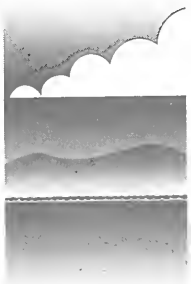
A STANDARD FOR TRITIUM

A recommendation
to the Minister
of the
Environment and Energy

ACES

Advisory
Committee
on Environmental
Standards

Comité
consultatif
sur les normes
environnmentales



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ACES Report 94-01
May, 1994
ISBN: 0-7778-2979-7

Executive Summary

On December 16, 1993, The Honourable C.J. (Bud) Wildman, Minister of the Environment and Energy, wrote to the Advisory Committee on Environmental Standards (ACES) and requested that ACES conduct a public consultation on the Ministry's proposed Interim Ontario Drinking Water Objective (ODWO) for tritium of 7,000 Becquerels per litre (Bq/L). This referral arose as a result of public concern about a plan to expand the existing water supply plant in Ajax, Ontario. This plant would draw raw water from Lake Ontario and is adjacent to the Pickering Nuclear Power Generating Station (PNGS), which discharges tritium in waste water into the lake.

Tritium is a radioactive form of hydrogen. It is long lasting, with a radioactive half-life of 12.3 years and a biological half-iife of 10 days to 2 years. Tritium occurs naturally, but the majority of tritium in Lake Ontario is a byproduct of CANDU nuclear reactor operations. Conventional water treatment is not able to remove tritium from drinking water as it passes through the water treatment plant. The only practical way to reduce tritium levels entering surface waters drawn by water treatment plants is to reduce emissions from CANDU nuclear facilities.

ACES invited public comment on the proposed ODWO by using a large mailing list and by advertising in newspapers. Respondents were sent a copy of the Ministry's *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium* (MOEE 1993) and were asked to comment on it. Public interest in this issue was widespread and resulted in new information not contained in the Rationale Document being brought to the attention of ACES. For example, ACES learned that readers of the Rationale Document would probably underestimate the fatal cancer risk posed by the proposed ODWO. The Ontario Ministry of the Environment and Energy's (MOEE) policy on Drinking Water Objectives states that lifelong exposure (estimated to be 70 years) must be considered. The documents used in deriving the ODWO for tritium, however, consider exposure for only one year. Although this approach has often been taken by nuclear regulatory agencies, it is clearly at odds with MOEE's policy on drinking water guidelines. Exposure to 7,000 Bq/L represents a risk of approximately 340 excess fatal cancers per million people exposed over their entire lives.

In many regulatory agencies, including MOEE, 1 excess cancer per million people exposed is often considered acceptable if there are multiple media for exposure to a given contaminant and a large population is affected. A higher level of acceptable risk of 1 excess cancer per hundred thousand people exposed is often used to derive standards when small populations are affected, and their exposure results from only a single medium. Exposure to tritium in Ontario occurs through drinking water and the affected population may be large. Exposure may also occur via air and perhaps, food. Therefore, ACES recommends that an acceptable level of risk for excess cancers due to exposure to tritium be 5 per million people at risk, as suggested by the MOEE in the Rationale document. Given a 70 year (lifelong) exposure, and assuming the annual

risk is additive, this would result in an Ontario Drinking Water Objective of 100 Bq/L.

There are many other sources of uncertainty and concern which were brought to the attention of ACES by members of the public during this consultation. For example, the risk calculations do not directly address non-fatal cancers nor health effects other than cancer, and there is scientific uncertainty regarding the relative biological effectiveness of tritium. Some members of the public also expressed concern that the most sensitive subpopulation (the developing fetus) was not considered in the risk calculation. For these reasons, ACES recommends that the ODWO for tritium be reduced over time to 20 Bq/L, corresponding to an acceptable level of risk of 1 excess cancer per million people following lifelong exposure. Several members of the public pointed out that tritium would meet the International Joint Commission's (IJC) definition of a persistent toxic substance and, on that basis, should be virtually eliminated from industrial discharges. Some respondents pointed out that on the basis of the IJC's recent Seventh Biennial report, tritium should be considered a candidate for "zero discharge". Others suggested that tritium be added to Ontario's Priority Pollutants List as it is a known carcinogen which is discharged into Provincial surface waters. ACES endorses these principles and recommends that discussions should be initiated with Ontario Hydro and AECL regarding the feasibility of reducing tritium emission levels from nuclear facilities in Ontario.

ACES consulted the public on the proposed Interim ODWO of 7,000 Bq/L and the feasibility of achieving this level. ACES is not aware of comprehensive information on the feasibility of achieving the lower recommended level of 100 Bq/L, nor was this issue addressed in the MOEE's Rationale Document. However, the monitoring data available through the Ministry's Drinking Water Surveillance Program (DWSP) suggest that 100 Bq/L is rarely exceeded. Therefore, it is a currently achievable standard which will only become more readily achievable as background levels of tritium decline due to the decay of nuclear fallout from atmospheric weapons testing.

The same monitoring data indicate that 20 Bq/L is not currently a routinely achievable standard in drinking water near nuclear facilities. Because conventional water treatment does not remove tritium, ACES recommends that feasibility studies be undertaken with the goal of reducing tritium emissions sufficiently to permit the ODWO to be lowered to 20 Bq/L within 5 years.

In conclusion, ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when the drinking water standard is exceeded, an alternative water supply should be made available.

Table of Contents

Referral

On December 16, 1993, the Honourable C.J. (Bud) Wildman, Minister of the Environment and Energy, requested that the Advisory Committee on Environmental Standards (ACES) consult with the public on the Ministry of the Environment and Energy's proposed Interim Ontario Drinking Water Objective (ODWO) of 7,000 Becquerels per litre (Bq/L) for the radionuclide tritium in drinking water. ACES was requested to review and provide recommendations on the proposed Interim Ontario Drinking Water Objective.

Recommendation for an Interim Ontario Drinking Water Objective for Tritium

ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when this drinking water standard is exceeded, an alternative water supply should be made available.

List of Acronyms

ACES	Advisory Committee on Environmental Standards
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
BEIR	The U.S. National Research Council's Committee on Biological Effects of Ionizing Radiation
Bq	Becquerel
CDWG	Canadian Drinking Water Guidelines
CANDU	CANadian Deuterium Uranium (the type of nuclear reactors used in Canada)
DWSP	Drinking Water Surveillance Program
EAAC	Environmental Assessment Advisory Committee
^{3}H	Tritium (Hydrogen 3)
DEL	Derived Emission Limit
ICRP	International Commission on Radiological Protection
IJC	International Joint Commission
MAC	Maximum Acceptable Concentration
MOEE	Ministry of the Environment and Energy
MOL	Ministry of Labour
mSv	Millisievert
NCRP	National Council on Radiation Protection and Measurements (US)
NGS	Nuclear Generating Station
ODWO	Ontario Drinking Water Objectives
OWRA	Ontario Water Resources Act

OBT	Organically Bound Tritium
RBE	Relative Biological Effectiveness
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
U.S. EPA	United States Environmental Protection Agency
WHO	World Health Organization
WSP	Water Supply Plant

Glossary

Activity:

The rate of decay (i.e. number of disintegrations or transformations per unit time) of a radioactive nuclide. The international unit of activity is the becquerel (Bq).

Background Radiation:

The amount of radiation to which a member of the population is exposed from natural sources including terrestrial radiation due to naturally occurring radionuclides in the soil and cosmic radiation originating in outer space. The main contributing factor to what is now referred to as "background" tritium levels is fallout from atmospheric nuclear weapons testing.

Beta Particles:

Fast moving electrons ejected from the nuclei of certain unstable radioactive atoms (e.g. tritium). Beta particles are not densely ionizing.

Becquerel (Bq):

International unit of measurement of the activity of a radioactive nuclide. One becquerel corresponds to one atomic transformation or disintegration per second and is equivalent to 2.7×10^{-11} Curies.

Carcinogen:

An agent that can cause cancer. Ionizing radiation is a carcinogen. Tritium, which emits ionizing radiation, is a carcinogen.

Committed Effective Dose:

The effective dose that will be accumulated over 70 years following a single intake of radioactive material into the body.

Curie (Ci):

A unit of activity equal to 3.7×10^{10} disintegrations per second.

Dose Equivalent:

A measurement that relates absorbed dose with the biological effectiveness (i.e. probability of causing biological damage) of various kinds of ionizing radiation. Dose equivalents are calculated by multiplying the absorbed dose by a quality factor that accounts for differences between different types of radiation. The international unit of dose equivalents is the sievert (Sv).

Gray:

The SI unit of absorbed dose where one gray equals one joule per kilogram, and one gray equals 100 rad.

Half-Life:

The time taken for the activity of a radionuclide to lose half its value by decay.

Ionizing Radiation:

Radiation that is capable of producing ions (particles with an electric charge) by dislodging electrons from an atom.

Maximum Acceptable Concentration (MAC):

A MAC is a type of Drinking Water Objective that is established for certain substances that are known or suspected to cause adverse effects on health. Each MAC has been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration.

Multimedia:

A multimedia assessment considers how a contaminant released to one medium (air, water, soil or sediment) may move to or impact other media. This approach also considers all human exposure routes including food, water, air and soil.

Organically Bound Tritium (OBT):

Tritium is bound organically either in exchange reactions or into stable bonds to carbon atoms only via enzymatically catalyzed reactions in which it replaces hydrogen. Tritiated organic matter is classified as a function of the fractions of the exchangeable and non-exchangeable bound tritium it contains, e.g. organic compounds that incorporate radioactive tritium in place of hydrogen, vegetable food and animal foods around Nuclear Generating Stations have higher OBT concentrations.

Rad:

A unit of absorbed dose, now replaced in international units by the gray, where one rad equals 0.01 gray.

Radioactivity:

The spontaneous emission of radiation, in the form of alpha particles, beta particles, etc.

Radionuclide:

An unstable nuclide that emits ionizing radiation

Relative Biological Effectiveness (RBE):

The biological potency of one type of radiation as compared with another to produce equivalent biological damage.

Rem:

A measure of dose equivalent (1 rem = 0.01 Sv).

Standard:

The term "standard" in this report includes interim standards, objectives, guidelines, and any other form of limitation which specify a tolerable level for environmental contaminants.

Sievert:

The SI unit of measure defined as the quantity of absorbed radiation that induces the same biological effect in a specified tissue as 1 gray of high-energy x-rays; 1 sievert = 100 rem or 1000 millisieverts. A sievert is used as an international unit of dose equivalents. The quantity is obtained by multiplying the dose equivalents to various tissues and organs by the risk weighting factor appropriate to each organ and summing the products.

Background

In 1990 the Region of Durham approved a recommendation to enlarge the existing water supply plant in Ajax to address the need for additional water supplies.

In 1992 the Minister of the Environment at the time, Ruth Grier, asked the Environmental Assessment Advisory Committee (EAAC) for advice on whether an individual environmental assessment should be required for the proposed water supply plant.

In its report to the Minister, the EAAC recommended against an individual environmental assessment for the proposed plant provided that certain recommendations were appropriately addressed.

With respect to concerns raised about tritium concentrations in drinking water due to the water supply plant's close proximity to the Pickering Nuclear Generating Station, EAAC recommended that the Minister request that the Advisory Committee on Environmental Standards (ACES) carry out a public review and advise the Minister on an appropriate standard for tritium in drinking water.

The Ministry of the Environment and Energy's Standards Development Branch produced the *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium* (MOEE 1993). The Minister then requested that ACES carry out a public consultation on the Interim ODWO for tritium proposed in the Rationale Document.

Public Health Significance

What is Tritium?

Tritium is a radioactive isotope of hydrogen. It has a half-life of 12.3 years (the amount of time it takes one half of a quantity of tritium to decay into non-radioactive helium). The biological half-life of tritium (the amount of time the body requires to excrete one half of the tritium absorbed) ranges between 10 days and two years, depending on its location in the body.

Tritium is a by-product of Canadian Deuterium Uranium (CANDU) nuclear reactor operations and it also occurs naturally. Tritium is produced in CANDU reactors through the absorption of a neutron into a deuterium atom in heavy water, which is used as a moderator and coolant. During reactor operation, a small fraction of the deuterium molecules in the heavy water take on an additional neutron and thus they become radioactive tritium (^3H). The resulting tritiated water is regularly discharged from these reactors. Radioactive tritium* (^3H) decays to non-radioactive helium (^3He) and emits a negatively charged beta particle (β^-).

The decay formula is as follows:

$$^3H \rightarrow {}^3He + \beta^-$$

This weak beta-emitter is used commercially as a light source in flares, emergency lights, exit signs, and luminous dials. It also has uses in medical research. As well as being an essential fuel for nuclear fusion, tritium can be used in nuclear weapons production.

Sources of Exposure to Tritium

Today, the main source of tritium released into the Canadian environment in air and water emissions is nuclear energy production facilities. In particular, the CANDU type water-cooled reactors used by Ontario Hydro, representing the largest Canadian point source of tritium, release tritium both operationally and accidentally.

*When "tritium" is used in this report it refers to tritiated water, unless otherwise specified.

The majority of tritium exposure is the result of human activities. Tritium is produced in nuclear explosions. Fallout from thermonuclear weapons testing, begun in the 1940s, is a source of tritium in the global environment. A very large quantity of tritium has been released from these activities, resulting in a sharp increase in the tritium content of rain water and atmospheric tritium. This was the main contributing factor to a rise in what is now referred to as "background" tritium levels. In recent years background levels of tritium have declined, reflecting the cessation of atmospheric nuclear testing and the decay of tritium over time from these explosions.

In nature, tritium is produced by the interaction of cosmic rays with molecules of nitrogen, oxygen and argon in the upper atmosphere. It is converted into tritiated water and precipitated into the global water cycle. Natural sources of tritium account for less than 1% of tritium exposure.

Routes of Exposure

Once released to the environment, tritium exposure to humans can occur from a variety of routes, namely via water, air, and food. Exposure to water-borne releases can occur through the consumption of drinking water supplies or through other water contact, e.g., swimming, bathing, showering, etc.

Air-borne tritium is also a source of exposure to communities around nuclear generating stations. Air-borne releases of tritium contaminate ambient air and can settle on surface waters and agricultural lands.

Exposure Pathways

Tritium can be taken into the body by inhalation, absorption through the skin, or ingestion. Tritium entering the body by inhalation is normally distributed uniformly among all the soft tissues in the body.

The absorption of tritiated water through the skin is a pathway of human exposure. Bathing, showering or recreational activities are examples of human dermal exposure routes.

Following ingestion, tritiated water is absorbed immediately from the gastrointestinal tract and then mixes rapidly with the total body water. In addition, ingestion of contaminated foods is a potential exposure pathway from air-borne tritium emissions. The ingestion of contaminated fruits, vegetables or food animal products raised near nuclear generating stations may be a significant source of organically bound tritium (OBT), i.e., organic compounds that incorporate radioactive tritium in place of normal hydrogen.

Adverse Health Effects of Tritium

Tritium is classified as a **human carcinogen** by the United States Environmental Protection Agency. There is no safe exposure level for any form of ionizing radiation. Low doses of radiation are known to cause genetic damage in living cells. Where reproductive cells are affected by radiation, mutations may occur and adverse effects may manifest in offspring.

Exposure to radiation may also result in the development of cancer. A cancer may occur at any dose of ionizing radiation.

The Tritium Challenge

The connection between tritium emissions from nuclear facilities and tritium levels in drinking water is critical. Levels of tritium in drinking water in excess of background are the result of emissions from nuclear facilities. Ontario Hydro, in their report entitled "Annual Summary and Assessment of Environmental Radiological Data for 1991", state that "Tritium concentrations in drinking water taken from Lake Ontario at the Ajax, Whitby, Oshawa, Scarborough and Toronto (Harris) plants exceeded the Lake Ontario average of 8.7 Bq/L due to emissions to water at the Pickering generating stations." Conventional water treatment is unable to remove tritium from drinking water supplies. Therefore, significant reductions in tritium levels in surface waters, which are a drinking water source, can only be achieved by additional emission controls at nuclear facilities.

Internal Review

Upon receipt of the Rationale Document from the Ministry, ACES undertook its own internal review. ACES concluded that the material presented in the Rationale Document (MOEE 1993) was adequate to proceed with public consultation, but ACES noted the absence of a scientific criteria document. ACES requested that the key references used in the development of the Rationale Document be compiled by the MOEE, and these documents were provided by ACES for public review during the consultation.

Public Consultation Process

ACES undertook a public consultation on a drinking water standard for tritium which involved several methods of reaching out to the interested public. These included mailing a consultation package to ACES's general mailing list, advertising in newspapers and magazines and holding public information meetings in the Ajax/Pickering area. ACES's general mailing list was compiled from several mailing lists provided by the Ministry of the Environment and from individuals or organizations who had expressed interest in ACES's previous consultations. A targeted list composed of additional groups who were thought to have a particular interest in this consultation was generated. They included: industrial groups, environmental organizations, labour unions, and Ajax/Pickering area residents/groups.

A package of background material (see Appendix 1) was prepared including:

-a cover letter describing the consultation;
-a copy of the advertisement that appeared in newspapers (which included the questions being posed);
-a list of the background documents used in the development of the proposed tritium standard and their locations for review;
-a copy of the News Release describing the referral of the tritium standard to ACES;
-a "Backgrounder" on tritium prepared by the Ministry of the Environment and Energy;
-information on the concurrent ACES public consultation on the proposed multimedia standards for lead.

Everyone was provided with a postage paid return envelope to encourage participation. This package was sent to approximately 6,600 people between January 10, 1994 and January 14, 1994.

The questions posed were as follows:

1. Is the proposed standard acceptable?
2. If not, what is the basis for finding the proposed level unacceptable?
3. Do you have an alternative level to propose?

Additional comments were also encouraged.

A second mail out was sent to 330 individuals and organizations who had been identified as having a special interest in the review of tritium but who had not responded to the first mail out after 28 days had elapsed.

In order to reach members of the potentially interested public who might not be on the mailing list, an advertisement, which included the above questions, appeared once in the Globe and Mail and in each of 19 newspapers in communities located near nuclear generating stations or other nuclear facilities during the week of January 10 to January 14, 1994. An advertisement also appeared in the Ontario Gazette on January 8, 1994 and on the Web Network on January 10, 1994. (The Web Network is a communication network to which many different organizations, including many environmental groups from around the world, subscribe.)

A package of supporting documentation was made available for review at the ACES Office in Toronto and at the Town of Ajax Clerk's office (see page 2 of Appendix 1).

A public information session was held on January 27, 1994 in Ajax, Ontario in order to explain ACES's public consultation process and to allow the Ministry of the Environment and Energy to provide the rationale for the development of the standard. An announcement of the meeting was included in the mail out packages and an advertisement outlining the times and location of the meeting was placed in 4 Ajax area newspapers. In order to make the meeting as accessible as possible to those who wished to attend, there were two times scheduled for this meeting, one in the afternoon and one in the evening. ACES ensured that the meeting room was wheel chair accessible and an audio technician provided amplification to the participants to facilitate hearing. A summary of the presentations was also provided in poster form outside the meeting room. These meetings were tape recorded and written transcripts were made available upon request. Approximately 100 copies of the transcripts were requested. In addition, the evening session of the meeting was video taped by MacLean Hunter Cable television and aired at least 8 times over the month of February, 1994.

Requests for oral deputations were received until February 7, 1994. A deputation session was held in Pickering on February 16, 1994, at which seven presenters made oral submissions to ACES. A second deputation session was held via teleconference on February 28, 1994, in which four presenters participated. This was the first time that ACES undertook a teleconference deputation, which permitted presenters from across the Province to make oral presentations to the Committee without travelling long distances. ACES felt that the consultation on the proposed Interim ODWO for tritium was effective and efficient, in part as a result of the combination of targeted advertisements and other audio-visual techniques.

The deadline for the public to send written responses on the proposed ODWO for tritium was March 10, 1994.

Review of Public Comment

A total of 226 requests for additional information were received in response to the initial mail out and advertisements. These respondents were sent the *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium* (MOEE 1993).

A total of 84 written responses were received and 11 deputation presentations were made dealing with various aspects of the rationale for setting an Interim ODWO of 7,000 Bq/L for tritium. A list of respondents is attached as Appendix 2.

In reviewing the comments submitted, every response was considered carefully. Comments ranged from short letters on the proposed standard through to detailed technical submissions. Comment summaries are provided in Appendix 3. All comments, whether oral or written, received equal consideration. Submissions received after March 10, 1994, were read and considered, but are not included in this report.

When analyzing the responses, a number of issues were identified. Many respondents addressed more than one issue.

These issues were categorized as follows:

- Overview of Public Response
- Exposure
- Risk
- Feasibility
- Implementation
- Need for Additional Studies
- Other Comments and Recommendations

Overview of Public Response

The consultation materials distributed posed three questions and encouraged additional comments. Responses to ACES's three consultation questions were divided into four categories depending on how the question regarding the acceptability of the proposed standard was answered. A summary is presented in Table 1.

Table 1. Summary of Responses Regarding the Proposed Standard

Comment	Number	%
Yes, the proposed standard is acceptable.	17	20
No, the proposed standard is not acceptable, the level should be lower.	43	51
No, the proposed standard is not acceptable, the level should be higher.	4	5
Question not answered directly.	20	24
Total comments received	84	100

The proposed standard was deemed acceptable by 17 people. The standard was deemed unacceptable by 46 respondents, 4 recommending that the level be higher and 42 recommending that the level be lower. The question was not answered directly by 20 respondents.

In addition to responding to these questions, the public provided ACES with information and supporting documentation of which the Committee had not been previously aware. This confirmed to ACES the value of the public consultation process.

Exposure

Summary of Public Comment

In response to ACES's question on the appropriateness of the proposed standard, two respondents brought to ACES's attention the fact that the basis of the risk assessment for tritium differed fundamentally from that for all non-radioactive contaminants. The entire paradigm, or model, on which risk assessments for radionuclides are based makes unique assumptions and calculations. The public comment on this issue pointed out that the lifetime risk associated with environmental radioactive contaminants is calculated based upon consumption of drinking water containing a radioactive contaminant every day for only one year. In contrast, the lifetime risk associated with environmental chemical contaminants is calculated based upon consumption of drinking water containing a chemical contaminant every day for 70 years (the average life-span).

Response by ACES

The final draft of the 1993 revision of the Ontario Drinking Water Objectives document states, in Section 1.2 Types of Objectives, that "Almost all objectives are based on a 70 kg person consuming 1.5 litres[1] of water *per day for 70 years* (emphasis added)." Setting an ODWO on a lifetime risk estimate based on only one year's exposure to a contaminant at a certain level represents a significant departure from this stated policy.

The proposed tritium level of 7,000 Bq/L represents a lifetime risk of 5 excess cancers per million people exposed for one year. The MOEE, in proposing 7,000 Bq/L, is consistent with the international radiation protection community's risk assessment practices. Lifelong (70 year) exposure to 7,000 Bq/L would result in approximately 340 excess fatal cancers per million people exposed[2]. ACES considers that the ODWO for tritium should be lower than the proposed level because the international radiation protection community based the lifetime risk level on only one year's exposure. Extending this exposure over a 70 year life-span would add to the lifetime cancer risk, especially if exposure occurred in one's early years (See further discussion under **Risk**).

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[1]The MOEE's proposed ODWO for tritium assumes a 2.0 litre per day consumption of drinking water.

[2]Please refer to the letter in Appendix 4 for the calculation of total lifetime risk of 0.1 mSv received annually for 70 years. This calculation was provided by Dr. P.J. Waight of the Radiation Protection Bureau of Health Canada.

For the purposes of this review, ACES accepts the international radiation protection community's derivation of 0.1 mSv in one year from the consumption of 2.0 litres of drinking water per day as the dose which will result in 5 fatal cancers per million exposed population. If this dose (i.e., 0.1 mSv) is lifelong (70 years), U.S. EPA estimates that between 300 - 1000 additional fatal cancers per million exposed would result.[1] The EPA numbers are derived from the BEIR V report which estimates that 520 additional fatal cancers per million exposed males and 600 additional fatal cancers per million exposed females will result from this lifelong dose (BEIR V 1990).

MOEE proposes, in the Rationale Document, that an acceptable level of risk for tritium in drinking water is 5 excess cancers per million people exposed. Based on this level of acceptable risk and with lifelong exposure, the following calculation was performed:

7,000 Bq/L (proposed level for one year's exposure) / 70 years (average life-span) = **100 Bq/L**.

An ODWO of 100 Bq/L represents a drinking water standard with an acceptable risk of 5 excess cancers per million people following lifelong exposure.

Risk

Summary of Public Comment

The acceptable risk level of the 5 additional cancers per one million people exposed, as proposed in the MOEE's Rationale Document, was challenged by three respondents. In general, they recommended a *de minimus* risk of 1 excess cancer per one million people exposed as a conservative public health approach.

It is possible that many of the respondents were not aware that the cancer risk referred to in the Rationale Document was the risk following one year's exposure and not a lifelong exposure (see further discussion under **Exposure**).

Health effects other than fatal cancer were cited by 16 of the respondents as a rationale for the lowering of the proposed standard. The public expressed particular concern about birth defects, non-fatal cancers, childhood leukaemia, effects on

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[1]A paper from the U.S. EPA's Science Advisory Board entitled *Harmonizing Chemical and Radiation Risk Reduction Strategies-A Science Advisory Board Commentary* discusses the two risk paradigms that have evolved and is found in Appendix 5.

immunity, and Down's Syndrome. One member of the public summed up their view on the use of fatal cancers as the only endpoint of concern by stating that "health is more than the absence of death". Several respondents referred to the AECB studies which reported a higher incidence of childhood leukaemia and Down's Syndrome around nuclear generating stations (Clarke and McLaughlin 1989, Clarke and McLaughlin 1991, Johnson and Rouleau 1991).

The public cited a number of additional factors which were not considered in the risk estimates. These factors included: the exposure of sensitive populations (12 commenters), (i.e., fetuses, young children, women of childbearing age, etc.); synergistic or additive effects of tritium with other contaminants, including radionuclides, in drinking water (11 commenters); other routes or sources of tritium exposure (4 commenters); organically bound tritium (3 commenters); the potential for tritium, particularly organically bound tritium, to bioaccumulate (2 commenters); the dose conversion factor used (2 commenters); the relative biological effectiveness (RBE) of tritium (3 commenters); the validity of extrapolating data from acute high doses to chronic low doses (1 commenter). The respondents generally supported a much lower standard for tritium in drinking water as a result of these factors.

Two commenters raised the issue of the potential effects on fetuses *in utero* of periodic "pulses" of tritium in drinking water. These pulses result from intermittent higher level tritium emissions. Their concerns centred on the exposure of pregnant women due to the susceptibility of rapidly dividing embryonic cells to radiation.

The "Petkau effect" was referred to by several respondents and one expressed concern over its implications for a greater risk of health problems following continuous low level radiation exposure.

Six respondents raised the issue of the historical risk assessment by international agencies such as the International Commission on Radiological Protection (ICRP), the World Health Organization (WHO) and the National Council on Radiation Protection and Measurements (NCRP). These agencies have reduced the acceptable risk by a factor of five in their most recent recommendations[1]. Respondents raised concerns regarding these agencies past underestimation of the risks associated with radionuclides and expressed a lack of confidence that these new risk estimates are "correct".

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[1]A revised estimate of the risk of a lifetime fatal cancer for the general population has been estimated by the International Commission on Radiological Protection (ICRP) to be 5×10^{-2} per sievert (ICRP 1990). In light of this change, the World Health Organization revised its reference level of committed effective dose to 0.1 mSv from 1 year's consumption of drinking water (WHO 1993). This is a five fold reduction from the WHO's previous reference level of 0.5 mSv.

Of the respondents who recommended a lower level (see **Overview of Public Responses**), 16% supported setting the standard at background levels and 51% supported zero discharge. (Many members of the public recommended zero as the acceptable level in drinking water. ACES recognizes that the ambient concentration will never be zero due to the existence of natural sources of tritium contamination and took the public's support of a drinking water standard of zero to indicate support of zero discharge). Numerous commenters cited the International Joint Commission's (IJC) position of virtual elimination of persistent toxins as their rationale. They stated that the IJC considers radionuclides with half-lives greater than six months as persistent toxic substances. In its *Seventh Biennial Report on Great Lakes Water Quality* (IJC 1994) the IJC suggests, in its Recommendations to Federal and State/Provincial Governments, that "Governments incorporate those radionuclides which meet the definition of persistent toxic substances in their strategy for virtual elimination."

Six percent of respondents went on to recommend staged reduction levels with precise time lines to reflect the decrease in background tritium levels as a result of the decay of tritium from weapons testing over time.

One respondent recommended that radioisotopes be included in the MOEE's Priority Pollutants List.

Response by ACES

1) Acceptable Risk Level:

The determination of an acceptable level of risk depends on a number of factors. When setting environmental standards, regulatory agencies will often accept a risk of 1 excess cancer per million people exposed if the following circumstances are met:

-multiple media through which exposure can occur;
-a large affected population.

A risk of one excess cancer per one hundred thousand people exposed (i.e., 10 per million) is often deemed acceptable if there is:

-a single medium of exposure;
-a limited affected population.

In the case of tritium, nuclear generating stations represent a point source for tritium in drinking water. However, there is more than one medium of exposure (e.g., air, food, etc.), and there is the potential for a large population to be impacted. Therefore, an intermediate risk level of 5 excess cancers per million people exposed is reasonable. MOEE currently has no formal policy on risk assessment which codifies the standard setting process.

2) Health Effects Other Than Fatal Cancers:
The risk estimates carried out by the international radiological community identify fatal cancers as the critical endpoint when setting an allowable dose. The WHO expressly excludes health risks from non-fatal cancers and hereditary effects. ACES considers that chronic environmental exposure to ionizing radiation presents health risks over and above fatal cancers, including non-fatal cancers and multigenerational effects.

The risk estimates for radionuclides served originally as a framework for occupational standards for radiation protection for atomic workers. There are substantial differences between occupational and environmental exposure to contaminants. Occupational standards are generally established based, in part, on the following assumptions:

-a healthy adult population;
-assuming a voluntary risk;
-individuals are exposed over a limited number of hours per day and a limited number of years, not over their lifetime.

Factors such as exposure of sensitive populations, additive effects, other routes of exposure, etc., are not taken into account in the risk estimates for radionuclides. These factors raise issues of uncertainty in the risk calculations. ACES agrees that these additional sources of uncertainty are areas of concern.

3) Uncertainty Factors:
The dose conversion factor used for tritium, its relative biological effectiveness and the contribution to risk of organically bound tritium are all subjects of controversy within the radiological community. For example, the RBE for tritium in the Rationale Document is assumed to be one. A recent article in the radiation protection literature concludes that the RBE is higher than one (Straume and Carsten 1993). Changes in any of the above cited issues would likely result in a reduction of the allowable dose.

The "Petkau effect" refers to cell membrane damage caused by continuous, low level exposure to beta emitters (Graeub 1992). This "effect" is based on the research carried out by Dr. Abram Petkau on non-living membranes. His studies showed that chronic exposure to low levels of tritium lowered the dose required to break the membrane. The Committee considered that, although interesting, the Petkau effect may not be relevant for human risk assessment because the studies were performed on artificial phospholipid membranes, *in vitro*, which lack the repair mechanisms present in living systems.

The combination of an intermediate acceptable risk level, uncertainties about other potential health risks from chronic environmental exposures to radiation and additional

uncertainties in the parameters used in determining the risk estimate for tritium provide impetus to lower the acceptable risk level from 5 excess cancers in one million people exposed to one in one million. This risk level would result in an ODWO of:

100 Bq/L (level reflecting lifelong exposure) ÷ 5 = **20 Bq/L**

4) Historical Risk Assessment:
ACES agrees that the agencies responsible for risk assessment of radionuclides have indicated that, in the past, they underestimated the risk these contaminants pose. Consequently, the latest recommendations of the ICRP and the WHO have been reduced by a factor of five to reflect the revised risk estimates.

5) Virtual Elimination:
ACES endorses the public's support of the principle of virtually eliminating persistent toxic substances from the environment and of establishing a schedule for this reduction over time. Tritium is persistent, with a half-life of 12.3 years, and is a human carcinogen. ACES agrees with the IJC position on the identification of radionuclides with a half-life greater than six months as persistent toxic substances.

Recommendations
ACES recommends that a multimedia approach be used in establishing tritium standards. Recognizing the existence of other potential pathways of exposure to tritium in addition to drinking water, ACES further recommends that the Minister of the Environment and Energy should undertake discussions with other jurisdictions to implement this recommendation.

ACES further recommends that the MOEE establish a policy on risk estimation with standard methodologies to evaluate risk and clear criteria for when deviations from that methodology are required.

ACES recommends that radioisotopes that are toxic, persistent, and that have the potential to bioaccumulate should be included in the Priority Pollutant List developed by the MOEE.

Feasibility

Summary of Public Comment
The issue of cost analysis in applying the ODWO was raised by 6 respondents. Comments centred on the need for demonstrated benefits in terms of pollution reduction given the potential economic costs of a stringent tritium drinking water

objective. Respondents felt that this was not "beyond the scope" of the report, as stated in the Rationale Document. The four respondents that supported an ODWO of 40,000 Bq/L all commented that the cost associated with a reduction of the standard was a factor in their recommendations.

Five commenters addressed the lack of treatment technologies to remove tritium from drinking water. They expressed concerns that due to the absence of treatment technologies, the tritium level the consumer receives is the same level as in the raw water. The respondents used this rationale to support a reduction in tritium emission levels. Concerns about the lack of treatment technologies for tritium in drinking water resulted in an additional 5 respondents discussing the location of water treatment plants, with recommendations that they be situated in areas that can meet whatever drinking water target level is set. One commenter recommended that Ontario adopt the United States ban on building water supply plants within a five mile radius of nuclear generating stations.

Response by ACES

ACES's consultation was based on the MOEE's proposed ODWO of 7,000 Bq/L and the feasibility thereof. The Rationale Document did not consider the feasibility of lower levels. ACES has no comprehensive information on the feasibility of an ODWO of less than or equal to 100 Bq/L. The information supplied by the MOEE's Drinking Water Surveillance Program (DWSP) suggests that 100 Bq/L is rarely exceeded and that 20 Bq/L is exceeded periodically near nuclear facilities[1].

Background levels of tritium in the environment are declining due to the decay of fallout over time. Currently, the most significant source of tritium in drinking water that would result in a drinking water level in excess of 20 Bq/L is emissions from nuclear facilities. No effective treatment technologies for the removal of tritium from drinking water supplies exist. ACES agrees that the lack of an effective treatment technology for tritium in drinking water is of concern and considers that this provides additional support for reducing tritium emissions.

ACES believes that there is a need to investigate an ODWO of 20 Bq/L and below in terms of technical feasibility and financial feasibility. Several years may be needed for these feasibility studies, therefore ACES proposes a five year target for the ODWO of 20 Bq/L and the policy options implied.

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[1]Page 19 of the *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium* (MOEE 1993) states that "...the levels of tritium in drinking water supplies in Ontario rarely exceed 100 Bq/L." Appendix E.1 (page 25) of the same document lists the tritium results of the 1991 Drinking Water Surveillance Program (DWSP). Of the 109 water supply plants surveyed, only the Ajax Water Treatment Plant reported a tritium level over 100 Bq/L.
Appendix 7 lists the 1991 tritium data from the Nuclear Surveillance Program as reported in Appendix E.2 of the MOEE Rationale Document.

Due to the lack of an effective means of removing tritium from drinking water, the proximity of nuclear facilities should be borne in mind when approvals are sought for the construction or expansion of water supply plants.

By summing the effects of all radionuclides and applying a committed effective dose to the total, the radiation risk assessment paradigm implicitly weighs the benefits of the nuclear industry at a much greater level than those of other industries (e.g., the agrochemical industry for which each additional pesticide or herbicide is evaluated and regulated independently). ACES challenges this weighting and questions the rationale for attributing these extraordinary benefits to the nuclear industry while other industrial sectors are treated less generously.

Recommendations

ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when this drinking water standard is exceeded, an alternative water supply should be made available.

ACES recommends that the MOEE undertake a comparative cost analysis of different methods to achieve the recommended ODWO of 100 Bq/L and the five year target of 20 Bq/L.

ACES further recommends that the MOEE ensure that the feasibility of additional tritium emission control strategies be assessed.

Implementation

Summary of Public Comment

A number of respondents (12) raised the question of jurisdictional authority over radionuclides. Many of those expressed confusion over the multiplicity and range of water-borne tritium standards, and were unsure about which ones are "safe". This range includes the current Atomic Energy Control Board's (AECB) derived emission limit for the Pickering Nuclear Generating Station of 210,000 Bq/L[1], the current Canadian Drinking Water Guideline of 40,000 Bq/L, the proposed ODWO of 7,000 Bq/L and the U.S. Environmental Protection Agency (U.S. EPA) drinking water standard of 740 Bq/L.

The inclusion of radionuclides as persistent toxins in the International Joint Commission's most recent biennial report was mentioned by 50% of those who commented on jurisdictional issues.

Four comments from respondents dealt with the monitoring of tritium and three comments addressed the impact of transboundary sources of tritium in drinking water, especially the Fermi II radioactive waste water releases by Detroit Edison to Lake Erie in February and March, 1994. The comments expressed concern that there is no reliable on line monitor for sampling and tracking tritium discharges into water.

Two respondents raised the issue of enforcement of the drinking water objectives. These comments expressed frustration with ineffective 'guidelines' and recommended that enforcement become "credible and rational".

An advisory level in addition to the standard was discussed by seven respondents, five of which supported this concept. The advisory was suggested to provide an alert to communities when tritium contamination exceeds background levels, so that people can choose not to drink the tap water.

Response by ACES

The regulation of radionuclides is, indeed, complex. Various jurisdictions have different responsibilities. The regulation of all "nuclear facilities" and their discharges is the mandate of the federal government under the *Atomic Energy Control Act*.

Because nuclear facilities represent a point source for tritium in drinking water and because there is no water treatment technique to remove tritium, the standard for tritium in Ontario drinking water may have an impact on the emissions, and therefore possibly the operations, of Ontario Hydro and AECL nuclear plants. ACES was unable to establish whether or not additional controls on tritium releases from these plants are possible, and based its recommendation primarily on the health considerations of tritium exposure from drinking water.

[1] The AECB derived emission limit is an allowable release standard to water from nuclear facilities. Although these emissions will affect tritium levels in drinking water, this is not a drinking water standard.

More than 90% of Canada's nuclear generating capacity resides in Ontario, under the auspices of Ontario Hydro. Ontario Hydro is a Provincial Crown corporation responsible for the production and delivery of electrical power. Ontario Hydro reports to the Minister of the Environment and Energy.

Each province has jurisdiction over its own water supplies. Section 29.(1) of the *Ontario Water Resources Act* states that "For the purposes of this Act, the Minister has the supervision of all surface waters and ground waters in Ontario." (OWRA 1994) Section 75.-(1)(i) of this same Act states that "[The Lieutenant Governor in Council may make regulations,] prescribing standards of quality for potable and other water supplies, sewage and industrial waste supplies, sewage and industrial waste effluents, receiving streams and water courses;". It is on these bases that the Province has jurisdiction over the quality of drinking water supplies.

In a section of their submission entitled "Different Limits for Tritium in Drinking Water" Ontario Hydro stated that "It should be noted that the AECB operating licenses specify that the nuclear station must also comply with all applicable provincial and local regulations. This implies that we must comply with the most restrictive regulations in cases where there is overlap of jurisdiction."

The most recent draft of the Ontario Drinking Water Objectives (MOEE, 1993) states that "The objectives outlined in this document prescribe standards of quality for drinking water supplies. In carrying out its responsibilities under section 53 OWRA [Ontario Water Resources Act], the MOEE applies the ODWO's in approving the establishment of any water works or the extension of or change in any existing water works...". The Approvals Branch of the MOEE, through the granting of Certificates of Approval, specifies monitoring requirements. Regional staff of the MOEE are responsible for enforcing these monitoring requirements at all water supply systems. The Medical Officer of Health, through the *Health Protection and Promotion Act* has the authority to judge whether water is safe for human consumption. ODWOs may be used for this purpose.

ACES supports the concept of easier public access to drinking water survey information. In their submission, Atomic Energy of Canada Limited Research (AECL) suggested that drinking water survey information be provided on a regular basis to the public in communities which express significant concern about their water quality. One means they suggested for providing this information was through the regular publication in newspapers of the concentrations in drinking water of all health related parameters in comparison to their respective limits.

Recommendations

ACES recommends that frequent monitoring and timely, regular and public reporting of tritium levels in nuclear facilities' emissions and water treatment plant intakes in the vicinity of nuclear facilities should be ensured by the MOEE.

ACES is unaware of any monitoring program currently in place that would detect tritium pulses. Due to the concerns raised regarding potential risks to the fetus *in utero*, ACES recommends that the MOEE ensure that the timely reporting of periodic tritium pulses is pursued.

ACES strongly supports the principles of pollution prevention and the phase out of persistent, toxic contaminants, like tritium. In keeping with these goals, ACES recommends that discussions should be initiated with Ontario Hydro and AECL regarding the feasibility of reducing tritium emission levels from nuclear facilities in Ontario.

ACES recommends that the Ministry of Labour Radiological Drinking Water Monitoring data should be made available to the public in an accessible and timely manner and published along with the Drinking Water Surveillance Program data.

Need for Additional Studies

Summary of Public Comment
Five submissions dealt with the issue of the need for additional health studies. Four commenters expressed concerns over the lack of information on long term, low level radiation ingestion exposure effects.

Response by ACES
ACES agreed that there is a lack of information on the long term, low level ingestion exposure effects of radiation and has concerns over the promised follow up health studies by the AECB that have yet to be conducted. ACES considers such studies to be required, but believes that the adverse health effects of ionizing radiation are sufficiently well established that public monies would be more effectively spent in controlling tritium releases to the environment rather than on further study of its health effects.

Recommendations
ACES recommends that follow up studies on long term, low level exposures to radiation be completed as recommended by previous AECB reports, but that these studies not proceed immediately if the cost associated with them would delay the implementation of the recommended standard.

ACES further recommends that representatives selected by the community be included in the planning committee for future health studies to increase public confidence in the study.

Other Comments and Recommendations

Summary of Public Comment

A number of other comments and recommendations were received during the consultation. These included suggestions regarding the process (3 comments), i.e., requests for a "full" tritium review, criticisms and suggestions for improvement of the structure and content of the Rationale Document (4 comments), and concerns regarding the ecosystem effects of tritium contamination (2 comments).

Response by ACES

In general, ACES was pleased with the process and with the extent and quality of the responses received to the request for comment. About 37% of those who requested additional information actually commented. ACES felt this degree of response was excellent given the scientific nature and complexity of the issues.

Summary of Recommendations

ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when this drinking water standard is exceeded an alternative water supply should be made available.

ACES recommends that a multimedia approach be used in establishing tritium standards. Recognizing the existence of other potential pathways of exposure to tritium in addition to drinking water, ACES further recommends that the Minister of the Environment and Energy should undertake discussions with other jurisdictions to implement this recommendation.

ACES further recommends that the MOEE establish a policy on risk estimation with standard methodologies to evaluate risk and clear criteria for when deviations from that methodology are required.

ACES recommends that radioisotopes that are toxic, persistent, and that have the potential to bioaccumulate should be included in the Priority Pollutant List developed by the MOEE.

ACES recommends that the MOEE undertake a comparative cost analysis of different methods to achieve the recommended ODWO of 100 Bq/L and the five year target of 20 Bq/L.

ACES further recommends that the MOEE ensure that the feasibility of additional tritium emission control strategies be assessed.

ACES recommends that frequent monitoring and timely, regular and public reporting of tritium levels in nuclear facilities' emissions and water treatment plant intakes in the vicinity of nuclear facilities should be ensured by the MOEE.

ACES is unaware of any monitoring program currently in place that would detect tritium pulses. Due to the concerns raised regarding potential risks to the fetus *in utero*, ACES recommends that the MOEE ensure that the timely reporting of periodic tritium pulses is pursued.

ACES strongly supports the principles of pollution prevention and the phase out of persistent, toxic contaminants, like tritium. In keeping with these goals, ACES recommends that discussions should be initiated with Ontario Hydro and AECL regarding the feasibility of reducing tritium emission levels from nuclear facilities in Ontario.

ACES recommends that the Ministry of Labour Radiological Drinking Water Monitoring data should be made available to the public in an accessible and timely manner and published along with the Drinking Water Surveillance Program data.

ACES recommends that follow up studies on long term, low level exposures to radiation be completed as recommended by previous AECB reports, but that these studies not proceed immediately if the cost associated with them would delay the implementation of the recommended standard.

ACES further recommends that representatives selected by the community be included in the planning committee for future health studies to increase public confidence in the study.

References

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Clarke, E.A., McLaughlin, J., and Anderson, T.W. 1989. Childhood leukaemia around Canadian nuclear facilities - Phase I. AECB.

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Ontario Hydro, Health and Safety Division. 1992. Annual Summary and Assessment of Environmental Radiological Data for 1991. Ontario Report HSD-HP-92-9.

Ontario Water Resources Act. 1994. Queen's Printer for Ontario.

Straume, T., and Carsten, A.L. 1993. Tritium radiobiology and relative biological effectiveness. Health Physics 65(6): 657-672.

World Heath Organization (WHO). 1993. Guidelines for Drinking Water Quality. Second Edition. World Health Organization, Geneva.

Ontario

Advisory Comrnittee on Environmental Standards

Comité consultatif des normes environnementales

40 St. Clair Avenue West
Suite 401
Toronto ON M4V 1M2

40, avenue St. Clair ouest
Bureau 401
Toronto ON M4V 1M2

TRITIUM

January, 1994

The Honourable Bud Wildman, Minister of the Environment and Energy, has asked ACES to conduct a public consultation and make recommendations on his Ministry's proposed **Interim Ontario Drinking Water Objective for Tritium of 7,000 Becquerels per litre (Bq/L).** The current Ontario Drinking Water Objective for radionuclides, including tritium, is 40,000 Bq/L.

ACES is an independent advisory body responsible for recommending to the Minister sound, practical standards for environmental contaminants, as well as policies, principles and procedures for setting environmental standards.

We are writing to ask for your comments on this proposed standard. If you are concerned about the environment and would like to make a difference, we urge you to get involved in this review.

ACES will be holding an information session in Ajax on **January 27, 1994**, at the **Ajax Recreation Centre, 75 Centennial Road, Ajax,** at which we will explain our public consultation process. We have invited Ministry of the Environment and Energy (MOEE) staff to answer your questions about the development of the standard. If you cannot attend this meeting and wish more information, a record of the session can be ordered. The advertisement on the reverse provides important information regarding the consultation program.

We would appreciate it if you would advise others who might have an interest in this issue of this consultation.

The deadline for written comments is **March 10, 1994.**

Disponible en francais sur demandé. **(Please see over)**

Important information enclosed regarding:
1) Consultation on the Proposed Soil, Drinking Water and Air Standards for Lead;
2) ACES's mailing list.

Setting a standard for environmental protection

WE WANT TO HEAR FROM YOU ABOUT TRITIUM

The Minister of the Environment & Energy has requested that the Advisory Committee on Environmental Standards (ACES) conduct a public consultation on the proposed new Interim Ontario Drinking Water Objective of 7,000 Becquerels/Litre (Bq/L) for Tritium. The current Ontario Drinking Water Objective is 40,000 Bq/L.

ACES was established to contribute to environmental improvement by advising the Minister on standards for environmental contaminants. We are seeking public input before reporting to the Minister and would like to invite you to take part in this public consultation.

ACES is particularly interested in your answers to the following questions, although we welcome any other comments you may have:

1. Is the proposed standard acceptable?
2. If not, what is the basis for finding the proposed level unacceptable?
3. Do you have an alternative level to propose and what is your rationale for suggesting this level?

The deadline for written comments is March 10, 1994. If you are concerned about the environment and would like to make a difference then we urge you to get involved!

For further information, and copies of the documentation, please contact:

Advisory Committee on Environmental Standards
40 St. Clair Ave. West, Suite 401
Toronto, Ontario M4V 1M2

Telephone: (416) 314-9265
Fax: (416) 314-9270

Ontario

Background Documents for Tritium

The following documents were used in the development of the proposed tritium standard:

1. Health and Welfare Canada. 1993. *Guidelines for Canadian Drinking Water Quality-Fifth Edition*. Canada Communications Group - Publishing. Ottawa, Canada.

2. National Council on Radiation Protection and Measurements (NCRP). 1987. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 93. National Council on Radiation Protection and Measurements. Bethesda, Maryland.

3. Committee on the Biological Effects of Ionizing Radiation (BEIR). 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation*. BEIR V. National Academy Press. Washington, D.C.

4. International Commission on Radiological Protection (ICRP). 1991. *1990 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60. Pergamon Press. Elmsford, N.Y.

5. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). 1988. *Sources, Effects and Risks of Ionizing Radiation*. United Nations. New York, N.Y.

6. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). 1986. *Genetic and Somatic Effects of Ionizing Radiation*. United Nations. New York, N.Y.

7. United States Environmental Protection Agency. 1991. *National Primary Drinking Water Regulations: Radionuclides*. Federal Register, V. 56, No. 138, July 18, 1991. pp. 33050-33127.

8. World Health Organization. 1993. *Guidelines for Drinking Water Quality*. Second Edition. World Health Organization, Geneva.*

These reports may be reviewed at the following locations:

Advisory Committee on Environmental Standards
Library
40 St Clair Ave. W
Suite 401
Toronto, Ontario
M4V 1M2

Clerks Department
Town of Ajax
65 Harwood Avenue South
Ajax, Ontario
L1S 2H8

For further information, please call the ACES office at (416) 314-9265.

*This document was not published until following the launch of the public consultation on January 10, 1994. The draft version was used by the MOEE in the development of the proposed ODWO. Copies were provided by ACES at the above listed locations with the other documents for review.

Ontario

news release

Ministry
of the
Environment

September 30, 1992

FOR FURTHER INFORMATION:

Elizabeth Janz (416) 440-3479
Environmental Assessment Branch

Gerry Merchant (416) 323-4333
Public Affairs and
Communications Services Branch

NEW AJAX WATER SUPPLY PLANT TO PROCEED ON THE BASIS OF CLASS ENVIRONMENTAL ASSESSMENT

Environment Minister Ruth Grier today announced she has decided not to require an individual environmental assessment of the proposed water supply plant in Ajax. The decision is subject to a series of conditions drawn from the Environmental Assessment Advisory Committee's (EAAC) report to the minister.

"I have taken steps to ensure that the community has the protection it needs without unduly delaying completion of a much-improved and needed area water supply," Mrs. Grier said. "I appreciate the concern area residents have about the potential effects of nuclear plant discharges on their drinking water and I have considered their comments very carefully."

In her decision, the minister considered requests from the public that the project be bumped-up to an individual environmental assessment. The major concerns expressed dealt with the plant's location on the waterfront and with potential tritium levels in water from the plant as a result of its proximity to the Pickering Nuclear Generating Station.

After the community's bump-up request was received by the Minister, she asked EAAC to advise her on whether the project should be subject to a full environmental assessment. The advisory committee recommended against the bump-up if a series of

conditions could be met by the region. They also advised that the province undertake a full review of Ontario's standards for tritium.

Mrs. Grier decided to address public concerns about tritium by referring Ontario's standards for tritium to the Advisory Committee on Environmental Standards (ACES) for public review. The development of the water plant will be allowed to proceed while this review is under way.

In addition, Mrs. Grier said staff of the ministry's Environmental Assessment Branch will be consulting Ontario Hydro, the Atomic Energy Board and the ministries of health, environment and energy on a recommendation by EAAC to establish a Durham Nuclear Health Committee.

Mrs. Grier agreed with EAAC that the Regional Municipality of Durham's planning process was adequate and that most of the environmental concerns can be addressed through appropriate terms and conditions. She set 21 conditions to which the region must agree before construction on the new plant can proceed.

- 30 -

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Ministry of Environment and Energy

FOR YOUR information

FALL 1993

Backgrounder on a recommended Interim Ontario Drinking Water Objective for Tritium

The Ministry of Environment and Energy is recommending that the current Ontario Drinking Water Objective (ODWO) for tritium of 40,000 becquerels per litre (Bq/L) be replaced by an interim Drinking Water Objective of 7,000 Bq/L (a becquerel is a unit used to measure radioactivity). This recommendation is based on a reassessment of the adverse human health effects resulting from exposure to radiation.

Background:

ODWOs are the primary tool used by the ministry to ensure the acceptability of public water supplies. Achieving drinking water objectives ensures aesthetically pleasing water that does not represent any significant risk to the health of the consumer.

The need to re-examine the basis of the ODWO for tritium resulted from a recommendation of the Environmental Assessment Advisory Committee (EAAC) concerning the new Pickering/Ajax water treatment plant proposed by the Region of Durham. EAAC advised that an individual environmental assessment for the plant was not necessary provided that certain concerns were addressed. One of these concerns centred on the levels of radioactive substances, specifically tritium, in drinking water.

To address this concern, EAAC recommended that the Minister ask the Advisory Committee for Environmental Standards (ACES) to carry out a public review and advise on an appropriate standard for levels of tritium in drinking water. In order to conduct this review, the ministry has prepared this backgrounder as a general introduction to the *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium.*

Properties of tritium:

Tritium is a naturally occurring, radioactive form of hydrogen. As part of its natural decay, tritium emits radiation which is relatively weak, compared to that emitted from other radioactive substances. Nevertheless, all radiation released by radioactive substances is considered carcinogenic in humans; the risk of developing cancer is considered to be proportional to the radiation dose received.

The most common form of tritium is tritiated water, which is a by-product of water-cooled nuclear generating stations and is indistinguishable in terms of taste, smell and texture from normal water. Human exposure to tritium results primarily from ingestion or inhalation; once taken in, tritium is distributed rapidly throughout the body.

The basis for the revised objective:

The revised ODWO for tritium is based upon the recommendation of the World Health Organization that the annual "dose" received from drinking two litres of water a day be set at 0.1 mSv (1000 mSv = 1 sievert; a sievert is the unit used to measure a radioactive "dose"). The recommended "dose" represents an estimated risk of five cases of cancer for every million people exposed; however, that figure is less than five per cent of the "dose" attributable to background radiation. The revised ODWO of 7,000 Bq/L for tritium is derived by converting sieverts into becquerels using an appropriate conversion factor for tritium.

Ontario

Sources of exposure to radiation:

Natural sources of radiation, such as cosmic rays and naturally occurring radioactive substances, account for more than 80 per cent of an individual's exposure to radiation. Other sources, such as medical X-rays, account for approximately 11 to 15 per cent of annual exposure. Exposure to tritium in drinking water generally accounts for less than 0.1 per cent of overall annual exposure.

In Ontario, tritium in drinking water is monitored under the Ontario Drinking Water Surveillance Program as well as under specific surveillance programs carried out in the vicinity of nuclear generating stations. Data obtained from these programs indicate that the level of tritium in drinking water in Ontario is generally very low and rarely exceeds 100 Bq/L. The maximum value recorded in 1991 was 370 Bq/L in Petawawa.

Application of the ODWO for tritium:

The revised drinking water objective for tritium applies when other radioactive substances are not present in the water. In those cases where more than one radioactive substance is present in drinking water supplies, the maximum allowable limit for all radioactive substances is set so that the "dose" derived from all radioactive substances in the drinking water does not exceed 0.1 mSv.

In the case of emergency situations, such as the spill or release of nuclear material, the Nuclear Emergency Plan administered by the Ministry of Solicitor General applies. In such situations, advice is sought from various ministries on a case-by-case basis as to an appropriate course of action. For decisions affecting the acceptability of drinking water supplies, the objectives for all radioactive substances, including tritium, would be among the factors considered when arriving at an appropriate decision.

The interim ODWO for tritium will be applied as a health-related maximum acceptable concentration and will be reviewed once the Canadian Drinking Water Guidelines for radioactive substances are revised.

For further information:

To obtain the *Rationale Document for the Development of an Interim Drinking Water Objective for Tritium* or other information related to the proposed review, please contact:

Advisory Committee on
Environmental Standards
40 St. Clair Ave. W.
Toronto, Ont.
M4V 1M2

Tel: (416) 314-9265

Appendix 2: List of Respondents in ACES's Public Consultation on Tritium

Members	Ajax Citizens for the Environment, Ajax, Ontario
A. Anderson	Director of Public Health Inspection, York Region, Newmarket, Ontario
M.E. Anderson	President, The Beaver Valley Heritage Society, Clarksburg, Ontario
M. Bednarz	
R. Bell	
B. Biederman	
C.B. Bigham	C. Bruce Bigham Consulting, Deep River, Ontario
J. Brackett/& I. Kock	Durham Nuclear Awareness, Oshawa, Ontario
K. Brosemer	Clean North, Sault Ste. Marie
P. Brown	Councillor, Ward 5, Town of Ajax, Ajax, Ontario
W.F.M. Brown	Walter Brown Associates, Mississauga, Ontario
E. Burt	
G. Colm	
W. Cooney	
H. Cross	
R. Cuyler	
A.G. Darnley	International Geochemical Mapping, Ottawa, Ontario
E. deQuehen	Northumberland Environmental Protection, Northumberland, Ontario
C. Duschenes	
M.J. Diamond	
R. Doomernik	Technical Director, Fasson Canada Inc., Ajax, Ontario

F. Eggert & S. Eggert	
V.E. Emerson	
V.E. Emerson	Pickering beach Residents' Association, Ajax, Ontario
H. Emery	President, The Brereton Field Naturalists' Club
I. Fairlie	
B. Fergusson	The Entry Group, Toronto, Ontario
M. Fisher	Town Engineer, Town of Dryden, Dryden, Ontario
J. Foster	Durham Wetlands and Watersheds, Oshawa, Ontario
R. Frank	Chairperson of the Conservation Committee of the Guelph Field Naturalists, Guelph, Ontario
J.C. Fraser	Manager, Water Quality, Windsor Utilities Commission, Windsor, Ontario
D. Golden-Rosenberg	
R.D. Graham	Manager, AECL Research, Chalk River, Ontario
H. Guttman	Chair, American Water Works Association, Toronto, Ontario
K. Hansenberger	
P. Hartwig	Community Liaison Group, Deep River, Ontario
O. Hendrickson	Concerned Citizens of Renfrew County, Ottawa, Ontario
H. Henrikson	President, The Little Cataraqui Environment Association, Kingston, Ontario
D. Hiner	Atikokan Citizens for Nuclear Responsibility, Mattawa, Ontario
P. Hutton	Conserver Society of Hamilton and District Inc. Hamilton, Ontario
J. Jackson	Citizens' Network on Waste Management, Kitchener, Ontario
I. Judah	Enviro-Hai-Tech, Montreal, Québec
M.J. Kern	

Z. Kleinau	Bruce Peninsula Environment Group, Lions's Head, Ontario
I. Kock	Durham Nuclear Awareness, Oshawa, Ontario
S. Leonhardt	Pickering Ajax Citizen's Together For The Environment, Pickering, Ontario
N.C. Lind	Professor Emeritus, University of Waterloo, Victoria, B.C.
A. Lovett	
C.W. Lundy	Regional Clerk, The Regional Municipality of Durham, Whitby, Ontario
P. Lush	
H. MacDonald	
R. MacIntyre	Sault Area Nuclear Awareness, Goulais River, Ontario
A. Macpherson	
R. Maruska	Ontario Hydro, Toronto, Ontario
P. Maslak	
J. McEwan	N.C.M.W.M., Grimsby, Ontario
K.G. McNeill	Professor Emeritus of Physics, University of Toronto, Toronto, Ontario
C. Mobbs	
D.K. Myers	
P.C. Nanda	Consumers' Association of Canada (Windsor), Kingsville, Ontario
K.E. Nash	Director, Nuclear Waste and Environment Services, Ontario Hydro Nuclear, Toronto,Ontario
J.S. Nathwani	Joint Committee on Health and Safety, The Royal Society of Canada, The Academy of Engineering, Toronto, Ontario
B. Neil	
O. Nigol	
N. Parrott	

T.E. Parry	Director of Engineering, Town of Whitchurch-Stouffville, Stouffville, Ontario
C. Peabody	
B. Pellier	Chair, Social Action Committee, Unitarian Congregation of South Peel, Mississauga, Ontario
R. Robinson	Ridgetown Public Utilities Commission, Ridgetown, Ontario
N. Rubin	Energy Probe Research Foundation, Toronto, Ontario
C. Sauriol	
J. Scott	
L. Segatti	
L.R. Silver	
H.B. Stevens	
I.J. Stuart-Sheppard	
J.E. Taylor	Director, Elgin St. Thomas Health Unit, St. Thomas, Ontario
B.J. Vandenhazel	
R. Waterston	Manager, Albright & Wilson Americas, Dunnville, Ontario
B. Willard	
S. Willard	Ajax Save the Waterfront Committee, Ajax, Ontario
R.S. Wilson	Black Hackle Engineering, Toronto, Ontario
P.R. Youakim	Technologist, Environment Canada, Burlington, Ontario
J. Young	

Appendix 3: Summary Tables of Public Comments

Please Note: ACES has endeavoured to present comment summaries that are a true reflection of the content and context of the responses received. Paraphrased comments are indicated by their inclusion in square brackets ([ ]). Complete written submissions are available for public review at the ACES office. The names of respondents not representing an organization have been removed in accordance with the *Freedom of Information and Protection of Privacy Act* requirements.

Comments Regarding the Proposed Level

Support no change from 40,000 Bq/L

Name	Comment
C. Bruce Bigham Consulting Deep River, Ont.	To answer the questions in your ad I offer the following: 1. No 2. See above [description of exposures from air travel, living in the mountains etc., also the "Perhaps we are adapted to higher levels and actually now suffer from a radiation deficiency."] 3. The current level (40,000) or higher depending on an economic analysis.
The Entry Group Toronto, Ont.	Leave it at 40,000 Bq/L if changing the standard will cost the people of Ontario one red cent in added measuring equipment, time required to create reports or creation of committees or advertising expenses or BUREAUCRACY.
Town of Dryden Dryden, Ont.	I would like to suggest that the present limits are low enough and dropping them represents over-kill and as such a cost to the country and to the environment. ...the present standard is amply safe and no reduction is warranted.
Ridgetown Public Utilities Commission Ridgetown, Ont.	In a day of increasing burdens, priority in the use of the dollar must be of upmost importance...I would request that no change be made to the current regulations at this time.

Support proposed level

Name	Comment
Individual	The proposed standards do not appear to have a negative impact [socio-economically]. There appears to be no contraindication to the reduction from 40,000 Bq/L to 7,000 Bq/L in drinking water.
Fasson Canada Inc. Ajax, Ont.	No issue with the proposals sent-support both.
The Brereton Field Naturalists' Club Barrie, Ont.	...agree with the proposed reduction of allowable parts per unit. We would urge the Ontario government to revise the standards.
AECL Research Chalk River Laboratories Chalk River, Ont.	...the proposed Interim [ODWO] for tritium of 7000 Bq/L to be generally within the range of what would be an acceptable standard, provided it is applied in the intended manner: that is as an upper limit of acceptability for lifelong consumption....AECL Research would strongly encourage ACES to recommend that Ontario adopt the revised CDWG standards once they are issued.
The Little Cataraqui Environment Association Kingston, Ont.	We strongly support the proposed reduction from 40,000 Bq/L....even at 7,000 Bq/L...the risk of cancer increases by 5 cases per million, which we believe should be the maximum acceptable...
Atikokan Citizens for Nuclear Responsibility Mattawa, Ont.	The Ministry is to be commended for their suggestion the interim objective be lowered. It's a step in the right direction.
Conserver Society of Hamilton and District Inc. Hamilton, Ont.	I feel from reading the brief information that even the new standard really isn't that useful in the general context, but would be an acceptable overall standard.
Individual	I agree that the proposed criterion of 7000 Bq/L has been determined using conservative reasoning and available science.
Fisons Instruments Inc. Ottawa, Ont.	These levels are acceptable
Durham Region Whitby, Ont.	...the Health and Social Services Committee of Regional Council considered the [ODWO for tritium] and ...adopted the following recommendations of Committee: that the proposed interim Ontario Drinking Water Objective for tritium be endorsed;...

Ontario Hydro Toronto, Ont.	Ontario Hydro is prepared to accept the recommendations of the international scientific community. We believe that at 7,000 Bq/L, the Drinking Water Objective provides a good measure of protection and can be applied practically as recommended by the World Health Organization.
Ontario Hydro Nuclear Toronto, Ont.	...Ontario Hydro supports the proposed interim level of 7,000 Bq/L for the drinking water objective for tritium.
Individual	I wish to record my support of a value of 7000 Bq/L for the interim ODWO for tritium.
Individual	The proposed [standard] is acceptable if it reduces the level of contamination to the lowest level possible.
Albright and Wilson Americas Dunnville, Ont.	We agree with these new maximum proposed standards. We would also like to commend the process being used to bring about the changes.
Black Hackle Engineering Toronto, Ont.	This letter is to confirm support for the proposed changes...The 7000 Bq/L (or lower) limit should be adopted not from a health perspective, but from a safety perspective to ensure that tritium sources are properly controlled.
Environment Canada Burlington, Ont.	The proposed standards are acceptable. However, I would like to suggest a reduction in levels with 2 sets of values in mind and 2 target dates say in 1995 and the year 2002.

US level

Name	Comment
Windsor Utilities Commission Windsor, Ont.	...would encourage the ODWO be further reduced and conform with the U.S. EPA proposed tritium limit in dw of 800 Bq/L.
Bruce Peninsula Environment Group Lion's Head, Ont.	We strongly feel that even the 7000 Bq/L limit is unacceptable and that this limit should be brought down to at least the U.S. EPA reading.
Consumers' Association of Canada (Windsor) Kingsville, Ont.	Since the lake waters are used by nuclear plants in USA and Canada, it would be advisable for both countries to consider harmonization of standards. It may be relevant to note that current USA standards are set at much lower levels than the proposed ACES standards.
Individual	...there is no economic reason for setting a tritium limit ...any higher than approximately 500 Bq\L. In order to have consistency with U.S., I would like to suggest that a limit of 800 Bq\L be adopted at this time.
Individual	...adhere to dw stds that are as stringent as those in the United States or better.
Individual	...my body is not more resilient to tritium than our neighbours to the south. Their level is a far cry from our existing Ontario level of 40,000 Bq/L. Additionally, Americans restrict construction within five miles of a nuclear plant, let alone building a water treatment plant.
Individual	A further lowering of the level to at least the U.S. level currently proposed i.e. 2300 per litre.

Standard should be set at background level

Name	Comment
Durham Nuclear Awareness Oshawa, Ont.	...an appropriate drinking water standard for tritium should be set at current background levels...between 5 and 10 Bq/L, and falling, so drinking water standards should tighten over time to reflect the decay of tritium from weapons testing.
Clean North Sault Ste. Marie, Ont.	[The standard should be set at less than 10 Bq/L, depending on location].
Individual	Drinking water from WSP located less than ten kilometres from a NGS shall provide drinking water with a maximum tritium level of 8.7 Bq/L. For all other WSPs the maximum amount allowed shall not exceed 300 Bq/L.
Durham Wetlands and Watersheds Oshawa, Ont.	...we want a Permanent Ontario Drinking Water Objective of 10 Bq/L and anything more is unacceptable...
Pickering Ajax Citizen's Together for the Environment Pickering, Ont.	The interim level for tritium should be set at 5 to 10 Bq/L until all information is gathered.
Individual	Commitment to zero tolerance of any levels of tritium above background levels must be a priority...In addition, for any level of tritium above background levels, I feel the public should be advised.
Ajax Save the Waterfront Committee Ajax, Ont.	...we recommend that the std set by the MOEE should be 8.7 Bq/L, which is reasonable and doable.

Zero discharge

Name	Comment
Individual	Any levels of tritium are totally unacceptable to me. Pure water is basic to good health.
Individual	Tritium should not be allowed in our drinking water.
Individual	As with the regulation of most other hazardous materials, tritium should be subjected to ZERO DISCHARGE objectives.
Individual	The proposed standard is not acceptable, it is too high. Preferably it should be zero.
Individual	If one molecule of a substance can destroy or change forever one cell then we recommend that a "zero" tolerance level be permitted and that a "zero" input standard be put in place.
Individual	I believe it is obvious that no toxic substance ought to be permitted to accumulate in our environment. There is no suitable alternative.
Conservation Committee Guelph Field Naturalists Guelph, Ont.	It is our understanding that the two Federal Governments around the Great Lakes are committed to zero discharge; why is this not the case?
Individual	...recommend zero tolerance of toxic materials in drinking water...[discussion of IJC virtual elimination recommendations]
Citizens' Network on Waste Management Kitchener, Ont.	In its Seventh Biennial Report on Great Lakes Water Quality, the IJC recommends that the "Governments incorporate those radionuclides which meet the definition of persistent toxic substances in their strategy for virtual elimination." We ask the province to therefore immediately begin to develop a strategy for eliminating the presence of tritium in water as a result of human activities.
Individual	No level above zero discharge is acceptable...Production and release of tritium at any level should be eliminated.
Sault Area Nuclear Awareness Goulais River, Ont.	...drinking water standards should reflect an attitude of zero tolerance of all toxic materials.
Individual	I understand any contamination from a nuclear plant is only acceptable at the level of NIL.
Individual	If it was not there in before then keep it out period...not try to tell people x% is OK when you don't know.

Individual	It is our considered opinion that the only "safe" level of tritium in drinking water is zero...
Consumers' Association of Canada (Windsor) Kingsville, Ont.	The Consumer Association of Canada commends the step towards the number of becquerels from 70,000 to 7,000 but would recommend ACES that it set further lower limits towards a zero tolerance.
Social Action Committee Unitarian Congregation of South Peel Mississauga, Ont.	...it is our contention that NO tritium should be allowed in our drinking water. Only ZERO tritium is acceptable.
Individual	...this committee owes it to my family and the other families in Ajax and Pickering to recommend a zero level of tritium.
Individual	My ideal standard for radiation in my drinking water is 0 Bq/L.
Individual	Economic considerations should not override ecological concerns...I therefore recommend that the Ajax water plant either will not proceed or be prevented from releasing tritium.
Individual	We propose a level of 0 Bq/L...the objective that you recommend to the MOEE should be 0 Bq/L, to honour your mandate to provide a reference level based only on health considerations.
Ajax Save the Waterfront Committee Ajax, Ont.	...the Ontario Drinking Water **Objective** for tritium in drinking water should be 0 Becquerels/Litre. This "objective" reflects what is desirable, based solely on health considerations, and is a "reference level". That is the objective we urge you to recommend to the MOEE, in accordance with your mandate. [go on to recommend a "standard" of 8.7 Bq/L]
Individual	...I must insist that the only "sound, practical standard" for radionuclides in water is zero. How long will the nuclear industry be given to meet the new objective of 0 Bq/L?

Recommended level other than proposed, US, background or zero.

Name	Comment
Individual	Drinking water from WSPs located less than ten km from a NGS shall provide drinking water with a max. level of 8.7 Bq/L, for all other WSPs the max. allowed shall not exceed 300 Bq/L. Rationale is as follows: in the vicinity of a NGS the max. acceptable level shall not exceed background level found in Lake Ont. Elsewhere the allowable limit shall not exceed 300 Bq/L which is a reasonable standard to live with.
Individual	It is my considered opinion that a reduction in the permissible limits of tritium (and any other radioactive material) in drinking water should be made as low as is possible (unmeasurable?).
Concerned Citizens of Renfrew County Ottawa, Ont.	The goal should be zero discharge for cmpds such as tritium that are known carcinogens. Recognizing that it will take time to achieve this goal, we recommend that interim stds achieve at least a 100 fold reduction in the max. allowable tritium concentration in dw, i.e., from the current 40,000 to less than 400 Bq/L.
Energy Probe Research Foundation Toronto, Ont.	...set the ODWO...at a level in the range of 10 to 30 Bq/L, if not lower.
Individual	I suggest that the "As Low as Reasonably Achievable" requirement also be added to the new standard.
Individual	...if the objective was set at 100 Bq/L then on the rare occasions when it's exceeded enforcement should result in the necessary steps being taken to correct the problem at the sources.
Town of Whitchurch-Stouffville Stouffville, Ont.	...allowable limits should be set much lower to ensure health protection...only naturally occurring tritium need be considered in the 100 Bq/L range.

Exposure

Basis of cancer risk calculation by WHO, ICRP etc.

Name	Comment
Individual	Applying the most recent dose to risk relationships published by the ICRP...the additional risk of serious radiation induced disease will be around 5 per million per year or about 1 in 3000 per lifetime. Risks of this magnitude ...are acceptable...
Energy Probe Research Foundation Toronto, Ont.	...several references [in the transcripts] to cancer risks to people "exposed over a lifetime" should refer to fatal cancer risks over a lifetime from exposure over only a single year.

2 litre drinking water consumption level

Name	Comment
American Water Works Association Toronto, Ont.	The Interim Objective calculation uses an annual consumption factor assuming 2 L/day. Almost all other objectives in the ODWO are based on a 70 kg person consuming 1.5 litres of water per day over 70 years. The document should outline the justification for varying from the norm when setting drinking water objectives.
Bruce Peninsula Environment Group Lion's Head, Ont.	We feel that the 2 l consumption factor is too conservative as DW is consumed as ingredient in cooking, baking, steaming, soft drinks, beer and other beverages.

Risk

Historical risk assessment by international agencies

Name	Comment
Durham Nuclear Awareness Oshawa, Ont.	The MOEE rationale document on tritium standards in dw adopts, without question, the position of international agencies which have historically underestimated the risks of radiation exposure.
Individual	The rationale document relies entirely on information generated by both the EPA and the WHO. The latter uses data based on studies of survivors of the atomic blasts in Hiroshima and Nagasaki. Interestingly,...the maximum allowable dose has been reduced from 0.5 mSv down to 0.1 mSv. Does this mean in another 13 years it will again be reduced?
Individual	Outline in their comments suspicion of any groups ability to assess the impact of tritium in drinking water due to historical view of radiation exposure, i.e., X-rays in the 1930s; atomic bomb tests in the 1940s etc.
Individual	Since for many decades, scientists have been underestimating the risks associated with radiation exposure and our understanding of radioactive substances is not yet complete, how can we be sure what exactly an appropriate margin of safety is when calculating life time exposures?
Energy Probe Research Foundation Toronto, Ont.	The official sources of the risk coefficients for radiation carcinogenesis the underlie the proposed ODWO...have...consistently underestimated the actual effectiveness of radiation at causing cancer. There is no scientific or political reason to assume this has ended...What is clear is that believing yesterday's...was not adequately prudent.
Individual	Are we supposed to be reassured by the fact that these groups of experts all were wrong by a factor of 5 between 1980 and 1993? What reassurances do we have that they are now right?

Acceptability of cancer risk

Name	Comment
Ontario Section American Water Works Association Toronto, Ont.	The rationale document cites the calculated cancer risk as 5 fatal cancers per 1 million people exposed. A conservative public health approach is to use a cancer risk level of 1 in 1 million over a 70 year lifetime.
Citizens' Network on Waste Management Kitchener, Ont.	Additional cancer risk of five in one million is an unacceptably high additional cancer risk. For example, the City of Toronto has set one in a million as the highest acceptable additional cancer risk.
Energy Probe Research Foundation Toronto, Ont.	...we know of no reason to believe that...an additional five-per-million risk of fatal cancer [is] an acceptable risk from one single contaminant in one year's drinking water. A lifetime of that exposure would present a 300 per million total additional risk of fatal cancer, and approx. a 750 per million total additional risk of non-fatal cancer.

Additional Sources of Uncertainty

Sensitive Populations

Name	Comment
Clean North Sault Ste. Marie, Ont.	[Susceptible populations need to be considered in risk assessment. Developmental effects are an issue.]
Individual	We request that in setting stds the Committee adopt a std which takes into consideration the effect on a developing fetus.
Individual	Medical research seems to have found that small children living down wind from a "Station" show a far greater risk of attracting LEUKAEMIA.
Citizens' Network on Waste Management Kitchener, Ont.	We find it disturbing to compare sources of radiation and say that tritium intake as a result of drinking water generally accounts for less than 0.1 % of overall exposure. It isn't general exposure that matters most. Standards must be set for those people who are subject to the highest exposures and receive the higher than average intake because of drinking water.
Bruce Peninsula Environment Group Lion's Head, Ont.	Risk assessment does not take into account that children have a much smaller ratio of body weight to water and food intake. They also have a much higher rate of metabolism. Children would be at a much higher than the 5 fatal cancers per million population. They would also have a longer exposure time than adults...radiation accumulates in the body over a lifetime.
Individual	I am particularly interested in potential impacts as they relate to children, and women--particularly women in their child bearing years.
Individual	Ingestion rates and dose conversion factors for infants and children are age-dependent, therefore the dose to tritium in dw relationship may be different to that of adults. I believe this should be addressed.
Individual	...[although this may appear to be a safe level for an adult]...due to the physiological changes occurring within a growing child, that may not be an appropriate exposure and thus would be exposing children to a greater risk than assumed. Also, no listed comparison was made with regard to a fetus or a pregnant woman...

Energy Probe Research Foundation Toronto, Ont.	[Concerns raised over exposure in pregnant women and the effects to the ova of her female fetus...i.e., the fetus' ova incorporate tritiated hydrogen which then decays over the next 12 to 25 years, damaging the surrounding genetic material and resulting in birth defects in her offspring]
Individual	It has been well established that young children, foetuses, and even the "stem cells"...are more vulnerable to various toxins than are healthy adults, because their cells are dividing much more rapidly.
Individual	We understand that the risk assessments for the proposed stds are based on "kilogram per body weight". Which body weight have you used? Is it the 155 lb. male?
Individual	The myth is that "One standard fits all". The reality is that "Standards for adults may be 100 to 1000 times too high for fetuses".

Concerns re: long term low level radiation exposure

Name	Comment
Ajax Citizens for the Environment Ajax, Ont.	We believe there should be testing done on the long term, low level, cumulative effects of tritium in drinking water, and new acceptable levels determined.
Individual	[The ODWO is based on] a radiation dose external to the body. The effects of long term low level tritium ingested in the dw, although not known at this time, are in all likelihood much more severe than that due to external radiation.
Individual	We are still not sure of the long term effects of low level radiation.
Individual	...how can the long term health effects from a life of drinking slightly tritiated water be deduced from studies of A-bomb victims?

Advisory level

Name	Comment
Individual	We urge that nothing above background levels be tolerated without a public advisory being given.
AECL Research Chalk River Laboratories Chalk River, Ont.	[An advisory level] appears to be contrary to the stated purpose and application of ODWO's and CDWG's...There appears to be no real reason to single out tritium in the province-wide ODWO's for special treatment which is not given to other health-related parameters. One alternative ...might be for municipal authorities in communities which express significant concern about water quality to routinely issue data directly to the public (e.g. though newspapers) on concentrations in [dw] of all health related parameters, including tritium, in comparison to their respective limits. Any such special provisions should be established as needed, and should not be established as Province-wide requirements in the ODWO's.
Durham Nuclear Awareness Oshawa, Ont.	...two action levels should be set for tritium in drinking water. The first action level should be set near normal background levels, and if that level is exceeded, a public advisory should be provided to allow people to make the choice of not drinking tap water. A second action level should be set which would trigger the shutdown of the water supply plant and a temporary shift to alternative water sources.
Individual	Commitment to zero tolerance of any levels of tritium above background levels must be a priority...In addition, for any level of tritium above background levels, I feel the public should be advised.
Sault Area Nuclear Awareness Goulais River, Ont.	The proposed standard of 7,000 Bq/L is too high, considering that the present background levels of tritium in the Great Lakes are less than 10 Bq/L. Any alternative levels beyond background levels should not be accepted without a full public advisory being given.
Individual	...I shudder to think of the spills we do not hear about. [could be interpreted as rec. for spills advisory?]
Ontario Hydro Nuclear Toronto, Ont.	We also support the method of application of the [dw] objective recommended by the [WHO]...and [MOEE]...a single action level where the situation is to be investigated and further possible action considered when concentrations reach 100% of the objective.

Sunsetting

Name	Comment
Durham Nuclear Awareness Oshawa, Ont.	...an appropriate drinking water standard for tritium should be set at current background levels...between 5 and 10 Bq/L, and falling, so drinking water standards should tighten over time to reflect the decay of tritium from weapons testing.
Individual	...phaseout and cut off deadlines and timetables reflecting the current serious situation of tritium and other radionuclide emissions.
Citizens' Network on Waste Management Kitchener, Ont.	In its Seventh Biennial Report on Great Lakes Water Quality, the IJC recommends that the "Governments incorporate those radionuclides which meet the definition of persistent toxic substances in their strategy for virtual elimination." We ask the province to therefore immediately begin to develop a strategy for eliminating the presence of tritium in water as a result of human activities. This strategy should include precise time lines.
Individual	What is needed is a phase out of polluting industries, clean up and rehabilitation programs, with an objective of eliminating man made contaminants from our environment...[the standard] should be reviewed yearly to reduce it even further.
Environment Canada Burlington, Ont.	I would like to suggest a reduction in levels with 2 sets of values in mind and 2 target dates say in 1995 and the year 2002.

Synergistic or additive effects

Name	Comment
Individual	Mixed with other chemicals, taken up by foliage, soil, plants and animals it becomes part of our food chain.
Individual	...the combined affect of all pollutants in our drinking water remains to be unknown. In my opinion the focus should be: ... 3. Combined effects of all pollutants.
The Little Cataraqui Environment Association Kingston, Ont.	...cancer incidence increases by 5 cases per million, which we believe should be at least the maximum acceptable, bearing in mind that this is just one of many chemicals that increase cancer rates.
Citizen's Network on Waste Management Kitchener, Ont.	The use of risk numbers to justify accepting a contaminant in water does not take into account the cumulative impact of the various sources of contaminants in our environment...[example given hypothesizing number of chemicals in evn. 110,000 and number that cause cancer 5,500;] If each of those chemicals contributes a 1 in 100,000 risk, that's a final risk of 1 in 20,000. According to present day de minimus standards, that's neither negligible nor acceptable.
Bruce Peninsula Environment Group Lion's Head, Ontario	Risk assessments target only the effects of one specific toxic chemical on human health but there is growing evidence that chemicals are entering into combinations with other substances with unknown effects on humans.
Individual	[reasons for finding std unacceptable]...how these unknowns will react with other chemicals already present or yet to be developed.
Individual	Issues which I feel must be addressed include: ...the synergistic effects of tritium and (other radioactive water) released by PNGS combined with Ontario Hydro's tritium removal facility at the DNGS and that which is released into the Great Lakes by other facilities (e.g., Detroit Edison) relative to the many hundreds of toxins in the environment...
Consumers' Association of Canada (Windsor) Kingsville, Ont.	...tritium is absorbed by the human body directly from the environment and is likely to produce stochastic effects (comprising malignant and hereditary diseases) simply or as synergistic effect along with other radioactive particles like Cesium 137, Iodine 131, Radium 226, and Strontium 90.

Social Action Committee Unitarian Congregation of South Peel Mississauga, Ont.	We are advised there are other radioactive substances in the drinking water as well as other toxic material. Only ZERO tritium is acceptable.
Individual	My second concern is the combination of tritium with other toxic chemicals in the lake...I would like ACES to look into this or recommend that it be further explored by the appropriate agencies.
Individual	["The experts"] have not looked at the synergistic effect of tritium with other pollutants.

Other routes of exposure

Name	Comments
Individual	It [tritium] can be ingested through the consumption of tritiated water as well as directly through the skin.
Individual	...whilst ingestion is a major pathway, inhalation and skin absorption will also play a part. I estimate that domestic showering and bathing could contribute an additional 1 or 2 percent of dose and that inhalation and skin absorption of tritium form indoor air whose humidity is partly evaporated tap water could contribute an additional 5 to 20 percent. In deriving a water quality objective, I believe these additional pathways should be acknowledged.
Town of Whitchurch-Stouffville Stouffville, Ont.	My feeling is that I would not want to bathe a sick baby, possibly with a skin rash, in water with a 7000 Bq/L standard nor would I want my children to drink or swim etc. in such water. [Quoting from Wang, Willis, and Loveland, 1975] Deposition of radioisotopes within the body...poses an entirely different problem. In this case, isotopes whose radiation have very short ranges are the most hazardous for they dissipate all their energy with a very restricted volume of tissue. Thus alpha emitters and weak beta (tritium type) emitters present the greatest hazard...
Individual	...I use drinking water for bathing, and we know tritium is absorbed through the skin. I also cook my food in the water, I swim in my pool in the summer, I water my vegetable garden with the water, and so on...we are also exposed to high levels of ground tritium and air-borne tritium.

Bioaccumulation

Name	Comment
Individual	[in reasons for finding std unacceptable]...how they will accumulate in the ecosystem, including humans.
Individual	...the half life of tritium is 12.3 years and is thus capable of bioaccumulation in our ecosystems.

Organically bound tritium

Name	Comment
Individual London, UK on behalf of Northumberland Environmental Protection	Chronic exposures to raised concentrations of [tritium in drinking water and air-borne tritium] may result in organically bound tritium building up in the food chain to ambient HTO levels, and in OBT contaminated food grown near the nuclear facilities being eaten. The ingestion of OBT is widely recognised as being more hazardous than the ingestion of HTO..."the radiation dose delivered to specific tissues, for example bone marrow, may be greater following the ingestion of OBT by almost an order of magnitude as compared to HTO". It is recommended that studies be carried out to ensure that food grown near nuclear facilities is not consumed nor used as feedstuffs, and to ascertain the levels of OBT in residents near nuclear facilities.
Energy Probe Research Foundation Toronto, Ont.	...the tritium in these organic compounds is much more [toxic and carcinogenic than tritiated water]because it is much more likely to incorporate itself into the molecular structure of our DNA, our proteins, fats and carbohydrates...
Durham Nuclear Awareness Oshawa, Ont.	...tritium can also become organically bound to molecules in the body, and this can result in a much longer biological half-life.

RBE of Tritium

Name	Comment
Individual London, UK on behalf of Northumberland Environmental Protection	The Quality factor, recently reconfigured approximately to the radiation weighting factor, for tritium remains at 1, although considerable radiobiological evidence exists that it should be increased to 2 and perhaps higher. The evidence...of increasing RBEs with decreasing doses of tritium is particularly worrying.
Environmental Protection Branch AECL Research Chalk River Laboratories Chalk River, Ont.	The RBE...is not a number carved in stone but can vary appreciably depending on the system and the endpoint studied. A high value in one particular system does not negate, or even contradict, a lower value obtained in another system. The RBE of a given radiation is the ratio of the dose of the reference radiation required to produce a given level of effect divided by the dose of the test radiation required to produce the same level of effect. If tritium was more effective, the denominator would be smaller than the numerator; a RBE >1 would result. The international standard for the reference radiation is 200-250 kVp X-rays. At low doses and dose rates (and protracted exposures), however, operation of an X-ray machine is difficult and Co60 gamma rays are often employed...Considerable evidence exists that the RBE for gamma rays referenced to X rays becomes $<$ 1 for low dose/low dose rate exposure; ...This means that if tritium beta rays were, in fact, materially indistinguishable in effect from X-rays, the beta rays would appear to have RBE >1 in reference to the gamma rays...an apparent high RBE (value >1) can result because the numerator is higher not because the denominator is lower (which would be the situation if the test radiation was more effective, as a lower dose would suffice). This view is borne out by a review of the AECB's Advisory Committee on Radiation Protection : "Observed RBE values at low doses and low dose-rates are usually about 2 to 3 when tritium beta rays are compared to cobalt 60 gamma rays but are closer to 1 to 2 when compared to 200 kVp X-rays. This conclusion is supported by microdosimetric considerations of the quality of tritium beta rays, cobalt 60 gamma rays and X-rays."
Durham Nuclear Awareness Oshawa, Ont.	Cell and animal experiments indicate that the RBE value for tritium should be at least 2, and that it may be as high as 5, depending on which type of effect is being considered. This means that tritium is likely 2 to 5 times more hazardous than is currently accepted by the ICRP.

Dose conversion factor

Name	Comment
Individual London, UK on behalf of Northumberland Environmental Protection	...tritium's internal doses may be underestimated in three ways. These are the use of a unconservative dose conversion factors; the use of incorrect metabolic models which ignore organically bound tritium; and the use of an incorrect Q factor from radiobiological evidence...To be conservative, the dose factor for HTO should be increased at least to the higher values in the US [US Nuclear Regulatory Commission uses a dose conversion factor of 3.4 x 10-11 Sv/Bq for ingestion and 2.2 for inhalation; US National Council on Radiation Protection and Measurements uses 2.4]
Environmental Protection Branch AECL Research Chalk River Laboratories Chalk River, Ont.	...calculate the ODWO on the basis of the primary dose conversion factor value, rather than on the basis of a secondary value calculated form the dose conversion factor and already rounded. This would give a value of 7600 Bq/L as noted in [the Rationale Document], which could be rounded to 8,000 Bq/L if desired.

Health effects other than cancer

Name	Comment
Individual	With cancer and birth defects rampant, we need to clean up our Great Lakes and not add to the toxins already there.
Clean North Sault Ste. Marie, Ont.	[MOEE considered only fatal cancer, other endpoints are very important, such as immune effects, lupus, crones, arthritis, etc. Morbidity must be considered, health is more than the absence of death.]
Individual	The only effect mentioned in the report is cancer. What about other effects such as old age diseases? The effects are insidious and concerned that a generation of people are being produced with an impaired ability to cope.
Individual London, UK on behalf of Northumberland Environmental Protection	...concern has been expressed about tritium doses near DNA...tritium from tritiated food is capable of entering the DNA molecule...the same is true from chronic tritiated water ingestion...Another key point in the possibility of high pulses of tritiated water resulting in the transient ingestion of high levels of HTO...Commerford et al 1982, found after a transient HTO exposure in mice, all the tritium remaining 8 weeks post exposure was bound to DNA and its histone...The half lives they found for DNA were extremely long...This has implications for the diets of pregnant women living near nuclear reactors discharging large quantities of tritiated water and water vapour.
Durham Wetlands and Watersheds Oshawa, Ont.	Recent studies suggest correlations between higher background radiation in [dw] and problems such as cancers, birth defects, mental abnormalities and genetic defects.
Individual Toronto, Ont.	...radioactivity in the body increases the risk of developing cancer, other health problems associated with immune deficiency as well as birth defects.
Durham Nuclear Awareness Oshawa, Ont.	the "end point" of interest should not be just death from cancer. The dose of radiation that causes other health impacts, such as birth defects, should be considered as well.
Individual	...what kind of baseline health analysis has been conducted with regard to human health impacts of tritium in this area? I refer not only to fatal cancers, but also to other impacts, including such things as respiratory illness, sex organs of males and females, fetal impact, etc.

Sault Area Nuclear Awareness Goulais River, Ont.	All exposure to radioactivity increases the risks of developing cancer, and accompanying health problems. The cumulative effects on descendant generations is highly debated by industry, but has been proven to include birth defects and sterility.
Individual	We see the Mongoloid children with their parents, or sometimes in groups in the mall. Our daughter in law had cancer but was operated on successfully. She is only 36 and does not drink nor smoke.
Individual	[someone raised to this person that Dr. Petkau's work came up at the deputation session] Most other international scientists in radiation protection have in recent years agreed that Dr. Petkau's studies are not directly relevant to presumed effects of radiation on living organisms and have pursued other lines of research.
Consumers' Association of Canada (Windsor) Kingsville, Ont.	...tritium is absorbed by the human body directly from the environment and is likely to produce stochastic effects (comprising malignant and hereditary diseases) simply or as synergistic effect along with other radioactive particles... Further quantitiative estimates of the number of genetic defects produced in the human population are usually arrived at by estimating the proportion of individuals affected per dose in fruit flies or mice and extrapolating the results to humans. This imparts considerable uncertainties to the results.
Town of Whitchurch-Stouffville Stouffville, Ont.	In addition to the five cancer deaths/million which in itself must only be a statistical estimate, what about the other illnesses precipitated by tritiated water. Was that factored into the five year death figure or ignored?
Energy Probe Research Foundation Toronto, Ont.	...it would appear prudent to assume that tritium-apparently the health dominant emission from those stations-is implicated [in the excesses of Down's syndrome and childhood leukaemia near Pickering and Bruce] The risk estimates on which the ODWO is based assume, contrafactually, that cancer is the only unfortunate health effect of consuming tritium...and that tritium is the only radionuclide (if not even the only carcinogen) in drinking water.

Ajax Save the Waterfront Committee Ajax, Ont	Concerns raised regarding incidence in Ajax/Pickering area of as outlined in AECB studies: Down's Syndrome (86% higher); five other infant abnormalities 25% to 71% higher: limb reduction abnormalities; ear, face, and neck abnormalities; urinary system abnor.; circulatory system abnor.; ventricular system abnor; infant death rates (2 to 5 times higher); childhood leukaemia deaths (34% higher) childhood leukaemia (34% higher); damage to the immune system and genetic damage caused by free radicals; rate of prostate cancer in men.
Individual	[concerns expressed about incidence of Down's syndrome, birth defects, infant standardized mortality ratios etc. in the Pickering/Ajax area] [Proposes a supralinear dose response curve, with greater effects at lower doses than a linear curve would predict; outlines "The Petkau Effect"]A protracted exposure to ingested beta emitters may be 1,000 times more harmful to cell membranes than a brief exposure to X-rays. The longer the exposure, the smaller the dose needed to damage cells.

Feasibility

Cost Analysis

Name	Comment
Individual	[raises questions regarding the changes proposed and whether they would have a significant reduction in pollution given what the economic costs may be.] In this day and age of cutbacks and economic uncertainty in the future, is what we are doing going to be seen as another barrier to business?
C. Bruce Bigham Consulting Deep River, Ont.	...the most difficult thing was obtaining a reasonable balance between safety measure implementation and cost. So my major comment on the proposal is that I feel this has not been studied adequately. It should not be 'beyond the scope' as stated in Section 10. It is a critical issue.
American Water Works Association Toronto, Ont.	all reasonable efforts to improve drinking water quality and to set drinking water standards based on a balanced evaluation of documented health effects research, demonstrated treatment techniques, and cost considerations.
Individual	No one can answer this question (is 7000 acceptable?) without having considered...what are the costs? and what are the expected benefits? If your government has not demanded that you provide a documented risk-benefit analysis with your recommendation it is behind the times....Your advertisement should have read "This std is expected to cost Ontario households $xx per year net but will prevent initiation of an estimated yy fatal cancers per year. Is that acceptable?" I hope that the Minister will feel obliged to provide such cost-effectiveness information when the standard is imposed.
Ontario Hydro Toronto, Ont.	The public must be aware of the costs and benefits of this guideline. [outlines the hypothetical costs and benefits of a water plant closure if level reaches 7,000 for one week]...then the benefit would be to have prevented the public from receiving a dose of approximately 1.8 uSv....And what is the cost to society? If an emergency is declared the cost of activating the emergency plan will be quite substantial. Furthermore the public becomes concerned about the quality of their drinking water. Some may purchase bottled water. Some may suffer anxiety. If Water Supply Plants are shutdown, the public will be directly affected. They may go without water. These costs are real.

Joint Committee on Health and Safety The Royal Society of Canada Toronto, Ont.	The first principle is that risks shall be managed to maximize the total expected net benefit to society...The goal of any risk mitigation effort ought to be the maximization of the net benefit to society in terms of the length of healthful life for all members at all ages...we would appreciate receiving the studies that the regulator has performed that would show that the detriments, in terms of public health impact, arising from current levels of tritium are unacceptable...We also note that reducing low levels of risk is expensive. Often, the societal costs for reducing small risks to an even lower level can be disproportionately high in relation to the benefit to be gained. [enclosed Health and Safety Policies: Guiding Principals for Risk Management booklet]

Water Treatment and Location of Drinking Water Plants

Name	Comment
Individual	...I am really concerned about the levels of tritium in our drinking water...I hope the result [of the consultation] will be such sound advice from the ACES Committee to the Minister...that they will insist on the plant being moved to a safer location.
Pickering Beach Residents' Association Ajax, Ont.	We urge you in your advisory capacity to the government to insist on a safer location for this proposed water supply plant.
American Water Works Association Toronto, Ont.	...given that there is no treatment it may be more critical to control discharges of tritium into the source water.
Bruce Peninsula Environment Group Lion's Head, Ont.	There is not...a choice available when it comes to drinking water: it is clearly stated that tritium contained in water cannot be readily distinguished...it also states that conventional treatment is believed to be of limited effectiveness for the removal of tritium.
Individual	We were very surprised at the information presented to you (at the Feb. 16, 1994 deputation) particularly the fact that tritium is in our drinking water, cannot be filtered or boiled out and that there are substantial differences in "safe" levels...
Consumers' Association of Canada (Windsor) Kingsville, Ont.	Whatever tritium level is drawn by intake pipes of water purification plants are supplied to consumers in their homes.
Individual	...with no proven method of eliminating or filtering tritium from water sources it makes enormous sense to prevent the problem in the first place.
Town of Whitchurch-Stouffville Stouffville, Ont.	We should strive to minimize the health risk by removing the source of higher levels of tritium or locating water supplies that meet the existing levels.
Individual	A direction for the building of NEW water supply plants to accept sites with the best probability of meeting a tritium level of 2300 Bq/L.

Ajax Save the Waterfront Committee Ajax, Ont.	...we also encourage ACES to recommend to the MOEE that no new water supply plant be constructed within 5 miles of a nuclear generating station, which is the law in the United States.

Implementation

Jurisdiction/Multiple water based standards

Name	Comment
Durham Nuclear Awareness Oshawa, Ont.	...the Seventh Biennial Report of the International Joint Commission recommends that governments incorporate radionuclides in their strategy for virtual elimination. This means that tritium pollution must stop.
Clean North Sault Ste. Marie, Ont.	[IJC has named tritium as a persistent toxin and therefore a candidate for zero discharge]
Individual	In my opinion the focus should be: ... 1. the allowable tritium releases to water by Ontario Hydro.
Individual	The recent International Joint Commission (IJC) report recommended that governments work towards the elimination of any radionuclides with a half life greater than six months. The half life of tritium is 12.3 years - 24 times longer than the IJC recommendation.
Durham Wetlands and Watersheds Oshawa, Ont.	The [IJC] has stated that only a zero tolerance level of additional tritium in the [dw] of the Great Lakes is acceptable.
Ontario Hydro Nuclear Toronto, Ont.	It should also be noted that the AECB operating licenses specify that the nuclear station must also comply wiht all applicable provincial and local regulations. This implies that we must comply with the most restrictive regulations in cases where there is overlap of jurisdiction.
American Water Works Association Toronto, Ont.	...given that there is no treatment it may be more critical to control discharges of tritium into the source water.
Atikokan Citizens for Nuclear Responsibility Mattawa, Ont.	Cynical persons, myself included, could come to the conclusion that the MOEE are using an attempt at usurping the AECB's efforts to set stds as a strategy to conflict as many jurisdictional layers of government as possible. These jurisdictional conflicts effectively make any court challenges as difficult, lengthy and expensive as possible. The MOEE must forswear their old trick of using blurred jurisdictional lines between the Provincial government and the Federal government to excuse inaction or indifference.

Citizens' Network on Waste Management Kitchener, Ont.	In its Seventh Biennial Report on Great Lakes Water Quality, the IJC recommends that the "Governments incorporate those radionuclides which meet the definition of persistent toxic substances in their strategy for virtual elimination." We ask the province therefore immediately begin to develop a strategy for eliminating the presence of tritium in water as a result of human activities.
Individual	...substantial differences in "safe" levels, depending on which side of the fence one is situated, i.e., AECL has adopted 210,000 Bq/L whereas our neighbours to the South have 700 Bq/L.
Individual	One of the most baffling aspects of standards for tritium in drinking water is their proliferation and range. We have identified at least 7 tritium concentration "limits", expressed in Becquerels per litre that are variously quoted....Which one is "safe"? Are any? Will a new ODWO interim standard make any difference to the other limits?
Ajax Save the Waterfront Committee Ajax, Ont.	The IJC is about to include radionuclides with a half life greater than 6 months to their list of "persistent toxic substances". The half life of tritium is 12.3 years. It qualifies as a persistent toxic substance, and standards must limit our exposure to it. [Other discussions re: IJC's "Precautionary Principle" and "Principle of Reverse Onus".]

Monitoring

Name	Comment
Windsor Utilities Commission Windsor, Ont.	...we suggest that continuous monitoring be instituted and guidelines established to prevent ingress of highly contaminated water into the Great Lakes system.
Individual	[The report says that the] "Procedure for determination of tritium in water begins with distillation of the samples." Is this a fair test? My understanding is that distilling the water removes a degree of tritium from the water-is this the way to do the test?
Individual	Ont. Hydro has still not developed a three dimensional dispersion model...and as such no predictable pattern of tritium dispersion can be evolved which will enable credible sampling or tracking. No current reliable on line monitor for tritium is available and development is still a long way off. This status is even more significant since we are building a New Water Treatment Plant on the Ajax waterfront, some 4-5 km from the PNGS discharge.
Elgin St. Thomas Health Unit St. Thomas, Ont.	Although we have no comment on the specific standards being proposed, we believe it is important that measurable and meaningful levels should be established for any material found in drinking water which may adversely effect public health.

Transboundry sources

Name	Comment
Conservation Committee Guelph Field Naturalists Guelph, Ont.	...there are several plants on the US side doing the same [releasing radioactive emissions]
Bruce Peninsula Environment Group Lion's Head, Ont.	Just think what a child born in 1993 would ingest with higher and higher concentrations of tritium laced water, especially if fate has put it in the Windsor-Detroit region where Detroit Edison's Ferme nuclear plant is starting to dump millions of litres of tritium laced water on a regular basis to Lake Eri.e.
Consumers' Association of Canada (Windsor) Kingsville, Ont.	Since the lake waters are used by nuclear plants in USA and Canada, it would be advisable for both countries to consider harmonization of standards.

Enforcement

Name	Comment
Atikokan Citizens for Nuclear Responsibility Mattawa, Ont.	Enforcement of future and present laws must be credible and rational. Leave industrial development schemes, political hand-outs and jurisdictional disputes OUT of the picture. The FUNDS for strict enforcement and compliance should be derived from the costs of producing nuclear electricity.
Individual	Also, improved objectives need to be accompanied by strict enforcement. I believe citizens are tired of ineffective 'guidelines' and press releases stating "no immediate health threat to the public", meanwhile the multitudes of cancer are increasing.

Need For Additional Health Studies

Need for additional studies

Name	Comment
Individual	While a public review is laudable, the lack of research as to low level exposure to radionuclides and its sudden elevated levels in drinking water, I find to be quite distressing. In my opinion the focus should be: ... 2. the effects of low level tritium exposure to the populace. While I understand that such studies will have a huge cost and will certainly not be completed overnight, their implementation are long overdue.
American Water Works Association Toronto, Ont.	Although supporting data indicate that reported tritium levels in Ont. drinking water are extremely low, the Section advises that additional data would provide background levels for all areas of the province.
Energy Probe Research Foundation Toronto, Ont.	ACES should...use its present mandate to conduct an investigation of the phenomenon of a short term tritium pulse in dw consumed by a pregnant mother being incorporated in the ova of her female child.
Ajax Save the Waterfront Committee Ajax, Ont.	These three studies [AECB Down Syndrome etc, AECB Leukaemia, Great Lakes Health Effects Program: Prostate Cancer] show that there is an abnormally high incidence of health problems in the Pickering/Ajax area. We question if this is just a coincidence, or can be dismissed as just statistical aberrations. Where are the independent studies to explain these occurrences in our area?
Individual	...there is little reliable information available on the effects of many forms of radiation, of various strengths, affecting various parts of the body. Only the government, which has supported the nuclear industry form its inception, and has promoted it at every opportunity, has the funding to do conduct the necessary comprehensive studies to obtain such information and... has refused to do so...

Other Comments and Recommendations

Name	Comment
The Beaver Valley Heritage Society Clarksburg, Ont.	Although we are interested in water quality, we have no expertise in the chemical arena and therefore are unable to contribute to your consultation.
York Region Public Health Department Newmarket, Ont.	...while we consider upgrading of stds to be beneficial our technical knowledge...limits our capacity to suggest alternate levels.
Ajax Citizens for the Environment Ajax, Ont.	...we are requesting a full tritium review before the new Water Treatment Plant planned for Ajax is underway.
Clean North Sault Ste. Marie, Ont.	[The Backgrounder refers to a "recommended dose", this is misleading because it makes it sound as though radiation is beneficial, like recommended daily vitamin intake. Dose represents five fatal cancers, that should be clear in the backgrounder.]
Walter Brown Associates Environmental Planners and Consultants Mississauga, Ont.	A general comment is the proposed ODWO is an exercise in futility because: a)Ont Hydro is the only source of tritium...only in conjunction with a spill...at $300/kg Hydro is not likely to have many spills b)lakes have a large dilution factor c)bkgd levels have not been factored in.
Individual	I suggested it would be useful to obtain information about standards or guidelines used in other Western countries, such as the U.K., France or Germany, and the rationale for these. ...I expect ACES will have taken appropriate action to obtain this type of information for themselves.
Northumberland Environmental Protection	We are therefore formally requesting that the ACES Committee recommend to the government that a full review process be set up...
International Geochemical Mapping Project c/o Geological Survey of Canada Ottawa, Ont.	...until the natural variations are properly established by systematic mapping there is a serious risk that administratively prescribed limits for "contaminants" may be unrealistic and could cause unnecessary alarm, litigation, and economically damaging consequences.
Individual	...you as a government will have to believe both sides [one saying there is no problem, the other saying there is] and take a middle viewpoint of both. Do not trust one or the other, not either or.

Conservation Committee Guelph Field Naturalists Guelph, Ont.	[concerns re:ecosystem effects]...many wildlife have to survive in this water year round.
American Water Works Association Toronto, Ont.	where decisions regarding resource use and resource development include alternatives adversely affecting the quality of the drinking water supply sources, preference should be given to the alternatives that protect or enhance the quality of the protected source.
Community Liaison Group Siting Task Force Low Level Radioactive Waste Management Deep River, Ont.	We cannot provide comments or recommendations on environmental issues as it is not in our mandate to do so. We cannot, therefore, assist you in this review.
Citizens' Network on Waste Management Kitchener, Ont.	We find it disturbing to compare sources of radiation and say that tritium intake accounts for less than 0.1% of overall exposure. It isn't general exposure that matters most. Stds must be set for those who are subject to the highest exposures and receive higher than average intake...We can't do much about the natural sources. Therefore we must focus on those things we can do something about.
Individual	[following some criticisms of the document] I respectfully suggest that future Rationale Documents used by ACES follow a specific format which includes: a statement of the population of concern, a definition of the critical endpoint, and the calculation of the criterion. This would make the review of the document easier to do.
Bruce Peninsula Environment Group Lion's Head, Ont.	We also strongly urge ACES to expand their advisory activity in taking a stand on eliminating all sources of tritium emission, most notably the aging nuclear reactors which should be taken out of service at the earliest possible date, seeing that there is overcapacity at Ontario Hydro.
Durham Nuclear Awareness Oshawa, Ont.	We would like to recommend that ACES contact an independent expert for an opinion on suitable dose conversion factors,...
Ontario Hydro Toronto, Ont.	...the drinking water objective must be used appropriately, in a fashion which represents true impact. ...This is our main concern: What use will be made of the drinking water objective? The rationale document quotes on page 14 exactly how the international scientific community intended this objective to be used...The [WHO recommended] that the level be used as a trigger to initiate further investigations.

University of Toronto Toronto, Ont.	[recommends clarification in wording of Rationale Document re: consumption level and duration and dose as well as spelling and grammatical errors] I have no objection to the WHO guidelines nor the Canadian or Ontario equivalents and can only emphasize that they must be applied rationally.
Individual	...the release of tritium into the natural environment will indeed impact other life forms...minimizing tritium could be very significant for entire ecosystems... [Comparisons with background-2 concerns]...1. the date on which natural bkgd was determined [should be pre-nuclear] 2. [thinning of the ozone may create more tritium in the upper atmosphere] Bkgd tritium as a beta particle is incapable of penetrating the outer layer of skin but tritiated drinking water is uniformly distributed among all of the soft tissues of the body. Is this not a potentially greater threat?
Energy Probe Research Foundation Toronto, Ont.	[recommendations for emission controls e.g. via BAT or BATEA instead of ODWO] 1. ACES should urge the Minister to begin treating tritium as a priority pollutant...either by adding it to the Emissions Monitoring Priority Pollutants List and monitoring and controlling it under MISA regulations, or by adding it to the Candidate Substances List for Bans or Phase Outs. In our view...either of these outcomes would be more appropriate and more beneficial...than any attempt to control human ingestion solely through an ODWO. 4. In its report to the Minister ACES should endeavour to correct the many false and misleading statements in the Rat. Doc., and should attempt to ensure [it is circulated] From March 10, 1994 submission: inclusion of tritium in Ontario's Effluent Monitoring Priority Pollutants List (of which radionuclides are expressly excluded) and/or Candidate Substances List for Bans or Phase-Outs. [Comparisons of acceptable risk level from ACES's recommendations re: NDMA and tritium risk levels] ACES should not adopt a double standard of acceptable risk.
Individual	General support of increasing water quality; interested in the designation of springs as heritage sites.

Pickering Ajax Citizen's Together for the Environment Pickering, Ont.	1. We feel that the tritium issue deserves a thorough investigation, and that participant funding, and if warranted, intravenor funding be made available to all parties. 2. The ACES report should be distributed to the public on the same day the Minister receives his copy, and that the minister review this report within a reasonable period of time.
Individual	feels that setting standards based on risk assessment is not sound and provides a rationalization to continue to produce tritium, keep people employed etc. Any risk analysis is not worth it
Individual	There appears to be no known rationales for tritium targets of allowable levels, be it 40,000 Bq/L, 7,000 Bq/L or the U.S. of 2,300 Bq/L.

FACSIMILE MESSAGE/BELINO

RADIATION PROTECTION BUREAU
BUREAU DE LA RADIOPROTECTION
775 Brookfield Road
Ottawa Ontario
K1A 1C1

TO/A: MS C. BENNETT
ADVISORY COMMITTEE ON
ENVIRONMENTAL STANDARDS

FROM/DE: DR.P.J.WAIGHT

NO OF PAGES/NO. DE PAGES: TWO
MESSAGE:

DEAR MS BENNETT,

THANK YOU FOR YOUR FAX WHICH I RECEIVED THIS MORNING. AS FAR AS THE PROPOSED ONTARIO STANDARD IS CONCERNED, 7 kBq REPRESENTS AN ANNUAL DOSE OF 0.0919 mSv, BUT I WILL ASSUME A DOSE OF 0.1 mSv FOR THE PURPOSES OF THIS REPLY.

THE NOMINAL PROBABILITY COEFFICIENT FOR FATAL CANCER INDUCTION IS GIVEN BY ICRP IN ITS PUBLICATION 60 ON PAGE 70 AS $5\ 10^{-2}\ Sv^{-1}$. THUS FOR 0.1 mSv RECEIVED ANNUALLY, THE TOTAL LIFETIME RISK WOULD BE

$$5\ 10^{-5} \times 0.1 \times 70 = 3.4\ 10^{-4}$$

TO PUT THIS IN PERSPECTIVE IT IS PERHAPS USEFUL TO COMPARE IT WITH THE LIFETIME RISK OF DYING OF CANCER IN THE CANADIAN POPULATION. THIS IS 26.38% FOR MALES AND 22.20% FOR FEMALES (CANADIAN CANCER STATISTICS 1992 PAGE 27). ASSUMING THAT THERE ARE EQUAL NUMBERS OF MALES AND FEMALES IN CANADA, THEN THE AVERAGE RISK WOULD BE 24.29% OR ABOUT ONE IN FOUR. THE DOSE OF 7 mSv WOULD ADD A RISK OF ABOUT ONE IN TWO THOUSAND NINE HUNDRED TO THIS RISK OF ONE IN FOUR. THIS IS AN ADDITIONAL RISK OF 0.034% TO THE EXISTING 24.29%. OTHER COMPARISONS CAN BE MADE:

THE AVERAGE EXPOSURE FROM BACKGROUND IS ABOUT 2.8 mSv y^{-1}, OR 196 mSv OVER 70 YEARS, COMPARED WITH THE DOSE FROM THIS HYPOTHETICAL SOURCE OF 7 mSv.

THE 0.1mSv IS ALSO WELL WITHIN THE ANNUAL FLUCTUATIONS IN THE

DOSE FROM BACKGROUND.

THE OTHER POINT THAT IS PROBABLY WORTH MAKING IS THAT BECAUSE A LIMIT IS SET, IT DOES NOT MEAN THAT THIS LEVEL WILL AUTOMATICALLY BE REACHED. THE CURRENT LEVELS OF TRITIUM IN DRINKING-WATER RANGE FROM NON-DETECTABLE TO A MAXIMUM OF 50 Bq/l CLOSE TO A NUCLEAR POWER STATION. THE INTRODUCTION OF A 7 kBq LIMIT WILL HAVE ABSOLUTELY NO IMPACT ON THIS LEVEL.

I AM A LITTLE CONCERNED THAT TRITIUM IN DRINKING-WATER IS BEING CONSIDERED IN ISOLATION FROM OTHER RADIONUCLIDES. THE WHO GUIDELINES ARE FOR ALL RADIONUCLIDES, NATURALLY OCCURING OR MAN-MADE, NOT TO EXCEED THE COMMITTED EFFECTIVE DOSE OF 0.1 mSv FROM ONE YEAR'S INTAKE.

I HOPE YOU FIND THESE COMMENTS USEFUL.

SIGNED: 

DATE: 14 MARCH 1994

HARMONIZING[1] CHEMICAL AND RADIATION RISK-REDUCTION STRATEGIES--A SCIENCE ADVISORY BOARD COMMENTARY

Introduction

Risk assessment and risk-reduction strategies for radiation have developed within a markedly different paradigm than has been the case for chemicals. Radiation risk assessment has been based largely on observations in humans exposed to relatively well-known doses of radiation, while chemical risk assessments are much more often based on projections from experiments with laboratory animals or on human epidemiology with relatively uncertain determinations of exposure. Perhaps more importantly, radiation risk-reduction strategies have developed almost from the start under the assumption that it would be necessary to balance these risks against the benefits of radiation or radiation-producing technologies, all within an environment that included unavoidable natural sources of background radiation. By contrast, chemical risk-reduction strategies evolveded from an initial assumption, developed early in this century for food additives, that public health could be completely protected. Only in the 1960s did a balancing approach become well established for chemicals, and (in retrospect) even then it was aimed at reducing risk to levels that would be considered low by almost any criterion, thereby favoring protection of health more than did the radiation paradigm. Furthermore, for many chemicals, significant natural sources were either absent or given relatively little consideration.

The discordance or lack of harmony between these different paradigms was not particularly evident until the Environmental Protection Agency (EPA) started to deal with radiation issues in the context of decisions that also needed to be made about chemicals, for example with respect to radionuclides as hazardous air pollutants under the Clean Air Act, or at hazardous waste sites, or in drinking water supplies where chemicals are also present. The application of standard chemical risk-reduction criteria to radionuclides in these situations leads to limitations on excess radiation dose that are small in comparison to natural background radiation. Knowing the history of the radiation paradigm, it should come as no surprise that some radiation scientists see such limitations on radiation exposures as unworkable or even misguided. Some chemical risk assessors who observe radiation protection

[1] As applied to environmental management, "harmonizing" is a word used extensively in Europe but not as much in the United States. Harmonization does not require that all environmental policies be identical or even wholly consistent; policies are in harmony when they are seen as in tune with an overall strategy and not discordant.

guidelines corresponding to risks greater than one in a thousand are similarly puzzled: how can such high absolute risks be tolerated?

Given this situation, some resolution of the discordance between the two paradigms is needed. The resolution could simply be to assert that radiation and chemicals are fundamentally different and should be assessed and managed differently, or some synthesis could be reached that takes into account both background issues and absolute risk levels. As an example of the latter approach, Kocher and Hoffman (1991) have recently proposed a specific risk management strategy that may be applied to both radiation and chemicals. The following sections describe the radiation and chemical paradigms in more detail and suggest some possible approaches to resolve the discordance between them.

The Radiation Paradigm

Current risk assessment approaches for radiation, whether from radionuclides or from other sources, developed out of the atomic energy program. It both served as a framework for radiation protection for atomic workers (and later for the general public) and, under the rubric of "damage assessment," was used to predict fatalities and residual health impacts from the radioactive fallout from nuclear weapons. In assessing risk, health physicists, radiobiologists, and radiation epidemi-ologists have been able to make risk estimates of relatively high precision from human data. While cancer risk estimates for radiation entail substantial uncertainties, especially at low doses and dose rates, they are seen as being sufficient to justify making a best estimate of risk within a *statistical* uncertainty factor of about 2 for all cancers combined for whole-body external radiation if the dose is known accurately (NCRP, 1989).[2] These best estimates of risk are used directly without further safety factors of any kind. Because best estimates are used and the degree of uncertainty is only moderate, risk assessment results for radiation can be compared with risk criteria for control decisions with some confidence.

Radiation risk assessment was heavily influenced by the thinking of physicists; in fact, "health physicists" are more likely to be involved in the practice of radiation protection than are the "radiobiologists" who study the fundamental biological aspects of radiation. Typically, the description of radiation risks emulated the mathematical treatments of physical systems, often using phenomenologic

[2] Radiation scientists generally acknowledge that no firm conclusions about risk can be made for total doses below about 10 rem. If the linear dose-response hypothesis is accepted for low-dose extrapolation, however, the risk estimates are relatively precise. In this report the units of rad and rem have been used rather than the corresponding SI units of Gy and Se. For conversion to the latter units all numerical values are divided by one hundred.

models with consideration of biological theory only as a secondary factor. The fit of curves to cancer data from radiobiological experiments were interpreted as reflecting linear, simple quadratic, or linear-quadratic dose-response relationships, and the underlying mechanisms were described by "target theory" as "one-hit" or "two-hit" and so on. Later, it was postulated that radiation created breaks in DNA which, if not repaired, could result in somatic mutations and eventually in cancer. While it is now believed that additional mechanisms – e.g., radiation effects on oncogenes – may play a role, the mutation hypothesis for radiation carcinogenesis still heavily influences radiation risk assessment and management (NCRP, 1989).

The analysis of epidemiologic information followed similar models, whether the data were from acute doses of whole-body gamma irradiation (Hiroshima and Nagasaki), fractionated X irradiation (tuberculosis patients, for example), or protracted irradiation from internally deposited radionuclides (the radium dial painters and the uranium miners). Issues arose about the existence of thresholds for radiation carcinogenesis (e.g., in the dial painters) or at least "practical thresholds" (e.g., the idea that cancer latency was inversely related to dose such that manifestation of risks at low doses could be delayed so long that no cancers would occur during a normal lifetime).

Underlying all this development was the knowledge that background exposures to radiation in the range of about 70 to 250 millirem per year (mrem/yr) and averaging perhaps 100 mrem/year dose equivalent (NCRP, 1987) were inescapable. At least initially, these background exposures were generally assumed not to confer *significant* risks. Thus, as recommended radiation standards became more stringent with the discovery of adverse effects at ever lower levels of protracted exposure, the radiation scientists kept in mind the difficulty of separating *excess* exposures from natural exposures when the former did not substantially exceed the latter. Consequently, cancer risk-reduction strategies for excess radiation exposures have very probably included comparison to background radiation in addition to the comparison of risks and benefits resulting from radiation-producing technologies, even though the background exposure issue has usually not been explicitly presented in such decisions.

When in the early days the critical endpoints for radiation protection were effects seen only at what are now considered to be high (e.g., erythema) doses, the allowable excess doses were easily separable from normal variability in background radiation. The standards have been tightened as the assumption of no threshold for radiation carcinogenesis and the possibility of a linear dose-response relationship have taken hold among most radiation risk assessors. These assumptions have been

employed in the development of radiation protection policy. Scientists have also learned, however, that many people are experiencing exposures to the lungs from radon and its progeny that confer risks several times that from the 100 mrem/year that arises from cosmic radiation, terrestrial gamma radiation, and internal potassium-40 radiation, averaging perhaps 200 mrem/yr (NCRP, 1987). And, at least for a time, medical diagnostic and therapeutic radiation increased the average radiation dose about 100 mrem/year on the average.

The International Commission on Radiological Protection (ICRP) currently recommends limiting excess environmental radiation exposures to a total of 100 mrem/yr for the general population (ICRP, 1991). In addition, the ICRP requires that there be a net positive benefit and that the ALARA principle be adhered to that is, that exposures should be kept As Low As Reasonably Achievable when economic and social factors have been taken into account. The ALARA concept appears to be the radiation protection community's equivalent of feasible technology-based standards for chemicals.

The potential cancer burden from 100 mrem/yr exposure is not always made explicit in radiation protection guidance. If continued over a lifetime, however, 100 mrem/yr is calculated with EPA's current risk coefficient for radiation carcinogenesis to cause cancer risks of almost 3 in a thousand (3×10^{-3}) (NAS/NRC, 1990). Some analyses would predict risks up to three times higher, i.e., close to one in one hundred.

The Chemical Paradigm

For chemicals, the paradigm is different. Most cancer risk assessments are based on the results of bioassays in animals dosed with chemicals at levels thousands of times those expected in the environment, not from human data of high reliability. To deal with the uncertainty, EPA in particular has adopted the use of the upper confidence limit on the slope of the linearized multistage model to project risks at low doses and has used a conservative procedure -- the surface area scaling rule -- to project from animal bioassays to assumed human responses. Both of these procedures are widely believed to produce risk estimates that are more likely to overestimate than underestimate human risk (EPA 1986; 1989). Thus risk estimates for chemicals are biased high (even though such may not be the case with every chemical). This conservative method of dealing with uncertainty ensures that in the vast majority of cases, the actual risk level achieved will be lower than the risk criterion used in a control decision.

Furthermore, the prototype chemical carcinogens were synthetic substances with no or limited natural sources. In calculating excess risk from human sources of a chemical, background levels, if any, are therefore frequently seen as irrelevant, even though in actuality background levels from either natural sources or anthropogenic sources other than the one being considered often exist.

Risk assessment for chemicals developed from the ideas of medical epidemiologists, biostatisticians, experimental biologists, and – perhaps most importantly – public health regulators. Again the idea was to protect people from the adverse effects of chemicals on health, most particularly potential carcinogenicity. Here the tradition was chemical safety, deriving from the early food and drug protection ideas to keep chemical exposures low enough to protect health with a substantial margin of safety. This was typically accomplished by finding some "no-effect level" and then dividing by "safety factors" with the goal of achieving nearly absolute safety. This approach is still used for non-carcinogenic chemicals.

The idea that some chemicals might be a little dangerous at *any* level of exposure (the no-threshold idea, applied especially to what were then called "radiomimetic chemicals") came as quite a shock to the regulators. Congress responded in 1958 by attaching the "Delaney Clause" to the amendments for the Food, Drug, and Cosmetics Act, which prohibited the addition to the human food supply of any chemical that can cause cancer in humans or animals. The idea remained to provide absolute protection against cancer risk.

From the start, however, FDA scientists and others realized that assuring complete absence of carcinogens in the food supply was impossible, particularly in view of the rapidly advancing ability of the analytic chemists to detect ever lower levels of chemicals in food, and the abundance of naturally occurring carcinogens. Almost from the outset of the Delaney era, therefore, the FDA was looking for the practical equivalent to absolute safety in a world where thresholds for carcinogenesis could not be assured. FDA and NIH scientists soon proposed that if risks calculated under the no-threshold assumption were below some small value, the carcinogen was effectively not present in the food and the Delaney Clause would be satisfied. The first proposal for a "virtually safe dose" was to limit cancer risk to one in 100 million (10^{-8}) over a lifetime of exposure (Rodricks et al., 1987). The idea was clearly tied to the assumption that all the people in the United States could be exposed at or near the virtually safe dose; at the then-current population of about 150 million, only one or two people currently alive could be affected even if all the conservative assumptions about exposure and potency proved to be true.

Shortly thereafter, it was realized that the 10^{-6} criterion itself put an almost impossible burden on the regulator for assuring the safety of food additives with considerable benefits. Almost as a reflex, the idea arose that one in a million (10^{-6}) was a lifetime risk that most people would find negligible. At that level, everyone in the nation could be exposed and only about 3 excess cancer cases *per year* would be incurred, again even if the risk estimates were accurate and not conservative. Given that everyone would not be so exposed if one calculated the risk for a reasonably highly exposed person, the resulting cancer toll would clearly be invisible and, for most people, the risk insignificant.

Although quasi-scientific arguments have been offered to justify the one-in-a-million criterion for acceptable risk, we must not forget that it originated as a number of convenience. Nevertheless, it became institutionalized over the next several years and, when cancer risks from environmental exposures became recognized in the late '60s and early '70s, the concept of negligible risk at 10^{-6} was applied there.[3] Early on, the types of risks of most concern were widespread ones such as exposures to PCBs or pesticide residues in the environment. Later, the same risk criteria began to be applied to much less widespread risks such as around industrial facilities or hazardous waste disposal areas.

Eventually, it became evident that 10^{-6} was a very stringent criterion when relatively few people were exposed. Studies of EPA decision-making show that EPA often has chosen not to require reductions in exposure when the calculated risks were as high as 10^{-4} or even 10^{-3} when the population exposed was small (Travis et al., 1987; Rodricks et al., 1987).

Moreover, some of the statutes that govern chemical regulation by EPA and other agencies allow or even require a balancing of the risks against the benefits of the technologies involved and the cost of control strategies in determining what risk is acceptable in a specific situation. Others simply demand action whenever risks are determined to be "substantial" or "significant," and many judicial battles have been fought over the meaning of these directives. For example, in the *Vinyl Chloride* case litigated under the Clean Air Act, the court ruled that chemical safety did not imply a complete and unambiguous freedom from risk, but also that the

[3] This level of risk limitation was not, and still is not, required in the occupational health arena where, both by virtue of arguably voluntary risk and by precedent from non-cancer risks, a lifetime risk criterion of about one in a thousand is considered reasonable for occupational exposure to carcinogens (See Rodricks et al., 1987, pp. 314). Even in the occupational arena, however, radiation exposure limits are less restrictive in risk terms than are chemical exposure limits. Currently allowable radiation doses, if actually incurred, would lead to a lifetime risk of well over one in a hundred, perhaps reaching one in ten (See NAS/NRC, 1990, pp. 172).

primary safety decision had to be made without considering benefits and control costs (Whipple, 1989). Later, risk/benefit balancing could be applied in determining an adequate margin of safety. Such risk-benefit balancing is conducted in the same spirit as the optimization principle in the radiation community, but at a different balance point, with radiation protection requiring lower expenditures per cancer avoided.

Recently, Don R. Clay, EPA's Assistant Administrator for Solid Waste and Emergency Response (which includes the Superfund program) has indicated that remediation at hazardous waste sites need not be undertaken when cancer risks for lifetime exposures are calculated to be below 10^{-4} (Clay, 1991). Cancer risk levels at or above 10^{-4} are also accepted in setting Maximum Contaminant Levels (MCLs) for carcinogens in drinking water (e.g., for chloroform from water disinfection) when limiting them further is not technically or economically feasible. Even so, many EPA programs still apply a risk criterion in the 10^{-6} to 10^{-4} range to a (sometimes only hypothetical) "maximally exposed individual" or "reasonable maximum exposure." This "individual risk" focus does not place as much weight on the overall protection of public health (individual risk times number of people exposed at that risk level) as does a "population risk" focus. Whether the Agency's judgment is focused on individual risk or on population risk for a specific situation depends on the provisions of the enabling legislation and the traditions of the EPA office implementing it. Risk-based legislation is more likely to result in an individual risk focus, whereas technology-based standards to some extent skirt the individual risk issue and implicitly favor a population risk approach.

Some chemical regulators and environmentalists are convinced that risk levels above one in a million are not acceptable for *any* person, invoking arguments regarding equity: why should any person bear a cancer risk for the benefit of other people? Why should all people not be afforded equal protection? Why should carcinogens be allowed in the environment at all? And everyone would agree that all opportunities to reduce risk should be seized as long as the costs -- economic, social, or other -- are not too high.

Progress toward such goals is much easier to measure when there is no natural background exposure. Synthetic organic chemicals often would not be observed in the environment at all if not for human activities; even when natural

sources can be identified, the risk levels for the natural levels of exposure are often not high when calculated with the linearized multistage model or an equivalent.

Notwithstanding these similarities to the radiation paradigm, the chemical carcinogen paradigm tends to view any risk levels above 10^{-4}, even to a very few individuals, as potentially excessive and therefore requiring action to reduce exposure and risk.

Discordance between the Paradigms

Although similarities and differences in risk *assessment* techniques for chemicals and radiation have been discussed, (NCRP, 1989) and although the difference in the risk-reduction strategies between these two paradigms has been recognized by some scientists and regulators for several years, the provinces of the health physicists and the chemical risk managers stayed relatively distinct until recently. As the EPA gradually took on greater and greater responsibility for regulating radiation sources as well as chemical ones, the discordance became more visible.

The difficulty became evident in several EPA program areas. When EPA had to promulgate National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for radionuclides, it needed to harmonize the residual risk levels with those allowable for other carcinogenic air pollutants such as benzene. In the course of analyzing sources of airborne radionuclides, more stringent controls were proposed for them than would have been thought necessary to keep radiation doses to 100 mrem/yr or somewhat less. Furthermore, EPA had to wrestle with the fact that prior emissions from (or other practices of) these facilities may have left residual radioactivity in communities across the country producing radiation doses with calculated risks greater than one in ten thousand.[4] The Radiation Advisory Committee (SAB, 1992a) recently commented on the Idaho Radionuclides Study, in which some people may have received *excess* gamma radiation of the same magnitude as typical background radiation levels, i.e., about 100 mrem/yr, from uranium-series radionuclides in elemental phosphorus slags distributed in their community. Elsewhere, EPA is dealing with radon emanations from phosphogypsum stacks or with radionuclides from processing of rare earths for radium, thorium, or non-radioactive materials.

[4] In a few situations – arsenic in drinking water comes to mind – the calculated risk levels of natural exposure are high. In such cases, the idea of comparison to background of chemical carcinogens is more likely to be invoked, often by stipulating that there is no excess exposure if measured concentrations are not beyond the confidence limits on the distribution of background concentrations.

A second area of discordance grew out of the recognition of waste problems involving radioactive materials that were under the purview of EPA or state environmental agencies rather than the Nuclear Regulatory Commission or the nuclear/radiation safety agencies in agreement states. The most striking of these are the radioactive or mixed waste problems at sites that have been placed on the National Priority List for attention by the Superfund Program. Here the wastes of most concern are often the radionuclides of the uranium or thorium series that are also found in nature, and which have for the most part been "technologically enhanced" by human activities, rather than created by them.

The facilities of the Department of Energy that are part of the nuclear weapons complex form another group of problem sites where radionuclides are a significant or even dominating part of the cancer risk equation. Whether these facilities are treated as Superfund (CERCLA) problems or current waste disposal sites under the Resource Conservation and Recovery Act (RCRA), the treatment of radioactive materials is seen as necessarily being subject to the same types of risk analyses and remedial responses that EPA has used for chemicals. The document "Risk Assessment Guidelines for Superfund" (RAGS), for example, contains a section on how to assess the cancer risks from exposure to radionuclides, but does not suggest any different risk-reduction strategies than for carcinogenic chemicals. The implication is that remediation is expected if the lifetime risks from radionuclides are calculated to exceed about 10^{-4} (or lower in some proposals for radiation sites).

The differences in the radiation and chemical paradigms have also become apparent in EPA's actions with respect to radon in homes. The current EPA guidance ("action level") for home remediation is 4 pCi/L of radon in air in the lowest lived-in area, which by current EPA risk assessment methods translates to a lifetime risk of over 1 in 100 or 10,000 in a million (1×10^{-2}) for an average person (smokers and nonsmokers combined) (EPA, 1991a). The Agency is clearly not implying that such a level of risk is acceptable in an absolute sense, but appears to be applying a rule of practicality based on the difficulty of reducing exposure levels much below 4 pCi/L within a reasonable budget. EPA also must work on the radon issue without a clear legislative mandate encouraging the Agency to regulate homeowners' choices.

EPA has reacted differently to the legislative requirement to control levels of radon in drinking water. Using an approximation of the chemical paradigm, the Office of Drinking Water has proposed that public water utilities must treat water that contains radon above 300 pCi/L (EPA , 1991b), a level yielding a risk in the vicinity of one in ten thousand (1×10^{-4}), even though this level of risk is two orders

of magnitude lower than what is recommended for radon in air and the cost per calculated life saved is substantially greater than for remediation of radon in household air (SAB, 1992a).

It can be argued that the discordance between radiation and chemical risk-reduction strategies is simply another manifestation of necessary differences in regulatory choices in different situations. Indeed, good reasons exist to make all risk-reduction decisions within a framework intended to reduce overall risk levels without excessive attention to keeping the risks from any one situation within inflexible guidelines. Clearly, the requirements of the various statutes enabling EPA's regulatory activities force the Agency to formulate and apply some *discordant and* seemingly inconsistent policies. Nevertheless, the Committee believes that the differences between the chemical and radiation paradigms are more troublesome than the variation within each area of regulation.

In each new case of radiation risk management, EPA can follow the chemical tradition of regulating risks to the vicinity of 10^{-4} or lower or the radiation tradition of tolerating (where inexpensive remedies are not readily available) an approximate doubling of the risks from natural background radiation, which are in the vicinity of $3 * 10^{-3}$ for background exclusive of radon and nearly one in a hundred (10^{-2}) when radon is included. This disparity can and has led to considerable lack of understanding and conflicts between health physicists and chemical risk managers. Even the existence of an analogy in the chemical world to the radionuclide problem -- the background levels of carcinogenic inorganic substances such as arsenic and the existence of substantial quantities of natural organic carcinogens in foods (Ames and Gold., 1990)-- has not brought about any resolution of this discordance.

Need for Harmonization

Clearly, EPA needs to adopt policies that will allow its staff, the regulated community, scientific consultants to both parties, and the general public all to know what to expect in EPA's regulation of residual radioactivity and other radiation issues. The Radiation Advisory Committee does not claim any special insight in how the resolution should be accomplished, but does emphasize the importance of achieving such harmonization. Interest in the comparative risks of radiation and chemicals has a substantial history (NCRP, 1989) and is now becoming more widespread (Kocher and Hoffman, 1991).

One approach could be to assert that radiation and chemical regulations are fundamentally different, perhaps because of the unavoidability of background

radiation. The guidance of the ICRP on dose limitation (currently, 100 mrem/yr whenever the ALARA principle does not result in lower levels) could become the explicit policy of the Office of Radiation Programs (ORP), and other branches of EPA could explicitly defer to ORP on radiation and radioactivity issues.

A second set of alternative approaches would strive for clear consistency between the radiation and chemical risk-reduction strategies. The two extreme cases are:

a. Use the optimization principle along with background risks from radiation as guidance for how much excess risk can be tolerated from any source, be it chemical or radiation. Excess risks in the range of 10^{-3} or a bit higher would be used as a criterion for remedial actions or regulations where remediation is expensive and not easily achieved. Use the ALARA principle whenever it applies, that is, when risks can be reduced without excessive penalties in terms of social or economic costs. Make provisions for dealing with hazards in those cases where exposures even at the calculated 10^{-3} risk level are not detectable or distinguishable from background (i.e., ALARA should apply whenever risk reduction can be reasonably anticipated even though it cannot be measured).

b. Regulate radiation risks exactly as chemical risks are now regulated. Use 10^{-4} as a standard criterion for remediation or regulation, regardless of how the corresponding standards compare with background levels of exposure. Use the absolute value of risk in excess of background risk as a criterion, not the fractional increment relative to background risk. Make practical exceptions for the inability to detect some of the regulated exposures at the selected level of risk, just as is done for chemical substances when the detection limit exceeds the target for regulation, as is the case for dioxin in water. Take costs and benefits into account where the applicable legislation provides for that possibility.

The Radiation Advisory Committee recognizes that neither of these latter options may be practicable given the history of how the two paradigms developed. Probably more likely to be accepted would be a third option that seeks a compromise risk-reduction strategy with an intermediate risk acceptance criterion or criteria.

As a third option, the Agency could determine that, because the physical characteristics of the two types of agents are so different and because the approaches to monitoring and regulating them have developed so differently, bringing the two areas into rigid conformity in the near term is very likely not possible, however societally or ethically desirable as a long-term goal. The Radiation Advisory Committee strongly suggests in this case that the two approaches be *harmonized*– that is, fitted into a common policy framework aimed at aggregate risk reduction but not necessarily achieving such reductions in identical ways or with identical risk criteria in every case (see Deisler, 1984, for an example of harmonization in the chemical safety field). The harmonization between chemical and radiation risks of different types could occur by clearly and explicitly taking into account the differences in risk-reduction criteria or strategies between hazards that have natural sources (rather than, or in addition to, anthropogenic sources) and those that have only anthropogenic sources: For example, risk criteria for substances with no natural sources (including radionuclides such as plutonium or americium) could be different from those used for substances that have natural sources (including carcinogenic inorganic substances and organic materials with significant natural sources).

Whatever the nature of harmonization between the radiation and chemical paradigms, it will need to incorporate as well the differences among ambient environmental and indoor and occupational exposures, and the distributions of risks and benefits among exposed individuals and the sources of the exposure.

Clearly, the choice among these options – and others that may exist – is a policy choice that transcends scientific analysis. The leadership of the Environmental Protection Agency has the authority and the responsibility to make the choice. We urge the choice to be articulated clearly so that the scientists who assess the risks of radiation and chemicals can understand the basis for subsequent decisions about risk reduction.

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Appendix 6: The Effect of Various Issues on the Recommended ODWO

Issue (Uncertainty)	Effect on ODWO (Reduction Factor)	Resulting Level of Risk (Excess Cancers per 1,000,000 Exposed)	ODWO (Bq/L)
MOEE proposed ODWO Rationale Document (Based on 1 year of exposure)	-	≥ 340	7,000 (MOEE's proposed Interim ODWO)
Lifelong Exposure (Based on a 70 year lifespan)	70	≥ 5	**100** (ACES's recommended Drinking Water Objective)
Risk Reduction from 5 excess cancers per million exposed to 1 excess cancer per million exposed.	5	≥ 1	**20** (ACES's recommended five year target)
RBE* 1 or >1; Dose Conversion Factors; Areas of Uncertainty; Organically Bound Tritium (longer biological half-life)	1 - 3 ?	< 1	**Natural Background** (Ultimate goal)

*RBE is the relative biological effectiveness of tritium (also see Glossary).

Appendix 7: 1991 Tritium Data from the Nuclear Surveillance Program and Analysis of Tritium in Drinking Water

Source: Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium. November, 1993. Standards Development Branch, Ontario Ministry of the Environment and Energy, 39 pp.

APPENDIX E.2 : 1991 TRITIUM DATA - NUCLEAR SURVEILLANCE PROGRAM

PLANT	Range (Bq/l) in Treated Water
AJAX WTP	< 9 - 50
AMHERSTBURG WTP	< 8 - 34
BOWMANVILLE WTP	< 9 - 27
DEEP RIVER	< 8 - 12
HARROW-COLCHESTER	< 8 - 12
KINCARDINE PUC	< 8 - 25
NEWCASTLE	< 8 - 24
OSHAWA WTP	< 9 - 36
PETAWAWA	< 9 - 370
PEMBROKE	< 9 - 270
PICKERING	17 - 21
TORONTO	< 8 - 57
WARKWORTH	< 9
WHEATLEY WTP	< 9 - 11
WHITBY WTP	< 8 - 36
VERNEER WTP	< 10

APPENDIX D : ANALYSIS OF TRITIUM IN DRINKING WATER

The analysis of tritium in drinking water is conducted by the Radiation Protection Service Laboratory (RPSL) of the Ontario Ministry of Labour.

The procedure used for the determination of tritium in water begins with the distillation of the samples. The middle fraction of the distillate is combined with a liquid scintillation cocktail and counted in a Liquid Scintillation Counter. Normal reported detection limits are approximately 7 Bq per litre.

Also see: Appendix E.1, p. 25. of *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium.*

ACES Members

Mark Goldberg*
Chair of ACES
GlobalTox International Consultants Inc.
& University of Guelph
Guelph

Beth Savan*
Vice Chair of ACES
Environmental Research and Education
University of Toronto
Toronto

Robert Boldt
Occupational Health and Environment
Sarnia

Ian Brindle
Analytical Chemistry
Brock University
St. Catharines

Terry Burrell
Environmental Economics and Law
Toronto

Doug Cook
Occupational Health and Environment
Taurscale Consultants Ltd.
Bridgenorth

Cindy O'Brien*
Occupational Hygenist
City of Toronto
Toronto

Sally Paterson*
Environmental Chemodynamics
University of Toronto
Toronto

David Pengelly
Air Pollution Epidemiology
McMaster University
Hamilton

Kim Perrotta
Occupational Health & Safety
Labour Consultant
Toronto

Catherina Spoel
Environmental Law
Miller Thomson
Toronto

Ralph Stanley*
Public Health Protection
Peel Regional Health Department
Brampton

Keith Winterhalder
Plant and Soil Ecology
Laurentian University
Sudbury

* Denotes Member of Tritium Workgroup

ACES Staff

Carol Bennett
Technical Advisor

Dianne Corrigan
Scientific and Technical Coordinator (Acting)

Kathy Paidock
Administrative Assistant

Carole Brown
Receptionist

Advisory Committee on Environmental Standards
Suite 401
40 St. Clair Ave. West
Toronto, Ontario
M4V 1M2
Phone: (416) 314-9265
Fax: (416) 314-9270

Ontario