyoto protocol for reducing greenhouse gas emissions. Austria, Belgium, Denmark, Greece, Ireland, Indonesia, Italy and Switzerland all declared themselves to be opposed to using nuclear in the context of Kyoto.

Even France, which produces 90 percent of its electricity from nuclear plants, rallied to the position of the European Community on the exclusion of nuclear power in the Kyoto context.

Indeed, Sweden, Germany and Belgium (among others) are committed to phasing out nuclear power. While it is true that these government policies, like many government policies, are controversial and provoke spirited debate among the respective populations, they are commitments and they are being adhered to.

The NWMO Report proudly refers to Sweden's plans for geologic disposal of irradiated nuclear fuel, but fails to mention that Sweden is also phasing out of nuclear power in accordance with a national referendum held 25 years ago.

In the 1980 Swedish referendum, people voted on three alternative ways of phasing out nuclear power; the vote gave no option to continue nuclear energy. As a result, the Barseback-1 nuclear reactor was closed in 1999, and the Barseback-2 reactor (responsible for almost 4 percent of Sweden's electricity) was closed in June 2005.

The Swedish Sustainable Development Ministry says measures to increase energy from renewable sources to replace the capacity lost through the closure of Barseback 1 and 2 have been completed.

Germany has also decided to phase out of nuclear power. Under current legislation, each of Germany's 19 reactors will be phased out on its 32nd birthday – at which point it is closed permanently. The first to close was the Stade nuclear reactor, near Hamburg. The second reactor, Brunsbuettel, was shut down in 2005. The Biblis A reactor, in service since 1975, will be the next one to close in February 2007.

To replace the nuclear plants, the German government is proposing investment in other sources such as wind power. Germany already produces 40 percent of all the world's wind power and the hope is that by 2010, wind will meet 12.5 percent of German energy needs. The country has 16,000 wind turbines, mostly concentrated in the north of the country, near the border with Denmark.

Germany's Environment Minister, Juergen Trittin, says "We are on a strategy to phase out nuclear, to raise the share of renewables, and to increase the efficiency of fossil power plants," he said. "We understand that this makes it possible that in the year 2020, when we have phased out nuclear, we will have been able to reduce greenhouse emissions by 40 percent compared with 1990."

Germany's ambitious plan to phase out nuclear power by 2020 while also reducing its reliance on fossil fuels has made it a leader in efforts to fulfil the Kyoto protocol.

In both the Swedish and the German examples, the electricity that was previously produced by nuclear reactors will be replaced by electricity from renewable sources. Of course, the nuclear industry continues to argue in favor of reliance on nuclear energy, but their arguments have not been found to be valid. As Mr. Trittin says:

> "Ten years ago people told us that there would never be enough capacity to have a relevant share produced by wind – now the same people tell me we have too much wind, and have to export electricity because we have such a huge share of wind energy. To hear such arguments from people who haven't learned anything in the last half century – I am very calm on that. So I can't take these [pro-nuclear] arguments seriously."

The Suzuki Foundation recently published a report by Ralph Torrie on the range of strategies available to Canada to meet the Kyoto targets for CO2 reduction. Nuclear power doesn't even make the list. A second Torrie report indicates that Canada could phase out of nuclear power completely while meeting all its energy demands.

The Canadian Government owes the Canadian population and its Parliament a say in deciding whether Canada should stay in the nuclear game or get out. No doubt, management of nuclear wastes will play an important part in the debate, as will the proliferation of weapons-usable plutonium through the export sales of CANDU reactors. But the most contentious issue will probably be how to achieve a nuclear-free Canada without increasing fossil fuel use. We will welcome such a debate.

5.1 The Reprocessing Option

Nuclear phase-out is not the only option that NWMO neglects to study. Plutonium reprocessing is another. In the core of an operating reactor, certain uranium atoms absorb neutrons without undergoing fission, and are transmuted into plutonium atoms. In fact, the first nuclear reactors in the world were built for the purpose of producing plutonium, the principal nuclear explosive in most nuclear weapons.

Plutonium is contained in the irradiated nuclear fuel. It is only one of hundreds of materials that have been created inside the uranium fuel matrix, but it is regarded as a uniquely valuable constituent because of its explosive and fissionable properties.

To extract plutonium from used nuclear fuel requires a reprocessing facility. Using robotic equipment to protect workers from the intense radiation fields, irradiated nuclear fuel is chopped into pieces which are then dumped into metal baskets suspended in boiling nitric acid, where the solid waste is dissolved. Once the waste is in liquid form, it is possible to chemically separate out the plutonium (one quarter of one percent) from the rest of the radioactive garbage. But millions of gallons of liquid radioactive waste are left behind, in a hot, corrosive, acidic solution.

Separated plutonium is a strategic nuclear material because it can be used to make an atomic bomb. However, plutonium can also be used to fuel a nuclear reactor. Most nuclear technologists, including many of those in Canada, believe that it would be a sin to bury the irradiated nuclear fuel from existing reactors without first separating out the plutonium for use as a fuel in future nuclear reactors. This is called the reprocessing option. It is described briefly in Appendix 8 of the NWMO Report, but without any historical context to give it meaning.

In the main report, the NWMO hints at the reprocessing option, but in a rather obscure way which fails to clarify the true nature of reprocessing technology:

> "Members of the public had a particular interest in reprocessing of used fuel, as it seemed to be related to desirable environmental concepts of recycling and re-use." *[CAWF, p. 13]*

> "There was a strong sense among some of the participants that the used fuel may represent a potential resource for future generations." *[CAWF, p. 45]*

> "Some participants took issue with the deep geological disposal approach in that sealing away the used nuclear fuel would deprive future generations of the opportunity to use the remaining energy within the spent fuel." *[p. 53]*

In these enigmatic remarks, no explanation is made of the fact that reprocessing involves extracting plutonium, which is a weapons-usable nuclear explosive material. No mention is made of the solid used fuel being dissolved in acid, releasing radioactive gases and yielding liquid wastes which are much more mobile in the environment than solid used fuel. No discussion is given of the associated risks to the health of workers and to the integrity of the surrounding environment. Nor is it pointed out that those suggesting reprocessing are in most cases nuclear advocates.

5.2 A Brief Historical Note on Reprocessing

Far from being a futuristic technology that may become available to future generations, reprocessing is an old technology that pre-dates the use of nuclear reactors to generate electricity. All countries with a nuclear weapons program also have a well-established reprocessing technology: USA, France, Britain, Russia, China, India, Pakistan, Israel....

During World War II, the USA constructed plutonium-producing reactors at Hanford Washington, together with a large reprocessing plant to separate out the plutonium that was subsequently used in the first atomic explosion at Alamagordo New Mexico in July, 1945. The same reprocessing facilities were used to obtain the plutonium for the atomic bomb that destroyed the city of Nagasaki on August 9 1945.

The current crisis over North Korea and its nuclear weapons capabilities has to do with the fact that that country has been reprocessing irradiated nuclear fuel to obtain plutonium, which can then be readily used to make nuclear weapons.

In the last two years of World War II, scientists from France and Britain worked with Canadian scientists at a secret wartime nuclear laboratory in Montreal to perfect the most efficient methods for producing and separating plutonium on a commercial scale. Partly as a result of their Montreal experiences, France and Britain became the world's foremost commercial reprocessors of irradiated nuclear fuel after the war.

For decades now, countries with power reactors have sent their irradiated nuclear fuel to France or to England where it is reprocessed. The separated plutonium and the re-solidified high-level radioactive waste are sent back to the country of origin. This is done for a hefty fee, because nuclear technologists in all these countries believe that plutonium is destined to replace uranium as principal fuel for reactors.

From the beginning, it has been assumed that uranium will be superceded by plutonium as a nuclear fuel for one simple reason: uranium supplies are not expected to outlast oil supplies if nuclear power is to be successful in displacing fossil fuels.

Thus countries like Japan, India, France, and Russia, routinely reprocess their irradiated nuclear fuel, creating large stockpiles of separated plutonium intended for commercial (non-military) use. Of course, this commercial plutonium could be used to make nuclear weapons if desired. Jane's Intelligence Review has estimated that if India were to convert all of its civilian stockpiles of separated plutonium to military use, its nuclear arsenal would be larger than Britain's.

None of this vital information is to be found in the NWMO report. The nuclear weapons connection, which is particularly acute in the case of reprocessing, is only briefly mentioned. The fact that reprocessing is a daily reality in many countries that rely on nuclear-generated electricity is never made clear. The idea that nuclear planners tend to regard the use of plutonium-based fuel as inevitable is nowhere expressed. How can NWMO expect to gain "informed consent" without informing?

5.3 Reprocessing and Waste Disposal in Canada

Canada's first reprocessing facility was built at Chalk River Ontario in the late 1940's in order to aid British scientists in their efforts to build the first non-American atomic bomb. First, irradiated fuel from the Canadian NRX reactor was reprocessed at Chalk River. Britain obtained its first sample of plutonium metal from this Canadian source in 1952, the year in which Britain exploded its first atomic bomb in Australia.

In 1974, the Indian government exploded its first atomic bomb using plutonium obtained from the reprocessing of irradiated nuclear fuel from the CIRUS reactor. CIRUS was an identical copy of the NRX reactor given by Canada as a gift to India. Once the plutonium had been separated, building the bomb was not too difficult.

Canada, however. was interested in developing nuclear power, not bombs, and AECL saw plutonium as the key to the future of its nuclear electricity-generating program.

In February of 1977. eight senior officials from Atomic Energy of Canada Limited held a day-long seminar in Ottawa for top civil servants. The purpose was to promote AECL's "Fuel Cycle Centre" for reprocessing spent CANDU fuel in order to recycle the plutonium. Ross Campbell, Chairman of AECL, opened the seminar:

> "The separation and use of plutonium would be a long-range job requiring careful planning and research.... We are already late in starting to bring this new energy source on stream in the critical last decade of this century, when real shortages of energy will appear."

What was being proposed was geologic disposal of irradiated nuclear fuel, but with one important proviso: some time before the irradiated fuel at the centralized storage facility is to be buried in a deep geological formation, it has to be reprocessed:

> "AECL believes that our major long term program should be development and demonstration of fuel recycle and disposal of radioactive wastes. Given a start this year and the availability of world technology through agreements with other countries, we believe that it is possible to complete this by the end of the century." *[Stan Hatcher of AECL's Whiteshell Research Centre]*

It was made crystal-clear to those present that, from AECL's perspective, the disposal of irradiated nuclear fuel is inseparably connected with the reprocessing of irradiated nuclear fuel; you can't have one without the other. The idea is to bring all the irradiated fuel to one central location, reprocess it, resolidify the liquid waste, and bury that stuff deep underground. John Foster, AECL President, closed the seminar:

> "I have not said much about the waste disposal aspect. This is not because it is not important – it is extremely important; but it is a part of the total program. It cannot be dissociated from the fuel cycle program.... Admittedly a positive decision with respect to the back end of the fuel cycle, today, takes a certain amount of guts because authorities all over the world are proceeding with understandable caution in the face of the bad name undeservedly attached to plutonium.... But plutonium is an extremely useful material and we will be dealing in it." *[John Foster, AECL President]*

Later that year, the Hare Report confirmed that all nuclear waste disposal plans in Canada had been made on the presupposition that reprocessing would take place:

> "The program to develop a permanent disposal method for fuel cycle wastes has proceeded on the assumption that the irradiated fuel would be processed to recover the plutonium and that the wastes would be those arising from such processing. Little detailed attention has been given to the idea of immobilizing and disposing of the irradiated fuel directly." *[The Management of Canada's Nuclear Wastes, EP77-6, p. 48]*

Meanwhile, the Royal Commission on Electric Power Planning was being told nothing about AECL's plans for reprocessing and plutonium recycle, even though the Commission had been conducting public hearings on nuclear power since 1976. Once AECL's plans were made known, the topic of reprocessing became a major focus of concern at the Royal Commission, and was featured in its 1978 report:

> "Spent fuel reprocessing and advanced [plutonium-based] fuel cycles should not be part of Ontario Hydro's system planning to the year 2000. Hence, there is no need for a central interim storage facility for spent fuel. All spent fuel should be stored at nuclear generating station sites, either in circulating water storage bays or in "dry storage" if this proves feasible." *[A Race Against Time, pp. xii-xiii]*

> "From health, environmental, and safety points of view, we believe that the existing CANDU cycle is much preferable to an advanced fuel cycle which would necessitate reprocessing and the management of high level liquid wastes." *[A Race Against Time, pp. 89-90]*

> "We prefer on-site (i.e. generating station site) spent fuel storage to a centralized facility. We believe that a central facility would presuppose the reprocessing of spent fuel; it would also involve more transportation and social and environmental problems." *[A Race Against Time, p. 95]*

Nowhere in its report does NWMO explain this historic and institutional linkage between management of used fuel (geologic disposal) and the reprocessing option.

Although the prospects for reprocessing spent nuclear fuel in Canada are not very good at the present time, the reprocessing option has never been taken off the table. AECL's 1994 Environmental Impact Study for the Geologic Disposal Concept states:

> "If used fuel were reprocessed, the most radioactive material that remained (the high-level [liquid] waste) would be solidified. The term 'nuclear fuel waste', as used in this document, refers to either the used fuel, if it is not to be reprocessed, or the solidified high-level waste from reprocessing." *[AECL EIS, Overview, p. i]*

And again, later in the document, when discussing the siting of a repository:

> "If retrieval was intended to provide used fuel for future reprocessing and recycling, it would be desirable to select a site for centralized storage and disposal that was also suitable for a reprocessing facility." *[AECL EIS, p. 333]*

5.4 Reprocessing, Plutonium and Nuclear Weapons

In 1977, US President Jimmy Carter passed a law, still in force today, against the commercial reprocessing of irradiated nuclear fuel in the USA. There is no such law in Canada. Carter, while President, tried to get reprocessing banned world-wide because it makes separated plutonium readily available. Separated plutonium can be used by any regime or terrorist group to make powerful nuclear explosive devices.

In 1978, Prime Minister Pierre Elliot Trudeau, speaking at the UN Special Session on Disarmament, articulated his famous "strategy of suffocation". Trudeau said that if the world wants to end the nuclear arms race it must begin by choking off the vital oxygen on which it feeds, i.e. by eliminating the two nuclear explosive materials: separated plutonium and highly enriched uranium. To achieve this, there would have to be a world-wide ban on reprocessing plants and uranium enrichment plants.

Since those events, Canadian nuclear scientists have learned not to speak too often or too openly about their hopes and aspirations for the eventual use of reprocessing and plutonium-based fuels. But those dreams are still present, just below the radar.

In the 1980's, at AECL's Whiteshell Nuclear Research Establishment in Manitoba, scientists built a secret facility to test the re-solidifcation of post-reprocessing liquid wastes as part of the research program on geologic disposal of irradiated nuclear fuel. The justification was, of course, that the spent fuel might end up being reprocessed, and the post-reprocessing waste would end up being buried in the Canadian Shield

Meanwhile, at AECL's Chalk River Nuclear Establishment in Ontario, working in gloveboxes, men fabricated over three tons of plutonium-based fuels by hand, using plutonium extracted from CANDU fuel bundles in a reprocessing plant in Italy, and flown into Mirabel airport in Quebec under a thick blanket of secrecy. This sizable quantity of plutonium-based fuel, called "MOX" (a "mixed oxide" of plutonium and uranium blended together), was used to fuel research reactors and even electricity-generating power reactors in Ontario, to prepare for its future use on a large scale.

Despite the unpopularity of plutonium among some Presidents and Prime Ministers, AECL continued to plan for the day when plutonium would be "rehabilitated" and accepted back into "polite society" as one of the fuels of the future. AECL knew that plutonium was already being recycled in Europe and that plutonium-based MOX fuel was being used on an almost routine basis there. But how could this be attempted in Canada, when reprocessing of irradiated nuclear fuel was not yet a possibility?

Opportunity knocked in 1996, when Prime Minister Jean Chrétien informed Russia and the USA that Canada would be willing to consider importing weapons-grade plutonium extracted from dismantled nuclear warheads. AECL's idea was that the weapons-grade plutonium could be blended with uranium to create MOX, which could then be used to fuel the Bruce reactors at Kincardine Ontario to make electricity. Stiff public opposition has so far prevented this plan from becoming a reality.

5.5 The NWMO and the Reprocessing Option

If reprocessing is ever to take place in Canada, it will be at the same site that is chosen as a central repository for irradiated nuclear fuel. Any potential host community must be made aware of this, as the health, environmental, and safety implications are great.

In its report, NWMO has failed to explain the reprocessing option in plain English, has failed to highlight the social and environmental problems associated with this technology, and has failed to make any recommendations on the subject.

Reprocessing requires converting the entire radioactive inventory of used nuclear fuel into a corrosive liquid form. Radioactive gases are liberated and radioactively contaminated liquid effluents are dumped into the local environment. Plutonium contamination of air, soil, surface waters, workers, clothing and equipment will occur.

In addition, the presence of separated plutonium makes any reprocessing facility a high-level security risk. The private lives of workers and the local population will have to be investigated and kept under scrutiny because of the dangers of infiltration by criminal or terrorist elements wishing to obtain weapons-usable materials.

The following is from a 1976 British Royal Commission Report, "Nuclear Energy and the Environment", written by Sir Brian Flowers, a prominent nuclear physicist:

> "We should not rely for energy supply on a process that produces such a hazardous substance as plutonium unless there is no reasonable alternative."
>
> "Plutonium appears to offer unique potential for threat and blackmail against society because of its great radiotoxicity and its fissile properties. The construction of a crude nuclear weapon by an illicit group is credible. We are not convinced that the Government has fully appreciated the implications of this possibility."
>
> "The unquantifiable effects of the security measures that might become necessary in a plutonium economy should be a major consideration in decisions on substantial nuclear development. Security issues require wide public debate."
>
> "There should be no commitment to a large nuclear programme . . . until the issues have been fully appreciated and weighed in the light of wide public understanding." *[Flowers Report, Principle Conclusions]*

We believe that the Canadian Government should enact a law prohibiting the reprocessing of irradiated nuclear fuel, as in the USA. Without such a law, there is a real danger that any "willing host community" for a centralized storage site may find itself. at some time in the future, the unwilling host of a reprocessing facility.

Indeed, it is difficult to justify the risk and the expense of transporting irradiated fuel to a central repository unless it is for the express purpose of eventual reprocessing. As the Porter Commission found in 1978, centralized storage presupposes reprocessing.

6.1 Managing to Overlook Nuclear Wastes ~ Part 1

The Nuclear Waste Management Organization is a misnomer; for it is not mandated to deal with the management of all nuclear waste, only with irradiated nuclear fuel.

There are over 200 million tons of radioactive tailings left behind from milling uranium ore, in Northern Ontario, Northern Saskatchewan, and the Northwest Teritories. These sand-like mill residues contain 85 percent of the radioactivity that was present in the original ore. They will remain dangerously radioactive for hundreds of thousands of years. The NWMO Report says nothing about them.

From these voluminous tailings deposits, radioactive dust and gas is constantly being dispersd into the atmosphere. Radioactive radium, polonium, and lead are seeping into surface waters and threatening to contaminate ground waters.

If human health and safety is to be a primary objective, it seems evident that uranium tailings pose a more immediate threat than irradiated nuclear fuel because the latter is contained far more securely than the former. As the Ontario Royal Commission on Electric Power Planning concluded:

> "The mining and milling of uranium ore produces very large volumes of long-lived, low-level radioactive tailings ... thereby posing serious health and environmental problems." [A Race Against Time, p. 64]

> "... the long term management of very large volumes of environmentally hazardous tailings, perhaps in perpetuity, represents an extremely difficult issue." [A Race Against Time, p. 147]

> "Uranium mill tailings will constitute an increasing health and environmental problem. An independent review committee should be established to study the problem.... The future of the nuclear program should be assessed in light of the committee's findings."
> [A Race Against Time, p. xiii]

The NWMO could have made a similar recommendation, but it chose not to do so.

It might be thought that the health and environmental risks of uranium ore and uranium residues, however serious, are not relevant to NWMO's main responsibility, which is the management of irradiated nculear fuel. However, in Appendix 2, "Nature of the Hazard", NWMO uses a natural uranium ore deposit as a baseline:

> "Over a million year time period ... the total radioactivity of used fuel then becomes comparable to the total radioactivity associated with [a] natural uranium ore deposit. This is considered by some people to be a useful benchmark." [CAWF, p. 241]

If a uranium ore body is to be a useful benchmark, the radiotoxicity of such a deposit should be studied or delineated by NWMO. Some uranium deposits in Northern Saskatchewan are so radioactive that the mining companies must use robots rather than humans to mine the ore Moreover, no uranium ore deposit on earth has a concentration of uranium as high as that of a fuel bundle (a "grade" of over 98 %).

6.2 Managing to Overlook Nuclear Wastes ~ Part 2

Part of the Adaptive Phased Management Strategy recommended by NWMO is to wait 30 years before moving the irradiated nuclear fuel from the existing reactor sites to a centralized storage site. During this time, NWMO expects the amount of irradiated nuclear fuel to double, as a result of refurbishment of existing reactors.

NWMO Board members are planning to refurbish CANDU reactors in Ontario, Quebec, and New Brunswick, at a cost of many billions of dollars. These reactors are suffering from a process of premature aging brought about by intense radiation, extreme temperatures, high pressures, and unexpected chemical reactions.

The refurbishment of Point Lepreau in New Brunswick and Gentilly-2 in Quebec, if approved, will cost more than two and a half billion dollars. Thousands of radio-active pressure tubes, calandria tubes, and feeder pipes, will be removed from the reactor core and replaced with new ones. They are now intensely radioactive due to "neutron activation". As nuclear wastes, they will remain hazardous for millennia.

In Ontario, refurbishment costs have soared out of sight at Pickering "A". Unit 4 was supposed to be restarted at a cost of $300 million, but by the time it was up and running, the cost was $1,400 million – and the reactor is still not running well. No one knows how many more billions will be spent if the other reactors at Pickering, Bruce and Darlington are refurbished. The only alternative is to shut them down.

But the NWMO accepts no responsibility for the refurbishment wastes, and says nothing about them. Although they are also nuclear wastes, they are in a different category from the irradiated fuel. Presumably, they will be the responsibility of their respective provincial governments; yet the NWMO does not even recommend that those governments make preparations to deal with those wastes on a permanent basis.

Refurbishment wastes are just the thin edge of the wedge; they are part of a much larger volume of nuclear wastes which will result from dismantling each reactor structure at the end of its useful lifetime. After the nuclear fuel has been removed, radiation levels inside the reactor are still so great that the industry recommends waiting 40 years before sending workers in to dismantle the reactor. (Those workers hired now to refurbish the reactors will not have the benefit of such a waiting period, so they will be have to work with radiation fields 100 times stronger.)

The bottom line is that there will be large volumes of long-lived, highly radioactive waste material from radioactive demolition – the equivalent of thousands of truckloads of radioactive rubble. There is as yet no long-term strategy to manage them. The NWMO does not accept responsibility for radioactive demolition wastes, even though the NWMO Board members will be the ones producing them.

We would have hoped that an organization having safety of the public and workers as its first priority would have seen fit to comment on these demolition wastes.

6.3 NWMO's Secondary Objective – Fairness

The NWMO highlights "safety – the protection of humans and the environment – and fairness to this and future generations" as two principal objectives. These sound like admirable goals, but how can they be embodied in wise and ethical decisions?

In siting a centralized repoaitory suitable for deep geologic disposal, NWMO says:

> "... we believe that our objective of fairness would best be achieved if the siting processes were focussed ... in the provinces associated with the nuclear fuel cycle." [CAWF, p. 160]

In Table 4-9, these provinces are identified as New Brunswick, Quebec, Ontario, and Saskatchewan. The first three qualify because they have operating power reactors, while Sasktachewan qualifies because it is Canada's only uranium-mining province,

Manitoba is conspicuously absent from the list, although that province hosted AECL's Whiteshell Nuclear Research Establishment for decades and produced irradiated nuclear fuel from its large research reactor. AECL's Underground Research Laboratory, presently being decommissioned, is also in Manitoba. This facility, extending 500 metres down into the bowels of a granite pluton near Pinawa, is where most of the research done in Canada in preparation for geologic disposal has been carried out.

NWMO says that the siting process should be designed to

> "ensure that those who benefit most from nuclear power (past, present, and perhaps future) are bearing the costs and risks of managing spent fuel and other nuclear materials." [CAWF, p. 24]

So why is Manitoba not considered a candidate for the irradiated fuel repository? Manitoba has surely benefitted from past nuclear activities and specifically from nuclear waste research. Manitoba even has its own stash of irradiated nuclear fuel.

Well, the NWMO report does not mention that the Government of Manitoba has enacted a law specifically prohibiting the importation of any irradiated nuclear fuel into the province if it is for the purpose of permanently storing that waste in Manitoba. In fairness, perhaps other provinces should consider passing similar laws....

Meanwhile, Saskatchewan, which – unlike Manitoba – has never produced irradiated nuclear fuel, is on the list of provinces which have benefitted from nuclear power (through uranium mining) and therefore should be willing, in fairness, to accept irradiated fuel from all the other provinces that have made it (including Manitoba).

But hold on. Saskatchewan has its own nuclear waste, and lots of it, in the form of radioactive uranium mill residues which will remain dangerous for many millennia. The town of Uranium City, for example, is a mess, with abandoned uranium tailings not properly managed and widespread radioactive contamination problems. Why should Saskatchewan feel any obligation to accept additional nuclear wastes from Ontario, a province that derived almost all of the benefits from nuclear electricity?

Indeed, why has the Government of Canada not passed legislation comparable to the Uranium Mill Tailings Radiation Control Act in the USA, whereby a federal agency is charged with the responsibility of stabilizing abandoned uranium mill tailings so as to protect people and the environment from the health hazards posed by these wastres? Or why is there no "Uranium Mill Tailings Organization", comparable to the NWMO, funded by the uranium mining companies who extract uranium from Canada for use elsewhere, leaving their wastes behind in Saskatchewan for future generations?

Is it fair, in fact, that the Government of Canada is dealing with the irradiated nuclear fuel question without simultaneously addressing the other nuclear waste problems?

What is the reason for this preferential treatment? Is it related to the fact that nuclear power reactors are located near urban areas whereas uranium mining activities are located in sparsely populated areas up north? Is it because the nuclear industry sees the irradiated fuel issue as a public relations problem that is preventing expansion of the industry, whereas uranium tailings are mainly impacting lakes, rivers, wildlife, food chains, and aboriginal people that are far away fom the corridors of power?

According to NWMO, fairness dictates that provinces which have benefitted from nuclear power should in fairness be willing to accept the irradiated nuclear fuel. However, the same principle apparently need not apply to communities:

> "... the initial siting decision for nuclear power plants and the acceptance of these communities did not extend to these sites being used for long-term storage of used nuclear fuel,,,. Requiring those communities to continue to store the used fuel over the long term would be unfair." [CAWF, p. 55]

So provinces who benefitted from nuclear powershould be prepared to accept the waste, but that's not necessarily the case with communities that so benefitted.

This begs the question: "Why did those communities that accepted nuclear power plants not also agree to accept the perpetual storage of nuclear fuel waste?" The answer, we believe, is that they were never asked. In fact they were never told that perpetual storage of irradiated fuel would be required. And just how fair is that?

We see no reason why northern communities should feel under an obligation to accept highly radioactive long-lived nuclear wastes from reactors that have provided electricity to southern urban populations. Only a twisted concept of fairness could lead to such a conclusion, in our opinion.

Given that residents in Northern Ontario have not received any direct benefits from nuclear electricity (since the southern grid does not feed these northern communities), fairness would dictate that they should be exempted from consideration just as the provinces of British Columbia, Alberta, Manitoba, Nova Scotia, Prince Edward Island, and Newfoundland are exempted. Indeed, parts of Northern Ontario have hosted uranium mining and refining facilities, but they have millions of tons of radioactive waste on their doorstep as a result. It would be grossly unfair to send them even more.

6.4 Transportation of Irradiated Nuclear Fuel

A vital issue for many Canadians is the prospect of routine transportation of irradiated nuclear fuel through their communities. The NWMO report says very little about it.

The word "transportation" appears nowhere in the table of contents, nor anywhere in Chapter 1, which people tend to regard as the Report Summary. Even the NWMO recommendation for Adaptive Phased Management [CAWF, p. 10] makes no mention of transportation, although the used fuel cannot arrive at the repository without it.

When transportation of irradiated fuel is finally mentioned in Chapter 3 [CAWF, p.51] we are told by NWMO that many Canadians view it "as a very significant limitation of this [geologic disposal] management approach" [CAWF, p. 52] – although in truth it applies to all the management approaches except Option 2, "on-site storage". A few serious concerns related to transportation are cited on page 52 of the NWMO report.

Then, in an astonishingly condescending paragraph, these concerns are blown away:

> "... some participants in the dialogues raised an alternative perspective for considering the transportation issue that some other participants found helpful. The suggestion was that the risk of moving used fuel, and its potential to cause harm in the event of an accident or sabotage, needed to be placed into context. In particular, the risk associated with the transportation of used fuel should be compared to experience in the management of other dangerous goods that are transported daily across this country. Such a comparison, it was suggested, would demonstrate that the transportation of this material, with appropriate equipment, procedures, and emergency preparedness and response programs in place, offered minimal real risk and may well have less risk than the transport of other dangerous materials that occur on a daily basis." *[CAWF, p. 53]*

Suddenly the used nuclear fuel is a dangerous "good" instead of a hazardous waste product that nobody wants! Meanwhile, we are told that if anyone were to take the trouble to compare the risk of moving irradiated fuel with the risk of moving other dangerous goods, then that hypothetical comparison (which NWMO doesn't do) will "demonstrate" that moving used fuel is as safe or safer than moving anything else.

The vacuousness of this argument is evident, in the absence of a careful comparative risk analysis. Yet the NWMO considers the debate over; in Chapter 4, the transportation risk is "judged to be very small" *[pp. 72, 73 & 74]* , and hence it is dismissed.

The transportation of irradiated nuclear fuel is no easy matter. The shipping casks typically weigh about 100 tons each, mainly because of the massive shielding needed to prevent the driver or innocent passers-by from receiving a deadly dose of radiation. Each cask has its own cooling system to prevent overheating of the used fuel within.

Despite the heavy shielding, penetrating radiation is continuously emitted through the cask walls. The US Nuclear Regulatory Commission has set an exposure limit of

10 millirems per hour at 2 metres from the cask surface. At that rate, a person would receive the equivalent exposure of one chest x-ray for each hour of exposure.

According to studies cited by the State of Nevada, individuals who reside, work, or are institutionally confined at locations 6 to 40 metres from a nuclear waste highway route, or within 6 to 50 metres of a nuclear waste rail route, could receive yearly radiation doses equal to, or even in excess of, the average annual background radiation dose.

These figures are confirmed by a report prepared for the US Department of Energy, called the Sandquist report. Maximally exposed individuals near highway routes could receive annual radiation doses ranging from 6 millirems to 960 millirems – equivalent to 2 percent and 266 percent, respectively, of background radiation. Drivers and passengers of vehicles in traffic gridlock incidents could receive significant radiation doses (as high as 40 millirems) as a result of being trapped for an extended period of time next to a truck with an undamaged cask containing used fuel

Workers responsible for safety inspections could receive significant radiation exposures. A 12-minute inspection at a distance of 3 metres from the cask center (near the personnel barrier) could result in a dose of 3 millirems. Over the course of a year, such an inspector could receive a radiation dose of up to 2,500 millirems.

As for accidents, it must be recognized that handling a 100-ton load is no easy task. Difficulties in manoevering and stopping under dangerous circumstances can lead to spectacular accidents. In the spring of 2005 there was an accident involving a high-speed train that crashed into an apartment building in Japan; a massive load at a lower speed can have comparable momentum and thus produce comparable results.

If the cooling system of the shipping cask is damaged, or if the spent fuel inside the cask is damaged, then volatile radioactive materials can vapourize and escape into the surrounding environment. Cesium-137 would be a particular problem in this regard.

If the reprocessing option were to be implemented at some future date, then the transportation route for moving irradiated fuel to the repository would also become the routes for moving separated plutonium away from the repository. In that case, very stringent security measures would have to be implemented all along the transportation route. The US Department of Energy notes that shipments of separated plutonium require the same degree of security as the transport of nuclear weapons.

Because of the risk of criminals or terrorists highjacking a shipment of separated plutonium, innocent civilians living along the transportation route may have to have their personal lives constantly investigated to ensure they do not have or develop criminal ties. Commenting on this eventuality, the Flowers Report warned that:

> "The dangers of the creation of plutonium in large quantities in conditions of increasing world unrest are genuine and serious.... The security measure that might become necessary to protect society could seriously affect personal liberties." *[Flowers Report, para. 506]*

7.1 Governance Issues – Balance and Objectivity

Good governance requires balance and objectivity. The nuclear industry has neither. Over the years, the Government of Canada has concentrated Canada's nuclear expertise within the pro-nuclear establishment. As a result, the federal cabinet itself has become utterly dependent on the nuclear establishment for information, analysis and advice. Too often, the information is biased, the analysis skewed, and the advice self-serving.

There is only one federal cabinet member that speaks with authority on nuclear issues, and that is the Minister of Natural Resources [NRCan]. His mission is clear – it is to promote nuclear power and uranium mining. The current Minister, John Efford, told the Canadian Nuclear Association, just two months after being appointed to cabinet:

> "I am with you in every way possible for the best interests of your industry, which are the best interests of Canadians and the best interests of our environment.... As your Minister in the Government of Canada, I am going to champion your industry right across this country. Make no mistake about it. ... AECL [is] the greatest company in the whole world, by the way." *[John Efford Speech to the CNA, February 18, 2004]*

In the same speech, Mr. Efford revealed how he first learned about his mission:

> "At first, I had very little knowledge of what was going on within Natural Resources Canada, and what my department was really responsible for. But I went into the department and met the tremendous staff — from within my own office and right throughout the department....
>
> "I've had several meetings with AECL [Atomic Energy of Canada Limited], and I've had a meeting with the CNSC [Canadian Nuclear Safety Commission] ... but it's only the beginning. In order for me to carry out my responsibilities as Minister, I have a responsibility to know and to understand your industry as much as possible....
>
> "Now, I'm not going to tell you that I'm going to be a physicist or a chemist, or develop nuclear parts, or address the things that you do on an engineering basis day by day. But ... in the short time that I've been there, I've learned a great deal. I have a great deal more to learn, but I've learned a great deal." *[John Efford Speech to the CNA, February 18, 2004]*

Every new Minister of Natural Resources is briefed by a phalanx of nuclear advisors. These civil servants are mostly drawn from the nuclear industry itself – people who have worked for AECL, Eldorado Nuclear, Ontario Hydro, or Cameco (the uranium mining giant); people who are committed to the vision of a nuclear-powered future.

By concentrating intellectual and financial resources within the pro-nuclear establishment, and channelling it all through a single cabinet member whose job is to promote nuclear power, the government has in effect deprived itself of balance and objectivity.

Politicians, like most Canadians, are seldom highly trained in science or engineering. The mystification that shrouds nuclear energy can cloud one's judgment; it is easy to be so dazzled by brilliant achievements that intractable problems seem readily solvable.

The NWMO calls the CNSC [Canadian Nuclear Safety Commission] an independent regulatory agency for Canada's nuclear industry. But the CNSC reports to the Minister of Natural Resources, who sees it mainly as an adjunct to the industry he's promoting:

> "CNSC has a great responsibility to make sure that safety regulations are put in place to ensure that Canadians as a whole are protected, and that the people who fear the industry most understand that there's a good, competent group of people working in the best interests of the industry and the people of this great country." *[John Efford Speech to the CNA, Feb. 18, 2004]*

The staff members of CNSC are mainly drawn from the same industries that CNSC regulates. While protecting the health and safety of workers and the public and safeguarding the environment are among CNSC's legislated duties, its reports and hearings seldom focus on health matters or on ecosystem concerns, but rather on engineered systems, regulations, and readings from monitoring equipment. Licenses are almost never revoked. Safety disputes are allowed to go on, unresolved, for years.

When seven nuclear reactors were shut down in Ontario in 1997 for safety-related reasons, it wasn't because of an order from the regulator agency, but because the Board of Directors of Ontario Hydro brought in a team of nuclear experts from the USA to advise them on the status of Ontario Hydro's nuclear reactors. The Chairman of the Board, Bill Farlinger, later told the media that Hydro's nuclear division had been functioning as a mysterious and secretive entity, hiding the truth from the Board:

> "The nuclear unit was operated ... as some sort of special nuclear cult. I'm told this is not that unusual in utilities elsewhere in the world.... Senior management didn't dig into what was going on in this special unit to the extent we might now say they should have. Nuclear was something different; [it was felt] it shouldn't be probed as deeply as other business units." *[Toronto Star, Aug. 14 1997]*

Independent bodies in Canada that have probed into various aspects of Canada's nuclear industry have all recommended that truly independent agencies are needed to provide balance and objectivity. The Seaborn Panel's basic recommendation was:

> " • that an NFWMA [Nuclear Fuel Waste Management Agency] ... be established quickly, at arm's length from the utilities and AECL ... ;
> • that it be fully funded ... {by] producers and owners of nuclear fuel wastes ... ;
> • that its board of directors ... be representative of key stakeholders;
> • that it have a strong and active advisory council representative of a wide variety of interested parties;
> • that it be subject to multiple oversight mechanisms ... [including] regular public review, preferably by Parliament."*[Seaborn Report, Exec. Summary]*

Instead, the Chrétien cabinet set up the NWMO under the control of the utilities and AECL, with Ontario Power Generation, Hydro-Québec and NB Power Corp. as its Board of Directors, reporting to the Minister of NRCan rather than Parliament.

If expertise and resources continue to be monopolized by the nuclear industry, balance and objectivity will be impossible, and good governance will remain an elusive goal.