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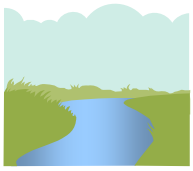
PUBLIC HEALTH ENGINEERING GUIDELINE:
SMALL WATER SYSTEMS DESIGN GUIDELINES – SURFACE WATER SOURCE



1. INTRODUCTION

These design guidelines provide guidance for small water system owners when they consider starting up a new water system or improving their existing water systems with a ***surface water source***. The requirements set out in these guidelines are not exhaustive. Details of any water system must be reviewed based on the specific conditions of each individual site.

1. The guidelines co-ordinate with Northern Health's drinking water treatment objectives:

4	log (99.99%) reduction or inactivation of enteric viruses (using *rotavirus* as target)
3	log (99.9%) reduction or inactivation of protozoan cysts (including *Giardia* and *Crypto*)
2	treatment processes (multi-barrier approach)
1	NTU turbidity maximum
0	*E. coli* and Total Coliforms

2. A valid ***Construction Permit*** is required before any work is started on water systems and application by a qualified professional engineer, experienced in the design of small water systems, is recommended. Applications *may* be accepted from a designer who is *not* a qualified professional under the following circumstances:

   - Designer is knowledgeable and experienced in the water supply field
   - Designer accepts legal liability for water supply system design
   - Small water system, serving fewer than 500 persons in any 24-h period
   - Acceptable source water quality, with no unusual chemistry
   - Standard water treatment equipment proposed, and used in a standard way.

The overall process of approving a ***new*** water supply system is outlined in **Figure 4** on page 5. If you have any questions, please contact an Environmental Health Officer (Drinking Water Officer) at your nearest Health Unit.

2. WATER SOURCE

1. The surface water source should be protected from potential contamination.
2. Water from man-made ponds is generally not acceptable.
3. Proper strainers should be provided at the intake. The intake should be located away from the bank, preferably a minimum of 300 mm (12") below the water surface and 300 mm (12") above the bottom of the creek or lake. Details on the design of the intake may be obtained from the Fisheries and Oceans Canada publication: *Fresh Water Intake End of Pipe Fish Screen Guideline* [www.dfo-mpo.gc.ca/Library/223669.pdf].

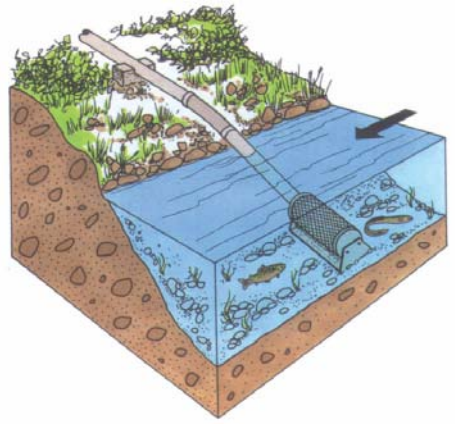


Figure 1. Example Fresh Water Intake (DFO, 1995)

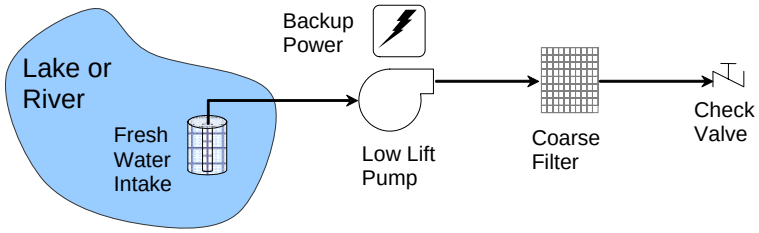


Figure 2. Typical Surface Water Source Intake and Raw Water Pump

4. The water supplier must arrange to analyse a sample of raw, untreated water from the source for the suite of water quality parameters listed in **Table 1** on page 6. Note that UVT (transmittance) is always required if UV disinfection is being considered. A list of laboratories approved by the BC Provincial Health Officer for drinking water is available from your Environmental Health Officer at the Health Unit, or on-line: using Google, search for EWQA. Select *Enhanced Water Quality Assurance* and then click on *PHO - Approved Laboratory List*.
5. A Water Licence from MoE is recommended to establish water rights.

3. PUMPING

1. Fuel, diesel pump or the electricity generator must be kept away from the water source and properly contained.
2. Fuel must not be spilled on the ground during refuelling of any equipment.
3. Backup equipment should be available.
4. A positive pressure [min. 140 kPa (20 psi)] must always be present in the distribution system.

4. FILTRATION

1. To prevent excessive blockage, raw water should be pre-filtered through a series of progressively finer filters; 20 micron (µm) and 5 micron filter in series are recommended.
2. A 1 micron **absolute** filter or membrane filter is needed if filtration is used to reduce the levels of protozoan cysts (*Crypto* and *Giardia*).
3. Disinfection (chlorination) of water is always required in addition to filtration.

5. ULTRA VIOLET TREATMENT

1. Ultra-violet (UV) treatment is effective at inactivating or killing pathogenic bacteria and protozoan cysts, and some viruses. Not all pathogenic viruses are inactivated by UV.
2. The UV unit must be certified to meet the NSF 55 Class A standard; this means that the equipment will have a minimum UV dose of 40 mJ/cm^2 at the alarm set point, with built-in sensors and automatic shut off when the dose rate is not achieved.
3. Raw water to be treated should have UV Transmittance (UVT) of more than 80%. Several samples should be tested for UVT throughout the year. Samples should be collected at the time of the year when the water quality is at its worst in terms of organic content.
4. If the UVT in the raw water is low due to high organic content (TOC), an appropriate ***activated carbon filter*** can usually improve the water quality to the extent that UV treatment is possible.
5. Maximum flow rate must be determined and the unit properly sized to meet the demand; In general, a single tap could discharge as much as 8 litres (2 gallons) per minute of water.

6. The safety features that are provided in the UV system should be listed; some of these features may be built-in but some may be external components that have to be installed. Provide a schematic diagram showing all ***mandatory*** features:
    - Flow restriction device
    - UV lamp intensity sensor (mostly built-in)
    - UVT sensor (mostly built-in)
    - Automatic shut off when the dose rate is not met or when the unit is unplugged
    - System failure alarms (list the alarms).
7. The assembly ***should*** include the following monitoring devices:
    - Flow meter
    - Pressure gauge at the downstream end of the UV unit.
8. The UV system should usually be installed after the pressure tank or in such a way that the raw water supply pump will be shut off when flow to the UV unit is shut off.
9. A 20 micron (µm) filter and 5 micron filter are required in series ***before*** the UV unit to protect it.
10. Bypass of the treatment unit is **not** allowed.
11. Whenever the UV unit is not operational, water should not be used for domestic purposes.
12. Chlorination of water is required **in addition** to UV treatment, to deal with pathogenic viruses and as part of the multi-barrier approach to drinking water security.

6. Disinfection (Chlorination)

1. Chlorination is effective at killing or inactivating pathogenic bacteria and viruses, but not protozoan cysts. Chlorination must be provided, regardless of whether UV and/or filtration are used, because surface water may contain pathogenic viruses which UV does not inactivate, and to provide a residual disinfectant to protect water in the distribution system (plumbing).
2. A 'concentration-time' of at least 12 min·mg/L must be provided. As a general rule, a residual "free chlorine" level of 1 mg/L for 20 minutes in a tank or pipe is recommended.
3. Adequate mixing should be provided; there should be sufficient storage time before the water is used and sufficient distance from the first user in the distribution system.
4. The amount of chlorine added should be measured with reasonable accuracy.
5. A chlorine meter that can measure down to 0.1 mg/L and up to at least 5 mg/L of free chlorine should be available and used on site.

7. Chemical Conditioning

1. Surface water may contain chemicals such as calcium, magnesium, iron, manganese, or colour that, while they are not dangerous to human health at normal levels, do affect the taste, odour, and suitability of water for other domestic purposes. In many cases, the aesthetic quality of the finished water can be improved by using filters and ion-exchange resins tailored to the particular water quality issues in the source water. Treatment for these aesthetic parameters is generally ***optional***.
2. Surface water may occasionally contain naturally-occurring chemicals which are hazardous to human health. In other cases, human activities, past or present, may have contaminated water with a variety of agricultural or industrial chemicals. In all cases, refer to the ***Guidelines for Canadian Drinking Water Quality*** for advice on the acceptable levels of these parameters. When specific parameters exceed the maximum acceptable concentration in the Canadian guidelines, treatment to reduce the levels of health-based parameters is usually ***mandatory***.

A "typical" treatment train conforming to steps 4 (Filtration), 5 (UV), and 6 (Chlorination) is presented in **Figure 3** below. This is a robust approach that works in many instances, but in every case, the actual treatment train should be tailored to the specifics of the source water chemistry and bacteriology. Chemical conditioning, such as softening or iron and manganese control, are common optional additions to improve the aesthetic quality of the finished water. The specific ***sequence*** of treatment units depends on the water chemistry, and needs to be carefully considered by the water treatment system designer.

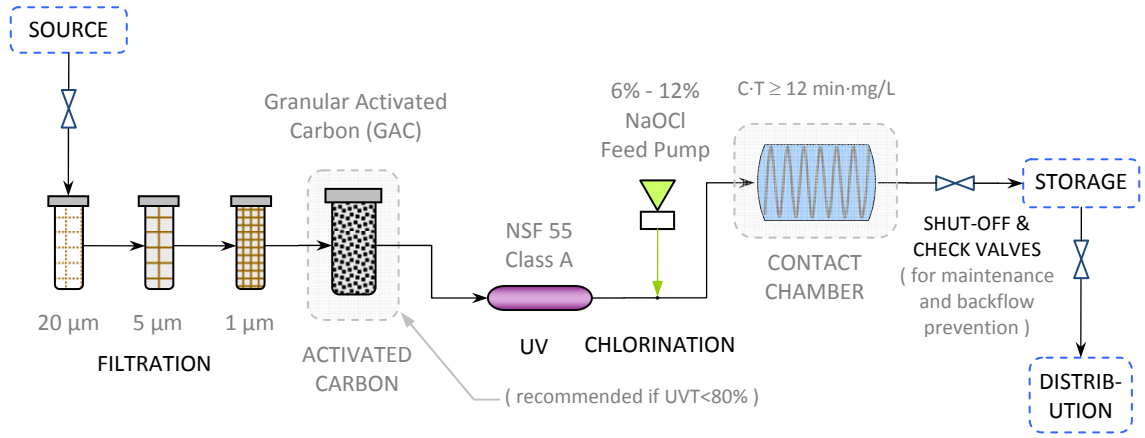


Figure 3. (EXAMPLE ONLY) **Typical Small Water System Surface Water Treatment Train**

8. PERMITTING

1. Under the *Drinking Water Protection Act*, every water system requires an **Operating Permit** before providing water service to users.
2. If this is a new water system, contact your local Environmental Health Officer to obtain the separate **Water System Application**.
3. A **Construction Permit** from Northern Health is required for commissioning of a new water system and also for every structural or mechanical change to an existing water system that may occur over time, but not including routine maintenance.
4. Construction, installation, alteration or extension of any part of a water supply system without a valid Construction Permit is an offence under **s45** of the Act.
5. Complete the submission package checklist included in your ***Waterworks Construction Permit Application***, to avoid delays due to incomplete documentation.
6. Allow 30-60 days lead time from the time an application with complete information is accepted to when your construction permit is issued.

The overall process of approving a ***new*** water supply system is outlined in **Figure 4** below. For ***existing*** water systems, the existing Operating Permit continues in force, so there is no need for a Water System Application, but most of the Construction Permit steps are identical. If you have any questions, please contact your local Environmental Health Officer.

Construction Permit (CP) *contact NH Public Health Engineer (PHE)*		**Operating Permit (OP)** *contact NH Drinking Water Officer (DWO)*
Steps 		
1. IDEA – the owner identifies a need for potable water supply.		
2. SOURCE – the owner decides on a proposed source of water for the system – usually surface water from a lake or stream, or groundwater from a well.	⇦	Owner should contact the DWO to advise on required analyses, sampling protocols, etc.
3. SAMPLES – the owner collects a first sample of water from the source for a complete suite of physical-chemical and bacteriological analyses – this allows an appropriate treatment system to be designed.		At this time, the owner needs to complete a **WATER SYSTEM APPLICATION**
4. DESIGNER – the owner usually hires a water system design specialist or professional engineering firm.		
5. DRAWINGS – the designer or owner prepares 1. regional location plan, 2. site plan, and 3. treatment system schematic to explain the proposed water system design.		
6. **CONSTRUCTION PERMIT APPLICATION** – the designer or owner applies to Northern Health PHE for a permit for construction of waterworks, together with all construction plans, equipment specifications, and a copy of the source water chemical analyses.		
7. **APPROVAL OF SOURCE** – the DWO reviews the source water chemistry and decides whether it is acceptable.	⇦	
8. CONSTRUCTION PERMIT REVIEW – PHE reviews the application against regulatory requirements and Northern Health policy. Allowing for design modifications, this step usually requires 30-60 days.		
CONSTRUCTION PERMIT ISSUED – PHE issues construction permit, with conditions.		
9. CONSTRUCTION * – installation of treatment, distribution, and storage facilities as per Construction Permit.	⇦	DWO may optionally inspect the works during construction
10. DISINFECTION – following construction, all new or altered works must be disinfected, with lab results from confirmatory samples sent to DWO.	⇨	DWO receives confirmation that the new equipment and distribution pipes are free of bacterial contamination
END OF CONSTRUCTION PERMIT PROCESS		**OPERATIING PERMIT ISSUED – DWO issues operating permit, with conditions.**

The Operating Permit (OP) process for a Water System can move forward in ***parallel*** with the Construction Permit process. For a ***new*** water system, the OP will not usually be issued until the CP process is completed. Key elements in the OP include:

- OPERATOR TRAINING – consistent with the level of complexity of the water system
- ROUTINE SAMPLING – locations, parameters and frequency
- CONTINGENCY & EMERGENCY RESPONSE PLAN

* Permits and approvals from other government agencies may be required before construction may begin.

Figure 4. The Process of Permitting a New Water System

Table 1. Required Surface Water Source Water Quality Parameters

Core Parameters	*Guideline*
☑ ***E. Coli***	***[none detected]***
☑ **Total Coliforms**	***[none detected]***
☑ HPC (1)	[~ 100-500 CFU/mL]
☑ Alkalinity	[~30-500 mg/L]
☑ Chloride	[250 mg/L]
☑ Colour	[15 TCU]
☑ Electrical Conductivity	[~800 µS/cm]
☑ **Fluoride**	**[1.5 mg/L]**
☑ Hardness	[~250 mg/L]
☑ Langelier Saturation Index	[~ -2 to +2]
☑ **Metals Scan**	**[varies]** (2)
☑ Nitrogen: (3)	
Ammonia	[~ 1.5 mg/L]
Organic N	[~ 0.5 mg/L]
Nitrate	**[10 mg/L]**
Nitrite	**[1 mg/L]**
☑ pH	[6.5 – 8.5]
☑ Sulphate	[500 mg/L]
☑ Total Dissolved Solids (TDS)	[~ 500 mg/L]
☑ Total Organic Carbon (TOC)	[2.5 mg/L]
☑ **Turbidity**	**[1 NTU]**

May require …	**Guideline**
☐ UV Transmittance (UVT) (4)	[~80%]
☐ **Disinfection By-Products (DBPs)** (5)	
THMs	**[0.100 mg/L]**
HAAs	**[0.080 mg/L]**
☐ Tannins & Lignins (6)	[~ 0.400 mg/L]
☐ Iron & Sulphate Bacteria (7)	[presence]
☐ Sulphide (8)	[0.050 mg/L]
☐ **Hydrocarbons** (9)	
Benzene	**[0.005 mg/L]**
Toluene	**[0.024 mg/L]**
Ethylbenzene	**[0.002 mg/L]**
Xylenes	**[0.300 mg/L]**

General Comments

1. The sampler must make arrangements for receiving and shipping of chemical/physical sample bottles and coolers with an accredited private lab. *Northern Health* may accept bacteriological samples only.
2. Analysis of additional parameters may be required based on the results of the initial analysis and on potential impact by nearby sources of contamination. The required parameters should be confirmed with *Northern Health* before sampling.
3. The analytical detection limit must be *less than 10% of the Guideline for Canadian Drinking Water Quality* where applicable. Other analyses must provide sufficient information to reasonably assess the water suitability for domestic use and to determine what, if any, treatment might be needed. Analyses must be conducted in accordance with the methods prescribed in *Standard Methods* (latest edition).
4. Analyses should be for total or closely equivalent concentrations, to represent potential quality problems.
5. A copy of all analytical results must be sent to the *Northern Health* Officer responsible for the water system.

Notes

(1) May be omitted if bacterial growth is not found during Total Coliform test – lab to note "*Other bacterial growth not present*".

(2) *Total metals* required. *Dissolved metals* optional, but recommended if turbidity is elevated. Scan to include both high and low level metals: *Aluminum (if coagulant used)*, ***Antimony (0.006)***, ***Arsenic (0.010)***, ***Barium (1)***, ***Boron (5)***, ***Cadmium (0.005)***, *Calcium (~100)*, ***Chromium (0.050)***, *Copper (0.500)*, *Iron (0.300)*, ***Lead (0.010)***, *Magnesium (~30)*, *Manganese (0.050 - **0.500**)*, *Molybdenum, Nickel, Phosphorus, Potassium*, ***Selenium (0.010)***, *Silver, Sodium (20-200), Zinc (5)* [expand scan if zone is mineralised to include ***Mercury (0.001)*** and ***Uranium (0.020)***].

(3) Required for source water characterisation. If all are < 1 mg/L as N, later samples may be analysed for **Total N** only.

(4) Required if UV disinfection is being considered as part of the water treatment process. The test must be conducted on a RAW, UNFILTERED water sample. [Modified version of *Standard Method* 5910B where the sample is not filtered or pH adjusted.]

(5) Required if chlorination is used or proposed and TOC>2.5 mg/L. For new sources, specify "*DBP **formation potential***". Different DBPs are required for chlorine dioxide or ozone disinfection.

(6) Required for TOC>2.5 mg/L and/or Colour>15 TCU.

(7) Required if bacterial regrowth is suspected in well or distribution piping. Contact laboratory for sampling procedure.

(8) Required if unsatisfactory odour is suspected. Analyse on site or preserve sample. Contact laboratory for sampling procedure.

(9) Required if hydrocarbon/gasoline type contamination is suspected. Contact laboratory for sampling procedure.

Colours: **red → health parameter**, violet → aesthetic, black → treatment options