CHAPTER 3

SYSTEM ANALYSIS

The ability of a water utility to meet current and anticipated future demands is an important consideration in water system planning. In addition to demand considerations, water quality plays a major role in determining the adequacy of a water system. The five components, which will be analyzed in this chapter, are as follows:

- System Design Standards
- Water Quality Analysis
- System Inventory, Description, and Analysis
- Summary of System Deficiencies
- Analysis of Possible Improvement Projects

System design standards identify performance and design criteria that are applicable to the Town of Friday Harbor. Water quality and facility analyses evaluate existing and water quality facilities according to identified design standards. Based on these analyses, a summary of water system deficiencies and recommendations to improve compliance are provided.

SYSTEM DESIGN STANDARDS

Performance and design criteria typically address sizing and reliability requirements for source, storage, distribution, fire flow, and water quality. Construction standards set forth material requirements and construction methods that contractors, developers, and the Town must adhere to when constructing water system improvements. In this chapter, design standards are divided between general facility standards and water quality standards and are discussed in the following order:

General Facility Standards

1. Average and Peak Day Demand
2. Peak Hour Demand
3. Storage Requirements
4. Minimum System Pressure
5. Minimum Pipe Sizes
6. Backup Power Requirements

Water Quality Analysis

1. Applicable Drinking Water Regulations
2. Existing Drinking Water Quality Standards
3. Anticipated Future Drinking Water Quality Standards
4. Water Quality Monitoring Schedule

GENERAL FACILITY STANDARDS

The Washington State Department of Health (DOH) relies on various publications, agencies, and the utility itself to establish appropriate design criteria. WAC 246-290-200, Design Standards, lists the various criteria recognized by the DOH. Table 3-1 summarizes the minimum allowable design standards. Following are brief descriptions of the two most widely recognized performance and design standards.

Water System Design Manual, **Washington State Department Of Health (DOH), (August 2001)**

Significant revisions to the State Waterworks Standards have recently been completed by the DOH. These standards will serve as a guideline for the preparation of plans and specifications for Group A public water systems in accordance with WAC 246-290 and build and expand on the current standards published in the Department's "Sizing Guidelines for Public Water Supplies". Where these documents specify standards different from the Ten States Standards, the provisions of the DOH Standards will govern. The design manual also includes procedures for establishing system capacity based upon ERUs.

Recommended Standards for Water Works, **A Committee Report of the Great Lakes - Upper Mississippi River Board of State Public Health and Environmental Manager (1992).**

Commonly known as the "Ten States Standards," this document formalizes the design standards recommended by a water supply committee representing ten Midwestern and Upper Great Lake States and the Province of Ontario. The report of the Water Supply Committee was first published in 1953, and subsequently revised and published in 1962, 1968, 1976, 1982, 1992, and 1997. The report presents recommendations for both design and construction standards; however, the construction standards are somewhat general in nature, with minor emphasis on materials specifications. Since surface water treatment is quite common in the Midwest and Upper Great Lakes, the committee report tends to concentrate on water treatment plant design and operation.

Table 3-1. General Facility Requirements

Standard	DOH Waterworks Standards	Town of Friday Harbor
Average Day and Peak Day Demand	▪ Average day demand (ADD) determined by historical water use data generated by accurate production and consumption meters. Maximum day demand is estimated approximately two times the ADD.	Adopt DOH criteria.
PHD= Peak Hour Demand MDD = Maximum Day Demand (gpd/ERU) C = Coefficient associated w/ERUS N = Number of ERUs F = Factor associated w/ERUs	PHD = $\frac{MDD}{1440}\left[(C)(N)+F\right]+18$ If ERUs > 500, C = 1.6, F = 225 If ERUs >100 but <250 (e.g. 460-foot zone), C = 2.0 and F = 75	Adopt DOH criteria.
Storage Requirements	The sum of: ▪ Operational Storage (OS, gallons) OS = depends on reservoir settings ▪ Equalizing Storage (ES, gallons) ES = (PHD-Qs)150, where Qs = sum of all non-emergency sources of supply in gpm ▪ Standby Storage (SB, gallons) SB = (2)(ADD) ▪ Fire Suppression Storage ▪ Dead Storage	Fire Storage: Rural: NA Residential: 15,000 gallons (or 500 gpm for 30 minutes) Commercial/Multi-family: 45,000 gallons (or 750 gpm for 60 minutes) Industrial: 60,000 gallons (or 1,000 gpm for 60 minutes)
Minimum System Pressure	The system should be designed to maintain a minimum of 30 psi in the distribution system under peak hour demand and 20 psi throughout the system under fire flow conditions.	Adopt DOH criteria.
Minimum Pipe Sizes	The minimum size for a transmission line should be determined by hydraulic analysis. The minimum size distribution system line shall not be less than 6-inches in diameter. Distribution mains must deliver PHD with 30 psi residual pressure, and fire flow at MDD with 20 psi system wide.	The system will maintain 8-inch minimum pipe size except for 6-inch minimum in single-family cul-de-sacs.
Backup Power Requirements	On-site back-up power equipment or gravity standby storage shall be provided unless the power grid meets the minimum reliability criteria established in Section 7.7, "Water System Design Manual".	Gravity storage provided for pressure zone 232, other zones provide a minimum of 50% of peak demand with largest pump out of service, with auxiliary power provided.

*From Water System Design Manual, August 2001.

WATER QUALITY ANALYSIS

The water quality analysis inventories the applicable water quality regulations, which can be viewed an analogous to design standards, for the Friday Harbor drinking water supply. The Town evaluates compliance with these regulations through regular monitoring of their source supply and distribution system.

Applicable Drinking Water Quality Regulations

The State Drinking Water Regulations (WAC 246-290), last updated December 14, 2001 provides broad oversight for the DOH over design, construction, and operation of the largest (Group A) public water systems in Washington. Existing state law contains regulations of bacteriological contaminants, inorganic chemicals (IOCs), physical characteristics, lead and copper, trihalomethanes (THMs), volatile organic chemicals (VOCs), synthetic organic chemicals (SOCs), and radionuclides. The State Drinking Water Regulations are in the process of being amended to reflect new EPA rules regarding surface water treatment, disinfection, public notification, radionuclides, lead and copper. A number of additional federal drinking water regulations are expected within the next ten years. These regulations will define new or additional water quality requirements for many contaminants found in drinking water, including arsenic, radon, MTBE, and aldicarb, as well as monitoring and reporting requirements, which may potentially affect the Town of Friday Harbor. Information and updates concerning these federal regulations can be found on the EPA website: www.epa.gov/safewater/regs.html.

Existing Drinking Water Quality Standards

The following existing drinking water standards apply to the Town of Friday Harbor.

Bacteriological. In accordance with WAC 246-290, water purveyors are required to conduct monthly distribution system sampling for bacteriological contamination according to an established coliform monitoring plan. The Town's current coliform monitoring plan is included in Appendix H. If coliform presence is detected in any sample, the sample must be analyzed for fecal coliform or *E. Coli* contamination and repeat samples collected and analyzed. Along with the coliform monitoring, residual disinfection concentrations must be measured within the distribution system as well.

An acute MCL for coliform bacteria occurs when:

- Fecal coliform is present in a repeat sample.
- *E. Coli* is present in a repeat sample.
- Coliform is present in a set of repeat samples collected as a follow-up to a sample with fecal coliform or *E. Coli* presence.

A non-acute MCL for coliform bacteria occurs when:

- Systems taking less than 40-month samples have more than one sample with coliform.

Inorganic Chemical and Physical Characteristics. The Department of Health has established both primary and secondary MCLs for inorganic chemicals and physical characteristics in WAC 246-290. As indicated in the WAC, primary standards are associated with chronic, non-acute, or acute human health effects. Secondary standards are based on factors other than health effects, typically aesthetics. The primary and secondary MCLs for inorganic chemicals and physical characteristics are summarized in Table 3-2 and Table 3-3.

Table 3-2. Inorganic Chemical Water Quality Standards

Chemical	Primary MCL (mg/L)
Antimony (Sb)	0.006
Arsenic (As)	0.01
Asbestos	7 million fibers/liter
Barium (Ba)	2.0
Beryllium (Be)	0.004
Cadmium (Cd)	0.005
Chromium (Cr)	0.1
Cyanide (HCN)	0.2
Fluoride (F)	4.0
Mercury (Hg)	0.002
Nickel (Ni)	0.1
Nitrate (as N)	10.0
Nitrite (as N)	1.0
Selenium (Se)	0.05
Thallium (Tl)	0.002
Chemical	**Secondary MCL (mg/L)**
Chloride (Cl)	250.0
Fluoride (F)	2.0
Iron (Fe)	0.3
Manganese (Mn)	0.05
Silver (Ag)	0.1
Sulfate (SO_4)	250.0
Zinc (Zn)	5.0

Source: State Board of Health Drinking Water Regulations, December 14, 2001.

Table 3-3. Physical Characteristic Water Quality Standards

Characteristic	Secondary MCL
Color	15 Color Units
Hardness	None Established
Specific Conductivity	700 mhos/cm
Total Dissolved Solids (TDS)	500 mg/L

Source: State Board of Health Drinking Water Regulations, effective December 14, 2001.

Volatile Organic Compounds and Synthetic Organic Compounds. A partial list of these compounds and their MCLs is included in Table 3-4. However, the number of required sampling constituents is increasing.

Table 3-4. Organic Chemical Water Quality Standards

Organic Chemical	Federal Regulation	Primary MCL (mg/L)	Organic Chemical	Federal Regulation	Primary MCL (mg/L)
Vinyl Chloride	Phase I	0.002	Chlordane	Phase II	0.002
Benzene	Phase I	0.005	Dibromochloro-propane	Phase II	0.0002
Carbon Tetrachloride	Phase I	0.005	2,4-D	Phase II	0.07
1,2-Dichloroethane	Phase I	0.005	Ethylene dibromide	Phase II	0.00005
Trichloroethylene	Phase I	0.005	Heptachlor	Phase II	0.0004
para-Dichlorobenzene	Phase I	0.075	Heptachlor epoxide	Phase II	0.0002
1,1-dichloroethylene	Phase I	0.007	Lindane	Phase II	0.0002
1,1,1-Trichloroethane	Phase I	0.2	Methoxychlor	Phase II	0.04
cis-1,2-Dichloroethylene	Phase II	0.07	Polychlorinated biphenyls (PCBs)	Phase II	0.0005
1,2-Dichloropropane	Phase II	0.005	Pentachlorophenol	Phase II	0.001
Ethylbenzene	Phase II	0.7	Toxaphene	Phase II	0.003
Monochlorobenzene	Phase II	0.1	2,4,5-TP	Phase II	0.05
ortho-Dichlorobenzene	Phase II	0.6	Benzo(a)pyrene	Phase V	0.0002
Styrene	Phase II	0.1	Dalapon	Phase V	0.2
Tetrachloroethylene	Phase II	0.005	Di(2-ethylhexyl) adipate	Phase V	0.4
Toluene	Phase II	1	Di(2-ethylhexyl) phthalate	Phase V	0.006
trans-1,2-Dichloroethylene	Phase II	0.1	Dinoseb	Phase V	0.007
Xylenes (total)	Phase II	10	Diquat	Phase V	0.02
Dichloromethane	Phase V	0.005	Endothal	Phase V	0.1
1,2,4-Trichloro-benzene	Phase V	0.07	Endrin	Phase V	0.002
1,1,2-Thrichloro-ethane	Phase V	0.005	Glyphosate	Phase V	0.7
Arochlor	Phase II	0.002	Hexachlorobenzene	Phase V	0.001
Aldicarb	Phase II	0.003	Hexachlorocyclopentadi ene	Phase V	0.05
Aldicarb sulfone	Phase II	0.003	Oxamyl (vydate)	Phase V	0.2
Aldicarb sulfoxide	Phase II	0.004	Picloram	Phase V	0.5
Atrazine	Phase II	0.003	Simazine	Phase V	0.004
Carbofuran	Phase II	0.04	2,3,7,8-TCDD (dioxin)	Phase V	0.00000003

Disinfection By-Products. Existing trihalomethane standards under WAC 246-290 are shown in Table 3-5. As will be discussed later in this Chapter, the THM standard will be lowered to 80 ug/l, and a new standard of 60 ug/l will be established for Halo Acetic Acids. In anticipation of the new standard, the Town conducted quarterly sampling for THMs and HAAs in 2001, with average results of 85 ug/l and 42 ug/l for THMs and HAAs, respectively. Based upon these samples, the Town may not comply with a lower THM standard. This issue is addressed later in this Chapter.

Table 3-5. Trihalomethanes Water Quality Standards

Parameter	MCL (mg/L)
Total Trihalomethanes (TTHM)	0.10

Source: State Board of Health Drinking Water Regulations, effective December 14, 2001.

Lead and Copper. Lead and copper sampling must be conducted in accordance with 40 CFR. For lead sampling, 90 percent of samples collected must have concentrations below the 0.015 mg/L action level. Similarly, 90 percent of copper samples must have concentrations less than a 1.3 mg/L action level. Systems exceeding the action levels are required to provide less corrosive water. The Town has completed the required initial monitoring, and is on a reduced lead/copper sampling program.

Radionuclides. Table 3-6 summarizes radionuclide MCLs as defined by WAC 246-290.

Table 3-6. Radionuclide Water Quality Standards

Parameter	MCL
Radium-226	3 pCi/L
Combined Radium-226 and Radium-228	5 pCi/L
Gross alpha particle activity, excluding uranium	15 pCi/L
Beta particle and photon radioactivity from man-made radionuclides	See WAC 246-290-310 (5)(6)

Sample Locations. Table 3-7 provides sampling locations for required water quality constituents.

Table 3-7. Sample Location

Sample Type	Sample Location
Asbestos	One sample from distribution system or, if required by department, from the source.
Bacteriological	From representative points throughout distribution system.
Complete Inorganic Chemical & Physical	From a point representative of the source, after treatment, and prior to entry to the distribution system.
Lead/Copper	From the distribution system at targeted sample tap locations.
Nitrate/Nitrite	From a point representative of the source, after treatment, and prior to entry to the distribution system.
Total Trihalomethanes -Surface Water	From points at extreme end, and at intermediate locations, in the distribution system from the source after treatment.
Potential Trihalomethanes -Ground Water	From the source before treatment.
Radionuclides	From the source.
Organic Chemicals (VOCs & SOCs)	From a point representative of the source, after treatment and prior to entry to distribution system.
Other Substances (unregulated chemicals)	From a point representative of the source, after treatment, and prior to entry to the distribution system, or as directed by the department.

Anticipated Future Drinking Water Regulations

The nature of this section is to identify all current and pending regulations that will affect water treatment and water quality criteria for the finished water leaving the plant and the water delivered to the consumer's tap. In addition, this chapter addresses finished water quality criteria to ensure compliance with regulations and to account for any water quality changes within the distribution system.

With the numerous water regulations that now exist and the several pending regulations that are anticipated, it is plausible to rather reliably forecast the regulatory horizon for developing a comprehensive, yet flexible water system plan. Regulations that govern water quality, treatment effectiveness, disinfection practices and disinfection by-products, wash water recycling, and distribution system contaminant levels are likely to be of prime importance for the Town.

Overview of Regulatory Requirements for Finished Water Quality

One of the major challenges for water utility capital planning is that drinking water regulations have been in a state of flux the last ten years. This section discusses the water quality regulations affecting the Town of Friday Harbor, identifies the principal issues surrounding them, presents emerging trends, and discusses the relevant implications for treatment plant improvements.

Drinking Water Quality Regulations and Regulatory Climate

Drinking water standards in Washington State are established by the United States Environmental Protection Agency (EPA) and the Washington State Department of Health (WSDOH) in accordance with EPA requirements. In general, water quality standards can be separated into two distinct groups: primary standards, and secondary standards. Primary standards are for the protection of public health, while secondary standards are for aesthetic considerations. Current drinking water regulations attempt to manage two distinct kinds of risk: microbial risks, and chemical risks.

Microbial risks stem from two sources: pathogens present in the source water; and opportunistic pathogens, typically bacteria which tend to grow in distribution system materials and consumer plumbing. Diseases of concern from source water include giardiasis and cryptosporidiosis, while opportunistic bacterial pathogens include *Legionella* (which causes Legionnaires disease), *Mycobacterium avium* infections, and other organisms that cause gastrointestinal upsets.

Since the sub-populations that are more susceptible to microbial contaminants are growing, increasing attention is being focused on emerging pathogens. These organisms include *Toxoplasma* (commonly transmitted by cats), *Microspora* (hosted by aquatic animals), *Cyclospora* (transmitted by humans), *Klebsiella*, and *Pseudomonas* (both of which are associated with biofilms in plumbing systems). All of these organisms may be transmitted through the water supply and are receiving increased attention from epidemiologists, doctors, and water treatment professionals.

Negative health impacts from chemical risks in drinking water include reproductive effects, neurological effects, and cancer. The chief areas of concern have to do with the compounds formed during disinfection of drinking water (termed disinfection by-products, DBPs) and trace metals associated with corrosion (e.g., lead, copper, and others).

Table 3-8 presents a summary of existing, proposed, or anticipated drinking water regulations and their potential impact on the Town. The most recent and potentially significant of these regulations are discussed in detail below.

Table 3-8. Drinking Water Quality Regulation Summary

Regulation	Applicable to Town	Effective Date	Summary of MCLs
Interim Enhanced Surface Water treatment Rule (ESWTR)	N	Current Regulation	Applies to system over 10,000 population
Long term 1 Enhanced Surface water Treatment Rule	Y	January 2005	▪ Implements ESWTR for systems <10,000 ▪ Requires individual filter monitoring and reporting ▪ Turbidity <0.30 NTU/95% of samples
Filter Backwash Rule	N	June 2006	Town does not recycle backwash water
Long Term 2 Enhanced Surface water Treatment Rule	Y	June 2006 (1)	▪ Requires source monitoring for Crypto ▪ Establishes treatment techniques (tools) for varying concentrations of Crypto detected in raw water supply
Disinfectants and Disinfection Byproducts Rule (Stage 1)	Y	January 2003	▪ TTHMs 0.80 mg/l ▪ HAAs 0.60 mg/l ▪ Chlorite 1.0 mg/l ▪ Bromate 0.010mg/l ▪ % TOC removal a function of alkalinity
Disinfectants and Disinfection Byproducts Rule (Stage 2)	Y	June 2006 (1)	Build on D/DBP 1, places limits on THM/HAAs levels at LRAA (running annual average at each location)
Radionuclides Rule	Y	December 2003	▪ Combined Radium 226 and 228 at 5 pCi/l ▪ Gross Alpha (minus U) 15 pCi/l ▪ Beta Particle and Photon emitters at 4 mrem/year ▪ Uranium 0.030 mg/l
Arsenic Rule	Y	January 2006	▪ 0.01 mg/ ▪ Town's Arsenic level is non-detect
Sulfate	Y	N/A	EPA decision expected summer 2002
Radon	Y	N/A	EPA decision expected 2002

The Safe Drinking Water Act (SDWA) was originally passed in 1974 and has been amended twice since, once in 1986 and again in 1996. In each amendment, microbes and disinfection by-products (DBP) have been primary concerns. Numerous critiques have been leveled at previous and current regulatory efforts. A major concern has been that regulations that are often promulgated independently and sequentially will sometimes be fundamentally in conflict with one another.

The EPA may be becoming more sensitive to this issue, particularly in the area of DBP regulations and corrosion control. The EPA Science Advisory Board just released a report, *Integrated Environmental Decision Making in the 21st Century*, which indicates that the EPA should focus on the reduction of total risk according to a risk management rationale rather than focusing on the reduction of individual risk factors (EPASAB, 2000). Attempts toward more integrated environmental decision-making are just beginning to be made. EPA is, in fact, authorized to incorporate such considerations by the 1996 SDWA Amendments:

> "...the level or levels or treatment techniques shall minimize the overall risk of adverse health effects by balancing the risk from the contaminant and the risk from other contaminants the concentrations of which may be affected by the use of a treatment technique or process that would be employed to attain the maximum contaminant level or levels"

A major limitation of such efforts is the lack of information regarding the health effects associated with various contaminants and controversies regarding the interpretation of information regarding health effects. This is of particular importance to the Town when it comes to the issue of DBP. Much controversy surrounds the method by which chemical risks are assessed. After three years of litigation (and over 10 years of research), the issue of setting a safe level for chloroform, a DBP, had to be decided in a United States Court of Appeals (March 31, 2000). Furthermore, the President's Commission Report on Risk Management (1997) cautions that the typical numerical risk estimates for individual chemical compounds (termed "bright lines") are problematic:

> "The all-or-nothing nature of use of a bright line could be misunderstood and construed to imply that there is an exact boundary between safety and risk, even though risk-based bright lines are burdened by all the uncertainty, variability, and assumptions inherent in… risk estimation."

Present regulatory approaches and health effect assessment methodologies largely focus on individual contaminants. It becomes the burden of utilities then, to maintain as broad a perspective as possible in managing overall risks and formulating plans to address known and emerging contaminants.

As summarized in Table 3-10, there are some regulations that have the potential for a significant impact on the Town, namely: the Long-Term 1 and 2 Enhanced Surface Water Treatment Rule, and the Stage 1 and 2 Disinfection/Disinfection By-Product Rule. Information on each of these regulations is presented below with detailed summaries of each to follow.

LT 1 Enhanced Surface Water Treatment Rule. The rule also includes provisions for states to conduct sanitary surveys. The rule builds upon the treatment technique requirements of the Interim Enhanced Surface Water Treatment Rule:

- Maximum contaminant level goal (MCLG) of zero for *Cryptosporidium*,
- 2-log *Cryptosporidium* removal requirements for systems that filter,
- Strengthened combined filter effluent turbidity performance standards,

- Reduction in TOC based upon alkalinity,
- Individual filter turbidity monitoring provisions,
- Disinfection profiling and benchmarking provisions,
- Systems using groundwater under the direct influence of surface water now subject to the new rules dealing with *Cryptosporidium*,
- Inclusion of *Cryptosporidium* in the watershed control requirements for unfiltered public water systems,
- Requirements for covers on new finished water reservoirs, and
- Sanitary surveys, conducted by States, for all surface water systems regardless of size.

The LT1ESWTR, with tightened turbidity performance criteria and required individual filter monitoring, is designed to optimize treatment reliability and to enhance physical removal efficiencies to minimize the *Cryptosporidium* levels in finished water. In addition, the rule includes disinfection benchmark provisions to assure continued levels of microbial protection while facilities take the necessary steps to comply with new DBP standards.

> *Potential Impacts.* The impact of LT1 to small systems is important in that a number of new filtration parameters must be met. The most significant of these are a reduced turbidity standard (95 percent of the combined filter effluent must be less than 0.3 NTU), and individual filter performance monitoring is required. The WDOH is conducting assessments of Water Treatment Plants in order to assist utilities in meeting the IESWTR and the LT1ESWTR. EPA publishes an excellent guidance document that can help utilities with surface water treatment plants meet the goals of these regulations. *Optimizing Water Treatment Plant Performance Using the Composite Correction Program,* EPA /65/6-91/027, 1998 edition, provides valuable guidance in assessing and correcting WTP deficiencies. The document is readily available from EPA, and it is a recommendation of this report that the Town utilizes this document as a tool to assess performance in anticipation of the new filter regulations.

Long Term 2 Enhanced Surface Water Treatment Rule. The SDWA, as amended in 1996, requires EPA to finalize a Stage 2 Disinfectants and Disinfection Byproducts Rule by May 2002. Although the 1996 Amendments do not require EPA to finalize a Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) along with the Stage 2 Disinfectants and Disinfection Byproducts Rule, EPA believes it is important to finalize these rules together to ensure a proper balance between microbial and DBP risks. The EPA anticipates proposing these rules in early 2001, with a finalized rule being out in May of 2002.

The EPA recognizes that systems may need to provide additional protection against *Cryptosporidium*, and that such decisions should be made on a system specific basis. The LT2ESWTR incorporates system specific treatment requirements based on a 'Microbial Framework' approach. This approach generally involves assignment of systems into different categories (or bins) based on the results of source water *Cryptosporidium* monitoring. Additional treatment requirements depend on the bin to which the system is assigned. Systems will chose technologies to comply with additional treatment requirements from a 'toolbox' of options.

Monitoring. For purposes of bin classification for systems that supply water for populations greater than 10,000, source water *Cryptosporidium* monitoring shall be conducted using EPA Method 1622/23 and no less than 10L samples. *Cryptosporidium*, *E. coli*, and turbidity source water sampling shall be carried out on a predetermined schedule for 24 months with two choices:

1. Bin classification based on highest 12 month running annual average of monthly samples, OR

2. Optional bin classification based on 2-year mean if facility conducts twice per month monitoring for 24 months (i.e. 48 samples). Systems may carry out additional sampling but it must be evenly distributed over the 2-year monitoring period.

Systems with at least 2 years of historical *Cryptosporidium* data, that is equivalent in sample number, frequency, and data quality (e.g. volume analyzed, percent recovery) to data that would be collected under the LT2ESWTR with EPA Method 1622/23, may use those data to determine bin classification in lieu of further monitoring. Systems that are able to use historical data in lieu of conducting new monitoring must submit such *Cryptosporidium* data to the State/Primacy Agency for consideration in selecting bin placement.

Systems that provide 2.5 logs of treatment for *Cryptosporidium* (equivalent to Bin 4, including inactivation) in addition to conventional treatment are exempt from monitoring for purposes of selecting bin placement. Conventional treatment is defined as coagulation, flocculation, sedimentation, and granular media filtration.

Action Bins. At present, bins have only been defined for Conventional Treatment Plants and it is unclear how the forthcoming direct filtration requirements will vary from those for conventional plants requirements. As indicated in Table 3-9, the conventional treatment bins have been structured considering the total *Cryptosporidium* oocyst count, uncorrected for recovery, as measured using EPA Method 1623 and 10 L samples.

Table 3-9. Conventional Treatment Bin Classifications And Requirements

Bin Number	Average *Cryptosporidium* Concentration	Additional Treatment Requirements, Systems with Conventional Treatment in Full Compliance with IESWTR
1	*Cryptosporidium* < 0.075/L	No action
2	0.075/L ≤ *Cryptosporidium* < 1.0/L	1-log treatment (systems may use any technology or combination of technologies from toolbox as long as total credit is at least 1-log)
3	1.0/L ≤ *Cryptosporidium* < 3.0/L	2.0 log treatment (systems must achieve at least 1-log of the required 2-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)
4	*Cryptosporidium* > or = 3.0/L	2.5 log treatment (systems must achieve at least 1-log of the required 2.5-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)

Systems have 3 years following initial bin classification to meet the treatment requirements associated with the bin. The State/Primacy Agency may grant systems an additional 2-year extension to comply when capital investments are necessary. Systems currently using ozone, chlorine dioxide, UV, or membranes in addition to conventional treatment may receive credit for those technologies towards bin requirements.

The additional treatment requirements in the bin requirement table are based, in part, on the assumption that conventional treatment plants in compliance with the IESWTR achieve an average of 3 logs removal of *Cryptosporidium*. The total *Cryptosporidium* removal requirements for the action bins with 1 log, 2 log, and 2.5 log additional treatment correspond to total *Cryptosporidium* removals of 4, 5, and 5.5 log respectively.

The advisory committee recommends that EPA request public comment on whether current guidance regarding *Giardia* treatment requirements for meeting the Surface Water Treatment Rule need to be revised (to be consistent with multiple barrier concept in the current guidance and the advisory committee recommendations herein).

The impact of the Long Term 2 Enhanced Surface Water Treatment Rule on the Town has yet to be determined. If *Cryptosporidium* is found in the source water, then additional treatment technologies maybe required to the requirements established by this rule. In addition, if raw water quality changes, the bin requirement for the Town might change.

Disinfectant/Disinfection By-Product Rule. Regulations for DBP have experienced multiple delays. In 1979, EPA adopted a primary drinking water standard for total trihalomethanes (THMs) of 0.1 mg/L. After the 1979 THM regulation, a new DBP regulation was to have been promulgated in 1989. This was then delayed into 1990, and then into 1991. In 1993 and 1994, development of this regulation was transferred to the negotiated rule making process, the first time EPA had used such a procedure for developing a drinking water regulation. A guiding principle of this process was to develop regulations for DBP concurrently with those governing disinfection. Emerging from the negotiated process were two surprises: a less stringent regulation than had been previously envisioned, and a commitment to a more stringent second stage regulation pending the outcome of additional health effects research.

The Disinfectant/Disinfection By-Product Rule (D/DBPR) promulgated a revised standard for THMs as well as regulation of other disinfection by-products. The D/DBPR includes lower limits for THMs and establishes limits for specific haloacetic acids (HAA5: chloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid, and dibromoacetic acid) under a two-stage regulatory process. It also requires optimization of organic precursor removal.

The D/DBPR works in conjunction with the SWTR to maintain a balance between microbial and DBP control. The intent of the two-stage rule was to allow better health effects information to inform the process. The data developed, however, was not as definitive as had been hoped. The questions pivoted around the complexity of determining what is best for protecting public health.

Health effect concerns for DBPs pivot around balancing the risk of infection from pathogens potentially present in drinking water sources against the carcinogenic and reproductive/ developmental effects associated with DBPs formed during disinfection. Brominated DBPs, such as bromodichloromethane (a trihalomethane species) and bromate (an ozone by-product) are of particular concern. In addition, tastes and odors are important to address since customers can see these as a proxy health measure.

Stage 1 Disinfectant/Disinfection By-Product Rule. Table 3-10 summarizes Stage 1 MCLs and MCLGs for TTHM and HAA5. Compliance with these MCLs will be based on running averages of monitoring data, similar to the current standard for THMs. Monitoring requirements will depend on a specific water system's size and source water.

Table 3-10. Stage 1 D/DBPR MCLGs And MCLs

Compound	MCLG (mg/L)	MCL (mg/L)
Total Trihalomethanes (THMs)	-	0.080
Chloroform	0	-
Bromodichloromethane	0	-
Bromoform	0	-
Dibromochloromethane	0.06	-
Haloacetic Acid 5 (HAA5)	-	0.060
Dichloroacetic Acid	0	-
Trichloroacetic Acid	0.3	-
Monochloroacetic Acid	-	-
Monobromoacetic Acid	-	-
Dibromoacetic Acid	-	-
Bromate	0	0.010
Chlorite	0.8	1.0

The Stage 1 D/DBPR also includes maximum residual disinfectant levels (MRDLs). Table 3-11 summarizes these levels. Short-term increases for chlorine and chloramine will be permitted to control specific microbiological problems.

Table 3-11. Stage 1 D/DBPR MRDLs

Disinfectant	MRDL (mg/L)
Chlorine	4 (as Cl_2)
Chloramine	4 (as Cl_2)
Chlorine Dioxide	0.8 (as ClO_2)

Compliance with the MRDLs for chlorine and chloramines will be based on a running annual average of quarterly samples. Compliance with the MRDL for chlorine dioxide will be based on consecutive daily samples. Monitoring requirements will depend on specific water system size and source water.

The rule also requires a reduction in TOC in accordance with Table 3-12.

Table 3-12. Stage 1 D/DBPR: Required Removal of TOC

Source Water TOC mg/l	Source Water Alkalinity (mg/l as $CaCO_3$). Percent Removal		
	0-60	>60-120	>120
> 2.0-4.0	35	25	15
>4.0-8.0	45	35	25
>8.0	50	40	30

Stage 2 Disinfectant/Disinfection By-Product Rule. The Stage 2 DBPR is designed to reduce DBP occurrence peaks in the distribution system based on changes to compliance monitoring provisions. Compliance monitoring will be preceded by an initial distribution system monitoring (IDSE)/study to select site-specific optimal sample points for capturing peaks. The EPA recognizes that TTHM and HAA5 concentrations vary over time and space and therefore agrees that compliance monitoring locations should reflect this variability. The effective date for this is expected to be June 2006.

TTHM/HAA5. Compliance with each MCL will be determined based on a Locational Running Annual Average (a running annual average must be calculated at each sample location). Systems will comply with the Stage 2 DBPR MCL in two phases:

- Phase 1: 3 years after rule promulgation, (with an additional 2 year extension available for systems requiring capital improvements), all systems must comply with a 120 and 100 μg/L Locational Running Annual Average (LRAA) for TTHM and HAA5 respectively based on Stage 1 monitoring sites and also continue to comply with the Stage 1 80 and 60 μg/L LRAA limits for TTHM and HAA5 respectively.

- Phase 2: 6 years after rule promulgation (with an additional 2-year extension available for systems requiring capital improvements) large and medium systems must comply with an 80 and 60 μg/L LRAA for TTHM and HAA5 respectively based on new sampling sites identified under the IDSE.

Initial Distribution System Evaluation (IDSE). IDSE studies conducted by Community Water Systems are intended to select new compliance monitoring sites that more accurately reflect sites representing high TTHM and HAA5 levels. The studies will be based either on system specific monitoring or other system specific data that provides equivalent or better information on site selection. Systems will recommend new or revised monitoring sites to their State/Primacy Agency based on their IDSE study. IDSE results will not be used for compliance purposes.

Systems conducting IDSE monitoring shall monitor for one year under a schedule determined by source water type (e.g., surface water vs. ground water) and system size. As a part of the monitoring schedule, all systems conducting IDSE monitoring must monitor during the peak historical month for DBP levels or water temperature. All IDSE samples will be paired (i.e., a TTHM and HAA5 sample at each site).

In lieu of the IDSE monitoring, systems may perform an IDSE study based on other system specific monitoring or system specific data that will provide comparable or superior selection of new monitoring sites that target high DBP levels. Systems that can certify to their State/Primacy Agency that all samples taken in the last 2 years were below 40 and 30 µg/L for TTHM and HAA5 respectively are not required to conduct the IDSE.

Long Term Compliance Monitoring (Phase 2). Principles of the reduced compliance monitoring strategy reflected in the Stage 1 DBPR shall be continued in the Stage 2 DBPR. These principles are designed for systems with very low DBP levels. Systems will collect paired samples (TTHM and HAA5) at each compliance monitoring sample site.

Bromate MCL. The Stage 2 M-DBP Advisory Committee allowed the bromate MCL to remain at 0.010 mg/L based upon current alternative technology utilization and upon current understanding of bromate formation as a result of bromide concentrations. EPA will review the bromate MCL as part of the 6-year review and determine whether the MCL should remain at 0.010 mg/L or be reduced to 0.005 mg/L or a lower concentration. As a part of that review, EPA will consider the increased utilization of alternative technologies and whether the risk/risk concerns remain valid in light of research on bromate detection, formation, treatment, and health effects.

Implications for the Town. The D/DPB rule presents some challenges for the Town. Raw water TOC's ranged from 5.1 mg/l to 5.6 mg/l through year 2000, and finished water TOC's ranged from 4.1 to 4.5 mg/l. Far example, an alkalinity of 60 mg/l, would require a TOC reduction of 45 percent. The required finished water TOC under this scenario would be about 3 mg/l. There are a number of methods by which the WTP could reduce TOC's including enhanced coagulation and activated carbon. However, any alternative treatment processes must first be pilot tested under actual plant conditions. To do so requires pilot testing of recommended alternatives. It is recommended that the Town perform a pilot study to establish the optimum method to reduce TOC.

Filter Backwash Recycle Rule. The Filter Backwash Recycle Rule establishes filter backwash requirements for public water systems. The requirements are aimed at reducing the potential risks associated with recycling contaminants removed during the filtration process (i.e. backwash water, filter to waste water, waste wash water, etc.) back through the treatment process. The rule applies to all systems that recycle regardless of population served. The following are the two provisions that would apply to the Town:

- Recycle systems will be required to return spent filter backwash water, thickener supernatant, and liquids from solids dewatering processes to their conventional or direct filtration treatment processes prior to the point of primary coagulant addition such that recycled flows are subjected to the entire conventional or direct filtration processes, unless the State specifies an alternative location;

- Direct filtration systems recycling to the treatment process must provide detailed recycle treatment information to the State, which may require that modifications to recycle practice be made.

The rule was promulgated on June 8, 2001. The Town does not currently recycle spent backwash water. While it is anticipated that this rule will not affect the Town, that determination cannot be made until the State has reviewed relevant Town information and made an assessment. Compliance with this rule is required by June 8, 2004. A 24-month extension may be granted for systems that will need capital improvements in order to achieve compliance.

Emerging Issues

Brominated Organic Compounds. Use of ozone or UV light minimizes free chlorine contact time which is the principal treatment factor in forming these compounds suspected to be of greater health significance than their chlorinated analogues. Simple removal of natural organic matter and any significant contact time with chlorine, however, favors the formation of brominated compounds. These compounds, however, do not appear to be an issue for the Town.

Pesticides and Herbicides. Ozonation coupled with GAC can remove these compounds, depending on the ozone dose and the GAC condition. Coupling ozone with hydrogen peroxide further improves removal efficiency. A concern raised in Identifying Future Drinking Water Contaminants (NAS, 1999) is that degradates and by products of herbicides are often found, even when very little of the parent compound is detected. As the health effects of many of these degradates and by products are not known it is unclear how significant they will become. How resistant to ozone these degradates and by products are has not been thoroughly investigated. Given the activities in the Town watersheds, these compounds are not anticipated to occur at significant concentrations.

MTBE. A fuel additive that has migrated into many water supplies, it is quite resistant to conventional treatment and is poorly adsorbed onto GAC. Ozone coupled with hydrogen peroxide, however, can be effective depending on dose. Additional biodegradation on GAC may effect further removal. It is unlikely MTBE will be an issue form the Town.

Algal Toxins. Associated with blue-green algae, these toxins have had significant impacts on cattle in other countries. In addition to their short-term effects, however, there is evidence that they may be potent liver carcinogens. The World Health Organization has set a 1 mg/L guideline for microcystin-LR. However, some Japanese researchers have suggested, based on their work in China, that the guideline level should be 100 times lower. Little work on quantification has been done in North America, though EPA has placed cyanobacteria and other algae and their toxins on the Drinking Water Contaminant Candidate List. From a treatment perspective, while chlorine is effective for a few of these toxins, ozone is very effective in oxidizing most of them (Humpage, 1999; http://www.fwr.org/waterq/fr0223.htm). Source water levels at the Town have not been determined.

Pharmaceuticals. Pharmaceutical use by humans and in animals are significant contributors to contaminant levels in wastewater effluents. Metabolites from analgesics, antirheumatics, and lipid regulators have been detected in German well waters (Giger, 1999). Chlorine is generally ineffective for oxidizing these compounds, and data from Berlin, Germany, indicates that ozonation removed carbamazepine and diclofenac extremely fast. Bezafibrate and clofibric acid, however, were only eliminated to a limited extent using ozonation. While granular activated carbon (GAC) filtration was also very effective for removal of carbamazepine, diclofenac, and bezafibrate, its elimination of clofibric acid depended on the water quality and on the processing-time of the GAC (Heberer, 2000). The source water for the Town is not anticipated to be affected by these types of contaminants.

Taste and Odor Causing Compounds. Aesthetic water quality probably have the most significant impact on customer satisfaction. Aesthetic issues have been identified as leading factors which contributing to customers seeking alternative sources (i.e., point of use devices, bottled water, etc.) and serve as surrogate for consumer sense of safety. Stating that the water meets all drinking water regulations, even though tastes or odors are present, is generally unpersuasive to customers (McGuire, 1995). As noted by Jardine et al. (1997), customers may sometimes be right in reasoning that tastes and odors indicate a potential hazard since many potential water contaminants can pose a health concern at levels below those that can be detected by odor. They conclude:

> "The absence of offensive tastes or odors in drinking is a necessary, but not a sufficient condition for consumers to be assured of the safety of their drinking water. Unless very specific and reliable evidence can be provided.... consumers will have rational grounds to question the security of their water supply."

The Town has experienced problems with taste and odor. GAC filter caps alone can also effectively remove tastes and odors, though removal efficiencies are highly dependent on the taste-and-odor causing substances, empty bed contact time, and GAC replacement frequency. Other methods to control taste and odors include use of powdered activated carbon (PAC) and potassium permanganate ($KMnO_4$). As previously recommended, the Town should conduct a pilot study to assess methods to reduce TOC. By reducing TOC, the Town may also reduce the problem of taste and odor.

Other. Many other constituents may occur in drinking water. EPA's effort to identify these compounds is represented by the Drinking Water Contaminant Candidate List. Of most interest for the Town are *Mycobacterium avium* (a bacterium that can grow distribution systems and in customer plumbing), and *Microsporidium* (a parasite akin to *Cryptosporidium* only smaller). It appears that *Mycobacterium avium* is best addressed by building managers (how plumbing systems are managed) while *Microsporidium* can be addressed by ozone (no data for UV, yet).

Summary

Clearly, the regulatory focus on the issues of LT1ESWTR and DBP are the highest priority for the Town. Based on current and anticipated requirements, it appears that the associated regulations will impact the City's operations. Consequently, staff should undertake its own prioritization of issues and evaluate the treatment process alternatives in terms of maximizing benefits at a reasonable cost.

Water Quality Monitoring Schedule

Water quality monitoring is required for regulatory compliance and to monitor water system conditions.

Table 3-13 lists water quality monitoring required by State law. Bacteriological monitoring is addressed in further detail in Appendix H. Water quality monitoring requirements for VOCs and SOCs depend in part on the availability of monitoring waivers from the DOH. The Town should expect to receive a letter from DOH in the near future regarding the renewal of these waivers.

Table 3-13. Water Quality Monitoring

Parameter	Sample Location	Frequency	Consequence of Exceeding Standard
Bacteriological	See Coliform Monitoring Plan in Appendix H	2 per month	Follow-up and repeat sampling
Turbidity	Source	Every 3 years	Public notification
Inorganics	Source	Every 3 years	Possible treatment modifications
VOCs	Source	Await DOH instructions	Possible treatment modifications
SOCs	Source	Await DOH instructions	Possible treatment modifications
Lead and Copper	Distribution System	20 samples annually, following Corrosion Control Treatment Installation	Additional treatment modifications
Trihalomethanes	Distribution System	Quarterly	Possible treatment modifications
Radionuclides	Source	Await DOH instructions	Possible treatment modifications

The objective of this section is to determine if the existing system facilities are capable of supplying a sufficient quantity of water to meet existing and projected demands as identified in Chapter 2, Basic Planning Data. Based on recent data and projections as described in Chapter 2, Table 3-14 summarizes current and future average and peak demands.

Table 3-14. Summary of Water Demands

Year	Average Day Demand[2] (gpd)	Maximum Day Demand[3] (gpd)	Peak Hour Demand[4] (gpm)	ERUs[5]	Demand per ERU[6](gpd /ERU)
Current[1]	306,916	613,832	742	2,285	133.8
2008	339,151	678,302	813	2,535	133.8
2022	390,603	781,206	928	2,919	133.8

[1]Average of 1999-2001 demand data, based on production data, from Table 2-3
[2]Based on 2001 Water Conservation Plan projected production, shown in Table 2-4
[3]Using a peaking factor of 2.0
[4]From equation presented in Table 3-1
[5]From Table 2-4
[6]Demand per ERU is 1999-2001 average demand calculated in Table 2-2

Table 3-14 illustrates that demand per ERU is assumed constant in the future for purposes of the water system analysis.

Source

In the immediate future it is unlikely that additional sources of supply will be incorporated into the water system to meet anticipated increased demand. The Town of Friday Harbor must, therefore, rely on existing sources. Based on the 1994 Trout Lake Study, the water supply system is able to provide 193 MG annually (Trout Lake, with AUG 1, AUG 2, and dead storage). In the 1997 Water System Plan Update, projected water use was expected to exceed existing sources' sustainable yield in the year 2000 with no water conservation, and 2001 with 10 percent conservation.

Based on projections in the 2001 Water Conservation Plan and summarized in Chapter 2, Basic Planning Data, the Town's projected annual production will approach the sustainable yield threshold in 2038, and projected use will approach the sustainable yield threshold in 2046, well beyond the 20-year projections for this report (see Exhibit A at the end of this Chapter).

The allowable ERUs associated with the Town's raw water source capacity were determined using equations from the DOH Water System Design Manual, 2001. Using this analysis method, the source capacity for the Town of Friday Harbor is sufficient through the year 2022 based on maximum day demand. Table 3-15 summarizes the allowable ERUs for the 6 and 20-year projections for raw water source capacity.

Table 3-15. Allowable ERUs for Raw Water Source Capacity

Year	Projected ERUs	MDD[1] (gpd/ERU)	Allowable ERUs Based on MDD Approach[2]
2008	2,535	267.6	3,767
2022	2,919	267.6	3,767

[1]MDD = ADD x 2 = 133.8 x 2 = 267.6

[2]Allowable ERUs = V ÷ (MDD), where V = volume of water available and used for a maximum day's demand for the system (gallons/max day = 700 gpm = 1.008 million gallons/day).

Treatment

Table 3-16 shows the estimated allowable ERUs based on water treatment source capacity.

Table 3-16. Allowable ERUs for Water Treatment Plant Source Capacity

Year	Projected ERUs	MDD (gpd/ERU)	ERU Capacity Based on MDD[1] Approach	Excess ERU Capacity
2008	2,535	267.6	3,767	1,232
2022	2,919	267.6	3,767	848

[1]ERUs = V ÷ MDD, where V = volume of water used for a maximum day's demand of the system (gallons/max day = 700 gpm = 1.008 million gallons/day).

The existing plant has sufficient detention time to provide adequate disinfection at flows up to 700 gpm (see Tracer Study in Appendix I). Table 3-16 above demonstrates that this is more than enough capacity to serve the projected number of ERUs through the 20-year planning period. When the treatment capacity is expanded, provisions for additional detention time must be made; for instance, by constructing clearwell storage or a dedicated transmission pipeline. However, it does not appear that additional water treatment plant capacity will be required through the 20-year planning period. The focus of future improvements to the water treatment plant should be water quality driven. In particular, the Town must reduce TOC in order to comply with future D/DBP regulations.

207, 232 and 357 Foot Pressure Zone Storage Analysis

The total capacity of a reservoir is the sum of Operating Storage (OS), Equalizing Storage (ES), Standby Emergency Storage (ESS), Fire Suppression Storage (FSS), and Dead Storage. Operating Storage and Dead Storage are normally subtracted from the total volume of storage, and the difference is considered the effective volume of storage.

The 207, 232 and 357-foot pressure zones are all intertied, and thus have been analyzed in regards to storage as one system.

Table 3-17. Analysis of Available Storage for 207, 232 and 357[4] Foot Pressure Zones

Zone	Total Volume gallons	Operating Storage[1] gallons	Dead Storage[2] gallons	Effective Storage[3] gallons
207	0.5 MG	125,000	N/A	375,000
232	1.0 MG	200,000	N/A	800,000
			Total Useable	**1,175,000**

[1]Volume of water depleted from reservoir before pumps are called to replenish.
[2]The availability of booster pump stations with emergency power makes the entire volume of both reservoirs usable.
[3]Volume of storage available for equalizing, standby, and fire suppression.
[4]357-foot pressure zone does not have storage.

Table 3-17 presents calculations as to the usable volume of storage for zones 207, 232 and 357. Normally, there is some dead storage associated with all reservoirs. However, due to the configuration of the 207 and 232 reservoirs, and the availability of emergency power, the total volume of these reservoirs is considered usable, less the amount needed to prevent pump cycling.

The requirements for treated water storage now and in future years within Friday Harbor is to provide fire protection, standby for peak demands, and equalization of the peak demands for the 20-year planning horizon. Table 3-18 summarizes the storage requirements based on projected demands and storage estimate equations as provided in the DOH Water System Design Manual, 2001.

Table 3-18. Summary of Projected Storage Requirements (gallons)

Year	Projected Equalizing Storage Required[1], gallons	Projected Standby Storage Required[2], gallons	Projected Fire Suppression Storage Required[3], gallons	Total Storage Required, gallons	Total Effective Storage Available[4], gallons	Excess Effective Capacity, gallons
Current (2002)	6,293	613,832	135,000	755,126	1,175,000	419,874
2008	17,022	678,302	135,000	830,324	1,175,000	344,676
2022	34,174	781,206	135,000	950,380	1,175,000	224,620

[1]Equalizing Storage = (PHD – Qs)*150, where PHD is shown in Table 3-14; Qs = 700 gpm.
[2]Standby Storage = 2*ADD, where ADD is shown in Table 3-14.
[3]Given in Table 3-1.
[4]Given in Table 3-17.

Existing total usable storage for the 207-, 232-, and 327-foot pressure zones is 1.175 MG, which is adequate for requirements through the year 2022.

The allowable ERUs associated with the Town's standby storage requirements were determined using equations from the DOH Water System Design Manual, 2001. Based on these criteria, allowable ERUs for the 6 and 20-year projections were determined, as shown in Table 3-19. This estimate provides further evidence that the Town's projected standby storage capacity is sufficient for the 20-year planning period.

Table 3-19. ERU Capacity for Standby Storage Requirements

Year	Projected ERUs	Projected Standby Storage Required and Available (2 x ADD) gallons	ERU Capacity Based on Standby Storage[1, 2] Requirements
2008	2,535	678,302	5,070
2022	2,919	781,206	5,839

[1]From equation 6-5, page 6-15 in the Water System Design Manual.

[2]$N = \frac{SBt}{(SBi)(Td)}$ where Td=1 day, SBt = 2 x ADD, Sbi=Demand per ERU shown in Table 3-14 (133.8).

460-Foot Pressure Zone Storage Analysis

The 460-foot pressure zone is supplied by two 120 gpm pumps from the 232-foot pressure zone, and is located on a hillside north of the three pressure zones discussed above. For these reasons it has been analyzed, in regards to storage requirements, separately from the other pressure zones.

Table 3-20. Analysis of Available Storage for 460-foot Pressure Zone

Zone	Total Volume, gallons	Operating Storage[1], gallons	Dead Storage[2], gallons	Effective Storage[3], gallons
460	50,000	5,000	NA	45,000
			Total Useable	**45,000**

[1]Volume of water depleted from reservoir before pumps are called to replenish.
[2]The entire volume of the reservoir is usable due to its high elevation in relation to the service area
[3]Volume of storage available for equalizing, standby, and fire suppression.

Table 3-20 presents the useable volume of storage for the 460-foot pressure zone. Normally, there is some dead storage associated with all reservoirs. However, due to the high elevation of the 460-zone reservoir, the total volume of this reservoir is considered useable, less the amount needed to prevent pump cycling.

The service area for the 460-foot pressure zone consists of a single subdivision (all single-family residential) with 113 ERUs at present, with 141 ERUs planned at build-out. Table 3-21 summarizes the number of ERUs and projected demands for the 460-foot pressure zone.

Table 3-21. Summary of Water Demands for 460-foot Pressure Zone

Year	ERUs[1]	Demand per ERU[2] (gpd/ERU)	Average Day Demand[3] (gpd)	Maximum Day Demand[4] (gpd)	Peak Hour Demand[5] (gpm)
Current[1]	113	133.8	15,119	30,239	73.9
2008	141	133.8	18,866	37,732	84.3
2022	141	133.8	18,866	37,732	84.3

[1]Based on assumption that zone will reach maximum build-out (141 ERUs) before 2008
[2]As calculated in Table 3-14.
[3]Multiplying number of ERUs with Demand per ERU.
[4]Using a peaking factor of 2.0.
[5]From equation presented in Table 3-1.

The requirements for treated water storage now and in future years within Friday Harbor is to provide fire protection, standby for peak demands, and equalization of the peak demands for the 20-year planning horizon. Table 3-22 summarizes the storage requirements for the 460-foot pressure zone based on projected demands shown above and storage estimate equations as provided in the DOH Water System Design Manual, 2001.

Table 3-22. Summary of Projected Storage Requirements (gallons)

Year	Projected Equalizing Storage Required[1], gallons	Projected Standby Storage Required[2], gallons	Projected Fire Suppression Storage Required[3], gallons	Total Storage Required, gallons	Total Effective Storage Available[4], gallons	Excess Effective Capacity, gallons
Current (2002)	0	30,239	15,000	45,239	45,000	-239
2008	0	37,732	15,000	52,732	45,000	-7,732
2022	0	37,732	15,000	52,732	45,000	-7,732

[1]Equalizing Storage is zero because the peak hour demand for the system is less than the source of supply capacity.
[2]Standby Storage = 2*ADD, where ADD is shown in Table 3-21.
[3]500 gpm for 30 minutes.
[4]From Table 3-20.

The existing tank in the 460-foot pressure zone (Hillview Terrace) has sufficient capacity for the current demands. If the Hillview Terrace subdivision continues to grow at the same pace as the rest of Friday Harbor, the 50,000 gallon storage tank may not have sufficient storage to meet the subdivision's future demands. However, given the small deficit and the availability under DOH guidelines to use the larger of fire protection and standby storage, the construction of additional storage is not recommended.

DISTRIBUTION SYSTEM/HYDRAULICS

Computer Hydraulic Modeling

The analysis for the Town of Friday Harbor water system was performed with the aid of the EPANET 2 hydraulic analysis program. EPANET is available at no charge by the EPA EPANET was used to the Towns existing distribution system and future conditions. These analyses were performed to determine existing and future problem areas. Additionally, alternative improvement plans were tested to evaluate their hydraulic effectiveness.

The hydraulic network analysis program can analyze both steady-state flow conditions and extended-period simulation. WDOH allows either type of analysis, although larger more complicated utilities are encouraged to use the extended period simulation.

Typical input data required by the program are as follows:

- Pipe length
- Roughness
- Minor loss coefficients
- Pump data
  - Performance curve
  - Horsepower
- A water demand from each demand point in the system
- Storage tank data.

The program computes the following:

- Flow rate in each pipe
- Velocity in each pipe
- Direction of flow
- Head loss
- Pump head
- Minor loss
- Pressure at selected node
- Hydraulic grade line at selected nodes
- Reservoir inflow and outflow.

The development of the input data file requires an understanding of how the Town currently operates the system. Most of the input data was obtained from Town records, including pipeline data such as length, diameter, material, and elevation of the water supply system.

Initially, the pipe network is modeled as nodes and pipelines. Nodes are located at junction points where two or more pipes intersect, and at dead ends. Pipelines connect two node points, and for each pipeline in the system, the length, diameter, and friction coefficient are determined. Some of the pipes can be combined to simplify the system, but the present modeling includes all known pipe mains operated by the Town.

User demands, including water consumed by households and businesses and water lost through damaged or leaky mains, are placed at the nodes and include all demands adjacent to that node. Water demands used in the model include peak hour demand, and maximum day demand plus fire flow in each of the Towns primary zones, 232, 357 and 460 pressure zones. Since actual flow records are available for all supply meters, these records were used to establish average daily, peak day, and peak-hour flows. The distribution of these demands was accomplished by estimating the demands by zone, and then distributing the demands evenly among the nodes within those zones. Figure 3-1 presents a pipe and node map developed by the EPANET-2 Model.

Under condition of peak hour demand, pressures in the system must not fall below 30 pounds per square inch (psi). A minimum of 20 psi is required system wide under conditions of maximum day demand plus fireflow. It must be demonstrated that this condition applies in each pressure zone. The quantity of the fire flow at the nodes was simulated by increasing the water demand at that node to appropriate levels, depending on the maximum fireflow required in that zone.

The conditions under which the Town's system was analyzed, as well as a summary of the results, is presented in Table 3-23. For the purpose of this analysis, the reservoir elevations were lowered to 50 percent of storage volume. This very conservative condition represents depletion of equalizing, operating and fireflow storage. In addition, the pump stations were operated with the largest pump out of service. Copies of the model input files are included in Appendix J.

Table 3-23. Hydraulic Distribution System Modeling Results Using Epanet-2 in a Single Period Analysis.

Scenario	Year	Fireflow (gpm)	Fireflow Location	Lowest Three Pressures (psi)	Highest Three Pressures (psi)	COMMENTS
1	2002	500	Zone 460 EL. 320' NODE 105	31.82 NODE 5 32.09 NODE 6 32.70 NODE 23	142.62 NODE 103 117.19 NODE 68 115.03 NODE 43	Zone 460 appears capable of meeting a 500 gpm fireflow under conditions of current MDD. However, a small number of homes at and above the reservoir elevation, presently supported by a small 3hp booster station, do not have fireflow.
2	2002	500	Zone 327 EL. 205' NODE 42	-272.50 NODE 42 -227.23 NODE 41 -224.64 NODE 40	152.73 NODE 103 96.67 NODE 2 94.26 NODE 97	Zone 327 currently unable to support a 500 gpm fireflow under conditions of MDD. The highest pressure occurs just downstream of the 460 zone pump station. See Scenario 7.
3	2002	1000	Zone 232 EL. 95' (school) NODE 44	21.80 NODE 48 24.44 NODE 23 25.74 NODE 24	152.06 NODE 103 117.19 NODE 68 115.03 NODE 43	Zone 232 appears capable of meeting a 1000 gpm fireflow under conditions of MDD. The highest pressure occurs just downstream of the 460 zone pump station.
4	2022	500	Zone 460 EL. 320' NODE 105	31.30 NODE 5 31.58 NODE 6 31.87 NODE 23	142.35 NODE 103 116.75 NODE 68 114.59 NODE 43	Zone 460 appears capable of supporting a 500 gpm fireflow under year 2022 conditions of MDD. The highest pressures occur just downstream of the zone 460 pump station
5	2022	500	Zone 327 EL. 205' NODE 42	-281.29 NODE 42 -235.89 NODE 41 -233.30 NODE 40	152.55 NODE 103 95.96 NODE 2 93.49 NODE 97	Zone 327 is unable to support a 460 gpm fireflow under conditions of a year 2022 500 gpm fireflow. See Scenario 7.
6	2022	1000	Zone 232 EL. 95' (School) NODE 44	20.01 NODE 48 22.81 NODE 23 24.11 NODE 24	151.84 NODE 103 116.75 NODE 68 114.598 NODE 43	Zone 232 appears capable of meeting a 1000 gpm fireflow under conditions of MDD. The highest pressure occurs just downstream of the 460 zone pump station.
7	2022	750	Zone 327 EL. 205' NODE 42	20.12 NODE 42 31.34 NODE 5 31.62 NODE 6	152.55 NODE 103 111.96 NODE 68 110.18 NODE 43	Zone 327 is capable of supporting a 750 gpm fireflow under year 2022 conditions of MDD given the following system improvements: A third pump is added for zone 327 (750 gpm @ a head of 220 ft) and activated during the analysis. 1,500 L.F. of 4" diameter pipe in Zone 327 was replaced with 8" diameter pipe and 310 L.F. of 6" diameter pipe was also replaced with 8" diameter pipe.
8	2022@170%	N/A	**N/A**	29.19 NODE 23 30.04 NODE 5 30.35 NODE 6	151.69 NODE 103 114.65 NODE 68 112.50 NODE 43	The existing system is capable of meeting peak hour demands without a fireflow through year 2022.

Insert Figure 3-1.

Development of the Model

The EPANET-2 model prepared for this plan was developed based upon information obtained from the Town's 1990 KYPipe input file (the 1997 input file was not available), an updated distribution system map provided by the Town, and field fire flow testing conducted by the Town's water department. Node elevations were determined by comparing USGS topography maps of the area to the elevations described in the Town's 1990 hydraulic model. Information on pipe materials needed to develop pipe friction values was not available for all the pipe. As a result, the friction values identified in the Town's 1990 plan were used.

Calibration

The calibration for the hydraulic distribution system modeling was based on three field flow tests done by the Town of Friday Harbor. The field test consisted of measuring the static pressure and obtaining the residual pressure during a fire flow test. Based on the water system map provided by the Town of Friday Harbor, hydrants No. 135, 99, and 55 (nodes 81,107, and 108) were tested. Hydrant 135 is located about 115 feet north of the intersection between Stanford Lane and Mullis Street; hydrant 99 is located about 336 feet northeast of the intersection between Spring and Caines Streets; and hydrant 55 is located about 531 feet east of the intersection between Park and Price Streets. The water levels for the 0.5 and 1.0 million-gallon tanks were measured at 35.9 and 17.2 feet respectively at the time of the three tests performed. The model analysis was conducted under an estimated flow condition of average day demand. The fire flow tests were performed on October 27, 2002 between 11:00 AM and 12:00 PM. The following table shows the calibration data:

Table 3-24. Calibration Data

Hydrant No.	Model Node No.	Field Static Pressure, psi	Epanet Static Pressure, psi	Field Fire Flow, gpm	Field Residual Pressure, psi	Epanet Residual Pressure, psi
135	81	47	51	1090	42	28
99	108	68	65	1210	52	45
55	107	48	52	1090	42	42

Results and Recommendations

The results of two of the three tests (nodes 108 and 107) demonstrate the relative accuracy of the model. Some error in the results is not surprising given the variability of input data such as friction values, node elevations and water demand patterns on the day of the flow testing. The model accuracy will improve as additional distribution data and water use patterns becomes available. Brown and Caldwell will provide the Town an electronic copy of the input files for this model for use with the nonproprietary (EPANET-2) model. It is a recommendation of this report that the Town allows training of their staff in the use of this model. By doing so, modifications and improvements can be routinely incorporated as the information becomes available, thereby improving the models overall accuracy.

Pressure Zones

The Town of Friday Harbor's pressure zones were analyzed individually to determine their capability to deliver adequate quantities of water under existing and future demand conditions. A minimum pressure of 30 psi at any location in the system was used as the criterion for peak-hour flow in the absence of any fire demand. A minimum pressure of 20 throughout the system was the criterion used for analyzing the impact of fire flow on system capacity during a maximum day demand. The fire flow analysis was performed with the largest pump out of service.

Model node refers to the actual location designated in the computer model. Fire flows shown have been simulated under peak hour demand conditions.

207- and 232-Foot Pressure Zones. This zone is capable of meeting the peak hour demands and MDD demands with fireflow through the 20-year planning period.

327-Foot Pressure Zone. The existing 327-pressure zone is unable to support fire flow demands. This deficiency can be mitigated by the addition of an additional pump with a capacity of 750 gpm and 220 ft head, together with the installation 2,500 ft of new 8 inch main.

460-Foot Pressure Zone. Hydraulically, the 460 zone is capable of meeting the peak hour demands and MDD demands with fireflow through the planning period.

SUMMARY OF SYSTEM DEFICIENCIES

Several deficiencies have been identified throughout this chapter. A summary of these deficiencies, together with possible mitigation measures is provided.

1. Preliminary TOC and THM data collected from the Water Treatment Plant (WTP) and distribution system indicate that the Town may not comply with Stage 1 D/DBP. It is a recommendation of this report that the Town immediately begin pilot testing alternative treatment and disinfection strategies at the WTP in order to reduce finished water THM and TOC level.

2. There is inadequate hydraulic (pumping) capacity within the Town's 327 zone to support a 750 gpm fireflow through the 20-year planning period. To mitigate this problem, the following improvement project is required within the 327 zone: a) A new pump with a capacity of at least 750 gpm and 220 ft of head, b) Replace 1,500 ft of existing 4 inch main in Marguerite Street (from the booster station north) with 8 inch main. c) Replace 1,000 ft of existing 4- and 6-inch main between Hillcrest and Marguerite with new 8 inch main. d) Upgrade the emergency generator in order to support the new 750 gpm pump.