Measures to Mitigate Risk of Contaminated Hauled Water:
A Focused Practice Question

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Key Messages

Key mitigation measures to prevent contaminated hauled water include:

1. Ensuring the use of an approved water source
2. Ensuring the design of the hauling tank and associated equipment (hoses, piping, pumps, lubricants, etc.) is non-toxic, easy-to-clean, and protective from contamination
3. Ensuring proper cleaning and disinfection of tanks/equipment
4. Ensuring tanks/equipment are protected from cross-contamination
5. Maintaining a free chlorine residual in the hauled water
6. Conducting water tests and record keeping

1 Background

Rural residences that lack access to sufficient drinking water sources (e.g. absence of a public water distribution system or low-yield well water system) may rely on tanker trucks to haul potable water for drinking, cooking, and other daily activities. Emergency situations which may pose a public health risk to or cause an interruption in the water supply may also result in communities, businesses or homes relying on water haulers to provide a temporary potable water supply.

The process of filling the tanker truck from the water source, storing, transporting and delivering the water to the desired destination may introduce potential avenues for contamination of the water, which may lead to waterborne illness in consumers.

In accordance with the Drinking Water Protocol under the Ontario Public Health Standards, boards of health are required to inspect water hauling vehicles transporting drinking water annually using the Drinking Water Haulage Guidance Document (2008)[1]. Currently, there are no requirements under the *Health Protection and Promotion Act* regulating the operation of water haulage vehicles. Although, public health inspectors (PHIs) may issue an order in the event a health hazard has been identified, they can only rely on this guideline[1] during their inspections. There is much uncertainty among PHIs regarding the inspection of water haulage vehicles. In addition, inconsistency in interpretation and implementation of this guideline may exist not only among PHIs but across health units.

Furthermore, in preparation for the Pan Am Games this summer, organizers were requesting that potable water be potentially hauled to the venues (two of which are

located in Peel Region) for public consumption. There are three known water hauling companies in Peel region (two in Caledon, one in Brampton), which acquire potable water from bulk filling stations (municipal water supply). Four bulk water filling stations are also located in Peel (Bolton, Brampton/Snelgrove, Caledon). Given this context, a literature review was conducted to determine what measures mitigate the risk of contaminated hauled water.

2 Literature Review Question

What measures mitigate the risk of consuming contaminated hauled water?

3 Literature Search

A literature search was conducted in May 2015 in Medline, HealthSTAR, Global Health, and Environment Complete databases, and the Cochrane Database of Systematic Reviews. A search of the grey literature was also conducted in the TRIP database, Google Scholar, and a variety of environmental, water safety, and/or health organizations websites. Searches were limited to synthesized research (reviews and guidelines) published in 2000 and onward in the English language. Refer to Appendix A: Search Strategy for further details.

4 Relevance Assessment

The search results were screened by two reviewers for the following criteria:

Inclusion criteria:

- Mitigation measures include actions taken to prevent the human consumption of contaminated hauled drinking water during processes of water source selection, collection, delivery to consumer, and water storage
- Contaminants may be microbiological, chemical or physical
- Focus on urban or semi-urban mix setting in North America (especially Canada)

Exclusion criteria:

- Mitigation measures focused on odour or taste of the water

Articles that met inclusion/exclusion criteria were then assessed to meet the following relevancy criteria:

- Publication year since 2010
- Not redundant (i.e. standards based heavily on other standards or nearly identical)
- Comprehensive in detail and focus on water hauling; not too broad
- Does not focus on maintenance of cisterns or receiving potable water tanks

5 Results of the Search

No relevant synthesized peer-reviewed research was found from the literature search. Many standards/procedures, mainly from government health authorities, were found in the grey literature. Although the titles of these documents included the term “guidelines”,

they were more like procedures and protocols, which did not include a literature review. Following relevancy assessment by two reviewers, nine articles (eight standards or procedures[2-9]; one regulation[10]) were included in this review (Appendix B: Literature Search Flowchart).

6 Critical Appraisal

Two reviewers independently appraised the nine articles using a modified form of the Critical Appraisal of Textbooks, Textbook Chapters Appraisal Worksheet (Appendix C: Critical Appraisal of Environmental Health Procedures). Discrepancies were resolved through discussion. Methodologies of developing the procedures were obtained by contacting the corresponding authors or organizations. Following quality assessment, the Canadian Standards Association (CSA) standards[2] and American Water Works Association (AWWA) standards[3] were rated as moderate-to-strong quality. The Centers for Disease and Control (CDC)/AWWA guidelines[4], Manitoba Health Protection guidelines[5], and the Ohio Department of Health regulation[10] were rated as moderate. The World Health Organization (WHO)[7], Fraser Health Authority[8], and the Navajo Nation Environmental Protection Agency[9] guidelines were rated as weak quality. Those that were at least of moderate quality were selected for synthesis: three moderate[4,5,10] and two moderate-strong quality[2,3] articles. The remaining four articles were excluded due to weak quality[6-9].

7 Description of Included Articles

Four procedures/standards[2-5] and a regulation[10] that was supplemented with implementation guidance documents were found. Upon review of these articles,

recurring themes were identified related to mitigation of contaminated hauled water including: water source, water hauling tank/equipment design, cleaning/disinfection of tank and associated equipment, potential for cross-contamination, chlorine residual, water testing, and record keeping. The description of each included article is provided below (see Appendix D: Data Extraction Tables for more details).

1. Canadian Standards Association (CSA) B126 Series-13 Water Cisterns Standard[2]

- This standard, rated moderate to strong quality, covered mobile water cisterns (B126.5) which is analogous to transporting water via a haulage vehicle.
- Detailed specifications were outlined regarding the requirements for material and design of water tanks and associated equipment (e.g. hoses, pumps).
- Specific information on disinfection procedures and when to clean and disinfect or shock chlorinate tank and equipment were also contained in the standard.
- Cross-contamination measures, and other measures related to visual inspections of tank/equipment, and chlorine residual and microbial testing were also described. Recordkeeping practices were also included in the standard.

2. American Water Works Association (AWWA) Standard C652-11 Disinfection of water storage facilities[3]

- The AWWA standard was also rated to be of moderate to strong quality. However, the scope of this standard is limited to disinfection of water storage facilities (tanks).

- This standard specified detailed procedures for disinfection of water holding tanks using a variety of forms of chlorine with varying application methods, chlorine concentrations, and contact times.

- Bacteriological quality, chlorine residual and optional testing for potential chemicals in water were also described in the standard.

3. Manitoba Health Protection Bulk water hauling guidelines[5]

- The overall content of this guideline, rated as moderate quality, was relatively comprehensive.

- It included tank and equipment material specifications, and frequency of cleaning/disinfection of tanks/equipment. In particular, it provided detailed procedures for routine disinfection as well as emergency disinfection in the event of contamination.

- Cross-contamination mitigation measures were described as well as information pertaining to visual inspections, bacteriological testing, and recordkeeping.

4. Centers for Disease Control (CDC) & AWWA Emergency water supply planning guide for hospitals and health care facilities[4]

- The context of this procedure differed from other procedures/standards since it pertained to emergency water supply planning for health care facilities. This procedure was rated to be of moderate quality.

- This procedure included information on tank/equipment design, a brief description of proper disinfection procedure, and cross-contamination mitigation measures.

- Information on bacteriological and chlorine residual testing was also outlined.

- This procedure also included information on considerations if the water hauling vehicle is to be connected to building plumbing for water distribution.

5. Ohio's rules for water haulers (Chapter 3701-28-16, Private Water Systems Rules, Ohio Administrative Code)[10]

- This regulation was in force since the 1980's and has been revised to reflect current NSF requirements. Considering the development process, this regulation was rated to be of moderate quality.

- Specific requirements for materials of tank and equipment were described, as well as requirements for free chlorine residual testing, and cross-contamination protection measures.

Overall comparisons between these procedures in terms of tank/equipment design, cleaning/disinfection, cross-contamination mitigation, and chlorine residual and water testing are displayed in Tables 1 to 4. More details on each specific standard/procedure are described in Appendix D: Data Extraction Tables.

Table 1a: Comparison of Tank/equipment Design

Procedures/Standards[1]			
Canadian Standards Association (2013)	**Centers for Disease Control & AWWA (2012)**	**Manitoba Health Protection (2013)**	**Ohio Department of Health (2011)**
-Materials, components of tanks, and lubricants in contact with potable water should comply with NSF/ANSI Standard 61[3] **Tanks can be made of**[2]: -stainless steel (type 316) -concrete -fibre-reinforced plastic -polyethylene (NSF 61[3]- approved virgin material) or -other material provided it complies with this standard **All components of tank/equipment should be:** -safe and durable -non-corrodible, resistant to chipping -watertight, smooth, non-absorbent -free of areas where water can stagnate -designed to minimize surge under normal transport conditions **Tanks should:** -have access ports and hatches (from top of tank) to allow inspection and cleaning. They should be closable with watertight covers and permanently mounted food grade gaskets, securely sealed with screw or clamp fasteners, provided with security locks, and elevated off tank shell -if provided, vent opening should terminate in downward direction and covered with mesh screen or filter -have inlets/outlets protected from contamination, sloped to drain, and securely capped (i.e. threaded or clamped caps) at all times except when filling/draining tank -have a drain opening that would allow tank to be effectively emptied -have an overfilling prevention mechanism -have structural integrity -be painted white, aluminum colour or equivalent on upper 2/3 of surface area of uninsulated tank (unless covered with jacket made of aluminum, stainless steel or equivalent)	**Tanks must:** -be food grade certified (i.e. NSF/ANSI Standard 61[3]) -be contaminant-free, watertight -be easy to clean and disinfect -not be previously used to transport materials such as chemicals -have a drain and vent to allow for complete emptying of tank for cleaning and repairs Hoses and other equipment should also meet NSF/ANSI Standard 61[3]	**Tank (material or interior coating) should:** -meet NSF/ANSI Standard 61[3] or equivalent for food/water grade materials -be non-corrodible (e.g. stainless steel, fiberglass, plastic, approved epoxy liner) **Equipment:** -Hoses, nozzles, pump lubricants and other equipment should also be constructed of food grade materials -Equipment should be maintained in good repair and in sanitary condition -Equipment design must allow for easy access for cleaning purposes (i.e. access ports).	**Tank material must be:** -NSF Standard 61 certified[3] -stainless steel -aluminum (specific wrought alloys and casting alloys that meet food grade requirements) -food grade plastic (FDA approved)[4] -Easily cleanable -Contain no toxic metal surfaces (e.g. lead, cadmium) -Inlets/outlets and openings of tanks must be covered to prevent contamination **Equipment (hoses, fittings, piping, valves, permanent or flexible connections) must:** -Meet NSF Standard 61[3] -Be easily cleanable

Labelling -Tanks/equipment must be labeled with “potable water only” *This is an overview of the requirements. See **Appendix D** for further details.	**Labelling:** -Tanks should be labeled “DRINKING WATER ONLY”	**Labelling:** -Tank must be permanently labelled “POTABLE WATER ONLY”	**Labelling:** -Vehicle must be labeled with health board approval sticker, and contact info of water hauler

[1] AWWA standard only covered disinfection procedure of water tanks and not tank design, so is omitted from this table.
[2] Details on specific tank materials provided in **Appendix D- Data extraction tables**
[3] NSF International. (2011). NSF/ANSI Standard 61-2011 Drinking water system components- health effects.
[4] Food & Drug Administration (FDA) 21 C.F.R. part 177 “Indirect Food Additives: Polymers”.

Table 1b: Comparison of Cleaning/disinfection procedures for tank/equipment

Procedures/Standards				
Canadian Standards Association (2013)	**American Water Works Association (2011)**	**Centers for Disease Control & AWWA (2012)**	**Manitoba Health Protection (2013)**	**Ohio Department of Health (2011)**
Cleaning/disinfection: • Scrub with 200 ppm chlorine (use emulsifying detergent and warm water prior to disinfection if tank or equipment previously used to haul food) • Disinfect with 50 ppm chlorine with minimum contact time of 30 min. • Check with manufacturer on aluminum tanks, plastic/organic coated tanks affected by heat/alkalinity • Dispose of chlorinated water in accordance with local environmental regulations **When to clean/disinfect:** • before use after construction, repair, modification, periods of non-use • following use to transport food • prior to use • depends on frequency of use • Water tanks/equipment should be routinely disinfected if not used for ≥ 4 weeks **Shock chlorination:** • Wash with pressure washer/stiff brush to remove debris • Pump out sludge • Refill tank with potable water • Disinfect with 50 ppm chlorine with minimum 6 hour contact time (ensure sealants/materials compatible with	**Cleaning of tank:** • Remove any materials not part of tank • Clean with high pressure water or scrub to remove any dirt or debris using potable water • Check vent screen, overflow screen, and other openings to ensure in good repair **Disinfection of tank:** *3 methods:* 1) Chlorination of tank resulting in chlorine residual of no < 10 ppm • If sodium hypochlorite or calcium hypochlorite used: min. contact time 24 hrs (or 6 hrs if chlorine fed through chemical pump) • If liquid chlorine used (via chemical feed): min. contact time 6 hrs • Drain tank completely or blend with potable water to have lower chlorine residual 2) Spraying/painting tank surface with 200 ppm chlorine • Add 200 ppm chlorine to surfaces in contact with water when at overflow elevation • Use brushes/spray equipment • Coat surfaces including inlet/outlet piping and drain piping until free chlorine residual no < 10 ppm when filled with water • Allow contact time of at least 30	**Disinfection:** • Use NSF 60 approved sanitizer • Disinfect using min. 50 ppm chlorine for at least 30 min. contact time • Refer to state drinking water agency/AWWA for exact contact time	**Routine disinfection:** • Clean/remove debris (use detergent and rinse, if necessary) • Disinfect with 100 ppm bleach for 20 min. contact time **When to disinfect tanks:** • at least 3 times/year • immediately after any contamination • following a failed water test • Movable equipment (nozzles) need to be cleaned/sanitized daily **Emergency disinfection:** • Clean/remove debris (use detergent and rinse, if necessary) • Disinfect using 200 ppm bleach for 2	**No cleaning or disinfection procedure specified.** **When to clean/disinfect:** • before use • when being repaired, maintained, altered • when contamination occurs/suspected • at least weekly during periods of operation

chlorine dosage) • Repeat if chlorine residual < 10 ppm • Dispose of chlorinated water in accordance with environmental regulations • Flush and refill tank with potable water **When tank should be shock chlorinated:** • before commissioning • on a frequency to sustain water quality • when water source changes • whenever contamination occurs/suspected	min. • Add potable water and drain chlorinated water from drain piping. 3) <u>2-step process</u> of chlorinating the bottom surface with 50 ppm chlorine followed by filling to overflow and maintaining residual of at least 2 ppm for 24 hrs • Add at least 50 ppm chlorine to tank to fill about 5% of total tank volume • Allow for contact time of at least 6 hrs • Fill to overflow level with potable water and hold for at least 24 hrs • Purge highly chlorinated water from drain piping • Ensure chlorine residual is no < 2 ppm • Chlorine dosage table provided in appendix B of the document • Other disinfectants may be used subject to approval from local regulatory agency		min. contact time	

Table 1c: Comparison of Cross-contamination mitigation measures

Procedures/Standards[1]			
Canadian Standards Association (2013)	**Centers for Disease Control & AWWA (2012)**	**Manitoba Health Protection (2013)**	**Ohio Department of Health (2011)**
Tanks should: -Be filled through an air gap (if tank designed to be top-filled) or equipped with check valve on intake line (if tank bottom-filled) to prevent backflow	**Tanks should:** -Be completely enclosed -Have covers sealed or locked to prevent tampering -Filled/emptied using sanitary methods (valve to valve connections or air gaps) -Have connections and fittings for filling and emptying tank protected from contamination	-Protect water, tank, equipment from contamination during filling, storage, transportation and delivery -Tanks and equipment should be dedicated to hauling potable water only	**Vehicle/tank/ equipment should:** -not have been used to previously transport hazardous substances, surface water, or unapproved water source -be dedicated to the purpose of hauling potable water only -be clean, sanitary, and protected from contamination
Hoses should: -Be stored off ground -Be capped at both ends when not used (e.g. threaded or clamped caps) -Have ends disinfected before filling tank at water delivery point -Clean/disinfect tanks/hoses prior to use -If any contamination occurs/suspected, shock chlorinate equipment -tanks/equipment should be dedicated for potable water hauling use only	**Hoses/equipment should be:** -Stored off ground -Disinfected before use -Maintained in sanitary condition -Capped at each end or connected together when not used	-Hoses and nozzles should be protected from contamination when not in use (i.e. threaded or clamped caps) -If hose, nozzle or other equipment contaminated during water delivery (e.g. dropping equipment on ground, protective cover falling), employ emergency disinfection procedure	-Flexible connector ends should be protected and capped at all times except during filling or emptying of tank -Tank/equipment must be cleaned/disinfected before use

[1] AWWA standard only covered disinfection procedure of water tanks and not other aspects of water hauling process, so is omitted from this table.

Table 1d: Comparison of water testing and record keeping procedures

Measures	Procedure/Standard				
	Canadian Standards Association (2013)	**American Water Works Association (2011)**	**Centers for Disease Control & AWWA (2012)**	**Manitoba Health Protection (2013)**	**Ohio Department of Health (2011)**
Minimum free chlorine residual to maintain during water delivery	1 ppm (minimum 2 ppm in some jurisdictions)	N/A	0.5 to 2 ppm	---	0.2 ppm
Chlorine residual testing	-Advised at time of filling tank from water source -Water should not be stored in tanks > 3 days without checking chlorine residual	Advised	Advised	**---**	Advised
Bacteriological testing of hauled water	Advised	-Coliform testing advised before use of tank -Coliforms must be absent	Before: -filling tanker and -discharging water from tanker	Testing for *E. coli* and heterotrophic organisms recommended 4 times/year	**---**
Optional testing	---	Testing for other chemicals in water depending on tank material (e.g. VOCs)	**---**	**---**	**---**
Record keeping of	-Date, time, location of each occasion where tanker filled and water delivered -Chlorine residual of water at time of filling -Volume of water delivered to each location -Water sample results -Problems encountered with source water, hauling vehicle and equipment -Comments on condition of tank (e.g. rust)	**---**	Results of chlorine residual and bacteriological tests	-Date & location of each water fill and delivery -Date of any emergency disinfection work -Problems encountered with water supply or hauling equipment -Routine equipment maintenance work -Water test results	All deliveries of water for 90 days from date of last delivery

8 Synthesis of Findings

Key mitigation measures to prevent contaminated hauled water include:

1) Ensuring the use of an approved water source

- All procedures/standards advised obtaining a water source such as a public water system approved by the relevant drinking water legislation[2-5,10].

2) Ensuring the design of the hauling tank and associated equipment (hoses, piping, pumps, lubricants, etc.) is non-toxic, easy-to-clean, and protective from contamination.

- Nearly every procedure/standard recommended or required the use of tanks and equipment that are approved by National Sanitation Foundation/American National Standards Institute (NSF/ANSI) Standard 61 [11] or are food grade or equivalent such as stainless steel[2,4,5,10].

- Procedures/standards also recommended or required that tanks and associated equipment likely to come in contact with potable water (e.g. hoses, joints) be watertight, non-corrodible, and/or non-absorbent[2,4,5]. They should also be easily cleanable (i.e. tanks designed to allow for complete draining; easily accessible for cleaning via access ports/hatches)[2,4,5,10]. Tanks/hoses should also be labeled for "potable water only"[2,4,5].

3) Ensuring proper cleaning and disinfection of tanks/equipment

- The use of potable water and chlorine for cleaning and disinfecting water hauling tanks and equipment was recommended by all procedures/standards[2-5,10].

- Most procedures/standards recommended that tanks/equipment be cleaned and removed of dirt/debris prior to disinfection[2,3,5].

- Most procedures/standards recommended that disinfection of the tank/equipment should be done using a chlorine concentration with the appropriate contact time[2-5]. The higher the concentration of chlorine, the lower the contact time (e.g. 50 ppm chlorine for at least 30 minutes; 100 ppm chlorine for at least 20 minutes). A couple of procedures/standards recommended emergency disinfection or shock chlorination in the event of contamination, which involved either a greater chlorine concentration or a greater contact time for disinfection[2,5].

- Most procedures/standards indicated that tanks/equipment should be cleaned and disinfected routinely[2,5,10]. Some specifically indicated that they should be done before use and following maintenance/repair[2,10], and particularly after contamination/suspected contamination[2,5,10].

4) Ensuring tanks/equipment are protected from cross-contamination

- Most procedures/standards advised cleaning and disinfecting tanks and hoses prior to use or shock chlorinated in the event of known/suspected contamination[2,4,5], ensuring all openings (of tanks/hoses) are securely closed when not in use[2,4,5,10], and ensuring tanks/equipment are protected from contamination (e.g. hoses are not

stored on the ground)[2,4,5,10]. Most also required or recommended that tank/equipment are dedicated for potable water hauling use only[2,5,10].

- A couple of procedures/standards recommended that tanks have a means of backflow prevention[2,4], which would be relevant in a situation where tanks are directly connected to a building water distribution system.

5) Maintaining a free chlorine residual in the hauled water

- Free chlorine residuals recommended by procedures/standards to be maintained in the hauled water during delivery to the consumer ranged from 0.2 to 2 ppm[2,4,10].

6) Conducting water tests and record keeping

- Testing the chlorine residual[2-4,10] and the bacteriological quality[2-5] of the water were recommended by most procedures/standards.

- A couple of procedures/standards recommended regular inspections of tanks/equipment to ensure they are in good repair and sanitary condition[2,5].

- Most also recommended that some form of documentation be kept on water hauling activity and maintenance[2,4,5,10].

9 Limitations and Gaps

- Lack of peer-reviewed research on mitigation measures to prevent contamination of hauled water. Procedures/standards included in this review are primarily based on expert consensus and stakeholder consultation.

- This review was limited to the process of hauling water. Maintenance and storage of hauled water in receiving water tanks or cisterns is also important to protect water from contamination.

10 Relevance to Practice

- Revisions to the policies and procedures for inspecting water hauler vehicles are being considered. Tools for conducting inspections such as the inspection checklist may be revised.
- Educational tools and resources for water haulers may be developed.

References

[1] Ontario Ministry of Health and Long-Term Care. (2008). Drinking Water Haulage Guidance Document. Toronto, ON: Queen's Printer for Ontario.

[2] Canadian Standards Association (CSA) Group. (2013). B126 Series-13 Water Cisterns. Mississauga, ON, Canada. http://media.iccsafe.org/standards/2014/B126_Series_13_ICC.pdf. Accessed June 1, 2015.

[3] American Water Works Association (AWWA). (2011). C652-11 Disinfection of water storage facilities. Denver, CO, USA.

[4] Centers for Disease and Control (CDC) and AWWA. (2012). Emergency water supply planning guide for hospitals and health care facilities. Atlanta, GA, USA. http://www.cdc.gov/healthywater/pdf/emergency/emergency-water-supply-planning-guide.pdf. Accessed June 1, 2015.

[5] Manitoba Health Protection. (2013). Bulk water hauling guidelines. http://www.gov.mb.ca/health/publichealth/environmentalhealth/protection/docs/bulkwater.pdf. Accessed: June 1, 2015.

[6] Water, Engineering and Development Centre (WEDC) and World Health Organization (WHO). (2013). Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies: Delivering safe water by tanker.

[7] WEDC and WHO. (2013). Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies: Cleaning and disinfecting water storage tanks and tankers.

[8] Fraser Health Authority. (2010). Guideline for bulk water hauling. http://www.mapleridge.ca/DocumentCenter/View/1042. Accessed: June 1, 2015.

[9] Navajo Nation Environmental Protection Agency, Public Water Systems Supervision Program. (2010). Guidelines for hauling and transporting regulated water for human consumption. http://www.navajopublicwater.org/Guidelines_Hauling-TransportingRegulatedWater_HumanConsumption_WordDoc.pdf. Accessed: June 1, 2015.

[10] Ohio Department of Health, Bureau of Environmental Health. (2011). Chapter 3701-28-16 Registration of water haulers, hauled water trucks, inspections, Private Water Systems Rules, Ohio Administrative Code.

[11] NSF/ANSI Standard 61. (2011). Drinking Water System Components- Health Effects.

[12] NSF/ANSI Standard 60. (2013). Drinking Water Treatment Chemicals- Health Effects.

Appendices

Appendix A: Search Strategy

Appendix B: Literature Search Flowchart

Appendix C: Critical Appraisal of Environmental Health Procedures

Appendix D: Data Extraction Tables

Appendix A: Search Strategy

Medline Search Strategy

Database: EBM Reviews - Cochrane Database of Systematic Reviews <2005 to March 2015>, Global Health <1973 to 2015 Week 18>, Ovid Healthstar <1966 to March 2015>, Ovid MEDLINE(R) <1946 to May Week 1 2015>, Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations <May 07, 2015>

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1 hauled water.ti,ab. (1)
2 bulk water.ti,ab. (2987)
3 potable water.ti,ab. (3856)
4 truck*.ti,ab. (6012)
5 water.ti. (214958)
6 carter*.ti,ab. (2697)
7 haul*.ti,ab. (1927)
8 deliver* water.ti,ab. (158)
9 4 or 6 or 7 (10390)
10 5 and 9 (96)
11 1 or 2 or 3 or 8 or 10 (7081)
12 contamin*.ti,ab. (317573)
13 virus*.ti,ab. (926840)
14 microbe*.ti,ab. (44969)
15 bacteria.ti,ab. (427877)
16 exp water microbiology/ (50613)
17 exp water pollutants,chemical/ (97309)
18 12 or 13 or 14 or 15 or 16 or 17 (1736913)
19 11 and 18 (2267)
20 limit 19 to english language [Limit not valid in CDSR; records were retained] (2131)
21 limit 20 to yr="2000 -Current" (1573)
22 remove duplicates from 21 (890)
23 water*.ti. (242494)
24 22 and 23 (526)
25 review*.ti,ab. (2656657)
26 meta-analy*.ti,ab. (157453)
27 guideline*.ti,ab. (422685)
28 standard*.ti,ab. (1592043)
29 best practi*.ti,ab. (25267)
30 25 or 26 or 27 or 28 or 29 (4419340)
31 24 and 30 (164)
32 remove duplicates from 31 (164)
33 canad*.in. (769751)
34 united state*.in. (173765)

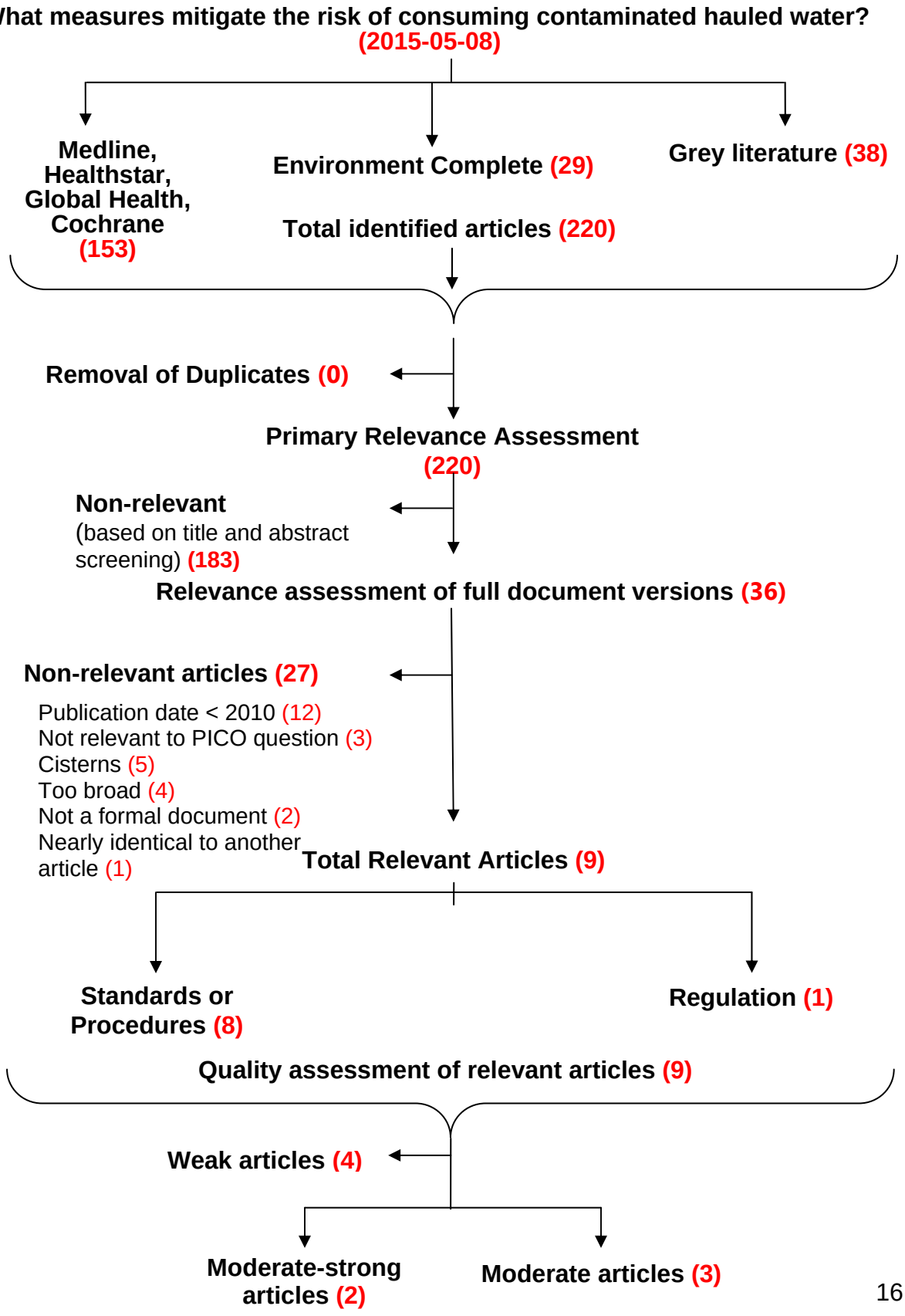
35 USA.in. (5958019)
36 33 or 34 or 35 (6879213)
37 32 and 36 (35)
38 limit 32 to yr="2000 -Current" (164)
39 dental.ti. (180084)
40 38 not 39 (153)

Note: A search of the other databases (i.e. Environment Complete, Global Health, HealthSTAR) was also conducted by adapting the Medline search terms.

Grey Literature Databases/Websites

Google Scholar, Trip database, American Water Works Association, Walkerton Clean Water Centre, Water Research Foundation, the United States Environmental Protection Agency (US EPA), Centers for Disease Control (CDC), World Health Organization (WHO), National Collaborating Centre for Environmental Health (NCCEH), Canadian Institute for Public Health Inspectors (CIPHI), National Association of County and City Health Officials (NACCHO), and provincial/federal health authorities (including Alberta Health Services, Manitoba Health, and Ontario Ministry of Health and Long-Term Care (MOHLTC), Public Health Ontario (PHO), Health Canada, and Public Health Agency of Canada (PHAC))

Appendix B: Literature Search Flowchart



Appendix C: Critical Appraisal of Environmental Health Procedures (Protocols)

(adapted from Critical Appraisal of Textbooks, Textbook Chapters Appraisal Worksheet*)

Source:
Date of appraisal:
Completed by:

Criteria	Questions	Yes/Somewhat/No/Can't tell	Notes
1. Initial Appraisal			
a) Author/Publisher	i) Is the author/publisher reputable?		
	ii) Does the author have expertise in this field?*		
b) Date of Publication	When was it published? (current or out-of-date)		
c) Target audience	Was the target audience defined?		
2. Content Development			
a) Scope/purpose	i) Was the public health issue/problem or the rationale/purpose of the procedure defined?		
	ii) Was the scope of the procedure defined?		
b) Process* (Was the procedure evidence-informed?)	i) Was the procedure informed by research evidence? • Are there references or any supporting documents (describing any research or the development process)?		
	a. Is the most current evidence being considered in the development of the procedure?		
	b. Was the review of the literature systematic?		
	c. Has the quality of evidence been considered?		
	ii) Were relevant stakeholders consulted in the development of the procedure?		
	a. Were relevant groups of expertise consulted?		

	b. Were target users consulted?		
	iii) Was the procedure development process formal/systematic?		
	iv) Was conflict of interest evident in the development of the procedure (e.g. development committee members)?		
c) Comprehensiveness	Was the procedure comprehensive enough to meet the needs of the target audience within the intended scope (see item #2aii)? • Are there any gaps in the procedure/protocol?		
d) Revision/update process	i) Was there a schedule for review/update of the procedure?		
	ii) Was there a process for updating/reviewing the procedure?		
3. Presentation			
a) Was the procedure organized logically and easy to navigate?			
b) Were the main points clearly presented, specific, and contain an appropriate amount of detail (e.g. technical terms are defined)?*			
c) Were there any tools/practical examples provided to assist with implementation?			
4. OVERALL RATING			
How would you rate the quality of this procedure and why? (S=Strong; M=Moderate; W=Weak) *Items weighted more heavily in determining overall rating			
5. Context/Applicability	Does the content of this procedure meet the needs of our research question in Peel? • Does this procedure fit in with Ontario's legislation and standards?		
Would you recommend this procedure for use?			

* Critical Appraisal of Textbooks, Textbook Chapters Appraisal Worksheet. http://www.peelregion.ca/health/library/pdf/critical-appraisal-worksheet.pdf

Appendix D: Data Extraction Tables

Items reviewed	Guideline #1 of 5: Water cisterns B126 Series-13
Author(s), Date	Canadian Standards Association (CSA), 2013
Quality rating	Moderate to strong quality using textbook critical appraisal tool adapted by two independent appraisers (**Appendix C**)
Focus & Objectives	***Overall*** To provide a set of standards for cisterns (container that holds water in storage for potable and non-potable use) consisting of the following: o B126.0, General requirements and methods of testing for water cisterns o B126.1, Installation of water cisterns o B126.2, Commissioning and field inspection of water cisterns o B126.3, Operation and maintenance of water cisterns o B126.4, Decommissioning of water cisterns o B126.5, Mobile water cisterns **Relevant standards:** ▪ Mainly B126.5, Mobile water cisterns (a tank, drum or other bulk container with which water obtained, transported, and delivered) ▪ B126.0, General requirements and methods of testing for water cisterns ▪ B126.3, Operation and maintenance of water cisterns. ***Area of focus*** (for the purposes of this briefing note): • Specify requirements for mobile water cisterns used to transport potable water to onsite cisterns, and provide direct access to water at events and other locations Note: Potable water is defined as water satisfactory for drinking and for culinary and domestic purposes and meets requirements of appropriate authority having jurisdiction.
Target audience	Remote households that do not have access to municipal water or well facilities.
Standards	<u>1. Construction of mobile water cisterns/tanks and equipment</u> ***Design of cisterns/tanks*** • Cisterns should be designed to minimize surge under normal transport conditions • Lubricants (that may come in contact with water) should be NSF/ANSI 61 certified[1] • Inlets and outlets should be o positioned to protect from contamination (e.g. waste discharge, road dust, oil, grease) o sloped to drain to allow complete drainage of tank o equipped with threaded or clamped caps tethered to ports with chain/cable. Securely capped at all times except when filling/draining tank. • Tanks should be designed with access ports and hatches opening from the top of the tank for inspection and cleaning. They should be: o closable with watertight and weatherproof overlapping covers and permanently mounted food grade gaskets

	o securely sealed with screw or clamp fasteners to prevent entry of vermin, foreign materials and substances o provided with security locks to prevent unauthorized intrusions o elevated off tank shell at least 13 mm to prevent surface wash from entering tank • Fitting with V-type threads on water tank inlet or outlet should only be allowed when a hose permanently coupled • If provided, water tank vent should terminate in downward direction and covered with: o a 16 gauge mesh screen or equivalent when vent in protected area, or o a protective filter when vent in area not protected from windblown dirt and debris • Unless covered with a jacket made of aluminium, stainless steel or other bright non-tarnishing metal, every uninsulated tank permanently attached to transportation vehicle should be painted white, aluminum colour or similar reflecting colour on upper 2/3 of surface area of tank ***Structural integrity*** • Tank should be supported by o external cradles where it functions, in whole or in part, as stress member replacing frame of vehicle, and o external cradles or longitudinal members where cistern mounted on frame of vehicle. Cradles should extend to at least 120 degrees of tank shell circumference. • Longitudinal deceleration protection for tanks should be achieved according to following: a) tank shells and heads should be designed to withstand combined loads of design pressure and dynamic pressure from longitudinal deceleration of 2 g b) allowable stress value used in item a) should not exceed ultimate strength of material of construction using safety factor of 1.3 c) performance testing, analytical methods, or combination of two may be used to satisfy requirements in item a) as long as methods accurate and verifiable d) longitudinal decelerative force in item a) may be reduced by 0.25 g for each baffle assembly in tank but to no less than 1.0 g. • Tanks should be constructed and maintained so that body, chassis, or other parts of transporting vehicle afford rear-end protection provided by bumper • Securing of tank to vehicle chassis (for vehicle with frame) or to vehicle suspension and coupler components (where tank forms all or an integral part of vehicle frame) should be designed to withstand static loading, in any direction, equal to twice weight of tank when filled with load and all tank-mounted accessories, using design factor of at least 4, based on specified minimum tensile strength of material used • Tank that is not integral part of vehicle chassis should be secured by components that draw tank down tight to frame. Anchors, stops or other components should restrict relative motion between tank and vehicle chassis, except as required to absorb normal chassis flex when vehicle is in operation. Such components should be readily accessible for inspection and maintenance, except that insulation and jacketing may cover them. ***Labelling*** • Tanks should have at least one data plate with the following information: o manufacturer's name o intended use (i.e. "Suitable for potable water" or "Not suitable for potable water") o working capacity o tank construction material o serial number or date of manufacture, expressed in yyyy/mm/dd format. Where a serial number is used, manufacturer needs to maintain records for 10 years to indicate date of manufacture

- CSA Standard designation (i.e. CSA B126.0)
- intended installation (e.g. above-ground or below-ground) as applicable

- Tanks and any removable equipment should be clearly labelled “drinking water” or “potable water” with letters of at least 15 cm high, and easily readable.

Other design requirements

- All components of a mobile water cistern should also comply with applicable items within these standards:
  - CGSB 43.146-2002 UN Intermediate Bulk Containers[2]
  - CSA B126.0 General requirements and methods of testing cisterns

CSA B126.0 General requirements and methods of testing cisterns:

- Materials and components of cisterns in contact with potable water should comply with requirements of NSF/ANSI Standard 61[1].
- Cisterns should have the following openings:
  - at least one access opening for maintenance with
    - minimum dimension of 600 mm, when human access required or
    - minimum dimension of 300 mm when human access not required
  - a vent opening to allow air to enter/escape during filling and emptying. Vent openings should have a flow capacity $\geq$ the flow capacity of the largest of the filling openings, plumbing connections, or drainage outlets
  - an opening for filling
  - an opening to receive a plumbing connection
  - an opening to receive a water level indicator
  - an opening for fill alarm systems
  - for above-ground cisterns:
    - an opening for draining located at the lowest point and
    - an overflow opening
- All cisterns should be capable of being effectively emptied
- Cisterns should have a means to prevent overfilling (e.g., overflow openings, alarm systems, mechanical overflow signals, or overfill valves). Overfill openings, when used, should have a flow capacity equivalent to flow capacity of largest filling opening.
- Inlet and outlet connectors should provide for a watertight connection and protect the connection from shearing forces (i.e. impact during backfilling, ground settling, frost heaving) when installed in accordance with the manufacturer’s installation instructions
- Inlet and outlet connectors should not require installation methods involving impact or mechanical removal of cistern wall material other than:
  - full coring of a steel, fibre-reinforced plastic, polyethylene, or polyvinyl chloride cistern wall
  - full coring of a concrete cistern wall or
  - impact removal of up to 50% of a concrete cistern wall thickness (e.g. knockouts)
- Inlet and outlet connectors installed by any of the methods specified should be placed within a zone designated by the manufacturer
- Interior of cisterns should be:
  - smooth to allow for complete cleaning
  - free of areas where water can stagnate

- completely drained prior to cleaning where there are corrugations in interior of cisterns

- Potable water cisterns should be watertight and disinfected before use, and have filling ports that do not allow hoses to be introduced into cistern or its access openings (e.g. cam locks, screening, and/or cross bars)
- Materials and components of cisterns (e.g., fittings, pipes, fasteners, coatings, liners, and partitions) should be durable and capable of withstanding:
  - exposure to environmental conditions in which they are intended to be used (e.g., representative climatic conditions of the intended installation location)
  - stresses and wear during shipping, installation, and operation (e.g. vibration, mechanical impact)
- Materials other than those specified (steel, stainless steel, concrete, fibre-reinforced plastic, polyethylene) may be used provided that the cistern complies with all of the requirements of this Standard
- Joints shall be as durable and watertight as cistern
- Surfaces shall be smooth and free from rough or sharp edges that can interfere with the installation, maintenance, safety, or operation of the cistern.
- Stainless steel cisterns intended for potable water applications should be made of type 316 stainless steel
- Concrete cisterns should comply with Clause 6 of CSA B66[3]
- Hand- aid or contact moulding fibre-reinforced plastic cisterns should comply with Clause 7 of CSA B66[3] or with AWWA D120[4] Type 1
- Filament winding fibre-reinforced plastic cisterns should comply with AWWA D120[4] Type 2.
- Compression moulding fibre-reinforced plastic cisterns should comply with AWWA D121[5]
- Polyethylene cisterns should
  - comply with applicable requirements of Clause 8 of CSA B66[3], including the requirements for ultraviolet radiation protection, and
  - be manufactured from virgin material only and shall comply NSF/ANSI 61[1]
- Volumes, capacities, rates, and dimensions should be determined by one or more of the following methods:
  - mathematically
  - actual measurement of the volume of water
  - weighing before and after filling
- Cisterns should be tested for watertightness to prevent leakage and ingress of contaminants
- Steel cisterns should be pressure tested in accordance with the standard to which the cistern has been manufactured
- Cisterns made of concrete, fibre-reinforced plastic, polyethylene, polyvinylchloride or other suitable polymer should be filled to working capacity for 24 hours and not leak or permanently deform
- Cisterns should not allow light penetration in excess of 0.15 lumens/cm^2 or 1500 lux
- The manufacturer should provide instructions for transportation, handling, storage, installation, operation, maintenance, proper inspection and cleaning of the cistern

Design of transfer hoses and accessories

- Hoses should be:
  - safe and durable,
  - non-absorbent,
  - resistant to corrosion, pitting, chipping, scratching, scoring, distortion or decomposition,
  - smooth (in interior surface), and
  - NSF/ANSI 61 certified[1]

- Hoses and pumps must be dedicated for potable water use only (those used for liquid foods may be acceptable provided they are cleaned and sanitized prior to use)
- Where transfer is effected using compressed air, air supply line should be equipped with filters so oil/oil vapours should not enter air supply between compressor and water tank when compressed air used to charge/empty water tank
- A cap and keeper chain closed cabinet, closed storage tube, or other approved protective cover/device should be provided for water inlet, outlet, hoses
- Each filling and discharge line should be provided with manual shut-off valve located as close to tank as practicable. When automatically closing internal shut-off valve used, a manual shut-off valve should be located in line ahead of hose connection

2. Cleaning & Disinfection

Frequency

- Water tanks, pumps and hoses should be sanitized
    - before use after construction, repair, modification, or periods of non-use,
    - following use to transport food grade products, or
    - prior to transporting potable water
- Potable water hauling tanks and hoses should be sanitized depending on frequency of use
- If tanks and hoses used regularly and continuously to transport chlorinated water with residual > 1 ppm, they should be disinfected at frequency as required by jurisdiction having authority

Scrubbing and disinfection

- Water hauling equipment should be scrubbed using 200 ppm chlorine to remove rust and sediment
- After scrubbing and rinsing, disinfect using 50 ppm chlorine for minimum contact time of 30 minutes.
- Dispose of heavily chlorinated waters using proper personal protective equipment to local sanitary sewer or environment (with written permission from local sewer department, or de-chlorinate water using neutralizer such as sulphur dioxide, sodium bisulphate, sodium sulphate or citric acid until free chlorine residual of < 1 ppm)

Tanks also used for food-grade materials

- Tanks, hoses, pumps, other equipment previously used for hauling food grade materials should be:
    - scrubbed, flushed with warm water and emulsifying detergent (with minimum temperature of 60 degrees C)
    - Change location of nozzle to continuously keep interior wet
    - Rinsed thoroughly with warm water
    - Disinfected using 50 ppm chlorine with minimum contact time of 30 minutes
    - Drain and rinse chlorinated water into sanitary sewer
- Check with manufacturer if using aluminum tanks and tanks with plastic or other organic coating which may be affected by heat/alkaline materials, and follow their recommendations.

Shock chlorination

- Tank should be shock chlorinated:
    - before commissioning

	o on a frequency to sustain water quality. Annually or in consultation with local jurisdiction. o when water supply sources change o whenever contamination has occurred or suspected to have occurred (e.g. contaminated water filling or after undergoing maintenance or repairs) • Shock chlorination method: o wash cistern with pressure washer or a stiff brush to clean debris and sediment from all surfaces o pump out the sludge. A wet-dry vacuum may be used o refill the cistern with potable water to the normal operating level or slightly higher o add chlorine and blend it to mix with the stored water to obtain a free chlorine concentration of 50 ppm o leave the mixed chlorinated water in the cistern for contact time of at least 6 hours o measure free chlorine residual concentration of the shock-chlorinated water. Use chlorine test kit to measure free chlorine residual. If < 10 ppm, repeat chlorination o dispose the shock-chlorinated water in a safe manner and in accordance with environmental regulations o flush and refill the cistern with potable water o test the free chlorine in the water to verify proper flushing • Sealants and materials used in this procedure shall be compatible with the chlorine dosage (50 ppm chlorine) • Water obtained from shock chlorination should not be o used as potable water o discarded into an onsite wastewater treatment system o discharged into communal wastewater treatment system without the consent of the operator, but should be disposed of in accordance with local requirements <u>3. Transportation of water</u> • All water tanks should be visually inspected, scrubbed, flushed, and disinfected before hauling water • Free chlorine residual of 1 ppm before transporting (some jurisdictions require at least 2 ppm) • Tanks designed to be top-filled should be filled through air gap which should be maintained at all times to prevent backflow. Once tank filled, hatch should be closed and tightly sealed. • Tanks designed to be bottom-filled should be equipped with check valve on intake line designed to prevent backflow from water tank into water source. • All hoses should be stored off the ground at all times. Hoses should be capped at both ends when not used. Ends of hoses should be provided with threaded or clamped caps. • Water should not be stored in tanks for > 3 days without verifying chlorine residual. • When tank not in use, all hatches should be locked, inlet and outlet pipes securely capped, and hoses capped and stored off the ground in secure location. • If sanitary condition of tank, hoses and equipment compromised, they should be shock chlorinated • Water tanks, hoses and equipment should be routinely disinfected if not used for 4 weeks or more. • At water delivery point, hose ends should be disinfected before filling cistern with water <u>4. Inspection, sampling and testing</u> • Tanks and equipment must be visually inspected to ensure integrity

	• Owner/operator of tank should collect water samples for microbial quality <u>5. Record keeping</u> Owner/operator of tank should maintain logbook that records: • Date, time, location of each occasion where tanker filled • Chlorine residual of water at time of filling from water source • Date, time and location of each water delivery • Volume of water delivered to each location • Date and time when equipment cleaned and sanitized • Water sample results • Comments about problems encountered with source water supply, water haulage vehicle and any equipment used in operation • Comments on condition of tank including presence of rust
Implementation tools	Details on cleaning/disinfection of cistern (Annex 5- Potable water monitoring, disinfection, long-term storage, and corrective actions)
Gaps/limitations	Extent of research evidence contributing to formation of standards unknown since based on expert consensus. No formal systematic review of the literature.

[1] NSF International. (2011). National Sanitation Foundation/American National Standards Institute (NSF/ANSI) Standard 61-2011 Drinking water system components- health effects.

- Sets health effects criteria for water system components including protective barrier materials, joining and sealing materials, mechanical devices, pipes, plumbing devices, process media, and non-metallic potable water materials.

[2] Canadian General Standards Board (CGSB). (2002). CGSB 43.146-2002 UN Intermediate Bulk Containers.

- Specifies requirements for design and manufacture of UN standardized intermediate bulk containers with capacity $\leq$ 3000 L and their selection and use for transport of dangerous goods included in Class 3, 4, 5, 6.1, 8 or 9.

[3] CSA Group. (2010). CSA B66-10 Design, material, and manufacturing requirements for prefabricated septic tanks and sewage holding tanks.

[4] American Water Works Association (AWWA). (2009). AWWA D120-09 Thermosetting fibreglass-reinforced plastic tanks.

[5] AWWA. (2012). D121-12 Bolted FRP panel-type tanks for water storage.

Items reviewed	Guideline #2 of 5: Emergency water supply planning guide for hospitals and health care facilities
Author(s), Date	Centers for Disease and Control (CDC) & American Water and Wastewater Association (AWWA), 2012
Quality rating	Moderate quality using textbook critical appraisal tool adapted by two independent appraisers (**Appendix C**)
Focus & Objectives	To help health care facilities develop a robust Emergency Water Supply Plan as part of its overall facility Emergency Operations Plan and to meet the standards of the Joint Commission and the Center for Medicare and Medicaid Services **Relevant section**: Section 7.4- Evaluating alternatives for emergency water supplies: Tanker-transported water (procedures related to potable water)
Target audience	Any health care facility
Guideline recommendations	***Water source*** • Use a safe and approved water source (typically a nearby public water supply approved by state drinking water authority) • Identify where tanker can draw water from supply (e.g. storage tank connection) • Provide temporary storage for tanker-transported water • If tanker water to be connected to building plumbing, isolate potable water systems from any non-potable systems (e.g. used for toilet flushing, cooling towers). Ensure tanker trucks being used to transport non-potable water, and receiving tanks/bladders are clearly labeled "DO NOT DRINK/NON-POTABLE WATER ONLY". ***Construction of tanker, hoses and other handling equipment*** • Tanks should be made of food grade certified (meet NSF/ANSI Standard 61[1]) material that can be easily cleaned and disinfected, contaminant-free, and watertight. • Tanks previously used to transport materials such as chemicals cannot be used for hauling potable water • Tanker truck must be labeled "DRINKING WATER ONLY" • All hoses and other handling equipment used in the operation should meet NSF/ANSI Standard 61[1] ***Proper cleaning and disinfection of tanker truck*** • The tank, hoses, pumps, and other equipment, must be cleaned and sanitized using a sanitizer meeting NSF/ANSI Standard 60[2]. • The inside surfaces of the tanks and other equipment should be exposed to a minimum chlorine dose of 50 ppm for at least 30 minutes. The state drinking water agency should be consulted to determine the amount of time that the equipment must be exposed to the chlorine solution. As an alternative, AWWA Standard for disinfecting water storage facilities[3] may be used. • After contact time, the chlorine solution must be drained. Check with local wastewater utility to determine appropriate method for disposal of solution. • Tank should be flushed with safe source of water and drained. ***Practices related to conveyance of water*** • All hoses and other equipment should be stored off ground at all times, and be thoroughly flushed and disinfected before use. Hoses should be capped at each end or connected together when not in use • Tankers need to be filled or emptied using sanitary methods. Preferably, this will include valve-to-valve connections or air gaps. • Connections and fittings for filling/emptying tank must be properly protected to prevent any extrinsic contamination. • Any hoses or piping must be maintained in a sanitary condition.

	• A drain and vent must be provided that will allow for complete emptying of tank for cleaning or repairs. • Tanks should be completely enclosed and covers should be sealed or locked to protect water from tampering. • Water stored in tanker truck should be maintained at a free chlorine residual between 0.5 and 2.0 ppm. Levels above 2 ppm can create taste issues. Warm weather conditions can cause chlorine to dissipate from the tanks so more frequent monitoring of chlorine levels may be necessary. *If tanker is conveying water to building plumbing:* • Building plumbing must be isolated from the primary water supply. Note that some health care facilities have more than one service connection to main water distribution system. The emergency plan should include a diagram or written description of shut-off or isolation valve locations and what special tools, if any, may be required. This procedure should be coordinated with the water utility staff, plumbing officials, health department, and appropriate regulatory agencies. • A pump for potable water, a pressure bladder tank, a pressure switch, pipes, and fittings are needed to connect tanker to building plumbing. Fittings, pipes, and associated plumbing should meet local and state plumbing codes. If installation is not regulated by a plumbing code, ensure NSF/ANSI Standard 61[1] is met. • Pumps must not exert pressure greater than the pressure rating of the piping or pressure bladder, whichever is lower. Pump operation needs to be controlled to prevent surge or water hammer from rupturing piping and attached equipment. • Tanker will need to park close to the building where connective piping can enter system without crossing traffic areas. Knowing connection locations will allow for placement of truck and will help with estimating amount of pipe needed to make a connection. • Facilities should evaluate the need for special pipe fittings including any required for backflow prevention that may be necessary to connect to the building, to fire hydrants, or to other pipes within the water distribution system. Consideration should be given to obtaining and storing hard-to-find fittings and other necessary hardware. ***Inspection, water sampling, chlorine testing*** • Water source should be tested for microbiologic indicators and chlorine residual before filling the tanker and before discharging water from tanker into health care facility. • More frequent monitoring of chlorine levels may be necessary during warm weather since chlorine may dissipate. ***Recordkeeping*** • It is recommended that all testing be documented.
Implementation tools	Case studies, example emergency plan, loss-of-water scenario, water use audit forms found in appendices. However, none are specific to tanker-transported water.
Gaps/limitations	• Different, but applicable context. • Information on water quality and chlorine residual testing and recordkeeping are lacking in detail.

[1] NSF International. (2011). NSF/ANSI Standard 61-2011 Drinking water system components- health effects.
[2] NSF International. (2009). NSF/ANSI Standard 60-2009 Drinking water treatment chemicals- health effects.
[3] American Water Works Association (AWWA). (2002). AWWA C652-2002 Disinfection of water-storage facilities.

Items reviewed	Guideline #3 of 5: Standard C652-11 Disinfection of water storage facilities
Author(s), Date	American Water Works Association(AWWA), 2011
Quality rating	Moderate to strong quality using textbook critical appraisal tool adapted by two independent appraisers (**Appendix C**)
Focus & Objectives	• To define the minimum requirements for disinfection of water storage facilities (tanks) including preparation of facilities, application of chlorine, disinfecting underwater inspection and cleaning equipment, and sampling and testing for presence of coliform bacteria, chlorine residual, and acceptable aesthetic water quality. • Focus will be on disinfection of water storage facilities for potable water (safe and satisfactory for drinking and cooking).
Target audience	Manufacturers (water industry), consumer and general public
Standards	***Materials and cleaning*** • Materials should comply with requirements of the Safe Drinking Water Act[1] and other federal regulations for potable water, wastewater, and reclaimed water systems as applicable • Scaffolding, planks, tools, rags, and other materials not part of structural or operating facilities of the tank should be removed. Surfaces of walls, floor, and operating facilities of storage facility should be cleaned thoroughly using high-pressure water jet, sweeping, scrubbing, or equally effective means. Any accumulated water, dirt, and foreign material should be removed. Water used for cleaning, preparation of solutions, and tank filling should be potable. • Following cleaning, vent screen, overflow screen and any other screened openings should be checked and put in satisfactory condition to prevent birds, insects, and other possible contaminants from entering the facility. Any material required to be in operating storage facility after cleaning should be clean and sanitary when placed in facility. Minimize the introduction of dirt/foreign material. ***Forms of chlorine for disinfection*** • Forms of chlorine that may be used in disinfection are: o Liquid chlorine conforming to ANSI/AWWA B301 standard[2] (100% available chlorine). Only used: ▪ in combination with appropriate gas-flow chlorinators and ejectors to provide controlled high-concentration solution feed to water to be chlorinated ▪ under direct supervision of person who is familiar with chlorine's physiological, chemical and physical properties, and trained and equipped to handle any emergency ▪ with appropriate safety practices to protect workers and public o Sodium hypochlorite conforming to ANSI/AWWA B300[3] (about 5-15% available chlorine by volume). Care must be taken to control storage conditions and length of storage to minimize deterioration. o Calcium hypochlorite conforming to ANSI/AWWA B300[3] (about 65% available chlorine by weight) stored in cool, dry, dark environment to minimize deterioration. • Note that disinfectants other than chlorine may be appropriate to use subject to approval from local regulatory agency. ***Methods of chlorination*** 1) Chlorination of full storage facility such that, at end of appropriate retention period (contact time), water will have free chlorine residual of not < 10 ppm. Method differs by form of chlorine used: o Liquid chlorine: ▪ introduced into water to give uniform chlorine concentration (i.e. portable chlorination equipment including liquid-chlorine cylinder, gas-flow chlorinator, chlorine ejector, safety equipment and solution tube inserted through valve on inlet pipe) ▪ Retention period: no < 6 hours

	o Sodium hypochlorite: ▪ added to water via: • chemical-feed pump (using solution tube to inject uniformly) , or • applied manually by pouring into storage facility (through the cleanout or inspection manhole in lower level of facility, in riser pipe of elevated tank or through roof manhole). Sodium hypochlorite should be poured in water when water no > 3 ft in depth nor < 1 ft in depth or as close to manhole locations permit ▪ Water filling of storage facility should begin immediately thereafter or as soon as any removed manhole covers closed ▪ Retention period: no < 6 hours if chemical pump used; no < 24 hours if manual fed o Calcium hypochlorite granules/tablets: ▪ crushed to sizes no > ¼ inch maximum dimension poured into storage facility through cleanout or inspection manhole in lower level of facility, into riser pipe of elevated tank or through roof manhole ▪ placed in storage facility before water added, and located in facility such that they get dissolved during filling operation ▪ placed only on dry surfaces unless adequate precautions to provide ventilation or protective breathing equipment ▪ Retention period: no < 24 hours ▪ After retention period, free chlorine residual in storage facility should be reduced to concentration appropriate for distribution by completely draining storage facility and refilling with potable water, or by combination of additional holding time and blending with potable water having lower chlorine concentration. ▪ Disposal of chlorinated water: if likelihood of causing damage to environment, reducing agent should be applied to water to neutralize chlorine residual in water. Follow appropriate legislative authority for specific disposal instructions. 2) Spraying/painting storage facility water-contact surfaces with solution of 200 ppm available chlorine o Suitable brushes or spray equipment may be used o Apply chlorine solution directly to surfaces of storage facility that would be in contact with water when facility full to overflow elevation. Thoroughly coat surfaces including inlet and outlet piping, and any separate drain piping such that it will have available chlorine of no < 10 ppm when filled with water. Overflow piping need not be disinfected. o Retention period: at least 30 minutes contact time with strong chlorine solution, after which potable water added, drain piping purged of 10 ppm chlorinated water, and storage facility filled to overflow level. 3) Two-step process of chlorinating bottom portion of storage facility with 50 ppm available chlorine followed by filling to overflow and maintaining free chlorine residual of at least 2 ppm for 24 hours. o See 1) for method of adding chlorine o 5 % of total storage volume filled with 50 ppm chlorine o 1st Retention period: no < 6 hours o Fill storage facility with potable water to overflow level o 2nd Retention period: no < 24 hours o Resulting free chlorine residual should be no < 2 ppm. o Purge highly chlorinated water from drain piping • In selecting the appropriate chlorination method, the following considerations should be made: o the availability of materials and equipment for disinfection o training of personnel performing the disinfection o chlorinated water disposal options o safety

	Water quality sampling and testing
	• After chlorination, water from full facility should be sampled and tested for coliform bacteria and chlorine residual in accordance with latest edition of *Standard Methods for Examination of Water and Wastewater*[4]
	• Bacteriological testing should show no coliforms
	• If test for coliforms is:
	  o negative and chlorine residuals at acceptable distribution system levels→storage facility may be in service
	  o positive for coliforms→repeat samples should be taken until two consecutive samples are negative, or the storage facility should again be subjected to disinfection.
	• Samples should be taken from:
	  o tap on outlet piping from storage facility,
	  o tap connected directly to storage facility, or
	  o from top of tank/hatch such that sampling of water in storage facility.
	• Sample equipment and methods should follow aseptic techniques for bacteria sampling
	• Recommended additional sampling
	  o to collect samples of water flowing into storage facility to determine if coliforms present in potable water source, particularly if coliforms found in tank.
	• Optional sampling/testing
	  o following disinfection and prior to using tank, water in storage tank should be tested to confirm water quality using parameters such as pH, alkalinity, turbidity, odor, and specific conductance.
	  o If paint or epoxy applied to tank, testing for levels of VOCs or other components may be necessary. Number of samples will depend on size of storage facility (e.g. one sample for tanks ≤ 10 MG and additional sample for each additional 10 MG volume using another tap or hatch if available.

Implementation tools	Appendices on: • Chlorine residual testing using DPD drop dilution method • Chlorine dosages • Disposal of highly chlorinated water
Gaps/limitations	• These standards only cover the disinfection of water storage tanks • Extent of research evidence contributing to formation of standards unknown since based on expert consensus. No formal systematic review of the literature.

[1] U.S. Environmental Protection Agency. Safe Drinking Water Act.
[2] AWWA/ANSI B301-10 Liquid chlorine standard.
[3] AWWA/ANSI B300-80 Standard for hypochlorites.
[4] American Public Health Association, AWWA, and Water Environment Federation. Standard methods for examination of water and wastewater. Washington, D.C.

Items reviewed	Guideline #4 of 5: Bulk water hauling guidelines
Author(s), Date	Manitoba Health Protection, 2013
Quality rating	Moderate quality using textbook critical appraisal tool adapted by two independent appraisers (**Appendix C**)
Objectives	To outline guidelines/standards for owners of vehicles used to transport or distribute bulk water (potable water intended for human consumption) to prevent contamination of water that can pose a risk to public health
Target audience	Owners of vehicles used to transport or distribute bulk water (water haulers)
Guideline recommendations	***Water source*** • All bulk water must be obtained from an approved source such as a public water or semi-public water supply[1]. ***Vehicle/equipment design*** • Container used to transport potable water must meet NSF/ANSI Standard 61[1] or equivalent standards for food/water grade containers. For example, tank interior made of or coated with food grade, non-corrodible material (e.g. stainless steel, fibreglass, plastic, approved epoxy liner). • Hoses, nozzles, pump lubricants, and other equipment must also be constructed of food grade materials. • All equipment must be maintained in good repair and kept in sanitary condition. • Use of "pre-owned" equipment limited to components that have been used exclusively for potable water. • Water tanks and equipment must not be used for any other purpose other than hauling potable water unless approved by a public health inspector (PHI). • Bulk water tanks must clearly and permanently be labeled "POTABLE WATER ONLY" or similar wording approved by PHI in contrasting letters at least 15 cm tall. • Equipment design must allow for easy access for cleaning purposes. ***Operation/handling of equipment*** • Measures must be taken to protect water, storage tank and equipment from contamination during filling, storage, transportation and delivery (e.g. prevent dropping of hose ends and nozzles, prevent protective covers from falling off). • Hoses and nozzles used for water intake or discharge must be protected from contamination when not in use (i.e. threaded or clamped caps). ***Cleaning and disinfection*** • Tanks must be cleaned and sanitized at least 3 times per year (spring, summer, fall), and immediately after any contamination incident or failed bacteriological water analysis. • Routine cleaning and disinfection procedure for water tanks: o Draining water from tank o Wash and remove dirt from interior tank surfaces using high pressure hose o Remove wash water and sediments from bottom of tank. A vacuum may be used. o Rinse interior tank surfaces with potable water and remove the rinse water. o Disinfect interior tank surfaces and distribution lines by filling tank with potable water, and adding household bleach to create 100 ppm chlorine solution and mix well. o Run water from hose until chlorine smell detected. o Let chlorine sit in water tank and system for at least 20 minutes. o Completely drain chlorine solution from tank to municipal sewer/suitable location that will not adversely affect aquatic life. • Movable equipment (e.g. nozzles) should be cleaned and sanitized daily by using a 100 ppm bleach solution or equivalent.

	• In the event water truck equipment accidentally contaminated during water delivery, this procedure must be followed using personal protective equipment: o Remove visible dirt by running potable water from truck through hose, nozzle or other contaminated equipment o Fill a plastic container with potable water and thoroughly rinse all visible dirt from hose end, nozzle or other contaminated equipment o Discard water and thoroughly rinse plastic container with potable water o Fill plastic container with potable water from water truck to level that will completely immerse contaminated equipment. It is recommended to pre-mark the water level on container for future reference. o Add chlorine bleach to create 200 ppm solution. o Completely immerse equipment in solution and allow minimum 2 minutes of contact time. • A written procedure for emergency disinfection of equipment following a contamination incident must be kept in the truck. ***Inspection/Record keeping*** • Daily visual inspections must be conducted to ensure access/fill hatch seals are in good repair and providing a proper sanitary seal. • Operators of bulk water hauling vehicles must keep an activity log book in the vehicle, and make it available to a PHI or Drinking Water Officer upon request. Logbook records should include: o Date & location of each water fill and water delivery o Date of any emergency disinfection work o Any comments/observations regarding problems encountered with water supply or water hauling equipment o Routine equipment maintenance work o Bacteriological test results ***Bacteriological sampling*** • As a condition of their permit, operators of water hauling vehicles must ensure that water sampling of the bulk water vehicle (i.e. from fill hose or tank outlet) is conducted and submitted to an accredited lab for analysis of *E. coli* and heterotrophic plate count 4 times per year. • All lab results must be kept on file by operator at least 2 years and made available for review upon request of PHI. • All positive *E. coli* results (exceedances above Health Canada guideline limits; *E. coli* > 0[3]) must be reported immediately to a PHI and measures taken for disinfection of water tanks. ***Boil water advisories (BWA)*** • In the event of a BWA, bulk water haulers must follow the instructions on special operating measures provided by the PHI. • Failure to abide may result in temporary suspension of operating permit.
Implementation tools	Permit application form, specific procedures for disinfection, and activity log book provided in appendices.
Gaps/limitations	• No systematic literature review. • Stakeholder consultation may not be formal/systematic

[1] Under the Drinking Water Safety Act, C.C.S.M.c.D101, Province of Manitoba:
Public water system defined as having ≥ 15 service connections, and *semi-public water system* defined as being neither public nor private.
[2] NSF International. (2011). NSF/ANSI Standard 61-2011 Drinking water system components- health effects.
[3] Health Canada. (2010). Guidelines for Canadian Drinking Water Quality.

Items reviewed	Guideline #5 of 5: Chapter 3701-28-16 Registration of water haulers, hauled water trucks, inspections, Private Water Systems Rules, Ohio Administrative Code
Author(s), Date	Ohio Department of Health, Bureau of Environmental Health, 2011
Quality rating	Moderate quality using textbook critical appraisal tool adapted by two independent appraisers (**Appendix C**)
Scope of regulation (Chapter 3701-28-16, Registration of water haulers, hauled water trucks, inspections)	• Water hauler trucks delivering water to private water systems in Ohio are required to comply with requirements set by the Ohio Department of Health under Sections 3701.344 to 3701.347 of the Ohio Revised Code and Chapter 3701-28 of the Ohio Administrative Code. • Private Water Systems are potable water wells, ponds, springs, cisterns and hauled water storage tanks that provide drinking water to fewer than 25 people, less than sixty days out of the year, or have less than 15 service connections. e.g. single water supplies that serve homes, small businesses, small churches, small mobile home parks or communities with fewer than 25 residents.
Subjects of regulation	Water haulers
Regulation	***Water source*** • All water received from transportation equipment should be: o potable (satisfactory for all drinking, culinary, and domestic purposes; including flushing toilets and doing laundry), and o from an approved public water system ***Water hauling practices*** • Vehicle and/or transportation equipment used to distribute potable water should: o not have been previously used to transport a noxious, hazardous, or a toxic substance or liquid o not be used to transport or distribute water from streams, rivers, springs, ponds, lakes or other water source not approved as a public water system for the use in a private water system; o be clean and sanitary and protected from contamination at all times • Each vehicle should display name and telephone number of water hauler and current approval sticker issued by board of health • Each tank load of water should be dosed with a sufficient amount of chlorine to produce minimum chlorine residual of 0.2 ppm. • All water received from transportation equipment should have minimum 0.2 ppm free chlorine residual at time of delivery ***Water hauling equipment construction*** • The interior, piping, valves, and permanent or flexible connections should be so constructed and of materials which meet NSF standard 61[1] and can be easily cleaned and sanitized. • The inlet or opening to every container should be constructed to prevent entrance of insects, rodents or other foreign material that may cause contamination of water. With exceptions of cleaning, inspecting, or filling the tank, the inlet openings should be kept closed at all times. • Outlet connections should be constructed and protected to prevent contamination of potable water. Protection from contamination should be provided at times of delivery and non-use. • Flexible connector ends should be protected and capped at all times except during filling or emptying of transportation equipment.

	• Any tank or other container that is used for the purpose of hauling water should only be used to haul potable water and should not be used to carry any other substances. • Note: supplementary document indicated that older hoses (pre-2001) not meeting NSF standards but in good condition are acceptable for now provided that they be flushed with water for about 1 minute prior to filling consumer water holding tank. ***Tank specifications*** • Tanks and other containers with which water comes in contact are to be made of materials that meets NSF Standard 61[1] except: o Stainless steel o Aluminum. Must be one of the following grades: ▪ Wrought alloys 1000-6000 series ▪ Casting alloys 218, 308, 319, 332, 356, 460, 413, B443, 514, 520, 713 o Food grade plastic tanks meeting FDA 21 C.F.R. part 177[2] requirements for contact with food • Note: supplementary document indicated that existing non-stainless steel or other metal tanks coated on inside with NSF-approved epoxy coating are acceptable (although not recommended) • Tanks must be constructed that every portion of interior can be easily cleaned and sanitized. Lead, cadmium, and other toxic metals are not to be used on surfaces which come in contact with the water ***Cleaning and disinfection*** • The water contact surfaces and equipment should be cleaned and disinfected: (1) Before it is put into use; (2) When the system or any of its parts have been dismantled or replaced for purpose of repair, maintenance or alteration; (3) Any time contamination is suspected; and (4) At least weekly during periods of operation. ***Testing and recordkeeping*** • A water hauler should keep equipment to test the free residual of chlorine in the tank and should test the tanks of water that are delivered. If < 0.2 ppm is detected then the hauler should add sufficient chlorine to obtain a residual chlorine concentration of 0.2 ppm. • A water hauler should keep record of all deliveries of water for 90 days from date of last delivery.
Implementation tools	Supplemental documents providing more detailed information on: • acceptable water hauler tank materials and • maintaining chlorine residuals for hauled water
Gaps/limitations	• No known review of literature conducted other than review of NSF standards • No specific procedures for cleaning and disinfection of tank or transportation equipment • No requirement to test bacteriological quality of water

[1] NSF International. (2011). NSF/ANSI Standard 61-2011 Drinking water system components- health effects.
[2] Food & Drug Administration (FDA) 21 C.F.R. part 177 “Indirect Food Additives: Polymers”.