Manitoba
Health
Health Protection Unit

APPENDICES 1-8 of the COMMERCIAL PREPACKAGED and NON-PREPACKAGED WATER GUIDELINES (Volume 2)

Under *The Public Health Act* regulations, the operators of **Water Bottling Plants** or **Water Vending Machines** must obtain regulatory approval to process and sell water for domestic purposes.

These types of facilities *must be designed, operated and maintained* in a sanitary manner to ensure that water does not become contaminated and pose a risk to Public Health.

For the purposes of harmonization of standards with other jurisdictions, the appendices portion of this guideline is a close adaptation of the *"Code of Hygienic Practice for Commercial Prepackaged and Non-Prepackaged Water",* as published by the Canadian Food Inspection System (CFIS) committee.

These are appendices to the companion guidelines. Additional items may be required by the Public Health Inspector and/or Health Officer pursuant to the *Food and Food Handling Establishments Regulation (The Public Health Act) and associated guidelines.* For more information and access to downloadable documents, go to: manitoba.ca/healthprotection

January 2016 **Guideline #2016-01 (Vol. 2)**

APPENDICES 1-8 of the COMMERCIAL PREPACKAGED & NON-PREPACKAGED WATER GUIDELINES

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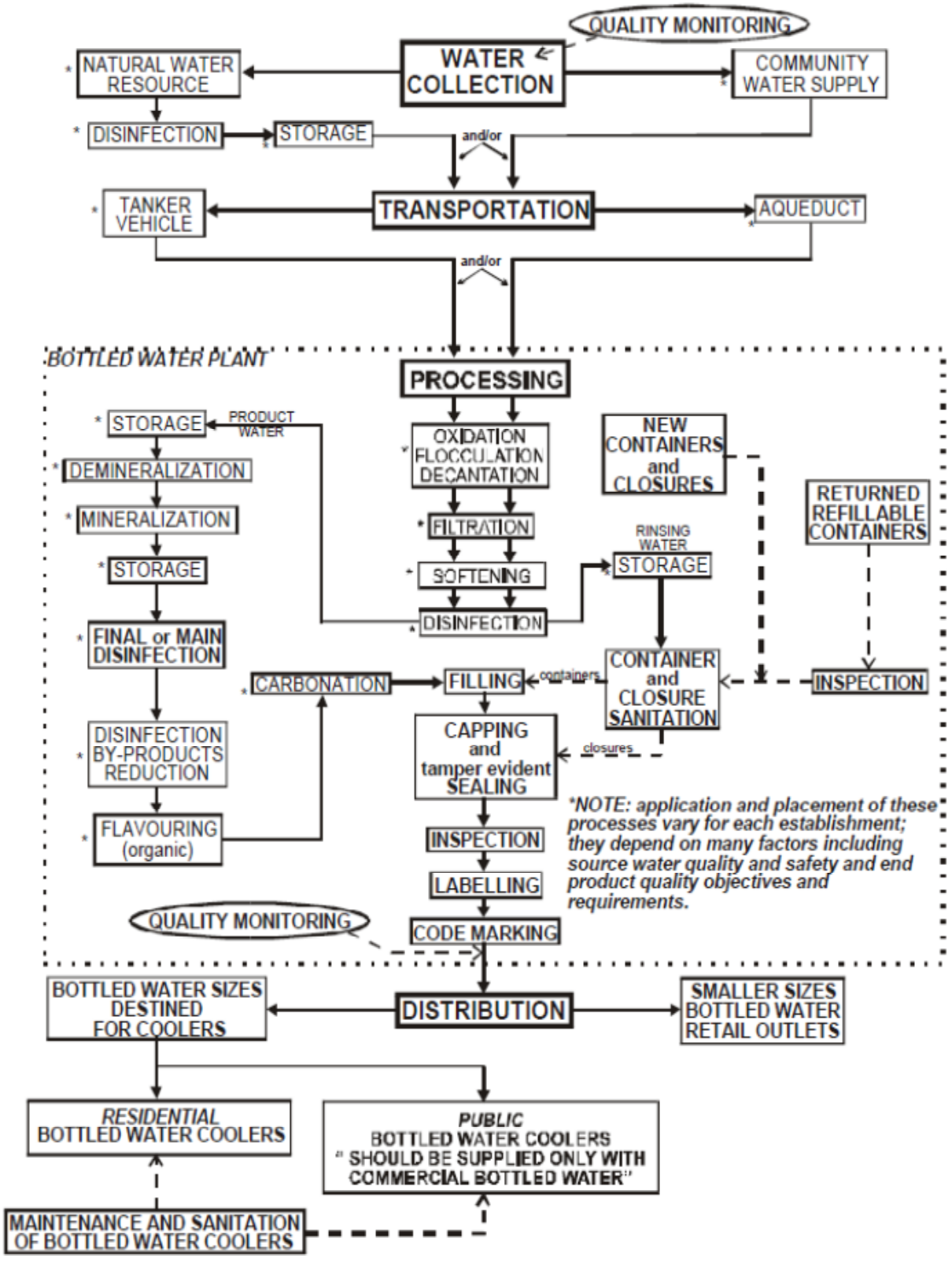
APPENDIX 1:

UNIVERSAL WATER FLOWCHART FOR PRE PACKAGED WATER



APPENDIX 2: PRODUCT IDENTIFICATION AND RECALL PROCEDURES

Rationale: By developing a complaint response and recall system in advance, an operator can reduce consumer exposure to product that may have a quality problem or health hazard and reduce disruption to the water operation. This provides greater consumer protection and can significantly reduce costs in the event of a recall. This necessitates product batch identification so that only implicated product is involved in a recall.

2.1 Product Identification

2.1.1 Lot Identification

a) Each product container including refillable containers should be marked in code or should clearly identify the packager and the lot.

b) Packages of the same lot (which is the quantity of water produced under identical conditions) should bear a lot number that identifies the production of a specific plant, during a specific time interval, including the “line” or other critical processing unit. A maximum of 24 hours is recommended.

2.2 Production Records

a) Permanent, legible and dated records of pertinent processing and production details should be kept concerning each lot.

b) These records should be kept for a period that exceeds the shelf life of the product but unless a specific need exists they need not be kept for more than two years.

c) Records by lot number should be kept of the initial distribution.

2.3 Product Complaints

Rationale: Product complaints are an important indicator of possible deficiencies in the areas of processing or manufacturing controls. Deficiencies in the complaint handling system can result in a failure to identify and eliminate health risks and unnecessarily expose the consumer to a health hazard.

2.3.1 Complaint Handling Procedure

a) The water processor should develop and implement a written procedure that is capable of receiving, recording and investigating all complaints.

b) A person should be designated responsible for receiving, evaluating, categorizing and/or investigating the complaint.

2.3.2 Investigation

When a complaint is received the operator should: i) categorize it according to health and safety risk; ii) forward it immediately (particularly serious complaints) to appropriate personnel for action; iii) provide trained staff to investigate all complaints;

a) include an examination of the complainant's specimen in the investigation;
b) consider expanding the investigation to include similar code product at the retail level;
c) evaluate the risk and investigate similar complaint trends;
d) identify deviations during the investigation, and take appropriate remedial action; and
e) determine if the product poses a safety or health concern and, if so, notify the regulatory authority immediately.

2.3.3 Complaint documentation

Complaint documentation should include:

a) a record of all complaints;
b) all investigation findings and corrective action taken;
c) consumer information, i.e. complainant's name, and appropriate contact information such as address, telephone number, date complaint received, details of complaint and/or other illness, product name (code and size), purchase date and the name of the retail outlet where it was purchased; and
d) investigation results including the name of the investigator, date and corrective action.

2.4 Recall Procedure

The operator should:

a) notify the regulatory authority as soon as possible, if the results of the investigation indicate that the water may constitute a hazard to the public;
b) prepare a written procedure for product recalls;
c) maintain adequate product distribution records to facilitate locating product in the event of a recall; and
d) simulate the record keeping and recall procedures periodically to verify that the products can be rapidly identified and recalled.

References:

Food Recalls: Make a Plan and Action it! Manufacturer's Guide and the Guide to Food Labeling and Advertising

The Canadian Food Inspection Agency Website: www.inspection.gc.ca

APPENDIX 3: EQUIPMENT STANDARDS

Rationale: Proper equipment design and construction protects final product quality by ensuring mechanical and sanitary criteria for storage and processing equipment. When equipment and utensils are designed, constructed, and installed as intended it permits effective cleaning and sanitation, thereby preventing contamination.

3.1 General Processing Equipment

3.1.1 Equipment should be designed, constructed and installed so as:

a) to ensure that it functions as intended;

b) to be accessible for cleaning, sanitizing, maintenance and inspection;

c) to be self draining with no dead ends, impediments to product flow nor sites where contamination may build up; and

d) to be easily accessible for inspection and for cleaning either in an assembled position or when removed.

3.1.2 Water product contact surfaces should:

a) be constructed of stainless steel or other corrosion resistant material that is smooth, non toxic, non-absorbent and cleanable;

b) be highly resistant to strong oxidizing chemicals such as ozone;

c) have the ability to control the development of surface biofilm; and

d) be capable of being regularly cleaned and sanitized.

3.1.3 Plastics and coatings used as part of the equipment should be food grade material.

a) Non-product contact surfaces should be of corrosion resistant materials that are smooth, non-absorbent, durable and easily cleaned.

b) Processing equipment should be of sanitary design and construction so as to minimize the risk of product contamination (e.g., oil, leaks, dirt, mould, mildew, grease, flaking material, etc.).

c) Where necessary, equipment should be exhausted through an appropriate ozone destructor to the outside to prevent excessive condensation and ozone gas buildup.

d) Clean in Place (CIP) including spray balls (if used) should be designed to allow for inspection and removal of debris. e) All processing equipment should be designed and operated so as to preclude any cross connections.

3.2 Equipment Maintenance and Calibration

Rationale: Any equipment that may impact on the safety of water should perform consistently as intended and prevent contamination of product. Equipment manufacturers should provide written protocols, including calibration methods and frequencies for proper operation and maintenance of equipment.

3.2.1 Written protocols, including calibration methods and frequencies, as established by the manufacturer of the equipment, should be onsite and available for review.

3.2.2 Written records should be kept on the operation, maintenance and adjustments or calibrations of the equipment and should include:

a) a listing of equipment requiring regular maintenance; and

b) the maintenance and frequencies of these procedures.

3.2.3 Equipment should be maintained so as to ensure that no physical or chemical hazards could result, such as inappropriate repairs, flaking paint or rust, and excessive lubrication.

3.3 Water Storage Tanks

Rationale: All storage tanks and their accessories should be designed, constructed and maintained to ensure the safe storage and the integrity of the stored product to prevent microbial growth or physical contamination. Water tanks should be third-party certified to meet recognized standards such as:

- Canadian Standards Association (CSA) for Water Cisterns, B126 Series-13; or
- **NSF**/ANSI 61 standards for drinking **water** components

3.3.1 Water storage tanks should be:

a) constructed of materials, which have been approved for use with potable water;

b) scratch resistant and resistant to corrosion caused by cleaning and sanitizing chemicals and disinfectants such as ozone ;

c) strongly supported to prevent strain and warping; and d) designed so that the inside surfaces are accessible (via a cover for small tanks or a man-hole in larger tanks).

3.3.2 Tanks should be filled and drained through properly constructed piped inlets and outlets. Filling through manholes or access ports is not recommended.

3.3.3 Inlets should be capped when not in use.

3.3.4 The bottom of tanks should be sufficiently sloped to a drain located at the lowest point in the tank to allow for complete drainage.

3.3.5 Ventilation ports and overflow outlets should be suitably screened and tight fitting. All replacement air should be filtered.

3.3.6 Storage tanks should be designed and constructed so that they may be readily cleaned and sanitized. Spray balls in larger tanks should be located, designed and have an adequate number to allow the spray to reach all inside surfaces.

3.3.7 Potential cross connections should be protected by using an atmospheric break or a back flow prevention device.

3.3.8 Water level gauges should be of sanitary design and construction. The use of external tube water level gauges is not recommended.

3.3.9 Tanks located outside buildings, should be insulated for temperature control.

3.3.10 Hoses used for filling and draining tanks should be made of food grade material with capped ends.

3.3.11 Hoses should be sanitized before use.

3.4 Pumps

3.4.1 Product water pumps should be of sanitary construction and designed to be completely self-draining.

3.4.2 Gaskets with product contact surfaces should be designed to be removable and resistant to cleaning, sanitizing and disinfecting chemicals including ozone.

3.4.3 All shaft seals used on water pumps should be sanitary in design.

3.5 Pipelines and Fittings

3.5.1 Product water pipelines should be constructed of materials approved for use with potable water.

3.5.2 Gaskets, seals, O-rings and fittings should be constructed of approved food grade materials. Paper gaskets are not recommended.

3.5.3 Product water pipelines should be rigid, adequately supported and sloped so that they are completely self-draining.

3.5.4 Permanently welded pipelines should have suitable access points to enable inspection.

3.5.5 Removable fittings may be used, with or without gaskets, provided they form flush interior joints with no dead ends.

3.5.6 CIP fittings (instrument fittings, pressure gauges, sample cocks, etc.) should be capable of being disassembled for manual cleaning, sanitizing and inspection.

3.6 Valves

3.6.1 Product valves should be of sanitary design and constructed of food grade material.

3.6.2 When open, valves should not impede product flow and should be tight fitting when closed.

3.6.3 Product valves should be located immediately adjacent to the product water line to reduce dead space in the production line.

3.6.4 Valves should be self-draining and easily accessible for manual cleaning.

3.7 Sampling Ports

3.7.1 Sampling ports should be designed and constructed of food grade materials.

3.7.2 If flame sterilization is used, heat resistant materials should be incorporated.

3.7.3 Short nozzles are recommended to facilitate sterilization.

3.7.4 Nozzle design and flow controls should prevent splashing.

3.7.5 Sampling ports should be easily accessible and designed to permit placement of sample bottles.

3.7.6 It is recommended that sampling ports be situated after each applicable component or process identified as a HACCP Critical Control Point (see Appendix 4.1). These Critical Control Points may for example include:

a) the connection point to community water distribution system;

b) the point of entry into the bottling plant, when supplied by aqueduct from the direct tapping of the source;

c) the tanker truck outlet;

d) the storage tank outlets;

e) the mixing tank outlets;

f) the filter outlets;

g) process equipment outlets (distiller, reverse-osmosis, etc.); and

h) point of connection for the plant water supply, if different from the product water.

***Note: When sampling for microbiological analyses, aseptic sampling techniques must be used, as per the *Standard Methods for the Examination of Water and Wastewater, available online at:* www.standardmethods.org

3.8 Equipment Sanitation

3.8.1 Sanitation Program

The equipment manufacturer should provide an effective sanitation program that includes:

a) the name of responsible person;

b) the frequency of the activity;

c) the chemicals and concentration used *(note: approved chemicals are listed in the Reference Listing of Accepted Construction, Packaging Materials and Non Food Chemical Agents published by the Canadian Food Inspection Agency*); www.inspection.gc.ca

d) the temperature requirements; and e) the procedures for cleaning and sanitizing.

3.8.2 Cleaned-out-of-Place Equipment (C.O.P.), i.e. hand-cleaned

A sanitation program for equipment designed to be cleaned out of place should include:

a) the identification of all equipment and utensils;

b) the disassembly/re-assembly instructions required for cleaning and inspection;

c) the identification of the areas requiring special attention; and

d) the recommended methods of cleaning, sanitizing and rinsing.

3.8.3 Clean in Place Systems (CIP)

A sanitation program for equipment designed to be cleaned in place should include the following conditions:

a) All equipment and utensils should be identified.

b) Solution contact surfaces should be constructed from food grade material.

c) Solution lines leading to product lines should have permanent fittings installed that are easily dismantled.

d) Pipelines should be rigid, adequately supported and self-draining.

e) Cleaning circuits should be designed and constructed with access points to enable inspection.

f) Accurate circuit diagrams of the CIP system should be available.

g) There should be no cross connections between cleaning solutions and the product water. This may be accomplished by an air break or an approved backflow prevention device.

h) The system should meet the original manufacturer's specifications for flow rate, time and temperature, and cleaning and sanitizing solution strengths.

APPENDIX 4.1: QUALITY ASSURANCE AND DOCUMENTATION

4.1.1 Hazard Analysis and Critical Control Point

Rationale: Establishing a quality assurance program that monitors potential hazards will ensure the production of a safe and wholesome product. Ideally, the quality assurance system should be modelled on HACCP (Hazard Analysis and Critical Control Points). A comprehensive review of the manufacturing process for each product will identify the Critical Control Points.

Steps to establish a HACCP Plan:

1) Perform a hazard analysis.

2) Identify the Critical Control Points (CCP).

3) Define and identify specific critical limits for each CCP.

4) Establish monitoring procedures for each CCP in order to identify any deviation from the critical limits.

5) Establish a corrective action plan outlining the response and procedure for any deviation from critical limit. The plan should ensure that product of questionable quality be eliminated from product flow.

6) Regularly review and update the HACCP plan when processing or equipment has been modified.

7) Verify that the HACCP plan has been properly implemented and is effective.

4.1.2 Finished Product Standards (Treated Water)

4.1.2.1 Microbiological Parameters

Bacteriological samples of the treated water must be tested according to the predetermined frequency outlined in Sections 3.11.1 (Bottling Plants) or 7.2.7 (Vending Machines) of Volume 1 of the Guidelines.

4.1.2.2 Chemical and Physical Parameters

An annual test is recommended on prepackaged water produced by bottling plants. A laboratory acceptable to the regulatory authority should perform the analysis. The

water must meet the health and safety parameters outlined in the most recent edition of the *Guidelines for Canadian Drinking Water Quality*.

4.1.2.3 Radiological Parameters

It is recommended that a sample of each type of bottled water produced should be sampled and analyzed annually for radiological parameters. See the most recent edition of the Guidelines for Canadian Drinking Water Quality. A laboratory acceptable to the regulatory authority should perform the analysis.

The water should meet the health and safety parameters outlined in the most recent edition of the Guidelines for Canadian Drinking Water Quality.

**Note: Quality assurance and process monitoring records should be maintained at the plant for a minimum of two years. These records should be available for review by the regulatory agency.*

APPENDIX 4.2: ROUTINE ANALYSIS OF SOURCE WATER

*(**Untreated water from sources not subject to licensing under *The Drinking Water Safety Act)*

4.2.1 Parameters, Objectives and Sampling Recommendations

*Note: All samples should be taken routinely on the source water prior to treatment and meet the requirements of the most recent edition of Health Canada's Guidelines *for Canadian Drinking Water Quality* – or as often as prescribed by the Medical Officer of Health. www.hc-sc.gc.ca

4.2.1.1 Testing for Chemical and Physical Quality

a) C1 Testing Parameters for General Water Composition: The C1 parameters (listed below) generally represent more than 98% of the dissolved solids of all types of waters. They are generally not related to health concerns but their consistency throughout the year may be indicative that the source is well protected.

Basic characteristics:

- Sodium (Na), potassium (K), calcium (Ca), magnesium (Mg)
- Chlorine (CL2), sulphate (SO4), hydrogen carbonate (HCO3), carbonate (CO3)

- Silicone dioxide (SiO2) (where applicable)
- pH
- TDS or total dissolved solids (should be the “filterable dry residue at 180ºC” method)
- Conductivity at 25ºC

b) Guidance for Water Evaluation:

- pH results above 8.5 or lower than 6.0 should be investigated for possible pollution.
- Chloride is usually naturally occurring but it also may be the result of pollution from road salt, animal farming and other environmental influences.
- Very low silica levels (<5mg/l are generally characteristic of surface waters).
- Water with more than 500 mg/l of total sulfates1 may have a laxative effect.

c) Testing for Physical Parameters:

- Turbidity
- True colour (on centrifuged sample)
- Temperature (of water collection point)
- Turbidity higher that 0.5 Nephelemetric Turbidity Unit (NTU) may hinder disinfection efficiency.
- True colour above the expected value (from the naturally present ferric and manganic ions) may be indicative that the source is not well protected.
- Unaccounted colour may be due to presence of humic acids, which are associated with surface water, or other colour producing pollutants.
- Ground water with less than 0.5 mg/l of iron and manganese should have a true colour of less than 1 True Colour Unit (TCU) or pollution or other external influence should be investigated.
- A constant year-round temperature is usually an indication that the water is less influenced by meteorological conditions and the source may be characterized as having a higher degree of safety.
- A constant year-round mean water temperature that is close to local mean year-round 2 air temperature may be an indication that the source is safer. (except for thermal groundwater)

d) Testing Parameters for Unstable Minerals:

- Total iron. Iron content is not a health concern and usually occurs naturally.
- Total manganese. Manganese tends to become oxidized into less soluble compounds when in contact with atmospheric oxygen. This reaction increases when the water is ozonated. In addition to creating an aesthetic problem, the precipitation complicates the safe processing of water. It may also promote the

formation of filamentous or non-filamentous iron bacteria resulting in the need for a comprehensive treatment program.

- Sulphides (and more rarely, elemental sulphur).

e) Testing Parameters for Nutrients:

- Nitrate and nitrite (NO3 + NO2)
- Nitrite (NO2)
- Ammoniacal nitrogen
- Total phosphorus
- Dissolved total organic carbon
- Abnormally high levels for these parameters may indicate agricultural pollution.
- The normal natural nitrogen cycle from the natural flora environment in Canada should produce water nitrate content of less than 1 mg/l, except in rare cases of geological deposits of natural nitrate.
- A higher nitrate level is indicative of the use of fertilizers and other environmental influences in the recharge and contribution area.

f) C2 Testing Parameters for Natural Toxic Inorganic Substances:

- Present *maximum acceptable concentration (*MAC) and *interim maximum acceptable concentration (*IMAC) values are listed in Health Canada's Guidelines *for Canadian Drinking Water Quality.* www.hc-sc.gc.ca

g) C3 Testing Parameters for Pesticides:

- Screening for all types of pesticides (an exception may be in the most pristine watershed) should be conducted initially because pesticides may persist in the environment for several years.
- The presence of a pesticide below MAC level is indicative of source vulnerability to pesticide and other contamination risks.

h) C4 Testing Parameters for Other Organic Compounds:

- General GC – MS 6 screening of volatile organic compounds (VOCs). These include some mononuclear hydrocarbons and many halogenated hydrocarbons and most BTEX 7 compounds.
- General GC – MS screening of semi-volatile organic compounds (SVOCs). These include polynuclear hydrocarbons, phenolic compounds and some plastifiers.
- Surfactants (these relate to detergents).

The presence of any of these substances, including results below the MAC level, may be indicative of a risk situation or may show that a source is vulnerable to other contamination risks.

Rationale: The absence of microbiological parameters *(M1 to M4)* and all other parameters in these annexes, indicates that there is no direct external influence (mainly surface water intrusion) on the water source.

4.2.1.2 Testing for Microbiological Quality

a) M1 Testing Parameters for Bacteriology:

- Source water must be tested and meet the requirements of the most recent edition of Health Canada's *Guidelines for Canadian Drinking Water Quality.*
- The absence of pathogens or indicators of direct external influence may indicate the source may be considered at a *maximum level of safety* (see section 3.3.1, Guideline, Volume 1). It is recommended that source water be sampled routinely – or as often as prescribed by the Medical Officer of Health.
- If the geometrical average 8 of all total bacteria (HPC) results is low (usually less than 20 per ml) it is an indication of the absence of external influences.
- This average is obtained by multiplying together all the results and then squaring this product to the Nth power, where N is the number of results; compared to the usual arithmetic average, the geometrical average lessens the weight of results whose values are very different from the main body of results.

b) M2 Testing Parameters for Parasitology:

- *Cryptosporidium parvum* per 1000 litres
- *Giarda lamblia* per 1000 litres

Viable parasites should not be found. Presence of viable or non-viable parasites may be an indication that the source is vulnerable to contamination from natural or near surface fauna. If non-viable parasites are detected, additional parasite checks should be performed.

NOTE: The sampling process can be challenging and may yield inaccurate results. For this reason, greater emphasis is placed on monitoring of the treatment system to ensure optimum performance. Monitoring of turbidity levels and UV lamp intensity helps to ensure a minimum 3 log reduction of crypto/giardia.

4.2.1.3 Testing for Radiological Quality

a) R1 Testing Parameters for Radiological Safety:

i.Gross Beta activity: Gross Beta activity above 1.0 Bq/l may be indicative of pollution by artificial (man-made) radionuclides and should prompt further analysis, to identify the responsible substance(s) and the source of pollution. In the absence of such pollution most Beta activity is due to the natural radioisotope, potassium-40, which is not considered injurious to health.

ii.Gross alpha activity : Gross alpha activity above 0.1 Bq/l should lead to further investigation and analysis of other radioactivity parameters.

iii.Radium– 226 activity: Radium-226 occurs naturally and is the foremost health related criteria for drinking water.

Note: For the most up to date information on MAC and IMAC values for radiological parameters, refer to the most recent edition of Health Canada's *Guidelines for Canadian Drinking Water Quality*. www.hc-sc.gc.ca

4.2.1.4 Sampling Protocol

The following recommendations will assist in obtaining reliable analytical results that represent actual water quality at the time of sampling.

a) Samples should be taken at the maximum authorized flow rate.

b) Analysis of parameters C1, C2, C3, C4, M1, M2 and R1 should be carried out for the initial source evaluation. C1 and M1 analyses should be carried out on a regular ongoing basis.

APPENDIX 4.3: PRESCREENING ANALYSIS OF PROPOSED SOURCES*

*(*Untreated water from sources not subject to licensing under *The Drinking Water Safety Act)*

Rationale: A pre-monitoring plan must be used to assess the consistency of water quality and safety criteria of a proposed source if it is not yet an 'approved source'. This is important if there is doubt about the safety of the source or if there is no other way to assess its safety, as may be the case for glacier or iceberg water sources. It is not necessary for bottling plants or vending machines that use water supply systems licensed under *The Drinking Water Safety Act* as those are subject to routine monitoring and auditing requirements. The water quality monitoring information is available to the

4.3.1 Pre-Monitoring Plan

4.3.1.1 Time Period for Pre-Monitoring

For a source to be considered at the *maximum level of safety* a minimum pre-monitoring period of one year should be used. If pre-monitoring of the source is not possible, it should be considered at a *minimum level of safety* and the water will require appropriate treatment.

**Note: See section 3.3 of the Guideline (Volume 1) for information on levels of safety.*

4.3.1.2 Testing Parameters and Sampling Frequency

Basic testing parameters (<u>all cases</u>):

a) Unless otherwise specified by the Medical Officer of Health, test weekly to semi-monthly for the microbiological parameters set forth in the most recent edition of the Guidelines For Canadian Drinking Water Quality.

b) Unless otherwise specified by the Medical Officer of Health, test quarterly for General Water Composition (see Appendix 4.2, section 4.2.1.1 (a), C1 parameters). Testing parameters may depend on the nature of the suspected contamination risks to the source. For example, it may be nitrates or a particular pesticide used in a risk area or BTEX.

APPENDIX 5.1: DETERMINING GROUND WATER RISK SUBZONES

This appendix is one example of evaluating ground water sources. Other equivalent science-based methods may be acceptable. It is recommended to use the services of a qualified hydrogeologist to carry out a comprehensive risk assessment.

The following is a general summary of one method of a ground water risk assessment.

Rationale: The closer human and wildlife activities are to the water collection point (within the recharge and contribution area), the greater the risk of contamination incidents. The degree of geological protection will vary by location and each site should be individually assessed for all parameters.

5.1.1 Ground water risk

**Note: The recharge and contribution area can have different hazards associated with the distance of potential contamination sources from the collection point. Identifying these hazards and determining the distances to the collection point of water will assist in determination of the actual risk to the source.*

a) Identify the hazards and evaluate the potential risks to the recharge and contribution area[1] of the projected point of collection (well or spring) rather than the entire basin watershed.

b) This area (parabola shaped) should only be determined by a professional hydrogeologist.

c) Determine the boundaries where the subterranean water flows towards the point of collection and the lateral ground surface areas that are sloped towards the area that sheds runoff water. This may carry contaminants and organisms that may leach into the main underground flow of water supplying the proposed water collection point.

5.1.2 Recharge and contribution area investigation

*Note: Water soluble chemicals will migrate farther and faster towards the collection point than water insoluble chemicals. All human and wildlife sources of biological hazards should be identified. Most viral health hazards are due to human enteric viruses. In the absence of human activity, such as in a “pristine” environment, natural surface or near surface flora and fauna may be a contamination hazard. If the geological stratum above the aquifer is

[1] *The recharge and contribution area encompasses the area where ground water is drawn towards the collection point and all nearby grounds sloped towards this area causing runoff water (and contaminants or organisms carried with it) to reach the said area.*

inadequate, the natural barrier may be unpredictable and allow chronic or seasonal contamination at the collection point.

5.1.2.1 Locations

The recharge and contribution area may be divided into sub-zones, each one relating to a particular level and class of contamination risks (see Figure 1):

a) Sub-zone 1: Relatively safe sub-zone that is a low risk area greater than 5 kilometers from the collection point:

- The risk is low because dilution and other attenuating factors are significant for most chemicals, harmful viruses and parasites and pathogenic or nuisance bacteria.

b) Sub-zone 2: Risk for chemical contamination for the area within 5 kilometers[2] of the collection point.

- Unconsolidated[3] aquifer media: covers 550 days[4] isochrone[5] from the point of collection within the recharge and contribution or area as most viruses will not migrate greater than this distance or survive the time for ground water to travel to the collection point.
- Consolidated[6] aquifer media: covers the first 1000 meters[7] (1.6 km if the media is karstic) from the point of collection within the recharge and contribution zone.

c) Sub-zone 3: Risk for virological contamination. The type of aquifer (consolidated or unconsolidated) will affect the level of risk.

d) Sub-zone 4: Risk for bacteriological and parasitological contamination.

- Unconsolidated aquifer media covers the 200 days[8] isochrone from the point of collection within the recharge and contribution zone as most parasites will not travel over that distance and most bacteria will not survive that length of time of travel.

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[2] *Based on reported cases of ground water chemical contamination with an added margin of safety.*
[3] *Like sand, silt or any other particulate matter.*
[4] *Based on reported survival time in ground water of most viruses with an added margin of safety.*
[5] *The isochrone corresponds to a distance or a line from which all ground water takes an equal amount of time to reach the water collection point. Isochrones can be calculated with reasonable precision only for aquifers made of particulate matter.*
[6] *Like slate, sandstone or any other fractured rock aquifer.*
[7] *Based on reported survival time in ground water of most viruses with an added margin of safety.*
[8] *Based on reported survival time in ground water of most viruses with an added margin of safety.*

- Consolidated aquifer media covers the first 500[9] meters (800 meters if the media is karstic) from the point of collection within the recharge and contribution area.

5.1.2.2 Contaminants

a) Sub-zone 2: Chemical vulnerability sub-zone:

- Water-soluble chemicals will migrate farther and faster to the collection point than water insoluble chemicals. b) Sub-zone 3: Virological vulnerability sub-zone:
- Most health hazards from viruses are due to human enteric viruses therefore all potential sources of human sewage should be located.

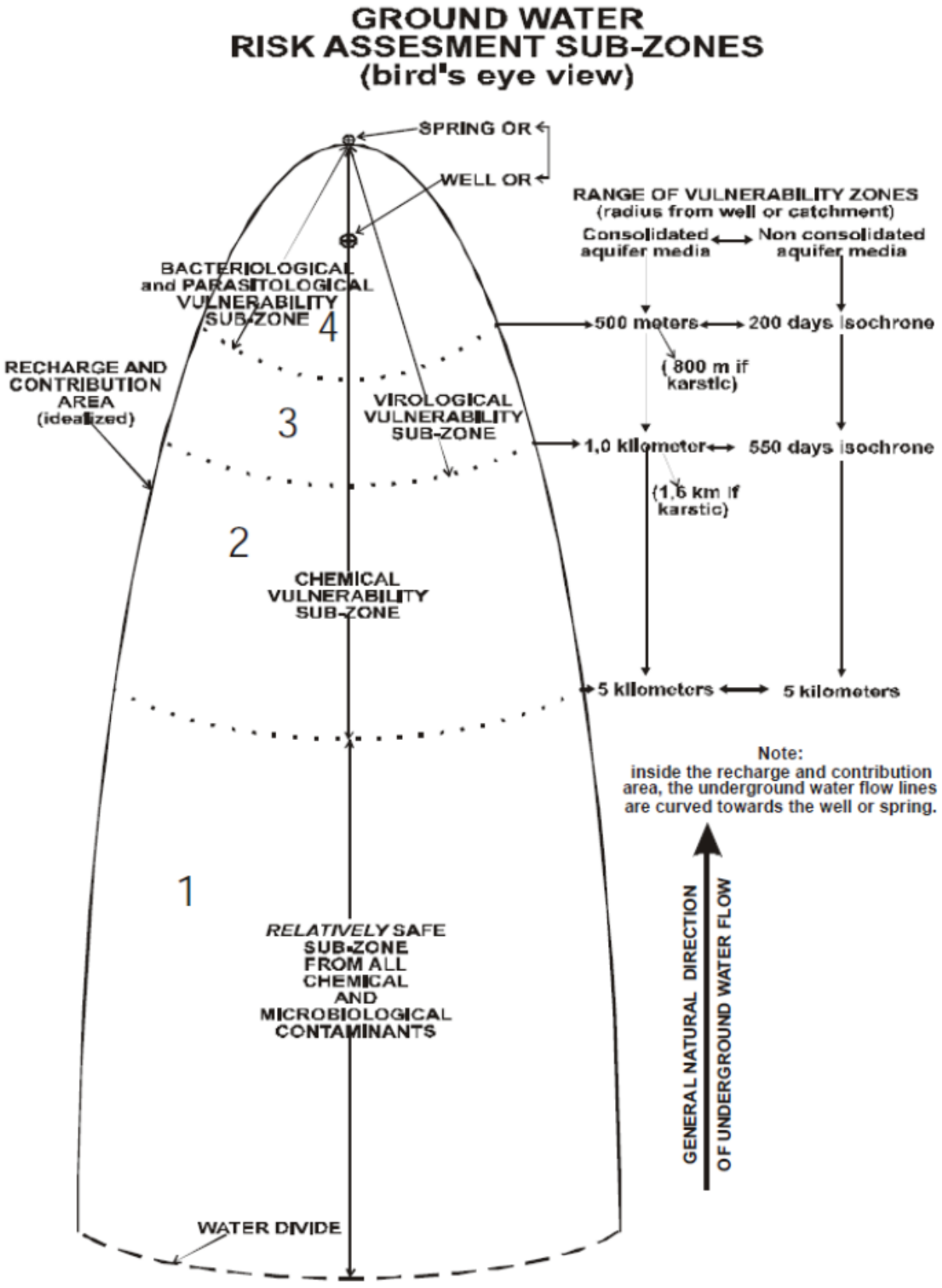
c) Sub-zone 4: Bacteriological and parasitological vulnerability sub-zone:

- All human and wildlife sources of biological hazards should be located. Even in the absence of human activity, including pristine environments, natural surface or near surface flora and fauna are always sources of potential contamination[10]. If the geological stratum above the aquifer is an inadequate natural barrier there may be chronic or seasonal episodes of contamination at the collection point.

[9] *Based on reported survival time in ground water of most viruses with an added margin of safety.*

[10] *Some microorganisms endogenous to wild environments are possible human pathogens.*

Figure 1


GROUND WATER
RISK ASSESMENT SUB-ZONES
(bird's eye view)
SPRING OR
WELL OR
RANGE OF VULNERABILITY ZONES
(radius from well or catchment)
Consolidated aquifer media
Non consolidated aquifer media
BACTERIOLOGICAL and PARASITOLOGICAL VULNERABILITY SUB-ZONE
4
500 meters
200 days isochrone
(800 m if karstic)
RECHARGE AND CONTRIBUTION AREA (idealized)
VIROLOGICAL VULNERABILITY SUB-ZONE
3
1,0 kilometer
550 days isochrone
(1,6 km if karstic)
2
CHEMICAL VULNERABILITY SUB-ZONE
5 kilometers
5 kilometers
Note:
inside the recharge and contribution area, the underground water flow lines are curved towards the well or spring.
1
RELATIVELY SAFE SUB-ZONE FROM ALL CHEMICAL AND MICROBIOLOGICAL CONTAMINANTS
GENERAL NATURAL DIRECTION OF UNDERGROUND WATER FLOW
WATER DIVIDE

APPENDIX 5.2: EVALUATING THE NATURAL VULNERABLITY OF GROUND WATER

This appendix is one example of evaluating ground water sources. Other equivalent science-based methods may be available. It is recommended to use the services of a qualified hydrogeologist to carry out a comprehensive risk assessment. The following is a general summary of one method of a ground water risk assessment.

Rationale: Surface water may contain contaminants and organisms. This water can penetrate or leach vertically into the ground water and reach the aquifer. Once in the aquifer, it can travel or migrate horizontally into the main underground "water stream". Surface ground media may be impervious to water penetration (e.g. clay media) or it may filter the contaminants and organisms (e.g. silt media). These attenuating properties should be considered in the risk assessment process.

5.2.1 Attenuation Mechanisms

a) Filtration, chemical self-degradation or reaction with the water encasing media

b) Dilution

c) Physical dispersion

d) Biological uptake

e) Maximum life span or survival time (of organisms)

f) Chemical and physical properties of the contaminant and the media through which the water must travel g) Distance between the point of contamination and the point of collection h) Quantity and rate of contamination and local precipitation

5.2.2 Evaluation Steps

a) Identify potential contamination risk sub-zones. b) Identify human or other activities which could present a microbial or chemical contamination risk within the sub-zones.

c) Determine the natural barriers' ability to filter or stop the vertical penetration of the potential contaminants (including those generated by the natural flora and fauna).

**Note: Few assessment systems exist for ground water that will determine and scale its vulnerability to microbiological and chemical contaminant penetration or vertical leaching into aquifers.*

5.2.3 Risk assessment models

a) Drastic Model: Figures 2 and 3 illustrate one example of ground water vulnerability evaluation using the “DRASTIC modified method” explained in Appendix 5.3.

b) AVI Model

c) Other models may be used.

Consultation with a hydrogeologist can determine which model is suitable. The regulatory authority may have additional information to assist in making this assessment.

Figure 2

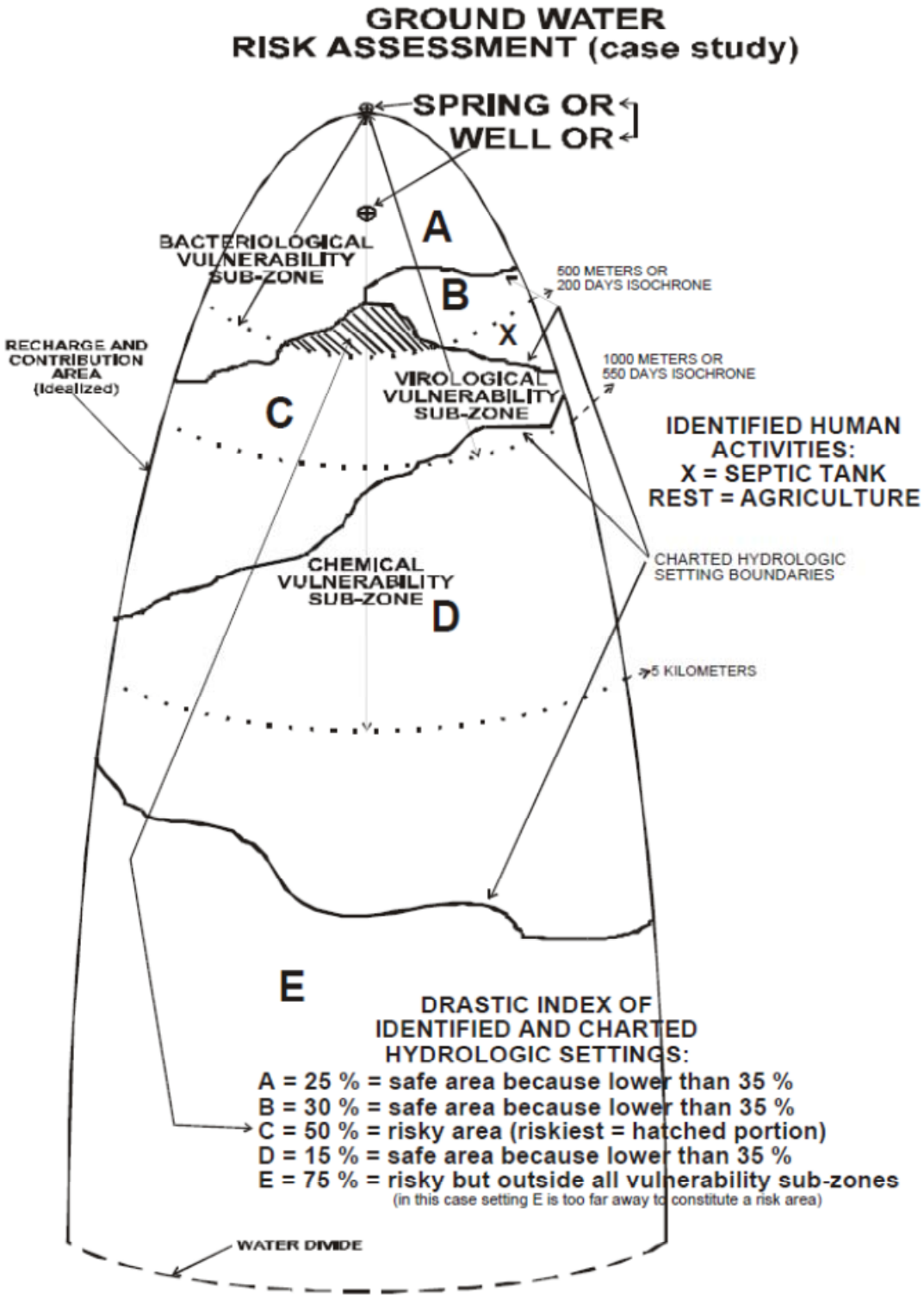
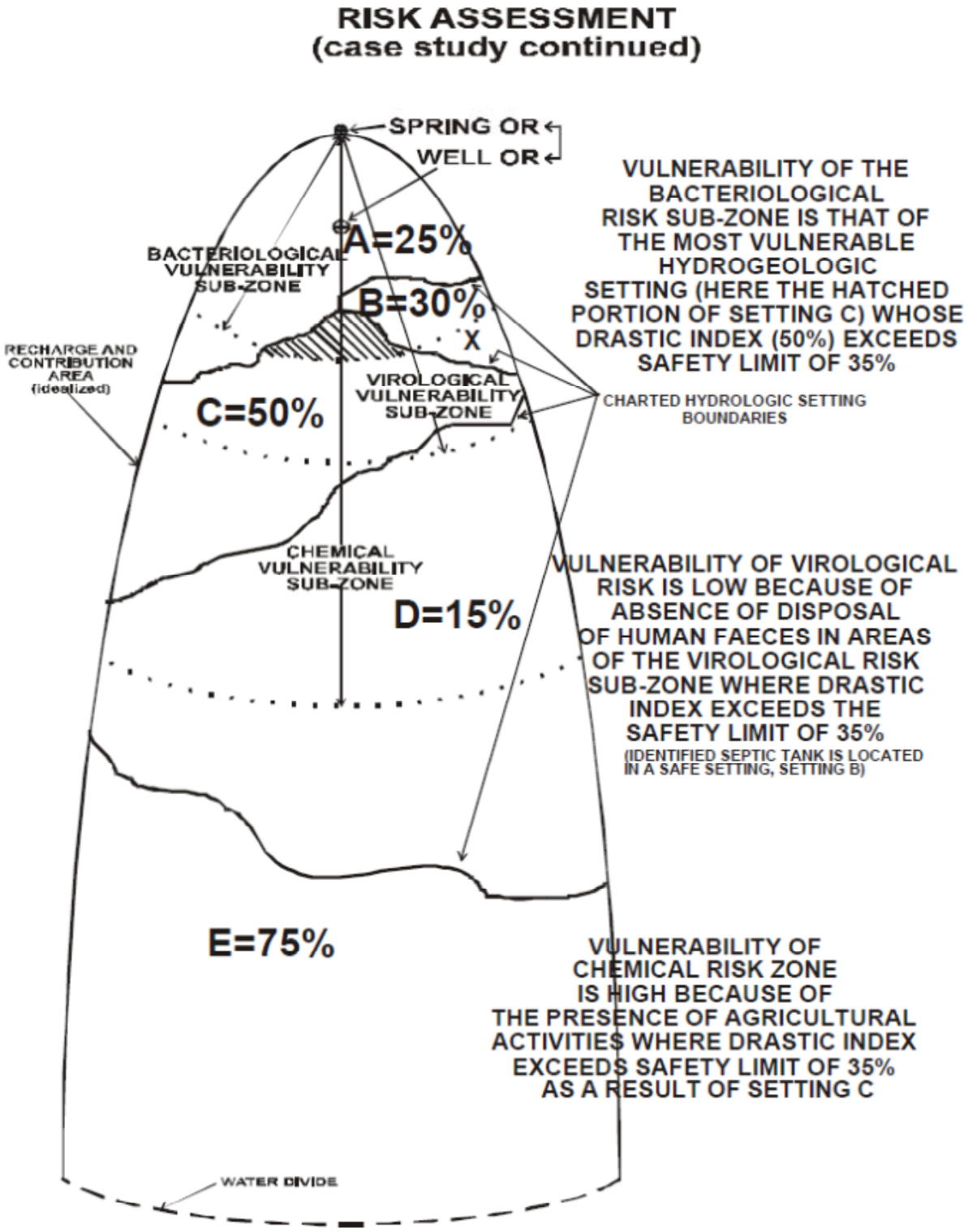

GROUND WATER
RISK ASSESSMENT (case study)
SPRING OR
WELL OR
A
BACTERIOLOGICAL
VULNERABILITY
SUB-ZONE
500 METERS OR
200 DAYS ISOCHRONE
B
X
RECHARGE AND
CONTRIBUTION
AREA
(idealized)
1000 METERS OR
550 DAYS ISOCHRONE
VIROLOGICAL
VULNERABILITY
SUB-ZONE
C
IDENTIFIED HUMAN
ACTIVITIES:
X = SEPTIC TANK
REST = AGRICULTURE
CHARTED HYDROLOGIC
SETTING BOUNDARIES
CHEMICAL
VULNERABILITY
SUB-ZONE
D
5 KILOMETERS
E
DRASTIC INDEX OF
IDENTIFIED AND CHARTED
HYDROLOGIC SETTINGS:
A = 25 % = safe area because lower than 35 %
B = 30 % = safe area because lower than 35 %
C = 50 % = risky area (riskiest = hatched portion)
D = 15 % = safe area because lower than 35 %
E = 75 % = risky but outside all vulnerability sub-zones
(in this case setting E is too far away to constitute a risk area)
WATER DIVIDE

Figure 3


RISK ASSESSMENT
(case study continued)
SPRING OR
WELL OR
A=25%
BACTERIOLOGICAL VULNERABILITY SUB-ZONE
B=30%
X
RECHARGE AND CONTRIBUTION AREA (idealized)
C=50%
VIROLOGICAL VULNERABILITY SUB-ZONE
CHEMICAL VULNERABILITY SUB-ZONE
D=15%
E=75%
WATER DIVIDE
VULNERABILITY OF THE BACTERIOLOGICAL RISK SUB-ZONE IS THAT OF THE MOST VULNERABLE HYDROGEOLOGIC SETTING (HERE THE HATCHED PORTION OF SETTING C) WHOSE DRASTIC INDEX (50%) EXCEEDS SAFETY LIMIT OF 35%
CHARTED HYDROLOGIC SETTING BOUNDARIES
VULNERABILITY OF VIROLOGICAL RISK IS LOW BECAUSE OF ABSENCE OF DISPOSAL OF HUMAN FAECES IN AREAS OF THE VIROLOGICAL RISK SUB-ZONE WHERE DRASTIC INDEX EXCEEDS THE SAFETY LIMIT OF 35%
(IDENTIFIED SEPTIC TANK IS LOCATED IN A SAFE SETTING, SETTING B)
VULNERABILITY OF CHEMICAL RISK ZONE IS HIGH BECAUSE OF THE PRESENCE OF AGRICULTURAL ACTIVITIES WHERE DRASTIC INDEX EXCEEDS SAFETY LIMIT OF 35% AS A RESULT OF SETTING C

APPENDIX 5.3: ESTABLISHING THE PROTECTION PERIMETERS

This appendix is one example of evaluating ground water sources. Other equivalent science-based methods may be available. It is recommended to use the services of a qualified hydrogeologist to carry out a comprehensive risk assessment. The following is a general summary of one method of a ground water risk assessment.

Figure 4 shows the case study analyzed (see Figure 2 and Figure 3) where each protection perimeter is located based on the guiding principles.

5.3.1 "Immediate protection perimeter"

The immediate protection perimeter is an area several meters in radius around the collection point that is usually fenced.

5.3.2 "Close protection perimeter"

a) Microbiological risks are a priority. Waterborne illness is usually from microbiological causes. In the diagram, hydrogeologic area C is vulnerable because its DRASTIC index is above 35%. Part of area C falls in the bacteriological and virological vulnerability sub-zones therefore the "close protection perimeter" should cover at least that part of setting C.

b) The "close protection perimeter" should include the balance of area C (even though it is situated beyond the microbiological risk sub-zone) because it is in the chemical vulnerability sub-zone and susceptible to chemical risks (DRASTIC index above 35%) and risks identified by agricultural activities.

c) Although areas A and B are not vulnerable to contamination (DRASTIC indexes less than 35%), contaminated water could leach through a badly constructed well or from a future mine or quarry. These developments could have an immediate impact on water quality and safety so these areas are included in this classification.

d) Protection measures in the "close protection perimeter" include: acquiring the property in the most vulnerable area (the hatched area C) to prevent contamination from farm animals or fertilizers and pesticides; securing legal contracts with property owners to implement an agro-environmental fertilizer and pesticide plan in area C; contracting with adjacent property owners to have only pump out septic tanks in area C which is located in the virological vulnerability sub-zone; reconstructing poorly constructed wells of adjacent property owners located throughout the "close protection perimeter".

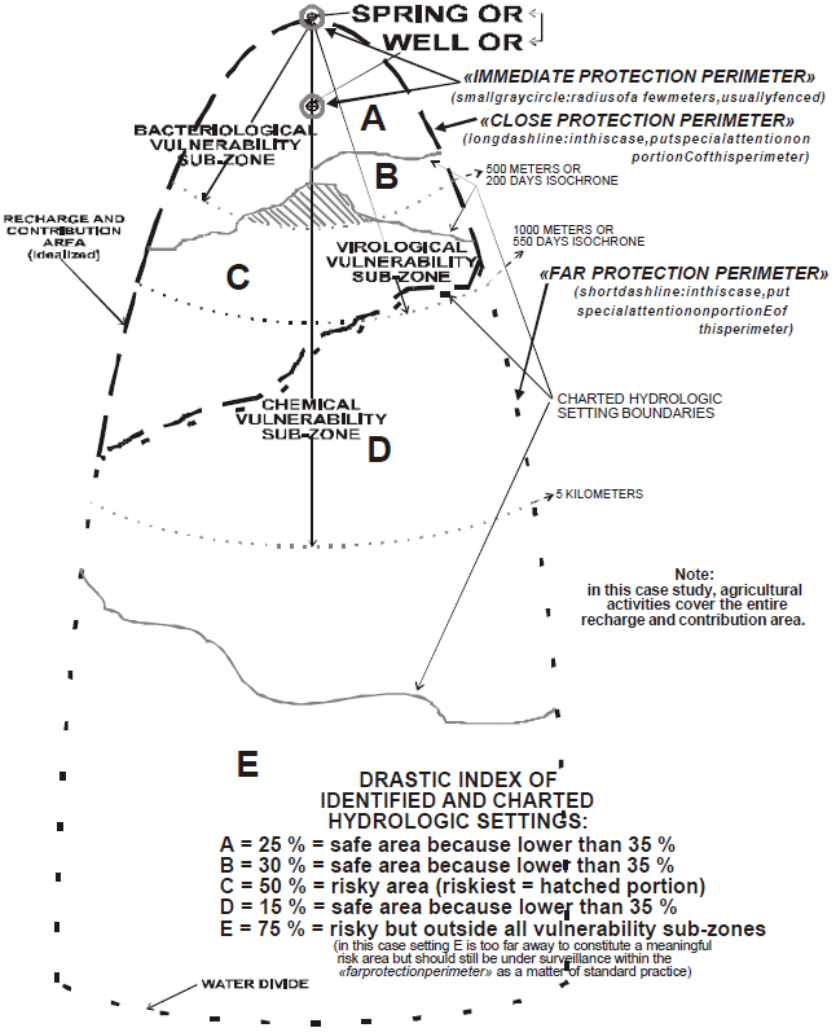
5.3.3 “Far protection perimeter”

a) Once the “close protection perimeter” has been determined, the balance of the recharge and contribution area becomes the “far protection perimeter”.

b) Protection measures may be limited to surveillance of large scale human activities, such as a public or industrial waste disposal sites, that may have long-term contamination effects on the water quality and safety.

Figure 4

ESTABLISHMENT OF THE THREE CLASSICAL PROTECTION PERIMETERS
(case study continued)



APPENDIX 6: OZONATION

6.1 Characteristics of Ozone

a) Ozone is a triatomic form of oxygen which is created by passing normal diatomic oxygen through an electric discharge field.

b) Ozone is an extremely powerful oxidant, capable of reacting with many of the constituent materials normally found in water.

c) When dissolved in water, ozone undergoes two types of chemical reactions: direct oxidation of some of the organic or inorganic constituents normally found in different types of water; and rapid decomposition forming free hydroxyl radicals that react with many of the constituents in the water.

**Note: Proper control and monitoring should be in place when working with ozone.*

6.2 Uses of Ozone for Water Treatment

6.2.1 Disinfection

a) Ozone is capable of achieving the same level of disinfection in less time with a smaller concentration than some other disinfectants, such as chlorine.

b) Ozone is an unstable compound and rapidly breaks down in water leaving no residual disinfectant. Therefore, when used to disinfect bottled water, the bottle should be sealed immediately after the final ozone bactericidal treatment to prevent recontamination.

6.2.2 Oxidation and Removal of Iron and Manganese

The addition of ozone to water containing iron and manganese compounds causes these compounds to convert into insoluble precipitates which can be easily removed by settling or filtration.

6.2.3 Oxidation of Taste, Odour and Colour

Many compounds associated with taste, colour and odour problems are highly resistant to other treatments or types of oxidation. Ozone will often react and break down these materials so they can be removed.

6.3 Factors Governing the Efficiency of Ozone Disinfection

**Note: There are two important factors governing the use of ozone as an effective disinfecting agent noted in the CT Factor (Chick-Watson Law) a) the residual concentration of ozone (C) in mg/l dissolved in the water; and b) the time of exposure or contact in the water (T) as expressed in minutes.*

6.3.1 General requirements

a) To be effective an ozone disinfection process requires a minimum disinfection of a 4-log reduction of waterborne viruses and a 3-log reduction of Giardia cysts at the minimum temperature of the product stream.

b) The product water should always contain a sufficient residual ozone concentration for an adequate contact time to destroy or remove all waterborne pathogens. The appropriate CT values for Giardia reduction and virus reduction are given in Table 1 and Table 2 referenced at the end of this appendix.

6.4 Additional Ozonation Disinfection Considerations

6.4.1 pH

a) Ozone disinfection efficiency varies with pH.

b) These differences are not consistent among different groups of microorganisms.

c) These differences are a result of changes in the ozone decomposition rate and do not significantly alter the disinfection rate.

d) The most important impact of pH on ozonation is the control of disinfection by-products.

e) Lowering the pH may significantly reduce the conversion rate of bromide to bromate.

6.4.2 Temperature

a) Ozone becomes less soluble and less stable as water temperature increases.

b) Higher temperatures increase the rate of ozone decomposition. Tables 1 and 2 for CT values (referenced at the end of this appendix) reflect the temperature dependence for adequate disinfection.

6.4.3 Suspended Matter or Turbidity

a) Turbidity is caused by suspended particulate matter in water, such as clay, silt, organic and inorganic matter. Increased levels of particulate matter impact the disinfection efficiency of ozone by: increasing the ozone demand of the water so there will be an inadequate level of ozone for disinfection; and adsorption of microorganisms to the surface of the particulates where they may be shielded from the disinfection process.

b) Suitable controls should be established so turbidity does not exceed acceptable levels.

6.5 Inactivation of Microorganisms

6.5.1 Bacteria

a) Ozone destroys bacteria by: attacking and destroying the cell membrane, and disrupting enzyme activity by interfering with the sulfhydryl groups of enzymes.

b) Bacterial spores tend to be more resistant to ozonation than vegetative cells. Spores of gram positive Bacillus and Mycobacterium are the most resistant.

c) Relatively low levels of ozone will kill most vegetative bacteria, whereas viruses and protozoa are most resistant.

6.5.2 Viruses

a) Ozone destroys most viruses by attacking the virion capsid.

b) Ozone disrupts the virus-host attachment sites and breaks down the capsid releasing the genetic material into the environment.

c) Viruses are more resistant to ozonation than vegetative bacteria but can be less resistant than Mycobacterium spores.

6.5.3 Protozoa

a) Ozone destroys most protozoa by attacking and damaging the cell membrane resulting in increased porosity and/or cell rupture.

b) Protozoa cysts are more resistant to ozone than bacteria or viruses.

c) Cysts of different species of protozoa have a wide variation in susceptibility to ozone. Cryptosporidium and Acanthameoba (pathogenic protozoa found in surface waters) are ten times more resistant to ozone than Giardia cysts.

d) If protozoa contamination of water is suspected, a microfiltration step may be necessary to physically remove any cysts from the water.

For information including tables for ozone disinfection for Giardia, viruses, etc. consult the Alternative Disinfectants and Oxidants Guidance Manual (EPA 815/R-99-014), published by the United States Environmental Protection Agency.

APPENDIX 7: WHEN DISINFECTION IS NECESSARY

Section 8 of the *Water Supplies Regulation (M.R. 330/88R)* under *The Public Health Act* of Manitoba states:

> ***Disinfecting water supply***
> ***8(1)*** *All surface water shall be considered unsafe for domestic purposes unless boiled, chlorinated, or otherwise disinfected to the satisfaction of the medical officer of health.*
>
> ***8(2)*** *All private drinking water derived from shallow wells shall be disinfected to produce a microbiologically safe water, but disinfection is not required in the absence of erratic or high level coliform contamination or other contaminating factors.*

To ensure overall end product safety, disinfecting the water prior to distribution to consumers is usually necessary and required by the permitting agency. The decision to require disinfection and the type of treatment is dependent upon the level of safety of the water supply and the water bottling process.

Sources which may be safe enough to use without disinfection include a licensed municipal system or the direct tapping of a ground water of the maximum level of safety as defined in section 3.3.1 of the Guideline (Volume 1). Since most processes and handling practices have a risk of microbiological contamination, even water from these sources should incorporate a disinfection treatment. This is especially crucial during public Boil Water Advisory situations – see Section 8.0 in Volume 1 of the Guidelines.

Every situation is different and should be evaluated on a risk basis. For example, hauling water in tanks creates a potential contamination risk. This risk may be minimized if the tanker is dedicated to water. The incorporation of stringent safety controls for the filling and the emptying of the tank may reduce the risk so that the product may be bottled in sterile containers without prior disinfection. However, most bottlers disinfect prior to bottling to ensure water safety.

Water that would **not** be suitable for use without a disinfection treatment includes:

a) water from a surface water source;

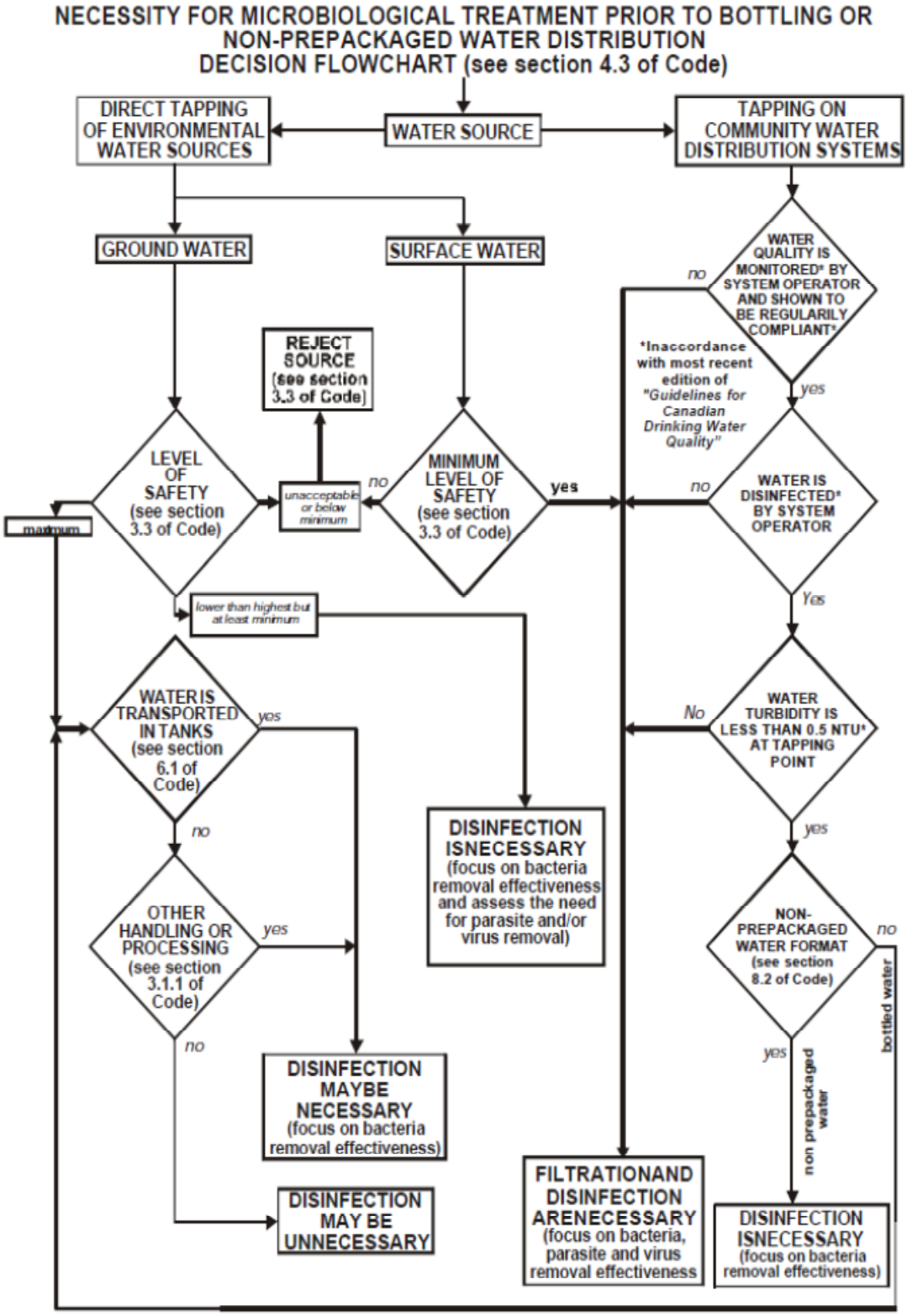
b) water from a public or private water system that is not disinfected, adequately monitored or demonstrated to be safe in accordance with the most recent edition of Health Canada's *Guidelines for Canadian Drinking Water Quality*; or

c) water obtained from a ground water source which does not meet the requirements for the *maximum level of safety*.

Water that originates from or includes surface water *(note: this may include water distribution systems)* should be filtered to remove possible parasites and treated to remove or inactivate harmful viruses and bacteria. Ground water which is not of the *maximum level of safety* should be assessed for the need to remove parasites and should be treated to remove or inactivate harmful viruses and bacteria.

Non-prepackaged water should be disinfected immediately before distribution to the consumer.

APPENDIX 7: WHEN DISINFECTION IS NECESSARY



APPENDIX 8: PREVENTION OF BROMATE FORMATION

DECISION FLOWCHART (see section 4 of the Code)