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# **Drinking Water Advisories in First Nations Communities in Canada**

A National Overview  
1995-2007

**Canada** 

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For further information or to obtain additional copies, please contact:

Publications  
Health Canada  
Ottawa , Ontario K1A 0K9  
Tel.: (613) 954-5995  
Fax: (613) 941-5366  
E-Mail: [info@hc-sc.gc.ca](mailto:info@hc-sc.gc.ca)

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## **Authors**

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Alan Willsie, PhD, Health Canada

Georgine Pastershank, PhD, Health Canada

Kathleen Lydon-Hassen, BSc, Health Canada

Caroline Mimeault, PhD, Health Canada

Cheng Wu, MSc, Health Canada

Ellen Travis, PhD, Health Canada

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## Definitions

**Boil Water Advisory (BWA):** An advisory issued to the public when the water in a community's water system is contaminated with faecal pollution indicator organisms (such as *Escherichia coli*) or when water quality is questionable due to operational deficiencies (such as inadequate chlorine residual). Under these circumstances, bringing the water to a rolling boil for at least one minute will render it safe for human consumption (Health Canada, 2008a).

**Do Not Consume Advisory:** An advisory issued to the public when the water in a community's water system contains a contaminant, such as a chemical, that cannot be removed from the water by boiling (Health Canada, 2008a).

**Do Not Use Advisory:** An advisory issued to the public when the contaminant that poses a health risk cannot be removed from the water by boiling and exposure to the water could cause skin, eye, and/or nose irritations or when an unknown contaminant has polluted the drinking water supply (e.g. a chemical spill) (Health Canada, 2008a).

**Drinking Water Advisory (DWA):** Preventive measures to protect public health from confirmed or suspected microbiological and/or chemical contamination in drinking water. They include “Boil Water”, “Do Not Consume,” and “Do Not Use” advisories (Health Canada, 2008a).

**Long-term Drinking Water Advisory:** For the purpose of this analysis, long-term advisories are defined as being in effect for more than one year.

## Abstract

Through the Drinking Water Safety Program, Health Canada works in partnership with First Nations communities in Canada to assist them in establishing monitoring programs for drinking water quality as per the *Guidelines for Canadian Drinking Water Quality* (GCDWQ). An important aspect of such monitoring programs is the ability of communities to alert their members to water quality problems when they occur by issuing Drinking Water Advisories (DWA). DWA are preventive measures for protecting public health from confirmed or suspected microbiological and/or chemical contamination in drinking water. They include “Boil Water”, “Do Not Consume,” and “Do Not Use” advisories.

This analysis provides a national overview of DWA in First Nations communities from 1995 through 2007. The objective of this report is to describe the duration, frequency and reasons for issuing DWA in First Nations communities in Canada. Trends for the period 2003–2007 and seasonal variability are also examined.

Reported regional DWA data from the years 1995-2007 were compiled to form a national dataset. Advisory variables included: type of advisory; reason(s) for issuing; date set; and, date lifted. Because reporting is more consistent after 2003, trends were examined for the period 2003-2007.

Results can be briefly summarized as follows. The median duration of DWA was 39 days. The most commonly cited reasons for issuing DWA were: unacceptable microbiological quality, inadequate disinfection, and equipment malfunction. Most remedial actions required to rescind DWA were related to operational challenges and upgrades and repairs of parts or of whole water systems. The number of DWA issued, as well as the number of DWA revoked, increased during the period 2003-2007. Implementation of increased drinking water sampling and other interventions through the First Nations Water Management Strategy since 2003-04 may contribute to these increases. Finally, analysis suggests seasonal effects in DWA issuances.

It is anticipated that this national overview and analysis will inform stakeholders involved with drinking water in First Nations communities.

## 1. INTRODUCTION

Drinking Water Advisories (DWA) are preventive measures for protecting public health from waterborne microbiological and/or chemical contamination that could be or are known to be present in drinking water (Health Canada, 2008a). They include “Boil Water”, “Do Not Consume,” and “Do Not Use” advisories. A Boil Water Advisory is “issued to the public when the water in a community's water system is contaminated with faecal pollution indicator organisms (such as *Escherichia coli*) or when water quality is questionable due to operational deficiencies (such as inadequate chlorine residual)”. Under these circumstances, bringing the water to a rolling boil for at least one minute will render it safe for human consumption” (Health Canada, 2008a). A Do Not Consume Advisory is “issued to the public when the water in a community's water system contains a contaminant, such as a chemical, that cannot be removed from the water by boiling” (Health Canada, 2008a). Finally, a Do Not Use Advisory is “issued to the public when the contaminant that poses a health risk cannot be removed from the water by boiling, and exposure to the water could cause skin, eye, and/or nose irritations or when an unknown contaminant has polluted the drinking water supply (e.g. a chemical spill)” (Health Canada, 2008a).

Through the Drinking Water Safety Program, Health Canada works in partnership with more than 600 First Nations communities in Canada to ensure that drinking water quality monitoring programs are in place. Drinking water quality is determined by testing drinking water for bacteriological, chemical, physical, and radiological contaminants. Tests are carried out by a Community-Based Water Monitor, an Environmental Health Officer (EHO) employed by Health Canada, or a First Nations community member.

EHOs review and interpret drinking water quality tests. If the drinking water quality is found to be unsatisfactory, the EHO will immediately communicate the appropriate recommendation(s) to Chief and Council for action such as, for example, issuing a DWA. It is the responsibility of Chief and Council to issue a DWA in the affected community. Chief and Council are also responsible for taking the necessary actions to communicate

DWA to residents and other appropriate stakeholders. Health Canada, Indian and Northern Affairs Canada, and other partners are available to provide advice and assistance (Health Canada, 2007a).

## **2. OBJECTIVE**

This report presents a national overview of the duration, frequency, and reasons for issuing DWA in First Nations communities in Canada from 1995 to 2007.

## **3. METHODS**

DWA reported by the seven Regional Environmental Health Services offices of First Nations and Inuit Health for the years 1995-2007 were compiled to form a national DWA dataset. Reported DWA mainly apply to water systems of 5 connections or more and to public water systems. Data collected includes type of advisory; date set; date lifted; reason(s) for issuing; and, remedial actions required to rescind the advisory. Incomplete data for date set or date lifted in 6 advisories resulted in the exclusion of these advisories from the analysis. A total of 654 advisories were analysed in June 2008 for mean and median duration of DWA as of December 31, 2007. Any advisories relating to the study period but reported after this date were excluded from the analysis.

Reasons for issuing the advisory were provided in 645 cases. Regional databases categorize reasons according to a list of reasons developed by the Federal-Provincial-Territorial committee on Drinking Water (Health Canada, 2001). Reasons are grouped in the following categories: significant deterioration in source water quality; equipment malfunction during treatment or distribution; inadequate disinfection or disinfectant residuals; unacceptable microbiological quality; unacceptable turbidities or particle counts; operation of system would compromise public health; situations where epidemiological evidence indicates that the drinking water is or may be responsible for an

outbreak of illness; and other. In this report, the names of these categories are abbreviated as follows: source water; equipment; disinfection; microbiological quality; turbidity; operation of system; epidemiological evidence; and other.

Qualitative data on remedial actions EHOs identified as required to lift advisories were analysed for this study. Two researchers independently coded written descriptions of remedial actions EHOs identified as necessary for lifting advisories. The researchers compared and revised their categories to produce a common set of categories capturing relevant and recurring features of the remedial actions described by EHOs. Because a combination of actions is sometimes required to lift a given advisory, more than one remedial action category is attributed in some cases. Remedial actions were grouped in the following five categories: operational challenges; removal of arsenic/uranium; staffing and training; upgrades and repairs; and other.

This report employs a number of terms for defining the status of advisories and locating them in time. When an advisory is issued by Chief and Council, it is *in effect* until the reason for the advisory has been addressed. An advisory *in effect* indicates that the Chief and Council recommends following the actions prescribed for the specific type of advisory issued. The advisory can be *lifted* by Chief and Council after the necessary steps to remedy the problem have been taken and the water is safe for consumption. This report employs, as well, special terminology to locate advisories *in effect* within specific timeframes of analysis, as, for example, within a single fiscal year or across one or more fiscal years. A ***new*** DWA indicates that the advisory was issued during the specific time period. A ***carried over*** DWA indicates that the advisory was set prior to the defined time period. A ***continuing*** DWA indicates that an advisory remains *in effect* at the end of the defined time period. Finally, a ***long-term*** DWA indicates that the advisory has been in effect for more than one year.

Time series analysis was used to detect if there was a trend in the number of DWA in effect annually between 2003 and 2007. Linear regression analyses were performed on the annual number of DWA issued and revoked and on the number of newly carried-over

DWA for the years 2003 to 2007 using the statistical program SigmaStat 3.5 (Systat software, Inc.).

Statistical analysis of the mean number of advisories issued by season was conducted to determine if there was significant variation. Because reporting of DWA data to Health Canada Headquarters was more consistent after 2003, investigation of seasonal variability in the issuing of advisories was limited to the period from and including summer 2003 to the end of 2007 (n=541). March 21, June 21, September 23, and December 21 were used as the starting dates for spring, summer, fall and winter respectively. A seasonality test was used to determine the significance of the seasonal pattern in the number of DWA issued. The mean number of DWA per season and 95% confidence intervals for the mean were calculated. Comparison of the difference in means between seasons was conducted using one way ANOVA, followed by a post hoc Bonferroni test for multiple comparisons of means between seasons. In addition, an overall analysis of the number of DWA issued per season was conducted using a Mann-Kendall test to determine the trend and estimate the slope. The statistical software SYSTAT 12 was used for these analyses.

To investigate if there were any differences in the reported duration of DWA in effect before and after the inception of the First Nations Water Management Strategy in 2003, tests of homogeneity were used to compare the duration of DWA in effect 5 years before and 5 years after December 31, 2002.

## 4. RESULTS

### 4.1. Description of all DWA

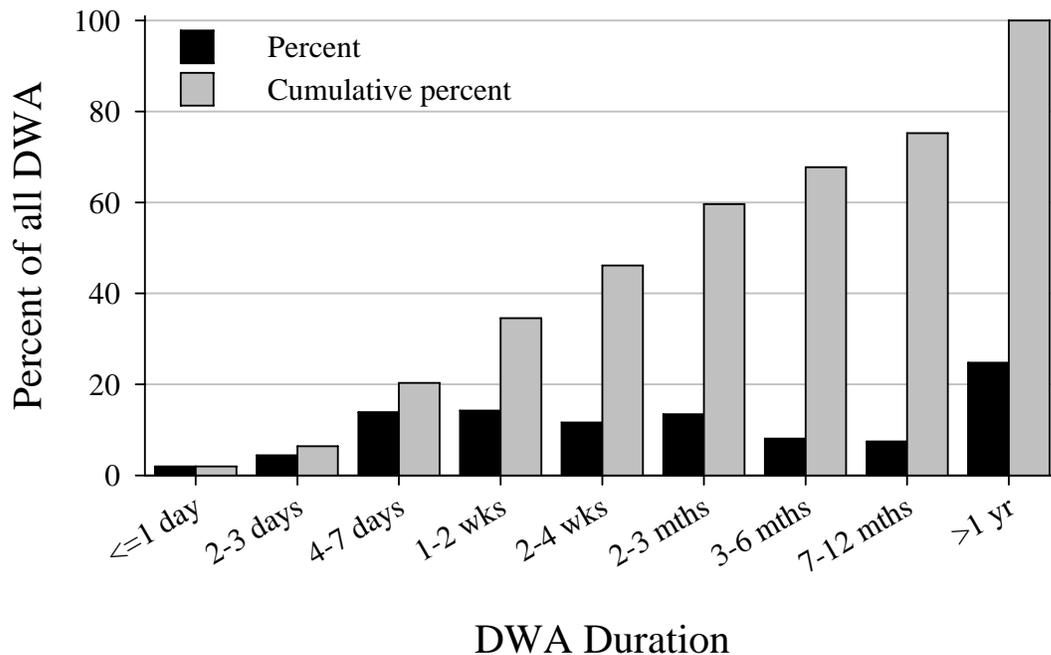
As of the end of December 2007, the briefest advisories were in effect for less than one day (issued and lifted within the same day) and the lengthiest was close to 13 years. The average duration for all DWA is 343 days but the skewed distribution and the wide range in duration makes the median a better reflection of the usual duration of DWA. The median indicates that half of all DWA issued were lifted within 39 days (Table 1).

Between 1995 and 2007, 2% of all DWA were in effect for one day or less, 6% for 3 days or less, 20% for one week or less, 35% for 2 weeks or less, 46% for 4 weeks or less, 60% for 3 months or less and 68% for 6 months or less (Fig. 1). Overall, three quarters (75%) of advisories lasted for less than one year in duration, translating into one quarter (25%) of all advisories being in effect for over a year (long-term advisories).

**Table 1.** Summary statistics of the duration of all DWA reported between 1995 and 2007 (n=654).

Summary Statistics	Duration (days)
Mean	343
Median	39
Std. Deviation	638
Minimum	< 1*
Maximum	4716

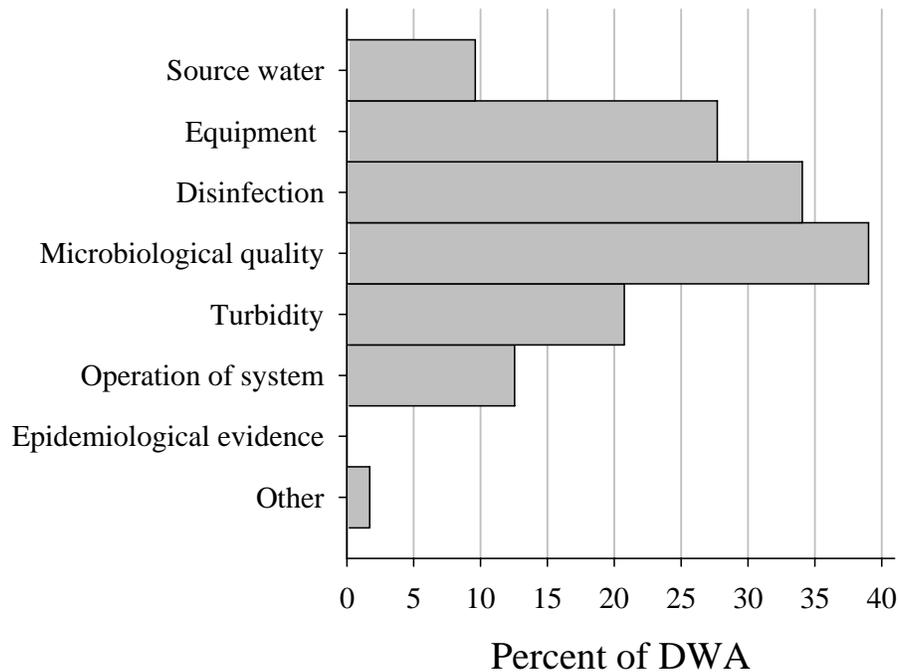
*\*some advisories are set and lifted within the same day*



**Figure 1.** Distribution of duration of all DWA reported between 1995 and 2007 (n=654).

The most commonly cited reasons for issuing a DWA were unacceptable microbiological quality (39%), inadequate disinfection or disinfectant residuals (34%) and equipment malfunction during treatment or distribution (28%) (Fig. 2). Other reasons include flooding and high levels of uranium. It is noteworthy that no advisory has ever been issued due to epidemiological evidence that drinking water is or may be responsible for an outbreak of illness. The reasons for issuing advisories were missing in 8 of 654 advisories (1%).

Advisories attributed to inadequate disinfection or disinfectant residuals had the longest median duration, at 159 days, followed by situations where operation of the system may compromise public health, at 151 days. The “other” category is used primarily in one region for advisories related to weather events such as flooding. These had the shortest median duration of 3 days. Significant deterioration in source water and unacceptable turbidity had median durations of 16 and 20 days, respectively (Table 2).



**Figure 2.** Reported reasons for advisory issuance as of December 31, 2007 (n=939; note that there can be more than one reason for a given advisory and that therefore the number of reasons (n=939) exceeds the number of advisories (n=646)).

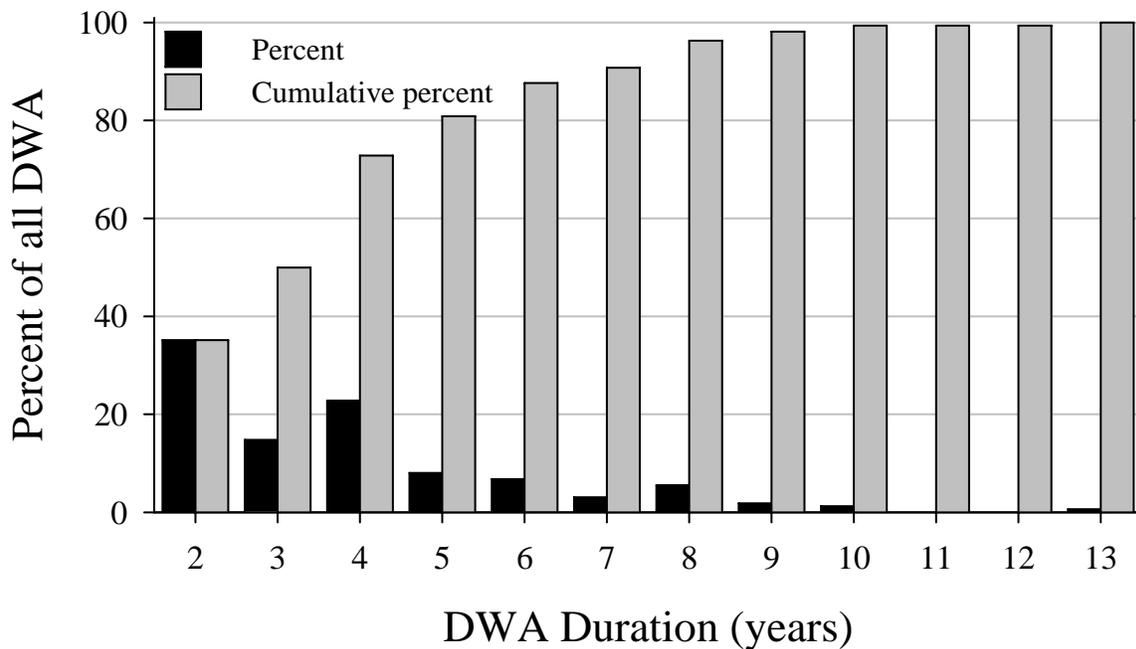
**Table 2.** Summary statistics of the duration of DWA per reasons for advisory issuance (n=939 reasons cited for 646 DWA).

Reported reasons	Duration (days)				
	Mean	Median	SD	Min	Max
Source water	324	16	780	1	3639
Equipment	318	33	618	1	3227
Disinfection	590	159	806	< 1	4716
Microbiological quality	361	77	614	< 1	3639
Turbidity	139	20	303	1	2139
Operation of system	590	151	839	< 1	3286
Other *	128	3	401	2	1336

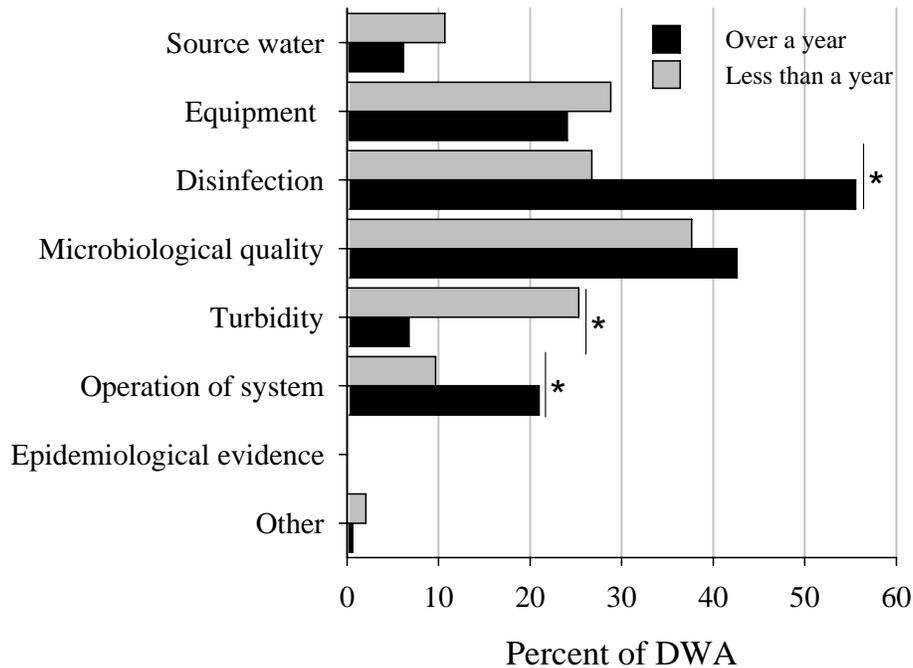
\* This category is used in one region and is used primarily for weather related events. This category also includes one long-term advisory attributed to unacceptable levels of naturally occurring uranium.

## 4.2. Description of long-term DWA

A more detailed analysis of long-term advisories (DWA in effect for one year or more) was conducted in order to better understand the factors contributing to their continuation. One quarter (25%) of all advisories were reported to be long-term advisories, of which half were lifted within 3 years (Fig. 1). Of all long-term advisories reported, 35% (57 communities (com.)) were in effect up to 2 years, 15% (24 com.) up to 3 years, 23% (37 com.) up to 4 years, 8% (13 com.) up to 5 years, 7% (11 com.) up to 6 years, 3% (5 com.) up to 7 years, 6% (10 com.) up to 8 years, 2% (3 com.) up to 9 years, 1% (1 com.) up to 10 years, and 1% (1 com.) up to 13 years (Fig. 3).



**Figure 3.** Distribution of duration of long-term DWA (in years) as of December 31, 2007 (n=162).



**Figure 4.** Reported reasons for issuing DWA lasting for less or more than one year, as of December 31, 2007. Any given advisory can be attributed to more than one reason and therefore the sum of proportions will exceed 100% (n = 685 reasons for 485 DWA lasting less than a year and n = 254 reasons for 161 DWA lasting more than a year). Asterisks indicate statistical differences.

**Table 3.** Summary statistics of duration of DWA in effect for over one year as of December 31, 2007 per reasons for advisory issuance (n=254 reasons for 161 DWA as a given advisory can be attributed to more than one reason).

Reported reasons	Duration (days)				
	Mean	Median	SD	Min	Max
Source water	1808	1834	1092	472	3639
Equipment	1243	943	799	394	3227
Disinfection	1340	1272	791	377	4716
Microbiological quality	1144	1151	720	369	3639
Turbidity	989	1015	510	420	2139
Operation of system	1323	1141	860	408	3286
Other *	1075	1075	NA	1075	1075

\* This category is used in one region and is used primarily for weather related events. This category also includes one long-term advisory attributed to unacceptable levels of naturally occurring uranium.

Between 1995 and 2007, a total of 162 advisories had been in effect for longer than one year. Reason(s) for issuing was/were missing for one advisory. Inadequate disinfection or disinfectant residuals was the most commonly cited reason in 56% of advisories, followed by unacceptable microbiological quality (43% DWA), equipment malfunction (24% DWA), and situations where operation of the system may compromise public health (21%) (Fig. 4). For comparison purposes, reasons for issuing advisories that lasted less than a year were also included in Figure 4. Unacceptable microbiological quality was the most commonly cited reason in 38% of advisories in effect for less than one year, followed by equipment malfunction (29%), inadequate disinfection or disinfectant residuals (27%) and unacceptable turbidity (25%) (Fig. 4). No advisory has ever been issued based on epidemiological evidence that drinking water is or may be responsible for an outbreak of illness. Statistical analyses revealed the percentage of advisories issued was different for advisories lasting for less than one year than for long-term advisories on three variables: inadequate disinfection; unacceptable turbidity; and situations where the operation of the system may compromise public health (tests of homogeneity,  $p < 0.001$ ).

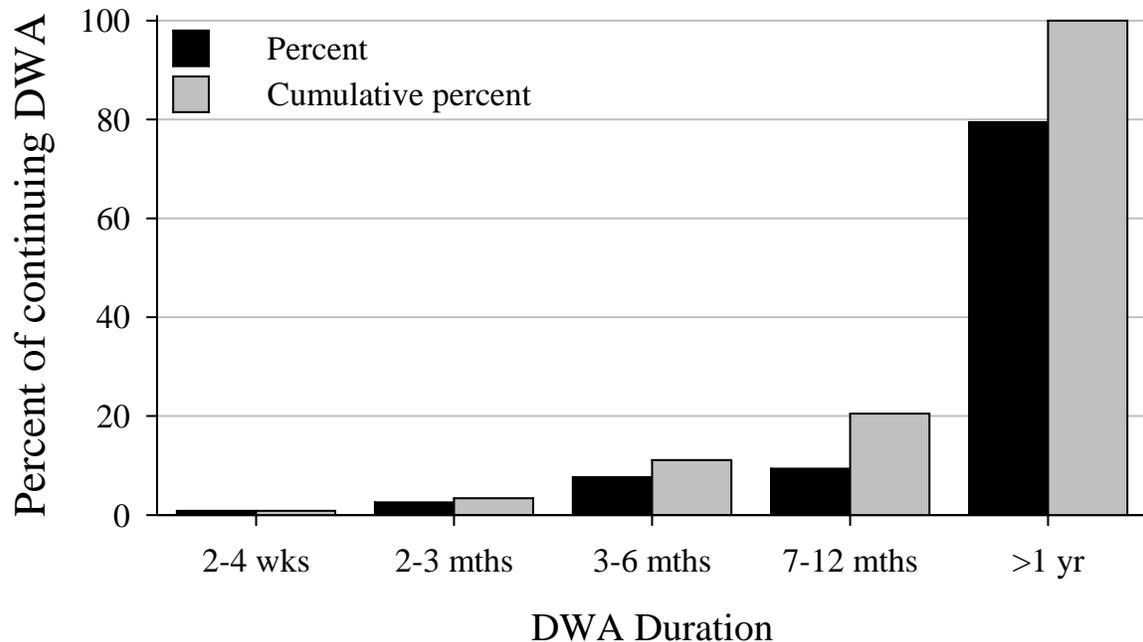
On average, about 15% of long-term advisories in effect were lifted in any given year. By implication, 85% of long-term advisories continue into the year(s) following the year in which the advisories were set (Table 4).

**Table 4.** Number of long-term DWA in effect and lifted for the years 2003 to 2007.

<b>Year</b>	<b>Number of long-term DWA in effect</b>	<b>Number of long-term DWA lifted</b>	<b>Percent of long-term DWA lifted</b>
2003	53	7	13%
2004	68	8	12%
2005	95	22	23%
2006	90	14	16%
2007	104	11	11%

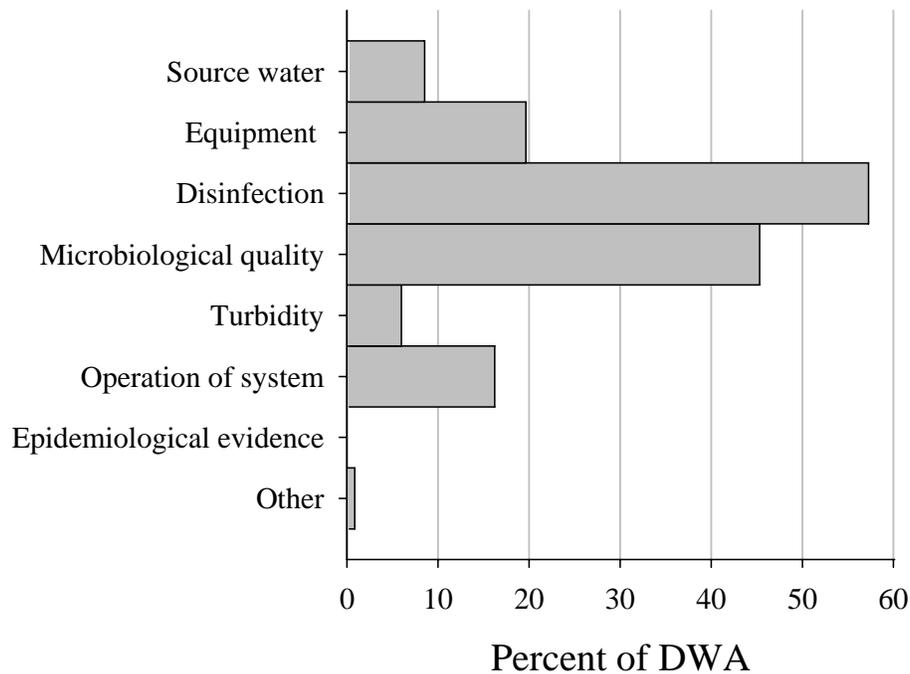
### **4.3. Description of DWA continuing at the end of 2007**

As of December 31, 2007, a total of 117 advisories remained in effect. Less than one percent had been in effect for less than 4 weeks, 3% for less than 3 months, 11% for less than 6 months, 21% for less than a year, and 79% in effect for more than one year (Fig. 5).



**Figure 5.** Distribution of duration of continuing DWA after December 31, 2007 (n=117).

The reasons attributed to continuing advisories have a similar profile to all long-term advisories (Fig. 6). Inadequate disinfection was cited as a reason in the majority (57%) of advisories, followed by unacceptable microbiological quality (45%), equipment malfunction (20%), and situations where operation of system could compromise public health (16%).



**Figure 6.** Reasons for issuing DWA continuing after December 31, 2007 (n=180 reasons for 117 DWA as a given advisory can be attributed to more than one reason and therefore the sum of proportions will exceed 100%).

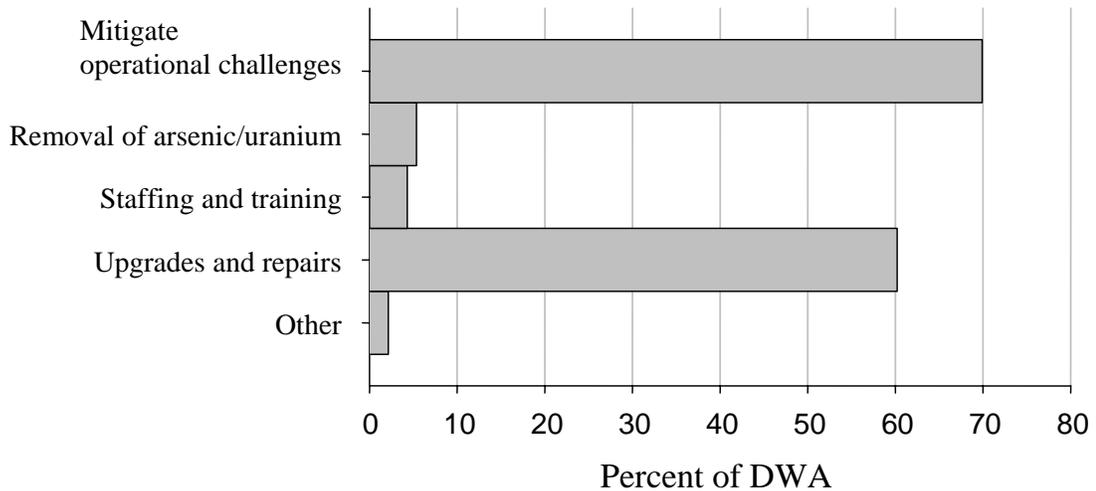
**Table 5.** Summary statistics of duration of DWA continuing after December 31, 2007 per reasons for advisory issuance (n=180 reasons for 117 DWA).

Reported reasons	Duration (days)				
	Mean	Median	SD	Min	Max
Source water	1189	946	927	138	2708
Equipment	1267	943	1027	21	3227
Disinfection	1306	1272	899	60	4716
Microbiological quality	1008	1088	747	61	3227
Turbidity	835	572	746	165	2139
Operation of system	1437	1166	1023	151	3286
Other *	1336	1336	NA	1336	1336

\* This category is used in one region and is used primarily for weather related events. This category also includes one long-term advisory attributed to unacceptable levels of naturally occurring uranium.

#### **4.4. Remedial actions required to lift long-term advisories continuing in 2008**

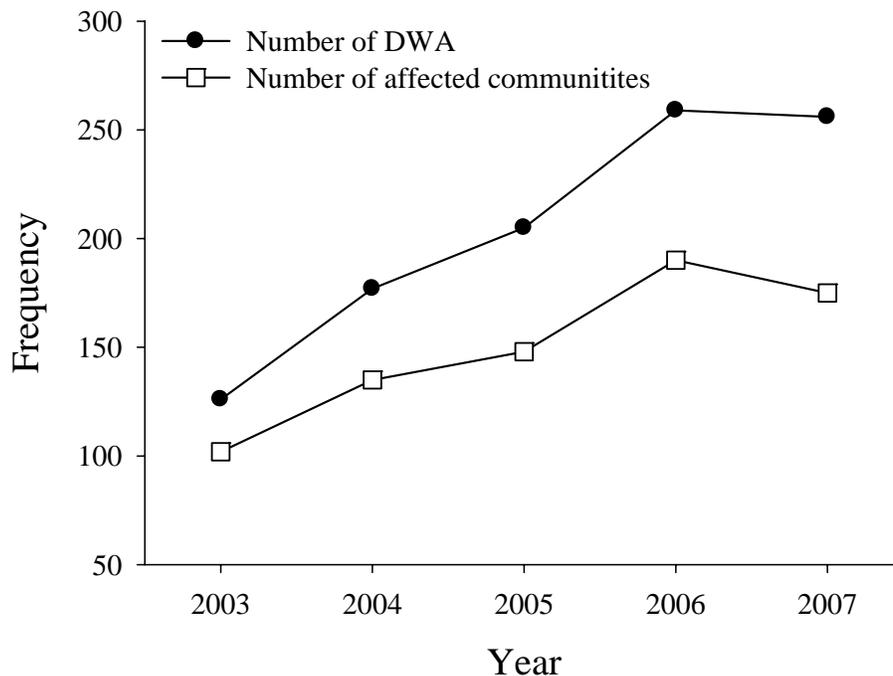
The most cited remedial actions required to rescind long-term DWA still in effect as of December 31, 2007 were the following categories: mitigate operational challenges (70%), and upgrades and repairs (60%) (Fig. 7). The category, mitigate operational challenges includes matters related to the operation of the system, including testing procedures and/or chlorination (when chlorine levels do not meet the recommendations or chlorinators are not connected). Upgrades and repairs may involve construction of part or a whole system.



**Figure 7.** Remedial actions required to rescind long-term DWA continuing in 2008 (n=166 identified remedial actions for 84 out of 93 DWA). More than one remedial action can be associated with a given advisory.

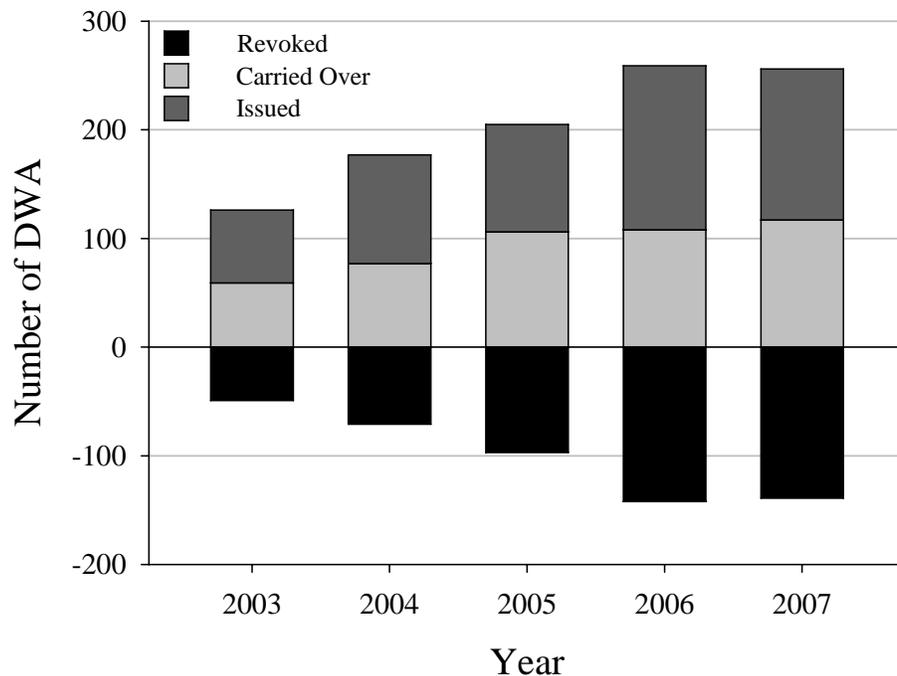
#### **4.5. Frequency of DWA (2003-2007)**

Analysis of data shows the existence of a significant increasing trend in the number of DWA *in effect* between the periods 2003 to 2007 (Mann-Kendall test,  $p = 0.042$ ) (Fig. 8). The number of First Nations communities affected by the DWA also follows a significant upward trend during the same period (Mann-Kendall test,  $p = 0.042$ ).



**Figure 8.** Number of DWA in effect and number of First Nations communities affected for the period of 2003 to 2007.

The annual number of advisories in effect in any given year is influenced by the number *carried over* from the previous year as well as the number of new advisories issued during the year. The number of advisories *carried over* into the following year increased during 2003–2005, stabilized in 2006, and increased again in 2007. Nevertheless, the number of new advisories carried over did not increase significantly over the same period ( $p = 0.402$ ) (Fig. 9). The number of DWA *issued* fluctuated annually over the period 2003-2007 with an overall increasing trend ( $p = 0.032$ ). The number of DWA *revoked* also fluctuated annually with an increasing trend ( $p = 0.007$ ) (Fig. 9).

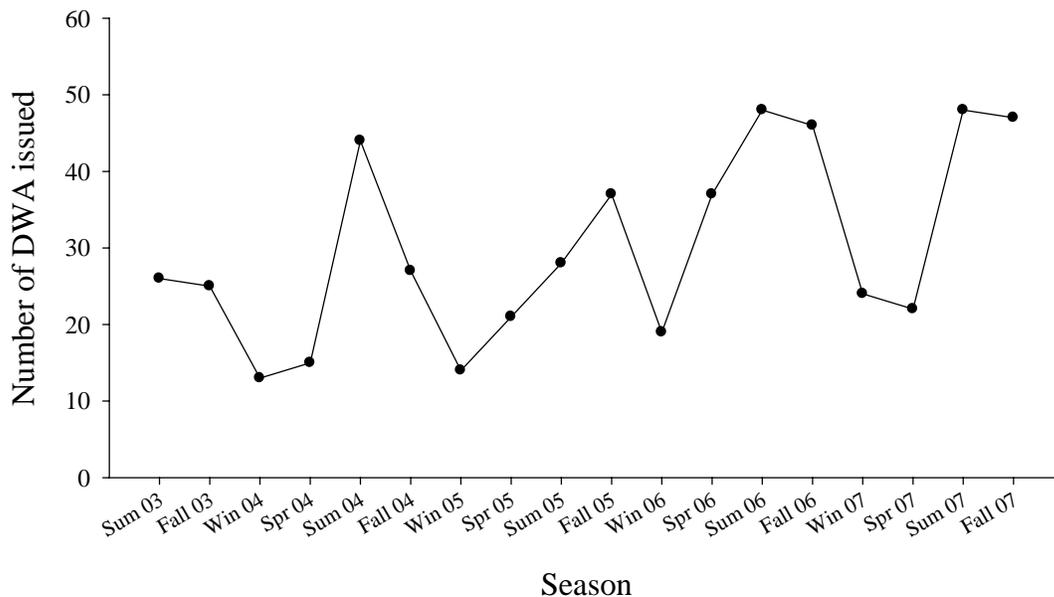


**Figure 9.** Annual number of DWA issued, carried over, and revoked for the period of 2003 to 2007.

#### **4.6. Seasonal trends in number of DWA issued**

The visual examination of the number of advisories issued per season suggests a seasonal cycle confirmed by a seasonality test ( $p < 0.05$ ) (Fig. 10). Analysis of the mean number of advisories issued by season found a statistical difference between seasons ( $p=0.013$ ). The mean number of advisories issued in summer is higher than the mean number in winter ( $p = 0.02$ ) (Table 6). There was borderline evidence of a statistical difference between the mean number of advisories issued in the fall and winter ( $p=0.06$ ).

It is also interesting to mention that there is an overall significant upward trend in the number of advisories issued between summer 2003 and fall 2007 (Mann-Kendall trend analysis,  $p < 0.05$ , slope 1.250).



**Figure 10.** Number of DWA issued each season from summer 2003 to fall 2007.

**Table 6.** Summary statistics of the number of DWA issued in First Nations communities across Canada by season from summer 2003 to fall 2007. Different letters indicate statistically significant differences between the mean numbers of DWA per season. Abbreviations: *Std*, standard deviation, *SEM*, standard error of the mean, *MIN*, minimum and *MAX*, maximum.

Season	Number of seasons	Mean	Std.	SEM	95% Confidence Interval for Mean		MIN	MAX
					Lower Bound	Upper Bound		
Winter	4	18 (A)	5	3	9	26	13	24
Spring	4	24 (AB)	9	5	9	39	15	37
Summer	5	39 (B)	11	5	25	52	26	48
Fall	5	36 (AB)	10	5	24	49	25	47
All seasons	18	30	12	3	24	36	13	48

#### **4.7. Comparison of duration of DWA before and after 2003**

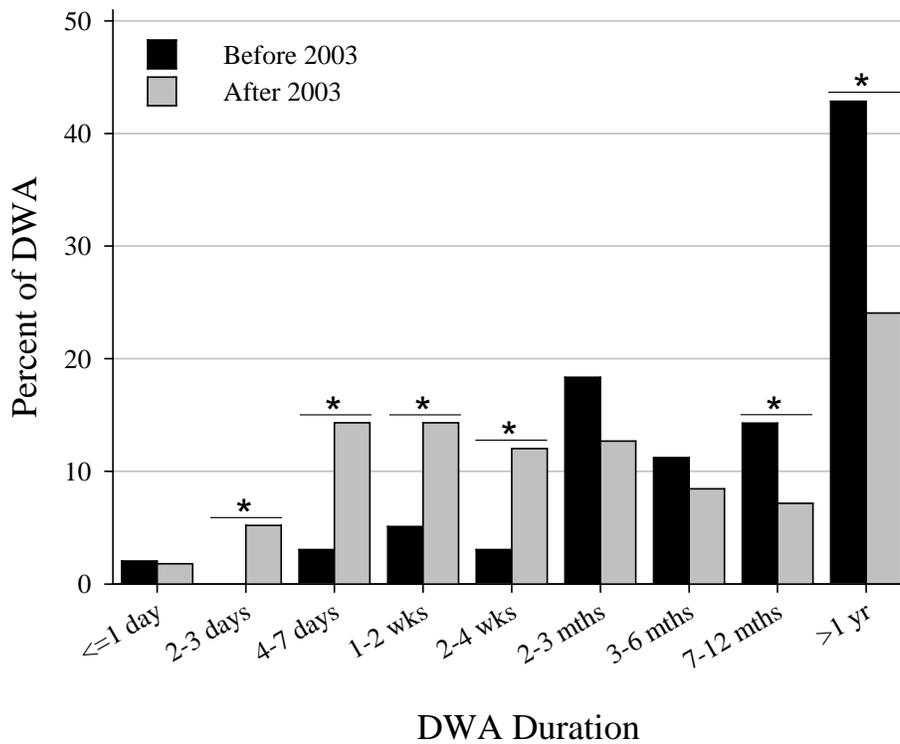
The duration of advisories in effect before and after the implementation of the First Nations Water Management Strategy in 2003 was compared. Fewer advisories were reported to be in effect before 2003 (n=98) than after (n=615). Both the mean and the median of the duration of DWA in effect before 2003 were higher than DWA in effect after 2003 (Table 7).

While the percentage of advisories in effect for less than a day was the same before and after 2003 (2%), the percentages of advisories in effect for 2-3 days, 4-7 days, 1-2 weeks and 2-4 weeks were lower before 2003 (0%, 3%, 5% and 3%, respectively) than after 2003 (5%, 14%, 14% and 12%, respectively) (Fig. 11) (Chi-square analyses,  $p = 0.021$ ,  $0.002$ ,  $0.012$  and  $0.008$ , respectively). In contrast, the percentage of advisories in effect for 7-12 months was higher before 2003 (14%) compared to after 2003 (7%) (Chi-square analysis,  $p = 0.016$ ). Finally, the percentage of advisories that remained in effect for over a year was also higher before 2003 (43%) than after 2003 (24%) (Chi-square analysis,  $p < 0.001$ ).

**Table 7.** Summary statistics of the duration of DWA issued before and after 2003.

Summary Statistics	Duration (days)	
	BEFORE 2003	AFTER 2003
	DWA in effect between Jan 1, 1998 and Dec 31, 2002 (n=98)	DWA in effect between Jan 1, 2003 and Dec 31, 2007 (n=615)
Mean	425	295
Median	307	35
Std. Deviation	458	499
Minimum	< 1*	< 1*
Maximum	1825	1825

*\*some advisories are set and lifted within the same day*



**Figure 11.** Distribution of the duration of DWA in effect before 2003 (black bars, n=98) and after 2003 (gray bars, n=615). Asterisks indicate statistical differences between the percent of advisories issued before and after 2003.

## 5. DISCUSSION

The overall average duration of DWA in First Nations communities is close to one year (343 days), but because there is a wide range in durations as well as a skewed distribution the median provides a better estimate of the usual duration of advisories, indicating that half are lifted in less than 39 days. This suggests that most advisories were lifted within a relatively short timeframe even though one quarter of all advisories issued between 1996 and 2007 were in effect for over one year.

Analysis of long-term advisories revealed that, on average, only 15% of long-term advisories were lifted in any given year between 2003 and 2007. In addition, 79% of advisories continuing into 2008 were greater than one year in effect suggesting that long-term advisories are difficult to resolve.

There was a significant increase observed in the number of DWA *in effect* in First Nations communities between 2003 and 2007. Two separate factors are reflected in this finding: an increasing number of advisories *issued* annually and the cumulative effect of unresolved long-term advisories *carried over* from the previous year(s). The First Nations Water Management Strategy began in 2003 and several factors related to its implementation may have influenced the absolute number of DWA during 2003-2007. For example, the number of water samples tested increased seven fold from 2002 to 2006 (Health Canada, 2007a). In addition, the number of First Nations communities with access to Community-Based Water Monitors and the number of communities with access to portable kits for bacteriological analysis has more than doubled while the number of Environmental Health Officers has increased by one third (Health Canada, 2007a). When water-quality monitoring and reporting is increased, it is more likely that problems will be detected, which in turn increases the number of DWA issued. At the same time, the number of DWA lifted also significantly increased between 2003 and 2007, suggesting a concurrent increase in the number of adequate interventions to address advisories and make water safe for consumption.

There is also strong evidence of a seasonal cycle in the issuance of DWA. Further research is needed to explore the factors that influence the observed seasonal variability. Possible factors may include increased frequency of severe weather events, increased temperatures and lower water levels in summer and fall. Moreover, it is possible that there is an increase in the frequency of sampling or application of a more precautionary approach during these periods.

The most commonly cited reasons for issuing of DWA between 1995 and 2007 were unacceptable microbiological quality, inadequate disinfection or disinfectant residuals,

and equipment malfunction during treatment or distribution. These reasons for issuing advisories were the most frequently cited across several timeframes, including advisories lasting less than one year, long-term advisories, and long-term advisories continuing into 2008. There are also differences in cited reasons for advisories across timeframes: unacceptable turbidity is a reason reported over three times more often in advisories in effect for less than one year than in long-term DWA. Source deterioration is reported almost twice as often in advisories that last for less than one year compared to long-term advisories. Unacceptable turbidity and source deterioration are also reasons reported to have the shortest mean and median duration of DWA. These observations suggest that DWA issued for those reasons are more likely to be resolved in less than one year. On the other hand, inadequate disinfection and operation of system are reasons reported more than twice as often for long-term advisories compared to advisories in effect for less than one year. Examples of situations in which the operation of the system would compromise public health include high levels of arsenic or uranium in the source water and situations in which it is difficult to maintain an acceptable balance of the concentrations of chemicals used in the treatment of water. Inadequate disinfection and operation of system are the reasons associated with the longest mean and median durations, suggesting that advisories issued for these reasons are more likely to become long-term advisories. Particular attention should therefore be given to advisories issued for these reasons. It is important to note that there has not been a single DWA reported due to epidemiological evidence indicating that drinking water was or may have been responsible for an outbreak of illness in First Nations Communities.

The categories of reasons for issuing DWA are prompted by regional databases during data entry, but criteria associated with some reasons vary. For example, the criteria relating to unacceptable microbiological quality vary. Some jurisdictions issue advisories exclusively on the confirmed presence of an unacceptable level of total coliforms or heterotrophic plate counts. In other jurisdictions, advisories are only issued in response to confirmed presence of *E.coli* /thermo-tolerant coliforms (Health Canada, 2007b). Further analysis of advisories issued for unacceptable microbiological quality would be

required to determine the extent of variation between and/or within regions in the criteria associated with this category.

Remedial actions required to address long-term continuing advisories at the end of 2007 were mostly related to operational challenges and to upgrades/repairs of the water systems. These findings represent further evidence of the underlying operational and infrastructure-related causes for most long-term DWA.

One of the objectives of the First Nations Water Management Strategy was to implement “a set of integrated water quality management protocols with clearly defined roles and responsibilities consistent with national performance standards along with improvements in emergency response procedures” (Indian and Northern Affairs Canada, 2008). A comparison was done to assess the impact of the strategy on the duration of reported advisories since its implementation in 2003. In total, there were 98 DWA in effect during the previous 5 years before the implementation of the Strategy in 2003 (an average of 19.6 DWA in effect every year) compared to 615 in the following 5 years (an average of 123 DWA in effect every year). As discussed above, this important difference might simply be a reflection of increased monitoring since 2003 and changes in some federal guidelines. On the other hand, advisories in effect since 2003 were lifted more quickly than those in effect before 2003. Whereas the median duration of advisories in effect before 2003 was 307 days, the median duration after 2003 was 35 days. The percentage of advisories lifted within 4 weeks rose from 13% before 2003 to 48% after 2003. In addition, there were fewer long-term advisories in effect since 2003. This comparative analysis suggests that advisories issued since the implementation of the FNWMS are resolved more quickly than before implementation. But because reporting of advisories has been more consistent since 2003, it is possible that the observed differences might partially be due to incomplete representation of advisories issued before 2003.

## 6. STRENGTHS AND LIMITATIONS

Data on DWA are collected prospectively in all regions of Canada. Five of the seven regions use the same data collection system. The remaining regions collect similar information for most variables, but there are some differences in formats and detail of information collected. The majority of data are entered into databases within a short period of the advisory being issued and most regions report data to Headquarters on a weekly basis.

Data entry errors are minimized through weekly reporting and timely reconciliation of any discrepancies. Though rare, data entry is sometimes delayed by up to six months after a DWA is issued. Since this report is produced 6 months after the reporting period for the majority of the data, the effect of reporting delay is anticipated to be minimal.

Because incomplete data represents approximately 1% of the entire data set, any effect of their exclusion is considered negligible.

This study introduces a set of categories for coding remedial actions required to lift advisories. Investigation of the reliability and validity of the categories devised for this study could be performed to create a standardized set of categories that could be embedded in regional databases.

Finally, when comparing the DWA in effect before and after the implementation of the First Nations Water Management Strategy in 2003, it should be noted that DWA reporting to Headquarters has been more consistent since the implementation of the Strategy. It is therefore possible that observed differences reflect incomplete representation of advisories issued before 2003.

## 7. CONCLUSIONS

Since the implementation of the First Nations Water Management Strategy, significant progress in enhancing drinking water quality monitoring has led to increased ability to detect and address potential drinking water quality issues in First Nations communities. These measures include improved staffing and increased water sample testing that allow timely and informed decisions for the protection of public health (Health Canada, 2007b). The Strategy has also included initiatives contributing to an improved water management system such as the development and distribution of national procedures, frameworks and training tools. Examples of publications produced through these initiatives include the revised *Procedure Manual for Safe Drinking Water Quality in First Nations Communities South of 60°* (Health Canada, 2007a); the *Procedure for Addressing Drinking Water Advisories in First Nations Communities South of 60°* (Health Canada, 2007b); and the *Guidelines for the Review of Water and Wastewater Project Proposals in First Nations Communities South of 60°* (Health Canada, 2007c).

Despite these advances, operational and infrastructure-related challenges remain in addressing long-term drinking water advisories in many First Nations communities. More specifically, issues related to drinking water disinfection were associated with several long-term advisories. Renewed commitment and enhanced collaboration will be required among First Nations and all levels of government involved in the management of water supplies from source to tap to successfully address these long-term advisories.

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