DISCUSSION PAPER

Arrowsmith Water Service
Englishman River Water Intake Study
Phase 1 – Conceptual Planning

Discussion Paper 4-2 – Drinking Water Quality Criteria

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1 Introduction

This discussion paper defines the drinking water quality objectives for the future Englishman River Water Treatment Plant. Current B.C. drinking water legislation and Canadian guideline recommendations relevant to the treatment plant are identified, and future developments in water quality regulation are predicted. By comparing the water quality data compiled in Discussion Paper 4-1 to these regulations, treatment objectives are established.

2 Existing Legislation and Guidelines

Drinking water quality legislation in Canada is developed on a provincial level, thus each province and territory has different regulations in place. On a federal level, Health Canada develops drinking water quality guidelines that each province can choose to incorporate into their regulations as they see fit. These guidelines are the Guidelines for Canadian Drinking Water Quality (GCDWQ).

In British Columbia, drinking water legislation is 'outcome-based', meaning that no specific water treatment processes are stipulated. Instead, the legislation states that the final water product delivered to consumers must meet a specified standard determined by the local Drinking Water Officer (DWO). Where the standard is not met, treatment is required.

2.1 Provincial Legislation

The two key pieces of BC legislation applying to drinking water quality are the Drinking Water Protection Act (DWPA) and the Drinking Water Protection Regulation (DWPR).

2.1.1 Drinking Water Protection Act

The DWPA (MHLS, 2001) grants authority to the DWOs to stipulate directives that must be followed by the public water supplier. The DWOs are organized into five

regional authorities. For Vancouver Island, this is the Vancouver Island Health Authority (VIHA). Typically VIHA requires that drinking water must be treated to a level that satisfies the GCDWQ, discussed in Section 2.2.

VIHA has also commonly adopted the "4-3-2-1-0 Drinking Water Objective" (Interior Health, 2006), published by the Interior Health regional authority, which states the following requirements:

- Minimum 4-log inactivation of viruses.
- Minimum 3-log inactivation of *Cryptosporidium* and *Giardia*.
- Minimum of two separate treatment processes for all surface water drinking water systems, specifically filtration and disinfection.
- Maximum turbidity of 1 NTU with a target of 0.1 NTU.
- 0 total coliforms, fecal coliforms, and *Escherichia coli* detected.

The VIHA document "Guidelines for the Approval of Water Supply Systems" (VIHA, 2006) reiterates the 4-3-2-1-0 rule, with the exception of not mandating filtration for all surface waters, but also stating that treated drinking water should normally produce a minimum chlorine residual of 0.2 mg/L or a chloramine residual of 1 mg/L throughout the distribution system. Where filtration has been avoided, VIHA has usually referred to the "Exclusion of Filtration" criteria in the GCDWQ Turbidity technical document.

2.1.2 Drinking Water Protection Regulation

The DWPR is a component of the DWPA (MHLS, 2008). In addition to listing the minimum number of monthly samples required from a public distribution system based on population size, the DWPR lists the acceptable limits for microbiological parameters in the final treated water product:. Essentially the DWPR is the only part of BC legislation that has specific values for water quality parameters, in this case for bacterial activity. Water that reaches the public must contain:

- No detectable fecal coliform bacteria per 100 mL.
- No detectable Escherichia coli per 100 mL.
- Little to no detectable total coliform bacteria, depending on the frequency of samples taken:
  - If only 1 sample was taken in a 30 day period, no detectable total coliform per 100 mL is permitted.
  - If more than 1 sample was taken in a 30 day period, at least 90% of samples are to have no detectable total coliform bacteria and no sample to have more than 10 total coliform bacteria per 100 mL.

2.2 Federal Guidelines

Health Canada has developed and continually updates the GCDWQ (Health Canada, 2008). The GCDWQ is not part of BC legislation, but DWOs under the DWPA typically require that water from new treatment facilities satisfy the GCDWQ criteria. The most current edition of the GCDWQ is available on the Health Canada website, and a summary of the GCDWQ can be found at the following address:
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

2.2.1 Turbidity

Based on the water quality data reviewed in Discussion Paper 4-1 the Englishman River raw water generally conforms to the maximum acceptable concentrations (MACs) and aesthetic objectives (AOs) developed under the GCDWQ. The one significant exception is turbidity (Health Canada, 2003).

Typically treatment of turbidity involves particulate removal processes in the form of direct filtration or clarification followed by filtration. The GCDWQ recommends filtration for all surface waters. The guideline lists different turbidity objectives depending on the type of filtration process employed, specifically:

- For chemically-assisted filtration, which includes direct filtration or clarification followed by filtration, turbidity shall be less than or equal to 0.3 NTU in at least 95% of the measurements made or 95% of the time each calendar month, and shall never exceed 1.0 NTU.
- For slow sand or diatomaceous earth filtration, turbidity shall be less than or equal to 1.0 NTU in at least 95% of the measurements made or 95% of the time each calendar month, and shall never exceed 3.0 NTU.
- For membrane filtration, turbidity shall be less than or equal to 0.1 NU in at least 99% of the measurements made or 95% of the time each calendar month, and shall never exceed 0.3 NTU.

If membrane filtration is the sole treatment technology employed, the GCDWQ indicates that some form of virus inactivation should follow the filtration process. This requirement would need to be satisfied as part of VIHA's requirements.

The turbidity guideline details disinfection credits that are granted for typical processes. The credits granted for different filtration technologies are detailed in **Table 2-1**.

Table 2-2
Disinfection Credits for Filtration

Technology	*Cryptosporidium* / *Giardia* Credit	Virus Credit
Conventional filtration	3.0 log	2.0 log
Direct filtration	2.5 log	1.0 log
Slow sand filtration or diatomaceous earth filtration	3.0 log	2.0 log
Membrane filtration	Removal efficiency demonstrated through challenge testing and verified by direct integrity testing.	No credit for microfiltration and ultrafiltration. For nanofiltration and reverse osmosis, removal efficiency demonstrated through challenge testing and verified by direct integrity testing.

2.2.2 Aluminum

A MAC has not been set for Aluminum under the GCDWQ. However the supporting guidance document (Health Canada, 1998) directs that aluminum concentrations should not increase by more than 0.100 mg/L over raw water levels during conventional treatment and no more than 0.200 mg/L for other types of treatment systems. Coagulant chemicals, which are used in pre-treatment steps to filtration, are often aluminum based. This guideline is significant to Arrowsmith in that coagulant doses at the future water treatment plant should be optimized to ensure that aluminum concentrations do not increase excessively during treatment.

2.3 Summary

Based on current BC legislation and expected VIHA standards, the proposed Englishman River Water Treatment Plant will need to satisfy the following objectives:

- Subject Englishman River water to at least filtration and disinfection.
- Reduce treated water turbidity to less than 0.1 NTU to 1.0 NTU, depending on the filtration process used.
- Achieve a minimum 4-log removal or inactivation of viruses and 3-log removal or inactivation of *Cryptosporidium* and *Giardia*.

- Achieve a minimum 0.2 mg/L free chlorine (or 1.0 mg/L chloramine) residual in the distribution system.
- Maintain total coliform, fecal coliform, and *E.Coli* levels to below detection in the distribution system.
- Minimize the increase of aluminum concentrations during treatment.

These objectives will need to be met while not exceeding the MACs for any parameters under the GCDWQ and preferably not exceeding the AOs.

3 Future Regulations

In addition to meeting existing standards and guidelines, it is prudent to anticipate future changes to drinking water regulations, which are likely to become more stringent as time progresses.

The GCDWQ is continuously reviewing and producing new guidelines. Health Canada lists "Upcoming documents" for water quality parameters that are currently being reviewed. Examples of these upcoming documents that are relevant to Arrowsmith include the following:

- Currently being prepared for public consultation:
  - Protozoa – guidance technical document
  - Enteric viruses – guidance technical document
- Currently being prepared for final approval/posting:
  - Corrosion control – guidance document

Historically Canadian drinking water objectives have generally followed changes to US regulations, albeit often with a lag of several years. In other areas such as radionuclides, the GCDWQ could be considered ahead of the U.S. regulations. A review of current US drinking water quality regulations is one indicator of potential changes to Canadian legislation predicted to occur within the lifetime of the new Englishman River Water Treatment Plant.

Two series of US drinking water regulations are of interest, which focus on filtration and disinfection. These two sets of regulations are discussed below.

3.1 Enhanced Surface Water Treatment Rule

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), states that the extent of Cryptosporidium inactivation required is dependant on the levels of the protozoan present in raw water (USEPA, 2006A). The different levels of inactivation, organized into "Bins", are shown in **Table 3-1**.

Table 3-1
***Cryptosporidium* Inactivation Goals under the LT2ESWTR**

Bin	Raw Water *Cryptosporidium* Levels (count/L)	Required *Cryptosporidium* Inactivation
1	< 0.075	3-log (99.9%)
2	0.075 to < 1.0	4-log (99.99%)
3	1.0 to < 3.0	5-log (99.999%)
4	≥ 3.0	5.5-log (99.9997%)

If *Cryptosporidium* counts in the Englishman River exceed the 0.075 count/L criteria for Bin 1, *Cryptosporidium* removal requirements under this rule will be more stringent than the Canadian objectives. The rule is still in its initial phase of implementation, in that the majority of US treatment plants are not yet required to comply. It is therefore likely that a Canadian equivalent of this rule will not be developed until several years into the life of the new Arrowsmith Water Treatment Plant. If it is determined that Englishman River water fits into Bin 2 or higher, and sufficient treatment is not incorporated to achieve this level of *Cryptosporidium* inactivation when the plant is first constructed, provisions should be made to allow an upgrade for greater *Cryptosporidium* inactivation in the future.

3.2 Disinfectants and Disinfection Byproducts Rule

The Stage 1 Disinfectants and Disinfection Byproducts Rule (S1DBPR), focuses on regulating the formation of disinfection byproducts, particularly trihalomethanes (THMs) and haloacetic acids (HAAs) (USEPA, 1998). Limits and long term goals for specific THMs and HAAs are defined, as well as total THM and HAA limits which are slightly more stringent than the GCDWQ. The S1DBPR is also significant in that it requires a minimum level of total organic carbon (TOC) removal, depending on initial water quality conditions as detailed in **Table 3-2**. The purpose of TOC removal is to reduce the level of potential THM and HAA precursors before they can react with chemicals used in the disinfection process.

Table 3-2
TOC Minimum Removal under the S1DBPR

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 to 60	>60 to 120	> 120
> 2.0 to 4.0	35.0%	25.0%	15.0%
> 4.0 to 8.0	45.0%	35.0%	25.0%
> 8.0	50.0%	40.0%	30.0%

The S1DBPR offers alternative compliance criteria for treatment systems that cannot achieve the target levels of TOC removal. The criteria relevant to Arrowsmith are as follows:

- The treated water TOC is less than 2.0 mg/L.
- The raw water TOC is greater than 4.0 mg/L and alkalinity is greater than 60 mg/L as $CaCO_3$, and the treated water contains less than 0.040 mg/L THMs and 0.030 mg/L HAAs.
- Treated water contains less than 0.040 mg/L THMs and 0.030 mg/L HAAs, and only chlorine is used for primary disinfection and to maintain a residual in the distribution system.
- The Specific Ultraviolet Absorbance (SUVA) of the raw and treated water is less than 2.0 L/mg-m.

Based on the water quality data presented in DP 4-1, between 45 and 50% TOC removal from Englishman River raw water would be required under the S1DBPR. Alternatively, the future Englishman River water treatment plant would need to satisfy at least one of the S1DBPR alternative compliance criteria.

The Stage 2 Disinfectants and Disinfection Byproducts Rule (S2DBPR) builds on S1DBPR by stipulating that public water suppliers must identify the locations in their distribution systems where the greatest formation of THMs or HAAs occur, and monitor these locations regularly to ensure the yearly average levels at these locations are below the THM and HAA Maximum Contaminant Levels (USEPA, 2006B). Previously, measurements of disinfection byproducts were made at the discharge of the water treatment plant. As formation of these compounds is time dependent, monitoring within the distribution system effectively makes the limits more stringent. This approach should be used for the Arrowsmith Water Service system.

3.3 Other Parameters

The U.S. EPA also provides a source of information as to parameters of concern to them by publish a “Contaminant Candidate List” (CCL). The list of contaminants is available at www.epa.gov/safewater/ccl/ccl3.html (USEPA, 2009)

Some of the CCL chemicals fall under a group of chemicals commonly referred to as “Pharmaceuticals, Personal Care Products and Endocrine Disrupting Compounds”. This is an emerging area of concern and there is considerable research underway around the world to ascertain if regulated limits should be established for these compounds in drinking water. There are thousands of such compounds, usually at low concentrations in source waters. Treatment needs vary based on the chemicals present. Fortunately, the presence of these chemicals in the Englishman River is expected to be extremely low and not of concern.

3.4 Summary

Canada has historically generally followed the US in developing drinking water quality standards and regulations. By looking at existing US federal legislation relevant to treating water from the Englishman River, the following changes to Canadian drinking water quality standards and legislation are anticipated in the future:

- A greater level of *Cryptosporidium* removal/inactivation being required during treatment. Depending on typical concentrations of the oocyst in raw water, between 4-log and 5-log removal/inactivation may be required.
- A minimum of 45-50% TOC removal will be required during treatment, depending on typical TOC in the raw water. Otherwise, an alternative compliance criteria will need to be met, related to treated water TOC or SUVA levels, or THM and HAA concentrations in the distribution system.

4 Other Considerations

Englishman River water is generally neutral in pH, but the low alkalinity and hardness suggest that corrosion in the distribution system may occur. The draft Health Canada document “Corrosion Control in Drinking Water Distribution Systems” (Health Canada, 2007) and existing US federal legislation (USEPA, 2004) considers corrosion an issue only in that lead, copper, or iron concentrations may increase in treated water as corrosive water leaches metal from distribution pipe. Elevated copper and iron levels can reduce the aesthetic appeal of drinking water, while high lead concentrations are a health issue. Beyond water quality, however, corrosive water may be of concern in that it will slowly degrade the integrity of water pipe and reduce the life of household fixtures such as hot water tanks. Infrastructure asset

replacement is a significant issue in North America, and more frequent maintenance and pipe replacement may be required for corrosive waters. With the very low alkalinity and hardness in the Englishman River water, ensuring a stable treated water will be important.

5 Water Treatment Objectives

Based on a review of existing and predicted changes drinking water legislation in BC, the new Arrowsmith water treatment plant should achieve the following objectives:

- Include filtration, disinfection, and water stabilization for corrosion control as treatment processes.
- Reduce turbidity to significantly less than 1.0 NTU, depending on the filtration process used.
- Achieve the following microbiological treatment objectives at minimum:
  - 3-log (99.9%) removal or inactivation of *Cryptosporidium* and *Giardia*.
  - 4-log (99.99%) removal or inactivation of viruses
- Reduce raw water TOC levels by 45-50% or satisfy the alternative compliance criteria related to low treated water TOC and SUVA, or low THM and HAA formation in the distribution system.
- Achieve a minimum 0.2 mg/L free chlorine or 1.0 mg/L chloramine residual in the distribution system.
- Maintain total coliform, fecal coliform, and *E.Coli* levels to below detection in the distribution system.
- Minimize the increase of aluminum concentrations during treatment.
- Provide flexibility in the treatment process for potential future addition of processes that may be required to address new regulations.

6 List of References

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