DESIGN GUIDELINES

FOR FIRST NATIONS WATER WORKS

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FOREWORD

The Design Guidelines for First nations Water Works (Design Guidelines) were developed to serve as a general guide to engineers in the preparation of plans and specifications for public water supply systems on First Nations Lands.

The intent of this Document is to propose limiting values for parameters and components from which an evaluation may be made by the reviewing authority of the engineer's plans and specifications. The fundamental intent of this Document is therefore to establish, as far as is practical, a uniformity of design and practice for First Nations water systems.

In recent years, some chemical contaminants have had their maximum acceptable concentration (MAC) levels reduced while concern for microbiological contaminants in public water supplies has heightened. Recent events in Canada have emphasized the need for both filtration and continuous disinfection of any surface water or groundwater under the direct influence of surface water (GUDI).

As far as is practicable, this document includes recently developed processes and equipment currently available to the water industry.

The policy of these Design Guidelines is to encourage, rather than obstruct, the development of new processes and equipment. Thus, recent developments may be acceptable if they meet at least one of the following conditions:

1. Have been thoroughly tested in full scale comparable installations under competent supervision;
2. Have been thoroughly tested as a pilot plant operated for a sufficient time to indicate satisfactory performance, or
3. A performance bond or other acceptable arrangement has been made to the owners, or official custodians are adequately protected financially or otherwise in case of failure of the process or equipment.

In addition to the above conditions, in order to be considered acceptable, recent developments must be proven to be effective in treating the same type of water as will actually be treated at the project site.

This document is intended for use by individuals who, are qualified to exercise the professional judgment necessary to select and design water supply facilities. The individual must be able to substantiate and define the design criteria based on engineering and scientific principles. Users should be cognizant of all applicable federal and provincial regulations, standards, protocols, and guidelines.

The terms “shall” and “must” are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding of the public health justifies such definite action. Other terms, such as “should”, “recommended”, and “preferred”, indicate desirable procedures or methods, with deviations subject to individual considerations.

Where reference is made to the “reviewing authority” this refers to the person or body that will provide guidance or council on specific standards or as regulated by the appropriate government agencies.

This Document, adopts the same format, chapter structure and general contents as the “*Recommended Standards for Water Works – 2003 Edition*” prepared by The Great Lakes - Upper Mississippi River Board Water Committee (commonly known and referred to as the “Ten State Standards”). But, this document is updated and revised as necessary to suit the requirements and needs of First Nations communities.

These Design Guidelines address most of the additions and revisions of the 2003 Edition of the Ten State Standards and include these Policy Statements:

a. Pre-engineered water treatment plants.
b. Control of organic contamination for public water supplies.
c. Internal corrosion control for public water supplies.
d. Trihalomethanes removal and control for public water supplies.
e. Reverse osmosis and nanofiltration for public water supplies.
f. Automated/unattended operation of surface water treatment plants.
g. Bag and cartridge filters for public water supplies.
h. Microfiltration and ultrafiltration for public water supplies.
i. Ultraviolet light for treatment of public water supplies.
j. Infrastructure security for public water supplies.

ACKNOWLEDGEMENTS

The source for many of the standards adopted herein is the publication "*Recommended Standards for Water Works – 2003 Edition*" which is a report of the Committee of the Great Lakes - Upper Mississippi River Board of State Engineers (of which the Province of Ontario is a member). As noted in the title of the source document, these Standards, better known as the 10-State Standards, were last updated in 2003.

These Design Guidelines are based on "INAC Design Guidelines for Water Works in BC Region, Fourth Edition" prepared by:

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POLICY STATEMENT ON PRE-ENGINEERED WATER TREATMENT PLANTS

Pre-engineered water treatment plants are normally modular process units, which are pre-designed for specific process applications and flow rates and purchased as a package. Multiple units may be installed in parallel to accommodate larger flows.

Pre-engineered water treatment plants have numerous applications but are especially applicable at small systems where conventional treatment may not be cost effective. As with any design the proposed treatment must fit the situation and assure a continuous supply of safe drinking water for water consumers. The reviewing authority may accept proposals for pre-engineered water treatment plants on a case-by-case basis where they have been demonstrated to be effective in treating the source water being used.

Factors to be considered include:

1. Raw water quality characteristics under normal and worst case conditions. Seasonal fluctuations must be evaluated and considered in the design.
2. Demonstration of treatment effectiveness under all raw water conditions and system flow demands. This demonstration may be on-site pilot or full scale testing or testing off-site where the source water is of similar quality. On-site testing is required at sites having questionable water quality or applicability of the treatment process. The proposed demonstration project must be approved by the reviewing authority prior to starting.
3. Sophistication of equipment. The reliability and experience record of the proposed treatment equipment and controls must be evaluated.
4. Unit process flexibility which allows for optimization of treatment.
5. Operational oversight that is necessary. At surface water sources full-time operators are necessary, except where the reviewing authority has approved an automation plan. See Policy Statement on Automated/Unattended Operation of Surface Water Treatment Plants.
6. Third party certification or approvals such as National Sanitation Foundation (NSF) for (a) treatment equipment and (b) materials that will be in contact with the water.
7. Suitable pre-treatment based on raw water quality and the pilot study or other demonstration of treatment effectiveness.
8. Factory testing of controls and process equipment prior to shipment.
9. Automated troubleshooting capability built into the control system.
10. Start-up, commissioning, follow-up training and troubleshooting to be provided by the installation contractor and equipment supplier.
11. Operation and maintenance manual. This manual must provide a description of the treatment, control and pumping equipment, necessary maintenance and schedule, and a troubleshooting guide for typical problems.
12. On-site and contractual laboratory capability. The on-site testing must include all necessary continuous and daily testing as deemed necessary by the Consulting Engineer. Contract testing may be considered for other parameters.

13. Manufacturers warranty and replacement guarantee. Appropriate safeguards for the water supplier must be included in contract documents. Consideration should be given to innovative technology where there is sufficient demonstration of treatment effectiveness and contract provisions to protect the water supplier should the treatment not perform as claimed.
14. Water supplier revenue and budget for continuing operations, maintenance and equipment replacement in the future.

POLICY STATEMENT ON CONTROL OF ORGANIC CONTAMINATION FOR PUBLIC WATER SUPPLIES

Although standards and advisories for organics are being developed, there have been numerous cases of organic contamination of public water supply sources. In all cases, public exposure to organic contamination must be minimized. There is insufficient experience to establish design standards which would apply to all situations. Controlling organic contamination is an area of design that requires pilot studies and early consultation with the reviewing authority. Where treatment is proposed, best available technology shall be provided to reduce organic contaminants to the lowest practical levels. Operations and monitoring must also be considered in selecting the best alternative. The following alternatives may be applicable:

1. Alternate Source Development.

2. Existing Treatment Modifications.

3. Air Stripping For Volatile Organics (See Section 4.3.5 Aeration).

4. Granular Activated Carbon

Consideration should be given to:

a. Using contact units rather than replacing a portion of existing filter media;

b. Series and parallel flow piping configurations to minimize the effect of breakthrough without reliance on continuous monitoring;

c. Providing at least two units. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved rate. Where more than two units are provided, each unit shall be capable of meeting the design capacity at the approved rate with one or more units removed from service;

d. Using virgin carbon; this is the preferred medium. Regenerated carbon using only carbon previously used for potable water treatment can be used for this purpose.

e. Acceptable means of spent carbon disposal.

Except for temporary, emergency treatment conditions, particular attention should be given to developing an engineering report which, in addition to the normal determinations, includes the following:

1. For organic contaminants found in surface water sources:

a. Type of organic chemicals, sources, concentration, frequency of occurrence, water pollution abatement schedule, etc.

b. Possible existing treatment plant modifications to lower organic chemical levels. Results of bench, pilot or full scale testing demonstrating treatment alternatives, effectiveness and costs;

c. A determination of the quality and/or operation parameters which serve as the best measurement of treatment performance, and a corresponding monitoring and process control program.

2. For organic contamination found in groundwater sources:

a. Types of organic chemicals, sources, concentration, estimate of residence time within the aquifer, plume delineation, flow characteristics, water pollution abatement schedule, etc.,

b. Results of bench or pilot studies demonstrating treatment alternatives, effectiveness, and costs,

c. A determination of the quality and/or operational parameters which serve as the best measure of treatment performance, and a corresponding monitoring and process control program,

d. Development and implementation of a wellhead protection plan.

The collection of the type of data listed above is often complicated and lengthy. Permanent engineering solutions will take significant time to develop. The cost of organic analyses and the availability of acceptable laboratories may further complicate both pilot work and actual operation.

Alternative source development or purchase of water from nearby unaffected systems may be a more expedient solution for contaminated groundwater sources.

POLICY STATEMENT ON INTERNAL CORROSION CONTROL FOR PUBLIC WATER SUPPLIES

Internal and external corrosion of a public water supply distribution system is a recognized problem that cannot be completely eliminated but can be effectively controlled. Aside from the economic and aesthetic problems, the possible adverse health effects of corrosion products, such as lead and copper, is a major consideration. See Section 8.6.7 for external corrosion control.

Corrosion of metallic pipes is a chemical oxidation process, which requires that both water and an oxidizing agent be present at metal surfaces. The process is driven by the energy released when atoms from the metal surface are converted into hydrated metal cations. The three main factors which can accelerate corrosion are:

a. Failure of the water chemistry to provide a coherent protecting film of corrosion products on the metal surface,

b. Increased biofilm activity as a result of loss of the regular controlling disinfectant residual, and

c. Direct electrical contact between different metals in the presence of high conductance water.

Control of corrosion is a function of the design, maintenance, and operation of a public water supply. These functions must be considered simultaneously in order for the corrosion control program to function properly. Corrosion problems must be solved on an individual basis depending on the specific water quality characteristics and materials used in the distribution system. Specific information can be obtained from publications of technical agencies and associations such as USEPA (Corrosion Manual for Internal Corrosion of Water Distribution Systems, 1984; Control of Lead and Copper in Drinking Water, 1993; Lead and Copper Regulations, 1994) and the American Water Works Association (Lead and Copper Strategies, 1990; Chemistry of Corrosion Inhibitors in Potable Waters, 1990; Internal Corrosion of Water Distribution Systems 2nd edition, 1996). Broad areas of consideration for a corrosion control program follow.

Internal Corrosion

1. Provide for a system of records by which the nature and frequency of corrosion problems are recorded. On a plat map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified.

2. When complaints are received from a customer, follow up with an inspection by experienced personnel or consultant experienced in corrosion control. Where advisable,

obtain samples of water using appropriate sampling protocols for chemical and microbiological analyses and piping and plumbing material samples. Analyses should be made to determine the type and, if possible, the cause of the corrosion.

3. Establish a program or conduct desktop analyses or pipe loop studies to determine the corrosiveness of the water in representative parts of the distribution system. Analysis for alkalinity, pH, temperature, calcium, specific conductance or total dissolved solids, chlorides, sulphates and corrosion products (such as lead, cadmium, copper, zinc and iron) should be performed on water samples collected at the treatment plant or wellhead and at representative points in the distribution system including first draw samples taken after the water had sat overnight at locations where lead-soldered copper internal plumbing is in use. By comparing the analyses of the source water with the distribution system water, and the first draw or flush water significant changes in alkalinity, pH, or corrosion products would indicate that corrosion may be taking place and thereby indicate that corrective steps may need to be taken.

4. Where possible, especially when corrosion has been detected provide a program that will measure both the physical and chemical aspects of the corrosion phenomena. Physical measurement of the rate of corrosion can be made by the use of coupons, easily removed sections of pipe, connected flow-through pipe test sections or other piping arrangements. At the same site, estimate the relative degree of corrosivity on a routine basis by using desktop analyses or corrosion indices such as the Langelier Index, Ryznar Index, calcium carbonate precipitation potential or Aggressiveness Index (AWWA C-400). Correlation of the data from the physical measurement with the data from the selected corrosion analysis may provide information to determine the type of corrective treatment needed (though the different indices may not always agree) and may allow for the subsequent use of the corrosion analysis alone to determine the degree of corrosivity in select areas of the distribution system.

5. If corrosion is found to exist throughout the distribution system, corrective measures at the treatment plant, pump station or well head should be initiated. A chemical feed can be made to provide a stable to slightly depositing water or water quality which mitigates the solubility of targeted parameters. In calculating the stability index and the corresponding chemical feed adjustments, consideration must be given to items such as the water temperature, if it varies with the season and within various parts of the distribution system; the velocity of flow within various parts of the distribution system; the degree of stability needed by the individual customer; and the dissolved oxygen content of distributed water, especially in water having low hardness and alkalinity. Threshold treatment involving the feeding of a ortho-or blended phosphate or a silicate to control corrosion may be considered for both ground and surface water supplies.

6. Additional control of corrosion problems can be obtained by a regulation or ordinance for the materials used in or connected to a distribution system. Careful selection of materials

compatible with the physical system or the water being delivered can aid in reduction of corrosion product production.

Note: Adjustment of pH for corrosion control must not interfere with other pH dependent processes (e.g., colour removal by alum coagulation) or aggravate other water quality parameters (e.g., THM formation). In addition, the use of ortho-or blended phosphates should not aggravate distribution microbial concerns or adversely impact wastewater facilities.

POLICY STATEMENT ON TRIHALOMETHANE REMOVAL AND CONTROL FOR PUBLIC WATER SUPPLIES

Trihalomethanes (THMs) are formed when free chlorine reacts with organic substances, most of which occur naturally. These organic substances (called "precursors"), are a complex and variable mixture of compounds. Formation of THMs is dependent on such factors as amount and type of chlorine used, temperature, concentration of precursors, pH, and contact time. Approaches for controlling THMs include:

1. Control of precursors at the source.

    a. Selective withdrawal from reservoirs - varying depths may contain lower concentrations of precursors at different times of the year.

    b. Plankton Control - algae and their by-products have been shown to act as THM precursors.

    c. Alternative sources of water may be considered, where available.

2. Removal of THM precursors and control of THM formation.

    a. Moving the point of chlorination to minimize THM formation.

    b. Removal of precursors prior to chlorination by optimizing:

        i. Coagulation/flocculation-sedimentation-filtration
        ii. Precipitative softening/filtration
        iii. Direct filtration

    c. Adsorption by powdered activated carbon (PAC).

    d. Lowering the pH to inhibit the reaction rate of chlorine with precursor materials. Corrosion control may be necessary.

3. Removal of THM.

    a. Aeration - by air stripping towers.

    b. Adsorption by:

        i. Granular Activated Carbon (GAC)
        ii. Synthetic Resins

4. Use of Alternative Disinfectants - Disinfectants that react less with THM precursors may be used as long as microbiological quality of the finished water is maintained. Alternative disinfectants may be less effective than free chlorine, particularly with viruses and parasites. Alternative disinfectants, when used, must be capable of providing an adequate distribution system residual. Possible health effects of by-products that may be produced by using alternative disinfectants must be taken into consideration.

Using various combinations of THM controls and removal techniques may be more effective than a single control or a treatment method.

All proposed modifications to existing treatment process must be approved by the reviewing authority. Pilot plant studies are desirable and may be necessary depending on the specific site conditions.

POLICY STATEMENT ON REVERSE OSMOSIS AND NANOFILTRATION FOR PUBLIC WATER SUPPLIES

Reverse osmosis (RO) is a physical process in which a suitably pre-treated water is delivered at moderate pressures against a semi-permeable membrane. The membrane rejects most solute ions and molecules, while allowing water of very low mineral content to pass through. The process produces a concentrated waste stream in addition to the clear permeate product. Reverse osmosis systems have been successfully applied to saline groundwater, brackish water, and seawater, as well as for inorganic contaminants such as radionuclides, nitrates, arsenic, etc. and other contaminants such as pesticides, viruses, bacteria and protozoa. A lower pressure RO called nanofiltration (NF), also known as membrane softening, has been successfully utilized for hard, high colour and high organic content feed water. NF has a lower monovalent ion rejection, making it more attractive to water with low salinity, thereby reducing post treatment and conditioning as compared to RO.

The following items should be considered in evaluating the applicability for reverse osmosis and nanofiltration:

1. Membrane Selection: Two types of membranes are typically used. These are cellulose acetate based and polyamide composites. Membrane configurations typically include tubular, spiral wound and hollow fibre. Operational conditions and useful life vary depending on type of membrane selected, quality of feed water, and process operating parameters.

2. Useful Life of the Membrane: The membrane replacement represents a major cost component in the overall water production costs. Membrane replacement frequency can significantly affect the overall cost of operating the treatment facility. Power consumption may also be a significant cost factor for RO plants.

3. Pre-treatment Requirements: Acceptable feed water characteristics are dependent on the type of membrane and operational parameters of the system. Without suitable pre-treatment or acceptable feed water quality, the membrane may become fouled or scaled and consequently shorten its useful life. Pre-treatment is usually needed for turbidity reduction, iron or manganese removal, stabilization of the water to prevent scale formation, microbial control, chlorine removal (for certain membrane types), and pH adjustment. Usually, at a minimum, cartridge filters should be provided for the protection of the membranes against particulate matter.

4. Treatment Efficiency: RO is highly efficient in removing metallic salts and ions from the raw water. However, efficiencies do vary depending on the ion being removed and the membrane utilized. For most commonly encountered ions, removal efficiencies will range from 85% to over 99%. Organics removal is dependent on the molecular weight, shape and charge of the organic molecule and the pore size of the membrane utilized.

Removal efficiencies may range from as high as 99% to less than 30%, depending on the membrane type and treatment objective.

5. Bypass Water: RO permeate will be virtually demineralised. NF permeate may also contain less dissolved minerals than desirable. The design should provide for a portion of the raw water to bypass the unit to maintain stable water within the distribution system and to improve process economics as long as the raw water does not contain unacceptable contaminants. Alternative filtration is required for bypassed surface water or ground water under the direct influence of surface water.

6. Post Treatment: Post treatment typically includes degasification for carbon dioxide (if excessive) and hydrogen sulphide removal (if present), pH and hardness adjustment for corrosion control and disinfection as a secondary pathogen control and for distribution system protection.

7. Reject Water: Reject water may range from 10% to 50% of the raw water pumped to the reverse osmosis unit. For most brackish water and ionic contaminant removal applications, reject is in the 10-25% range while for seawater it could be as high as 50%. The reject volume should be evaluated in terms of the source availability and from the waste treatment availabilities. The amount of reject water from a unit may be reduced to a limited extent by increasing the feed pressure to the unit. However, this may result in a shorter membrane life. Acceptable methods of waste disposal typically include discharge to a municipal sewer system, to waste treatment facilities, or to an evaporation pond.

8. Cleaning the Membrane: The membrane must be periodically cleaned with acid, detergents and possibly disinfection. Method of cleaning and chemicals used must be approved by the reviewing agency. Care must be taken in the cleaning process to prevent contamination of both the raw and finished water system. Cleaning chemicals, frequency and procedure should follow membrane manufacturer's guidelines.

9. Pilot Plant Study: Prior to initiating the design of a membrane treatment facility, the reviewing agency should be contacted to determine if a pilot plant study will be required. In most cases, a pilot plant study will be required to determine the best membrane to use, the type of pre-treatment, type of post treatment, the bypass ratio, the amount of reject water, system recovery, process efficiency and other design and operational criteria.

10. Operator Training and Start-up: The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training shall be provided prior to plant start-up.

POLICY STATEMENT ON AUTOMATED/UNATTENDED OPERATION OF SURFACE WATER TREATMENT PLANTS

Recent advances in computer technology, equipment controls and Supervisory Control and Data Acquisition (SCADA) Systems have brought automated and off-site operation of surface water treatment plants into the realm of feasibility. Coincidentally, this comes at a time when renewed concern for microbiological contamination is driving optimization of surface water treatment plant facilities and operations and finished water treatment goals are being lowered to levels of <0.1 NTU turbidity and < 20 total particle counts per millimetre.

Any measures, including automation, which assist operators in improved plant operations and surveillance functions are encouraged.

Automation of surface water treatment facilities to allow unattended operation and off-site control presents a number of management and technological challenges which must be overcome before an approval can be considered. Each facet of the plant facilities and operations must be fully evaluated to determine what on-line monitoring is appropriate, what alarm capabilities must be incorporated into the design and what staffing is necessary. Consideration must be given to the consequences and operational response to treatment challenges, equipment failure and loss of communications or power.

An engineering report shall be developed as the first step in the process leading to design of the automation system. The engineering report to be submitted to review authorities must cover all aspects of the treatment plant and automation system including the following information/criteria:

1. Identify all critical features in the pumping and treatment facilities that will be electronically monitored, have alarms and can be operated automatically or off-site via the control system. Include a description of automatic plant shut-down controls with alarms and conditions which would trigger shut-downs. Dual or secondary alarms may be necessary for certain critical functions.

2. Automated monitoring of all critical functions with major and minor alarm features must be provided. Automated plant shutdown is required on all major alarms.

3. The plant control system must have the capability for manual operation of all treatment plant equipment and process functions.

4. A plant flow diagram which shows the location of all critical features, alarms and automated controls to be provided.

5. Description of off-site control station(s) that allow observation of plant operations, receiving alarms and having the ability to adjust and control operation of equipment and the treatment process.

6. A certified operator must be on "standby duty" status at all times with remote operational capability and located within a reasonable response time of the treatment plant.

7. A certified operator must do an on-site check at least once per day to verify proper operation and plant security.

8. Description of operator staffing and training planned or completed in both process control and the automation system.

9. Operations manual which gives operators step by step procedures for understanding and using the automated control system under all water quality conditions. Emergency operations during power or communications failures or other emergencies must be included.

10. A plan for a six month or more demonstration period to prove the reliability of procedures, equipment and surveillance system. A certified operator must be on-duty during the demonstration period. The final plan must identify and address any problems and alarms that occurred during the demonstration period. Challenge testing of each critical component of the overall system must be included as part of the demonstration project.

11. Schedule for maintenance of equipment and critical parts replacement.

12. Sufficient finished water storage shall be provided to meet system demands and CT requirements whenever normal treatment production is interrupted as the result of automation system failure or plant shut-down.

13. Sufficient staffing must be provided to carry out daily on-site evaluations, operational functions and needed maintenance and calibration of all critical treatment components and monitoring equipment to ensure reliability of operations.

14. Plant staff must perform, as a minimum, weekly checks on the communication and control system to ensure reliability of operations. Challenge testing of such equipment should be part of normal maintenance routines.

15. Provisions must be made to ensure security of the treatment facilities at all times. Incorporation of appropriate intrusion alarms must be provided which are effectively communicated to the operator in charge.

POLICY STATEMENT ON BAG AND CARTRIDGE FILTERS FOR PUBLIC WATER SUPPLIES

Bag and cartridge technology has been used for some time in the food, pharmaceutical and industrial applications. This technology is increasingly being used by small public water supplies for treatment of drinking water. A number of states in the U.S.A. have accepted bag and cartridge technology as an alternate technology for compliance with the filtration requirements of the Surface Water Treatment Rule.

The particulate loading capacity of these filters is low, and once expended the bag or cartridge filter must be discarded. This technology is designed to meet the low flow requirement needs of small systems. The operational and maintenance cost of bag and cartridge replacement must be considered when designing a system. These filters can effectively, remove particles from water in the size range of *Giardia* cysts (5-10 microns) and *Cryptosporidium* (2-5 microns).

At the present time, filtration evaluation is based on *Giardia* cyst removal. However, consideration should be given to the bag or cartridge filters ability to remove particles in the size range of *Cryptosporidium* since this is a current public health concern.

With this type of treatment there is no alteration of water chemistry. So, once the technology has demonstrated the required removal efficiency, no further pilot demonstration may be necessary. The demonstration of filtration is specific to a specific housing and a specific bag or cartridge filter. Any other combinations of different bags, cartridges, or housings will require additional demonstration of filter efficiency.

Treatment of surface water should include source water protection, filtration, and disinfection.

The following items should be considered in evaluating the applicability of bag or cartridge filtration.

Pre-design/Design

1. The filter housing and bag/cartridge filter must demonstrate a filter efficiency of at least 2-log reduction in particles size 2 micron and above. Demonstration of higher log removals may be required by the reviewing authority depending on raw water quality and other treatment steps to be employed. The reviewing authority will decide whether or not a pilot demonstration is necessary for each installation. This filtration efficiency may be accomplished by:

    a. Microscopic particulate analysis, including particle counting, sizing and identification, which determines occurrence and removals of micro-organisms and other particle across a filter or system under ambient raw water source condition, or when artificially challenged.

b. *Giardia*/*Cryptosporidium* surrogate particle removal evaluation in accordance with procedures specified in NSF Standard 53 or equivalent. These evaluations can be conducted by NSF or by another third party whose certification would be acceptable to the reviewing authority.

c. "Particle Size Analysis Demonstration for *Giardia* Cyst Removal Credit" procedure presented in Appendix M of the EPA Surface Water Treatment Rule Guidance Manual.

d. "Nonconsensus" live *Giardia* challenge studies that have been designed and carried out by a third party agent recognized and accepted by the reviewing authority for interim evaluations. At the present time uniform protocol procedures for live *Giardia* challenge studies have not been established. If a live *Giardia* challenge study is performed on-site there must be proper cross-connection control equipment in place and the test portion must be operated to waste.

e. Methods other than these that are approved by the reviewing authority.

f. System components such as housing, bags, cartridges, membranes, gaskets, and O-rings should be evaluated under NSF Standard 61 or equivalent, for leaching of contaminants. Additional testing may be required by the reviewing authority.

2. The source water or pre-treated water should have a turbidity less than 5 NTU.

3. The flow rate through the treatment process shall be monitored with a flow valve and metre. The flow rate through the bag/cartridge filter must not exceed 80 Lpm unless documentation at higher flow rates demonstrates that it will meet the requirements for removal of particles.

4. Pre-treatment is strongly recommended. This is to provide a more constant water quality to the bag/cartridge filter and to extend bag and cartridge life. Examples of pre-treatment include media filters, larger opening bag/cartridge filters, infiltration galleries, and beach wells. Location of the water intake should be considered in the pre-treatment evaluation.

5. Particle count analysis can be used to determine what level of pre-treatment should be provided. It should be noted that particulate counting is a 'snap shot' in time and that there can be seasonal variations such as algae blooms, lake turnover, spring runoff, and heavy rainfall events that will give varied water quality.

6. It is recommended that chlorine or another disinfectant be added at the head of the treatment process to reduce/eliminate the growth of algae, bacteria, etc. on the filters. The impact on disinfection-by-product formation should be considered.

7. A filter to waste component is strongly recommended for any pre-treatment pressure sand filters. At the beginning of each filter cycle and/or after every backwash of the pre-filters a set amount of water should be discharged to waste before water flows into the bag/cartridge filter. Filter to waste shall be provided for the final filter(s) and a set amount of water shall be discharged to waste after changing the filters.

8. If pressure media filters are used for pre-treatment they must be designed according to Section 4.3.2.2.

9. A sampling tap shall be provided ahead of any treatment so a source water sample can be collected.

10. Pressure gages and sampling taps shall be installed before and after the media filter and before and after the bag/cartridge filter.

11. An automatic air release valve shall be installed on top of the filter housing.

12. Frequent start and stop operation of the bag or cartridge filter should be avoided. To avoid this frequent start and stop cycle the following options are recommended:

    a. A slow opening and closing valve ahead of the filter to reduce flow surges.

    b. Reduce the flow through bag or cartridge filter to as low as possible to lengthen filter run times.

    c. Install a recirculating pump that pumps treated water back to a point ahead of the bag or cartridge filter. Care must be taken to make sure there is no cross connection between the finished water and raw water.

13. A minimum of two bag or cartridge filter housings should be provided for water systems that must provide water continuously.

14. A pressure relief valve should be incorporated into the bag or cartridge filter housing.

15. Complete automation of the treatment system is not required. Automation of the treatment plant should be incorporated into the ability of the water system to monitor the finished water quality. It is important that a qualified water operator is available to run the treatment plant.

16. A plan of action should be in place should the water quality parameters fail to meet the Guidelines for Canadian Drinking Water Quality.

Operations

1. The filtration and backwash rates shall be monitored so that the pre-filters are being optimally used.

2. The bag and cartridge filters must be replaced when a pressure difference of 200 kPa or other pressure difference recommended by the manufacturer is observed. It should be noted that bag filters do not load linearly. Additional observation of the filter performance is required near the end of the filter run.

3. Maintenance (o-ring replacement) shall be performed in accordance with the manufacturers recommendations.

4. Sterile rubber gloves and a disposable face mask covering the nose and mouth shall be worn when replacing or cleaning the cartridge or bag filters.

5. The filter system shall be properly disinfected and water shall be ran to waste each time the cartridge or bag filter vessels are opened for maintenance.

6. The following parameters should be monitored:

   a. Flow rate, instantaneous

   b. Flow rate, total

   c. Operating pressure

   d. Pressure differential

   e. Turbidity.

POLICY STATEMENT ON MICROFILTRATION AND ULTRAFILTRATION FOR PUBLIC WATER SUPPLIES

Low pressure membrane filtration technology has emerged as a viable option for addressing current and future drinking water regulations related to treatment of surface water sources and groundwater under the direct influence of surface water sources. Recent research and applied full scale facilities have demonstrated the efficient performance of both microfiltration (MF) and ultrafiltration (UF) as feasible treatment alternatives to traditional granular media processes. Both MF and UF have been shown to be effective in removing identified parameters of the Surface Water Treatment Rule, such as" *Giardia*, *Cryptosporidium*, bacteria, turbidity and possibly viruses (for UF). The following provides a brief description and characteristics of each process as well as general selection and design considerations.

Characteristics: MF and UF membranes are most commonly made from organic polymers such as: cellulose acetate, polysulfones, polyamides, polypropylene, polycarbonates and polyvinylidene fluoride (PVDF). The physical configurations include hollow-fibre, spiral wound and tubular. MF membranes are capable of removing particles with sizes down to 0.1-0.2 microns. UF processes have a lower cutoff rating of.005-.01 microns.

Typical flux (rate of finished water permeate per unit membrane surface area) at 20°C for MF ranges between 2.05m/day to 4.1m/day whereas the typical UF flux range is 0.41 m/day to2.05 m/day. Required operating pressures ranges from 35 to 70 kPa for MF and 50 kPa to 350 kPa.

Since both processes have relatively small membrane pore sizes, membrane fouling, caused by organic and inorganic compounds as well as physical contaminants, can occur if the system is not properly selected or operated. Automated periodic back flushing and cleaning is employed on a timed basis or once a targeted transmembrane pressure differential has been reached. Some systems utilize air/water back flush. Typical cleaning agents utilized include acids, bases, complexing agents, surfactants, enzymes and certain oxidants, depending upon membrane material and foulants encountered. Chemicals used for cleaning and the method and procedure of cleaning process must be acceptable to the membrane manufacturer and approved by the reviewing authority.

Overall treatment requirements and disinfection credits must be discussed with and approved by the reviewing authority. Disinfection is required with membrane filtration for additional pathogen control and distribution system protection.

Selection and Design Considerations

1. A review of historical source raw water quality data, including turbidity and/or particle counts, seasonal changes, organic loading, microbial activity, and temperature differentials as well as other inorganic and physical parameters should be conducted. The

data should be used to determine feasibility and cost of the system. The degree of pre-treatment may also be ascertained from the data. Design considerations and membrane selection at this phase must also address the issue of target removal efficiencies and system recovery versus acceptable transmembrane pressure differentials. On surface water supplies, pre-screening or cartridge filters may be required.

2. A pilot study is required to confirm the suitability of the proposed membranes unless there is acceptable performance data available from other installations already using the same water supply. The pilot testing should last a minimum of three months, and cover two chemical cleans. Sufficient testing shall be conducted to show that the membrane can be satisfactorily cleaned, and that significant irreversible fouling will not occur in the full-scale design. Cold water performance, flux rates, pressure, power and waste treatment requirements should be investigated. Any virus removal credit must also be documented through an appropriate piloting process.

3. The life expectancy of a particular membrane under consideration should be evaluated during the pilot study or from other relevant available data. Membrane replacement frequency is a significant factor in operation and maintenance cost comparisons in the selection of the process.

4. Some membrane materials are incompatible with certain oxidants. If the system must rely on pre-treatment oxidants for other purposes, for example, taste and odour control or iron and manganese oxidation, the selection of the membrane material becomes a significant design consideration.

5. The source water temperature can significantly impact the flux of the membrane under consideration. At low water temperatures, the flux can be reduced appreciably (due to higher water viscosity and resistance of the membrane to permeate), possibly impacting process economics by the number of membrane units required for a full scale facility. Seasonal variation of design flow rates may be based on documented lower demand during colder weather.

6. Back flushing volumes can range from 5-15 percent of the permeate flow depending upon the frequency of flushing/cleaning and the degree of fouling and this should be considered in the treatment system sizing and the capacity of the raw water source.

7. An appropriate level of finished water monitoring as well as periodic integrity testing shall be provided to routinely evaluate membrane and housing integrity and overall filtration performance. Monitoring options may include particle counters, manual and/or automated pressure testing, air diffusion tests, sonic testing, and biological testing. Consult the appropriate regulatory agency regarding process monitoring requirements.

8. Cross connection control considerations must be incorporated into the system design, particularly with regard to chemical feeds and waste piping used for membrane cleaning, waste stream and concentrate.

9. Redundancy of critical control components including but not limited to valves, air supply, and computers shall be required as per the reviewing authority.

10. Other pre and post-membrane treatment requirements must be evaluated in the final design to address other contaminants of concern such as colour and disinfection by-product precursors.

POLICY STATEMENT ON ULTRA VIOLET LIGHT FOR TREATMENT OF PUBLIC WATER SUPPLIES

Ultra Violet (UV) Light treatment devices may be used to treat bacteriologically unsafe groundwater from drinking water wells. However, reviewing authorities expect water system owners to take all steps possible to obtain a naturally safe water source before considering treatment. A naturally safe water source provides the best long-term public health protection and there is no reliance on a treatment device to assure safe water. There must be a determination that the bacteriologically unsafe water is not due to the influence of surface water.

Recent research has demonstrated the effectiveness of UV as a primary disinfectant. While this policy statement does not specifically cover UV treatment for surface water or groundwater under the direct influence of surface water, it is not the intent of this policy to discourage such use. Portions of this policy are applicable to the treatment of effectively filtered surface water. The reviewing authority shall be contacted regarding use of UV treatment for these applications.

When a naturally safe groundwater source is not available, or the system owner wishes to provide UV treatment for other reasons, the following criteria shall be considered. Supplemental disinfection to provide a residual in the water distribution system will be required by the approval authority. When UV light treatment devices are used for non-health related purposes the UV device may provide doses less than indicated in the following criteria.

A. CRITERIA FOR UV WATER TREATMENT DEVICES

1. UV water treatment devices must comply with criteria approved by the reviewing authority or Class A criteria under ANSI/NSF Standard 55 - Ultraviolet Microbiological Water Treatment Systems; each UV water treatment device shall meet the following standards:

   a. Ultraviolet radiation at a wavelength of 253.7 nanometres shall be applied at a minimum dose of 40 millijoules per square centimetre (mJ/cm^2) at the failsafe set point at the end of lamp life.

   b. The UV device shall be fitted with a light sensor to safely verify that UV light is being delivered into the reactor.

   c. The UV light assembly shall be insulated from direct contact with the influent water by a quartz (or high silica glass with similar optical and strength characteristics) lamp jacket to maintain proper operating lamp temperature.

   d. The design and installation of the UV reactor shall ensure that the manufacturer’s maximum rated flow and pressure cannot be exceeded.

e. The UV assemblies shall be accessible for visual observation, cleaning and replacement of the lamp, lamp jackets and sensor window/lens.

f. A narrow band UV monitoring device shall be provided that is sensitive to germicidal UV light. It shall be accurately calibrated so that it indicates the true irradiances (mJ/cm^2) at 253.7 nanometres and be installed at the location critical for that unit. The device shall trigger an audible alarm in the event the sensor or lamp fails or if insufficient dosage is detected as defined in item ‘a’ above.

g. An automatic shut-down valve shall be installed in the water supply line ahead of the UV treatment system that will be activated whenever the water treatment system loses power or is tripped by a monitoring device when the dosage is below its alarm point of 40 mJ/cm^2). When power is not being supplied to the UV unit the valve shall be in a closed (fail-safe) position.

h. The UV housing shall be stainless steel 304 or 316L.

2. A flow or time delay mechanism wired in series with the well or service pump shall be provided to permit a sufficient time for tube warm-up per manufacturer recommendations before water flows from the unit upon start-up. Where there are extended no-flow periods and fixtures are located a short distance downstream of the UV unit, consideration should be given to UV unit shutdown between operating cycles to prevent heat build-up in the water due to the UV lamp.

3. A sufficient number (required number plus one) of parallel UV treatment systems shall be provided to assure a continuous water supply when one unit is out of service.

4. No by-passes shall be installed.

5. All water from the well shall be treated. The well owner may request a variance to treat only that portion of the water supply that is used for potable purposes provided that the daily average and peak water use is determined and signs are posted at all non-potable water supply outlets.

6. The well or booster pump(s) shall have adequate pressure capability to maintain minimum water system pressure after the water treatment devices.

B. PRE-TREATMENT

Pre- and post-treatment should be determined on a case-by-case basis depending on raw water quality. See Section G for raw water quality limitations. If coliform bacteria or other microbiological organisms are present in the untreated water, a 5-micron filter shall be provided as minimum pretreatment.

C. PROCESS CONTROL WATER QUALITY MONITORING

Total coliform monitoring and other parameters required by the reviewing authority will be used to evaluate UV treatment effectiveness. The minimum monitoring frequency will be as follows:

1. Start-up and two weeks after start-up - one raw and one treated sample.

2. Monthly thereafter - raw and treated.

3. Monitoring for additional parameters or total coliform on an increased frequency may be required by the reviewing authority.

D. ONLINE MONITORING, REPLACEMENT PARTS

UV light intensity of each installed unit shall be monitored continuously. Treatment units and the water system shall automatically shutdown if the UV dosage falls below the required output of 40 mJ/cm^2). Water systems that have source water exceeding 5 NTU turbidity may be required to install an online turbidimeter ahead of the UV water treatment device. An automatic shutdown valve shall be installed and operated in conjunction with the turbidimeter. Each owner shall have available on site at least one replacement lamp, a 5 micron replacement filter and, where applicable, a replacement cyst reduction filter and any other components necessary to keep the treatment system in service.

E. SEASONAL OPERATIONS

UV water treatment devices that are operated on a seasonal basis shall be inspected and cleaned prior to use at the start of each operating season. The UV water treatment system including the filters shall be disinfected prior to placing the water treatment system back into operation. A procedure for shutting down and starting up the UV treatment system shall be developed for or by each owner based upon manufacturer recommendations and submitted in writing to the review authority.

F. RECORD KEEPING AND ACCESS

A record shall be kept of the water quality test data, dates of lamp replacement and cleaning, a record of when the device was shutdown and the reason for shutdown, and the dates of pre-filter replacement.

The reviewing authority shall have access to the UV water treatment system and records.

Water system owners will be required to submit operating reports and required sample results on a monthly or quarterly basis as required by the reviewing authority or the Environmental Health Officer.

G. RAW WATER QUALITY CHARACTERISTICS

The water supply shall be analyzed for the following water quality parameters and the results shall be included in the UV application. Pretreatment is required for UV installations if the water quality exceeds any of the following maximum limits. When an initial sample exceeds a maximum limit, a check sample shall be taken and analyzed .

Parameter	**Maximum**
UV 254 nm Absorption	20 percent at 1 cm
Dissolved Iron	0.3 mg/L
Dissolved Manganese	0.05 mg/L
Hardness	120 mg/L as $CaCO_3$ (See note #1 below)
Hydrogen sulphide (if odour is present)	Non-detectable
Iron Bacteria	None
pH	6.5 to 8.5
Suspended Solids	10 mg/L max.
Turbidity	1.0 NTU max.
Total Coliform	1,000/100 ML
E. Coli	See Note #2 below
Cryptosporidium	See Note #2 below
Giardia	See Note #2 below

Note #1: A higher hardness may be acceptable to the reviewing authority if experience with similar water quality and reactors shows there are no treatment problems or excessive maintenance required.

Note #2: These organisms may indicate that the source is either a surface water or groundwater under the direct influence of surface water and may require additional filtration pretreatment.

Raw water quality shall be evaluated and pretreatment equipment shall be designed to handle water quality changes. Variable turbidity caused by rainfall events is of special concern.

POLICY STATEMENT ON INFRASTRUCTURE SECURITY FOR PUBLIC WATER SUPPLIES

Security for public water system facilities is imperative. Review of public water systems security infrastructure and practices has shown an industry-wide vulnerability to intentional acts of vandalism, sabotage and terrorism. Protection from these types of threats must be integrated into all design considerations. Many public drinking water systems have implemented effective security and operational changes to help address this vulnerability, but additional efforts are needed.

Security measures are needed to help ensure that public water suppliers attain an effective level of security. Design considerations need to address physical infrastructure security, and facilitate security related operational practices and institutional controls. Because drinking water systems cannot be made immune to all possible attacks, the design needs to address issues of critical asset redundancy, monitoring, response and recovery. All public water supplies need to identify and address security needs in design and construction for new projects and for retrofits of existing drinking water systems.

The following concepts and items should be considered in the design and construction of new water system facilities and improvements to existing water systems:

1. Security shall be an integral part of drinking water system design. Facility layout shall consider critical system assets and the physical needs of security for these assets.

2. The design should identify and evaluate single points of failure that could render a system unable to meet its design basis. Redundancy and enhanced security features should be incorporated into the design to eliminate single points of failure when possible, or to protect them when they cannot reasonably be eliminated.

3. Consideration should be given to ensure effective response and timely replacement of critical components that are damaged or destroyed. Critical components that comprise single points of failure (e.g. high volume pumps) that cannot be eliminated should be identified during design and given special consideration. Design considerations should include component standardization, availability of replacements and key parts, re-procurement lead times, and identification of suppliers and secure retention of component specifications and fabrication drawings. Readily replaceable components should be used whenever possible and provisions should be made for maintaining an inventory of critical parts.

4. Human access should be through controlled locations only. Intrusion deterrence measures (e.g. physical barriers such as fences, window grates and security doors; traffic flow and check-in points; effective lighting; lines of sight; etc.) and effective intrusion detection should be incorporated into the facility design and operation to protect critical

assets and security sensitive areas. Effective intrusion detection should be included in the system design and operation to protect critical assets and security sensitive areas.

5. Vehicle access should be through controlled locations only. Physical barriers such as moveable barriers or ramps should be included in designs to keep vehicles away from critical assets and security sensitive areas. It should be impossible for any vehicle to be driven either intentionally or accidentally into or adjacent to finished water storage or critical components without facility involvement. Designated vehicle areas such as parking lots and drives should be separated from critical assets with adequate standoff distances to eliminate impacts to these assets from possible explosions of material in vehicles.

6. Sturdy, weatherproof, locking hardware must be included in the design of access for all tanks, vaults, wells, well houses, pump houses, buildings, power stations, transformers, chemical storage, delivery areas, chemical fill pipes, and similar facilities. Vents and overflows should have their passages restricted through the use of baffles or other means to prevent the introduction of contaminants.

7. Computer based control technologies such as SCADA must be secured from unauthorized physical access and potential cyber attacks. Wireless and network based communications should be encrypted as deterrence to hijacking by unauthorized personnel. Vigorous computer access and virus protection protocols should be built into computer control systems. Effective data recovery hardware and operating protocols should be employed and exercised on a regular basis. All automated control systems shall be equipped with manual overrides to provide the option to operate manually. The procedures for manual operation including a regular schedule for exercising and insuring operator's competence with the manual override systems shall be included in facility operation plans.

8. Facilities and procedures for delivery, handling and storage of chemicals should be designed to ensure that chemicals delivered to and used at the facility cannot be intentionally released, introduced or otherwise used to debilitate a water system, its personnel, or the public. Particular attention should be given to potentially harmful chemicals used in treatment processes (e.g. strong acids and bases, toxic gases and incompatible chemicals) and on maintenance chemicals that may be stored on-site (e.g. fuels, herbicides, paints, solvents).

9. Each community should develop an Emergency Response Plan which would meet the recommendations of the document entitled "Emergency Response Planning for Small Waterworks Systems" published by the Province of British Columbia.

INTERIM STANDARD - NITRATE REMOVAL USING SULFATE SELECTIVE ANION EXCHANGE RESIN

Four treatment processes are generally considered acceptable for Nitrate/Nitrite removal. These are anion exchange, reverse osmosis, nanofiltration and electro dialysis. Although these treatment processes, when properly designed and operated will reduce the nitrate/nitrite concentration of the water to acceptable levels, primary consideration shall be given to reducing the nitrate/nitrite levels of the raw water through either obtaining water from an alternate water source or through watershed management. Reverse osmosis, nanofiltration or electro dialysis should be investigated when the water has high levels of sulfate or when the chloride content or dissolved solids concentration is of concern.

Most anion exchange resins used for nitrate removal are sulfate selective resins. Although nitrate selective resins are available, these resins typically have a lower total exchange capacity.

SPECIAL CAUTION

If a sulfate selective anion exchange resin is used beyond bed exhaustion, the resin will continue to remove sulfate from the water by exchanging the sulfate for previously removed nitrates resulting in treated water nitrate levels being much higher than raw water levels. Therefore it is extremely important that the system not be operated beyond design limitations.

PRE-TREATMENT REQUIREMENTS

An evaluation shall be made to determine if pre-treatment of the water is required if the combination of iron, manganese, and heavy metals exceeds 0.1 milligrams per litre.

DESIGN

Anion exchange units are typically of the pressure type, down flow design. Although a pH spike can typically be observed shortly before bed exhaustion, automatic regeneration based on volume of water treated should be used unless justification for alternate regeneration is submitted to and approved by the reviewing authority. A manual override shall be provided on all automatic controls. A minimum of two units must be provided. The total treatment capacity must be capable of producing the maximum day water demand at a level below the nitrate/nitrite MCL. If a portion of the water is by-passed around the unit and blended with the treated water, the maximum blend ratio allowable must be determined based on the highest anticipated raw water nitrate level. If a by-pass is provided, a totalling metre and a proportioning or regulating device or flow regulating valve must be provided on the by-pass line.

EXCHANGE CAPACITY

Anion exchange media will remove both nitrates and sulfate from the water being treated. The design capacity for nitrate and sulfate removal expressed as $CaCO_3$ should not exceed 37 g/L when the resin is regenerated with 160 g/L of resin when operating at 0.27 to 0.4 L/min per litre. However, if high levels of chlorides exist in the raw water the exchange capacity of the resin should be reduced to account for the chlorides.

FLOW RATES

The treatment flow rate should not exceed 17.5 m/hr to 20 m/hr. The back wash flow rate should be 5 m/hr to 7.5 m/hr with a fast rinse approximately equal to the service flow rate.

FREEBOARD

Adequate freeboard must be provided to accommodate the backwash flow rate of the unit.

MISCELLANEOUS APPURTENANCES

The system shall be designed to include an adequate under drain and supporting gravel system, brine distribution equipment, and cross connection control.

MONITORING

Whenever possible, the treated water nitrate/nitrite level should be monitored using continuous monitoring and recording equipment. The continuous monitoring equipment should be equipped with a high nitrate level alarm. If continuous monitoring and recording equipment is not provided, the finished water nitrate/nitrite levels must be determined (using a test kit) no less than daily, preferably just prior to regeneration of the unit.

WASTE DISPOSAL

Generally, waste from the anion exchange unit should be disposed in accordance with Section 9.2 of these Standards. However, prior to any discharge, the reviewing authority must be contacted for wastewater discharge limitations.

ADDITIONAL LIMITATIONS

Certain types of anion exchange resins can tolerate no more than 0.05 mg/L free chlorine. When the applied water will contain a chlorine residual, the anion exchange resin must be a type that is not damaged by residual chlorine.

SYNOPSIS

PART 1 - SUBMISSION OF PLANS

(1) Synopsis

Part 1 specifies the deliverables and Performance Standards for services provided by Consulting Engineers for new and/or upgraded water systems.

(2) Check List

The following deliverables are required to satisfy this Part:

- Feasibility report required if source water has not been identified, life cycle costs and Class ‘D’ cost estimate required. (See 1.1.5).
- Geotechnical and/or hydrology - hydrogeotechnical report to be included as part of Pre- design report (1.2.2).
- Pre-design report to be completed including Class ‘B’ or ‘C’ cost estimate. (See 1.2.12).
- Final design drawings and contract documents (See 1.3 and 1.4).
- Design brief summarizing all design criteria submitted with detail design package. (See 1.5).
- Cost estimates to Class ‘A’ accuracy following detail design. (See INAC’s cost estimate classification sheet).
- O&M manuals required (See 1.8).
- Emergency Response Plan required (See 1.9).

1 SUBMISSION OF PLANS

Part 1 specifies performance standards for services provided by consulting engineers during the feasibility, pre-design, and design phases of a water works project. The engineer's reports for each phase should be submitted for review and approval prior to the preparation of final, complete, detailed drawings and specifications.

No approval for pre-design or total design can be issued until a final and complete feasibility study has been submitted to the reviewing authority and found to be satisfactory. Permits for construction, for waste discharges, for stream crossings, etc., may be required from other federal, provincial or local regulatory agencies.

According to the phase of the project, documents submitted for formal approval shall include but not be limited to:

a. Feasibility study as detailed in Section 1.1;

b. The pilot plant study, if applicable to the project as detailed in Section 1.1.3;

c. The pre-design report which will include the criteria used in the basis of design (see details in Section 1.2);

d. The design brief (see details in Section 1.5);

e. Operation requirements, including operation and maintenance manuals and plans where applicable;

f General layout;

g. Detailed drawings;

h. Specifications;

i. Cost estimates;

j. Proposed start-up and commissioning activities;

k. Emergency Response Plan;

l. A water servicing agreement between water suppliers and water purchasers where applicable.

Metric (S.I.) units shall be used throughout.

Refer to the INAC document entitled ***"Practical Guide to Capital Projects***" for further details on each phase of the project.

1.1 FEASIBILITY STUDY

In the event that the water source, and/or the treatment process has not been determined, a feasibility report shall precede the pre-design report and shall include the advantages and disadvantages of each water source under consideration as well as an evaluation of at least two water treatment techniques to render the water potable. A clear recommendation will then be stated in the report on the optimum choice with due consideration to capital costs, O&M costs, life cycle costs, ease of operation and practicality. The reviewed options should include the use of bottled water that would be transported to the community. Give reasons for selecting the option that is recommended, including workers safety, financial considerations, and a comparison of the minimum qualifications of water works operator required for operation of each alternative facility.

The feasibility study shall also include the following general information identified below.

1.1.1 General Information

General information should be provided in the feasibility report, including:

- Project rationale;
- Description of the existing water works and wastewater facilities;
- Identification of the community or area served;
- Description of the nature and extent of the area to be served;
- Provisions for extending the water system to include additional areas;
- Appraisal of the future requirements for service, including existing and potential industrial, commercial, institutional, and other water supply needs;
- Design Horizon;
- Elevations at representative locations;
- Water pressures which will be made available by the proposed system during expected operating conditions;
- Distribution leakage allowance;
- Detailed analysis of advantages & disadvantages of each option analysed;
- Preferred recommended option with reference to INAC’s Level of Service Standards (LOSS) (note: bench scale study results, or pilot studies, or demonstrations may be required later on to establish adequacy of recommended process, OR, may be required as part of the deliverables of the feasibility study);
- Automation, SCADA and/or HMI;
- Simple process flow diagram;
- Detailed analysis of operation & maintenance cost for all options, including the requirement for a certified operator. (As such, for certain projects, the First Nations may have to consider hiring an outside certified contractor to operate the system and train First Nation members to a certified status. This should be included in the estimate of the operation & maintenance cost).
- Life cycle cost analysis of all options;
- Sub-consultants investigations;
- Groundwater Under Direct Influence (GWUDI) of surface water statement;

- Environmental Scoping Report (including Species at Risk Act and a timber permit assessment);
- Residuals Management;
- Regulatory Impacts (ie permits and licenses that will be required for the project);
- Land requirements (including for future expansion);
- All permits and applicable water licenses that will be required for the project;

1.1.2 Sources of Water Supply

Describe the proposed source or sources of water supply to be developed, the reasons for their selection, and provide information as described in Part 3, and as follows:

1.1.2.1 Surface Water Sources

Include:

a. Hydrological data, stream flow and weather records;

b. Safe yield, including all factors that may affect it (e.g., other water licenses);

c. Maximum flood flow, together with approval for safety features of the spillway and dam from the appropriate reviewing authority;

d. Description of the watershed, noting any existing or potential sources of contamination (such as highways, railways, chemical facilities, sanitary wastes, landfill sites etc.) which may affect water quality;

e. Chemical, physical and microbiological quality of the raw water with special reference to the historical fluctuations in quality, changing meteorological conditions and possible sources of contamination. The following raw water parameters should be evaluated in the report:

    1. colour, with weekly measurement for a minimum of one year;
    2. turbidity, with minimum weekly measurement for a minimum of one year;
    3. bacterial concentration such as total coliforms, and *E. Coli*;
    4. microscopic biological organisms such as *Giardia*, and *Cryptosporidium*;
    5. temperature;
    6. total solids;
    7. general inorganic chemical characteristics;

8. total organic carbon, with weekly measurement for a minimum of one year;

9. trihalomethane formation potential, (THMFP) with quarterly measurement for minimum of one year;

10. additional parameters as required by the reviewing authority.

The report should also include a description of methods and work to be done during a pilot plant study or, where appropriate, an in-plant demonstration study.

f. Source water protection issues or measures that need to be considered or implemented;

g. Surface water elevation with respect to proposed water plant sites and the community.

1.1.2.2 Groundwater Sources

Include:

a. Sites considered;

b. Advantages of the site selected;

c. Elevations with respect to surroundings;

d. Probable characteristics of the geological formations through which the source is to be developed;

e. Geological conditions affecting the site;

f. Groundwater Under Direct Influence (GWUDI) of surface water statement;

(note: The consulting team must balance the scope of the true groundwater determination, or, the groundwater under direct influence (GWUDI) effective in-situ filtration investigation, against the cost of treatment, the time required to conduct the assessment and the various risks to public health. For smaller systems, the team should consider recommending assumption of GWUDI and then design an appropriate surface water treatment process that utilizes any demonstrated in-situ filtration).

g. Locations of any existing wells in relation to the proposed site and the anticipated interference between wells;

h. Summary of source exploration, test well depth, and method of construction; placement of liners and screens; test pumping rates and their duration; water levels and specific yield;

i. Summary of chemical, physical, radiological, and microbiological water quality as outlined in Section 1.1.2.1.e (including Total Organic Carbon);

j. Sources of possible contamination such as sewers and sewage treatment facilities, individual septic fields, highways, railways, landfills, outcroppings of consolidated water-bearing formations, or chemical facilities;

k. Wellhead protection measures being considered;

l. GPS locations in latitude and longitude;

m. Bench scale testing results or pilot plant study if applicable (refer to policy statements).

1.1.3 Pilot Plant Studies

After approval of the feasibility study, a pilot study or in-plant demonstration study shall be conducted. The study must be conducted over a sufficient time to treat all expected raw water conditions throughout the year. The study shall emphasize but not be limited to, the following items:

a. chemical mixing conditions including shear gradients and detention periods;

b. chemical feed rates;

c. use of various coagulants and coagulant aids;

d. flocculation conditions;

e. filtration rates;

f. filter gradation, types of media and depth of media;

g. filter breakthrough conditions;

h. adverse impact of recycling back-wash water due to solids, algae, trihalomethane formation and similar problems.

Prior to the initiation of design plans and specifications, a final report including the engineer’s design recommendations shall be submitted to the reviewing authority.

The pilot plant filter must be of a similar type and operated in the same manner as proposed for full scale operation.

The pilot study must demonstrate the minimum contact time necessary for optimum filtration for each coagulant proposed.

1.1.4 Project Sites

Include:

a. Discussion of the various sites considered and advantages of the recommended ones;

b. The proximity of residences, industries, and other establishments;

c. Any potential sources of pollution that may influence the quality of the supply or interfere with effective operation of the water works system, such as sewage absorption systems, septic tanks, privies, cesspools, sink holes, sanitary landfills, or refuse and garbage dumps;

d. Environmental impacts;

e. Information regarding land ownership;

f. Information regarding permits, licenses, and upgrades required.

1.1.5 Financing

Include:

a. Estimated cost of integral parts of the system;

b. Detailed estimated annual cost of operation and maintenance (Operation costs should include estimates for labour, chemicals, special equipment contracts, heat, and electricity. Maintenance cost information should include cost estimates for labour, materials, equipment, spare parts, specialized tools and the identification of contract requirements and costs.

   If stainless steel storage tanks are part of the designed site, cleaning of the steel tanks every three to five years (Section 7.0) and steel tank inspections (Section 7.21) must also be included in maintenance cost estimates.

   Also, the requirement for a certified operator should be included in the analysis. As such, for certain projects, the First Nations may have to consider hiring an outside certified contractor to operate the system and train First Nation members to a certified status. This should be included in the estimate of the operation & maintenance cost;

c. Life-cycle costs for replacing chemical feeding equipment every five years with feeding equipment sized for larger capacities (Sections 4.3.3.2.2 and 5.4.1);

d. The estimated normal useful life of the assets and annualized replacement costs;

e. Present day worth of various options stating principal amount, O&M costs, term and interest applied;

f. The methods proposed to finance both capital costs, and **operating and maintenance expenses**. Of special note: considerations should be given to public private partnership possibilities.

1.2 PRE-DESIGN REPORT

The pre-design report for water works improvements shall, where pertinent, present the following information:

1.2.1 General Information

The pre-design report should include :

a. the general information as listed in Sections 1.1.1 to 1.5.1, but expanded to a higher level (as specified in subsequent sections to 1.2.1);
b. preliminary P&ID diagrams;
c. hydraulic profile through the system;
d. sixty percent (60%) complete design drawings (full size).

1.2.2 Soil, Climate, Groundwater Conditions, and Foundation Problems

Include a description of the following:

a. The characteristics of the soil through which water mains are to be laid;

b. Foundation conditions prevailing at sites of proposed structures;

c. The approximate elevation of groundwater in relation to subsurface works;

d. Climatic conditions;

e. Expected depth of frost.

1.2.3 Water Use Data

Include:

a. A description of the population trends as indicated by available records, and the estimated population to be served by the proposed water supply system or expanded system;

b. Present water consumption and the projected average and maximum daily demands;

c. Present and/or estimated yield of the sources of supply;

d. Estimated present water leakage in system.

1.2.4 Fire Flow Requirement

Include:

a. Fire flows required or recommended in the service area;

b Fire flows which will be made available by the proposed or enlarged system;

c. Water pressures at representative locations in the distribution system during simultaneous fire flow and maximum day demand conditions;

d. An evaluation of fire protection options including use of residential fire sprinklers;

e. Hydraulic analyses based on flow demands and pressure requirements.

1.2.5 Existing Water System

Describe the present water system including supply, treatment, storage, and distribution systems. Describe previous water quality problems including any boil water orders if applicable.

1.2.6 Wastewater System Available

Describe the existing wastewater system and sewage treatment works, with special reference to their relationship to existing or proposed water works structures which may affect the operation of the water supply system, or which may affect the quality of the supply.

1.2.7 Proposed Treatment Processes

Summarize and establish the adequacy of proposed processes and unit parameters for the treatment of the specific water under consideration. Include occupational health considerations in this evaluation. Bench scale tests, pilot plant studies, or demonstrations may be required to establish adequacy.

1.2.8 Waste Disposal

Discuss the various wastes from the water treatment plant, their volume, proposed treatment and points of discharge. If discharging to a sanitary sewerage system, verify that the system, including any lift stations, is capable of handling the flow to the sewage treatment works and that the treatment works is capable and will accept the additional loading.

1.2.9 Automation

Provide supporting data justifying automatic equipment, including the servicing and operator training to be provided. Manual override must be provided for any automatic controls. Highly sophisticated automation may put proper maintenance beyond the capability of the plant operator, leading to equipment breakdowns or expensive servicing.

1.2.10 Process Control

Provide a narrative that describes the proposed operation and control of all pumps and process mechanical equipment. Provide a preliminary process control schematic.

1.2.11 Project Sites

See Section 1.1.4 for required information related to project site.

1.2.12 Financing

Include financing considerations as listed in Section 1.1.5.

1.2.13 Future Extensions

Summarize planning for future needs and services.

1.3 DRAWINGS

Drawings should be prepared and submitted in discipline order as follows:

- Civil;
- Architectural;
- Structural;
- Mechanical Process;
- Mechanical Building Services;
- Electrical;
- Instrumentation.

Drawings for waterworks improvements shall, where pertinent, provide the following:

1.3.1 General Layout

Include:

a. Suitable title;

b. Name of community, First Nations community or other entity or person responsible for the water supply;

c. Area or institution to be served;

d. Scale, in metres;

e. North arrow;

f. Datum used;

g. Boundaries of the area to be served;

h. Name and address of the designing engineer;

i. Imprint of professional engineer's seal, his signature and date of signature;

j. Legible prints suitable for reproduction and microfilming, and storage in an appropriate electronic file format;

k. Location and size of existing water mains;

l. Location and nature of all proposed water works;

m. Location and nature of existing water works structures and appurtenances affecting the proposed improvements;

n. Location and nature of existing wastewater works affecting the proposed improvements.

1.3.2 Detailed Drawings

i. General - typical contract drawings to include:

- Title sheet and drawing index;
- Location plan;
- Site plan;
- Architectural details (if applicable);
- Structural and building details;
- Process and Instrumentation Diagrams (P&ID’s);

- Hydraulic Profile;
- Mechanical Process Details;
- Mechanical, Building Services Details;
- Electrical Details;
- Instrumentation and Controls Details and Loop Diagrams.

ii. Include following drawing details:

a. Stream crossing, providing profiles with elevations of the stream bed and the normal and extreme high and low water levels;

b. Profiles having an appropriate horizontal scale, with both scales clearly indicated;

c. Location and size of the property to be used for the groundwater development with respect to known references such as roads, streams, section lines, or streets;

d. Topography and arrangement of present or planned wells or structures, with contour intervals not greater than 1.0 metre to G.S.C;

e. Elevations of the highest known flood level, floor of any structure, upper terminal of protective casing, outside surrounding grade, important adjacent features such as lake and river water levels;

f. Plan and profile drawing of well construction, showing diameter and depths, grouting depths, elevations and designation of geological formations, water levels and other details to describe the proposed well completely;

g. Location of all existing and potential sources of pollution within 300 metres of the source and within 30 metres of underground water storage facilities;

h. Size, length, and the identity and location relative to plant structure of:
   - water mains;
   - sewers;
   - drains.

i. Schematic flow diagrams (P&ID's) and hydraulic profiles showing the flow through various plant units with the main stream flow in bold or heavy line;

j. Piping in sufficient detail to show flow through the plant, including waste lines;

k. Locations of all chemical storage areas, feeding equipment and points of chemical application;

l. Locations of sanitary or other facilities, such as lavatories, showers, toilets, and lockers, when applicable;

m. Locations, dimensions, and elevations of all proposed plant facilities;

n. Locations of all sampling taps;

o. Adequate description of any features not covered by the specifications;

p. Size and location of "bleed" lines.

1.4 SPECIFICATIONS

Complete, detailed technical specifications shall be supplied for the proposed project, including a program for keeping existing water works facilities in operation during construction of additional facilities so as to minimize interruption of service. Where a groundwater supply will replace a surface water supply, the physical disconnection of the existing surface water supply from the water works must be clearly specified. Specification prepared in the National Master Specification (NMS) format are preferred, including:

- Invitation to Tender;
- Instructions to Tenderers;
- Tender Form;
- Contract Agreement;
- General Conditions and Supplementary General Conditions;
- Technical Specifications from Division 1 to 16.

1.5 DESIGN BRIEF

A summary of complete design criteria shall be submitted, along with the final design documents for the proposed project, containing but not limited to the following:

a. Refer to Physical Development Plan (PDP) if applicable;

b. Refer to Level of Service Standards (LOSS);

c. Long-term dependable yield of the source of supply;

d. Reservoir surface area, volume, and a volume-versus-depth curve, if applicable;

e. Brief description of watershed, if applicable;

f. Estimated average and maximum day and peak hour water demands for the design period, based on an analysis of the specific site;

g. Number of proposed services;

h. Fire fighting requirements;

i. Population served (present and future), based on previous population statistics and analysis of present and future trends;

j. Area served (present and future) in hectares;

k. Design flows used for sizing intakes, pumps, treatment, storage and distribution facilities;

l. Summary of design criteria used for intakes, pumping stations, treatment systems, storage facilities and distribution systems;

m. Design calculations used in sizing various components of the waterworks system including:

- design criteria for mixers and flocculators (if application);
- hydraulic loading rate for clarifiers and filters;
- CT values for chlorine contact tanks and T10/T values;
- Pre-and post-conditioning data;
- hydraulic profile;
- P&ID.
- disinfection requirements, single or two stage;
- UV irradiation criteria and validation tests;
- residuals management;
- reservoir storage and short circuit mitigation.

n. Summary of capacities provided in the various components of the proposed system;

o. Water pressures at representative locations in the distribution system during various flow conditions;

p. Raw water quality, proposed treatment methods and treated water quality criteria;

q. Outline of operation and maintenance procedures;

r. Water license information, where applicable (include existing water license information and new water license required for the project);

s. Land ownership information;

t. Provide a written description of procedures that should be conducted for start-up and commissioning of the water works, with special attention to water treatment facilities. Provide detailed descriptions of tests that should be done prior to start-up to demonstrate that the facilities are capable of meeting the design flows, and other performance criteria. Refer to INAC's Commissioning Guidelines;

u. Commissioning plan as per the INAC Start-up and Commissioning Guidelines for Water Works;

v. Wastewater disposal permit, if applicable;

w. Highway permits, if applicable;

x. Signed and sealed Class A cost estimate;

y. Detailed Operation and Maintenance cost analysis;

z. Operation and Maintenance manual as per Section 1.8;

aa. Environmental assessment report as dictated in the Canadian Environmental Assessment Act (CEAA) and the Species at Risk Act (SARA).

1.6 REVISIONS TO APPROVED PLANS

Any deviations from approved drawings or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment process, or the quality of water to be delivered, must be approved by the reviewing authority before such changes are made. Revised drawings or specifications should be submitted in time to permit the review and approval of such plans or specifications before any construction work, which will be affected by such changes, is begun.

1.7 ADDITIONAL INFORMATION REQUIRED

The reviewing authority may require additional information which is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, or copies of contracts.

1.8 OPERATION AND MAINTENANCE INFORMATION

This section describes the desired content of the Operation and Maintenance Manual herein referred to as the Manual.

All material should be bound in a booklet that will allow for removal of pages with originals on white bond paper, and drawings and charts folded to fit within the booklet.

The Manual should include the information listed below if applicable:

1.8.1 Submittals Before Construction

The following shall be prepared by the First Nation's professional consulting engineer AND SUBMITTED AS PART OF THE PROJECT DELIVERABLES WHEN REQUESTING FUNDS for the construction phase:

a. A description of the general operation of the equipment or system as a whole during normal flow conditions;

b. A simplified schematic plan or flow chart, clearly identifying all components of the system; a detailed description of each process including the design criteria;

c. Procedures for inspecting, maintaining and servicing of all elements of the water system including the source, treatment, storage and transmission/distribution;

d. Detailed operating procedures such as start-up and shut-down;

e. seasonal operations, normal valve positions, switches and control settings, and chemical container disposal;

f. A description of water treatment processes, including the aim and methodology;

g. P&ID's;

h. Emergency procedures in the event of line breaks or failure of pumping stations;

i. Schematic drawings for electrical controls including pump circuits, lighting, alarm system and heaters;

j. Trouble-shooting instructions for pump stations;

k. Necessary safety practices and measures including cleanliness and suggested wearing apparel;

l. Provision or maintenance checklists to facilitate recording of maintenance done, expenses incurred and materials used for each component of the system;

m. A list of spare equipment and parts which should be on hand for routine or emergency maintenance repairs and suggested locations for storage of parts and tools;

n. An estimate of annual operation and maintenance costs including labour, equipment, materials and contracts. Operation costs shall include an estimate for heat (fuel) and electricity;

o. Operation and maintenance of wastewater disposal systems from water treatment processes;

p. Laboratory procedures; daily, weekly, monthly and annual testing;

q. The estimated normal useful life of new assets and their major components be established and recorded so that there is a clear understanding and record of the expected timing and nature of major repairs, overhauls and replacements;

r. Provincial and/or federal Permits if required. (including water licenses and permits for use of Crown Land).

1.8.2 Subsequent to Start-up and Commissioning

No longer than two months following final commissioning, the following shall be prepared by the First Nation's professional consulting engineer:

a. Inclusion of site construction photographs or sketches which supplement or simplify the explanation of various operation and maintenance procedures;

b. An assembly of manufacturer's literature catalogued and indexed for ease of finding information:

- Material and equipment information (names, model numbers, types, sizes, warranties);
- Instructions and schedules for recommended O & M practices;
- Exploded views and parts lists;
- Suppliers' names, addresses and phone numbers.

c. Comprehensive as-built drawings of the system; where a groundwater supply has replaced a surface water supply, the disconnection of the existing surface water supply from the water works must be clearly recorded on the as-built drawings;

d. For each lot provide a sketch with dimensions to dwellings, poles, hydrants, etc., sufficient to locate the house sewer and water services including curb and corporation stops;

e. Complete the relevant "Capital Asset Inventory System" (CAIS) forms (available from Indian and Northern Affairs Canada) for all additions and deletions to the water works. Send the forms to Chief and Council for their signature. Upon return include copies of the signed forms in the manual;

f. Provide a written description of procedures that were conducted for start-up and commissioning of the water works, with special attention to water treatment facilities. Provide the results of tests that demonstrate that the facilities are capable of meeting the design flows, and other performance criteria as outlined in the INAC document entitled “Start-up and Commissioning Guidelines for Water Works”;

g Provide a written description of the Performance Monitoring Plan that is implemented over the next 12 months following commissioning of the facility. Refer to the INAC Start-up and Commissioning Guidelines for Water Works for details;

h. Provide a table that describes the testing, setup, and calibration activities for equipment, including but not limited to: inline water quality monitoring instruments, chemical feed pumps, flow meters, control valves, pumps, and water treatment equipment. Include information about the results and dates of completion, for the testing, setup, and calibration activities.

1.9 EMERGENCY RESPONSE PLAN

A complete, detailed Emergency Response Plan shall be supplied for the proposed project, along with the final design documents. The Emergency Response Plan should meet the recommendations of the document entitled “Emergency Response Planning for Small Waterworks Systems” published by the Province of British Columbia.

SYNOPSIS

PART 2 – GENERAL DESIGN CONSIDERATIONS

(1) Synopsis

Part 2 provides General Design Considerations that should be included in the water supply system and/or plant.

(2) Check List

The following general items must be taken into consideration in the overall general design.

- Plant layout with respect to future expansion, access, chemical delivery, site security, drainage, flood protection, and disinfection. (See 2.2, 2.15, 2.18 and 2.19).
- Building layout with respect to HVAC, lighting, electrical controls, operator safety, chemical storage and feed. (See 2.3).
- Standby power, review need for gen-set and minimum connected load. (See 2.6).
- Check maintenance facilities and storage space provided for spare parts.
- Check main control room, records space, laboratory space and analytical testing equipment. (See 2.8, 2.9).
- Ensure that there adequate sample taps for water profile testing through the process train. (See 2.10).
- Essential instrumentation monitoring and controls.

2 DESIGN CONSIDERATIONS

The design of a water supply system or treatment process encompasses a broad area. Application of this part is dependent upon the type of system or process involved.

2.1 DESIGN BASIS

The system including the water source and treatment facilities shall be designed for maximum day demand at the design year or horizon.

Existing water demand and water leakage must be measured and analyzed during the pre-design stage and the results should be included in the engineering report. If previous records spanning over several years are available, they shall be included in the study.

Design the water works to service the community for 10 years with provision for expansion to accommodate a 20 year design. Sustainable engineering principles should be applied when determining the design flow.

The design maximum day demand should not be less than 2.5 times the average day demand.

Trucked water delivery systems shall provide at least 90 litres per person per day.

2.2 PLANT LAYOUT

Design shall consider:

a. Functional aspects of the plant layout;

b. Provisions for future plant expansion;

c. Provisions for expansion of the plant waste treatment and disposal facilities;

d. Access roads;

e. Site grading;

f. Site drainage, including flooding potential;

g. Walkways;

h. Driveways;

i. Chemical delivery;

j. Site security.

2.3 BUILDING LAYOUT

Design shall provide for:

a. Adequate ventilation;

b. Adequate lighting;

c. Adequate heating;

d. Adequate drainage;

e. De-humidification equipment, if necessary;

f. Accessibility of equipment for operation, servicing, and removal;

g. Flexibility of operation;

h. Operator safety;

i. Convenience of operation;

j. Chemical storage and feed equipment in a separate room to reduce hazards and dust problems;

k. Provisions for plant expansions.

2.4 LOCATION OF STRUCTURES

The appropriate regulating authority must be consulted regarding any structure which is so located that normal or flood stream flows may be impeded.

2.5 ELECTRICAL CONTROLS

Main switchgear electrical controls shall be located above grade, in areas not subject to flooding or from possible deluge from process piping or equipment. Electrical equipment for processes shall be conveniently located for operation, with direct visual contact, wherever possible with the specific component.

2.6 STANDBY POWER

Standby power may be required by the reviewing authority so that water may be treated and/or pumped to the distribution system during power outages to meet the average day demand. The history of power outages, existing and proposed system storage, and current and projected water use shall be reviewed to determine the need for portable, or in-place auxiliary power. Carbon monoxide detectors with alarms are recommended where internal combustion engine driven generators are housed.

2.7 SHOP SPACE AND STORAGE

Adequate facilities should be included for maintenance shop space and storage consistent with the designed facilities.

2.8 LABORATORY FACILITIES

Each public water supply shall have its own equipment and facilities for routine laboratory testing necessary to ensure proper plant operation. Laboratory equipment selection shall be based on the characteristics of the raw water source and the complexity of the treatment process involved. The laboratory shall be equipped to meet the applicable Workers' Compensation Board (W.C.B) safety requirements.

Laboratory test kits which simplify procedures for making one or more tests may be acceptable. An operator qualified to perform the necessary laboratory tests is essential. Persons designing and equipping laboratory facilities shall confer with the reviewing authority before beginning the preparation of plans or the purchase of equipment. Methods for verifying adequate quality assurances and for routine calibration of equipment should be provided.

2.8.1 Testing Equipment

As a minimum, the following laboratory equipment shall be provided:

a. Surface water supplies shall provide the necessary facilities for microbiological testing of water from both the treatment plant and the distribution system. If contacted, the First Nations Internal Health Board will provide colilert equipment and the necessary reagents free of charge to all First Nation communities. The reviewing authority may allow deviations from this requirement;

b. Surface water supplies shall have nephelometric turbidimeter meeting the requirements of the latest edition of the Standard Methods for the Examination of Water and Wastewater;

c. Each surface water treatment plant utilizing flocculation and sedimentation, including those which use lime softening, shall have a pH meter, jar test equipment, and titration equipment for both hardness and alkalinity;

d. Each ion-exchange softening plant, and lime softening plant treating only groundwater shall have a pH meter and titration equipment for both hardness and alkalinity;

e. Each iron and/or manganese removal plant shall have test equipment capable of accurately measuring iron to a minimum of 0.01 milligrams per litre, and/or test equipment capable of accurately measuring manganese to a minimum of 0.001 milligrams per litre;

f. Public water supplies which chlorinate shall have test equipment and reagents for determining both free and total chlorine residual by methods in the latest edition of the Standard Methods for the Examination of Water and Wastewater;

g. Public water supplies which fluoridate shall have test equipment and reagents for determining fluoride by methods in the latest edition of the Standard Methods for the Examination of Water and Wastewater;

h. Surface water supplies shall provide the necessary equipment for true and apparent colour testing using the platinum-cobalt colourimetric method and capable of measuring true and apparent colour to a minimum of 1 colour unit being equal to 1 milligram per litre platinum as chloroplatinate ion;

i. Each colour/organics removal plant using chemical coagulation/flocculation processes shall have test equipment, reagents, and calibration materials where applicable for:

- measuring alkalinity to a minimum of 1 milligram per litre as calcium carbonate;
- measuring pH, with temperature read-out, to a minimum of 0.01 pH units;
- a six (6) stirrer, programmable mixing station which can be set for stirrer speeds from 5 to 300 RPM in one-RPM increments, with run times from 1 second to 100 minutes in 1 second increments, including six (6) two-litre volume square jars.

j. Sufficient glassware, not limited to beakers, graduated cylinders, erlenmeyer flasks, and volumetric flasks, in varying volumetric capacities for the preparation and testing of samples;

k. Other laboratory equipment such as pipets, glassware drying rack, wash bottles, safety glasses, latex gloves, and kimwipes;

l. Public water supplies which feed poly and/or orthophosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 20 milligrams per litre;

m. Surface water supplies which utilize aluminum based coagulants shall have test equipment capable of accurately measuring aluminum to a minimum of 0.01 milligrams per litre.

2.8.2 Physical Facilities

Sufficient bench space, adequate ventilation, adequate lighting, storage room, laboratory sink, and auxiliary facilities such as an eyewash and deluge shower unit (in accordance with WCB requirements) shall be provided.

2.9 MONITORING EQUIPMENT

Water treatment plants should be provided with equipment (including recorders, where applicable) to monitor the water as follows:

a. Plants treating surface water and ground water under the direct influence of surface water should have the capability to monitor and record turbidity, free chlorine residual, water temperature and pH at locations necessary to evaluate adequate CT disinfection, and other important process control variables as determined by the reviewing authority. Turbidimeters should be positioned/installed after each filter so that the turbidity of treated water leaving each individual filter can be monitored separately. Continuous monitoring and recording is required. Of note: As per Health Canada Guidelines for Canadian Drinking Water Quality - Supporting Documentation on Turbidity – for chemically assisted filtration (i.e., continuous feed of a coagulant with mixing ahead of filtration), source water turbidity levels should be measured at least once per calendar day directly in front of where the first treatment chemical is applied.

b. Plants treating ground water using iron removal, manganese removal, and/or ion exchange softening should have the capability to monitor and record free chlorine residual.

c. Ion exchange plants for nitrate removal should continuously monitor and record the treated water nitrate level.

2.10 SAMPLE TAPS

Sample taps consistent with sampling needs shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment, including a sample from the finished water product. Taps used for obtaining samples for bacteriological analysis shall be of the smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator, or other such appurtenance.

2.11 FACILITY POTABLE WATER SUPPLY

The facility potable water supply service line and the plant finished water sample tap shall be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed, and the required disinfectant contact time has been achieved. There shall be no cross-connections between the facility potable water supply service line and the plant non-potable service water, or any piping, troughs, tanks, or other treatment units containing wastewater, treatment chemicals, raw or partially treated water.

2.12 WALL CASTINGS

Consideration will be given to providing extra wall castings built into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

2.13 METERS

All water supplies shall have an acceptable means of metering the finished water.

2.14 PIPING COLOUR CODE

To facilitate identification of piping in plants and pumping stations it is recommended that the following colour scheme be utilized:

Water Lines

Raw	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue

Chemical Lines

Alum or Primary Coagulant	Orange
Caustic	Yellow with Green Band
Chlorine and Solution	Yellow
Fluoride	Light Blue with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Soda Ash	Light Green with Orange Band
Ozone	Yellow with Orange Band

Wastewater Lines

Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Grey

Other

Compressed Air	Dark Green
Gas	Red
Other Lines	Light Grey

The name of the liquid or gas and arrows indicating the direction of flow should also be on the pipe. In situations where two colours do not have sufficient contrast to easily differentiate between them, a 150 mm band of contrasting colour should be on one of the pipes at approximately 750 mm intervals. The name of the liquid or gas should also be on the pipe. In some cases it may be advantageous to provide arrows indicating the direction of flow.

2.15 DISINFECTION

All wells, pipes, tanks, and equipment which can convey or store potable water shall be disinfected in accordance with current AWWA procedures. Plans or specifications shall outline the procedure and include the disinfectant dosage, contact time, and method of testing the results of the procedure. Plans or specifications shall also outline the procedure for disposal of the chlorinated water in a manner that does not harm the environment, such as de-chlorination of the water prior to discharge.

2.16 EQUIPMENT CONTAINING MERCURY

Equipment containing mercury may not be connected to any liquid system within a water treatment plant where it is possible that mercury may escape into water which subsequently is delivered to consumers.

2.17 OPERATOR SAFETY

Design shall consider the plant Operator’s safety by meeting all Worker’s Compensation Board requirements with particular emphasis to chemicals, rotating equipment, confined space entry, and electrical hazards. Operators should also attend approved courses on WHIMIS and MSDS.

2.18 SECURITY

Security measures shall be installed and instituted as required by the reviewing authority. Appropriate design measures to help ensure the security of water system facilities shall be incorporated. Such measures, as a minimum, shall include means to lock all exterior doorways, windows, gates and other entrances to source, treatment and water storage facilities. Other measures may include fencing, signage, close circuit monitoring, real-time water quality monitoring, and intrusion alarms. (See Policy Statement on Security for more details).

2.19 FLOOD PROTECTION

Other than surface water intakes, all water supply facilities and water treatment plant access roads shall be protected to at least the 200 year flood elevation or maximum flood of record, as required by the reviewing authority. A freeboard factor may also be required by the reviewing authority.

2.20 CHEMICALS AND WATER CONTACT MATERIALS

Chemicals and water contact materials shall be approved by the reviewing authority or meet the appropriate ANSI/AWWA and/or ANSI/NSF Standards. Fluoridation chemicals, if used, should be selected according Health Canada’s “Community Water Fluoridation in First Nations and Inuit Communities” (1998).

2.21 SITING REQUIREMENTS

The plant design and land ownership surrounding the plant shall allow for modifications and expansion of the plant.

2.22 OTHER CONSIDERATIONS

Consideration must be given to the design requirements of other federal, provincial, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing and electrical codes, construction in the flood plain, etc.

SYNOPSIS

PART 3 – SOURCE DEVELOPMENT

(1) Synopsis

Part 3 specifies the requirements, with guidelines, for selecting the optimum source for the raw water supply and includes groundwater, surface water and groundwater under the direct influence of surface water or surface contamination.

(2) Check List

- Confirm that the water source selected is the best available within the serviced area, with due consideration to the long term demands and the water quality of the water source(s), ensure that the final system selected provides the highest water quality with the least degree of operational sophistication.
- Check if an MTSA may be a better option as a water source.
- Ensure that extreme drought conditions have been taken into consideration when selecting the water source.
- Review intake structure design to ensure compliance with 3.1.3.
- For groundwater ensure that water is not under the direct influence of surface water, if there is the slightest doubt of surface contamination, such as an unconfined aquifer, close proximity to a lake or river or the presence of surface microbiological biota in the groundwater then treat as surface water. (See 3.2)
- Confirm the number of raw water sources that are available. (See 3.2.1).

3 SOURCE DEVELOPMENT

In selecting the source of water to be developed, the designing engineer must prove to the satisfaction of the reviewing authority that an adequate quantity of water will be available, and that the water which is to be delivered to the consumers will meet the "Guidelines for Canadian Drinking Water Quality ” Latest Edition, published by Health Canada. In order to keep interested parties informed of changes to the Guidelines between publication of new editions, a summary table entitled "Summary of Guidelines for Canadian Drinking Water Quality" is updated and published every spring on Health Canada's website (www.hc-sc.gc.ca/waterquality). The "Summary of Guidelines for Canadian Drinking Water Quality" supercedes all previous versions, including that contained in the published booklet.

Each water supply should take its raw water from the best available source which is economically reasonable and technically possible.

When a groundwater supply has replaced a surface water supply as the source of water, then the old surface water supply must be physically disconnected from the water system. Any type of connection of the old surface water supply, including the use of a water-main with a closed valve, is not acceptable and will be considered a cross connection.

3.1 SURFACE WATER

A surface water source or watershed includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake. A source water protection plan enacted for continued protection of the watershed from potential sources of contamination shall be provided as determined by the reviewing authority.

3.1.1 Quantity

The quantity of water at the surface water source shall:

a. Be adequate to supply the design maximum day demand during a moderate drought. A <u>moderate drought</u> is considered to be a 7-day period of stream flow so low that only with an average frequency of once in ten years would the flow, or regulated flow, be as low. Requirements for flows downstream of the intake, shall be in compliance with the applicable reviewing authorities;

b. Be adequate to compensate for all losses such as distribution leakage, silting, evaporation, seepage, etc.;

c. Be in compliance with a provincial water license where required by provincial regulations;

d. Provide a reasonable surplus for anticipated growth.

3.1.2 Quality

A sanitary survey and study shall be made of the factors, both natural and man made, which could affect quality. Such survey and study shall include, but not be limited to:

a. Describing the watershed, noting any existing or potential sources of contamination which may affect water quality; The location of each existing or potential source of contamination shall be shown on a scale map;

b. Summarizing quality of the raw water with special reference to fluctuations in quality, changing meteorological conditions, etc. Obtain samples over a sufficient period of time to assess the microbiological, physical, chemical and radiological characteristics of the water (including total organic carbon sample results);

c. Determining possible future uses of impoundments or reservoirs;

d. Determining degree of control of watershed by owner;

e. Assessing the degree of hazard to the water supply by agricultural, industrial, recreational and residential activities in the watershed and/or by accidental spillage of materials that may be toxic, harmful or detrimental to any proposed treatment processes;

f. Assessing all waste discharges, both point sources and non-point sources, and other activities that could impact the water supply. The location of each waste discharge shall be shown on a scale map;

g. Assessing the capability of the proposed treatment process to reduce contaminants to applicable standards;

h. Considering currents, winds and ice conditions, and effects of tributary streams.

3.1.3 Intake Structures

3.1.3.1 Intake Structure Design Requirements

Design of intake structures shall provide for:

a. Withdrawal of water from more than one level if quality varies with depth;

b. Where frazil ice may be a problem, controlling the velocity of flow into the intake structure to a minimum, generally not to exceed 0.15 m per second;

c. A velocity of flow through the intake conduit of 0.65 to 1.0 m/sec at rated capacity;

d. Routine back flushing and cleaning of the inlet lines;

e. Adequate markers or identification of intakes, intake pipe locations, anchoring and protection against rupture by shipping, recreation boats, dragging anchors, ice, etc.;

f. Ports located above the bottom of the stream, lake or impoundment, but at sufficient depth to be kept submerged at low water levels and under severe ice conditions - normally 1 to 3 m below low water level;

g. Screens to be readily accessed for cleaning (preferably self-cleaning) and acceptable to the Fisheries and other authorities having jurisdiction;

h. Prevention of the accumulation of gases in the inlet line;

i. Gravity intake in the river or lake with low lift pumps, where needed, installed on land in stations with practical access to facilitate maintenance. It is unacceptable to use submerged pumps to pump water to shore. Use separate high lift pumps wherever possible when pressures exceed 500 kPa through treatment train and into system;

j. Having a Ground Force Circuit Interrupter (GFCI) protection device as per the BC Electrical Code on all submerged electrical motors;

k. As specified in the Fisheries Act and by the Department of Fisheries and Oceans, a diversion device capable of keeping large quantities of fish or debris from entering an intake structure;

l. Provisions to the intake structure in order to control potential aquatic nuisances when deemed necessary;

m. Submission of the proposed intake plans in a timely fashion to the appropriate regulatory agencies for approval. Typical approval authorities would include but not limited to the following:

- Environment Canada, CEAA;
- Department of Fisheries and Oceans;
- Species at Risk Act, SARA;
- Transport Canada, Navigable Waters Act.

3.1.3.2 River Intake

River intakes should be sited in a stable reach of the channel, where erosion or deposition will not endanger the works and in such a way that the natural regime of the river will not be upset.

3.1.3.3 Stream-bed Intake

Stream-bed intakes (infiltration galleries) should incorporate either a standby duplicate intake or a submerged intake for use in the event of problems with the stream-bed intake.

When buried surface water collectors are used, sufficient intake opening area must be provided to minimize inlet headloss. Particular attention should be given to the selection of backfill material in relation to the collector pipe slot size and graduation of the native material over the collector system.

3.1.3.4 Off-stream Raw Water Storage Reservoir

The off-stream raw water storage reservoir is a facility into which water is pumped during periods of good quality and high stream flow for future release to treatment facilities. These off-stream raw water storage reservoirs shall be constructed to assure that

a. Water quality is protected by controlling runoff into the reservoir;

b. Dykes are structurally sound and protected against wave action and erosion;

c. Intake structures and devices meet requirements of Section 3.1.3.1;

d. Point of influent flow is separated from the point of withdrawal;

e. Separate pipes are provided for influent to and effluent from the reservoir.

3.1.4 Impoundments and Reservoirs

3.1.4.1 Site Preparation

Site preparation shall provide where applicable:

a. Removal of brush and trees to high water elevation;

b. Protection from floods during construction;

c. Abandonment of all wells which will be flooded or overflowed, in accordance with the relevant provincial guidelines.

3.1.4.2 Approval Requirements

Construction may require:

a. Approval from the appropriate regulatory agencies of the safety features for stability and spillway design;

b. A permit from the appropriate regulatory agency for controlling stream flow or installing a structure on the bed of a fish bearing stream or navigable river.

3.1.4.3 Water Supply Dams

Water supply dams shall be designed and constructed in accordance with the requirements of BC Dam Safety Regulations and the Canadian Dam Association.

3.2 GROUNDWATER, AND GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

For the purpose of this document, a raw water supply which is groundwater means water located in subsurface aquifer(s) where the aquifer overburden and soil act as an effective filter that removes micro-organisms and other particles by straining and antagonistic effect, to a level where the water may already be potable.

Groundwater under the direct influence of surface water (GWUDI) means ground water having incomplete or undependable subsurface filtration of surface water and infiltrating precipitation.

Prior to draft approval of the proposed plan, a quantitative and qualitative evaluation of the groundwater resources at the site shall be made by a professional hydrogeologist or information based on previous studies shall be provided. The evaluation shall include a determination of whether the source is in the category of groundwater under the direct influence of surface water based on the document entitled “Procedure for Disinfection of Drinking Water in Ontario” - Latest Version, Province of Ontario – Section 2.2 of the document.

Additional guidance is available in Section 2 of Ontario Regulation 170/3, and the document entitled “Terms of Reference - Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water”- Latest Version, Province of Ontario, and Section 2 of the document entitled “Guidance Manual for the Surface Water Treatment Rule”, USEPA.

Note: The consulting team must balance the scope of the true groundwater determination, or, the groundwater under direct influence (GWUDI) effective in-situ filtration investigation, against the cost of treatment, the time required to conduct the assessment and the various risks to public health. For smaller systems, the team should consider recommending assumption of GWUDI and then design an appropriate surface water treatment process that utilizes any demonstrated in-situ filtration.

Both documents by the Province of Ontario, referenced above, are included in Appendix A.

3.2.1 Quantity

3.2.1.1 Source Capacity

The total developed groundwater or GWUDI source capacity shall equal or exceed the design maximum day demand and equal or exceed the design average day demand with the largest well out of service.

3.2.1.2 Number of Sources

A minimum of two sources of groundwater or GWUDI is recommended, particularly for remote communities and in larger communities.

3.2.1.3 Stand-by Power

The history of power outages, existing and proposed system storage, and current and projected water use shall be reviewed to determine the need for portable, or in-place auxiliary power.

3.2.2 Quality

3.2.2.1 Microbiological Quality

a. Disinfection of every new, modified or reconditioned groundwater or GWUDI source:

   - shall be provided after completion of work, if a substantial period of time elapses prior to test pumping or placement of permanent pumping equipment;
   - shall be provided after placement of permanent pumping equipment.

b. After disinfection, one or more water samples are required to be submitted to Health Canada or approved testing laboratory for microbiological analysis. Satisfactory results must be obtained prior to placing the well into service.

3.2.2.2 Physical and Chemical Quality

a. Every new, modified or reconditioned groundwater or GWUDI source shall be examined for applicable physical and chemical characteristics by tests of a representative sample in a certified laboratory satisfactory to the reviewing authority with the results reported to such authority (including total organic carbon sample results);

b. Samples shall be collected at the conclusion of the test pumping procedure and examined as soon as practical;

c. Field determinations of physical and chemical constituents or special sampling procedures may be required by the reviewing authority;

d. Seasonal variations in water quality shall be identified where practical;

e. The potential for undesirable dissolved gases and bacteriological growths and surface water influences shall be assessed.

3.2.2.3 Radiological Quality

Every new, modified or reconditioned groundwater or GWUDI source shall be examined for radiological activity by tests of a representative sample in a laboratory satisfactory to the reviewing authority to whom the results must be reported.

3.2.3 Location

3.2.3.1 Well Location

The reviewing authority shall be consulted prior to design and construction regarding a proposed well location as it relates to required separation between existing and potential sources of contamination and groundwater development. The optimum well location is to be determined by a professional hydrogeologist. Wells must be located outside the control building, except where line shaft turbines are used.

3.2.3.2 Continued Protection

Continued protection of the well site from potential sources of contamination shall be provided either through ownership, zoning, easements, leasing or other means acceptable to the reviewing authority. Fencing of the site may be required.

3.2.3.3 Wellhead Protection

A wellhead protection **area**, for continued protection of the wellhead from potential sources of contamination, shall be provided as delineated by the reviewing authority.

3.2.4 General Well Construction

Water wells shall be designed, constructed and tested in general accordance with AWWA Standards and relevant provincial guidelines. All wells shall be constructed by BC registered drillers as required by the B.C. Ground Water Protection Regulations.

Of note: wells must be located outside of control buildings except where line shaft turbine is in use.

3.2.4.1 Upper Terminal Well Construction

a. Permanent casing for all groundwater or GWUDI sources shall project at least 300 mm above the pump house floor or concrete apron surface, and at least 450 mm above final ground surface;

b. Where a well house is constructed, the floor surface shall be at least 200 mm above the final ground elevation;

c. Sites subject to flooding shall be provided with an earth mound to raise the pump house floor to above the 200 year flood elevation, or an elevation at least 0.6 metres above the highest known flood elevation on record, whichever is higher, or other suitable protection as determined by the reviewing authority;

d. The top of the well casing at sites subject to flooding shall terminate at least 1.0 metre above the 200 year flood elevation or the highest known flood elevation on record, whichever is higher, or as the reviewing authority directs;

e. Sites subject to flooding shall have a mounded access road to the well head that is above the 200 year flood elevation, or an elevation at least 0.6 metres above the highest known flood elevation on record, whichever is higher, or other suitable protection as determined by the reviewing authority;

f. The production well casing shall have a diameter of at least 200 mm;

g. Protection from physical damage shall be provided as required by the reviewing officer. For example drilling wells by a roadside should be avoided.

3.2.4.2 Drilling Fluids and Additives

a. Shall not impart any toxic substances to the water or promote bacterial contamination;

b. Shall be acceptable to the reviewing authority;

3.2.4.3 Minimum Protected Depths

Minimum protected depths of drilled wells shall provide watertight construction to such depths as may be required by the B.C. Provincial Regulations and Guidelines, to:

a. exclude contamination;

b. seal off formations that are, or may be, contaminated or yield undesirable water.

3.2.4.4 Temporary Steel Casing

Temporary steel casing used for construction shall be capable of withstanding the structural load imposed during its installation and removal.

3.2.4.5 Permanent Steel Casing Pipe shall

a. be new single steel casing pipe meeting AWWA Standard A-100, ASTM or API specifications for water well construction;

b. have minimum weights and thickness in accordance with accepted practices;

c. have additional thickness and weight ,if minimum thickness is not considered sufficient, to assure reasonable life expectancy of a well;

d. be capable of withstanding forces to which it is subjected;

e. be equipped with a drive shoe when driven;

f. have full circumferential welds or threaded coupling joints.

3.2.4.6 Polyvinyl Chloride Plastic (PVC) Well Casing

The reviewing authority may approve the use of PVC casing for all or for limited applications. Where approved, PVC casing, as a minimum:

a. shall be new pipe meeting ASTM F480 and ANSI/NSF Standard 61 and be appropriately marked;

b. shall have a minimum wall thickness equivalent to SDR (standard dimension ratio) 21; diameters of 200 mm or greater may require greater thickness to meet collapse strength requirements;

c. shall not be used at sites where permeation by hydrocarbons or degradation may occur;

d. shall be properly stored in a clean area free from exposure to direct sunlight;

e. shall be assembled using couplings or solvent welded joints; all couplings and solvents shall meet ANSI/NSF Standard 14, ASTM F480, or similar requirements;

f. shall not be driven.

3.2.4.7 Other Nonferrous Casing Materials

a. approval of the use of any nonferrous material as well casing shall be subject to special determination by the reviewing authority prior to submission of plans and specifications;

b. nonferrous material proposed as a well casing must be resistant to the corrosiveness of the water and to the stresses to which it will be subjected during installation, grouting and operation.

3.2.4.8 Packers

Packers shall be of material that will not impart taste, odour, toxic substances or bacterial contamination to the well water. Lead packers shall not be used.

3.2.4.9 Screens

a. be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations (stainless steel);

b. have size of openings based on sieve analysis of formation and/or gravel pack materials;

c. have sufficient length and diameter to provide adequate specific capacity and low aperture entrance velocity. Usually the entrance velocity should not exceed 30 mm per second;

d. be installed so that the pumping water level remains above the screen under all operating conditions;

e. where applicable, be designed and installed to permit removal of replacement without adversely affecting water-tight construction of the well;

f. be provided with a bottom plate or wash-down bottom fitting of the same material as the screen.

3.2.4.10 Grouting Requirements

All permanent well casing shall be surrounded to a minimum of 40 mm of grout to the depth required by the reviewing authority. Other forms of grouting may be approved for driven casing. All temporary construction casings shall be removed. Where removal is not possible or practical, the casing shall be withdrawn at least 1.5 metres to ensure grout contact with the native formation.

a. Neat Cement Grout

 i. cement conforming to AWWA A100 Section 7, and water, with not more than 23 litres of water per 43 kg of cement applied in accordance with the B.C. Ground Water Protection Regulation, must be used for 40 mm openings;

 ii. additives may be used to increase fluidity provided they adhere to the B.C. Ground Water Protection Regulation.

b. Concrete Grout

 i. equal parts of cement conforming to AWWA A100 Section 7, and sand, with not more than 23 litres of water per 43 kg of cement may be used for openings larger than 40 mm;

 ii. where an annular opening larger than 100 mm is available, gravel not larger than 12 mm in size may be added.

c. Clay Seal

Where an annular opening greater than 150 mm is available a clay seal of clean local clay mixed with at least 10% swelling bentonite may be used when approved by the reviewing authority and in accordance with the B.C. Ground Water Protection Regulation.

d. Application

i. sufficient annular opening shall be provided to permit a minimum of 40 mm of grout around permanent casings, including couplings;

ii. prior to grouting through creviced or fractured formations, bentonite or similar materials may be added to the annular opening, in the manner indicated for grouting;

iii. when the annular opening is less than 100 mm, grout shall be installed under pressure by means of a grout pump from the bottom of the annular opening upward in one continuous operation until the annular opening is filled;

iv. when the annular opening is 100 mm or more and less than 30 m in depth, and concrete grout is used, it may be placed by gravity through a grout pipe installed to the bottom of the annular opening in one continuous operation until the annular opening is filled;

v. when the annular opening exceeds 150 mm, is less than 30 m in depth, and a clay seal is used, it may be placed by gravity;

vi. after cement grouting is applied, work on the well shall be discontinued until the cement or concrete grout has properly set.

e. Guides

The casing must be provided with sufficient guides welded to the casing to permit unobstructed flow and uniform thickness of grout.

3.2.4.11 Development

a. every well shall be developed to remove the native silts and clays, drilling mud or finer fraction of the gravel pack;

b. development should continue until the maximum specific capacity is obtained from the completed well;

c. where chemical conditioning is required, the specifications shall include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of waste and inhibitors;

d. where blasting procedures may be used, the specifications shall include the provisions for blasting and cleaning. Special attention shall be given to assure that the grouting and casing are not damaged by the blasting.

3.2.4.12 Capping Requirements

a. a welded metal plate or a threaded cap is the preferred method for capping a well. All well caps, temporary or permanent, shall be effectively located/sealed against the entrance of water and contaminants;

b. at all times during the progress of wok, the contractor shall provide protection to prevent tampering with the well or entrance of foreign materials.

3.2.4.13 Tagging Requirements

Phase I of the BC Ground Water Protection Regulations stipulates tagging requirements for newly completed or closed wells. The requirements are summarized below:

a. upon closure or completion of any water supply wells, vertically drilled recharge and injection wells, or permanent vertically drilled dewatering wells require a well identification plate securely attached to the well casing, well cap or well cover so that the well identification number set out on the well identification plate is plainly visible;

b. if it is not possible to secure the well identification plate to the well casing, well cap, or well cover, the well identification plate may be attached to a nearby post, pump house, or building adjacent to the well so that the well identification number set out on the well identification plate is plainly visible;

c. the well identification number must be recorded on the well construction report. The well construction report and the reporting requirements form must be submitted to the comptroller within 90 days after the well completion date;

d. on the permanent closure of a well, a person engaged in that work must remove any existing well identification plate, complete the well closure report form specified by the comptroller, and return the well identification plate and report form to the comptroller within 90 days after the work is complete;

e. the First Nations owner must:

- maintain and safeguard the well identification plate from any physical damage;
- ensure that the well identification number set out on the well identification plate remains plainly visible;
- report any missing or damage well identification plate to the comptroller;
- request a replacement well identification plate within 30 days after discovering its loss or damage.

f. if two or more wells with separate well identification numbers are contained in a single protective casing, each of those wells must have a well identification plate;

g. all wells required well identification plates, as identified in 3.2.4.13 (a), are required to report the well identification number to the comptroller in the well construction report or in a separate form as specified in the Ground Water Protection Regulations.

3.2.4.14 Well Abandonment

a. test wells and groundwater sources which are not in use shall be sealed by such methods as necessary to restore the controlling geological conditions which existed prior to construction or as directed by the appropriate regulatory agency;

b. wells to be abandoned shall

   i. be sealed to prevent undesirable exchange of water from one aquifer to another;

   ii. preferably be filled with neat cement grout;

   iii. have fill materials other than cement grout or concrete, disinfected and free of foreign materials;

   iv. when filled with cement grout or concrete, these materials shall be applied to the well hole through a pipe, tremie, or bailer.

3.2.5 Testing and Records

3.2.5.1 Yield and Draw-down Tests

a. A yield and draw-down test shall be conducted in accordance with a protocol pre-approved by the reviewing authority;

b. Shall be performed on every production well after construction or subsequent treatment and prior to placement of the permanent pump;

c. Shall have the test methods clearly indicated in the project specifications;

d. Shall have a test pump capacity, at maximum anticipated draw down, at least 1.5 times the quantity anticipated;

e. Provide for continuous pumping for at least 24 hours at the design pumping rate or until stabilized drawdown has continued for at least six hours when test pumped at 1.5 times the design pumping rate;

f. Shall provide the following data:

   i. Test pump capacity-head characteristics;
   ii. Static water level;

iii. Depth of test pump setting;
iv. Time of starting and ending each test cycle;
v. The zone of influence for the well or wells.

g. Shall provide recordings and graphic evaluation of the following at one hour intervals or less as may be required by the reviewing authority:

i. Pumping rate;
ii. Pumping water level;
iii. Draw down;
iv. Water recovery rate and levels.

3.2.5.2 Plumbness and Alignment Requirements

a. Every well shall be tested for plumbness and alignment in accordance with the applicable AWWA standards;

b. The test method and allowable tolerance shall be clearly stated in the specifications;

c. If the well fails to meet these requirements, it may be accepted by the engineer if it does not interfere with the installation or operation of the pump or uniform placement of grout.

3.2.5.3 Geological Data

Geological data shall:

a. Be determined from samples collected at 1.5 metre intervals and at each pronounced change in formation;

b. Be recorded and samples submitted to the appropriate authority;

c. be supplemented with a driller's log, accurate geographical location such as latitude and longitude from GIS co-ordinates, and other information on records of drill-hole diameters and depths, assembled order of size and length of casing, screens and liners, grouting depths, formations penetrated, water levels, and location of any blast charges.

3.2.5.4 Retention of Records

The owner of each well shall retain all records pertaining to each well, until the well has been properly abandoned.

3.2.6 Well Pumps, Discharge Piping and Appurtenances

3.2.6.1 Line Shaft Pumps

Wells equipped with line shaft pumps shall

a. Have the Casing firmly connected to the pump structure or have the casing inserted into a recess extending at least 12 mm into the pump base;

b. Have the pump foundation and base designed to prevent water from coming into contact with the joint;

c. Avoid the use of oil lubrication at pump settings less than 120 m. Lubricants must meet ANSI/NSF Standard 61 or be approved by the reviewing authority.

3.2.6.2 Submersible Pump

Where a submersible pump is used:

a. The top of the casing shall be effectively sealed against the entrance of water under all conditions of vibration or movement of conductors or cables;

b. The electrical cable shall be firmly attached to the riser pipe at 6 metre intervals or less.

3.2.6.3 Discharge Piping

a. The discharge piping shall:

   i. Be designed so that the friction loss will be low;

   ii. Have control valves and appurtenances located above the pump house floor when an above-ground discharge is provided;

   iii. Be protected against the egress of contamination;

   iv. Be equipped with a check valve, a shut-off valve, a pressure gauge, a means of measuring flow, and a smooth nosed sampling tap located at a point where positive pressure is maintained;

   v. Where applicable, be equipped with an air release-vacuum relief valve located upstream from the check valve, with exhaust/relief piping terminating in a down-turned position at least 0.6 metres above the floor and covered with a 16 mesh corrosion resistant screen;

   vi. Be valved to permit test pumping and control of each well;

   vii. Have all exposed piping, valves and appurtenances protected against physical damage and freezing;

   viii. Be properly anchored to prevent movement;

   ix. Be protected against surge or water hammer.

b. The discharge piping shall be provided with a means of pumping to waste, but shall not be directly connected to a sewer;

c. The discharge piping (or any other piping that is in contact with the drinking water) should not be galvanized steel. Piping 50 millimetres in diameter or greater can be stainless steel. Stainless steel is recommended for piping less than 50 millimetres in diameter.

3.2.6.4 Pitless Well Units

a. The reviewing authority must be contacted for approval of specific applications of pitless units. A typical cross section of a pitless adaptor is provided in Appendix C;

b. Pitless units shall:

   i. Be full barrel industrial standard for well pumps requiring 63.5 mm or larger drop pipe sets;

   ii. Side of casing mounts can be used to 50 mm or smaller pump sets if the pitless unit can accept the total set weight;

   iii. Be of watertight construction throughout;

   iv. Be of materials and weight at least equivalent and compatible to the casing;

   v. Have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection;

   vi. Terminate at least 450 mm above final ground elevation or 900 mm above the 200 year flood elevation or the highest known flood elevation, whichever is higher, or as the reviewing authority directs.

c. The design of the pitless unit shall make provision for:

   i. Access to disinfect the well;

   ii. A properly constructed casing vent meeting the requirements of Section 3.2.6.5;

   iii. Facilities to measure water levels in the well (see Section 3.2.6.6);

   iv. A cover at the upper terminal of the well that will prevent the egress of any form of contamination;

v. A contamination-proof entrance connection for electrical cable;

vi. An inside diameter as great as that of the well casing, (up to and including casing diameters of 300 mm) to facilitate work and repair on the well, pump, or well screen;

vii. At least one check valve within the well casing or in compliance with requirements of the reviewing authority.

d. If the connection to the casing is by field weld, the ship-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing.

3.2.6.5 Casing Vent

Provisions shall be made for venting the well casing to atmosphere. The vent shall terminate in a down-turned position, at or above the top of the casing or pitless unit in a minimum 40 mm diameter opening covered with a #16 mesh, corrosion resistant (usually stainless steel) screen. The pipe connecting the casing to the vent shall be of adequate size to provide rapid venting of the casing.

3.2.6.6 Water Level Measurement

a. Provisions shall be made for periodic measurement of water levels in a production well by means of water level meter or wetted tape. Installation of a Class 150 or greater PVC pipe 25 mm (ips) diameter or greater and attached firmly to the drop pipe or pump column using corrosion resistant materials, is required to facilitate this measurement.

b. Provision shall be made for permanent water level measurement in a production well by means of electronic measuring equipment. Installation of a class 150 or greater PVC pipe 25 mm ips diameter or greater and attached firmly to the drop pipe or pump column using corrosion resistant materials, is required to facilitate measurement if using submersible pressure tranducers. The water level shall be clearly displayed continuously in the pump control room.

3.2.6.7 Observation Wells

Shall be:

a. Constructed in accordance with the requirements for permanent wells if they are to remain in service after completion of a water supply well;

b. Protected at the upper terminal to preclude entrance of foreign materials.

3.2.7 Aquifer Types and Construction Methods - Special Conditions

3.2.7.1 Sand or Gravel Wells

a. If clay or hard pan is encountered above the water bearing formation, the permanent casing and grout shall extend through such materials;

b. If a sand or gravel aquifer is overlaid only be permeable soils the permanent casing and grout shall extend to at least 7.5 meters below original or final ground elevation, whichever is lower. Excavation of topsoil around the well casing should be avoided;

c. If a temporary outer casing is used, it shall be completely withdrawn as grout is applied.

3.2.7.2 Gravel Pack Wells

a. Gravel pack shall be well rounded particles, 95 percent siliceous material, that are smooth and uniform, free of foreign material, properly sized, washed and then disinfected immediately prior to or during placement;

b. Gravel pack shall be placed in one uniform continuous operation;

c. Gravel refill pipes, when used, shall be Schedule 40 steel pipe incorporated within the pump foundation and terminated with screwed or welded caps at least 0.3 metres above the pump house floor or concrete apron;

d. Gravel refill pipes located in the grouted annular opening shall be surrounded by a minimum of 40 mm of grout;

e. Protection from leakage of grout into the gravel pack or screen shall be provided;

f. Permanent inner and outer casings shall meet requirements of Section 3.2.4.4 (Temporary Steel Casing);

g. Minimum casing and grouted depth shall be acceptable to the reviewing authority.

3.2.7.3 Radial Water Collector

a. Locations of all caisson construction joints and porthole assemblies shall be indicated;

b. The caisson wall shall be reinforced to withstand the forces to which it will be subjected;

c. Radial collectors shall be in areas and at depths approved by the reviewing authority;

d. Provisions shall be made to assure that radial collectors are essentially horizontal;

e. The tope of the caisson shall be covered with a watertight floor;

f. All openings in the floor shall be curbed and protected from entrance of foreign material;

g. The pump discharge piping shall not be placed through the caisson walls. In unique situations where this is not feasible, a water tight seal must be obtained at the wall.

3.2.7.4 Infiltration Lines

a. Infiltration lines should be considered only where geological conditions preclude the possibility of developing an acceptable drilled well;

b. The area around infiltration lines shall be under the control of the water purveyor for a distance acceptable to the reviewing authority;

c. Flow in the lines shall be by gravity to the collecting well;

d. Water from infiltration lines shall be considered as GWUDI unless demonstrated otherwise.

3.2.7.5 Dug Wells

a. Dug wells may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well;

b. A watertight cover shall be provided;

c. Minimum protective lining and grouted depth shall be at least 3 metres below original or final ground elevation, whichever is lower;

d. Openings shall be curbed and protected from entrance of foreign material;

e. Pump discharge piping shall not be placed through the well casing or wall.

3.2.7.6 Limestone or Sandstone Wells

a. Where depth of unconsolidated formations is more than 15 metres, the permanent casing shall be firmly sealed in uncreviced or unbroken rock. Grouting requirements shall be determined by the consulting engineer;

b. Where the depth of unconsolidated formations is less than 15 metres, the depth of casing and grout shall be at least 15 metres.

3.2.7.7 Naturally Flowing Wells

a. Shall require special consideration by the reviewing authority where there is an absence of an impervious confining layer;

b. Flow shall be controlled. Overflows shall discharge at least 0.45 metres above grade and flood level, and be visible. Discharge shall be to an effective drainage structure;

c. Permanent casing and grout shall be provided;

d. If erosion of the confining bed appears likely, special protective construction may be required by the reviewing authority.

SYNOPSIS

PART 4 - TREATMENT

Page 1 of 10

(General and Clarification)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List

- Confirm if the water source is the ideal choice before proceeding with the water treatment evaluation.
- In most cases groundwater will be the best choice of the water source over surface water, unless the groundwater contains high levels of heavy metals or toxins such as arsenic which mandates sophisticated treatment equipment, and operation and maintenance, compared with the surface water option.
- Determine need and type of treatment from pilot studies, develop protocol for piloting before proceeding with tests, at least two treatment options should be piloted.
- Plate settlers are the preferred method of clarification; check that hydraulic upflow rate conforms to guidelines based on projected area.

SYNOPSIS

PART 4 - TREATMENT

(Clarification and Filtration)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Static mixers are the preferred type of flash mix, provide water flushing feature and include in design provision for minimum flows during early operation of plant. Check detention times at various flow rates.

- Hydraulic flocculation is the preferred option, include in design for minimum flow conditions during the early years of operation of the plant. Check detention time at various flow rates particularly cold water conditions.

- Check to ensure flushing lines, drains and sludge disposal features are included in the design for flocculators and clarifiers.

- Filtration, Slow Sand Filters are the preferred method of filtration if filtration is deemed necessary, followed by rapid rate gravity filters and rapid rate pressure filters.

- Bag and cartridge filters are suitable on small systems and where the water quality permits their use.

(Disinfection)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Disinfection: Disinfection is required for all surface water supplies and groundwater under the direct influence of surface water.
- Chlorine is the preferred disinfecting agent, using sodium or calcium hypochlorite.
- Check that system capacity can maintain a chlorine residual of 2 mg/L at the design maximum day demand.
- Include 100% redundancy in the design of the chlorine feed equipment.
- Review contact time and CT requirements to accomplish the required log inactivation and destruction levels.
- Confirm that a the design ensures that a chlorine residual will be maintained in the distribution system of at least 0.2 mg/L
- Review the need for two stage disinfection using UV light and chlorine.

SYNOPSIS

PART 4 - TREATMENT

PAGE 5 of 10

(Softening)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Softening: Review need for softening, confirm if there are other raw water sources available before proceeding with softening. Hardness levels of 250 mg/L or less need not be softened. Where hardness levels exceed this level consider split treatment and blending. Only ion-exchange softening should be considered.
- Check levels of TDS and sodium in treated water following the ion exchange process with respect to health concerns.
- Check for pre-treatment required particularly if there are high levels of turbidity, iron and manganese in the raw water.
- Review disposal of spent brine during regeneration.
- Ensure that there is ample storage space for sodium chloride in the plant design.
- Ensure that construction materials are compatible with the aggressive nature of salt.

(Aeration)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Aeration: Consider aeration for taste and odour removal, air stripping of volatile organics, hydrogen sulphide and pre-oxidation of iron and manganese if the pH of the water permits a weak oxidant.
- A natural or forced draft air system may be used.
- All aerators must be housed in a heated and protected enclosure.
- Noise control features must be included if a forced air system is utilized.
- Consider range of water temperatures of the water to be treated due to its effect on contaminant removal efficiency.
- Conduct a pilot study to determine the minimum volumetric air to water ratio if there is limited past performance data available.
- Use corrosion resistant materials in the construction of all aeration equipment.

SYNOPSIS

PART 4 - TREATMENT

(Iron and Manganese Control)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Iron and manganese control: Iron and manganese removal will be required if the iron and manganese levels exceed 0.3 mg/L and 0.05 g/L respectively.
- Recommended oxidizing methods are aeration and the use of strong oxidizers such as sodium hypochlorite. Potassium permanganate, although a strong oxidizer, is not recommended for First Nation iron and manganese removal plants. The pH of the raw water is a significant parameter for the type of treatment selected.
- Cation ion exchange methods are acceptable if the heavy metals in the raw water do not exceed 0.3 mg/L.
- Silica sand with a blend of manganese dioxide is an acceptable method of filtration; a minimum cap of 400 mm of anthracite should overlay the silica sand/pyrolucite blend. The filter must act as a contactor and filter based on previous pilot work.
- Check hydraulic loading rates of filters and backwash rates.

SYNOPSIS

PART 4 - TREATMENT

(Water Conditioning)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Water Conditioning: Conditioning of water is required if the alkalinity is too low to ensure effective coagulation for subsequent treatment or the water is so aggressive that serious corrosion could occur in the distribution piping or in internal plumbing systems in homes. Conditioning will increase the pH and alkalinity of the water.
- Where coagulation and flocculation treatment is required the preferred form of conditioning method is with the use of a limestone contactor.
- Check empty bed contact time and configuration of tank shape, ensure that each contactor has a drain for de-watering.
- Pre-screening is required for all contactors and a bypass is necessary for blending raw water with conditioned water.
- Check specifications of lime rock with guidelines.
- Include provision for an efficient airwash and water backwash to remove inerts and sediments from the contactor basin.

SYNOPSIS

PART 4 - TREATMENT

PAGE 9 of 10

(Water Conditioning and Arsenic Removal)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Water Conditioning: Where water conditioning is required for reducing corrosivity only then alternative treatment solutions should be reviewed such as the addition of sodium hydroxide (caustic soda) or sodium carbonate (soda ash).

- Arsenic removal: Where levels of arsenic exceed 0.025 mg/L in any one sample in the raw water then an alternative raw water source should be sought. If there is no other source available then arsenic treatment must be applied to reduce the levels below 0.010 mg/L

- At least two arsenic removal treatment processes must be piloted to determine the optimum form of treatment.

- Review life cycle costs, and complexity of operation in the review analysis. Ensure that accurate test equipment is available to readily measure and record arsenic levels in the raw and treated water.

SYNOPSIS

PART 4 - TREATMENT

PAGE 10 of 10
(Arsenic Removal)

(1) Synopsis

Part 4 suggests various treatment options and guidelines to permit a variety of raw water, both groundwater and surface water, to be treated in order to comply with the physical, chemical and microbiological levels recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) and potential pathogenic biota levels required by INAC.

(2) Check List (Continued)

- Arsenic is most easily removed when it exists in trivalent and pentavalent forms which in turn is related to the pH of the water. Several methods are available however the following methods should be explored:

  .1 Adsorption onto a granular ferric oxide medium,

  .2 By reverse osmosis,

  .3 Alum chemical coagulation and sedimentation with pre-oxidation as necessary,

  .4 Activated alumina.

- Consider removal and handling of rejects and waste streams generated from the treatment process both efficiently and safely.

4 TREATMENT

Water which is to be delivered to consumers must meet the "Guidelines for Canadian Drinking Water Quality" Latest Edition, published in a booklet by Health Canada. In order to keep interested parties informed of changes to the Guidelines between publication of new editions, a summary table entitled "Summary of Guidelines for Canadian Drinking Water Quality" is updated and published every spring on Health Canada's website (www.hc-sc.gc.ca/waterquality). The "Summary of Guidelines for Canadian Drinking Water Quality" supercedes all previous versions, including that contained in the published Health Canada booklet.

The design of treatment processes and devices shall depend on an evaluation of the nature and quality of the particular water to be treated, seasonal variations, the desired quality of the finished water and the mode of operation planned. **Continuous disinfection is required for all water supplies.**

Water containing high turbidity may require pretreatment, usually coagulation, flocculation and clarification with the addition of coagulation chemicals. Water containing colour greater than 15 True Colour Units (TCU), or Total Organic Carbon (TOC) in a concentration that it may produce disinfection by-products during disinfection with chlorine may require pre-treatment with the addition of coagulation chemicals.

As per Health Canada Guidelines for Canadian Drinking Water Quality - Supporting Documentation on Turbidity – for chemically assisted filtration (i.e., continuous feed of a coagulant with mixing ahead of filtration), source water turbidity levels should be measured at least once per calendar day directly in front of where the first treatment chemical is applied.

The above notwithstanding all designs should provide for low mechanical content to the greatest extent possible. **For example, water systems and processes based on flow of water by gravity are preferred over pumped or mechanical systems**.

The design shall prevent cross connections, and common walls, between potable and non-potable water.

4.1 GROUNDWATER

Where the drinking water system obtains water from a raw water supply which is groundwater, the treatment process must, as a minimum, consist of disinfection and must be credited with achieving an overall performance that provides at least 2-log (99%) inactivation or removal of viruses before water is delivered to the first consumer.

Where the drinking water system obtains water from a raw water supply which is groundwater that is of questionable sanitary quality, the treatment process shall as a minimum, consist of disinfection and must be credited with achieving an overall performance that provides at least 4-log (99.99%) inactivation or removal of viruses before water is delivered to the first consumer.

Plants designed for processing groundwater with treatment other than disinfection shall be designed according to the applicable process descriptions noted further in this Section Part 4. The process shall provide a level of treatment which achieves at least 4-log (99.99%) inactivation or removal of viruses.

Primary disinfection processes that do not produce a disinfection residual must be followed by a secondary disinfectant. The use of chlorine as secondary disinfection by applying chlorine to provide a residual disinfectant is recommended.

4.2 SURFACE WATER AND GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

Filtration and Disinfection may be required for all surface water, and groundwater under the direct influence of surface water. Disinfection is mandatory and will ideally include two distinct stages, a primary stage using UV irradiation to inactivate or destroy bacteria, protozoa and some viruses and a secondary stage using chlorine to complete the destruction of potential pathogens and maintain a working residual in the distribution system.

Filtration is required at all treatment plants ***unless the avoidance criteria for filtration is met*** as detailed in the Health Canada Guidelines for Canadian Drinking Water Quality - Supporting Documentation on Turbidity. Filtration of a surface water source or a groundwater source under the direct influence of surface water may not be necessary if ***all*** of the following conditions are met:

1. Overall inactivation is met using a minimum of two disinfectants: ultraviolet irradiation or ozone to inactivate cysts/oocysts; chlorine (free chlorine) to inactivate viruses; and chlorine to maintain a residual in the distribution system.

2. Disinfection should reliably achieve at least a 99% (2-log) reduction of *Cryptosporidium* oocysts,* a 99.9% (3-log) reduction of *Giardia lamblia* cysts and a 99.99% (4-log) reduction of viruses. If mean source water cyst/oocyst levels are greater than 10/1000 L, more than 99% (2-log) reduction of *Cryptosporidium* oocysts and 99.9% (3-log) reduction of *Giardia lamblia* cysts should be achieved. Background levels for *Giardia lamblia* cysts and *Cryptosporidium* oocysts in the source water should be established by monitoring as described in the most recent "Protozoa" guideline document, or more frequently during periods of expected highest levels (e.g., during spring runoff or after heavy rainfall).

3. Prior to the point where the disinfectant is applied, the number of *Escherichia coli* bacteria in the source water does not exceed 20/100 mL (or, if *E. coli* data are not available, the number of total coliform bacteria does not exceed 100/100 mL) in at least 90% of the weekly samples from the previous 6 months. dAverage daily source water turbidity levels measured at equal intervals (at least every 4 hours), immediately prior to where the disinfectant is applied, are around 1.0

NTU but do not exceed 5.0 NTU for more than 2 days in a 12-month period. Source water turbidity also does not show evidence of protecting microbiological contaminants.

4. A watershed control program (e.g., protected watershed, controlled discharges, etc.) is maintained that minimizes the potential for faecal contamination in the source water.

Water treatment facilities designed for processing surface water, and groundwater under the direct influence of surface water shall be designed according to the applicable and/or pertinent treatment process described later in this Part 4. The following minimum level of treatment for microbiological contaminants shall be provided:

Potential Pathogen	Removal/Inactivation
Cryptosporidium	2 log (99%)
Giardia	3 log (99.9%)
Viruses	4 log (99.99%)
Bacteria (*E-coli*)	100%

At least 0.5-log removal or inactivation of *Giardia* cysts, and 2-log removal or inactivation of viruses must be provided through the disinfection portion of the overall water treatment process.

The requirements of the document entitled “Procedure for Disinfection of Drinking Water in Ontario” - Latest Version, Province of Ontario, should be met for determining whether water treatment facilities provide the minimum level of treatment for microbiological contaminants. The document is available in Appendix A.

4.3 TREATMENT PROCESSES

The following treatment processes and devices are included as guidelines that will depend on the nature and quality of the raw water to be treated. Such treatment when selected as the preferred option must ensure that the treated water complies fully with the latest edition of the Guidelines for Canadian Drinking Water Quality and the criteria noted under 4.1 and 4.2 above for microbiological removal or inactivation.

The treatment processes addressed in this document are:

The treatment processes addressed in this document are:

- Clarification
  - Presedimentation

  - Rapid mix
  - Flocculation
  - Sedimentation
  - Plate settlers
- Filtration
  - Rapid rate gravity filters
  - Rapid rate pressure filters
  - Slow sand filters
  - Direct filtration
- Disinfection
  - Chlorination
  - Ultraviolet irradiation
- Softening
  - Cation exchange process
- Aeration
  - Natural draft aeration
  - Force or induced draft aeration
  - Spray aeration
  - Pressure aeration
  - Packed tower aeration
- Iron and manganese removal
  - Oxidation, detention and filtration
  - Silica sand/manganese coated filter
  - Ion exchange
- Fluoridation
- Stabilization
  - Alkali feed
  - Limestone contactor
  - Other treatment
- Taste & Odour Control
- Microscreening
- Arsenic Removal
  - Conventional coagulation employing aluminum or iron salts
  - Adsorption onto a granular ferric oxide bed
  - Adsorption onto an activated alumina
  - Separation by reverse osmosis

4.3.1 Clarification

a. provide a minimum of one unit each for rapid mix. flocculation and sedimentation;

b. be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time;

c. provide multiple-stage treatment facilities when required by the reviewing authority;

d. be started manually following shutdown;

e. minimize hydraulic head losses between units to allow future changes in processes without the need for repumping.

4.3.1.1 Presedimentation

Water containing high turbidity may require pre-treatment, usually sedimentation with or without the addition of coagulation chemicals:

a. Basin Design - presedimentation basins must provide arrangements for dewatering and having access for equipment for manually cleaning the basin;

b. Inlet - incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented;

c. Bypass - provisions for bypassing presedimentation basins shall be included;

d. Detention Time - three hours detention is the minimum period recommended; greater or less detention may be required based on tests performed at the specific location.

4.3.1.2 Rapid Mix

Rapid mix shall mean the rapid dispersion of chemicals throughout the water to be treated, usually by violent agitation. The engineer shall submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added, water temperature, colour and other related water quality parameters.

a. The need for rapid mixing shall be determined from bench scale (JAR) tests or pilot tests;

b. Hydraulic mixing is the preferred method of mixing. Consideration should be given to variable flow over the life of the facility to ensure adequate mixing during low flow conditions;

c. Mixing - the detention period shall be not more than thirty seconds;

d. Location - The rapid mix and flocculation basin shall be as close together as possible.

4.3.1.3 Flocculation

Flocculation shall mean the agitation of water at low velocities for long periods of time.

a. Basin Design - inlet and outlet design shall minimize short-circuiting and destruction of floc. A drain and/or pumps shall be provided to handle dewatering and sludge removal;

b. Detention - the flow-through velocity should be not less than 0.15 m/min nor greater than 0.50 m/min with a detention time for floc formation of at least 30 minutes. Bench scale (JAR) testing or pilot plant testing shall be used to determine extended detention time for cold water conditions, i.e. less than 10°C;

c. Equipment - agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.15 m to 1 m per second;

d. Flocculation - hydraulic flocculation is the preferred method of gentle mixing. Mechanical flocculation may be used only after consultation and approval from the reviewing authority;

e. Piping - flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be not less than 0.15 m nor greater than 0.50 m per second. Allowances must be made to minimize turbulence at bends and changes in direction. Care must be taken to prevent the breaking up of floc, particularly colour floc;

f. Other Designs - baffling may be used to provide for flocculation in small plants only after consultation with the reviewing authority. The design should be such that the velocities and flows noted above will be maintained;

g. Superstructure - a superstructure over the flocculation basins may be required.

4.3.1.4 Sedimentation

Sedimentation shall follow flocculation. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units:

a. Detention Time - shall provide a minimum of four hours of settling time. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated or when overflow rate is not more than 1.2 m/hr. The overflow rate is for turbidity removal. For colour removal the overflow rate should be reduced to 60% of the value given;

b. Inlet Devices - inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and must project sufficient distance below the water surface to dissipate inlet velocities and provide uniform flows across the basin;

c. Outlet Devices - outlet weirs or submerged orifices shall maintain velocities suitable for settling in the basin and minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow. Outlet weirs and submerged orifices shall be designed as follows:

   i. the rate of flow over the outlet weirs or through the submerged orifices hall not exceed 250 m3/day/m of the outlet launder;

   ii. submerged orifices should not be located lower than 1 m below the flow line;

   iii. the entrance velocity through the submerged orifices shall not exceed 0.15 m per second.

d. Velocity - the velocity through settling basins shall not exceed 0.15 m per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification;

e. Overflow - an overflow weir or pipe designed to establish the maximum water level desired on top of the filters should be provided. The overflow shall discharge by gravity with a free fall at a location where the discharge will be noted;

f. Superstructure - a superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure;

g. Sludge Collection - hoppers and drains or mechanical sludge collection equipment should be provided;

h. Drainage - basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than 8%;

i. Flushing Lines - flushing lines or hydrants shall be provided and must be equipped with back flow prevention devices acceptable to the reviewing authority;

j. Safety - permanent ladders or handholds shall be provided on the inside walls of basins above the water level. Guard rails must be included. Compliance with other applicable safety requirements, such as Workers Compensation Board, shall be required;

k. Sludge Removal - sludge removal design shall provide that:

  i. sludge pipes shall be not less than 75 mm in diameter and so arranged as to facilitate cleaning;

  ii. entrance to sludge withdrawal piping shall prevent clogging;

  iii. valves shall be located outside the tank for accessibility;

  iv. the operator can observe and sample sludge being withdrawn from the unit.

l. Sludge Disposal - facilities are required by the reviewing authority for disposal of sludge. See Part 9.

4.3.1.5 Plate Settlers

Proposals for settler unit clarification must include pilot plant and/or full scale demonstration data on water with similar quality prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped plates which are installed in multiple layers and at an angle to the flow may be used for sedimentation, following flocculation.

4.3.1.5.1. General Criteria

a. Inlet and Outlet Considerations - design to maintain velocities suitable for settling in the basin and to minimize short-circuiting. Plate units shall be designed to minimize uneven distribution across the units;

b. Drainage - drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant;

c. Protection from Freezing - although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended;

d. Application Rates for Plate Settlers - for turbidity removal a maximum plate loading rate of 1.2 m/hr based on 80% of the projected horizontal plate area shall be used. After pre-treatment for colour removal a maximum plate loading rate of 0.3 m/hr based on 80% of the projected horizontal plate area shall be used;

e. Flushing Lines - flushing lines shall be provided to facilitate maintenance and must be properly protected against back flow or back siphonage.

4.3.2 Filtration

Acceptable filters shall include, upon the discretion of the reviewing authority, the following types:

a. Rapid rate gravity filters;

b. Rapid rate pressure filters;

c. Slow sand filtration;

d. Direct filtration;

e. Membrane filtration (see Policy Statements on Reverse Osmosis and Nanofiltration for Public Water Supplies and Microfiltration and Ultrafiltration for Public Water Supplies and Microfiltration and Ultrafiltration for Public Water Supplies at the front of this document);

f. Bag and cartridge filters (see policy statement on Bag and Cartridge Filters for Public Water Systems at the front of this document).

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed.

4.3.2.1 Rapid Rate Gravity Filters

4.3.2.1.1. Pre-treatment

The use of rapid rate gravity filters shall require pre-treatment.

4.3.2.1.2. Rate of Filtration

The rate of filtration shall be determined through consideration of such factors as raw water quality, degree of pre-treatment provided, filter media, water quality control parameters, competency of operating personnel, and other factors as required by the reviewing authority. In any case, the filter rate must be proposed and justified by the design engineer to the satisfaction of the reviewing authority prior to the preparation of final plans and specifications.

4.3.2.1.3. Number

At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

4.3.2.1.4. Structural Details and Hydraulics

The filter structure shall be designed to provide for:

a. vertical walls within the filter;

b. no protrusion of the filter walls into the filter media;

c. cover by superstructure;

d. head room to permit normal inspection and operation;

e. minimum depth of filter box of 2.5 m;

f. minimum water depth over the surface of the filter media of 1 m;

g. trapped effluent to prevent back flow of air to the bottom of the filters;

h. prevention of floor drainage to the filter with a minimum 100 mm curb around the filters;

i. prevention of flooding by providing overflow;

j. maximum velocity of treated water in pipe and conduits to filters of 0.6 m per second;

k. clean-outs and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening;

l. wash-water drain capacity to carry maximum flow;

m. walkways around filters, to be not less than 600 mm wide;

n. safety handrails or walls around all filter walkways;

o. construction to prevent cross connections and common walls between potable and non-potable water.

4.3.2.1.5. Wash-water Troughs

Wash-water troughs shall be constructed to have:

a. the bottom elevation above the maximum level of expanded media during washing;

b. a 50 mm freeboard at the maximum rate of wash;

c. the top edge level and all at the same elevation;

d. spacing so that each trough serves the same number of square metres of filter area;

e. maximum horizontal travel of suspended particles to reach the trough not to exceed 1 m.

4.3.2.1.6. Filter Material

The media shall be clean silica sand or other natural or synthetic media free from detrimental chemical or bacterial contaminants, approved by the reviewing authority, and having the following characteristics:

a. a total depth of not less than 600 mm and generally not more than 750 mm;

b. an effective size range of the smallest material no greater than 0.45 mm to 0.55 mm;

c. a uniformity coefficient of the smallest material not greater than 1.65;

d. a minimum of 300 mm of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter;

e. types of filter media:

    1. Anthracite - clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and shall have:

        a. effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone;

        b. effective size of 0.8 mm - 1.2 mm with a uniformity coefficient not greater than 1.85 when used as a cap;

        c. effective size for anthracite used as a single media on potable groundwater for iron and manganese removal only shall be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies or other demonstration acceptable to the reviewing authority).

2. Silica Sand - silica sand shall have:

   a. effective size of 0.45 mm to 0.55 mm;

   b. uniformity coefficient of not greater than 1.65;

   c. larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions.

3. Granular Activated Carbon (GAC) - Granular activated carbon as a single medium may be considered for filtration only after pilot or full scale testing and with prior approval of the reviewing authority. The design shall include the following:

   a. the media must meet the basic specifications for filter media as noted under Filter Material, except that larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions;

   b. there must be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution;

   c. there must be means for periodic treatment of filter material for control of bacterial and other growth;

   d. provisions must be made for frequent replacement or regeneration.

4. Other Media - other media will be considered based on experimental data and operating experience.

5. Torpedo Sand - a three inch layer of torpedo sand shall be used as a supporting media for filter sand where supporting gravel is used, and shall have:

   a. effective size of 0.8 mm to 2.0 mm;

   b. uniformity coefficient not greater than 1.7.

6. Gravel - gravel, when used as the supporting media shall consist of cleaned and washed, hard, durable, rounded silica particles and shall not include flat or elongated particles. The coarsest gravel shall be 50 mm in size when the gravel rests directly on a lateral system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution.

Size	**Depth**
60 mm to 50 mm	125 mm to 200 mm
50 mm to 20 mm	75 mm to 125 mm
20 mm to 10 mm	75 mm to 125 mm
10 mm to 5 mm	50 mm to 75 mm
5 mm to 2.5 mm	50 mm to 75 mm

Reduction of gravel depths and other size gradations may be considered upon justification to the reviewing authority for slow sand filtration or when proprietary filter bottoms are specified.

4.3.2.1.7. Filter Bottoms and Strainer Systems

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese may clog them. The design of manifold-type collection systems shall;

a. minimize loss of head in the manifold and laterals;

b. ensure even distribution of wash-water and even rate of filtration over the entire area of the filter;

c. provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003;

d. provide the total cross-sectional area of the laterals at about twice the total area of the final openings;

e. provide the total cross-sectional area of the manifold at 1-1/2 to 2 times the total area of the laterals;

f. lateral perforations without strainers shall be directed downward.

4.3.2.1.8. Surface Wash or Subsurface Wash

Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus. All devices shall be designed with:

a. a provision for water pressures of at least 310 kPa;

b. a properly installed vacuum breaker or other approved device to prevent back siphonage if connected to the treated water system;

c. rate of flow of 4.9 m/hr of filter area with fixed nozzles or l.2 m/hr with revolving arms;

d. air wash can be considered based on experimental data and operating experiences.

4.3.2.1.9. Air Scouring

Air scouring can be considered in place of surface wash:

a. air flow for air scouring the filter must be 0.9 to 1.5 m3/min/m2 when the air is introduced in the under-drain; a lower air rate must be used when the air scour distribution system is placed above the under-drains;

b. a method for avoiding excessive loss of the filter media during backwashing must be provided;

c. air scouring must be followed by a fluidization wash sufficient to restratify the media;

d. air must be free from contamination;

e. air scour distribution systems should be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles shall be designed to prevent media from clogging the nozzles or entering the air distribution system;

f. piping for the air distribution system shall not be flexible hose which will collapse when not under air pressure and shall not be a relatively soft material which may erode at the orifice opening with the passage of air at high velocity;

g. air delivery piping shall not pass down through the filter media nor shall there be any arrangement in the filter design which would allow short circuiting between the applied unfiltered water and the filtered water;

h. consideration should be given to maintenance and replacement of air delivery piping;

i. the back-wash water delivery system must be capable of 40 m/hr; however, when air scour is provided the back-wash water rate must be variable and should not exceed 30 m/hr unless operating experience shows that a higher rate is necessary to remove scoured particles from filter media surfaces;

j. the filter under-drains shall be designed to accommodate air scour piping when the piping is installed in the under-drain;

k. the provisions of the section describing “Back-wash” shall be followed.

4.3.2.1.10. Appurtenances

a. the following shall be provided for every filter:

1. influent and effluent sampling taps;

2. an indicating loss of head gauge;

3. an indicating rate-of flow metre. A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a flow metre in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the reviewing authority;

4. where used for surface water, provisions for filtering to waste with appropriate measures for back-flow prevention.

b. It is recommended the following be provided for each filter:

1. a continuous recording turbidimeter on each filter effluent line;

2. wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing;

3. a 25 mm to 40 mm pressure hose and storage rack at the operating floor for washing filter walls;

4. additional continuous monitoring equipment to assist in the control of coagulant dose may be required by the reviewing authority.

4.3.2.1.11. Back-wash

Provisions shall be made for washing filters as follows:

a. a minimum rate of 37 m/hr, consistent with water temperatures and specific gravity of the filter media. A rate of 50 m/hr or a rate necessary to provide for a 50% expansion of the filter bed is recommended. A reduced rate of 24 m/hr may be acceptable for full depth anthracite or granular activated carbon filters;

b. filtered water provided at the required rate by wash-water tanks, a wash-water pump, from the high service main, or a combination of these;

c. wash-water pumps in duplicate unless an alternate means of obtaining wash-water is available;

d. not less than 15 minutes wash of one filter at the design rate of wash;

e. a wash-water regulator or valve on the main wash-water line to obtain the desired rate of filter wash with the wash-water valves on the individual filters open wide;

f. a rate-of-flow indicator, preferably with a totalizer, on the main wash-water line, located so that it can be easily read by the operator during the washing process;

g. design to prevent rapid changes in back-wash water flow;

h. back-wash shall be operator initiated. Automated systems shall be operator adjustable.

4.3.2.1.12. Miscellaneous

Roof drains shall not discharge into the filters or basins and conduits preceding the filters.

4.3.2.2 Rapid Rate Pressure Filters

The normal use of these filters is for iron and manganese removal. Pressure filters shall not be used in the filtration of surface or other polluted water.

4.3.2.2.1. General

Minimum criteria relative to rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

4.3.2.2.2. Rate of Filtration

The rate shall not exceed 7.2 m/hr except where in plant testing as approved by the reviewing authority has demonstrated satisfactory results at higher rates.

4.3.2.2.3. Details of Design

The filters shall be designed to provide for:

a. loss of head gauges on the inlet and outlet pipes of each battery of filters;

b. an easily readable metre or flow indicator on each battery of filters. A flow indicator is recommended for each filtering unit;

c. filtration and back-washing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes;

d. minimum side wall shell height of 1.5 m. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth;

e. the top of the wash-water collectors to be at least 450 mm above the surface of the media;

f. the under-drain system to efficiently collect the filtered water and to uniformly distribute the back-wash water at a rate not less than 40 m/hr;

g. back-wash flow indicators and controls that are easily readable while operating the control valves;

h. an air release valve on the highest point of each filter;

i. an accessible manhole to facilitate inspection and repairs for filters 900 mm or more in diameter. Sufficient handholds shall be provided for filters less than 900 mm in diameter. Manholes should be at least 600 mm in diameter where feasible;

j. means to observe the waste-water during back-washing;

k. construction to prevent cross-connection.

4.3.2.3 Slow Sand Filters

The use of these filters shall require prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply.

For conditions not included in this guideline, or at the direction of the reviewing authority, engineering studies should include operation of a pilot plant in order to determine the suitability of the proposed sand and to establish the required frequency of cleaning. The pilot plant should use the same sand as proposed for the full scale plant and the period of operation should include seasons with poor water quality conditions.

4.3.2.3.1. Quality of Raw Water

Slow sand gravity filtration shall be limited to water having maximum turbidities of 10 NTU's and maximum colour of 15 TCU; turbidity values must not be attributable to colloidal clay. Raw water quality data must include examinations for algae. These conditions pertain to raw water without coagulation pre-treatment.

Slow sand gravity filtration with coagulation pre-treatment (enhanced treatment) should have influent water to the filter with a maximum turbidity of 2 NTU and a maximum colour of 15 TCU.

4.3.2.3.2. Number

At least two units shall be provided in order to allow operation flexibility unless waived by the reviewing authority.

4.3.2.3.3. Structural Details and Hydraulics

Slow sand gravity filters shall be so designed as to provide:

a. a cover, unless it can be demonstrated that it is not a problem for filter cleaning or operation of the plant;

b. headroom to permit normal movement by operating personnel for scraping and sand removal operations. A minimum 2 m headroom is suggested;

c. adequate access hatches and access ports for handling of sand and for ventilation, easy access at grade shall be provided;

d. filtration to waste or to the inlet side of other filters during ripening process;

e. an overflow at the maximum filter water level that can be used for removal of scum and floating matter from the water when necessary;

f. protection from freezing unless it can be demonstrated that freezing is not a problem for filter cleaning or operation of the plant;

g. provision to drain off supernatant water prior to filter cleaning. (The drain inlet should be adjustable so that it is located near the top level of the sand over the full range of sand depths). The drain shall be constructed to not allow short circuiting of raw or pre-treated water to the filter under-drain;

h. the walls of the filter box shall be configured to prevent short circuiting of flow between the media and the walls;

i. provisions to permit filtered water (from another filter unit) to flow slowly upwards at a maximum rate of 0.1 m/hr from the bottom, through the gravel and sand bed, during start-up operation after sand cleaning;

j. provisions for a temporary hose connection between the outlet of the pre-treatment unit or raw water source and the outlet side of filters to permit water to flow slowly upwards from the bottom, through the drainage system and the gravel and sand bed, during plant start-up operation;

k. provisions for draining each filter tank;

l. a continuous, relatively uniform flow of water through the filter;

m. a valve to control rate of raw water into the supernatant water reservoir;

n. a valve capable of accurately controlling the rate of filtration;

o. an effluent pipe designed to maintain the water level above the top of the filter sand;

p. construction to prevent cross connections, and common walls, between potable and non-potable water.

4.3.2.3.4. Rates of Filtration

The permissible rates of filtration shall be determined by the quality of the raw water and shall be on the basis of experimental data derived from the water to be treated;

a. without coagulation pre-treatment, the nominal rate may be 0.1 to 0.3 m/hr at design maximum day demand. During filter cleaning operations, the filtration rate may be temporarily increased in the operating filter(s), but should not exceed 0.4 m/hr;

b. without coagulation pre-treatment the nominal rate may be somewhat higher when demonstrated to the satisfaction of the approving authority;

c. with coagulation pre-treatment the maximum permissible rate of filtration shall be 0.1 m/hr at design maximum day demand unless it can be demonstrated that frequency of cleaning can be met with a higher filtration rate. During filter cleaning operations, the filtration rate may be temporarily increased in the operating filter(s), but should not exceed 0.2 m/hr;

d. at design maximum day demand the time period between scraping should be at least one month during the worst water quality conditions.

4.3.2.3.5. Under-drains

a. each filter unit shall be equipped with a main drain and an adequate number of lateral under-drains to collect the filtered water. The under-drains shall be so spaced that the maximum velocity of the water flow in the under-drain will not exceed 0.25 m per second. The maximum spacing of laterals shall not exceed 1 m if pipe laterals are used;

b. the lateral drains should consist of slotted PVC pipe covered with layers of gravel of successively diminishing grain size to prevent the intrusion of filtering medium. The pipe must be CSA certified for potable water use;

c. the slot size and diameter of pipe is to be compatible with overlying gravel materials and specified flow rate and velocity.

4.3.2.3.6. Filter Material

a. the filtering material shall meet the requirements of the most current issue of AWWA B100 Filtering Material including all the testing requirements;

b. the initial thickness of the filter sand should be 1.2 m. This thickness shall be reduced to not less than 0.4 m after removing the upper sand layers during filter cleaning;

c. without pre-treatment, the effective diameter of the filter media, d10, should be between 0.15 mm and 0.35 mm and will be determined by pilot testing. With pre-treatment, the effective diameter of the filter media, d10, should be between 0.30 mm and 0.35 mm;

d. the uniformity coefficient should not exceed 3.0. A coefficient of less than 2.0 is preferable;

e. the filter sand should be hard and durable, rounded, free from clay, loam, and organic matter;

f. the sand should not contain more than 2% of calcium and magnesium, calculated as carbonates.

4.3.2.3.7. Filter Gravel

a. the support gravel shall meet the requirements of the most current issue of AWWA B100 Filtering Material including all testing requirements;

b. the filter sand shall be underlain by graded support gravel layers to prevent migration of the filter sand;

c. the support gravel system shall be built of various layers ranging from fine grain at the top to coarse grain at the bottom;

d. each gravel layer shall be graded such that the 10% and 90% passing diameters shall differ by a factor of not more than 1.41;

e. the upper layer of gravel must be selected with a d10 value more than four times greater than the d15 value of the coarsest filtration sand and less than four times greater than the d85 value of the finest filtration sand proposed to be used;

f. each successive gravel layer shall be graded so that the d10 particle diameters are not more than four times smaller than those of the layer immediately below;

g. the diameter of the smallest particle within the last gravel layer shall be at least two times greater than the slot size opening in the under-drainage system;

h. the thickness of each gravel layer shall be at least three times the diameter of the largest stone in its grading, but for practical purposes a minimum thickness of the layers shall be 50 mm to 70 mm for the finer material and 80 mm to 120 mm for the coarser gravel;

i. the support gravel shall be hard, rounded, with a specific gravity of at least 2.5, and should be free from silt, clay loam, and organic impurities of all kinds.

4.3.2.3.8. Depth of Water on Filter Beds

a. outlet controlled - the rate of filtration is regulated by a valve on the outlet. The depth of water on filter beds should be regulated to provide a relatively constant positive water head in the system of 2 m. This is the preferred mode of operation;

b. inlet controlled - the rate of filtration is regulated by a valve on the filter inlet. This mode of operation will be approved on a site - specific basis only. Initially the level of supernatant water will be low, but with time it will gradually rise to compensate for the increase in filter resistance. The final water depth should be 1.5 to 2 m.

4.3.2.3.9. Control Appurtenances

Turbidity test equipment must also be provided for measurement of raw water turbidity. The following shall be provided for each filter unit:

a. sampling taps for raw and filtered water, and also for settled water where coagulation pre-treatment is provided;

b. flow metre with rate-of-flow indicator, totalizer, and a signal suitable for input to an electronic recording device;

c. filter level site gauges which indicate filter head loss (for use during normal operation) and level of water in the sand (for use in back-filling and draining operations);

d. a continuous monitoring turbidimeter on the filter effluent, with a means to record results electronically.

4.3.2.3.10. Ripening

Slow sand filters shall be operated to waste after scraping or rebedding during a ripening period until the filter effluent turbidity falls to consistently below 5 NTU.

4.3.2.4 Direct Filtration

Direct filtration, as used herein, refers to the filtration of a surface water following chemical coagulation and possibly flocculation but without prior settling. The nature of the treatment process will depend upon the raw water quality. A full scale direct filtration plant shall not be constructed without prior pilot studies which are acceptable to the reviewing authority. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report shall be submitted prior to conducting pilot plant or in-plant demonstration studies.

4.3.2.4.1. Filtration

a. filters shall be rapid rate gravity filters with dual or mixed media. The final filter design shall be based on the pilot plant or in-plant demonstration studies and all portions of Section 4.3.2.1 “Rapid Rate Gravity Filters”. Pressure filters or single medium sand filters shall not be used;

b. a continuous recording turbidimeter shall be installed on each filter effluent line and on the composite filter effluent line;

c. additional continuous monitoring equipment such as particle counting or streaming current metering to assist in control of coagulant dose may be required by the reviewing authority.

4.3.2.5 Siting Requirements

See Section 2.20.

4.3.3 Disinfection

4.3.3.1 General

Disinfection is required for all raw water supplies, regardless of source. The required amount of primary disinfection needed shall be specified by the reviewing authority. Continuous disinfection is required for all water supplies. Consideration must be given to the formation of disinfection byproducts (DBP) when selecting the disinfectant.

Disinfection shall be accomplished using chlorine or ultraviolet light or if considered necessary by both. Chlorine is the preferred disinfecting agent and may be introduced into the water supply using either sodium or calcium hypochlorite. If calcium hypochlorite is used then the tablet form is preferred. (See Part 5 for further details of disinfecting agents).

4.3.3.2 Chlorination Equipment

4.3.3.2.1. Type

Hypochlorite feeders of the positive displacement type or in tablet form must be provided depending on the hypochlorite selected (see Part 5).

4.3.3.2.2. Design Capacity

The chlorination system must be able to provide a free chlorine residual of at least 2 mg/L once all demands are met after a contact time of at least 30 minutes under anticipated maximum chlorine demand conditions. The initial chlorine metering pumps should be designed for twice the maximum demand that will be achieved at the plant five years following pump installation. Every five years the feeder pumps should be replaced with pumps of higher capacity to meet twice the maximum day demand that will be reached five years after installation. The capacity of the replacement feeder pumps would increase until the plant design capacity has been reached. This will allow the pumps to operate more effectively during the low flows the plant will experience during the initial years of plant operation. The replacement of the feeder pumps every five years with greater capacity pumps must be included in maintenance cost estimates for treatment facilities (See Section 1.1.5).

4.3.3.2.3. Standby Equipment

Where chlorination is required for protection of the supply, standby equipment of sufficient capacity shall be available to replace the largest unit. Spare parts shall be made available to replace parts subject to wear and breakage.

4.3.3.2.4. Injector/Diffuser

The chlorine solution injector/diffuser must be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The centre of a pipeline is the preferred application point.

4.3.3.3 Contact Time and Point of Application

a. Due consideration shall be given to the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection byproduct formation potential and other pertinent factors. The disinfectant should be applied at a point which will provide adequate contact time after mixing. All basins (contact chambers) used for disinfection must be designed to minimize short circuiting. Additional baffling can be added to new or existing basins to minimize short circuiting and increase contact time;

b. At plants treating surface water, provisions shall be made for applying the disinfectant to the filtered water, and water entering the distribution system;

c. As a minimum, at plants treating groundwater, provisions shall be made for applying the disinfectant to the water entering the distribution system;

d. The amount of contact time provided will depend on the type of disinfectant used along with the parameters mentioned in 4.3.3.3 (a). As a minimum, for surface water and groundwater under the direct influence of surface water, the system must be designed to meet the CT standards noted in Appendix A of the guidelines. Disinfection for groundwater is required for all potable public water systems. Further guidance is provided in the USEPA Guidance Manual for the Surface Water Treatment Rule, March 1991 Edition, the USEPA "Disinfection Profiling and Benchmarking Guidance Manual", August 1999, and the Ministry of Environment Document "Procedure for Disinfection of Drinking Water in Ontario", which is provided in Appendix A;

e. Provisions should be made for applying chlorine as a secondary disinfectant to the water entering the distribution system.

4.3.3.4 Residual Chlorine

Free residual chlorination is the preferred practice. The overall waterworks should be capable of achieving, at all locations within the distribution system, a free chlorine residual of at least 0.2 milligrams per litre. Higher residuals may be required depending on pH, temperature and other characteristics of the water;

4.3.3.5 Testing Equipment

a. Chlorine residual test equipment recognized in the latest edition of Standard Methods for the Examination of Water and Wastewater shall be provided and should be capable of measuring residuals to the nearest 0.01 milligrams per litre.

It is recommended that all systems, as a minimum, use an instrument using the DPD colorimetric method with a digital readout and a self-contained light source;

b. Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time;

c. All treatment plants having a capacity of 2 ML/day or greater should be equipped with recording chlorine analyzers monitoring water entering the distribution system;

d. All surface water treatment plants must have equipment to measure chlorine residuals continuously entering the distribution system;

e. Systems that rely on chlorination for inactivation of bacteria or other micro-organisms present in the source water shall have continuous chlorine residual analyzers and other equipment that automatically shut down the facility when chlorine residuals are not met unless otherwise approved by the reviewing authority.

4.3.3.6 Chlorinator Piping

4.3.3.6.1. Cross-connection Protection

The chlorinator water supply piping shall be designed to prevent contamination of the treated water supply by sources of questionable quality.

4.3.3.6.2. Pipe Material

See Part 5 for further details.

4.3.3.7 Housing

See Part 5 for further details.

4.3.3.8 UV Disinfection

UV (ultraviolet light) disinfection may be considered as an alternative primary disinfectant if accepted by the reviewing authority. In order to be acceptable, the UV system must meet the following minimum requirements:

a. The specific UV equipment to be used (exact size and model number) must have been independently validated to demonstrate its effectiveness;

b. The design should include standby unit(s) and standby power to ensure that all water receives UV treatment at all times; water that has not been UV treated shall not be fed into the distribution system;

c. The UV dose shall be based on the quality of the water to be disinfected, taking into account lamp aging and fouling. The minimum UV dose shall be 40 mJ/cm2 at maximum flow;

d. Instrumentation to continuously monitor and record the performance of the UV system, including UV sensors and flow meters for each unit must be provided;

e. The design shall allow periodic replacement of UV lamps and sensors, and repairs. Spare parts shall be available to ensure that the equipment can be maintained and kept in service;

f. Lamp cleaning methods should be considered in the design and selection of equipment.

NOTE: In the near future the USEPA will be publishing UV dosage tables and a UV Guidance Manual for UV disinfection of drinking water.

4.3.3.9 Other Disinfecting Agents

Proposals for use of disinfecting agents other than those listed shall be approved by the reviewing authority prior to preparation of final plans and specifications. Although disinfecting agents other than chlorine are available, each can have shortcomings when applied to a small community water supply.

4.3.4 Softening

Only ion-exchange softening will be considered and where approved by the reviewing authority. Consideration must be taken into account for the disposal of brine wastes in accordance with the reviewing authority.

4.3.4.1 Cation Exchange Process

Alternative water sources should be investigated when the sodium content and dissolved solids concentration is of concern with respect to health (low sodium diets).

4.3.4.1.1. Pre-treatment Requirements

Iron, manganese, or a combination of the two, should not exceed 0.3 mg/L in the water as applied to the ion exchange resin. Pre-treatment is required when the content of iron, manganese, or a combination of the two is one milligram per litre or more. Water having 5 NTU's or more turbidity should not be applied directly to the cation exchange softener.

4.3.4.1.2. Design

The units may be of pressure or gravity type, of either an upflow or down-flow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by the reviewing authority. A manual override shall be provided on all automatic controls.

4.3.4.1.3. Exchange Capacity

The design capacity for hardness removal should not exceed 46 kg/m3 when resin is regenerated with 0.14 kg of salt per kg of hardness removed.

4.3.4.1.4. Depth of Resin

The depth of the exchange resin should not be less than 1 m.

4.3.4.1.5. Flow Rates

The rate of softening should not exceed 17 m/hr and the backwash rate should be 14-20 m/hr of bed area. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

4.3.4.1.6. Freeboard

The freeboard will depend upon the size and specific gravity of the resin and the direction of water flow. Generally, the wash-water collector should be 600 mm above the top of the resin on down-flow units.

4.3.4.1.7. Under-drains and Supporting Gravel

The bottoms, strainer systems and support for the exchange resin shall conform to criteria provided for rapid rate gravity filters.

4.3.4.1.8. Brine Distribution

Facilities should be included for even distribution of the brine over the entire surface of both upflow and down-flow units.

4.3.4.1.9. Cross-connection Control

Backwash, rinse and air relief discharge pipes shall be installed in such a manner as to prevent any possibility of back-siphonage.

4.3.4.1.10. Bypass Piping and Equipment

A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing metres must be installed in the bypass line and on each softener unit. The bypass line must have a shut-off valve and should have an automatic proportioning or regulating device. In some installations, it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

4.3.4.1.11. Additional Limitations

Silica gel resins should not be used for water having a pH above 8.4 or containing less than six milligrams per litre of silica and should not be used when iron is present. When the applied water contains a chlorine residual, the cation exchange resin shall be a type that is not damaged by residual chlorine. Phenolic resin should not be used.

4.3.4.1.12. Sampling Taps

Smooth-nose sampling taps must be provided for the collection of representative samples. The taps shall be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water shall be at least 6 m downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping.

4.3.4.1.13. Brine and Salt Storage Tanks

a. Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant;

b. The make-up water inlet must be protected from back-siphonage. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line;

c. Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or railcar. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs;

d. Overflows, where provided, must be protected with corrosion resistant screens and must terminate with either a turned down bend having a proper free fall discharge or a self-closing flap valve;

e. Two wet salt storage tanks or compartments designed to operate independently should be provided;

f. The salt shall be supported on graduated layers of gravel placed over a brine collection system;

g. Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

4.3.4.1.14. Salt and Brine Storage Capacity

Total salt storage should have sufficient capacity to store in excess of 1-1/2 carloads or truckloads of salt, and provide for at least 30 days of operation.

4.3.4.1.15. Brine Pump or Eductor

An eductor may be used to transfer brine from the brine tank to the softeners. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution.

4.3.4.1.16. Waste Disposal

Suitable disposal must be provided for brine waste (see Part 9). Where the volume of spent brine must be reduced, consideration may be given to using a part of the spent brine for a subsequent regeneration.

4.3.4.1.17. Construction Materials

Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping materials. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

4.3.4.1.18. Housing

Bagged salt and dry bulk salt storage shall be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.3.4.2 Water Quality Test Equipment

Test equipment for alkalinity, total hardness, carbon dioxide content, and pH should be provided to determine treatment effectiveness.

4.3.5 Aeration

Aeration may be used to help remove offensive tastes and odours due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc. and to introduce oxygen to assist in iron and/or manganese removal. The packed tower aeration process is an aeration process applicable to removal of volatile organic contaminants.

4.3.5.1 Natural Draft Aeration

Design shall provide:

a. Perforations in the distribution pan 5 mm to 12 mm in diameter, spaced 25 to 75 mm on centres to maintain a 150 mm water depth;

b. For distribution of water uniformly over the top tray;

c. Discharge through a series of three or more trays with separation of trays not less than 300 mm;

d. Loading at a rate of 2.5 to 12.5 m/hr of total tray area;

e. Trays with slotted, heavy wire (12 mm openings) mesh or perforated bottoms;

f. Construction of durable material resistant to aggressiveness of the water and dissolved gases;

g. Protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees;

h. Protection from insects by 24-mesh screen.

4.3.5.2 Forced or Induced Draft Aeration

Devices shall be designed to:

a. Include a blower with a weatherproof motor in a tight housing and screened enclosure;

b. Insure adequate counter current of air through the enclosed aerator column;

c. Exhaust air directly to the outside atmosphere;

d. Include a down-turned and 24-mesh screened air outlet and inlet;

e. Be such that air introduced in the column shall be as free from obnoxious fumes, dust and dirt as possible;

f. Be such that sections of the aerator can be easily reached or removed for maintenance of the interior or installed in a separate aerator room;

g. Provide loading at a rate of 2.5 - 12.5 m/hr;

h. Insure that the water outlet is adequately sealed to prevent unwarranted loss of air;

i. Discharge through a series of five or more trays with separation of trays not less than 150 mm or as approved by the reviewing authority;

j. Provide distribution of water uniformly over the top tray;

k. Be of durable material resistant to the aggressiveness of the water and dissolved gases.

4.3.5.3 Spray Aeration

Design shall provide:

a. A hydraulic head of between 1.5 m to 8 m;

b. Nozzles, with the size, number and spacing of the nozzles being dependent on the flow rate, space, and the amount of head available;

c. Nozzle diameters in the range of 25 mm to 40 mm to minimize clogging;

d. An enclosed basin to contain the spray. Any openings for ventilation, etc. must be protected with a 24-mesh screen.

4.3.5.4 Pressure Aeration

Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is applicable; it is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices shall be designed to:

a. Give thorough mixing of compressed air with water being treated;

b. Provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants.

4.3.5.5 Packed Tower Aeration

Packed tower aeration (PTA) which is also known as air stripping involves passing water down through a column of packing material while pumping air counter-currently up through the packing. PTA is used for the removal of volatile organic chemicals, trihalomethanes, carbon dioxide, and radon. Generally, PTA is feasible for compounds with a Henry's Constant greater than 100 (expressed in atm mol/mol) - at 12EC, but not normally feasible for removing compounds with a Henry's Constant less than 10. For values between 10 and 100, PTA may be feasible but should be extensively evaluated using pilot studies. Values for Henry's Constant should be discussed with the reviewing authority prior to final design.

4.3.5.5.1. Process Design

a. Process design methods for PTA involve the determination of Henry's Constant for the contaminant, the mass transfer coefficient, air pressure drop and stripping factor. The applicant shall provide justification for the design parameters selected (i.e. height and diameter of unit, air to water ratio, packing depth, surface loading rate, etc.). Pilot plant testing may be required.

   The pilot test shall evaluate a variety of loading rates and air to water ratios at the peak contaminant concentration. Special consideration should be given to removal efficiencies when multiple contaminations occur. Where there is considerable past performance data on the contaminant to be treated and there is a concentration level similar to previous projects, the reviewing authority may approve the process design based on use of appropriate calculations without pilot testing. Proposals of this type must be discussed with the reviewing authority prior to submission of any permit applications;

b. The tower shall be designed to reduce contaminants to below the maximum contaminant level (MCL) and to the lowest practical level;

c. The ratio of the column diameter to packing diameter should be at least 7:1 for the pilot unit and at least 10:1 for the full scale tower. The type and size of the packing used in the full scale unit shall be the same as that used in the pilot work;

d. The minimum volumetric air to water ratio at peak water flow should be 25:1. The maximum air to water ratio for which credit will be given is 80:1;

e. The design should consider potential fouling problems from calcium carbonate and iron precipitation and from bacterial growth. It may be necessary to provide pre-treatment. Disinfection capability shall be provided prior to and after PTA;

f. The effects of temperature should be considered since a drop in water temperature can result in a drop in contaminant removal efficiency;

g. Redundant capacity may be required by the reviewing authority.

4.3.5.5.2. Materials of Construction

a. The tower can be constructed of stainless steel, concrete, aluminium, fibreglass or plastic. Uncoated carbon steel is not recommended because of corrosion. Towers constructed of light-weight materials should be provided with adequate support to prevent damage from wind;

b. packing materials shall be resistant to the aggressiveness of the water, dissolved gases and cleaning materials and shall be suitable for contact with potable water.

4.3.5.5.3. Water Flow System

a. water should be distributed uniformly at the top of the tower using spray nozzles or orifice-type distributor trays that prevent short circuiting. For multi-point injection, one injection point for every 190 cm^2 of tower cross-sectional area is recommended;

b. a mist eliminator shall be provided above the water distributor system;

c. a side wiper redistribution ring shall be provided at least every 3 m in order to prevent water channelling along the tower wall and short circuiting;

d. sample taps shall be provided in the influent and effluent piping;

e. the effluent sump, if provided, shall have easy access for cleaning purposes and be equipped with a drain valve. The drain shall not be connected directly to any storm or sanitary sewer;

f. a blow-off line should be provided in the effluent piping to allow for discharge of water/chemicals used to clean the tower;

g. the design shall prevent freezing of the influent riser and effluent piping when the unit is not operating. If piping is buried, it shall be maintained under positive pressure;

h. the water flow to each tower shall be metered;

i. An overflow line shall be provided which discharges 300 mm to 350 mm above a splash pad or drainage inlet. Proper drainage shall be provided to prevent flooding of the area;

j. butterfly valves may be used in the water effluent line for better flow control, as well as to minimize air entrainment;

k. means shall be provided to prevent flooding of the air blower;

l. the water influent pipe should be supported separately from the tower's main structural support.

4.3.5.5.4. Air Flow System

a. the air inlet to the blower and the tower discharge vent shall be down-turned and protected with a non-corrodible 24-mesh screen to prevent contamination from extraneous matter. It is recommended that a 4-mesh screen also be installed prior to the 24-mesh screen on the air inlet system;

b. the air inlet shall be in a protected location;

c. an air flow meter shall be provided on the influent air line or an alternative method to determine the air flow shall be provided;

d. a positive air flow sensing device and a pressure gauge must be installed on the air influent line. The positive air flow sensing device must be a part of an automatic control system which will turn off the influent water if positive air flow is not detected. The pressure gauge will serve as an indicator of fouling buildup;

e. a backup motor for the air blower must be readily available.

4.3.5.5.5. Other Features that shall be provided:

a. a sufficient number of access ports with a minimum diameter of 600 mm to facilitate inspection, media replacement, media cleaning and maintenance of the interior;

b. a method of cleaning the packing material when iron, manganese, or calcium carbonate fouling may occur;

c. tower effluent collection and pumping wells constructed to clearwell standards;

d. provisions for extending the tower height without major reconstruction;

e. an acceptable alternative supply must be available during periods of maintenance and operation interruptions. No bypass shall be provided unless specifically approved by the reviewing agency;

f. disinfection application points both ahead of and after the tower to control biological growth;

g. disinfection and adequate contact time after the water has passed through the tower and prior to the distribution system;

h. adequate packing support to allow free flow of water and to prevent deformation with deep packing heights;

i. operation of the blower and disinfectant feeder equipment during power failures;

j. adequate foundation to support the tower and lateral support to prevent overturning due to wind loading;

k. fencing and locking gate to prevent vandalism;

l. an access ladder with safety cage for inspection of the aerator including the exhaust port and de-mister;

m. electrical inter-connection between blower, disinfectant feeder and well pump.

4.3.5.5.6. Environmental Factors

a. the applicant must contact the appropriate air quality office to determine if permits are required under the Clean Air Act;

b. noise control facilities should be provided on PTA systems located in residential areas.

4.3.5.6 Other Methods of Aeration

Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air, cascades and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the reviewing authority.

4.3.5.7 Protection of Aerators

All aerators except those discharging to clarification plants shall be protected from contamination by birds, insects, wind borne debris, rainfall and water draining off the exterior of the aerator.

4.3.5.8 Disinfection

Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment.

4.3.5.9 Bypass

A bypass should be provided for all aeration units except those installed to comply with maximum contaminant levels.

4.3.5.10 Corrosion Control

The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary.

4.3.5.11 Quality Control

Equipment should be provided to test for DO, pH and temperature to determine proper functioning of the aeration device. Equipment to test for iron, manganese, and carbon dioxide should also be considered.

4.3.6 Iron and Manganese Control

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated, and receive the approval of the reviewing authority. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the raw water to optimize the chemical reaction. Testing equipment and sampling taps shall be provided as outlined in Part 2.

4.3.6.1 Removal by Oxidation, Detention and Filtration

4.3.6.1.1. Oxidation

Oxidation may be aeration, as indicated in Section 4.3.5, or by chemical oxidation with chlorine with due consideration to the raw water pH, the total organic carbon in the raw water, and the potential formation of THM’s.

4.3.6.1.2. Detention

a. Reaction - a minimum detention time of 30 minutes for iron and 60 minutes for manganese (depending on raw water pH) shall be provided following aeration to ensure that the oxidation reactions are as complete as possible. This minimum detention may be omitted only where a pilot plant study indicates no need for detention. The detention basin may be designed as a holding tank without provisions for sludge collection but with sufficient baffling to prevent short circuiting;

b. Sedimentation - sedimentation basins shall be provided when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on the filters. Provisions for sludge removal shall be made.

4.3.6.1.3. Filtration

Filters shall be provided and shall conform to the applicable section in this part of the guidelines.

4.3.6.2 Removal by Silica Sand/Manganese Coated Media Filtration

This process consists of a continuous chlorine or other approved oxidizing agent to the influent of a silica sand/manganese coated media filter. Due consideration must be taken into account of the formation of THM’s.

a. a sodium hypochlorite solution shall be applied as far ahead of the filter(s) as is practical and to a point immediately before the filter(s);

b. the silica/manganese dioxide blend should be a minimum of 300 mm in depth, with at least 20% manganese dioxide material included;

c. an anthracite media cap of at least 400 mm or more as required by the reviewing authority shall be provided over the silica sand/manganese coated media;

d. the media bed will act as a combined contactor and filtration bed. The contact time shall be determined by pilot plant studies;

e. normal filtration rate is 7.2 m/hr;

f. normal wash rate is 20 - 24 m/hr with manganese green-sand and 37-49 m/hr with manganese coated media;

g. air washing shall be provided;

h. sample taps shall be provided:

  i. prior to application of oxidizer;
  ii. immediately ahead of filtration;
  iii. at the filter effluent;
  iv. should be provided at points between the anthracite media and the manganese coated media.

4.3.6.3 Removal by Ion Exchange

This process of iron and manganese removal should not be used for water containing more than 0.3 milligrams per litre of iron, manganese or combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen or other oxidants.

4.3.7 Fluoridation

Fluoridation shall be applied to a community water system if a referendum or plebiscite has been held in the community and the majority of eligible voters have voted to have it included as a prophylactic in the public water system. Fluoride when introduced into the water system has been found to have beneficial effects on children in their teeth and bone forming years.

4.3.7.1 Fluoride dosage

Accurate dosage of the fluoride ion is important and should be based on seasonal influences with approximately 0.7 mg/L of fluoride ion being added during the summer months and a maximum of 1 mg/L of fluoride ion being added during the other three seasons.

4.3.7.2 Fluoride Chemicals

The following three chemicals are considered suitable as commercially available feed chemicals for the application of fluoride:

.1 Sodium fluoride (NaF);

.2 Sodium silicofluoride (Na_2SiF_6);

.3 Hydrofluosilicic Acid (H_2SiF_6);

Consideration must be taken into account of the following parameters when selecting the appropriate chemical: the purity of the chemical, the percentage of fluoride ion in each kilogram of chemical, the solubility of the chemical in the solution water and the comparative costs.

All or any of the above chemicals when added to a public water supply will tend to depress the pH and increase the aggressive nature of the water. This is particularly important for many west coast water where the water is only lightly buffered. Therefore consideration should be taken into account with due regard to corrosion on distribution piping (old asbestos cement piping) and domestic plumbing before proceeding with fluoridation or selecting the appropriate chemical to apply fluoridation.

4.3.7.3 Fluoride feed equipment.

See Part 5 for further details of feed equipment for fluoride systems.

4.3.7.4 Other Standards

For other guidelines on fluoridation systems see the April 1999 Fluoridation Design Manual for Water Systems in B.C. Region.

4.3.8 Stabilization

Water that lacks alkalinity for coagulation treatment or is unstable, aggressive and/or corrosive due to previous or subsequent treatment shall be conditioned to improve coagulation or stabilized to reduce corrosion effects.

4.3.8.1 Alkali Feed

Water with low alkalinity or pH should be treated with percolating lime rock contactors or the application of an alkali chemical, such as sodium hydroxide (caustic soda) or sodium carbonate (soda ash). See below for details of limestone contactors and Part 5 for sodium hydroxide and sodium carbonate systems.

4.3.8.2 Limestone Contactor

Limestone contactors may be required prior to pre-treatment of the raw water (primary limestone contactor) to provide sufficient alkalinity for coagulation, or after the chlorine contact tank (secondary limestone contactor) for corrosion control. The following general design guidelines are provided for both limestone contactors, followed by special provisions for the primary and secondary limestone contactors.

4.3.8.2.1. General Limestone Contactor Design Guidelines

a. Contact Time - the required contact time is dependent on the quality of limestone used, and the pH and alkalinity of the raw water or filtered water;

b. Tank Design - the tank geometry will minimize the wall area to tank volume ratio and minimize short circuiting. The inlet, outlet, and flow through the contactor shall be designed to provide uniform flow through all of the limestone and to prevent short-circuiting;

c. Access - the limestone contactor shall be open at the top, or provided with sufficient access points to allow observation of the top of the limestone, and the easy installation and removal of limestone and internal components such as piping and valves;

d. Bypass - provisions for bypassing the limestone contactor shall be included;

e. Drainage - contactor tanks must be provided with a means for dewatering. The contactor’s floor should slope toward the drain at not less than 50 mm in 5 metres (1% slope).

4.3.8.2.2. Special Considerations for Primary Limestone Contactor

a. Pre-screening - a basket strainer shall be provided capable of preventing an accumulation of debris that cannot be removed by backwashing. Provide the ability to modify the size of screen openings after plant start-up if required;

b. Contact Time - a minimum 60 minute actual contact time is recommended. Testing shall be used to confirm the contact time required to increase the raw water alkalinity to an amount needed for adequate coagulation to occur. As an allowance of a safety factor, the contact time determined by the test shall be increased by 10%. An actual contact time of less than 60 minutes may be considered by the reviewing authority based on test results. The testing shall use the same limestone as proposed for the full scale limestone contactor.

c. Limestone Backwash - a water flushing system shall be provided to dislodge sediment that may accumulate in the limestone and remove and dispose of it;

d. the limestone contactor bypass shall include a throttling valve and required piping and fittings to allow the operator to blend limestone treated water with raw water;

e. The limestone shall be thoroughly washed at the treatment plant site prior to being placed into the contactor tanks.

4.3.8.2.3. Special Considerations for Secondary Limestone Contactor

a. Contact Time - a minimum 60 minute actual contact time is recommended. Testing shall be used to confirm the contact time required to increase the raw water alkalinity to an amount needed for adequate corrosion control to occur. As an allowance of a safety factor, the contact time determined by the test shall be increased by 10%. An actual contact time of less than 60 minutes may be considered by the reviewing authority based on test results. The testing shall use the same limestone as proposed for the full scale limestone contactor.

4.3.8.2.4. Limestone

The following specifies requirements for the supply, installation and testing of limestone for the limestone contactor(s):

a. the limestone shall yield results similar to the test results used to determine the contact time. The consultant’s specifications shall require certification of dissolution performance;

b. the limestone must comply with the latest issue of ANSI/NSF 60 Drinking Water Treatment Chemicals - Health Effects;

c. the material provided and installed shall be high calcium content limestone with greater than 95% calcium carbonate (CaCo3) and have a high rate of dissolution. Impurities such as aluminum (A1) and iron (Fe) shall be kept to a minimum. Testing shall demonstrate that the limestone will not increase aluminum, iron, and heavy metal concentrations in the treated water to concentrations above the Canadian Drinking Water Guidelines;

d. the limestone shall have an effective size, d10, of between 6 mm and 8 mm. The uniformity coefficient shall be 2 to 3. The maximum diameter of the limestone shall be 32 mm. The limestone gradation must be determined by using the latest issue of ASTM, Standard Test.

4.3.8.3 Other Treatment

Other treatment for controlling corrosive water by the use of calcium hydroxide, sodium hydroxide and sodium carbonate may be used where necessary. Any proprietary compound must receive the specific approval of the reviewing authority before use. Chemical feeders shall be as required in Part 5.

Unstable water resulting from the bacterial decomposition of organic matter in water (especially in dead end mains), the biochemical action within tubercles, and the reduction of sulfates should be prevented by the maintenance of a free and/or combined chlorine residual throughout the distribution system.

4.3.8.4 Control

Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment.

4.3.9 Taste and Odour

Provision shall be made for the control of taste and odour at all surface water treatment plants. Chemicals shall be added sufficiently ahead of other treatment processes to assure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odour problems are encountered, in-plant and/or pilot plant studies are required.

Acceptable treatment processes for taste and odour control are as follows:

- Chlorination
- Granular Activated Carbon
- Aeration

4.3.9.1 Flexibility

Plants treating water that is known to have taste and odour problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation.

4.3.9.2 Chlorination

Chlorination can be used for the removal of some objectionable odours. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential trihalomethane production through this process should be avoided by adequate bench-scale testing prior to design.

4.3.9.3 Granular Activated Carbon

Replacement of anthracite with GAC may be considered as a control measure for geosmin and methyl isoborneol (MIB) taste and odours from algae blooms. Demonstration studies performed by the Consulting Engineer may be required by the reviewing authority.

See Section 4.3.2.1.6 (Filter Material) for application within filters.

4.3.9.4 Aeration

See Section 4.3.5.

4.3.9.5 Other Methods

The decision to use any other methods of taste and odour control should be made only after careful laboratory and/or pilot plant tests and approval by the reviewing authority.

4.3.10 Microscreening

A microscreen is a mechanical supplement of treatment capable of removing suspended matter from the water by straining. It may be used to reduce nuisance organisms and organic loadings. It shall not be used in place of:

a. Filtration, when filtration is necessary to provide a satisfactory water; or
b. Coagulation, in the preparation of water for filtration.

4.3.10.1 Design

a. Give due consideration to:
   1. Nature of the suspended matter to be removed;
   2. Corrosiveness of the water;
   3. Effect of chlorination, when required as pre-treatment;
   4. Duplication of units for continuous operation during equipment maintenance;
   5. Automated backflushing operation when used in conjunction with microfiltration treatment;

b. Provide:
   1. A durable, corrosion-resistant screen;
   2. By-pass arrangements;
   3. Protection against back-siphonage when potable water is used for washing;
   4. Proper disposal of wash waters (See Section 9).

4.3.11 Arsenic Removal

4.3.11.1 General

Arsenic removal, as used herein, refers to treatment processes specifically related to reducing levels of arsenic below 0.025 mg/L in the treated water and preferably below 0.010 mg/L. Where raw water systems exceed 0.025 mg/L of arsenic then every effort should be made to locate an alternative raw water source or, if there is no other source available in the localized area then a treatment strategy must be planned to effectively reduce the total arsenic level to preferably below 0.010 mg/L.

4.3.11.2 Pilot Plant

A pilot plant will be necessary to determine the optimum form of treatment to be applied to site specific water, a complete protocol of the pilot work must be developed and submitted to the reviewing authority before the pilot work and testing commences. All pilot work and testing will be done in-situ close by the actual source of the raw water.

4.3.11.3 Treatment

Aqueous arsenic solutions are generally most prevalent in the trivalent and pentavalent states, each species in turn predominating as a function of the pH of the water. The trivalent species predominates as a weak acid in the pH range of 2 to 9, while the pentavalent species occurs as a strong acid. The disassociation properties and the pH of the treated water are therefore important criteria in the conventional coagulation process in the selection of the appropriate treatment process. The following treatment processes may be considered for the removal of arsenic:

.1 Conventional coagulation employing aluminum or iron salts;

.2 Adsorption onto a granular ferric oxide bed;

.3 Adsorption onto an activated alumina;

.4 Separation by reverse osmosis.

Not all the above treatment options are pH dependent, but where they are, consideration should be given to raising or depressing the pH of the raw water to suit the selected process with the appropriate chemical.

4.3.11.4 Rejects and Waste Streams

Adsorption media once spent will be replaced and not generated, the spent material shall be disposed of in suitable landfills with the approval of the reviewing authorities. Backwash streams or rejects from RO systems may be discharged to the sewer or to septic tanks with the approval of the reviewing authority.

4.3.11.5 Treatment Criteria

The selected treatment option shall take into consideration the required complexity of operation, the capital costs, operation and maintenance costs and the life cycle costs. A minimum of two treatment processes shall be piloted following a desktop study which identifies the pilot program and the protocol to follow.

4.3.11.6 Testing Equipment

Analytical testing equipment and proper laboratory procedures shall be included in the pilot plant and final prototype to accurately measure the levels of arsenic in the raw and treated water.

SYNOPSIS

PART 5 - CHEMICALS

(1) Synopsis

Part 5 identifies various chemicals recommended for First Nation Water Treatment Plants and suggests guidelines and the preferred method of feeding these chemicals.

(2) Check List

- Review chemicals to be used, application points and general equipment design, layout chemical building to facilitate delivery, handling, storage and also to minimize the length of feed lines to the point of application,
- Ensure that there is 100% redundancy built into chemical feed systems with ease of access for operation and maintenance
- Positive displacement pumps such as diaphragm metering or peristaltic units are preferred types of chemical pumps. Each pump system is to include calibration tubes, check valves, isolating valves and pressure relief valves,
- Check for cross connection control,
- Check that each chemical storage and feed system is located in a separate room with clear signage and identification of the chemical in the room and that it has outside access only,
- Design plant site, and building layout and building services to ensure maximum operator safety,
- Chemical feed rates shall be proportional to flow and have vacuum relief, syphon control and air gaps where necessary.

5 CHEMICALS

No chemicals shall be applied to treat drinking water unless specifically permitted by the reviewing authority. Chemicals shall meet requirements of NSF 60. Commercially available chemical solutions are preferred.

5.1 PLANS AND SPECIFICATIONS

Plans and specifications shall be submitted for review and approval as provided for in Part 1, and shall include:

a. descriptions of feed equipment, including maximum and minimum feed ranges;

b. location of feeders, piping layout and points of application;

c. storage and handling facilities;

d. specifications for chemicals to be used;

e. operating and control procedures including proposed application rates;

f. descriptions of testing equipment and procedures.

5.2 CHEMICAL APPLICATION

Chemicals shall be applied to the water at such points and by such means as to:

a. assure maximum efficiency of treatment;

b. assure maximum safety to consumer;

c. provide maximum safety to operators;

d. assure satisfactory mixing of the chemicals with the water;

e. provide maximum flexibility of operation through various points of application, when appropriate;

f. prevent back flow or back-syphonage between multiple points of feed through common manifolds.

5.3 GENERAL EQUIPMENT DESIGN

General equipment design shall be such that:

a. feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed;

b. chemical contact materials and surfaces are resistant to the aggressiveness of the chemical solution;

c. corrosive chemicals are introduced in such a manner as to minimize potential for corrosion;

d. chemical feeders are as near as practical to the feed point, and

e. chemical feeders and pumps operate at no lower than 20 percent of the feed range;

f. chemicals may be fed by gravity where practical;

g. chemicals that are incompatible are not stored or handled together;

h. shower and eyewash facilities using tempered water shall be installed in all chemical rooms.

5.4 FACILITY DESIGN

5.4.1 Number of Feeders

a. Where a chemical feed is necessary for the protection of the supply:

i. a minimum of two feeders (one of them being the standby unit) shall be provided with one injection point;

ii. the standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shut-downs.

b. a separate feeder and injection point shall be used for each chemical applied;

c. The initial feeder pumps should be designed for twice the maximum day demand and at the maximum calculated dosage rate that will be achieved at the plant five years following pump installation. Every five years the feeder pumps should be replaced with pumps of higher capacity to meet twice the maximum day demand that will be reached five years after installation at the maximum dosage rate. The capacity of the replacement feeder pumps would increase until the plant design capacity has been reached. This will allow the pumps to operate more effectively during the low flows the plant will experience during the initial years of plant operation. The replacement of the feeder pumps every five years with greater capacity pumps must be included in maintenance cost estimates for the treatment facilities (See Section 1.1.5);

d. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

5.4.2 Control

a. chemical feeders shall be manually or automatically controlled, with automatic controls being designed so as to allow override by manual controls;

b. at automatically operated facilities, chemical feeders shall be electrically inter-connected with the well or service pump and should be provided with a nonstandard electrical receptacle;

c. chemical feed rates shall be proportional to flow;

d. a means to measure water flow must be provided in order to determine chemical feed rates;

e. provisions shall be made for measuring the quantities of chemicals used;

f. measuring cylinders should be provided to calibrate metering pumps.

5.4.3 Positive Displacement Solution Pumps

Positive displacement type solution feed pumps should be used to feed liquid chemicals. Pumps must be sized to match or exceed maximum head conditions found at the point of injection.

5.4.4 Liquid Chemical Feeders - Siphon Control

Liquid chemical feeders shall be such that the solution cannot be siphoned into the water supply, by:

a. assuring discharge at a point of positive pressure; or

b. providing vacuum relief; or

c. providing a suitable air gap; or

d. providing other suitable means or combinations as necessary.

5.4.5 Cross-connection Control

Cross-connection control must be provided to assure that:

a. the service water lines discharging to solution tanks shall be properly protected from back flow;

b. liquid chemical solution cannot be siphoned through solution feeders into the water supply;

c. no direct connection exists between any sewer and a drain or overflow from the feeder, solution chamber or tank by providing that all drains terminate at least 150 mm or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle.

5.4.6 Chemical Feed Equipment Location

Chemical feed equipment shall:

a. be located in a separate room to reduce hazards;

b. be conveniently located near points of application to minimize length of feed lines;

c. be readily accessible for servicing, repair, and observation of operation.

5.4.7 In-plant Water Supply

In-plant water supply (if required) shall be:

a. ample in quantity and adequate in pressure;

b. provided with means for measurement when preparing specific solution concentrations by dilution;

c. properly treated for hardness when necessary;

d. properly protected against back flow;

e. obtained from a location sufficiently downstream of any chemical feed point to assure adequate mixing.

5.4.8 Storage of Chemicals

a. adequate housing must be provided for equipment and for storing the chemicals; space should be provided for:

   i. at least 30 days of supply,

   ii. convenient and efficient handling of chemicals;

   iii. dry storage conditions;

   iv. a minimum storage volume of 1 ½ truck loads where purchase is by truck load lots.

b. storage tanks and pipelines for liquid chemicals shall be specified for use with individual chemicals and not used for different chemicals. Offloading areas must be clearly labelled to prevent accidental cross-contamination.

c. Chemicals shall be stored in covered or unopened shipping containers, unless it is transferred into an approved storage unit;

d. Liquid chemical storage tanks must:

  i. have a liquid level indicator;

  ii. have an overflow and receiving basin or drain capable of receiving accidental spills or overflows so that spilled chemicals will not enter watercourses.

e. Incompatible chemicals such as aluminum sulphate and chlorine shall not be able to mix in a common drain;

f. Acidic chemicals shall not be allowed to mix with sodium hypochlorite;

g. Washdown and drainage facilities shall be included in each chemical room;

h. Showers and eyewash facilities, using tempered water, shall be installed in all chemical rooms.

5.4.9 Solution Tanks

a. A means which is consistent with the nature of the chemical solution shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to maintain slurries in suspension;

b. Two solution tanks of adequate volume may be required to assure continuity of supply in servicing a solution tank;

c. Means shall be provided to measure the solution level in the tank;

d. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with overhanging covers;

e. Overflow pipes, when provided, should:

  i. be turned downward, with the end screened;

  ii. have a free fall discharge;

  iii. be located where noticeable.

f. Each tank shall be provided with a valved drain, protected against back flow;

g. Solution tanks shall be located and protective curbing provided so that chemicals from equipment failure, spillage or accidental drainage shall be contained and shall not enter the water in conduits, or storage basins;

h. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

5.4.10 Feed Lines

a. Should be as short as possible, and:

   i. of durable, corrosion-resistant material, PVC Schedule 80 is the preferred material;

   ii. easily accessible throughout the entire length;

   iii. protected against freezing;

   iv. readily cleanable.

b. Should slope upward from the chemical source to the feeder when conveying gases;

c. Shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixtures conveyed;

d. Should be colour coded.

5.4.11 Handling

a. Carts, tank dollies and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators;

b. Provisions shall be made for disposing of drums or barrels by an approved procedure which will minimize exposure to dust and environmental damage;

c. Provision shall be made for measuring quantities of chemical used to prepare feed solutions;

d. Provision must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of dust which may enter the room in which the equipment is installed. Control should be provided by use of:

i. facilities for emptying shipping containers in special enclosures; and/or

ii. exhaust fans and dust filters which put the hoppers or bin rooms under a slight negative pressure.

5.4.12 Housing

The building for well pump installation with chlorine or other chemical feed system should consist of three separate rooms accommodating process piping, electrical equipment and chemical storage and feed equipment. Access to the chemical room will be from the outside only (see typical drawing #8 in Appendix C);

b. Floor surfaces shall be smooth and impervious, slip-proof and well-drained with 75 mm per 3 metres minimum slope;

c. Vents from feeders, storage facilities and equipment exhaust shall discharge to the outside atmosphere above grade and remote from air intakes.

5.5 CHEMICALS

5.5.1 Shipping Containers

Chemical shipping containers shall be fully labelled to meet MSDS standards to include:

a. Chemical name, purity and concentration;

b. Supplier name and address;

c. Handling procedures and recommendations;

d. Disposal instructions.

5.5.2 Specifications

Chemicals shall be approved by the reviewing authority or meet the appropriate ANSI/AWWA standards and/or ANSI/NSF Standard 60.

5.5.3 Assay of Supplied Chemicals

Provisions may be required to verify the properties, purity, and content of chemicals delivered.

5.6 OPERATOR SAFETY

5.6.1 Ventilation

Special provisions shall be made for ventilation of chlorine feed and storage rooms to meet the BC Workers' Compensation Board requirements. The Chlorine room shall be fan force air exhausted by ducting from a point 300 mm above the floor level.

5.6.2 Respiratory Protection Equipment

Respiratory protection equipment shall meet the Workers' Compensation Board.

5.6.3 Protective Equipment

Protective equipment, including emergency eyewash facilities, shall be provided, and shall meet the requirements of the Workers' Compensation Board.

5.7 SPECIFIC CHEMICALS

5.7.1 Acids and Caustics

a. Liquid alum and sodium hydroxide (35% to 50% caustic soda) shall be stored in separate rooms with outside access doors only;

b. Where feasible viewing windows shall be installed between each chemical room and the central control room or interior walkways;

c. Clear identification of each chemical storage room shall be displayed on each chemical room;

d. The preferred shipping containers for liquid alum and sodium hydroxide are closed corrosion resistant 205 litre drums;

e. Sufficient drum storage shall be provided for 30 days at average day flows at the ten year design horizon at the estimated average dosage. Space shall be provided adjacent to the chemical rooms for expansion if required;

f. Liquid alum and sodium hydroxide shall not be handled from open vessels, but may be pumped in undiluted form from the original container by a suitable transfer pump and corrosion resistant hose to the point of application or to a covered day tank;

g. Day tanks shall be of corrosion resistant material such as AISI 316 alloy steel, FRP or a suitable polyethylene;

h. All storage tanks shall be contained in a curbed concrete containment area large enough to contain at least one full storage drum. A water dilution and disposal system shall be included in the sump to dilute chemicals until they are safe for disposal by pump out or draining;

i. Ventilation of both acid and caustic rooms shall comply with the applicable Workers Compensation Board requirement.

5.7.2 Sodium Carbonate (Soda Ash)

a. Sodium carbonate shall be stored in a separate room with outside access only;

b. Where feasible viewing windows shall be installed between each chemical room and the central control room or exterior walkways;

c. Clear identification of each chemical storage room shall be displayed on each chemical room;

d. Preferred shipping is by double walled 25 kg bags in granular form;

e. Sufficient storage shall be provided for 30 days at average day flows at the ten year design horizon at the estimated average dosage. Space should be provided adjacent to the chemical rooms for expansion if required;

f. A bag splitter, storage hopper, volumetric feeder and solution tank shall be used to make down a 5% to 10% slurry;

g. A manual make down system may be used as approved by the reviewing authority;

h. Ventilation shall comply with the applicable Workers Compensation Board requirements;

5.7.3 Polymers

a. Where polymers are used as a coagulant or filter aid a separate room shall be provided for storage and feed equipment;

b. Liquid polymers are preferred over dry granular materials;

c. Polymers may be anionic, cationic, or non-ionic depending on the water treatability tests;

d. Neat polymer solution shall be fed into specifically designed mixing and dilution equipment for direct application to the feed points;

e. Dilution rates shall be in strict accordance with the chemical supplier's recommendation;

f. Polymer shipping containers shall be stored in contained areas;

g. Sufficient storage shall be provided for 30 days use at average day flows at the ten-year design horizon at the estimated average dosage;

h. Ventilation shall comply with the applicable Workers' Compensation Board requirements;

i. Calibration tubes shall be installed on each polymer metering pump to permit regular testing of metering pump output;

j. Flow meters shall be installed on dilution water lines to the polymer makedown system;

k. A check and ball valve assembly shall be installed at the point of chemical application;

l. Feed rates shall be paced on flow with manual dosage adjustment;

m. See AWWA B451 (Polydiallyldimethyl ammonium chloride), B452 (Epichlorohydrin dimethylamine) and B453 (Polyacrylamide) for further details.

5.7.4 Polyaluminum Chloride (PACL)

a. Where PACL is used in a plant a separate chemical room should be provided;

b. PACL shall be custom blended based on in-situ treatability tests of the raw water;

c. PACL shall be injected undiluted directly into each application point from the original shipping container or a specific day tank;

d. All storage tanks shall be stored in contained areas;

e. Storage containers or tanks shall be sited out of the sunlight in a cool area and shall be vented to the outside of the building;

f. Ventilation shall comply with the applicable Workers' Compensation Board requirements;

g. Calibration tubes shall be installed on each PACL metering pump to permit regular testing of metering pump output;

h. A check and ball valve assembly shall be installed at the point of chemical application;

i. Feed rates shall be paced on flow with manual dosage adjustment.

j. Metering pumps shall be compatible with the specific PACL being used;

l. See AWWA B408 for further details.

5.7.5 Sodium Hypochlorite

Sodium hypochlorite storage and handling procedures should be arranged to minimize the slow natural decay process either by contamination or by exposure to more extreme storage conditions. In addition, feed rates should be regularly adjusted to compensate for this progressive loss in chlorine content.

a. Storage

i. sodium hypochlorite shall be stored in the original shipping containers or in sodium hypochlorite compatible containers;

ii. storage containers or tanks shall be sited out of the sunlight in a cool area and shall be vented to the outside of the building.

iii. wherever reasonably feasible, stored hypochlorite shall be pumped undiluted to the point of addition. Where dilution is unavoidable, deionized or softened water should be used;

iv. Sufficient storage area shall be provided for 30 days use at average day flows at the ten year design horizon at the estimated average dosage. Space should be provided adjacent to the chemical rooms for expansion if required;

v. storage areas, tanks and pipe work shall be designed to avoid the possibility of uncontrolled discharges using containment walls or spill containment bases complete with dilution and disposal facilities. A sufficient amount of appropriately selected spill absorbent shall be stored on-site;

vi. reusable hypochlorite storage containers shall be reserved for use with hypochlorite only and shall not be rinsed out or otherwise exposed to internal contamination;

vii. Special attention shall be given to mounting electrical panels in the hypochlorite room with due consideration being given to sealing, purging and selection of materials. If possible panels should be mounted outside with visual inside room contact via a viewing window;

b. Feeders

i. positive displacement pumps (either metering type or peristaltic type) with hypochlorite compatible materials for wetted surfaces shall be used;

ii. metering pumps shall have automatic variable speed and manually adjustable stroke to allow the feed rate to be paced on plant flow. Pump electrical controls shall be interlocked with the main plant flow;

iii. to avoid air locking of metering pumps in smaller installations, small diameter suction lines shall be used with foot valves and degassing pump heads;

iv. in larger installations flooded suction shall be used with pipe work arranged to ease escape of gas bubbles;

v. calibration tubes or mass flow monitors which allow for direct physical checking of actual feed rates shall be fitted. Calibration curves shall be developed for each pump at start-up;

vi. injectors shall be made removable for regular cleaning where hard water is to be treated;

vii. metering pumps shall be fitted with a priming device and relief valve.

5.7.6 Sodium Chloride

a. Food grade sodium chloride shall be used in accordance with NSF 60;

b. Sodium chloride shall be shipped in 20 kg to 25 kg double walled bags and stacked no more than 6 bags high;

c. Sodium chloride bags shall be stored on wooden pallets in a separate room with the regeneration equipment. Concrete shall be specially treated to resist the corrosive effects of the salt;

d. Ventilation shall comply with the applicable Workers’ Compensation Board requirements;

e. Sufficient storage shall be provided for 30 days use at average day flows at the ten-year design horizon at the estimated average dosage;

f. The storage and regenerating area shall be designed to facilitate the ease of handling and dumping salt into the brine tanks;

g. If possible electrical panels should be mounted outside of the sodium chloride room;

h. See AWWA B200 for further details.

5.7.7 Fluoride Chemicals

The following three chemicals should be considered as being suitable to add fluoride ion to a drinking water supply:

.1 Sodium fluoride;

.2 Sodium silicofluoride;

.3 Hydrofluosilicic acid.

5.7.7.1 Sodium Fluoride and Sodium Silicofluoride

a. Storage and handling of both these chemicals may be similar and when used should be stored in a separate room with outside access only;

b. Where feasible viewing windows shall be installed between the chemical room and the central control room or interior walkways;

c. Clear identification of each chemical storage room shall be displayed on each chemical room door;

d. Preferred chemical shipping is by double walled 25 kg bags in granular form;

e. Sufficient storage shall be provided for 30 days use at average day flows at the ten year design horizon at the estimated average dosage. Space shall be provided adjacent to the chemical rooms for expansion if required;

f. A bag splitter, storage hopper, volumetric feeder and solution tank shall be used to make down a 5% to 10% slurry;

g. A manual make down system may be used as approved by the reviewing authority;

h. Ventilation shall comply with the applicable Workers Compensation Board requirements;

i. Wash down and drainage facilities shall be included in each chemical room.

5.7.7.2 Hydrofluosilicic Acid

a. Neat hydrofluosilicic acid shall be stored in a separate chemical room with one outside access door only;

b. Where feasible viewing windows shall be installed between the chemical room and the central control room or interior walkways, plexiglass is the preferred material for the viewing window, silica based glass shall not be used;

c. Clear identification of the chemical storage room shall be displayed on the chemical room door;

d. The preferred shipping containers for hydrofluosilicic acid is in sealed 205 litre drums constructed of suitably lined corrosion resistant material;

e. Sufficient drum storage shall be provided for 30 days supply at average day flows at the ten year design horizon and at the estimated average dosage. Space should be provided adjacent to the chemical room for expansion if required;

f. Hydrofluosilicic acid should not be handled from open vessels and should be pumped in undiluted form from the original manufacturers container by a suitable metering or peristaltic feed pump and corrosion resistant piping to the point of application;

g. All storage tanks shall be contained in a curbed concrete containment area large enough to contain at least one full storage drum. A water dilution and disposal system shall be included in the sump to dilute chemicals until they are safe for disposal by pump out or draining;

i. Ventilation of hydrofluosilicic acid rooms shall comply with the applicable Workers Compensation Board requirement. All internal parts of the fan and ducting should be coated with a chlorine rubber compound or other suitable material to withstand the corrosive effects of the acid;

j. Concrete floors and walls up to one metre above the floor level should be coated a an approved epoxy coating able to withstand the corrosive effects of the acid;

k. Special attention shall be given to electrical components that are mounted in the acid room with respect to sealing, purging the panels and materials selected. If possible mount electrical components outside the room with outside visual view of the pumps and other equipment.

5.7.7.3 Other Standards

For other guidelines on fluoridation systems see the April 1999 Fluoridation Design Manual for Water Systems in B.C. Region.

SYNOPSIS

PART 6 - PUMPING STATIONS

(1) Synopsis

Part 6 provides general guidelines for the design of pumping stations.

(2) Check List

The following key items must be apparent in the design of a given pumping station.

- Adequate space provided for installation of additional units, if needed, as well as the necessary safety equipment (See 6.2).
- At least two pumping units must be provided (See 6.3).
- The inlet of a booster pump shall be at a minimum pressure of 140 kPa (See 6.4).
- The preferred layout of a pump station with any treatment is a three-room building, consisting of a chlorine or chemical room, a pump room, and an electrical room (See 6.6).

6 PUMPING STATIONS

Pumping facilities shall be designed to maintain the potable quality of pumped water. Subsurface pits or pump rooms and inaccessible installation should be avoided. No pumping station shall be subject to flooding.

6.1 LOCATION

The pumping station shall be so located that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard.

6.1.1 Site Protection

The station will be:

a. Elevated to a minimum of 0.9 metre above the 200-year flood elevation, or 0.9 metre above the highest recorded flood elevation, whichever is higher, or protected to such elevations;

b. Readily accessible at all times unless permitted to be out of service for the period of inaccessibility;

c. Graded around the station so as to lead surface drainage away from the station;

d. Protected to prevent vandalism and entrance by animals or unauthorized persons.

6.2 PUMPING STATIONS

Both raw and finished water pumping stations shall:

a. Have adequate space for the installation of additional units if needed, and for the safe servicing of all equipment;

b. Be of durable construction, fire and weather resistant and with outward-opening doors;

c. Have floor elevation of at least 200 mm above finished grade;

d. Have underground structure waterproofed;

e. Have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors shall slope to a suitable drain;

f. Provide a suitable outlet for drainage from pump glands without discharging onto the floor.

6.2.1 Suction Well

Suction wells shall:

a. Be watertight;

b. Have floors sloped to permit removal of water and accumulated solids;

c. Be covered or otherwise protected against contamination.

6.2.2 Equipment Servicing

Pump stations shall be provided with:

a. Crane-ways, hoist beams, eyebolts, or other adequate facilities for servicing or removal of pumps, motors or other heavy equipment;

b. Openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment;

c. A convenient tool board, or other facilities as needed, for proper maintenance of the equipment.

6.2.3 Stairways or Ladders

Stairways or ladders shall:

a. Be provided between all floors, and in pits or compartments which must be entered;

b. Have handrails on both sides, and treads of non-slip material. Stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand. They shall have risers not exceeding 200 mm and treads wide enough for safety.

6.2.4 Heating

Provisions shall be made for adequate heating for:

a. The comfort of the operator;

b. The safe and efficient operation of the equipment.

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or impairment of the treatment process.

6.2.5 Ventilation

Ventilation shall conform to existing provincial and/or federal codes. Adequate ventilation shall be provided for all pumping stations. Forced ventilation of at least six changes of air per hour shall be provided for:

a. All rooms, compartments, pits and other enclosures below ground floor;

b. Any area where unsafe atmosphere may develop or where excessive heat may be built up.

6.2.6 Dehumidification

In areas where excess moisture could cause hazards to safety or damage to equipment, means for dehumidification should be provided.

6.2.7 Lighting

Pump stations shall be adequately lighted throughout. All electrical work shall conform to the requirements for the Canadian Electrical Code (latest edition).

6.3 PUMPS

At least two pumping units shall be provided. With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system. The pumping units shall:

a. Have ample capacity to supply the peak demand without dangerous overloading;

b. Be driven by a prime mover able to meet the maximum horsepower condition of the pumps;

c. Have spare parts and tools readily available;

d. Be served by control equipment that has proper heater and overload protection for air temperature encountered;

e. Operate in alternating on/off sequence;

f. Prime movers shall be located in an area such that they are not subject to flooding.

6.3.1 Suction Lift

Suction lift shall:

a. Be avoided, if possible;

b. Be within allowable limits, preferably less than 5 metres.

If suction lift is necessary, provision shall be made for priming the pumps.

6.3.2 Priming

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means shall be provided to prevent back siphonage. When an air-operated ejector is used, the screened intake shall draw clean air from a point at least 3 metres above the ground or other source of possible contamination, unless the air is filtered by an apparatus approved by the reviewing authority. Vacuum priming may be used.

6.4 BOOSTER PUMPS

Booster pumps shall be located or controlled so that:

a. They will not produce negative pressure in their inlet lines;

b. The inlet pressure should be at least 140 kPa when the pump is in normal operation. Pumps taking suction from storage tanks must provide adequate net positive suction head;

c. Automatic cutoff pressure should be at least 140 kPa in the inlet line, unless otherwise acceptable to the reviewing authority. Pumps taking suction from ground storage tanks must be equipped with automatic shut-offs or low pressure controllers as recommended by the pump manufacturer;

d. Automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling;

e. A bypass is available.

6.4.1 Duplicate Pumps

Each booster pumping station should contain not less than two pumps with capacities such that peak hourly demands can be satisfied with the largest pump out of service. Consideration should be given for installing pumps only designed for the first ten year design horizon initially. Pump replacement must be included in life-cycle cost estimates for the treatment facilities (see Section 1.1.5).

6.4.2 Metering

All booster pumping stations shall include a flow indicator and flow totalizer meter and provide an analogue signal suitable for input to a SCADA system or data logger.

6.4.3 In-line Booster Pumps

In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

6.4.4 Fire Pumps

A fire pump should be provided in a water system when adequate pressure or quantity is not available to supply the fire flow requirements.

Where practical, it is preferred practice to provide the fire flow by means of an elevated tank. This eliminates maintenance requirements of diesel engine driven fire pumps, and provides much greater reliability.

It is recommended that, when fire pumps constitute the sole or primary water supply for fire protection purposes on large systems, at least two fire pumps be installed.

All fire pumps and drive units are to be installed and tested according to the requirements of ULC and NFPA 20, Standard for the Installation of Centrifugal Fire Pumps.

Diesel engine or electric motors are acceptable types of fire pump drivers. If other pump drivers are considered by the designer, it must be demonstrated that they will meet an acceptable performance standard similar to NFPA 20. Acceptable two-pump arrangements (where applicable) are:

a. Two diesel-driven pumps;

b. One diesel and one electric pump;

c. Two electric-driven pumps, provided there is an emergency power supply for at least one of the pumps.

6.5 APPURTENANCES

6.5.1 Valves

Pumps shall be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary, they shall have a net valve area of at least two and one half times the area of the suction pipe and they shall be screened. Each pump shall have a positive-acting check valve on the discharge side between the pump and the shut-off valve.

Surge relief valves or slow acting check valves should be designed to minimize hydraulic transients.

6.5.2 Piping

All piping 50 mm in diameter or smaller is recommended to be AISI 316 or 416 stainless steel. Piping larger than 50 mm in diameter could also be stainless steel, if preferred by the professional engineer. In general, piping shall:

a. Be designed so that the friction losses will be minimized;

b. Not be subject to contamination;

c. Have watertight joints;

d. Be protected against surge or water hammer;

e. Be such that each pump has an individual suction line or that the lines shall be so manifolded that they will ensure similar hydraulic and operating conditions;

f. Be so restrained that no movement or excessive vibration occurs when operating or test pressures are applied, while permitting the removal of individual pumps and appurtenances;

g. Any pipe, solder or flux which is used in installation or repair of any public water system or any plumbing in a facility providing water for human consumption shall be lead free.

The term "lead free" when used with respect to solders and flux refers to solders and flux containing not more than 0.2% lead. The term "lead free" when used with respect to pipes and pipe fittings refers to pipes and pipe fitting containing not more than 8.0% lead.

6.5.3 Gauges and Meters

Each pump shall have:

a. A standard pressure gauge on its discharge line;

b. A compound gauge on its suction line;

c. Recording gauges in the larger stations;

d. A means for measuring the discharge.

The station should have indicating, totalizing, and recording metering of the total water pumped. Flow meters should provide a signal suitable for input to a SCADA system and/or a data logger. A satisfactory straight section of pipe shall be installed upstream and downstream of the meter in accordance with the meter manufacturer’s recommendations to improve accuracy where required.

6.5.4 Water Seals

Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality, the seal shall:

a. Be provided with a break tank open to atmospheric pressure;

b. Have an air gap of at least 150 mm or two pipe diameters, whichever is greater, between the feeder line and the spill line of the tank.

6.5.5 Controls

Pumps, their prime movers and accessories, shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision shall be made for automatic alternation. Provision shall be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls shall be located above grade. Equipment shall be provided or other arrangements made to prevent surge pressures from activating controls which switch on pumps or activate other equipment outside the normal design cycle of operation.

6.5.6 Power

When power failure would result in cessation of minimum essential service, power supply should be provided from at least two independent sources, or a standby or an auxiliary source shall be provided.

If standby power is provided by onsite generators or engines, the generators shall be specified to have their own integral fuel storage. The installation must comply with the latest edition of the Installation Code for Oil-Burning Equipment (CSA-B139). If installed outside, the generator and integral fuel storage must be installed on a concrete pad to prevent spills from entering the ground. The concrete pad shall extend a minimum of 0.6 metres beyond the location of the fuel tank fill pipe.

The fuel storage capacity shall be sufficient to provide a minimum 24 hours operation at full load. As a conservative estimate, generators can be considered to produce 3 kWh per litre of fuel consumed. Therefore, for a 35 kW generator, a reasonable fuel storage amount for a 24 hour period could be calculated as:

$$\frac{35\text{ kW} \times 24\text{ hours}}{3\text{ kWh/L}} = 280\text{ Litres}$$

Note that this assumes operation at full load; the amounts for ½ loads or 1/4 loads are not directly proportional.

The fuel storage compartment on the generator shall be double-walled. The interstitial space on the fuel storage shall be monitored and alarmed to indicate if there is a leak in the interstitial space. Overfill protection of the tanks may be provided in the form of visual monitoring of the fuel level in the storage tank by employees in constant attendance throughout the transfer operation, who are located so as to be able to promptly shut down the flow. Spill response equipment, such as absorbent pads, should be stored in a weatherproof container near the generator.

6.5.7 Water Pre-lubrication

When automatic pre-lubrication of pump bearings is necessary and an auxiliary direct drive power supply is provided, the pre-lubrication line shall be provided with a valved bypass around the automatic control so that the bearings can, if necessary, be lubricated manually before the pump is started or the pre-lubrication controls shall be wired to the auxiliary power supply.

6.6 WELL PUMPING STATIONS AND CHLORINE SYSTEMS

Where a well pumping station and chlorine and/or chemical system is to be installed, the preferred layout is for a three-room building which includes a separate chlorine or chemical room, pump room and electrical room. Access to the chlorine or chemical room will be from the outside only with a viewing window between the pump room and chlorine or chemical room. See the construction sketch in Appendix C for more details.

SYNOPSIS

PART 7 - STORAGE

(1) Synopsis

Part 7 provides general guidelines for the design and construction of concrete and steel storage tanks. A distinction is made between surface and above ground storage tanks.

(2) Check List

The following key items must be incorporated into the design of storage tanks

- Storage facilities must have sufficient capacity to meet domestic demands, emergency demands, and fire flow demands where appropriate (See 7.1).
- The bottom of reservoirs and stand-pipes must be above the 100 year flood or the highest flood on record (See 7.2).
- All storage structures must have an overflow which is brought down to an elevation between 300 and 600 mm above the ground surface. The overflow cannot be connected directly to a sewer or storm drain. The outlet for the overflow on a ground-level storage reservoir must be equipped with a non-corrodible insect screen and a suitable rodent guard (See 7.7).
- At least two manholes shall be provided above the waterline at each compartment. The manholes shall be fitted with a solid watertight cover which can be lifted by one person, and provided with a locking device (See 7.8).
- Water storage structures must be vented, but designed in such a way to prevent contamination by external water sources, birds, animals, and pests, as well as from vandalism. A conceptual drawing of the vents is available in Appendix C (See 7.9).
- The roof and sidewalls of all structures must be watertight. The only allowable openings are vents, manholes, overflows, risers, drains, pump mountings, control ports, and piping for inflow and outflow (See 7.10).
- Metal surfaces must be given proper protection by paints and/or cathodic protective devices (See 7.18).
- Treated water should not be stored or conveyed in a compartment adjacent to untreated or partially treated water when the two compartments are separated by a single wall (See 7.22.3).

7 STORAGE

The materials and designs used for treated water storage structures shall provide stability and durability as well as protect the quality of the stored water. Water storage tanks are typically made of concrete or steel. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. When steel tanks are used, the owner of the treatment plant is responsible for ensuring that the tanks are cleaned every three to five years and prior to inspections. It is preferable that the manufacturer provide facilities for internal cleaning.

Equipment containing mercury may not be connected to any liquid system within a water storage facility where it is possible that mercury may escape into water which subsequently is delivered to consumers.

7.1 SIZING

Storage facilities shall have sufficient capacity, as determined from engineering studies, to meet domestic demands (equalization), emergency demands, and where fire protection is provided, fire flow demands. Emergency supply is required in case of events such as power outages and restriction in source capacity.

a. Fire flow requirements, as specified in Section 8.2 "Water Main Design", shall be satisfied where fire protection is provided. The storage facility shall provide fire protection storage capacity as indicated in the following table:

Fire Flow Required (L/s)	Duration (Hours)
15	1.0
30	1.0
45	1.25
60	1.50
75	1.75
100	2.0

Interpolate for intermediate figures.

(Note: this table is based on the publication "Water Supply for Public Fire Protection", Latest Edition by Fire Insurer's Advisory Organization.)

b. The required total effective storage should be based on the following formula:

Total Storage Required = A + B + C

A = fire protection storage capacity as required above

B = equalization storage capacity equal to 25% of projected maximum day demand (MDD)

C = emergency storage capacity (25% of (A + B))

c. For evaluating water storage standpipes and water storage tanks elevated on towers, emergency storage should be considered on the bottom, fire protection storage on top of emergency storage, and equalization storage volume on top;

d. The minimum storage capacity or (equivalent capacity) for systems not providing fire protection shall be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.

Dimensional requirements for bolted and welded steel tanks are specified in AWWA Standard D103 and D100, respectively.

7.2 LOCATION OF RESERVOIRS

When locating water storage facilities, consideration should be given to maintaining water quality. The bottom of reservoirs and stand-pipes should be placed at the normal ground surface and shall be above the 200 year flood or the highest flood of record. If the bottom of the reservoirs is below normal ground surface, then sewers, drains, standing water, and similar sources of possible contamination must be kept at least 15 metres from the reservoir. Water main pipe, pressure tested in place to 340 kPa without leakage, may be used for gravity sewers at distances greater than 6 m but less than 15 m from the reservoir.

7.3 ROOF PROTECTION

All water storage structures shall have suitable watertight roofs which exclude birds, animals, insects, and excessive dust. Appurtenances such as antenna must be installed in a manner that ensures that damage to the tank, coatings or water quality is avoided, or that damage that has occurred is corrected.

7.4 PROTECTION FROM TRESPASSERS

Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

7.5 DRAINS

No drain on a water storage structure may have a direct connection to a sewer or storm drain. The design shall allow draining the storage facility for cleaning or maintenance without causing loss of pressure in the distribution system. The water storage site and adjacent land shall be protected from erosion due to the draining of the storage tank.

When bolted or welded steel tanks are used the tank supplier shall make provisions for cleaning the tanks.

7.6 STORED WATER

System should be designed to facilitate turnover of water in the reservoir. Separate inlet and outlet pipes, as well as means to avoid stagnation and thermal stratification while encouraging mixing should be considered. Where baffles are installed in the reservoir, their purpose should only be to improve T_{10}/T ratios in order to meet or exceed regulation CT targets for microbiological inactivation or destruction, as per the CT tables shown in Appendix A.

7.7 OVERFLOW

All water storage structures shall be provided with an overflow which is brought down to an elevation between 300 mm and 600 mm above the ground surface, and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to a sewer or a storm drain. All overflow pipes should be located so that any discharge is visible.

a. When an internal overflow pipe is used on elevated tanks, it should be located within or adjacent to the access manway, such that it is visible from the outside when the access hatch is open;

b. The outlet for the overflow on a ground-level storage reservoir shall be equipped with twenty-four mesh non-corrodible insect screen and a suitable rodent guard installed within the pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a screen should be provided inside the valve;

c. The outlet for the overflow on an elevated tank shall be equipped with a four mesh noncorrodible insect screen and a suitable rodent guard installed within the pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a screen should be provided inside the valve;

d. The overflow pipe shall be of a sufficient diameter to permit waste of water in excess of the filling rate.

7.8 ACCESS

Access shall be provided to the interior for inspection, cleaning and maintenance. At least two (2) manholes shall be provided above the waterline at each compartment where space permits.

a. For elevated storage structures, at least one of the access manholes shall be framed at least 100 mm above the surface of the roof at the opening. For ground level structures, each manhole shall be elevated at least 600 mm above the top of the tank or covering sod, whichever is higher;

b. Shall be fitted with a solid watertight cover which can be lifted by one person and prevents access by rodents. The cover shall extend down around the frame at least 50 mm. For ground level structures, the frame shall be at least 100 mm high;

c. Should be hinged at one side;

d. Shall have a locking device.

Steel welded tanks require an opening near the access ladder and an additional opening at the roof centre. Dimensional requirements are specified in AWWA Standard D100. Additional openings may be required for ventilation during painting. Access to bolted steel tanks will adhere to AWWA Standard D103.

7.9 VENTS

Water storage structures shall be vented. Refer to Appendix C for concept drawing. Overflows shall not be considered as vents. Open construction between the sidewall and roof is not permissible. Vents for reservoirs:

a. Shall prevent the entrance of surface water and rainwater;

b. Shall exclude birds and animals;

c. Should exclude insects and dust, as much as this function can be made compatible with effective venting. For elevated tanks and standpipes, four-mesh noncorrodible screen may be used;

d. On ground-level structures, vents shall terminate in an inverted U construction with the opening located at least 600 mm above the roof or sod, and located above the expected snow depth; and covered with sixteen mesh noncorrodible screen installed within the pipe at a location least susceptible to vandalism.

At least one of the vents on steel welded tanks must be located near the centre of the roof.

7.10 ROOF AND SIDEWALL

The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded, or properly gasketed. In concrete tanks, these pipes shall be connected to standard wall casting which were poured in place during the forming of the concrete. These wall castings should have seepage rings embedded in the concrete;

b. Openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent contamination from surface or floor drainage;

c. Valves and controls should be located outside the storage structure so that the valve stems and similar projections will not pass through the roof or top of the reservoir.

7.11 DRAINAGE OF ROOF

The roof of the storage structure shall be well drained. Down spout pipes shall not enter or pass through the reservoir. Parapets, or similar construction which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided.

7.12 CONSTRUCTION MATERIALS

The material used in construction of reservoirs shall be acceptable to the reviewing authority. Porous material, including wood and concrete block, are not suitable for potable water contact applications.

7.13 SAFETY

The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations of Canada and the relevant province.

a. Ladders, ladder guards, balcony railings, and safely located entrance hatches shall be provided where applicable;

b. Elevated tanks with riser pipes over 200 mm in diameter shall have protective bars over the riser openings inside the tank;

c. Railings or handholds shall be provided on elevated tanks where persons must transfer from the access tube to the water compartment;

d. Confined space entry requirements shall be considered.

7.14 FREEZING

All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, shall be designed to prevent freezing which will interfere with proper functioning. Equipment used for freeze protection that will come into contact with the potable water shall meet ANSI/NSF Standard 61 or be approved by the reviewing authority. If a water circulation system is used, it is recommended that the circulation pipe be located separately from the riser pipe.

7.15 INTERNAL CATWALK

Every catwalk over finished water in a storage structure shall have a solid floor with raised edges so designed that shoe scrapings and dirt will not fall into the water.

7.16 SILT STOP

The discharge pipes form all reservoirs shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided.

7.17 GRADING

The area surrounding a ground-level structure shall be graded in a manner that will prevent surface water from standing within 15 m of it.

7.18 PAINTING AND CATHODIC PROTECTION

Proper protection shall be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems shall be acceptable to the reviewing authority. After proper curing, the coating shall not transfer any substance to the water which will be toxic or cause tastes or odours; Prior to placing in service an analysis for volatile organic compounds is advisable to establish that the coating is properly cured. Consideration should be given to 100% solid coatings;

b. Cathodic protection should be designed and installed by competent technical personnel.

Coatings applied to steel tanks must follow AWWA Standard D102. Cathodic protection of steel tanks must follow AWWA Standard D104.

7.19 DISINFECTION

a. Water storage structures shall be cleaned and disinfected in accordance with current AWWA Standard C652. Two or more successive sets of samples, taken at 24-hour intervals, shall indicate microbiologically satisfactory water before the facility is placed into operation;

b. Disposal of heavily chlorinated water from the tank disinfection process shall be:
   - Planned for by the consulting professional engineer;
   - Described in a procedural format in the CEAA report;
   - Specified and detailed in the contract specifications.

c. The disinfection procedure (AWWA C652 chlorination method 3, section 4.3) which allows use of heavily chlorinated water held in the storage tank for disinfection purposes is not recommended. When that procedure is used, it is recommended that the initial heavily chlorinated water be effectively dechlorinated to levels below 0.02 mg/L, then properly disposed in order to prevent release of water which may contain various chlorinated organic compounds into the distribution system.

7.20 PROVISIONS FOR SAMPLING

Appropriate sampling tap(s) shall be provided to facilitate collection of water samples for both bacteriologic and chemical analyses.

7.21 INSPECTION OF STEEL TANKS

Inspection of bolted and welded steel tanks shall follow AWWA Standard D100 and should conform to the guidelines given in AWWA Standard D101. The First Nations owner of the treatment facilities should retain a local contractor who is experienced in the inspection and clean-out of reservoirs to conduct the inspection. The Circuit Rider should also routinely verify that the internal condition of water storage tanks in the community is satisfactory. Expenses associated with the inspections must be incorporated into the cost estimates specified in Section 1.1.5.

7.22 TREATMENT PLANT STORAGE

The applicable design standards of Section 7.0 shall be followed for plant storage.

7.22.1 Filter Washwater Tanks

Filter washwater tanks shall be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Section 4.3.2.1.11. Consideration must be given to the backwashing of several filters in rapid succession.

7.22.2 Clearwell

Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use.

a. When finished water storage is used to provide disinfectant contact time (see Section 4.3.3.3) special attention must be given to tank size and baffling (see Section 7.22.2.b below);

b. To ensure adequate disinfectant contact time, sizing of the clearwell should include extra volume to accommodate depletion of storage during the night time for intermittently operated filtration plants with automatic high service pumping from the clearwell during non-treatment hours.

c. An overflow and vent shall be provided;

d. A minimum of two clearwell compartments shall be provided.

7.22.3 Adjacent Compartments

Finished water must not be stored or conveyed in a compartment adjacent to untreated or wastewater of any kind when the two compartments are separated by a single wall.

7.22.4 Other Treatment Plant Storage

Other treatment plant storage tanks/basins such as detention basins, backwash reclaim tanks, receiving basins and pump wet-wells for finished water shall be designed as treated water storage structures.

7.23 HYDRO-PNEUMATIC TANK SYSTEMS

Hydro-pneumatic (pressure) tanks, when provided as the only water storage, are acceptable only in very small water systems. Hydro-pneumatic tank storage is not to be permitted for fire protection purposes. Pressure tanks shall meet ASME Sections 8 and 9 of the Boiler and Pressure Vessel Code, as well as relevant Provincial requirements and regulations for the construction and installation of unfired pressure vessels.

7.23.1 Location

The tank shall be located above normal ground surface and be completely housed.

7.23.2 System Sizing

a. The capacity of the wells and pumps in a hydro-pneumatic system shall be at least ten times the average daily consumption rate;

b. The gross volume of the hydro-pneumatic tank, in litres, shall be at least tent times the capacity of the largest pump, rated in litres per minute. For example, a 250 L/m pump should have a 2,500 L pressure tank, unless other measures (e.g., variable speed drives in conjunction with the pump motors) are provided to meet the maximum demand;

c. Sizing of hydro-pneumatic storage tanks must consider the need for disinfectant contact time

7.23.3 Piping

The hydro-pneumatic tank(s) shall have bypass piping to permit operation of the system while the tanks is being repaired or painted.

7.23.4 Appurtenances

Each tank shall have an access manhole, a drain, and control equipment consisting of a pressure gauge, water sight glass, automatic or manual air blow-off, means for adding air, and pressure operated start-stop controls for the pumps. Where practical the access manhole shall be 600 millimetres in diameter.

7.24 DISTRIBUTION STORAGE

In addition to the preceding standards the following shall apply for distribution system storage:

7.24.1 Pressures

The minimum pressure during peak hourly demand in the distribution system shall be 275 kPa. When pressures exceed 760 kPa, pressure reducing devices shall be provided on mains in the distribution system. Pressure in house plumbing should not exceed 550 kPa. (See the section entitled "Water Main Design" for minimum pressure during fire flow.)

7.24.2 Drainage

Storage structures which provide pressure directly to the distribution system shall be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drain shall discharge to the ground surface with no direct connection to a sewer or storm drain.

7.24.3 Level Controls

Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Level-indicating devices should be provided at a central location;

b. Pumps should be controlled from tank levels;

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance 24 hours a day.

SYNOPSIS

PART 8 - DISTRIBUTION SYSTEMS

(1) Synopsis

Part 8 provides general guidelines on distribution systems, hydrants, shut-off valves and water mains.

(2) Check List

- Discharge from drainage collection and air relief valves cannot be directly connected to sewer systems (See 8.5.3).
- Water mains must be separated from sewers by a minimum horizontal distance of 3 m, edge to edge, and 0.45 m vertically (See 8.7).
- The minimum pipe diameter for water services shall be 25 mm or 38 mm, depending on the pipe pressure during maximum hourly demand plus 1.6 L/s sprinkler flow (See 8.10.1).

8 DISTRIBUTION SYSTEMS

Water distribution systems shall be designed to maintain treated water quality. Special consideration should be given to distribution main sizing, providing for design of multidirectional flow, adequate valving for distribution system control, and provisions for adequate flushing. Systems should be designed to maximize turnover and to minimize residence times.

8.1 MATERIALS

a. Pipe, fittings, valves, and fire hydrants shall conform to the latest standards issued by the AWWA or NSF. Flow Meters and pressure reducing valves which pass fire flows, and fire hydrants, should be U.L.C. listed. All products shall comply with ANSI/NSF Standards. In the absence of such standards, materials meeting applicable product standards and acceptable to the reviewing authority may be selected. Galvanized steel pipe shall not be used;

b. Special attention shall be given to selecting pipe materials which will protect against both internal and external pipe corrosion;

c. Plastic pipe should not be installed in locations subject to possible contact with petroleum products or other organic compounds. Pipe and joint materials which are not subject to permeation of the organic compounds shall be used. Non-permeable materials shall be used for all portions of the system including water main, service connections and hydrant leads;

d. All materials must be lead-free. Pipe previously used for conveying potable water shall not be reused without permission of the reviewing authority.

8.2 WATER MAIN DESIGN

8.2.1 Pressure

All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. Under conditions of simultaneous maximum day and fire flow demands, the pressure shall not drop below 140 kPa (with the exception that, at locations where non-residential sprinkler systems for fire protection are necessary, additional residual pressure conditions are required; as explained below. The pressure in the distribution system during peak hourly demand must not be less than 275 kPa.

8.2.2 Diameter

The minimum size of water main for providing fire protection and serving fire hydrants shall be 150 mm diameter. Larger size mains may be required to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure of 140 kPa.

8.2.3 Fire Protection

If the water supply system is designed to provide fire protection capability, then system design should address major fire risks projected for the community (or service area) within the 20 year design life of the waterworks.

a. The calculated required fire flow (at 140 kPa pressure) at any location should not exceed the projected maximum flow which the firefighting system will be able to effectively use. (The above "firefighting system" is defined as the portable and/or mobile firefighting pumps (and ancillary equipment) plus automatic sprinkler systems in public buildings, which can be expected to be available at the community within the 20 year design life of the waterworks), and;

b. As a separate condition, at those locations where non-residential sprinkler systems for fire protection are present, or may be installed during the design life of the water works, the system should provide at least 240 kPa pressure at ground level during fire flow of 25 L/s (plus simultaneous maximum day demand) for a period of 30 minutes and;

c. Areas Protected by Residential Sprinkler Systems: Where arrangements have been made to provide residential sprinkler systems in all residences in a service area; and if the service area will not include any public buildings such as schools, gymnasiums, community halls, commercial buildings or industrial buildings then the minimum required fire flow at hydrants is 15 L/s at 140 kPa pressure (See Sections 8.4, 8.10 and 8.11 for further guidelines for residential sprinklers);

d. For suburban residential areas composed of single or two family dwellings with a) lot widths exceeding 24 m, and, b) exposure exceeding 8 m, the recommended design fire flow is 30 L/s.

8.2.4 Hydrants

Water mains not designed to carry fire-flows shall not have fire hydrants connected to them.

8.2.5 Dead Ends

Dead ends should be minimized by looping of all mains whenever practical. Make provision for maintaining a minimum flow of water where necessary to maintain water quality. This is commonly referred to as provision for “bleeding” of water.

8.2.6 Flushing

Where dead-end mains occur they shall be provided with an approved blow-off or self draining stand pipe for flushing purposes. Flushing devices should be sized to provide flows which will give a velocity of at least 0.7 metres per second in the water main being flushed. No flushing device shall be directly connected to any sewer.

8.2.7 Provision for Cleaning of Rural Pipelines

A means to easily facilitate the cleaning of the interior surface of water mains (such as installing launch points for conducting swabbing or pigging of water mains) should be provided in rural long-distance low-flow pipelines where it is not practical to obtain adequate cleaning with flushing alone.

8.3 VALVES

Sufficient sectional valves shall be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more the 150 metres intervals in commercial districts and at not more than one block or 240 metre intervals in other districts. Where systems serve widely scattered customers and where future development is not expected the valve spacing should not exceed 1,800 m.

A rock plate should be installed on valve riser stem at a distance of 300 mm below ground surface. Refer to Appendix C for concept drawings.

8.4 HYDRANTS

8.4.1 Location and Spacing

a. Areas where homes are not protected by residential sprinklers:

   Hydrants should be provided at each street intersection and at intermediate points between intersections as required for the specific case. The distance between a fire hydrant and building should be less than 75 metres, and the distance between fire hydrants should not exceed 150 metres.

b. Areas where homes are protected by residential sprinklers:

   For areas where the conditions of clause 8.2.3(c) are true, the distance between a fire hydrant and a building should be less than 150 metres, and the distance between fire hydrants should not exceed 300 metres.

8.4.2 Valves and nozzles

Fire hydrants should have a bottom valve size of at least 125 mm and two 63 mm outlets. In those cases where a pumper outlet may be required, the pumper outlet diameter shall match the pumper suction inlet diameter. Outlet threads shall be compatible with the available fire fighting equipment.

8.4.3 Hydrant Leads

The hydrant lead shall be a minimum of 150 mm in diameter. Auxiliary valves shall be installed in all hydrant leads.

8.4.4 Drainage

At sites subject to a seasonally high groundwater table, hydrant drains shall be plugged. When the drains are plugged the barrels must be pumped dry after use during freezing weather. Where hydrant drains are not plugged, a gravel pocket or dry well shall be provided unless the natural soils will provide adequate drainage. Hydrant drains shall not be connected to or located within 3 metres of sanitary sewers, or storm drains. The hydrant shall have provision for plugging or unplugging the drain hole from the ground surface without excavation.

8.4.5 Concept Drawing

Refer to Appendix C for concept drawing.

8.5 AIR RELIEF VALVES: VALVE METER AND BLOW-OFF CHAMBERS

8.5.1 Air Relief Valves

At high points in water mains where air can accumulate provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

8.5.2 Air Relief Valve Piping

The open end of an air relief pipe from automatic valves shall be extended to at least 300 mm above grade and provided with a 16 mesh screened, downward-facing elbow. The pipe from a manually operated valve should be extended to the top of the pit. Use of manual air relief valves is recommended where ever possible. Discharge piping from air relief valves shall not connect directly to any storm drain, storm sewer or sanitary sewer.

8.5.3 Chamber Drainage

Chambers, pits or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer. Such chambers or pits shall be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground (if soil conditions are suitable) at sites not subject to a seasonally high groundwater table.

8.5.4 Concept Drawing

Refer to Appendix C for concept drawing.

8.6 INSTALLATION OF MAINS

8.6.1 Standards

Specifications shall incorporate the provisions of the AWWA standards and/or manufacturer’s recommended installation procedures.

8.6.2 Bedding

A continuous and uniform bedding shall be provided in the trench for all buried pipe. Backfill material shall be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench shall be removed for a depth of at least 150 mm below the bottom of the pipe.

8.6.3 Cover

All water mains shall be covered with sufficient earth or other insulation to prevent freezing.

8.6.4 Blocking

All tees, bends, plugs and hydrants shall be provided with reaction blocking, tie rods or joints designed to prevent movement.

8.6.5 Pressure and Leakage Testing

All types of installed pipe shall be pressure tested and leakage tested in accordance with the latest edition of AWWA Standard C600.

8.6.6 Disinfection

All new, cleaned or repaired water mains shall be disinfected in accordance with AWWA Standard C651. The specifications shall include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains. In an emergency or unusual situation, disinfection procedure shall be discussed with the reviewing authority.

8.6.7 External Corrosion

The following are recommended steps to determine the degree of external corrosion. See the relevant Policy Statement on this subject at the front of this document.

a. Provide for a system of records by which the nature and frequency of corrosion problems are recorded. On a plat map of the distribution system, show the location of each problem so that follow-up investigations and improvements can be made when a cluster of problems is identified;

b. If needed, perform a survey to determine the existence of facilities or installations that would provide the potential for stray, direct electric currents. Also, determine whether problems are caused by the users of water pipes as grounds for the electrical system;

c. In areas where aggressive soil conditions are suspect, or in areas where there are known aggressive soil conditions, perform analyses to determine the actual aggressiveness of the soil;

d. If soils are found to be aggressive, take necessary action to protect the water main, such as by encasement of the water main in polyethylene, provision of cathodic protection (in very severe instances), or using corrosion resistant water main materials.

8.7 SEPARATION DISTANCES FROM CONTAMINATION SOURCES

8.7.1 General

The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water and sewer pipes;

b. Soil conditions;

c. Service and branch connection into the water main and sewer line;

d. Compensating variations in the horizontal and vertical separations;

e. Space for repair and alterations of water and sewer pipes;

f. Off-setting of pipes around manholes.

8.7.2 Parallel Installation

Water mains shall be laid at least 3 metres horizontally from any existing or proposed sewer or septic tank adsorption field trench. The distance shall be measured edge to edge. In cases where it is not practical to maintain a 3 metres separation, the reviewing authority may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 0.45 metres above the top of the sewer.

8.7.3 Crossings

Water mains crossing sewers shall be laid to provide a minimum vertical distance of 0.45 metres between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer with preference to the water main above the sewer. At crossings, one full length of water pipe shall be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required.

8.7.4 Exception

The reviewing authority must specifically approve any variance from the requirements of Sections 8.7.2 and 8.7.3 when it is impossible to obtain the specified separation distances. Where separation distances cannot be met, the sewer materials shall be waterworks grade 1.0 Mpa pressure rated pipe, or equivalent, and shall be pressure tested for water tightness.

8.7.5 Sewer Manholes

No water pipe shall pass through or come in contact with any part of a sewer manhole. Water mains should be located at least 3 metres from sewer manholes.

8.8 SURFACE WATER CROSSINGS

Surface water crossings, whether over or under water, present special problems. The reviewing authority should be consulted before final plans are prepared.

8.8.1 Above-Water Crossings

The pipe shall be adequately supported and anchored, protected from damage and freezing, and accessible for repair or replacement.

8.8.2 Underwater Crossings

A minimum cover of 600 mm shall be provided over the pipe. When crossing water courses which are greater than 5 metres in width, the following shall be provided:

a. The pipe shall be of special construction, having flexible watertight joints;

b. Valves shall be provided at both ends of water crossings so that the section can be easily isolated for testing or repair; the valves shall be easily accessible, and not subject to flooding; and the valve closest to the supply source should be in a manhole;

c. Permanent taps should be made on each side of the valve within the manhole to allow insertion of a small meter to determine leakage and to obtain water samples.

8.9 CROSS-CONNECTIONS AND INTER-CONNECTIONS

8.9.1 Cross-connections

There shall be no connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system.

When a groundwater supply has replaced a surface water supply as the source of water, then the surface water supply must be physically disconnected from the water system.

Any type of connection of the surface water supply, including the use of valves is not acceptable.

8.9.2 Cooling Water

Neither steam condensate nor cooling water from engine jackets or other heat exchange devices shall be returned to the potable water supply.

8.9.3 Inter-connections

The approval of the reviewing authority shall be obtained for interconnections between potable water supplies. Consideration should be given to differences in water quality.

8.10 WATER SERVICES

8.10.1 General

a. Water services shall conform to the Canadian Plumbing code;

b. If residential fire sprinkler systems are expected to be installed in houses or multi-family dwellings, then residential sprinkler system flows and domestic supply flows should be combined in one service pipe.

In order to provide adequate flow for operation of the sprinklers in single family houses the minimum pipe diameter should be as follows:

Pressure at the water main during maximum hourly demand plus 1.6L/S sprinkler flow	Required Diameter of Service*
Greater than 500 kPa	25 mm
Between 275 and 500 kPa	38 mm

* If service length exceeds 50 m or if the highest house ceiling is more than 7 metres above ground surface (at water main location) or if a flow meter is to be installed on the service line, then the required diameter of water service shall be determined using NFPA-13D. Refer to Appendix C for concept drawing.

The diameter of services to provide adequate flow for operation of sprinklers in multi-family dwellings shall be based on NFPA-13 and NFPA-13D.

8.10.2 Booster Pumps

Individual booster pumps shall not be allowed for any individual service from the public water supply mains. Where permitted for other types of services, booster pumps shall be designed in accordance with Section 6.4.

8.10.3 Separation

Separation of sewer and water services from the main to the house should meet regional procedures.

8.10.4 Curb Valve

On each water service from a street main to a building an approved gate valve and valve box shall be installed between the property line and the curb. Combination stop and waste valves shall not be installed underground in water service piping.

8.11 SERVICE METERS

Each service connection should be individually metered if control of consumption is required to conserve a limited water supply quantity.

Where meters are installed on services which provide flows for residential sprinkler systems, the water service and flow meters shall meet the provisions of NFPA - 13D.

8.12 TRUCK LOADING STATIONS

Water loading stations present special problems since the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following principles shall be met in the design of water loading stations:

a. There shall be no risk of backflow to the public water supply. A device shall be installed on the fill line to provide an air break and prevent a submerged discharge line; Refer to Appendix C for concept drawing;

b. The piping arrangement shall prevent contaminant being transferred from a hauling vessel to others subsequently using the station.

8.13 TRUCK WATER DELIVERY

Vehicles and mechanisms for trucked water shall conform to the relevant federal and provincial standards and regulations for water vending.

SYNOPSIS

PART 9 - WASTE RESIDUALS

(1) Synopsis

Part 9 provides general guidelines on the handling and disposal of waste streams from water treatment plants.

(2) Checklist

- Sanitary waste must receive treatment, and should be discharged directly to a sanitary sewer system or on-site waste treatment facility. (See 9.1).

- Brine waste may be discharged to a stream if adequate dilution is available. A holding tank should be used to control discharge rates. (See 9.2).

- Aluminum Hydroxide sludge can be discharged to a lagoon. (See 9.3.2).

- Waste filter wash water from iron and manganese removal plants can be discharged to a lagoon or discharged to a community sanitary sewer. (See 9.4).

- Filter backwash can be discharged to a receiving stream provided waste quality meets environmental regulations. Waste recycling may be possible, but not if the presence of algae, protozoans, or disinfection by-products is likely. (See 9.5).

9 WASTE RESIDUALS

All waste discharges shall be governed by the applicable regulatory agency requirements. The requirements outlined herein must, therefore, be considered minimum requirements as environmental and water pollution control authorities may have more stringent requirements.

Provisions must be made for proper disposal of water treatment plant wastes, such as sanitary, laboratory, clarification sludge (aluminum hydroxide), ferrous hydroxide sludge, filter backwash water and brines. In locating waste disposal facilities, due consideration shall be given to preventing potential contamination of the raw water supply.

Alternative methods of water treatment and chemical use should be considered as a means of reducing waste volumes and the associated handling and disposal problems.

Appropriate backflow protection must be provided on waste discharge piping as needed to protect the public water supply.

9.1 SANITARY WASTE

The sanitary waste from water treatment plants, pumping stations, and other waterworks installations must receive treatment. Waste from these facilities shall be discharged directly to a sanitary sewer system, when available and feasible, or to an adequate on-site waste treatment facility approved by the appropriate reviewing authority.

9.2 BRINE WASTE

Waste from ion exchange plants, demineralization plans, or other plants which produce a brine, may be disposed of by controlled discharge to a stream if adequate dilution is available. Surface water quality requirements of the regulatory agency will control the rate of discharge. Except when discharging to large waterways, a holding tank of sufficient size should be provided to allow the brine to be discharged over a twenty-four hour period. Where discharging to a sanitary sewer, a holding tank may be required to prevent the overloading of the sewer and/or interference with the waste treatment processes. The effect of brine discharge to sewage lagoons may depend on the rate of evaporation from the lagoons.

9.3 ALUMINUM HYDROXIDE SLUDGE

9.3.1 General

Lagooning may be used as a method of handling aluminum hydroxide sludge. Lagoon size can be calculated using total chemicals used plus a factor for turbidity. Freezing changes the nature of aluminum hydroxide sludge so that it can be used for landfill. Aluminum hydroxide sludge may also be discharged to a sanitary sewer. However, initiation of this practice will depend on obtaining approval from the owner of the sewerage system as well as from the regulatory agency before final designs are made.

9.3.2 Lagoons

Lagoons should be designed to produce an effluent satisfactory to the regulatory agency and should provide for:

a. Location free from flooding;

b. Where necessary, dykes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoon;

c. A minimum usable depth of 1.75 m;

d. Adequate freeboard of at least 1 metre;

e. Adjustable decanting device;

f. Effluent sampling point;

g. Adequate safety provisions;

h. A minimum of two cells, each with appropriate inlet/outlet structures to facilitate independent filling/dewatering operations.

9.3.3 Land Application

Aluminum hydroxide sludge may be disposed of by land application either alone, or in combination with other wastes where an agronomic value has been determined and disposal has been approved by the reviewing authority.

9.4 "RED WATER" WASTE

Waste filter wash water from iron and manganese removal plants can be disposed of as follows:

9.4.1 Lagoons

Lagoons shall have the following features:

a. Be designed with a volume 10 times the total quantity of wash water discharged during any twenty-four hour period;

b. A minimum usable depth of 1.5 m;

c. Length four times width, and the width at least three times the depth, as measured at the operating water level;

d. Outlet to be at the end opposite the inlet;

e. A weir overflow device at the outlet end with weir length equal to or greater than depth;

f. Velocity to be dissipated at the inlet end;

g. Subsurface infiltration lagoons may be acceptable if approved by the reviewing authority.

9.4.2 Discharge to Community Sanitary Sewer

Red water can be discharged to a community sewer. However, approval of this method will depend on obtaining approval from the owner of the sewerage system as well as from the regulatory agency before final designs are made. A holding tank is recommended to prevent overloading the sewers. Design shall prevent cross connections and there shall be no common walls between potable and non-potable water.

9.4.3 Recycling "Red Water" Wastes

Recycling of supernatant or filtrate from "red water" waste treatment facilities to the head end of an iron removal plant shall not be allowed except as approved by the reviewing authority.

9.5 FILTER BACKWASH WATER

Filter backwash water from surface water treatment plants should have suspended solids reduced to a level acceptable to the regulatory agency before being discharged to any receiving stream in accordance with the CEPA. Many plants have constructed holding tanks and returned this water to the inlet end of the plant. The holding tank shall be of such a size that it will contain the anticipated volume of waste wash water produced by the plant when operating at design capacity. A plant that has two filters should have a holding tank that will contain the total waste wash water from both filters calculated by using a 15 minute wash at 50 m/hr. In plants with more filters, the size of the holding tank will depend on the anticipated hours of operation. It is recommended that waste filter wash water be returned at a rate of less than 10% of the instantaneous raw water flow rate enter the plant.

Filter backwash water shall not be recycled when the raw water contains excessive algae, when finished water taste and odour problems are encountered, or when disinfection byproduct levels in the distribution system may exceed allowable levels. Particular attention must be given to the presence of protozoans such as *Giardia* and *Cryptosporidium* concentrating in the waste water stream. Water Treatment Plans will be required to treat filter waste water prior to recycling or avoid reclaiming filter wash water given the increased risk to treated water quality.

9.6 RADIOACTIVE MATERIALS

Radioactive materials include, but are not limited to, granulated activated carbon (GAC) used for radon removal; ion-exchange regeneration waste from radium removal; and manganese greensand backwash solids from manganese removal systems, and reverse osmosis concentrates where radiological constituents are present. The buildup of radioactive decay products of radon shall be considered, and adequate shielding and safeguards shall be provided for operators and visitors. These materials may require disposal as radioactive waste in accordance with Nuclear Regulatory Commission regulations. Approval shall be obtained from the responsible regulatory agencies prior to disposal of all wastes.

9.7 SPENT SAND FROM SLOW SAND FILTERS

Spent sand shall be disposed of in an appropriate manner and in an area in conformance with CEPA requirements.

9.8 SPENT LIME ROCK

Spent lime rock shall be disposed of in an appropriate manner and in an area in conformance to the CEPA.

9.9 LABORATORY WASTES

Toxic laboratory wastes shall be drained to a separate holding tank and disposed of at a toxic waste facility or the local sewage plant.

9.10 FLOOR DRAINS

All floor drains shall be discharged to the sewer or to the plant wastewater holding ponds.

9.11 REJECTS FROM MEMBRANE PLANTS

All rejects from the membrane process shall be discharged to the sewer or to the plant wastewater holding ponds.

APPENDIX “A”

PROCEDURE FOR DISINFECTION OF DRINKING WATER IN ONTARIO

Available at :
http://www.ene.gov.on.ca/envision/water/sdwa/dwsr.htm
http://www.ene.gov.on.ca/envision/gp/4448e.htm

TERMS OF REFERENCE FOR HYDROGEOLOGICAL STUDY TO EXAMINE GROUNDWATER SOURCES POTENTIALLY UNDER DIRECT INFLUENCE OF SURFACE WATER

Available at:
http://www.ene.gov.on.ca/envision/water/sdwa/dwsr.htm
http://www.ene.gov.on.ca/envision/techdocs/4167e.htm

HEALTH CANADA - GUIDELINES FOR CANADIAN DRINKING WATER QUALITY : SUPPORTING DOCUMENTATION ON TURBIDITY, OCTOBER 2003

Available at :
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/turbidity/index_e.html

APPENDIX "B"

REFERENCE STANDARDS

NAME	AVAILABLE FROM
Automatic Sprinkler Systems Handbook, Third Edition, 1987 NFPA	National Fire Protection Association. www.nfpa.org
AWWA Standards	American Water Works Association. www.awwa.org
BC Water Protection Act, 1996	Ministry of Management Services. www.qp.gov.bc.ca
Canadian Environmental Assessment Act, 1992.	Department of Justice Canada. http://laws.justice.gc.ca
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Abbreviations

AWWA	-	American Water Works Association
NFPA	-	National Fire Protection Association
NSF	-	National Sanitation Foundation
NTU	-	Nephelometric Turbidity Unit
mg/L	-	Milligrams per litre
L/s	-	Litres per second
m/s	-	metres per second
mm	-	millimetres
GAC	-	granular activated carbon
m/h	-	metres per hour
m/min	-	metres per minute
THM's-		Trihalomethanes

APPENDIX "C"

CONCEPTUAL DRAWINGS

The drawings on the following pages have been prepared to provide practical information towards the provision of water works and water supply facilities. Their purpose is to minimize design time and expense, capital, operating and maintenance costs and to maximize system reliability and efficiency.

The drawings are to be used as a basis for detailed design and are not intended to be used in Contract Documents as detail drawings. Every effort has been made to ensure that all details and information is correct on each of the drawings, however "site specific" conditions and individual requirements will dictate the use of sound engineering judgment and good practice in the proper application of these plans to each specific application.

Drawing list:

.1 Acceptable Water Loading Services,

.2 Typical Water Service Connection,

.3 Valve Box Assembly Detail,

.4 Hydrant Connection Detail,

.5 Vent for Ground Level Water Storage Tank,

.6 Standard Air Valve Station - Coastal Area,

.7 Standard Air Valve Station - Cold Climate Area,

.8 Typical Well Pumping Station/Chlorine Room and Control Room (New),

.9 Typical Cross-Section of Well Pump.