Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Regulatory Experience in Applying a Radiological Environmental Protection Framework for Existing and Planned Nuclear Facilities

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CNSC CCSN

nuclearsafety.gc.ca

Outline

- Canadian Nuclear Safety Commission
- Environmental Protection Framework
- Biota Dose Assessment – the Last Decade
- Regulatory Approaches in the USA
- Regulatory Experiences in Canada

Canadian Nuclear Safety Commission

Established May 2000, under the
Nuclear Safety and Control Act (NSCA)

Replaced the AECB of the 1946
Atomic Energy Control Act

Celebrating 65 years of nuclear safety!

Canadian Nuclear Safety Commission

Regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy

Canada's nuclear watchdog

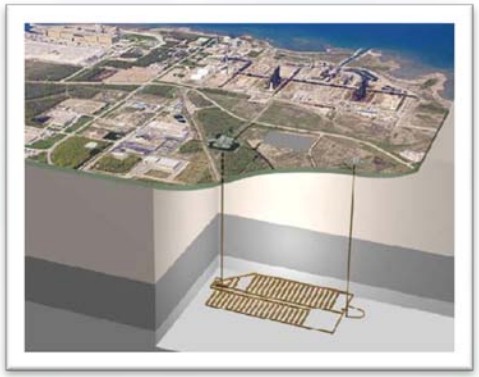
Independent Commission

- Quasi-judicial administrative tribunal
- Reports to Parliament through the Minister of Natural Resources Canada
- Commission members are independent
- Commission hearings are public and Webcast
- Decision can only be reviewed by Federal Court

Transparent, Science-based Decision-making

CNSC Regulates All Nuclear-Related Facilities and Activities

- Uranium mines and mills
- Uranium fuel fabricators and processing
- Nuclear power plants
- Waste management facilities
- Nuclear substance processing
- Industrial and medical applications
- Nuclear research and educational
- Export/import control



...From Cradle to Grave

Environmental Protection and the NSCA

- Under the NSCA and its regulatory authority, two of the CNSC's responsibilities are:
  - Direct protection of the environment
  - Regulatory responsibility for hazardous substances in addition to nuclear substances
- A holistic, "ecosystem approach" to environmental protection

- The NSCA and regulations contain numerous references to environmental assessment and protection. Key requirements are to:
  - Describe environmental risks and related measures to prevent or mitigate them
  - Prevent unreasonable risk to the environment
  - Make adequate provision for the protection of the environment
  - Take all reasonable precautions to control releases of radioactive or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity

Environmental Protection is Legislated

Environmental Protection in Canada
Environmental Protection Legislation

- The *Canadian Environmental Protection Act* (CEPA) is the federal umbrella legislation for environmental protection

- CEPA contributes to sustainable development and states that:

  - Pollution prevention is a national goal and priority approach to environmental protection
  - Integral role of science in decision making with due consideration of environmental and health risks, social, economic and technical matters

Environmental Protection in Canada
Environmental Assessment Legislation

- The *Canadian Environmental Assessment Act* (CEAA) and its regulations establish the legislative basis for the federal practice of environmental assessment in most regions of Canada

- Under the CEAA, decisions on projects are made on the basis of the significance of adverse environmental effects

- The CNSC cannot make a licensing decision until an EA under the CEAA has been made for a project

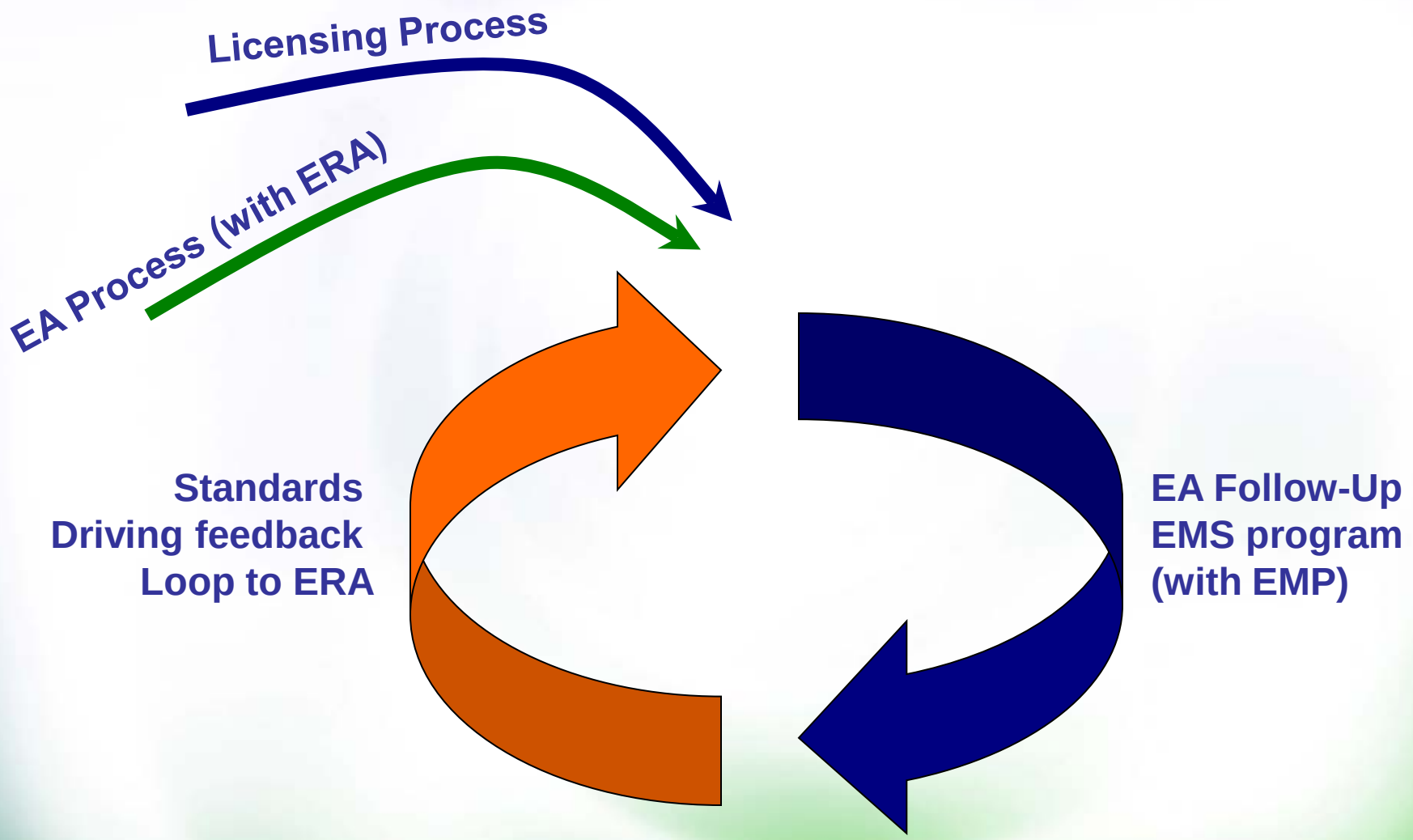
Environmental Risk Assessment

- Environmental Risk Assessment (ERA) forms part of the CNSC's licensing basis; it is also a key element of the CEAA with ongoing harmonisation of requirements under the CEAA and the NSCA

- Risk assessments are used to describe the environmental effects of licensed activities and as a basis for licensees proposed environmental protection programs:
  - Environmental Management System (EMS)
  - Effluent control and monitoring
  - Environmental monitoring

- Regulatory standards for these programs are described in Canadian Standards Association (CSA) documents that are important components of the CNSC's regulatory framework

Environmental Protection Framework



Radioecology – 20 Years Since ICRP 60

- **ICRP 1991 Publication 60**
  *"The Commission believes that the **standards** of environmental control needed **to protect man** to the degree currently thought desirable **will ensure that other species are not put at risk**."*

- **ICRP 2003 Publication 91**
  A Framework for Assessing the Impact of Ionising Radiation on Non-human Species

- **ICRP 2009 Publication 108**
  Environmental Protection: the Concept and Use of Reference Animals and Plants [Dosimetry and Effects]

- **UNSCEAR 2008**
  Effects of Ionizing Radiation on Non-Human Biota

- **IAEA Basic Safety Standard 2011**
- **European Commission Council Directive 2011**

- **FASSET, EPIC, ERICA, PROTECT, EMRAS, STAR ….**

The Basic Risk Calculation

Biota Dose "Screening Index"

$$\frac{\text{Exposure } \textbf{(often modelled)} \times \text{Dosimetry}}{\text{Effects Benchmark}}$$

LARGE uncertainties for Exposure
Heavy reliance on transfer factors from media to biota

Chronic effect benchmarks for only a few species
No relevant benchmarks for alpha emitters

Dosimetry not well-established for specific biota, but can be handled in a conservative manner

Effects - ICRP 108 Synthesis

"**Preliminary**" Derived Consideration Reference Levels
Simplified example for low thresholds of effects (~*μGy / h*)

Plants	**Terrestrial Animals**	**Aquatic Animals**	**Inverts**
40 - 400	40 - 400	40 - 400	**400 - 4000**
Pine tree - Morbidity, reprod effects	**Deer** - Possible reprod effects	**Trout** - Possible reprod effects	**Bee** - No info
Wild grass - No info	**Rat** - Possible reprod effects	**Flatfish** - Possible reprod effects	**Crab** - No info
Seaweed - No info	**Duck** - Possible reprod effects	**Frog** - No positive information	**Earthworm** - Effects unlikely

Effects – PROTECT Ecosystem Approach

- **Generic screening value = 10 µGy/h / 0.24 mGy/d**

  "To protect the sustainability of populations of the vast majority of all species and thus ensure ecosystem function now and in the future. Special attention should be given to keystone, foundation, rare, protected or culturally significant species."

  = Protect 95% of all species at a 10% effect level

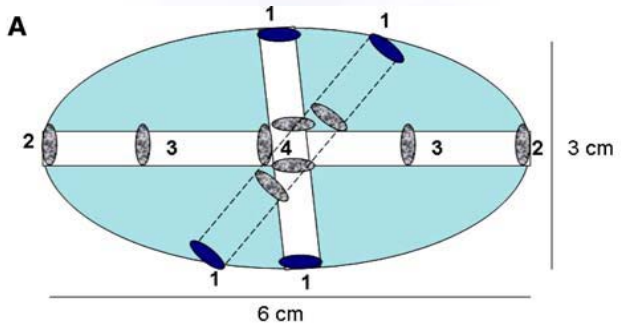
- **Organism group specific values**

  Vertebrates 2; Plants 70; Invertebrates 200 µGy/h considered to be "illustrative and indicative of the order of magnitude of values only"

  VERY large confidence intervals for benchmarks

Dosimetry – Improved Tools (ICRP), Validation Underway

Stark & Pettersson (2008) Radiation and Environmental Biophysics (2008) 47:481–489



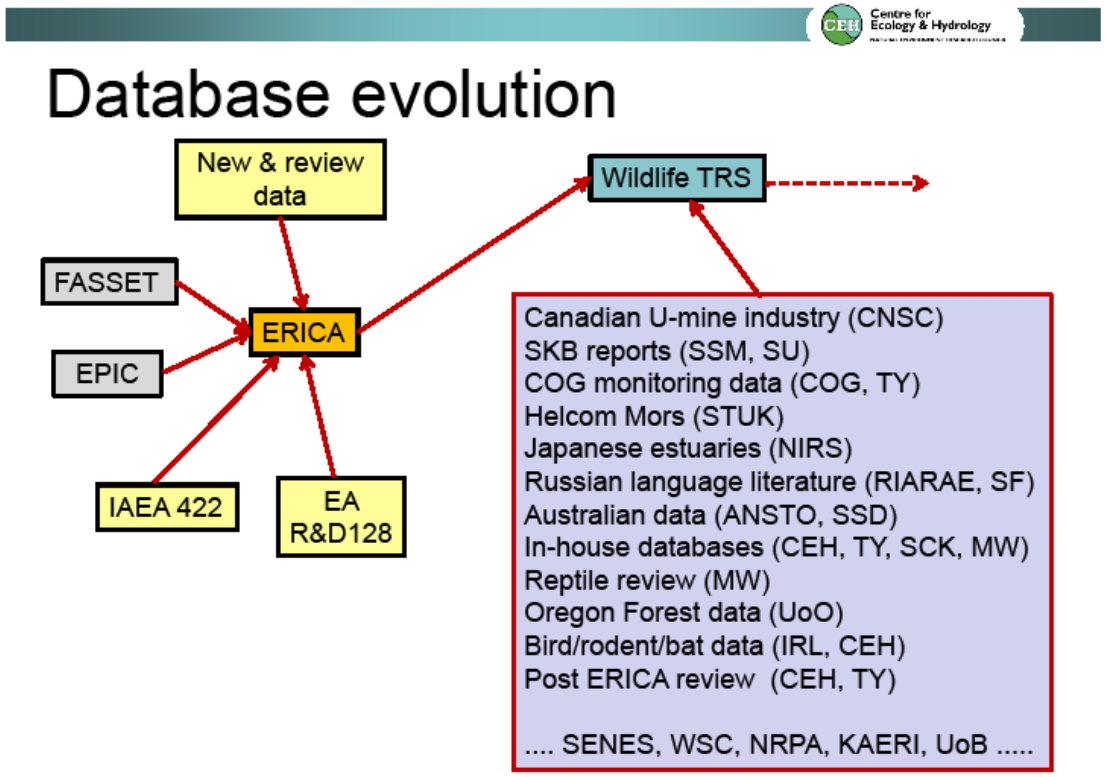
RESRAD & ERICA elliptical dose models vs actual doses

Acrylic Frog Phantom with TLDs

Measured doses lower overall but higher near the surface

Exposure – IAEA Wildlife Transfer Database

Still many, many data gaps, including ICRP Reference Animals and Plants
Order(s) of magnitude differences in transfer factors



Biota Dose Assessment Tools

- USA: Resrad Biota, DOE Graded Approach
- Canada: CEPA Approach
  (EC & HC, CNSC)
- United Kingdom: R&D 128
- Europe: ERICA Integrated Approach
  - Includes environmental transport models
  - Environmental Media Concentration Limits
  - The culmination of many coordinated scientific studies

Regulatory Approaches in the USA - DOE

- The Department of Energy (DOE) finalised a technical standard with a detailed assessment methodology and an accompanying spreadsheet tool in 2002 based on 1 mGy/d (terrestrial) and 10 mGy/d (aquatic) benchmarks

- Now implemented in Resrad-Biota; widely-used internationally, generally conservative

- Example of DOE application: SOP-5243
  Los Alamos National Laboratory (2009)

  Next review due 2014

  http://www.lanl.gov/environment/all/docs/qa_wes/SOP-5243.pdf

Los Alamos Assessment

A few contaminated sites approach up to 10% of the DOE benchmarks for maximum dose, e.g. TA-5 (Beta Site and Mortland Canyon)

radionuclide	Soil conc. (pCi/g)	maximum dose (mrad/day)		population dose (mrad/day)	
		Plant	Animal	Plant	Animal
Am-241	21	5	1	1	1
Pu-238,9	26	5	1	3	1
U-238	1	0	0	0	0
H-3	1	0	0	0	0
Cs-137	72	30	3	3	3
Sr-90	4	5	0	0	0

Regulatory Approach at the US NRC

- The NRC's position is that the limits established for humans are also conservative for other species
- Impacts to biota are being assessed in the context of NUREG-1555, with the technical rationale coming from NCRP, IAEA, and ICRP publications
- NRC Staff perform confirmatory analyses with NRCDose 2.3.10, using the LADTAPII (liquid), GASPARII (gas) codes, supported by Guide 1.109, NUREG-0172
- Resrad-Biota has also been applied to monitoring data from 15 operating nuclear plants
- NRC has estimated very low levels of risk in its analyses;
  it is monitoring international developments

Calvert Cliffs – New Build Example

New EPR reactor at site in Maryland with two existing units
http://pbadupws.nrc.gov/docs/ML1112/ML11129A179.pdf

Table G-9. Comparison of Dose Estimates to Biota from Liquid and Gaseous Effluents, Unit 3

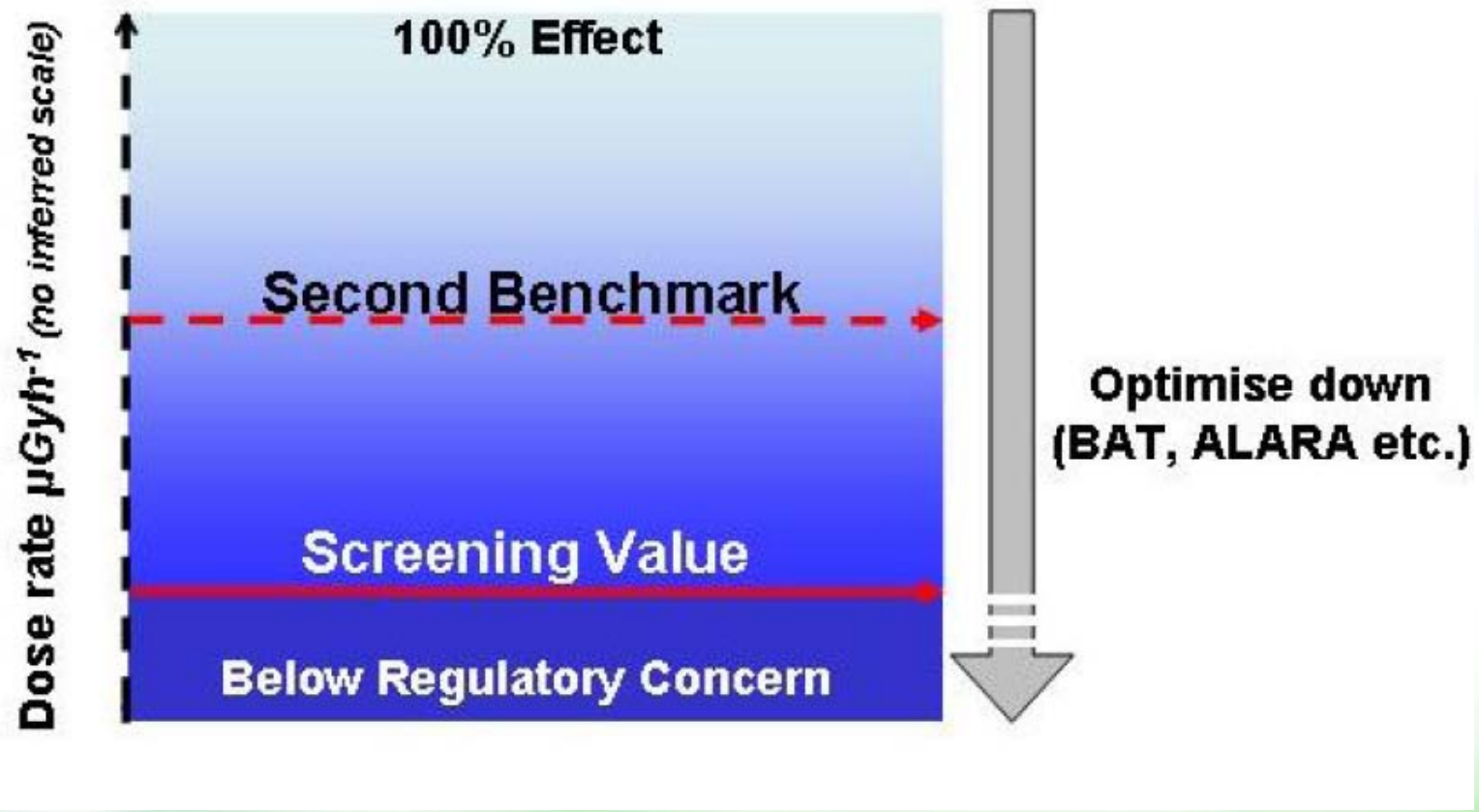
Biota	Pathway	UniStar ER (2010) (mrad/yr)	Staff Calculation (mrad/yr)	Percent Difference
Fish	Liquid	0.281	0.327	16
	Gaseous[(a)]	NA	NA	-
Muskrat	Liquid	1.16	1.20	3.4
	Gaseous	0.227	7.25	3094
Raccoon	Liquid	0.0469	0.046	-1.9
	Gaseous	0.227	7.25	3094
Heron	Liquid	0.173	0.17	-1.7
	Gaseous	0.227	7.25	3094
Duck	Liquid	1.17	1.02	-12.8
	Gaseous	0.227	7.25	3094
Algae	Liquid	5.62	5.97	6.2
	Gaseous[(a)]	NA	NA	NA
Invertebrate	Liquid	2.33	2.67	14.6
	Gaseous[(a)]	NA	NA	NA

(a) Fish, invertebrate species, and algae would not be exposed to gaseous effluents.

Very low doses

Canadian Regulatory Approach

First focus is on optimisation, as in Human Radiation Protection
Risks to biota then assessed; revisited throughout facility life cycle

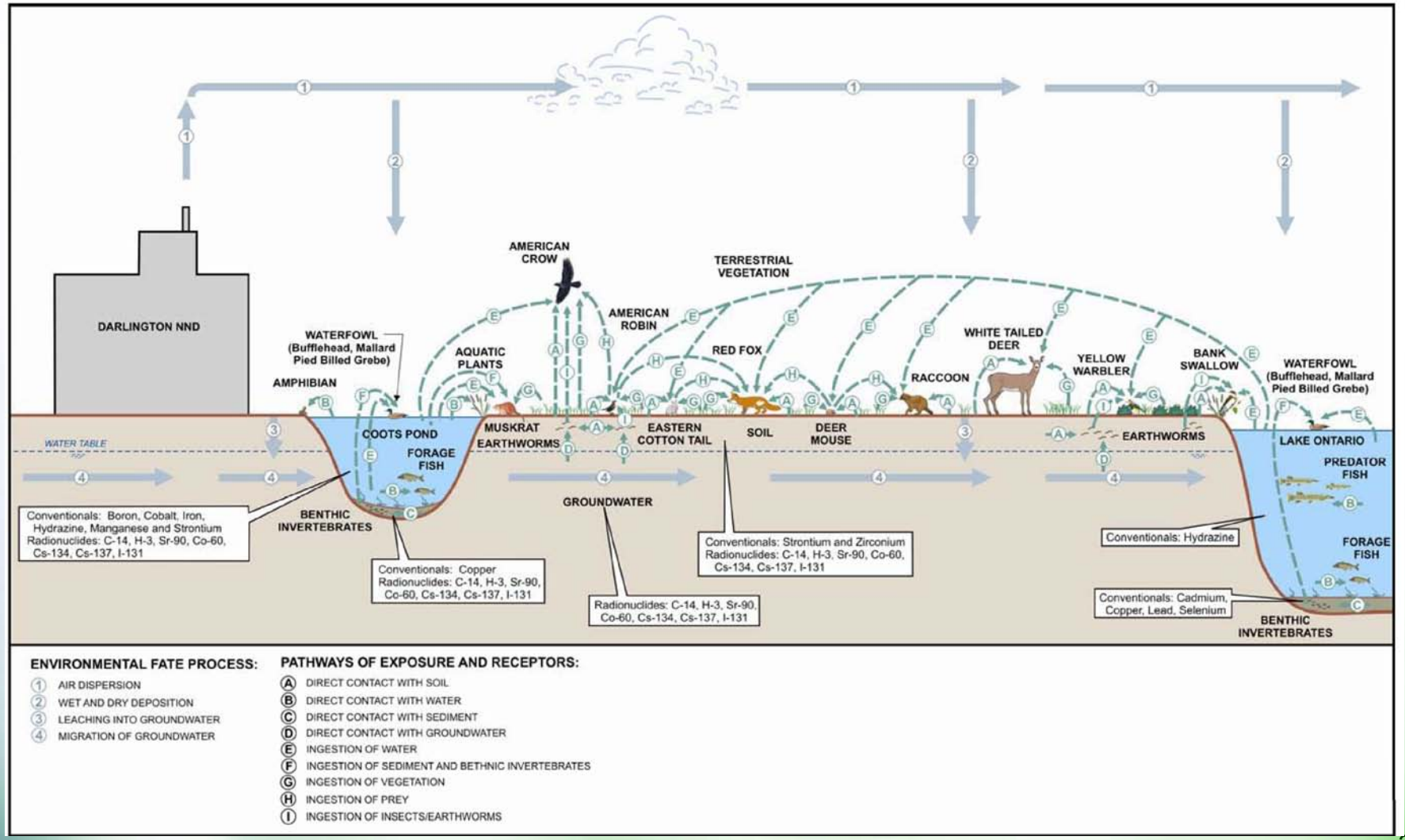


ERAs in Canada since 2000 – Common Themes

- Roughly 50 relevant ERAs in the last decade in Canada at the CNSC
- Entire life cycle - mining to power production to waste management

Power Reactors - New Build EA 2010

Figure 4.1-6 Conceptual Site Model for DN Site



Darlington Nuclear

Very Low Risks – all sites, all contexts

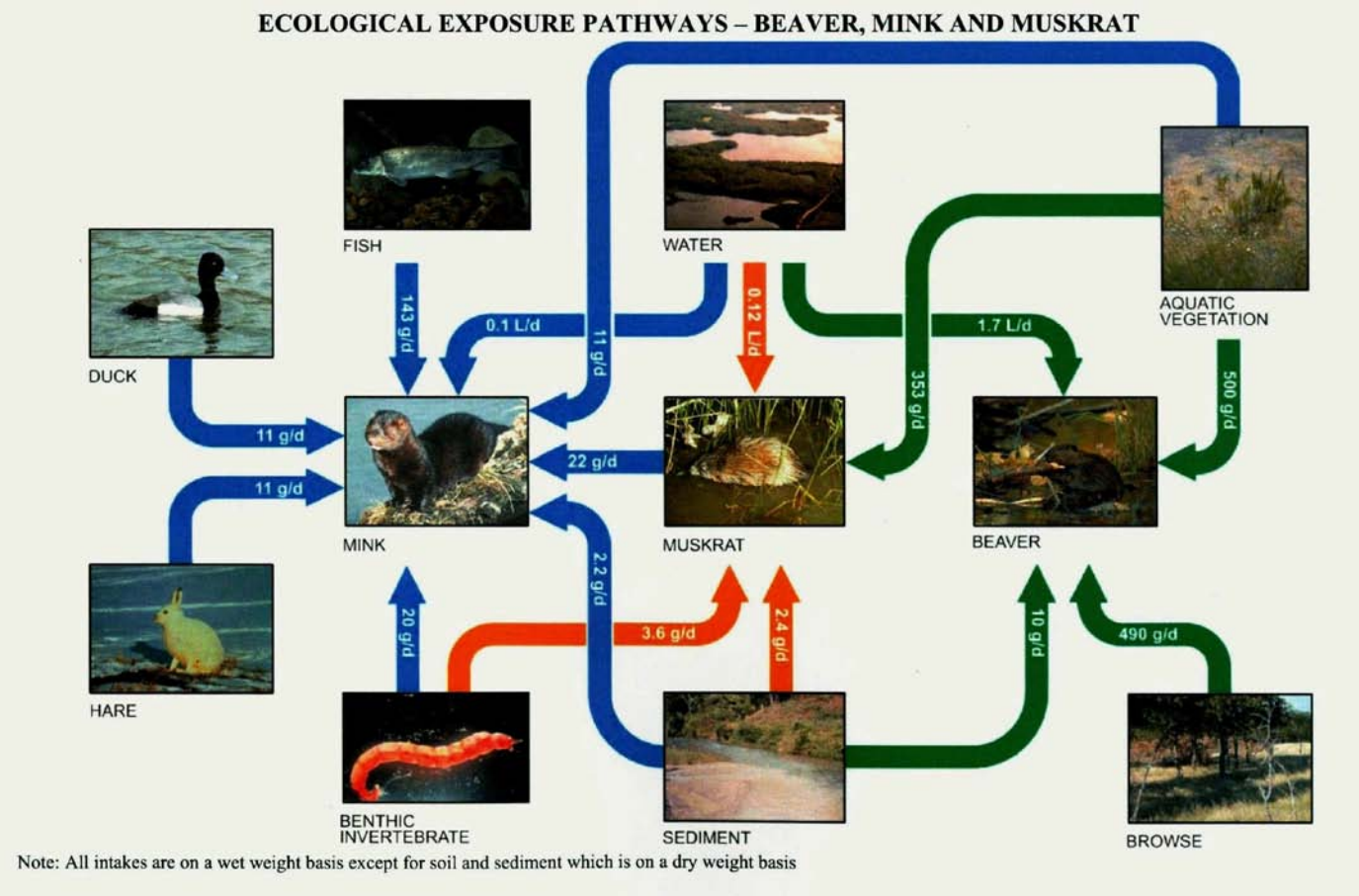
- CEPA approach, updated for modern transfer data
- Numerous "VECs", pathways monitored
- Spatial-temporal analysis
- Maximum site-wide values in table
- Results are mostly orders of magnitude below effects benchmarks
- Validation of results (targeted sampling of representative biota)

Receptor Category	Indicator Species	Total Dose (all radionuclides & all pathways) (mGy/d)	Reference Dose Rate	SI
Summary of Calculated Doses, in mGy/d for Terrestrial Species				
Terrestrial Invertebrates	Earthworm (soil)	9.95×10^{-5}	1	<0.001
	Earthworm (gw)	3.02×10^{-5}	1	<0.001
Terrestrial Vegetation	Plants	2.12×10^{-4}	1	<0.001
Mammals	Red Fox	4.71×10^{-3}	1	0.0047
	Eastern Cottontail	4.26×10^{-4}	1	<0.001
	Meadow Vole	5.53×10^{-5}	1	<0.001
	Deer Mouse	4.53×10^{-5}	1	<0.001
	White-tailed Deer	1.80×10^{-3}	1	0.002
	Raccoon	1.59×10^{-3}	1	0.002
	Short-tailed Weasel	1.03×10^{-4}	1	<0.001
Birds	Yellow Warbler	1.64×10^{-5}	1	<0.001
	Song Sparrow	1.69×10^{-5}	1	<0.001
	Bank Swallow	1.69×10^{-5}	1	<0.001
	Red-eyed Vireo	1.70×10^{-5}	1	<0.001
	American Crow	2.76×10^{-5}	1	<0.001
	American Robin	2.49×10^{-5}	1	<0.001
Summary of Calculated Doses, in mGy/d for Aquatic Species – Coots Pond				
Fish	Forage Fish	6.28×10^{-4}	0.6	0.001
	Predator Fish	5.92×10^{-4}	0.6	<0.001
Benthic Invertebrates		5.42×10^{-4}	6	<0.001
Aquatic Vegetation		9.31×10^{-5}	3	<0.001
Amphibians	Midland Painted Turtle	1.10×10^{-4}	3	<0.001
	Frog	1.10×10^{-4}	3	<0.001
Aquatic Mammals	Muskrat	4.77×10^{-4}	1	<0.001
Aquatic Birds	Bufflehead	5.48×10^{-5}	1	<0.001
	Mallard	6.80×10^{-5}	1	<0.001
	Pied-Billed Grebe	7.08×10^{-5}	1	<0.001

= Confidence in Predictions

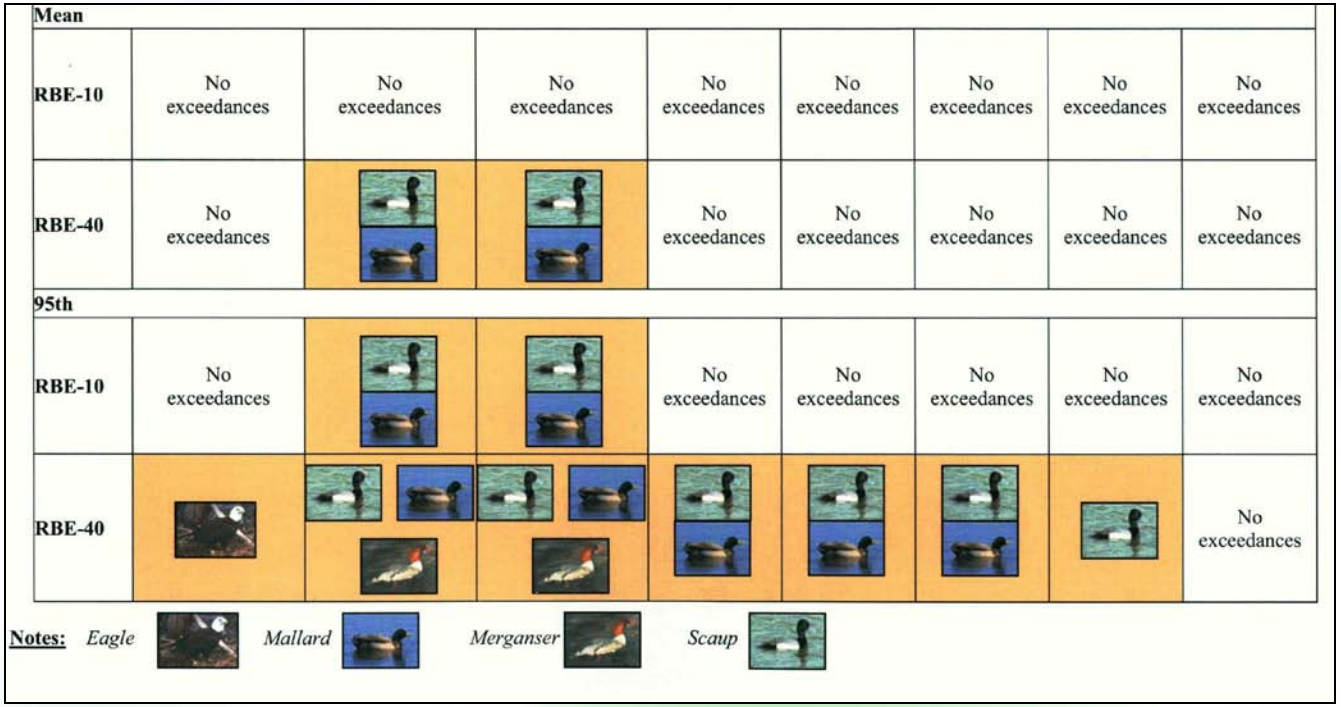
Uranium Mining / Milling – Many EAs

- Potential impacts on certain wildlife and aquatic biota in the near field
- Terrestrial impacts are minimal



Limited Risks Identified – Existing and Prospective

- Key issues are related mainly to waterfowl, but with many uncertainties due to a lack of data on exposure levels and radiation effects for birds
- Ongoing efforts to obtain relevant field data



Conclusions

- Simple, conservative biota dose assessment methods are "fit for purpose" for both modern operations and future activities
- Risks for operating facilities are small and are being effectively monitored and managed
- Need for methods to be "harmonisable" with methods for chemical contaminants (mixed effluent)
- Need to reduce uncertainty in exposure estimates and effects benchmarks, particularly for alpha emitters