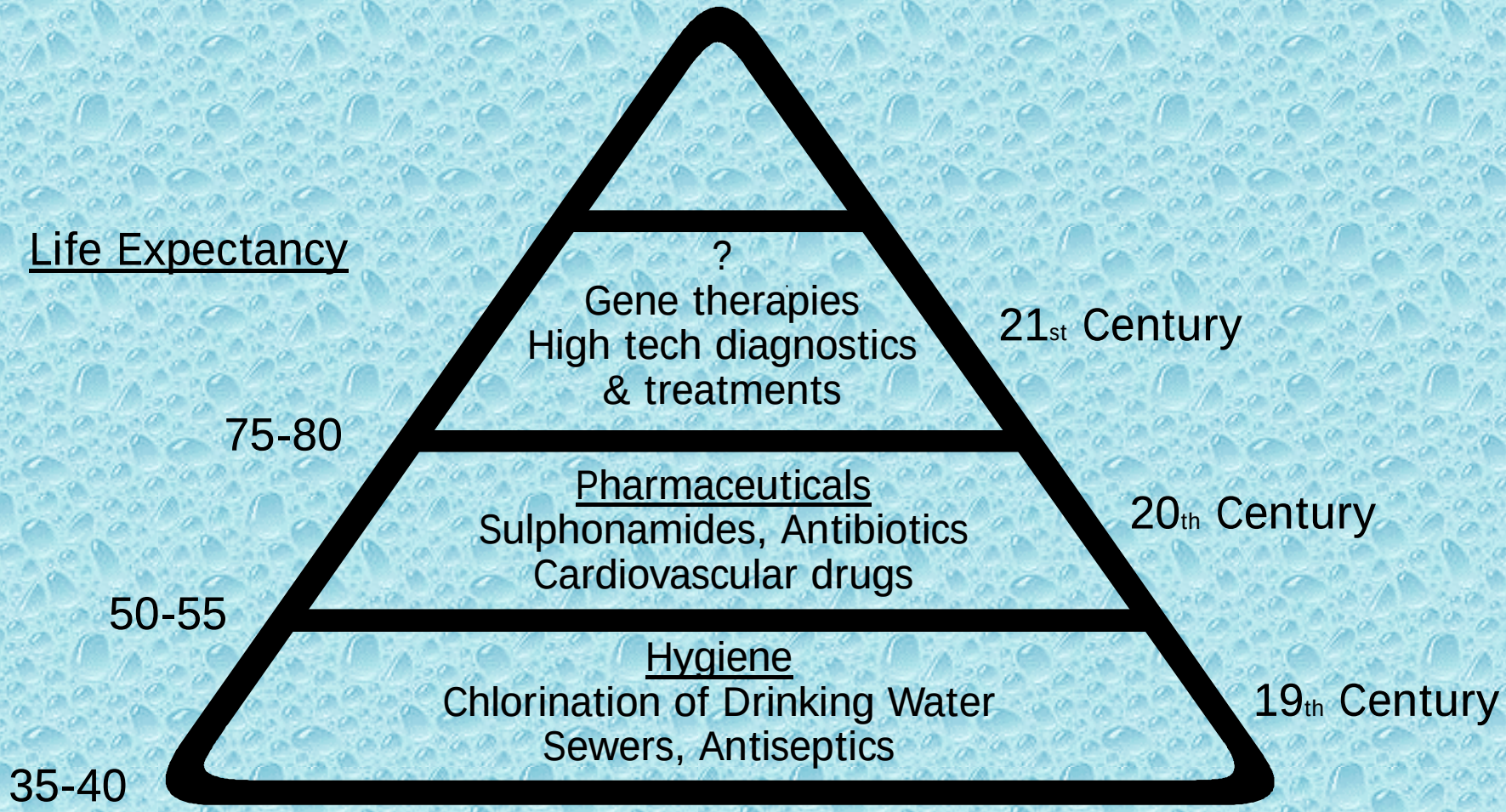
Public Health and Water Quality

Barry H. Thomas, Ph.D.
Consulting Toxicologist in Environmental Health
Tangier, Nova Scotia

Clean and Safe Drinking Water Workshop
Hotel Gander
Gander, Newfoundland
March 26 & 27, 2001

Premature Mortality

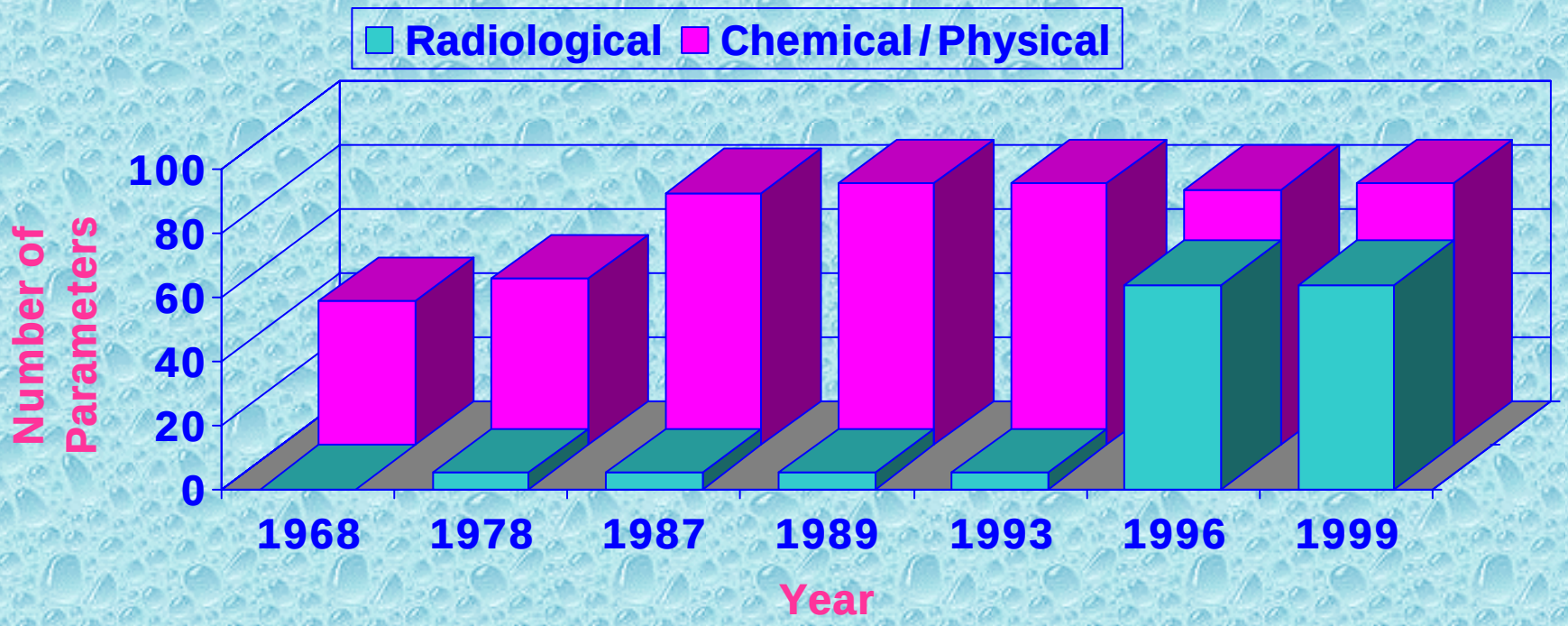


Federal-Provincial Subcommittee on Drinking Water

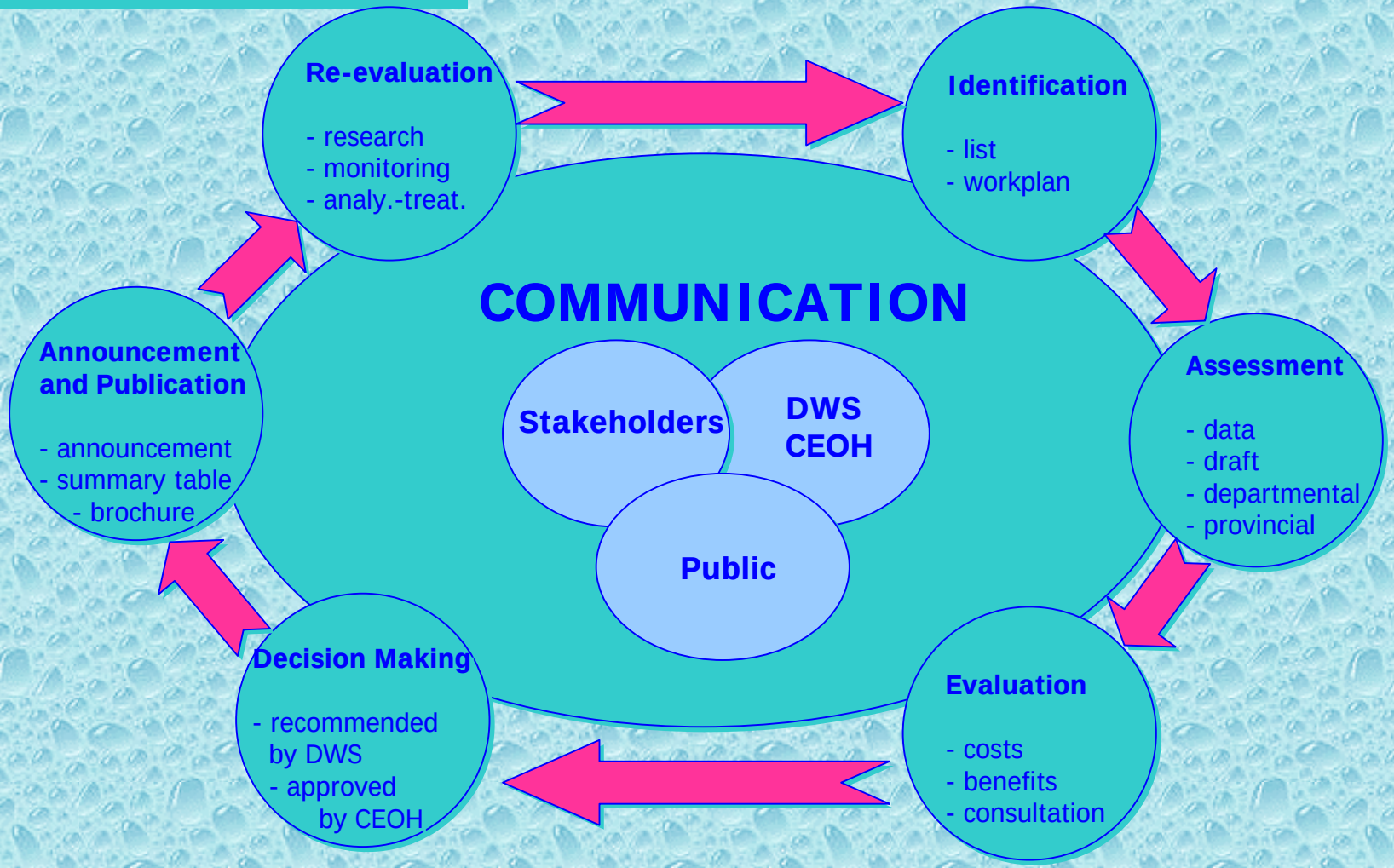
- Guidelines for Canadian Drinking Water Quality
- Subcommittee organization
  - Federal-provincial Committee on Environmental and Occupational Health (CEOH)
  - Federal, provincial and territorial representation
  - Secretariat - Health Canada
- Publications
  - Sixth edition of guideline booklet (1996)
  - Supporting documentation
  - Internet site: www.hc-sc.gc.ca/waterquality

Drinking Water Guidelines

Physical/Chemical and Radiological Parameters



Drinking Water Guideline Development Process - Overview



Drinking Water Guidelines Development Process - Identification

- Criteria for Inclusion
  - the substance is frequently detected in Canadian drinking water supplies
  - it has the potential to cause adverse health effects, and/or
  - it is detected at frequently elevated concentrations in Canadian drinking water supplies

Current Approaches to Guideline Development

Guidelines, expressed as Maximum Acceptable Concentrations (MAC) are developed for:

- Microbiological parameters
- Radiological parameters
- Chemical contaminants
  - carcinogens - non-threshold
  - non-carcinogens - threshold

Microbiological Parameters

- Protozoa, bacteria, enteric viruses
- Gastrointestinal (GI) illness
- For “no risk” to human health, standard for pathogens in drinking water is essentially zero
- MACs are based on indicator organisms
- Adequate water treatment methods to remove or inactivate pathogens

Chemical Contaminants Classification

- Criteria based on carcinogenicity

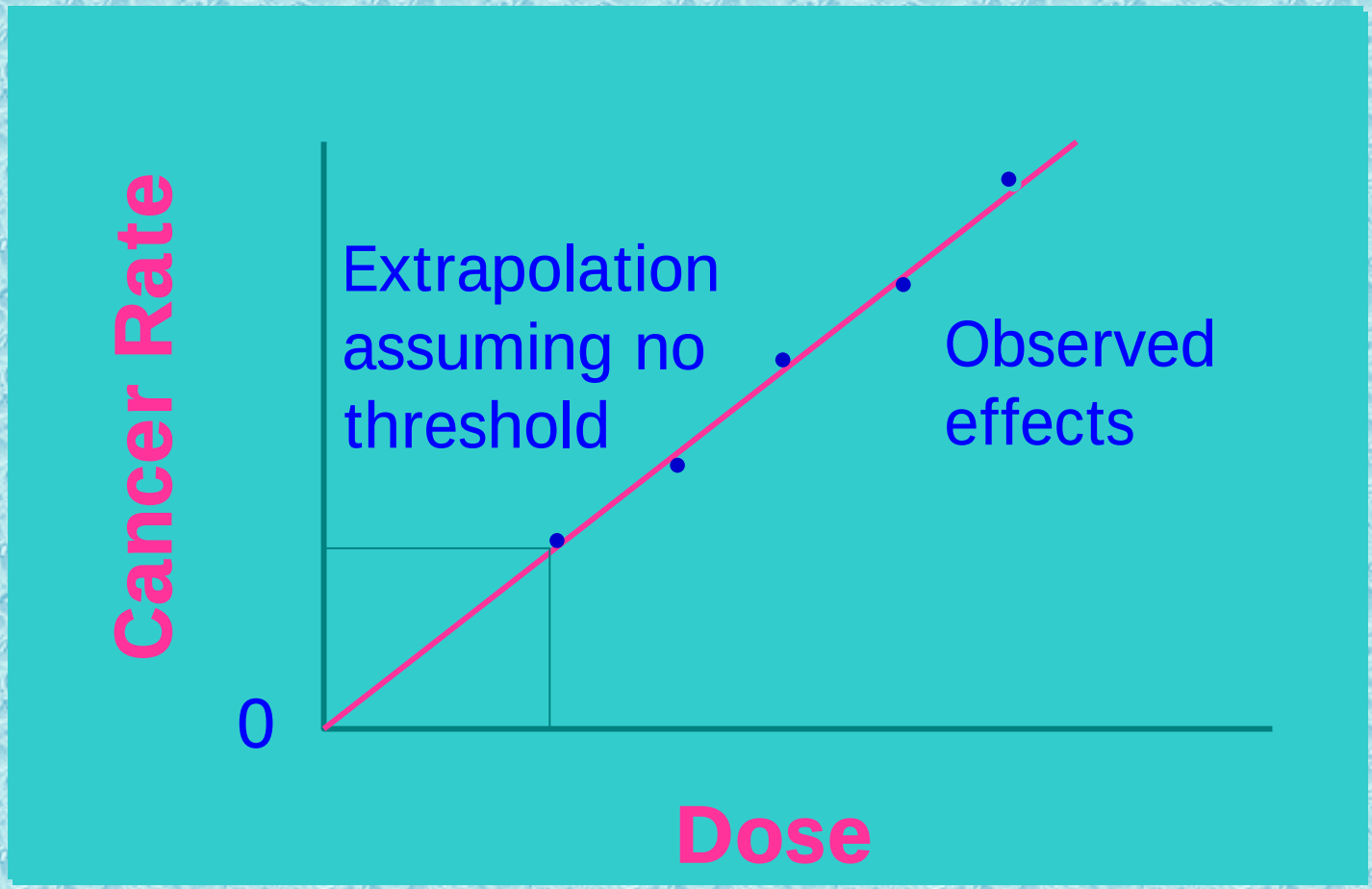
Group I - *Carcinogenic to humans*
Group II - *Probably carcinogenic to humans*

Group III - *Possibly carcinogenic to humans*
Group IV - *Probably not carcinogenic to humans*
Group V - *Inadequate data for evaluation*

Carcinogenic Chemicals

- Non-threshold effect
- Groups I and II
- Modelling dose-response data to exposure levels associated with "negligible" risk
- MACs must be:
  - achievable by available water treatment methods at a reasonable cost
  - reliably measurable by available analytical methods
  - have a theoretical lifetime cancer risk of 10^{-5} - 10^{-6} (i.e., upper 95% confidence limit)

Carcinogenic Chemicals



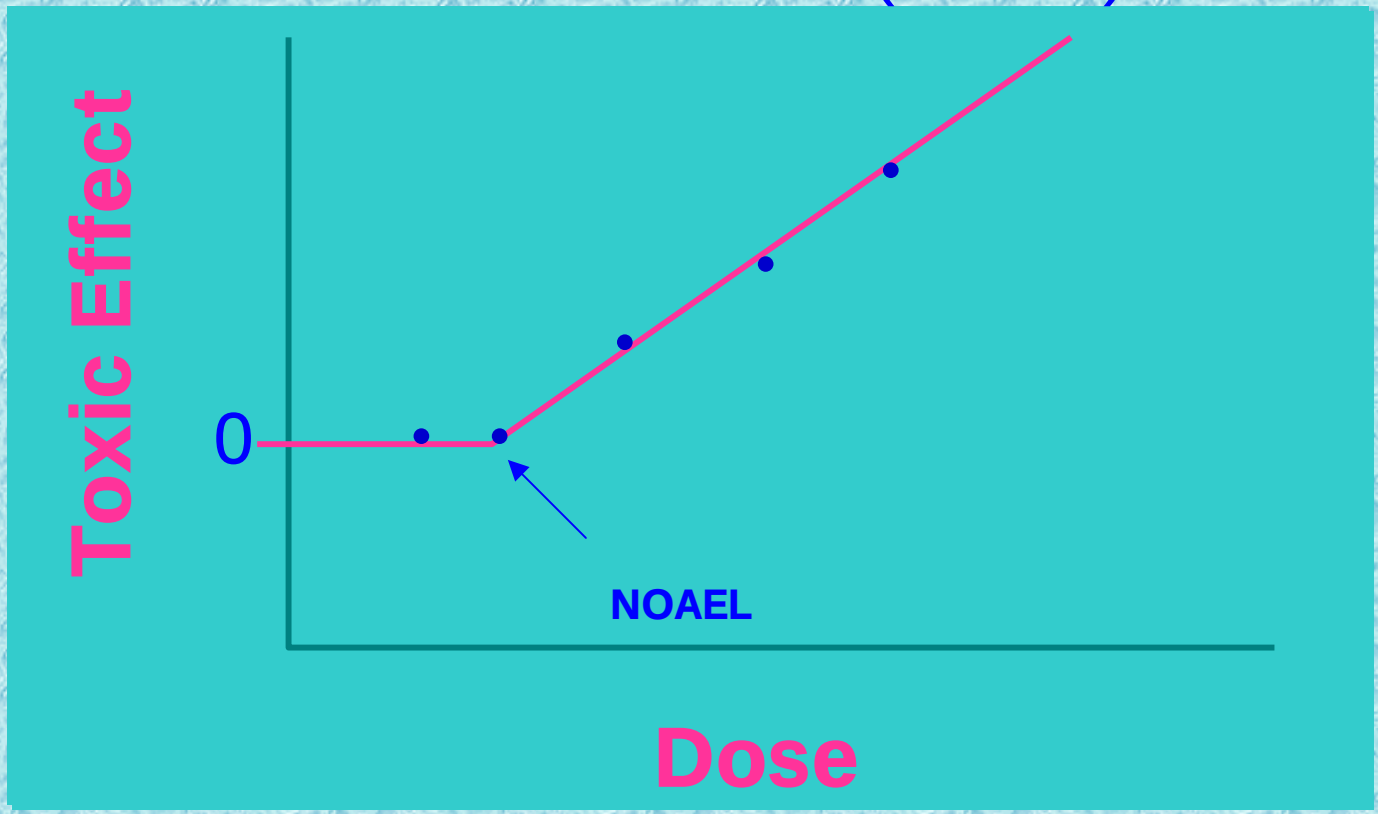
Carcinogenic Chemicals

Example: Arsenic (As)

- Dissolution of minerals/ores, industrial effluents, atmospheric deposition
- Dermal lesions, peripheral neuropathy, skin cancer, peripheral vascular disease
- Group I (*Carcinogenic to humans*)
- Estimated unit risk for 1 µg/L: 1.3×10^{-5} - 3.6×10^{-6} (skin cancer)
- IMAC = 0.025 mg/L (25 µg/L) (*interim* because of treatment technology limitations)

Non-Carcinogenic Chemicals

Toxicology studies in animals are designed to find the No-Observed-Adverse-Effect-Level (NOAEL)



Non-Carcinogenic Chemicals
Tolerable Daily Intake (TDI)
Calculation from NOAEL

$$\text{TDI (mg/kg bw/day)} = \frac{\text{NOAEL (mg/kg bw/day)}}{\text{Uncertainty factor}}$$

- Uncertainty factors are x1 to x10 for:
  - variation between species
  - variation among species
  - less than lifetime studies
  - severity of effect
  - equivocal or missing data

Non-Carcinogenic Chemicals Maximum Acceptable Concentration (MAC)

$$MAC\ (mg/L) = \frac{TDI \times bw \times AF}{WC}$$

- Where:
  - TDI = Tolerable Daily Intake (mg/kg bw/day)
  - bw = adult body weight = 70 kg
  - AF = allocation factor
  - WC = water consumption = 1.5 L/day

Non-Carcinogenic Chemicals
Example: 2,4-D

- Interim MAC =

$$\frac{0.01 \text{ mg/kg bw per day} \times 70 \text{ kg} \times 0.20}{1.5 \text{ L/day}} = 0.09 \text{ mg/L}$$

- Acceptable daily intake of 2,4-D is 0.01 mg/kg bw based on kidney effects in rats
- Allocation factor for drinking water is 0.20 (i.e. 20% for water, 80% for food)

- Guideline for 2,4-D rounded to **0.10 mg/L**

Sensitive Sub-populations

- **Babies** 7kg bw, water consumption 750mL/day
  (0-6 months)
  Adults 70kg bw, water consumption 1,500mL/day
  Therefore, babies consume 5 times more water per kg bw than adults

- **AIDS**
- **Hyper-sensitivities**
- **Genetic abnormalities**

- **Aged** Lower metabolic rates for detoxification of contaminants
  Lower rates of excretion can lead to poisoning
  Immune system less able to cope with infections

Chlorination

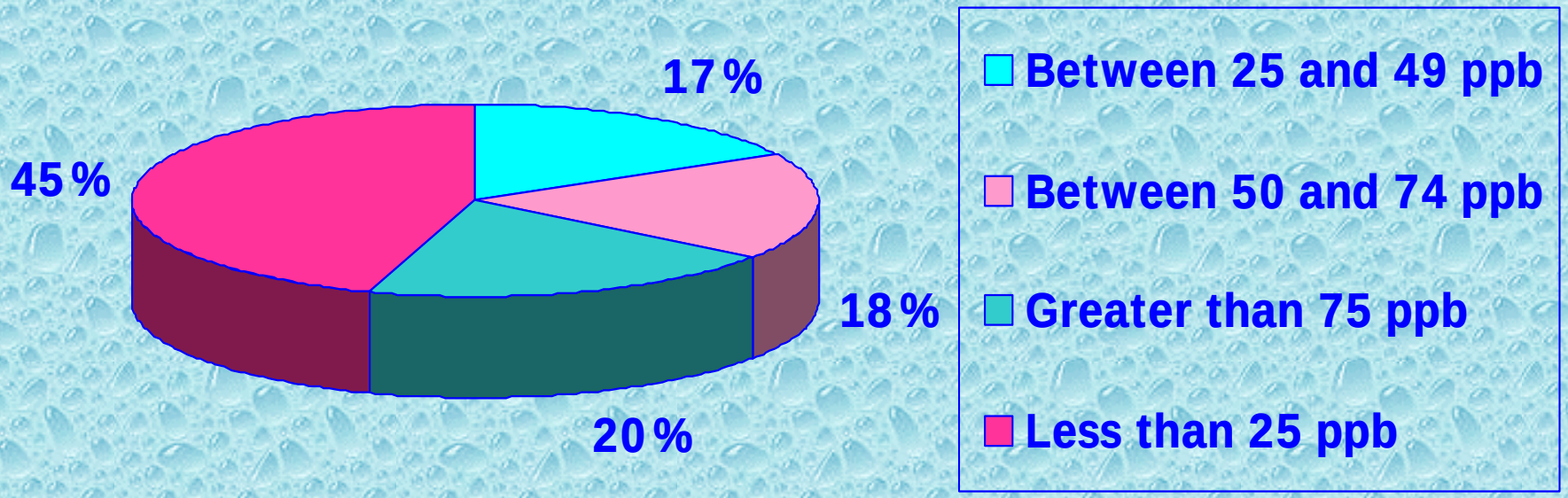
- Chlorine has been used as a disinfectant for nearly a century
- Virtual elimination of cholera and typhoid in the developed world
- Discovery in the 1970s that chlorine reacts with naturally-occurring organic matter to produce chlorinated disinfection by-products (CDBPs)
  - Levels of CDBPs observed are highly variable. They are dependent on a variety of factors, including raw water quality, temperature, etc.
- In 1976, animal studies showed that at least one group of CDBPs, the trihalomethanes (THMs) can produce cancer

Great Lakes Basin Cancer Risk Assessment Study - 1995

- Case-control study: relationship between various drinking water parameters and cancers of the bladder, colon and rectum
- Dr. L. Merrett, W. King (University of Toronto and Ontario Cancer Treatment and Research Foundation)
- Dr. Y. Mao (LCDC - Health Canada)
- 5,000 residents of Ontario counties south of Sudbury and Timiskaming (60% served by water from the Great Lakes)
- Cases identified from Ontario Cancer Registry and matched controls identified at random from telephone directories

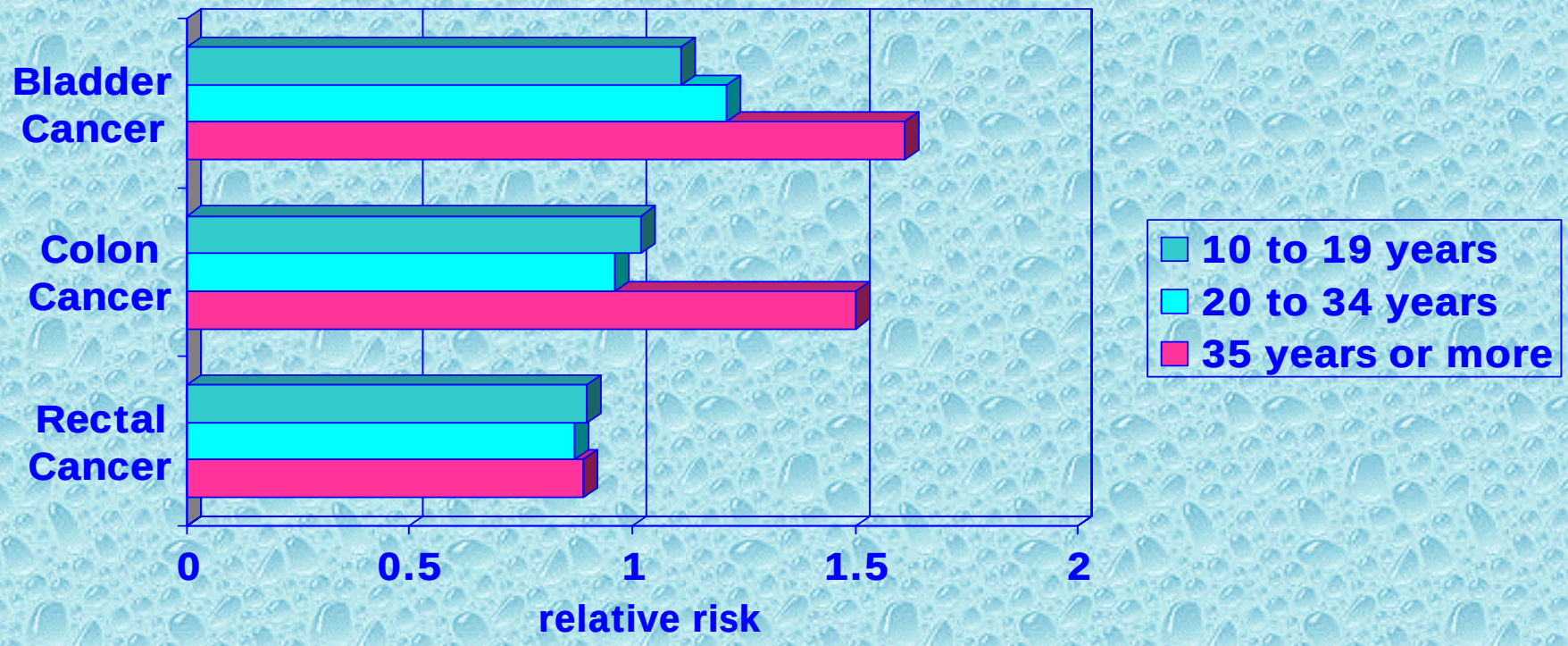
Trihalomethanes in Great Lakes Study

Distribution of study population according to estimated THM levels in their water supply in 1990



Trihalomethanes in Great Lakes Study

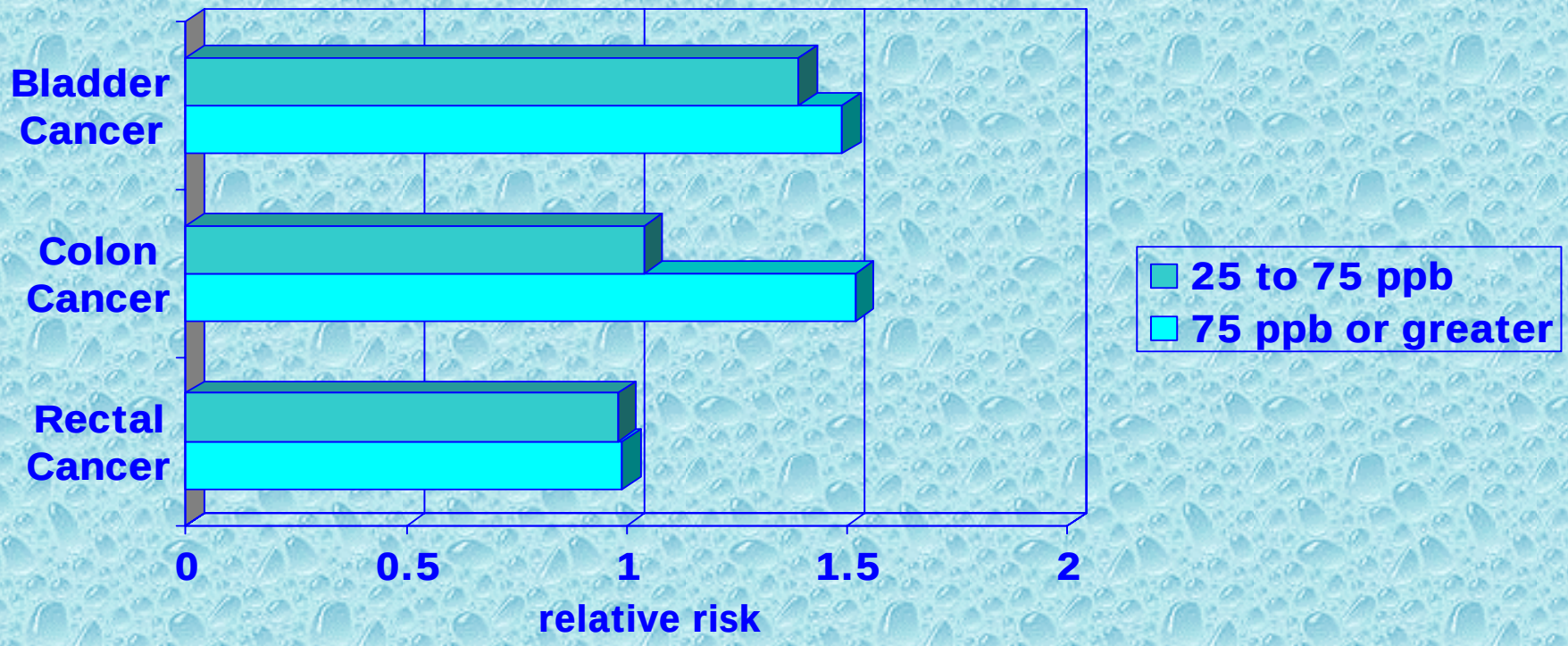
Cancer risks associated with years using water with THM levels greater than 50 ppb (parts per billion)



The above risks are relative to the risk associated with use of water with THM levels greater than 50 ppb for 0 to 9 years in the last 40 years.
SR = Increased risk: not likely due to chance

Trihalomethanes in Great Lakes Study

Cancer risks associated with the use of water with the specified THM levels for 25 years or more of the past 40 years



The above risks are relative to the risk associated with use of water with THM levels less than 25 ppb for 25 years or more

SR = Increased risk: not likely due to chance

CDBPs and Reproductive Effects

- Animal studies show adverse reproductive effects with THMs and Haloacetic acids (HAAs), particularly the brominated derivatives
- Epidemiological (human population) studies in California, Nova Scotia and New Jersey associate THMs levels with miscarriages, stillbirths and neural tube defects

Public Water Systems Responsibilities and Education

- Small to very large populations
- Government responsible for safe water
- Need for legislative framework that clearly describes delegation of authority
- Need for source water protection
- Need for mandated monitoring
- Need for mandated operator training and certification
- Need for enforcement of health standards
- Need for public to be informed at least annually of water quality analysis results
- Need for the public to be made aware of health risks, and the costs and benefits of improvements
- Need for national standards and certification of infrastructure components

Private Wells Responsibilities and Education

- Usually one family
- Individual financially responsible for well
- Need for legislation to protect groundwater
- Need for regulation of well installation
- Need to educate well owners on frequency of testing and maintenance
- Need for affordable, accessible water quality analysis service
- Need for reliable interpretation and advice regarding water analysis results
- Need for national standards and certification to ensure safety and effectiveness of water treatment devices

Summary

- Drinking water is essential for human life
- Disinfection of drinking water is the number one concern
- Prevention or removal of chemical contaminants is the number two concern
- Compliance with the *Guidelines for Canadian Drinking Water Quality* ensures that the water is safe and palatable
- A regulatory framework is necessary to guarantee compliance with the *Guidelines*
- Public education on the importance of safe drinking water will garner political support for adequate funds for public water systems, and alert private well owners to their responsibilities

Many thanks to...

Véronique Morisset, Health Canada
TASC, Guelph, ON
for technical assistance with this presentation

Don Monet, Health Canada
for original cartoons