

Boil Water Advisories and Health Risk from Source Water Pathogens: Time for a New Approach

Drinking Water Safety Workshop, Gander

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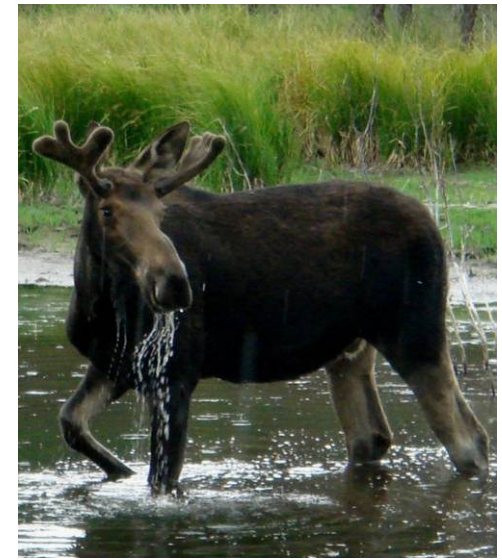
Risk Factors for Waterborne Disease Outbreaks



Reservoirs of Pathogens- Confirmed



Reservoirs of Pathogens- Probable



Waterborne Pathogens of Concern

Largest



Smallest

Protozoa



Giardia



Cryptosporidium

Bacteria

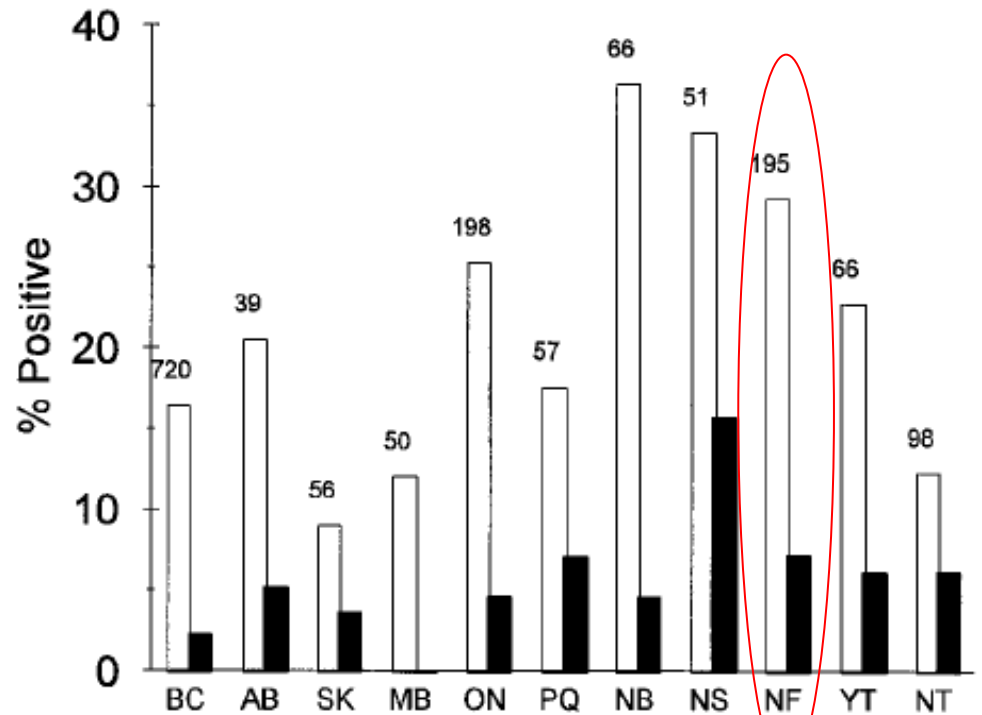


FIG. 1. Prevalence of *Giardia* cysts (□) and *Cryptosporidium* oocysts (■) in

barriers

Acc.V Spot Magn Det. WD Exp 2 μm
15.0 KV 4.0 9.951x SE 10.5 1

Campylobacter

Waterborne Outbreaks in NL

Table 2 Waterborne Illness Outbreak Summary – Newfoundland and Labrador

Month / Year	April 1983	August 1991	March 1992	August 1993	August – Sept. 1993	July 1994	August 1994	July–August 1999	April 2000	May 2002
Town	Harbour Grace	Botwood	Corner Brook	Robert's Arm	Bird Cove ³	Springdale	Deer Lake	Appleton / Glenwood	Pasadena	Botwood
Population ¹	2520	4200	24870	895	500	3555	6320	1425	4130	4200
Source	Unknown	<i>Giardia</i>	<i>Giardia</i>	<i>Giardia</i>	<i>Giardia</i>	<i>Giardia</i>	<i>Giardia</i>	Unknown	<i>Giardia</i>	<i>Giardia</i>
Cases of Illness	5 (confirmed)	136 (confirmed); 1,200 (suspected)	72 (confirmed)	16 (confirmed)	8 (confirmed); 242 (suspected)	5 (confirmed)	7 (confirmed)	4 (suspected)	13 (confirmed)	4 (confirmed)
Cause of Outbreak	Well not protected; broken well cap	Beaver population near supply intake; infective <i>Giardia</i> cysts were detected in raw water samples; disinfection residuals and contact time were inadequate to inactivate <i>Giardia</i> cysts.	Beaver population near supply intake; specimens from trapped beaver confirmed presence of <i>Giardia</i> ; disinfection residuals and contact time were inadequate to inactivate <i>Giardia</i> cysts.	Substandard chlorination facility; beaver population near supply intake; infective <i>Giardia</i> cysts were detected in raw water samples.	Muskrats were suspected however two captured muskrats tested negative; no beavers were noted. Water supply was from a pond that was in close proximity to housing development with sub-standard sewage disposal systems. Chlorination of the supply was sporadic.	Insufficient chlorination; beaver population in raw water supply; outdated chlorination equipment.	Animal population up stream of water intake; presence of <i>Giardia</i> cysts were confirmed by water sampling; chlorine disinfection levels and contact times were insufficient to inactivate <i>Giardia</i> cysts.	Under certain wind conditions & low water levels, discharge from Town of Appleton's sewage system in the Gander River has traversed upstream & impacted in the general area of the drinking water intake for these communities.	Animal population up stream of water intake; presence of <i>Giardia</i> cysts were confirmed by water sampling; chlorine disinfection levels and contact times were insufficient to inactivate <i>Giardia</i> cysts.	Low chlorine residuals in town at time of outbreak which were inadequate to inactivate <i>Giardia</i> cysts.
Other Information			A boil water advisory was issued and remained into effect until adequate CT values maintained to inactivate <i>Giardia</i> cysts.	A beaver lodge located directly in the mouth of a stream feeding into the intake was removed early in August.			A boil water advisory was issued and remained in effect until a municipal water treatment system was installed.		A boil water advisory was issued and remained in effect until a municipal water treatment system was installed.	
Current Water Treatment	Gas Chlorination	Water treatment and Gas Chlorination	Gas Chlorination	Gas Chlorination	Liquid Chlorination	Gas Chlorination	Membrane Filtration, Liquid Chlorination	Infiltration Gallery, Gas Chlorination	Filtration, UV, Gas Chlorination	Water treatment and Gas Chlorination
Protected Water Supply ²	Yes (2000)	Yes (1996)	Yes	Yes (1996)	No	Yes (1996)	Yes (1999)	Yes (2000)	Yes (1997)	Yes (1996)

Laboratory Confirmed Cases of Enteric Pathogens in NL

Pathogens	2007	2008	2009
Campylobacter	47	32	33
E. Coli	10	4	0
Cryptosporidium	1	3	0
Giardia	31	43	29
Rotavirus	63	20	95
Total (infections/people)	152 (3/10,000)	102 (2/10,000)	157 (3.1/10,000)

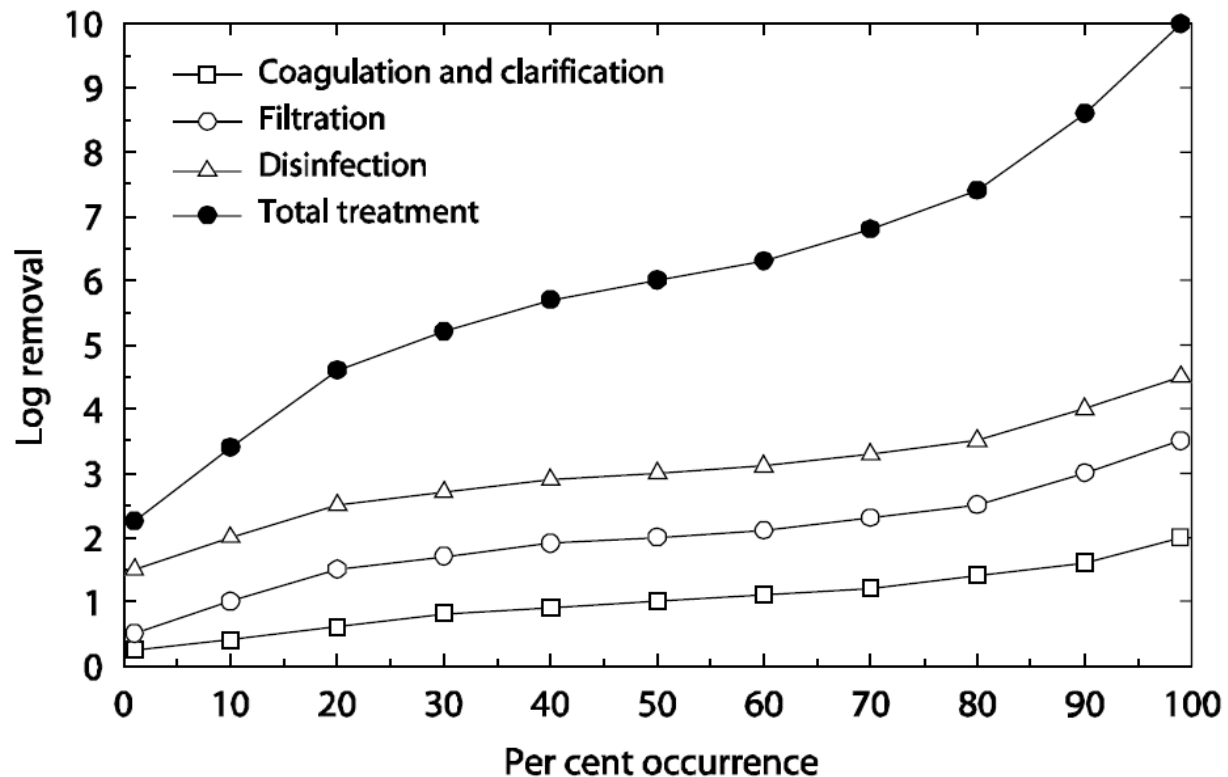
- WHO, USEPA target for microbiologically safe drinking water is less than one infection per 10,000 persons per year

Guidelines

E.Coli	Enteric Viruses (proposed 2010)	Giardia and Cryptosporidium (proposed 2010)
<ul style="list-style-type: none"> ▪ Maximum acceptable concentration (MAC) of Escherichia coli in public drinking water systems is none detectable per 100 mL 	<ul style="list-style-type: none"> ▪ Treatment goal of a minimum 4-log removal and/or inactivation of enteric viruses ▪ A greater log removal and/or inactivation may be required depending on the source water quality 	<ul style="list-style-type: none"> ▪ Treatment goal of a minimum 3-log removal and/or inactivation of cysts and oocysts ▪ A greater log removal and/or inactivation may be required depending on the source water quality

Log Removal

- A way to express levels of decreased microbiological contamination in drinking water effected by different water treatment technologies
- A 1-log reduction is nine out of 10 and would be equivalent to a 90 percent reduction
- A 2-log reduction would be 99 out of 100 or 99 percent reduction
- A 3-log reduction would be 999 out of 1000 or 99.9 percent reduction
- A 99.99 percent reduction would be called a 4-log reduction



Boil Water Advisories

- Boil water advisories are public announcements, issued by the province advising the public that they should boil their drinking water prior to consumption
- There are currently 21 “Standard Reasons” for issuing a BWA
- Issued as a result of:
 - Confirmed microbiological contamination
 - Possible risk of microbiological contamination

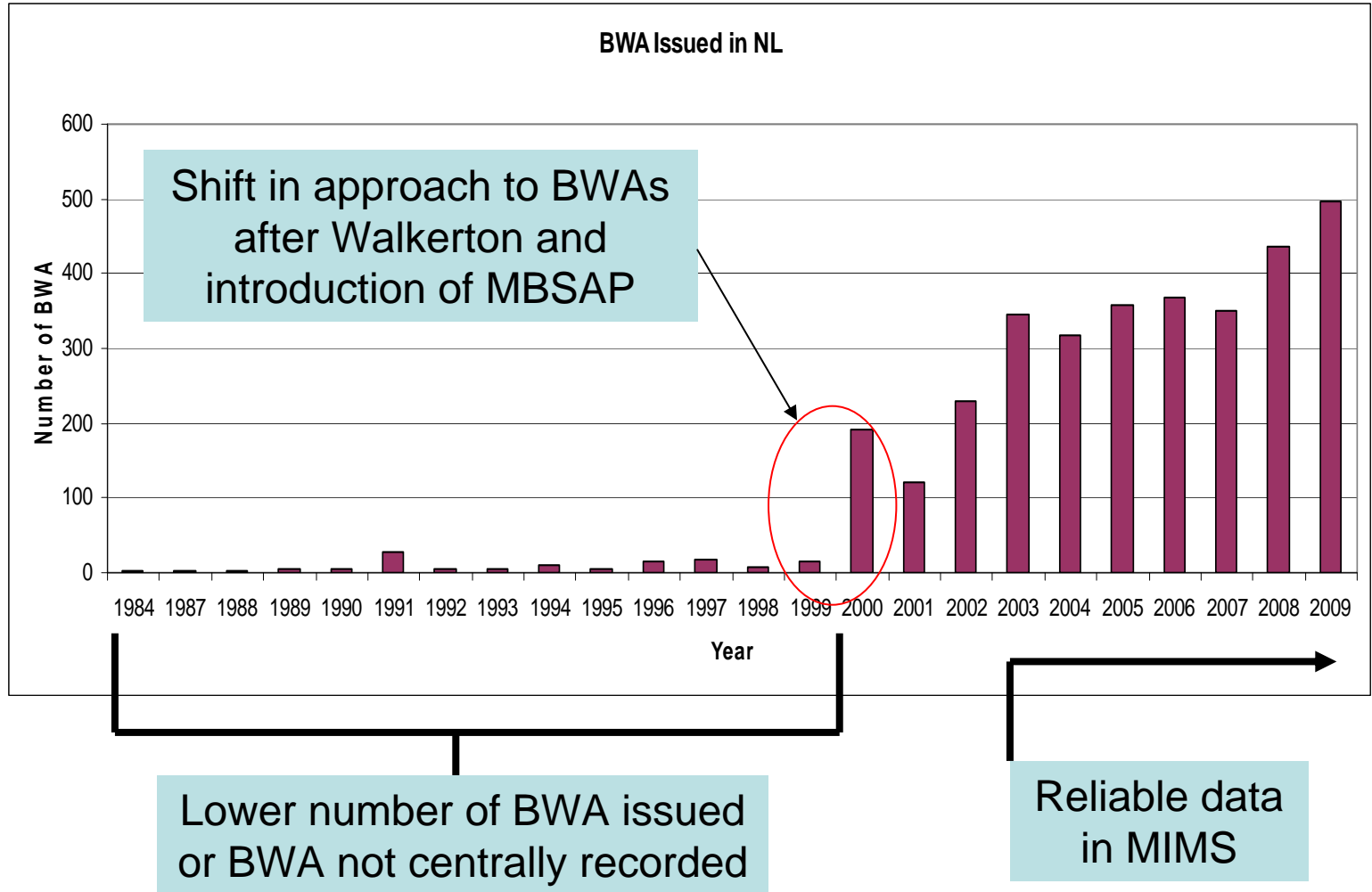
WARNING!

This Water Must Be
Boiled Before Drinking

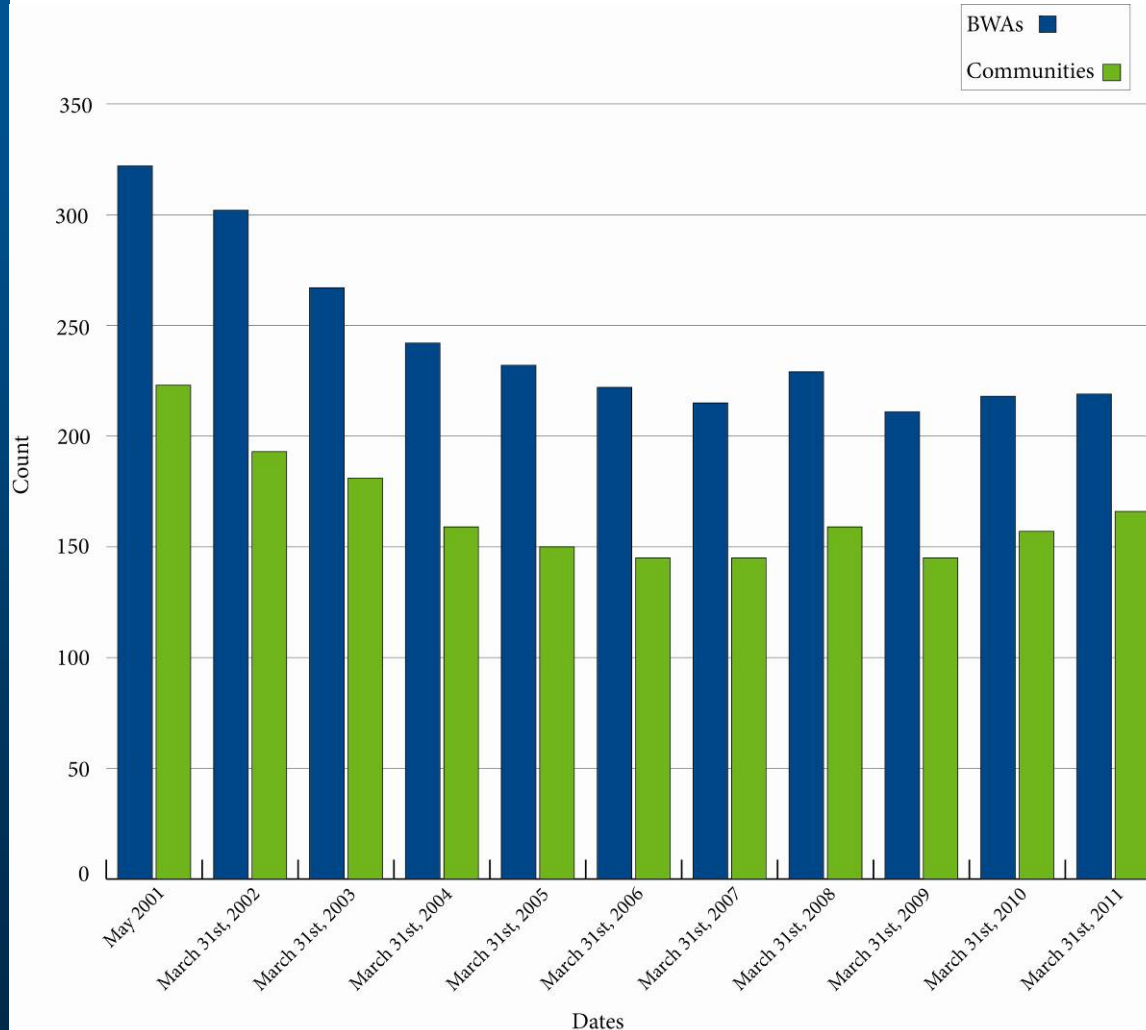


Department of Health and Community Services
Department of Government Services
Regional Health Authorities

Total BWA Issued in NL



Snapshot of Active BWA Since 2001



- As of Mar 31, 2011 there were 219 BWA affecting 166 communities in NL
- Flatlined since 2007

Main Types of Active BWA

Type of BWA	Number of BWAs (as of Mar 31, 2010)	Population Affected
No chlorination (Codes A and B)	70 (32%)	5907
Pathogenic Contamination (Codes F and H)	17 (8%)	2747
Mechanical or Operational Issues (Codes C, D, E, G)	130 (60%)	48,305
Samples not submitted	1	226
Total	218	57,185

- 174 active BWA are in towns with a population of 500 or less
- 34% of active BWA are for towns without a Permit to Operate

BWA and Certified Operators

Type of BWA	Number of BWAs (as of Mar 31, 2010)	Number with Certified Operators (Dist or WT)	Number without Certified Operators
No chlorination (Codes A and B)	70	3	67
Pathogenic Contamination (Codes F and H)	17	1	16
Mechanical or Operational Issues (Codes C, D, E, G)	131	14	117
Total	218	18	200

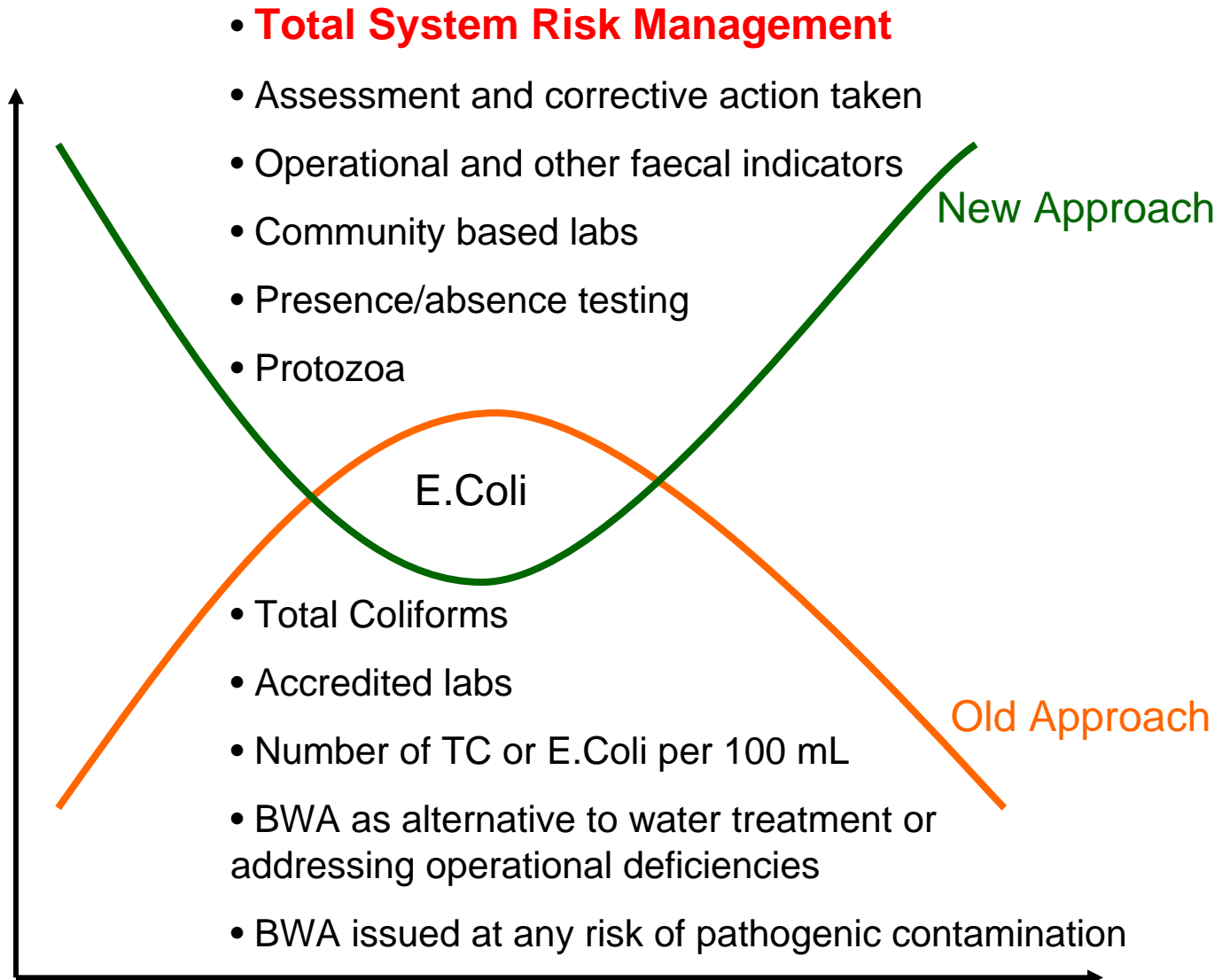
- 92% of active BWA are for systems that do not have a certified operator
- 55% of active BWA are for systems with volunteer operators

Days on BWA

Reason Code	Reason	Days on BWA (average)
A	No Disinfection	3495 (9.6 yrs)
B	Chlorination turned off	3057 (8.4 yrs)
C	Disinfection system mechanical/operational issues	2913 (8.0 yrs)
D	Distribution system mechanical/operational issues	1518 (4.2 yrs)
E	Residual issues	3377 (9.3 yrs)
F	Positive pathogenic tests	182 (0.5 yrs)

- Based on active BWA as of Nov 29, 2010
- 78% of active BWA are long term BWA (codes A-E)
- Average BWA lasts 2137 days (5.9 yrs)
- Average of 879 days (2.4 yrs) since last bacteriological sample
- Public compliance with BWA ranges from 47-74%

Shift in Approach



Risk Management

- The Walkerton Inquiry described some essential characteristics of risk management as:
 - being preventive rather than reactive
 - distinguishing greater risks from lesser ones and dealing first with the former
 - taking time to learn from experience
 - investing resources in risk management that are proportional to the danger posed

- Risk management is an exercise of decision-making under uncertainty

Quantitative Microbial Risk Assessment (QMRA)

- QMRA
 - A scientific and systematic basis for evaluating microbiological risks in drinking water
 - Evaluates probable consequences of exposure to infectious waterborne pathogens
- Health Canada is exploring the application of QMRA in drinking water
 - QMRA introduced in revisions to HC Guidelines for Enteric Protozoa and Enteric Viruses (from fecal sources)
 - Developed QMRA Model

Why QMRA?

- Comes out of the food industry and food safety
- Current approach to assessing microbiological quality is reactive and underestimates risk
 - End product testing of indicator organisms
- E.coli is not a good indicator of giardia or cryptosporidium
 - Outbreaks of waterborne illness in the absence of indicators
 - E.coli highest in summer, giardia/crypto highest in winter/spring
- Being used internationally:
 - WHO 2011 Guidelines
 - Dutch regulate that towns do a QMRA
 - US, Australia, EU
- QMRA is part of preventative risk management
- Can be used to assess risk to see if higher water treatment log removals are required

Health Risk

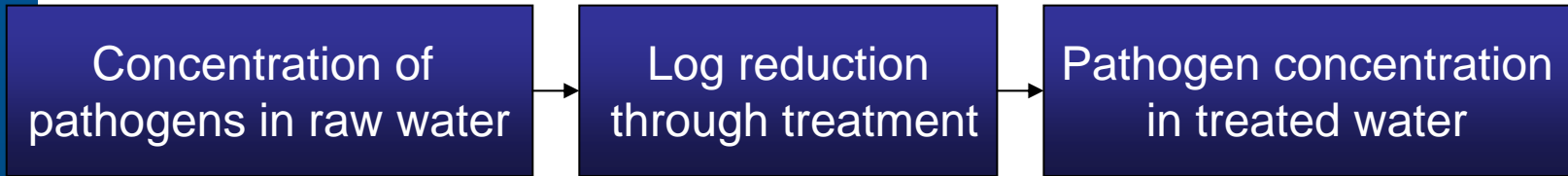
- Common metric to measure tolerable burden of disease associated with water-related hazards
 - Probability, severity and duration of effects
 - Allows for comparison between microbial, chemical and radiological risks
 - Aggregation of different impacts on the quality and quantity of life
- **DALY = Disability Adjusted Life Years**
 - Years of Life Lost (YLL) due to premature mortality
 - +
 - Years Lost due to Disability (YLD) as a result of a health condition
- 1 DALY = 1 lost year of a “healthy” life
- Pathogens have a range of health outcomes
- Health Canada is working towards establishing health based targets for drinking water
 - 10^{-6} DALYs/person/year (WHO guideline)
 - 1 case of illness/10,000/year (WHO guideline)

DALYs in Context

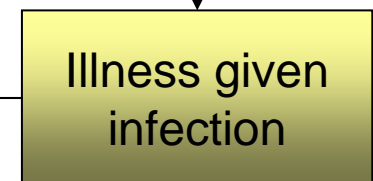
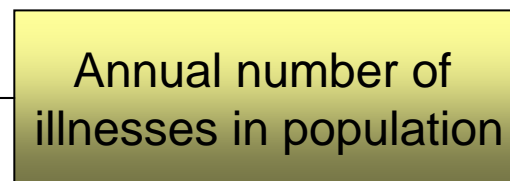
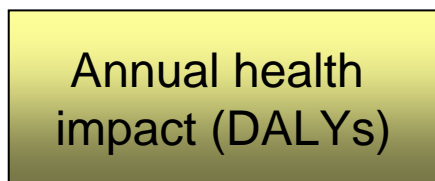
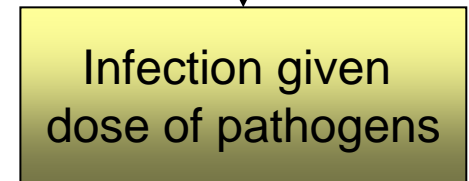
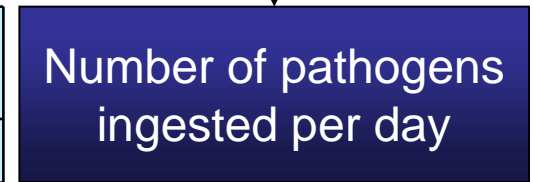
Illness	DALYs/case
Target DALY	0.000001
Cryptosporidiosis	0.0017 (0.62 days)
Campylobacteriosis	0.0046 (1.7 days)
GI from Rotavirus	0.0085 (3.1 days)
E.Coli O157:H7	0.025 (9.1 days)
Colon Cancer	3.1
Liver Cancer	11.0

- DALYs allows comparison of different health risks

QMRA Model



	Typical source water pathogen concentrations (# per 100 Litres)				
	Crypto	Giardia	Rotavirus	Campy	Ecoli
Pristine	0.1	0.5	0.1	100	100
Lightly Impacted	1	5	1	1000	10000
Moderately Impacted	10	50	10	10000	100000
Heavily Impacted	100	500	100	100000	1000000



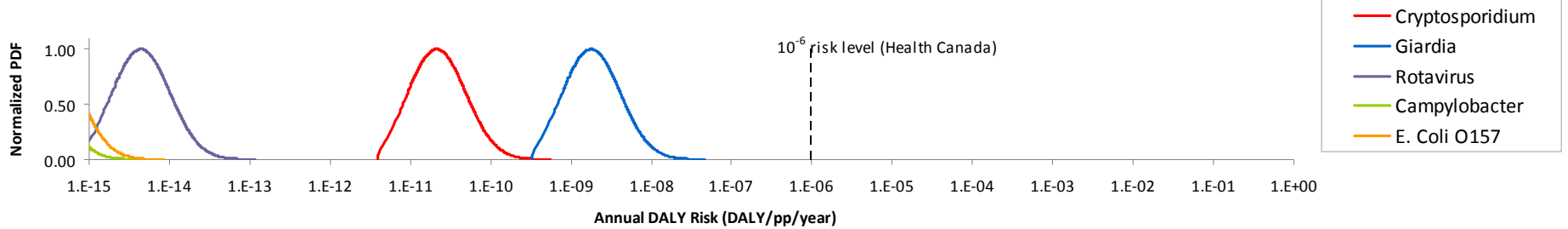
Example- Town A

- Pop= 9951
- Water Treatment Plant
 - Mixed media filtration
 - Ozone
 - GAC
 - Chlorine disinfection
 - pH adjustment
- Moderately impacted in terms of pathogen concentrations

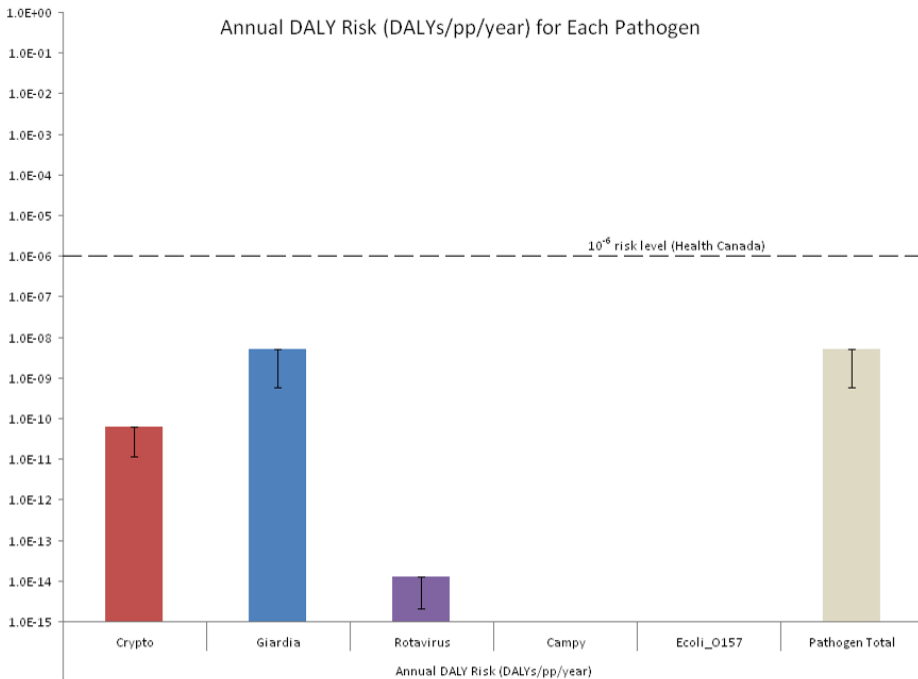
Results- Water Treatment Plant

Total number of illnesses per year in overall population: 0.0285

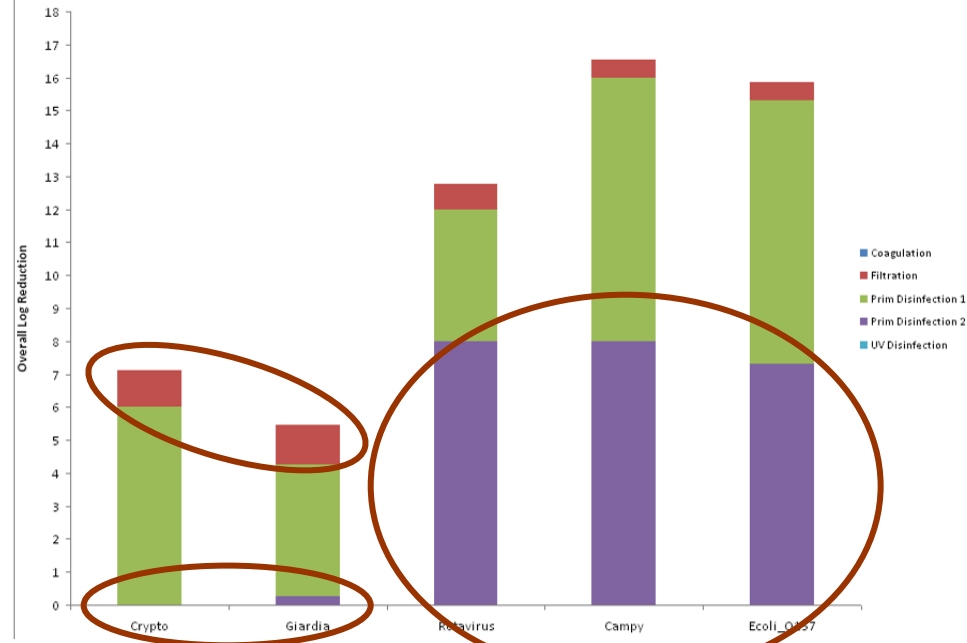
Probability Distribution for DALY Risk
(Crypto/Giardia/Rotavirus/Ecoli/Campylobacter)



Annual DALY Risk (DALYs/pp/year) for Each Pathogen



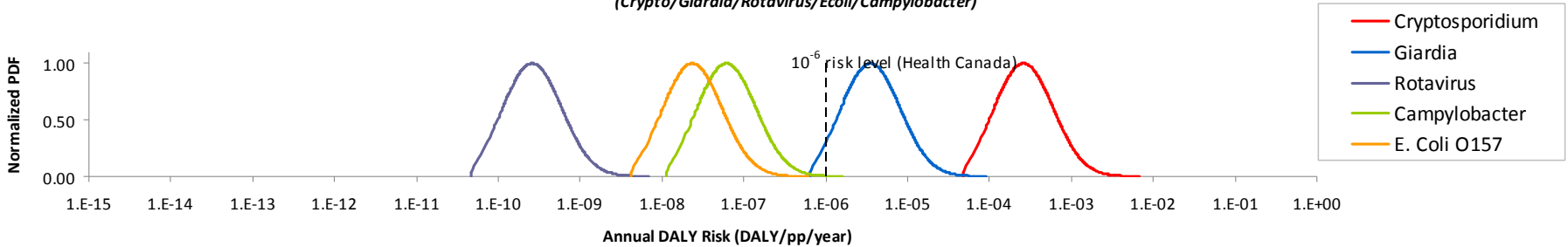
Log Reduction Values for Individual Treatment Barriers



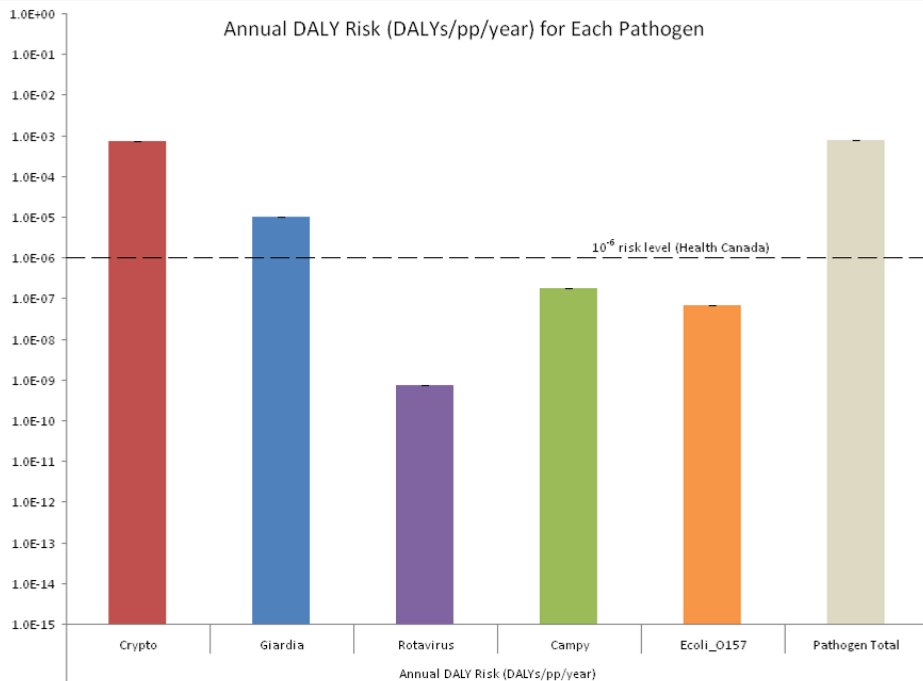
Results- Disinfection Only

Total number of illnesses per year in overall population: 4390

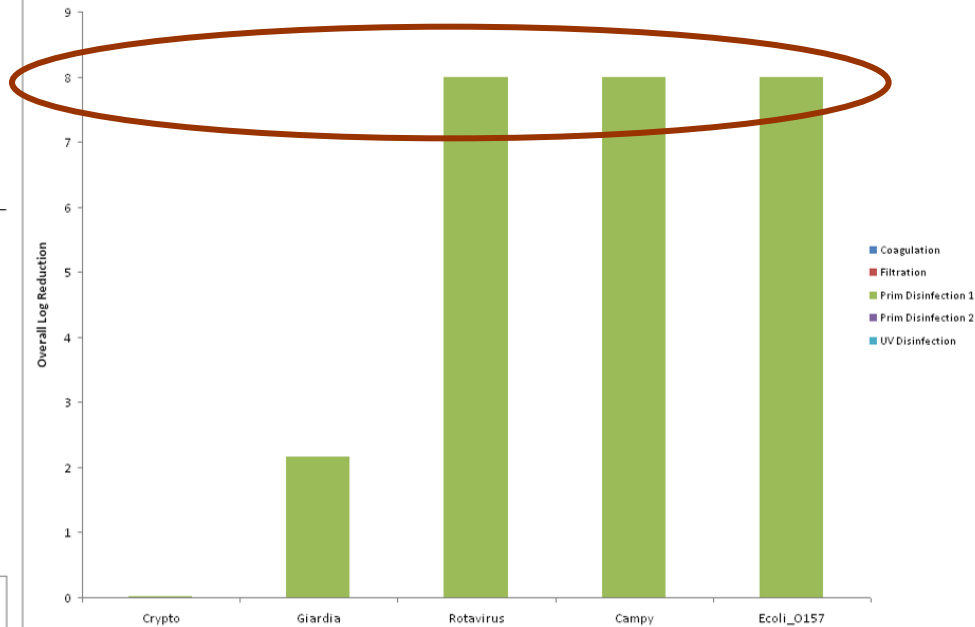
Probability Distribution for DALY Risk
(*Crypto/Giardia/Rotavirus/Ecoli/Campylobacter*)



Annual DALY Risk (DALYs/pp/year) for Each Pathogen



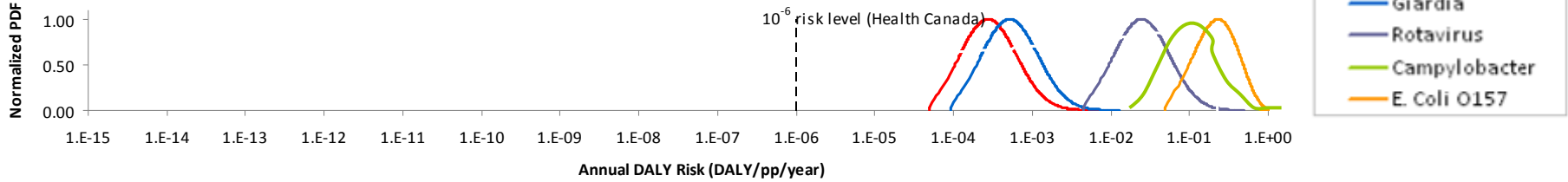
Log Reduction Values for Individual Treatment Barriers



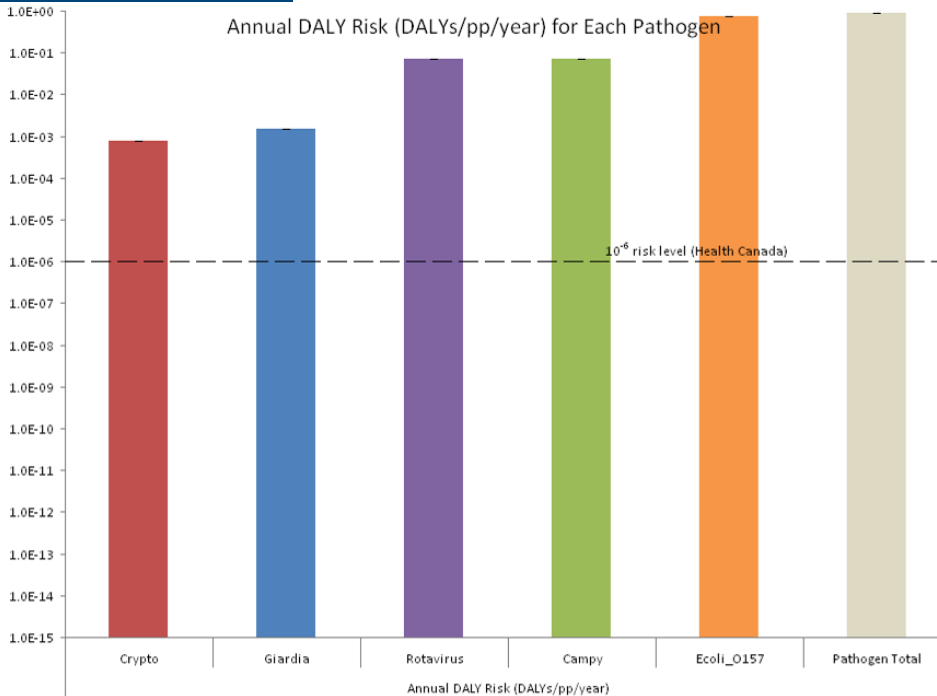
Results- No Treatment

Total number of illnesses per year in overall population: 434,000

Probability Distribution for DALY Risk
(Crypto/Giardia/Rotavirus/Ecoli/Campylobacter)



Annual DALY Risk (DALYs/pp/year) for Each Pathogen



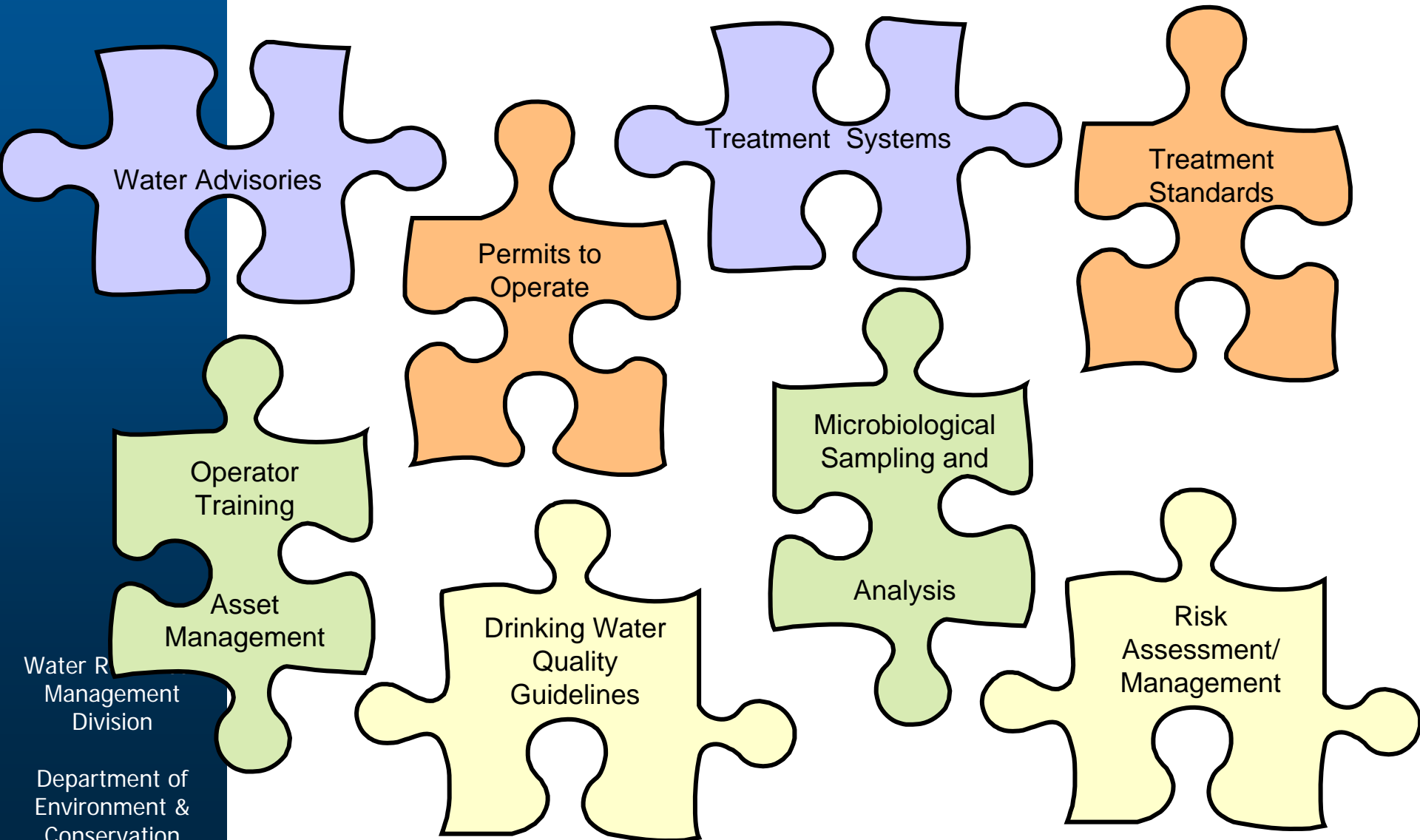
Log Reduction Values for Individual Treatment Barriers



What Now?

- Health-based targets can assist in determining specific interventions or corrective measures appropriate to delivering safe drinking water:
 - source protection
 - treatment processes
- Reduce the number of BWAs
- Better manage risk in drinking water systems
 - Health risk
 - Water system risk from source to tap
 - Financial risk
 - Reputation risk
 - Legal risk
- Incremental changes in drinking water safety management to address identified gaps

Fitting the Pieces Together



Fitting the Pieces Together



Questions?

