Water Treatment Plant and Water Supply Study

CITY OF SNOHOMISH, WASHINGTON

May 2009

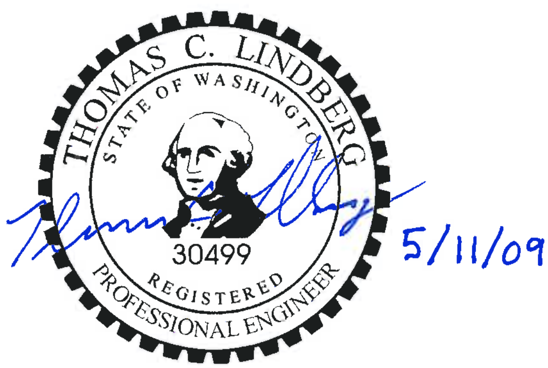
Murray, Smith & Associates, Inc.
Engineers/Planners

2707 Colby Avenue, Suite 1110 PHONE 425.252.9003
Everett, Washington 98201-3566 FAX 425.252.8853

CITY OF SNOHOMISH

WATER TREATMENT PLANT
AND
WATER SUPPLY STUDY

MAY 2009



Prepared by:

MURRAY, SMITH & ASSOCIATES, INC.
Engineers/Planners
2707 Colby Avenue, Suite 1110
Everett, Washington 98201-3566

In association with:

Casne Engineering, Inc.
Clair Olivers and Associates
FCS Group, Inc.
GordonDerr LLP
Peterson Structural Engineers, Inc.

07-0900

TABLE OF CONTENTS

EXECUTIVE SUMMARY

5. WATER SUPPLY CAPACITY ANALYSIS

6. WATER TREATMENT PLANT EVALUATION

7. FINISHED WATER TRANSMISSION MAIN EVALUATION

8. WATER SUPPLY ALTERNATIVES

9. ECONOMIC AND FINANCIAL REVIEW

10. WATER SUPPLY ALTERNATIVES EVALUATION

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

Purpose and Background

Murray, Smith & Associates (MSA) was retained by the City of Snohomish (City) to conduct a study of the City's existing Pilchuck River water treatment plant and alternative sources of water supply. The results of this study provide the City with information to assist with the planning of improvements for the existing water supply facilities and help guide the City in making decisions regarding water supply for the near-term and long-term.

The Pilchuck River water treatment plant has been operating under restrictions imposed by the State of Washington Department of Health (DOH) since June 2006. At that time DOH also identified a list of administrative, operational, and capital improvements that are needed to comply with performance goals that DOH developed for water treatment plants. The results of this study will help the City to achieve these performance goals. The restrictions imposed by DOH are expected to be lifted in 2009, upon completion of improvements to the water treatment plant that are currently underway.

Existing Water System

The City supplies drinking water to its customers from two sources. The City purchases treated water from the City of Everett for supply to customers located within the north half of the City (345 Zone, 358 Zone, 368 Zone, and 418 Zone). The remaining customers are located in the 222 Zone and are supplied with water from the City's own Pilchuck River source. The Pilchuck River source includes a diversion dam on the Pilchuck River, a direct filtration water treatment plant, and a 15-mile long finished water transmission main. The transmission main and water treatment plant were constructed in 1981 and the diversion dam was constructed in 1932. Approximately 93 customers are served directly off the main, which is constructed of 18-inch diameter asbestos cement pipe and 12-inch diameter Permastran (fiberglass/PVC composite) pipe.

The City's Everett supply system consists of five metered connections off of Everett's Transmission Line No. 5, which serves the City's higher elevation pressure zones. Historically, the Pilchuck River source has supplied approximately two-thirds to three-fourths of the drinking water to the City and the remainder being supplied from the Everett source. However, the amount of supply from the Pilchuck source has decreased since 2003, averaging approximately 44 percent of all supply from 2004 through 2007. This is primarily due to one of the four filters being out of service at the water treatment plant, which will be placed back in service upon completion of improvements in 2009. **Figure 2-1** in **Section 2** illustrates the water supply systems, the City's distribution system pressure zones, and major facilities.

Water Demands

Historical water supply data from the City's Pilchuck River source and Everett wholesale water purchases was collected and evaluated to determine the amount of past water use and to assist in projecting future water demands. The results of the demand evaluation were used to determine the amount of supply required to meet the future demands of the City's customers. A summary of historical water demand data is presented in **Table ES-1** below.

Table ES-1
Historical Water Demands

	Annual Water Supply (MG & MGD)				
Source	**2003**	**2004**	**2005**	**2006**	**2007**
Pilchuck WTP (MG)	228.02	211.88	183.84	124.23	87.20
Pilchuck WTP (MGD)	0.625	0.580	0.504	0.340	0.239
% of Total Supply	63.6%	59.8%	56.7%	37.6%	28.8%
Everett Supply (MG)	130.41	142.68	140.28	206.40	215.44
Everett Supply (MGD)	0.357	0.391	0.384	0.565	0.590
% of Total Supply	36.4%	40.2%	43.3%	62.4%	71.2%
Total Supply (MG)	**358.43**	**354.56**	**324.12**	**330.63**	**302.64**
Total Supply (MGD)	**0.982**	**0.971**	**0.888**	**0.906**	**0.829**

Estimates of future water demands, which were determined from population forecast data and historical per capita water demand data, are summarized below in **Table ES-2**.

Table ES-2
Future Water Demand Projections

Year	Population Forecast[1]	Average Day Demand (MGD)[2]	Peak Day Demand (MGD)[3]
2008	10,359	1.09	2.61
2009	10,896	1.14	2.75
2010	11,380	1.19	2.87
2011	11,599	1.22	2.92
2012	11,823	1.24	2.98
2013	12,050	1.27	3.04
2025	15,150	1.59	3.82
2026	15,442	1.62	3.89
2027	15,739	1.65	3.97
2028	16,042	1.68	4.04
2029	16,351	1.72	4.12
2030	16,666	1.75	4.20

1. Estimated population within City's UGA
2. Based on average day per capita demand of 105 gpcd
3. Based on peak day/average day peaking factor of 2.4

Water Supply Capacity

The capacity of the City's two existing supply systems, Pilchuck River water treatment plant and Everett supply facilities, were evaluated to determine their ability to meet existing and future demands of the City's water system. The original design capacity of the Pilchuck River water treatment plant and transmission main is 2.16 MGD (million gallons per day). However, hydraulic constraints within the plant currently limit its capacity to approximately 1.7 MGD, based on all four filters in operation. Since 2005, one of the filters has been out of service, which has reduced capacity further to approximately 1.3 MGD.

The City has sufficient capacity with its two sources from the Pilchuck River and the City of Everett to meet existing and future demands of the water system. The Pilchuck River water treatment plant operating at its current capacity of approximately 1.7 MGD meets existing demands of the area it serves, which includes the 222 Zone and customers along the transmission main, but will not be able to meet future demands without implementing improvements to increase the capacity of the plant. If the water treatment plant capacity is increased, excess capacity will be available to serve other areas of the water system that are currently served with Everett water. The amount of excess capacity that would be available to serve these other areas depends on the extent of improvements that are implemented for the Pilchuck River supply system. Additional improvements would also be necessary within the distribution system to supply water from the treatment plant to pressure zones other than the 222 Zone.

The City's five existing metered supply facilities have enough capacity to supply Everett water to the City's entire water system. Improvements to the distribution system would be required to accomplish this, as would an alternate means of supplying water to the City's transmission main customers.

Water Rights

The City holds a water right certificate for its Pilchuck River surface water source that authorizes the City to use 5.0 cubic feet per second (3.23 MGD) on a maximum instantaneous basis and 3,000 acre-feet (2.68 MGD) on an annual basis. The maximum instantaneous water right amount of 3.23 MGD is sufficient to meet the current peak day demand of the system, but is not enough to meet the future peak day demand of the entire system. Therefore, the City will need to continue purchasing water from Everett to meet future demands or additional water rights would be required to supply the entire system in the future with the City's own water source.

Water Treatment Plant Evaluation

The City's Pilchuck River water treatment plant has been operating since 1981 with minor improvements made over the years. The original design capacity of the plant is 2.16 MGD, but it cannot be operated at this rate due to hydraulic limitations within the facility. Furthermore, the plant cannot be operated during seasonal high turbidity events and must be shutdown until turbidity within the Pilchuck River drops to levels that the plant can treat.

An evaluation of the water treatment plant was conducted for this study to identify near-term capital improvements and operational changes that would allow the plant to meet the DOH performance goals. An evaluation was also conducted to determine the long-term capital improvements required to keep the plant in operation for the next 20 years at its original design capacity of 2.16 MGD and alternatively at a capacity of 3.23 MGD that would fully utilize all water rights. The details of the two evaluations are documented in two technical memorandums that are included in the appendices of the report. A summary of the results of the evaluations are presented in **Section 6** of the report.

The first part of **Section 6** summarizes the results of the evaluation and identifies near-term improvements that would allow the City to meet the DOH performance goals for water treatment plants. Capital improvements necessary to enable the water treatment plant to operate at its original design capacity of 2.16 MGD for the next 20 years were identified. These include a variety of improvements to the water treatment plant, 0.5 MG backwash tank, and Pilchuck River dam and intake facilities. The total cost for these improvements is estimated to be approximately $3.28 million to provide a plant capable of producing 2.16 MGD of treated water.

Three options for expanding the capacity of the existing water treatment plant were identified and evaluated on the basis of producing treated water at 3.23 MGD to fully utilize the City's maximum instantaneous water right. A description of each option is presented in **Section 6** of the report, including estimates for capital improvement costs and annual operations and maintenance costs. The three options are included in the evaluation of supply alternatives discussed below.

Transmission Main Evaluation

The existing transmission main delivers treated water from the City's Pilchuck River water treatment plant to customers within the southern half of the City limits (i.e., 222 Zone) and to approximately 93 customers outside the City limits that are directly connected to the transmission main. The original design capacity of the transmission main is 2.16 MGD, which was confirmed from calculations performed for this study. If the water treatment plant capacity is expanded in the future to fully utilize the City's maximum instantaneous water right, pumping improvements would be required to supply water at a rate of 3.23 MGD through the existing transmission main, or the transmission main would need to be replaced with larger diameter pipe.

The approximately 15-mile long transmission main was constructed in 1981 and has required few repairs. Most repairs have been related to damage caused by washed out roads during storm events. Based on a preliminary review of water supply and consumption data, some leakage is likely occurring in the transmission main, so it is recommended that the City implement leak detection on a regular basis in an effort to detect and eliminate leaks. The transmission main has functioned reliably and there are no immediate plans for replacement of it. Like all capital facilities, the transmission main will eventually reach the end of its useful service life and will need to be replaced, or rehabilitated at a minimum. For the purpose of this study, a service life of 50 years is assumed for the transmission main. It is prudent that the City plan for replacement or rehabilitation of the main just beyond the end of the 20-year planning period of this study. The estimated cost to replace the transmission main is approximately $18 million, based on the current cost of materials and construction.

Water Supply Alternatives Evaluation

The following water supply alternatives were identified for this study and evaluated for meeting the water supply needs of the City for the next 20 years and beyond. Alternatives 1-9 include a water treatment plant (WTP), Alternative 10 includes groundwater wells that will likely require treatment, and Alternative 11 consists entirely of supply from Everett.

- Alternative 1 – Existing Direct Filtration WTP (1.7 MGD)
- Alternative 2 – Riverbank Filtration Intake at Existing WTP (1.7 MGD)
- Alternative 3 – Existing Direct Filtration WTP Upgraded (2.16 MGD)
- Alternative 4 – Riverbank Filtration Intake at Existing WTP Upgraded (2.16 MGD)
- Alternative 5 – Expanded WTP with Conventional Treatment (3.23 MGD)
- Alternative 6 – Riverbank Filtration Intake at Existing WTP Expanded (3.23 MGD)
- Alternative 7 – Membrane Filters at Existing WTP Expanded (3.23 MGD)
- Alternative 8 – New WTP Downstream with Surface Water Intake (3.23 MGD)
- Alternative 9 – New WTP Downstream with Riverbank Filtration Intake (3.23 MGD)
- Alternative 10 – New Groundwater Wells Near City (3.23 MGD)
- Alternative 11 – Everett Supply Entire System

The maximum capacity of each alternative that utilizes the City's own water source is shown in parenthesis and is expressed in million gallons per day. For these (Alternatives 1-10), supply from Everett will be required to meet future peak demands that will be in excess of the City's own source capacity and water rights. The first seven alternatives are located at the site of the existing water treatment plant and depend on the long-term operation of the existing finished water transmission main and eventual improvements to this main.

Several key issues were identified and considered during the evaluation of water supply alternatives and are summarized below.

- <u>Cost of Water Supply</u> – Existing and future costs, including both capital and annual operations and maintenance (O&M) costs.
- <u>Transmission Main Future Replacement Costs</u> - The 15-mile long transmission main will eventually reach the end of its useful service life and need replacing. The cost to replace this long pipeline will be significant.
- <u>Water Service to Transmission Main Customers</u> – If the City selects a water supply alternative that doesn't require use of the transmission main (i.e., Alternatives 8-11), the City will need to make arrangements for an alternative method of providing water

service to the approximately 93 customers that are directly connected to the transmission main and currently supplied with treated water from the City's water treatment plant. Options to serve these customers are described in **Section 8** of the report.

- Water Rights – The City has sufficient water rights for its Pilchuck source to meet current demands, but not enough to meet the future demands of the entire water system, requiring either additional water rights or continued purchases of water supply from Everett. A court case underway at the time of this writing may result in an outcome that will impact water rights held by municipal water suppliers like the City of Snohomish.
- Dam, Intake and Fish Ladder – The City's diversion on the Pilchuck River, which includes an intake structure, dam, and fish ladder, is in need of improvements. The amount of required improvements to maintain the diversion on the Pilchuck River will likely increase during the next 20 years, due to the frequently changing regulatory requirements and the increasing need to protect fish.

An economic and financial analysis was performed to identify full lifecycle costs of each alternative, to provide a comparison of projected water rates and charges of the alternatives, and to present available funding options for the alternatives. The results of the lifecycle cost analysis, which were presented in net present value terms to capture all current and future costs of the alternatives, indicates that the Everett supply alternative (#11) and several of the other alternatives had very similar net present values. However, when the costs associated with replacement of the transmission main were included, the net present value of Alternatives 1-7 increased significantly, resulting in the Everett supply alternative being much less than the other alternatives.

The water supply alternatives were evaluated using the following criteria, which are discussed in more detail in **Section 10** of the report.

- Capital Costs
- Annual Operations and Maintenance Costs
- Complexity of Operations and Maintenance
- Supply Redundancy
- Risks
- Protected Watershed

The water supply alternatives were evaluated and scored by City staff, which resulted in a list of alternatives ranked from lowest to highest. The evaluation was based on a matrix of weighted criteria that was developed by City staff, utilizing elements of an initial matrix developed by MSA and the technical information provided within this study. The matrix used to evaluate the alternatives is included in **Appendix E**. The results of the evaluation ranked Alternative 11 (Everett Supply Entire System) the highest among all alternatives and substantially higher than the others. The Everett supply alternative has the lowest near-term capital costs ($1.86 million) among all alternatives and annual operations and maintenance costs that are comparable to the other alternatives. The Everett supply alternative also has the least impact on customer rates, especially in the future when the transmission main will need to be replaced for Alternatives 1 through 7.

Recommended Next Steps

Based on the results of the water supply alternatives evaluation and the City's intent to pursue the all Everett supply alternative, it is recommended that the City plan for the following next steps:

1. Initiate discussions with the regulatory agencies on decommissioning of the dam, intake structure, fish ladder, and water treatment plant.
2. Pursue funding programs that would offer favorable grants and low interest loans for removal of the diversion system from the Pilchuck River.
3. Conduct a study to research and investigate property records along the transmission main alignment to locate and document all easements, rights granted by the easements, and conditions imposed by the easements. The pipeline corridor and associated easements are a valuable asset that the City owns and should be well documented prior to pipeline abandonment and negotiation with others.
4. Initiate discussions with Snohomish County PUD regarding interim supply to transmission main customers, transfer of transmission main customers to the PUD's water system, and potential purchase of the transmission main and its easements.
5. Utilizing information from **Section 8** of the report, develop a plan to provide an alternative supply of water to approximately 93 City customers that are directly connected to the transmission main and a follow-up plan to decommission the transmission main.
6. Conduct a study of the City's existing water rights that includes a valuation of the water rights and a marketing plan for a potential sale of the water rights.
7. Initiate design of capital improvements to provide the capability to supply the entire system with water from Everett. This includes decommissioning the City's Pilchuck River supply facilities, a new pressure reducing station with reservoir level control capabilities to supply the 222 Zone with Everett water, and a new intertie with the PUD's Lake Roesiger system to provide interim supply to the transmission main customers until a long-term solution is identified.

Authorization and Purpose

Murray, Smith & Associates, Inc. (MSA) was authorized by the City of Snohomish (City) in September 2007 to undertake and complete this Water Treatment Plant and Water Supply Study. The purpose of this study is to evaluate the City's existing Pilchuck River water supply facilities (Pilchuck River diversion, water treatment plant, and finished water transmission main) and alternative sources of water supply.

Background

The City of Snohomish supplies drinking water to its customers from two sources. The City purchases treated water from the City of Everett for supply to customers located within the north half of the City limits. The remaining customers are supplied with water from the City's own Pilchuck River source. The Pilchuck River source includes a diversion dam on the Pilchuck River, a direct filtration water treatment plant, and a 15 mile long finished water transmission main. The finished water transmission main and water treatment plant were constructed in 1981. Approximately 93 customers spread out along the length of the finished water transmission main are served directly off the transmission main.

The water treatment plant was originally designed to treat 2.16 million gallons per day (mgd), but currently treats much less, due to seasonal high turbidity conditions and mechanical factors. The City has water rights on the Pilchuck River that are in excess of the design capacity of the plant.

The water treatment plant is currently operated under restrictions imposed by the State of Washington Department of Health (DOH) in June 2006. The restrictions are expected to be lifted in 2009, upon completion of improvements to the water treatment plant that are currently underway. DOH has also identified a list of administrative, operational, and other capital improvements that are needed for the City's water treatment plant to comply with the State of Washington Treatment Optimization Program performance goals. The results of this study will help the City to achieve these performance goals.

The City has conducted water supply studies in the past that looked at the City's Pilchuck River source and evaluated it against the Everett source and other sources. To date, the City has elected to continue operating the Pilchuck River source and currently desires to maximize the amount of supply from the water treatment plant to the extent possible within the constraints of the plant and DOH's operational restrictions. The results of this study will provide the City with information to assist with the planning of improvements for the Pilchuck River source water supply facilities and will help guide the City in making decisions regarding water supply for the near-term and long-term.

Scope of Work

A summary of the scope of work for this study follows.

- Determine near-term operational modifications and capital improvements at the water treatment plant to achieve compliance with current laws and regulations, including the DOH's performance goals. The results of this task are contained in the technical memorandum titled "Near-Term Water Treatment Plant Evaluation for Compliance with State of Washington Treatment Optimization Program Performance Goals", which is contained in **Appendix A**.
- Determine operational modifications and capital improvements needed to extend the water treatment plant's service life for another 20 years while maintaining compliance with laws and regulations. The results of this task are contained in the technical memorandum titled "Long-Term Water Treatment Plant Evaluation and Capital Improvements", which is contained in **Appendix B**.
- Develop and evaluate alternatives that will allow the City to utilize existing water rights to the maximum extent possible and reduce the purchase of water from the City of Everett to a minimum.
- Evaluate the condition of the City's water transmission main from the treatment plant to the City, and make recommendations regarding capital improvements and operational modifications needed to ensure another 20 years of service life.
- Evaluate all supply alternatives available, including supply options for the approximately 93 customers served from the City's finished water transmission main.
- Estimate capital and operating costs for the alternatives, calculate net present value costs and determine the impacts of each alternative on utility rates and charges.
- Preparation of a report documenting the work, discussing the findings with City staff, and presenting the results to City Council.

It is intended that the final document from this study will become the water supply element in the next update of the City's Comprehensive Water System Plan.

Report Outline

The remainder of this study's report is divided into the following sections:

- Existing Water System
- Existing Water Rights
- Water Demands
- Water Supply Capacity Analysis
- Water Treatment Plant Evaluation
- Finished Water Transmission Main Evaluation
- Water Supply Alternatives Evaluation
- Economic and Financial Review
- Executive Summary
- Appendices

General

This section documents the history of the City's water system and describes the existing water system components. A more detailed description of the individual components of the Pilchuck River supply system is contained in the technical memorandum titled "Long-Term Water Treatment Plant Evaluation and Capital Improvements", which is contained in **Appendix B**.

Community History and Background

Settlers began arriving in the Snohomish River valley in the late 1850's from Seattle. The settlers were drawn to the area because the land was flat and the valley soils were considered good for agricultural use. During the 1880's, the lumber industry arrived in the valley with the development of the railway. The first water system for the Snohomish community was developed in 1884 where the source water was pumped from a local stream north of First Street. In 1887, a water company was created to provide water for the City through a gravity feed system from Blackman's Lake. Snohomish was incorporated in 1890. Following the incorporation, several major fires occurred in 1893 and 1911, disrupting business. The 1911 fire was responsible for destroying 35 businesses.

By 1920, the population of the City had grown to slightly over 3,000, a number that would remain relatively stable for the next 40 years. In 1973, the City adopted a historic district ordinance protecting historic buildings and structures from inappropriate alterations and demolitions and encouraging the design of new construction in keeping with the historic character of the district. In 1974, the historic business district, a 36-block area, was placed on the National Register of Historic Places.

In the 1980's, Snohomish became a bedroom community for Everett and King County area workers. Although the City continued to maintain an agricultural base, the Snohomish School District became the major employer as enrollment in the public school system swelled as a result of surrounding area residential growth. The majority of the population shifted outside the city limits, with farmlands developed into small acreage homesteads and rural subdivisions. Major land value areas shifted from within the City to the outlying areas and the population has climbed dramatically since to approximately 9,018 in 2007.

Water System History

Water Supply System

In 1891, Snohomish chose the Pilchuck River as a water source and constructed a pumping station and a storage reservoir to aid in the water delivery system. The pump station and reservoir were replaced in 1912 with a dam on the Pilchuck River, a 12-inch wood stave transmission main, and a ground level open reservoir, all of which has since been abandoned.

A second reservoir was constructed in 1925 in the same area as the original reservoir. This 1.5 million gallon (MG) reservoir is referred to as Reservoir No. 1. Between 1932 and 1934 at approximately the same location as the original dam, the existing diversion dam was constructed. A fish ladder and fingerling bypass with a continuous flow was later installed to direct fingerlings away from the face of the intake screen.

A third reservoir with a capacity of 5.0 MG, now referred to as Reservoir No.2, was constructed in 1952 on the same site as the first two reservoirs. Both reservoirs (No. 1 and 2) remain in service today and provide storage to the City's 222 Zone. About the same time the third reservoir was constructed, the City of Everett constructed a finished water transmission main known as Everett Transmission Line No. 5 along the north end of the City. The City connected to this main on Terrace Avenue shortly after it was constructed in order to obtain an emergency water supply to its system.

A direct filtration water treatment plant (WTP) using the Pilchuck River for water supply was constructed in 1981 with the treated water being conveyed to Reservoirs No. 1 and 2. The transmission main from the WTP to the City was also replaced in 1981. At that time, water service connections were provided to residential customers along the transmission pipeline during construction of the pipeline.

Water Distribution System

The water distribution system within the City was originally constructed with wood stave pipe. Most of the distribution system south of 5th Street was replaced with cast iron pipe during the 1920's and 1930's. Cast iron water mains were primarily utilized for replacement and expansion until the 1970's. Other pipe materials, including plastic and galvanized steel have been installed over the years. In recent years, ductile iron pipe has been used for most water main replacements and new installations.

Expansion continued northward in the 1950's and 1960's with development of additional residential and commercial properties. Since the early 1950's, Snohomish has also relied on the City of Everett as a water supply source for the northern portion of its service area where the Pilchuck River supply cannot serve without pumping.

Reservoirs No. 1 and 2 were covered and lined in 1992. The upgrade helped to reduce the amount of re-chlorination required to maintain the appropriate level of disinfection. Reservoir interconnecting piping upgrades completed at the same time increased usable storage at the site by approximately one million gallons. Previous to the 1992 upgrade project, the reservoirs were arranged as an overflow system, thus only the storage in the 5.0 MG reservoir was available to the 222 Zone. Since Reservoir No. 2 was built at a slightly lower level than Reservoir No. 1, approximately 0.5 million gallons of potential storage in

No. 2 was lost due to the piping upgrades. The total volume in the two reservoirs is now approximately 6 million gallons as the piping modifications resulted in the water level in Reservoir No. 1 matching the level in Reservoir No. 2.

The City's newest reservoir, referred to as Reservoir No. 3, was constructed and put into operation in August 1991. This reservoir is a 70 foot high steel standpipe located at the highest point in the City, just one block east of Terrace Avenue and one block north of 16th Street. The 2.7 MG reservoir provides gravity storage to the City's 358 Zone. Besides providing fire flow reserve, this reservoir also reduces the peaking on the Everett supply system and provides for backup in the event that the Everett supply system is shut down.

Water System Overview

The City of Snohomish supplies drinking water to customers from two sources, the Pilchuck River and the City of Everett regional water system. The Pilchuck River system consists of a river diversion and intake structure, a water treatment plant, and a finished water transmission main, as described in more detail below. The City's Everett supply system consists of five metered connections off of Everett's Transmission Line No. 5, which serves the City's higher elevation pressure zones, as described in more detail below. Historically, the Pilchuck River source has supplied approximately two-thirds to three-fourths of the drinking water to the City with Everett supplying the remainder. However, the amount of supply from the Pilchuck source has decreased for at least the past four years, averaging approximately 44 percent of all supply from 2004 through 2007. This is primarily due to one of the four filters being out of service at the WTP. Improvements to the WTP are planned for 2009 that will enable the WTP to operate at higher production rates. **Figure 2-1** illustrates the water supply systems, the City's distribution system pressure zones, and major facilities.

Pilchuck River Dam and Intake Structure

The City owns and operates a diversion structure on the Pilchuck River. The diversion consists of a concrete dam approximately 10 feet high, a fish ladder and an intake structure. The diversion is located at River Mile 26.3, which is approximately 14 miles northeast of Snohomish. The intake is equipped with a traveling screen and a pump to clean the screen. Flow from the intake to the WTP is by gravity. The location remains a logical intake point for the WTP since virtually all property upstream of the diversion dam is owned by the Washington Department of Natural Resources (DNR). The watershed encompasses approximately 45 square miles.

Raw Water Transmission Main

An existing 18-inch diameter asbestos cement (AC) pipeline carries raw water by gravity from the Pilchuck River intake structure to the WTP. This pipeline is approximately 1,800 feet long and was installed in 1981 at approximately the same time that the finished water transmission main and WTP were constructed.

Pilchuck River Water Treatment Plant

The City's water treatment plant is a direct filtration package plant that was constructed in 1981 and put into operation in January of 1982. The plant consists of four granular media filters with a total area of 500 square feet and is equipped to feed alum and polymer for flocculation prior to filtration, soda ash for pH adjustment, and chlorine for disinfection. Plant operation is adversely effected by high turbidity events in the Pilchuck River. During the high turbidity events, the plant is shutdown depending on the turbidity level at the intake. These high turbidity events can extend from one to three days or more. During plant shutdown, customers that are directly served off the transmission main are supplied with filtered water from the plant backwash/reserve storage tank, which has a capacity of 500,000 gallons.

The WTP and finished water transmission main were originally designed for a capacity of 2.16 MGD (1,500 GPM). Recent production from 2004 through 2007 has averaged less than 20 percent of the original design capacity. The plant is not capable of producing required finished water turbidity levels while operating above 2.16 MGD. The current typical peak production rate is around 600 to 800 GPM when raw water turbidity is 10 nephelometric turbidity units (NTU). As raw water turbidity increases to approximately 25 NTU, the finished water turbidity starts increasing and at 30 NTU the plant is typically shut down.

The WTP is currently operated under restrictions that were imposed by the State of Washington Department of Health (DOH) in June 2006. These restrictions resulted from a sanitary survey of the City's water system conducted by the DOH Office of Drinking Water and a Comprehensive Performance Evaluation of the City's water treatment plant conducted by The Cadmus Group, an outside consultant contracted by DOH. The survey and evaluation identified a list of administrative, operational, and capital improvements needed at the City's water treatment plant. Some of the improvements have been completed and others are underway.

At least one of the restrictions imposed at that time has been removed because the conditions that required the restriction have been resolved. Some of the restrictions remain. One of the existing restrictions requires that the plant be operated only when an appropriately certified operator is present at the WTP. As a result, the plant is only operated eight hours per day, requiring the City to purchase more water from the City of Everett. This restriction will remain until the WTP has filter-to-waste in place and plant controls are upgraded to include automated shut-down when particle removal or disinfection criteria are not being met.

Finished Water Transmission Main

A 14.6-mile long transmission main, which was constructed in 1981, carries treated water from the City's WTP to Reservoirs No. 1 and No. 2, which serves the City's 222 Zone. The transmission main also serves approximately 93 customers spread out along the length of the main that are directly connected to this main. The transmission main consists of approximately 33,000 feet (6.2 miles) of 18-inch AC pipe from the WTP to approximately Creswell Road and approximately 44,000 feet (8.3 miles) of 12-inch Permastran pipe from approximately Creswell Road to the site of the Reservoirs No. 1 and No. 2. Permastran is a fiberglass composite pipe with a PVC inner core that is wrapped with fiberglass and bonded with epoxy resin. The lower end of the 12-inch Permastran pipe connects into a 14-inch pipe of unknown material that extends approximately 500 feet across the reservoir site and connects into the two reservoirs.

Treated water flows by gravity from the clearwell at the WTP to the City's Reservoirs No. 1 and No. 2. An electronically operated flow control valve located on the reservoir site near the end of the transmission main enables the WTP operator to remotely set the amount of supply to be provided to the system from the WTP. The remote control capability has been in place since 1991 when the telemetry system was installed.

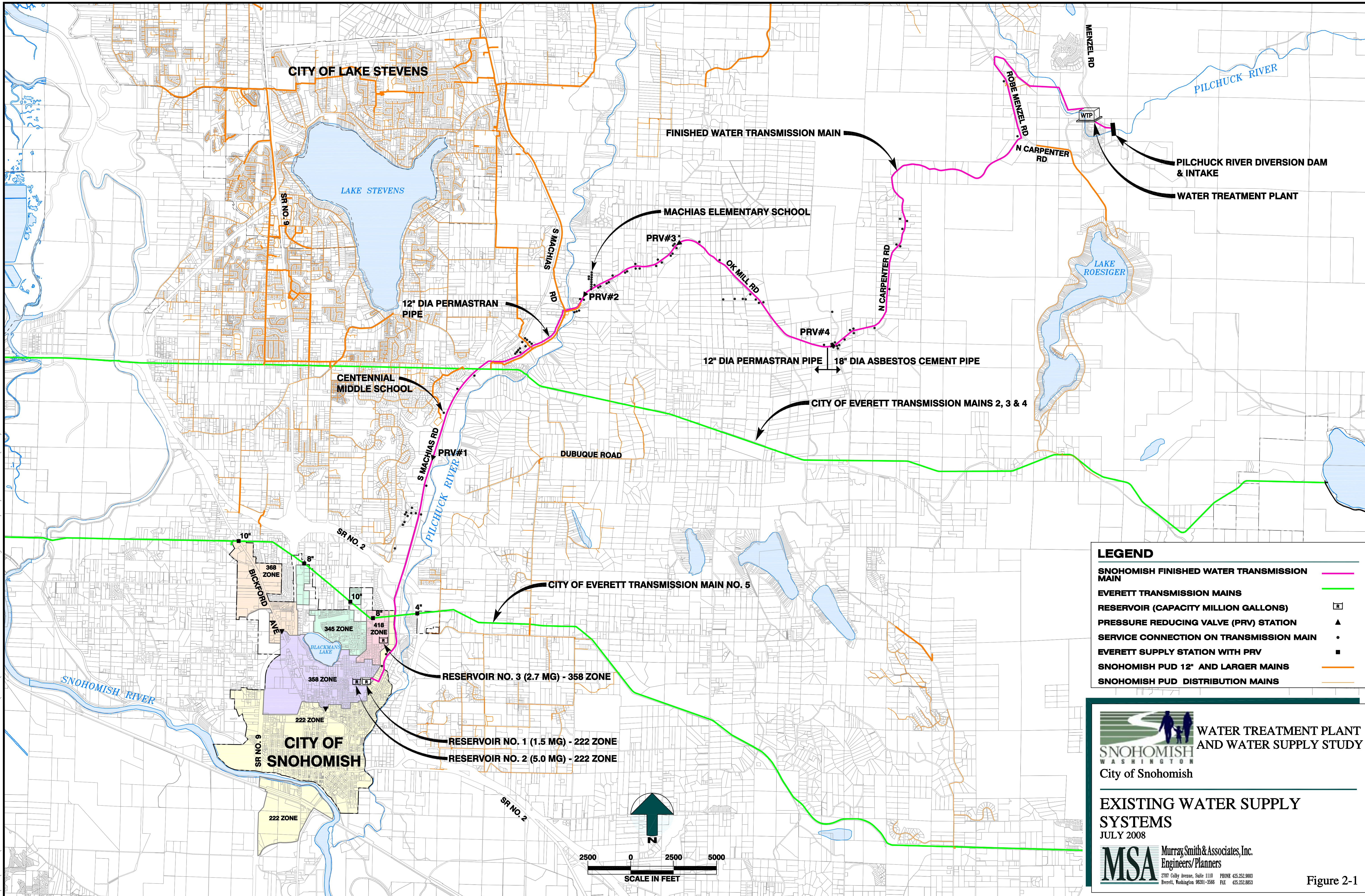
The difference in elevation of the water surface in the WTP clearwell (approximately 442 feet maximum) and Reservoirs No. 1 and No. 2 (approximately 220 feet maximum) is significant enough that pressure reducing valve (PRV) stations were installed at four locations along the transmission main to maintain a safe range of pressures along the entire length of the transmission main. Only the lower two PRV stations, PRV #1 and PRV #2, remain in service today. The other two PRV stations, PRV #3 and PRV #4, still exist, but the pressure reducing valve has been disabled in each, thereby allowing water to pass through without reducing the pressure. This was likely accomplished to provide higher pressures to transmission main customers downstream of these two stations and recognizing that the increase in pressures without the stations is moderate and doesn't justify the need to reduce pressures in these sections of the transmission main. The City regularly maintains the controls valves with the PRV stations with the most recent maintenance completed in March 2008.

Everett Supply

The City purchases wholesale water supply from the City of Everett to serve customers in the pressure zones that are too high to be served by the City's Pilchuck River source without pumping. These higher pressure zones are located in the northern portion of the service area and include the 345 Zone, 358 Zone, 368 Zone, and 418 Zone. This supply is provided through five master meters owned by Everett that are connected to the City of Everett Transmission Line No. 5. The following are the names and sizes of the master meters: Bickford Avenue (10"), King Charley (8"), Park Avenue (10"), Terrace Avenue (8"), and NEPA (4"). A separate PRV station owned by the City of Snohomish also exists at each master meter site to control the pressure of the water entering the City's system.

Supply System Planning

The combination of substantial distribution system storage volumes and the ability to augment the Pilchuck River supply with City of Everett water dramatically reduces the potential for water shortage problems due to potential capacity limitations of the Pilchuck River source. Long range supply is assured through two mechanisms. One involves coordination with the City of Everett through integration into their source needs and planning for the future, which includes sufficient supply for the City of Snohomish. Efforts are also underway to establish a formal contract with the City of Everett for long-term water supply. Current Everett planning documents include Snohomish in their continued supply forecasts. The City of Snohomish has relied upon the Everett supply for a portion of its service area since 1952. The other assurance of long-range supply is occurring through City efforts at maintaining and updating the Pilchuck River water supply system to maximize the value of the existing water right and constructed water supply facilities.



G:\07\0900\103 - WTP & Trans Main Evaluation\CAD\07-0900-103-OR-FIG2-1.dwg FIG1 1/21/08 16:20 (DAK)

General

This section summarizes the City's existing water rights based on available information from City records and Washington State Department of Ecology records. This section also includes a brief discussion of water rights issues.

Existing Pilchuck River Water Rights

The raw water supply for the City's Pilchuck River source is diverted from the river through a river intake located approximately 14 miles northeast of the City and at approximate river mile 26.3. The intake is associated with and integral to the existing Pilchuck River Dam No. 2 that was constructed in 1932.

The City holds Certificate of Water Right No. S1-00500C (Application No. 3571, Permit No. 1887) for this surface water source that authorizes the City to use 5.0 cubic feet per second (3.23 million gallons per day or 2,244 gallons per minute) on a maximum instantaneous basis and 3,000 acre-feet (2.68 million gallons per day average) on an annual basis. This certificate was issued on February 28, 1974 and has a priority date of December 9, 1931. The certificate is for municipal supply on a continuous basis and the place of use is the area served by the City of Snohomish.

The City also holds a water right claim (Claim No. 043282) that the City filed in 1973, in compliance with the Water Right Registration Act of 1967 (Ch. 09.14 RCW), to document a historical water use claim that dates to 1890 for 2.5 cubic feet per second. The point of diversion for the certificate and the claim is the existing intake structure. A copy of the water rights documents is included in **Appendix C**.

Water Rights Issues

The potential water supply alternatives set forth in **Section 8** of this report will involve water rights issues and action steps. Some key water rights issues relating to the water supply alternatives include the following. As a threshold point, municipal water rights are in a period of relative instability because of litigation concerning the constitutionality of significant municipal water legislation enacted in 2003 (Lummi Indian Nation v. State of Washington). The regulatory approaches of the State Departments of Health and Ecology will be in flux at least until the litigation is finally resolved, which could take more than a year. It is also unknown if the Legislature will revisit the subject.

Several of the alternatives will require the City to apply to the Department of Ecology for a change and transfer of water rights to authorize a new point of diversion or withdrawal. Changes to water rights typically involve review of relevant local and regional issues under applicable water rights statutes, primarily RCW 90.03.380 (surface water changes) and RCW 90.44.100 (switching to groundwater). The key issue will be whether the proposed change in the City's point of diversion will impair other existing water rights. Existing rights includes other parties who hold ground or surface water rights, and instream flows set by regulation. The Department of Ecology has adopted regulations that set minimum instream flow levels for the Pilchuck River and that close other streams in the Snohomish River basin to further water right allocations (Chapter 173-507 WAC). Review will also include effects on any specific provisions in the City's water rights documents. If impairment issues are present, then the City could potentially address them through a mitigation proposal. Alternatives that involve switching to a groundwater source would require showing through hydrologic analysis that it is the "same body" of water as the river.

In general, applying for new water rights is a lengthy and difficult process. In most areas, water is not generally available for allocation because of nonattainment of instream flows or impacts on other water rights. Depending on local conditions, new water rights may nonetheless be obtained if adequate mitigation can be secured. Other water right holders and interested stakeholders can be expected to scrutinize and participate in any such application process. In addition, the Department of Ecology has few staff assigned to process applications which lead to lengthy (i.e., several years) waits for decisions. A "cost reimbursement" program is available to expedite application processing by contracting with a consulting firm at the applicant's cost. In sum, applying for new water rights is a potential water supply option, but the many hurdles should be identified and evaluated to assess viability as a practical matter.

SECTION 4

General

This section summarizes water demands and population within the City of Snohomish water service area. Recent historical water demand characteristics for the service area were reviewed and analyzed. Utilizing forecasted population data and water demand characteristics, forecasts of future system water demands were developed.

The term "demand" refers to all water requirements of the system including residential, commercial, municipal, institutional and industrial as well as unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), million gallons per day (MGD), or gallons per minute (gpm). Demands may also be expressed in gallons per capita per day (gpcd).

Unaccounted-for water is the difference between total metered flows into the system from the sources of supply (Pilchuck River and Everett) and the total metered flows leaving the system from the usage of water system customers. Unaccounted-for water is non-metered water from various sources: water system leaks, fire hydrant usage, water main flushing, inaccurate supply metering, inaccurate customer metering, illegal water system connections, and malfunctioning control equipment causing reservoir overflows.

Historical Population within the City Limits

Two data sources were used to determine the City's current and past population. These sources include the U.S. Census Bureau and the Washington State Office of Financial Management – Forecasting Division (OFM). **Table 4-1** summarizes historical population data within the city limits and the annual percentage change in population. The U.S. Census provides City population data for 1970, 1980, 1990 and 2000. The OFM provides annual population data for cities and counties within the State of Washington. The OFM is considered to be the best available information for the City's more recent population.

Population Forecast within the Water Service Area

The water service area population forecast herein includes the population within the city limits and the City's UGA. The City of Snohomish Comprehensive Plan clearly indicates the future plan of providing full services, including water supply, throughout the UGA. Long-term forecasts of a community's population are essential in determining anticipated long-term water demands and the planning of improvements to meet those demands.

Table 4-1
Historical Population within the City Limits

Year	Population Within City Limits	Population Change Per Year
1970	5,174	--
1980	5,294	0.23%
1990	6,499	2.28%
2000	8,494	3.07%
2001	8,565	0.84%
2002	8,575	0.12%
2003	8,640	0.76%
2004	8,585	-0.64%
2005	8,700	1.34%
2006	8,920	2.53%
2007	9,018	1.10%

Source: U.S. Census for 1970 - 2000, OFM for 2001 - 2006, City for 2007

The population forecast data in the City of Snohomish Comprehensive Plan was used as the basis for future population and demand projections for this study. The City of Snohomish Comprehensive Plan forecasts population within the UGA for years 2010 and 2025. For the purposes of this study, the forecast is extended from 2025 to 2030 at the same rate of increase as between 2010 and 2025. **Table 4-2** summarizes the population forecast data for the City's UGA.

Table 4-2
Population Forecast for Snohomish UGA

Year	Population Within UGA	Percent Change Per Year
2010	11,380	--
2025	15,150	1.93%
2026	15,442	1.93%
2027	15,739	1.93%
2028	16,042	1.93%
2029	16,351	1.93%
2030	16,666	1.93%

Source: Year 2010 and 2025 population from City of Snohomish 2006 Comprehensive Plan. All other years extrapolated.

Historical Water Demands

Water supply to the City is provided by the City's Pilchuck River water treatment plant, which supplies the 222 Zone, and by the City of Everett regional water system, which supplies the City's 345, 358, 368, and 418 Zones through five metered connections to Everett's Transmission Line No. 5. Water production from the Pilchuck River water treatment plant is recorded on a daily basis. Supply through the five Everett metered connections is recorded every other month.

Table 4-3 summarizes the amount of supply from each source from 2003 through 2007. The total amount of supply of both of these sources represents the total water demand of the City's system, which includes metered consumption of all customers and all unaccounted-for water. The trend of decreasing production from the water treatment plant, especially in 2006 and 2007, is due to one of the filters being out of service and other plant performance issues that are planned to be resolved when plant improvements are completed in 2009.

Table 4-3
Historical Water Demand Summary

	Annual Water Supply (MG & MGD)				
Source	**2003**	**2004**	**2005**	**2006**	**2007**
Pilchuck WTP (MG)	228.02	211.88	183.84	124.23	87.20
Pilchuck WTP (MGD)	0.625	0.580	0.504	0.340	0.239
% of Total Supply	63.6%	59.8%	56.7%	37.6%	28.8%
Everett Supply (MG)	130.41	142.68	140.28	206.40	215.44
Everett Supply (MGD)	0.357	0.391	0.384	0.565	0.590
% of Total Supply	36.4%	40.2%	43.3%	62.4%	71.2%
Total Supply (MG)	**358.43**	**354.56**	**324.12**	**330.63**	**302.64**
Total Supply (MGD)	**0.982**	**0.971**	**0.888**	**0.906**	**0.829**

Table 4-4 provides a detailed summary of the amount of supply from the City of Everett for each of the five metered connections from 2003 through 2007.

Table 4-4
Historical Everett Metered Supply Summary

Meter Name	Primary	Annual Everett Water Supply (MG)				
and Size	**Zone**	**2003**	**2004**	**2005**	**2006**	**2007**
Bickford 10"	368	3.25	3.89	4.98	14.17	9.19
King Charlie 8"	345	5.05	4.98	4.54	5.26	4.93
Park 10"	345	2.41	2.08	2.07	2.58	2.21
Terrace 8"	358 & 418	119.19	131.31	127.88	183.78	198.59
Nepa 4"	Separate	0.51	0.43	0.81	0.60	0.52
Total		**130.41**	**142.68**	**140.28**	**206.40**	**215.44**

Table 4-5 provides a summary of the allocation of water supply to the different operating areas of the system, where an operating area is one or more pressure zones. This table illustrates the magnitude of demand in each operating area in terms of quantity and as a percentage of overall supply.

Table 4-5
Historical Water Demand Allocation

Source	Primary Zone[1]	Annual Water Supply (MG)					Approx Allocation[2]
		2003	2004	2005	2006	2007	
Pilchuck	222	200.17	193.64	174.22	114.18	77.52	55%
Pilchuck	Trans Main	27.85	18.24	9.62	10.05	9.68	6%
Everett	358 & 418	119.19	131.31	127.88	183.78	198.59	36%
Everett	345	7.46	7.05	6.61	7.84	7.14	2%
Everett	368	3.25	3.89	4.98	14.17	9.19	1%
Everett	Nepa	0.51	0.43	0.81	0.60	0.52	--[3]
Total		**358.43**	**354.56**	**324.12**	**330.63**	**302.64**	**100%**

1. 222 Zone demand includes increasing amount of Everett water transferred from 358 Zone to 222 Zone
(222 Zone demand includes water from Pilchuck shown and portion of Everett water from 358 Zone shown)
2. Approximate allocation based on average allocation for years 2003 - 2005
3. Nepa allocation negligible due to small portion of overall supply

Table 4-6 summarizes the historical per capita demands of the system from 2003 through 2007. Since daily demand records are not available for the Everett supply master meters, an updated peak day to average day peaking factor could not be calculated. For the purpose of this study, a peaking factor of 2.4 is used, which was developed in the past for other purposes and provided by the City. This peaking factor is reasonable and similar to other water systems in the Puget Sound area. The table below includes all system demands within the entire water distribution system, including services outside of the city limits and within the UGA, and services that are connected to the Pilchuck River water treatment plant finished water transmission main. In complying with the 2003 Municipal Water Law, which requires public water systems to increase water use efficiency, the City has implemented conservation measures and reduced water usage on a per capita basis, as shown in **Table 4-6**.

Table 4-6
Historical Per Capita Demands

Year	Population Within City Limits	Average Day Demand (MGD)	Peak Day Demand (MGD)[1]	Per Capita Demand	
				Average Day (GPCD)	Peak Day (GPCD)
2003	8,640	0.982	2.357	114	273
2004	8,585	0.971	2.331	113	272
2005	8,700	0.888	2.131	102	245
2006	8,920	0.906	2.174	102	244
2007	9,018	0.829	1.990	92	221

1. Peak day demand = average day demand x 2.4 peaking factor

Future Water Demands

Forecasts of future water demands were determined from population forecast data and historical per capita water demand data, as presented earlier in this section. Water demands are expressed as a flow rate per person over an average increment of time. Average day demand is used to forecast water quantities on an annual basis and is used to estimate future annual revenue and future annual water production costs. Peak day demand is used to size supply facilities, treatment plants, and transmission systems.

Per capita demand in the City's system for the average day during the period of 2003 through 2007 ranged from 114 to 92 gallons per capita per day (GPCD). This represents a considerable variation for five years of data. Therefore, for the purpose of this study, per capita demand of 105 GPCD was used for projecting future water demands, providing a conservative approach so as to not undersize future water system improvements. Future peak day demand projections are based on this per capita demand multiplied by the City's peaking factor of 2.4. **Table 4-7** below provides a summary of the future water demand projections for the system. The table includes demand projections each year for the next six years, for the year 2025 that the City provided a population projection, and for the five years thereafter. The demand projections shown in the table are conservative in that they do not include future reductions in water use from the City's ongoing water conservation program and upcoming efforts in complying with the new Water Use Efficiency Rule.

Table 4-7
Future Water Demand Projections

Year	Population Forecast[1]	Average Day Demand (MGD)[2]	Peak Day Demand (MGD)[3]
2008	10,359	1.09	2.61
2009	10,896	1.14	2.75
2010	11,380	1.19	2.87
2011	11,599	1.22	2.92
2012	11,823	1.24	2.98
2013	12,050	1.27	3.04
2025	15,150	1.59	3.82
2026	15,442	1.62	3.89
2027	15,739	1.65	3.97
2028	16,042	1.68	4.04
2029	16,351	1.72	4.12
2030	16,666	1.75	4.20

1. Estimated population within City's UGA
2. Based on average day per capita demand of 105 gpcd
3. Based on peak day/average day peaking factor of 2.4

Table 4-8 provides a summary of the future average day demand projections from **Table 4-7** and the estimated allocation of these demands among the pressure zones. **Table 4-9** is similar, showing the allocation of future peak day demands among the pressure zones. These tables are helpful in identifying the amount of future supply needed from the City's Pilchuck source to serve customers in the 222 Zone and potentially in other zones.

Table 4-8
Future Water Demand Allocation – Average Day Demand

Year	Average Day Demand (MGD)[1]	Average Day Water Demand Allocation (MGD)[2]					
		Trans Main	222 Zone	345 Zone	358 Zone	368 Zone	418 Zone
2008	1.09	0.07	0.60	0.02	0.29	0.01	0.10
2009	1.14	0.07	0.62	0.03	0.31	0.02	0.10
2010	1.19	0.07	0.64	0.03	0.32	0.02	0.11
2011	1.22	0.07	0.65	0.04	0.33	0.03	0.11
2012	1.24	0.07	0.66	0.04	0.33	0.03	0.11
2013	1.27	0.06	0.66	0.05	0.34	0.04	0.12
2025	1.59	0.05	0.73	0.13	0.40	0.13	0.16
2026	1.62	0.04	0.73	0.14	0.41	0.14	0.16
2027	1.65	0.04	0.74	0.15	0.42	0.14	0.16
2028	1.68	0.04	0.74	0.16	0.42	0.15	0.17
2029	1.72	0.04	0.75	0.17	0.43	0.16	0.17
2030	1.75	0.03	0.75	0.17	0.44	0.17	0.17

1. Projected demand data from Table 4-7
2. 2008 allocation from Table 4-5; 2030 allocation estimated; other years interpolated; estimated split among 358 & 418 Zones

Table 4-9
Future Water Demand Allocation – Peak Day Demand

Year	Peak Day Demand (MGD)[1]	Peak Day Water Demand Allocation (MGD)[2]					
		Trans Main	222 Zone	345 Zone	358 Zone	368 Zone	418 Zone
2008	2.61	0.16	1.44	0.05	0.70	0.03	0.23
2009	2.75	0.16	1.50	0.06	0.74	0.04	0.25
2010	2.87	0.16	1.55	0.08	0.77	0.05	0.26
2011	2.92	0.16	1.56	0.09	0.78	0.07	0.27
2012	2.98	0.16	1.57	0.10	0.79	0.08	0.27
2013	3.04	0.15	1.59	0.12	0.81	0.09	0.28
2025	3.82	0.11	1.75	0.31	0.97	0.30	0.37
2026	3.89	0.11	1.76	0.33	0.99	0.33	0.38
2027	3.97	0.10	1.77	0.35	1.00	0.35	0.39
2028	4.04	0.10	1.78	0.37	1.02	0.37	0.40
2029	4.12	0.09	1.79	0.40	1.03	0.40	0.41
2030	4.20	0.08	1.81	0.42	1.05	0.42	0.42

1. Projected demand data from Table 4-7, based on peak day/average day peaking factor of 2.4
2. 2008 allocation from Table 4-5; 2030 allocation estimated; other years interpolated; estimated split among 358 & 418 Zones

SECTION 5

General

This section presents the results of the analysis of the City's two existing supply sources to determine if they have sufficient capacity to meet the existing and future demands of the system. The supply capacity analysis is presented separately for the two supply sources, the Pilchuck River water treatment plant and the Everett supply facilities. The demand data used in the analysis is presented in **Section 4**. The water treatment plant capacity data used in the analysis is described in more detail in **Section 6**.

Existing Water Supply Facilities

The City owns and operates the Pilchuck River water treatment plant. That water treatment plant and finished water transmission main were originally designed for a maximum capacity of 2.16 MGD. However, limitations within the plant require that it be currently operated at a lower rate of approximately 1.70 MGD. The water treatment plant currently serves customers within the largest pressure zone, the 222 Zone, and approximately 93 customers that have direct service connections off of the finished water transmission main.

Water supply to the City's other four pressure zones is provided from the City of Everett's Transmission Line No. 5 through five metered connections. The Everett supply also serves as emergency supply to the 222 Zone in the event of a disruption to the Pilchuck River supply system.

Pilchuck River Water Treatment Plant Supply Capacity Analysis

Analysis Criteria

The supply capacity analysis for the Pilchuck River water treatment plant is based on the current configuration of the system where the water treatment plant supplies water to the 222 Zone and the customers along the transmission main, as described more in **Section 2**. The analysis criteria is based on the approach that water must be supplied at a rate that is equal to or greater than the peak day demand of the portion of the system that is receiving the water. Therefore, the analysis compares the capacity of the water treatment plant with the existing and future demands of the 222 Zone and the transmission main customers. The analysis is based on three scenarios for the water treatment plant, as described below.

Analysis Results

The first scenario, Scenario #1, evaluates the capacity of the water treatment plant in its existing state with all four filters operational, but with existing capacity limitations as described in **Section 6**. The results of the supply analysis for this scenario, as shown in **Table 5-1**, indicate that the existing capacity of the water treatment plant (1.70 MGD) is sufficient to meet the existing demands of the customers that it currently serves (transmission main and 222 Zone customers), but will not have sufficient capacity to meet the future demands of the area that it serves, starting sometime before the year 2013.

Scenario #2 evaluates the capacity of the water treatment plant with all four filters operational and proposed improvements that will increase the capacity of the water treatment plant to full capacity as it was originally designed. The results of the supply analysis for this scenario indicate that the water treatment plant operating at its design capacity (2.16 MGD) would be sufficient to meet the existing and future demands of the current area that it serves and have a limited amount of surplus capacity, as shown in **Table 5-1**.

Scenario #3 evaluates the capacity of the water treatment plant with all four filters operational and major proposed improvements to expand the capacity of the water treatment plant to fully utilize the water rights for the Pilchuck River source. The results of the supply analysis for this scenario indicate that the water treatment plant operating at an expanded capacity of 3.23 MGD would be sufficient to meet the existing and future demands of the current area that it serves and have surplus capacity, as shown in **Table 5-1**.

Table 5-1
Pilchuck River Water Treatment Plant Supply Capacity Analysis
(Based on existing system configuration of WTP supply to 222 Zone)

Description	Existing 2007	Future 2013 (+ 6 yrs)	2027 (+20 yrs)	2030 (+23 yrs)
Required Supply Capacity (MGD)				
222 Zone Peak Day Demand	0.51	1.59	1.77	1.81
Transmission Customers Peak Day Demand	0.06	0.15	0.10	0.08
Total Required Supply Capacity	**0.57**	**1.74**	**1.87**	**1.89**
Available & Surplus[4] Supply Capacity for 3 Scenarios (MGD)				
Scenario #1				
Pilchuck WTP - Existing Capacity[1]	1.70	1.70	1.70	1.70
Surplus Supply Capacity - Scenario #1	**1.13**	**-0.04**	**-0.17**	**-0.19**
Scenario #2				
Pilchuck WTP - Full Design Capacity[2]	2.16	2.16	2.16	2.16
Surplus Supply Capacity - Scenario #2	**1.59**	**0.42**	**0.29**	**0.27**
Scenario #3				
Pilchuck WTP - Expanded Capacity[3]	3.23	3.23	3.23	3.23
Surplus Supply Capacity - Scenario #3	**2.66**	**1.49**	**1.36**	**1.34**

1. Capacity of existing Pilchuck WTP.
2. Existing Pilchuck WTP with minor improvements to achieve original design capacity.
3. Existing Pilchuck WTP with major improvements to expand capacity to full instantaneous water right amount.
4. Surplus capacity shown can be fully utilzed in zones other than the 222 Zone.

Everett Supply Capacity Analysis

Analysis Criteria

The supply capacity analysis for the Everett supply source is based on a general approach to determine if the Everett source, as determined from the overall combined capacity of all five Everett metered connections, is sufficient to meet the existing and future demands of the pressure zones that they currently serve. The supply rate required to serve pressure zones without storage, which includes the 368, 345, and 418 Zones, must be equal to or greater than the peak hour demand of the zones. The supply rate required to serve the 358 Zone, which has storage, must be equal to or greater than the peak day demand of the zone. A more detailed analysis of the individual supply facilities is beyond the scope of this project, but is warranted when evaluating the supply facilities for specific improvements to each facility.

Analysis Results

The results of the analysis, as shown in **Table 5-2**, indicate that the combined capacity of the Everett supply facilities is sufficient to meet existing and future demands of the service area.

Table 5-2
Everett Supply Capacity Analysis
(Based on existing system configuration)

Description[1]	Existing 2007	Future 2013 (+ 6 yrs)	2027 (+20 yrs)	2030 (+23 yrs)
Required Supply Capacity (MGD)[2]				
368 Zone	0.06	0.15	0.58	0.70
345 Zone	0.12	0.19	0.59	0.70
418 Zone	0.54	0.47	0.65	0.70
358 Zone	0.98	0.81	1.00	1.05
Total Required Supply Capacity	**1.70**	**1.62**	**2.82**	**3.14**
Available Supply Capacity (MGD)[3]				
Bickford Ave (10", 368 Zone)	1.55	1.55	1.55	1.55
King Charlie - 99th (8", 345 Zone)	2.30	2.30	2.30	2.30
Park Ave (10", 345 Zone)	5.04	5.04	5.04	5.04
Terrace Ave (8", 358 & 418 Zones)	1.73	1.73	1.73	1.73
Total Available Supply Capacity	**10.62**	**10.62**	**10.62**	**10.62**
Surplus Supply Capacity (MGD)	**8.92**	**9.00**	**7.80**	**7.48**

1. Analysis illustrates overall surplus capacity of Everett supply and not specific to one pressure zone.
2. Required capacity based on meeting peak hour demands for zones without storage (368, 345, 418 Zones) and peak day demands for zones with storage (358 Zone). City's peak hour to peak day factor is 1.66.
3. Available supply values shown are from City's 1994 Water System Plan and have not been verified by field tests or hydraulic modeling.

Supply Capacity Analysis Summary

The City has sufficient capacity with its two sources from the Pilchuck River and the City of Everett to meet existing and future demands of the water system. The Pilchuck River water treatment plant operating at its current capacity meets existing demands of the area it serves, which includes the 222 Zone and customers along the transmission main, but will not be able to meet demands in the future without implementing improvements to increase the capacity of the plant. If the City elects to increase the capacity of the water treatment plant, excess capacity will be available to serve other areas of the water system that are currently served with Everett water. The amount of excess capacity that would be available to serve these other areas depends on the extent of improvements that are implemented for the Pilchuck River supply system. Additional improvements would also be necessary within the distribution system to supply water from the treatment plant to pressure zones other than the 222 Zone. A description of these improvements and related cost estimates are discussed in **Section 8**.

Should the City elect to reduce the amount of supply from the water treatment plant or eliminate the plant in the future, the analysis illustrates that the Everett source would have enough surplus capacity to also provide supply to the 222 Zone. However, supply to the transmission main customers could not be provided by the City's existing Everett supply facilities, requiring another means to supply these customers, as discussed more in other sections of this document. Improvements to the system would be required to properly supply the 222 Zone with water from the Everett supply facilities. Further discussion of these improvements is included in the presentation of supply alternatives in **Section 8**.

SECTION 6

General

This section summarizes the results of two technical memoranda prepared by Murray, Smith & Associates (MSA) as part of this study and included in **Appendix A** and **Appendix B** of this report. One memorandum focuses on the near-term operational modifications and capital improvements recommended for the water treatment plant (WTP) to achieve compliance with current laws and regulations and a set of treatment performance goals. The other memorandum focuses on operational modifications and capital improvements needed to extend the water treatment plant's service life for another 20 years and evaluates options for capital improvements that will allow the City to utilize existing water rights to the maximum extent possible. Also in this section are operations and maintenance cost estimates for the WTP capital improvement options and an evaluation of treatment plant staffing.

Background

The City's Pilchuck River WTP supplies drinking water to customers located within the 222 Zone of the water system and approximately 93 customers that are served directly off the finished water transmission main. The remaining customers are served with water that the City purchases on a wholesale basis from the City of Everett.

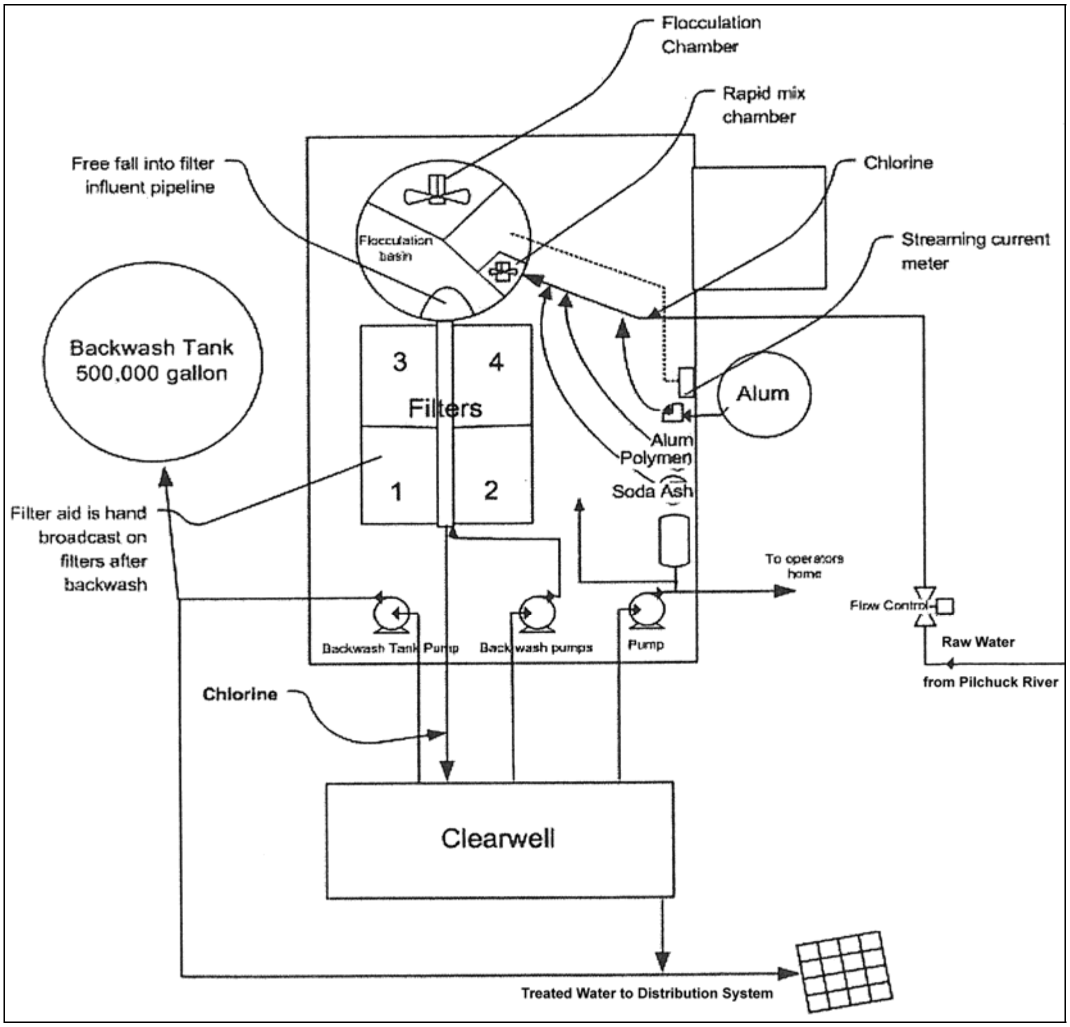
The WTP is currently operated under restrictions that were imposed by the State of Washington Department of Health (DOH) in June 2006. These restrictions resulted from a sanitary survey of the City's water system and a Comprehensive Performance Evaluation of the WTP. The survey and evaluation identified a list of administrative, operational, and capital improvements needed at the WTP. At least one of the restrictions imposed at that time has been removed because the conditions that required the restriction have been resolved. Some of the restrictions remain.

One of the existing DOH restrictions requires that the plant be operated only when an appropriately certified operator is present at the WTP. As a result, the plant is only operated eight hours per day, requiring the City to purchase more water from the City of Everett. This restriction will remain until the WTP has filter-to-waste in place and plant controls are upgraded to include automated shut-down when particle removal or disinfection criteria are not being met. The filter-to-waste and automated shut-down improvements are currently underway and expected to be completed in 2009. One of the four filters will also be placed back in service in 2009 after being offline since August 2005 when cracks in the steel basin were discovered.

Existing Water Treatment Plant Description

The City's water supply system consists of a diversion dam on the Pilchuck River, a direct filtration package water treatment plant, and a finished water transmission main that is approximately 15 miles long. The WTP and finished water transmission main were constructed in 1981. **Figure 6-1** is a simplified schematic of the WTP showing the different components of the plant. Schematics of the treatment process are attached to the technical memorandum contained in **Appendix B**.

Figure 6-1
Pilchuck River Water Treatment Plant Schematic



Source: 7/17/06 Memo re: City of Snohomish Filtration Plant Recommendations, The Cadmus Group, Inc.

The plant is equipped to feed coagulant, polymer and gas chlorine prior to flocculation, soda ash for post-filtration pH adjustment, and gas chlorination for disinfection after filtration. Four granular media filters with a total area of 500 square feet provide filtration. The original design capacity of the WTP and transmission main is 2.16 MGD (1,500 gpm). However, limitations within the plant require that it be currently operated at a lower rate of approximately 1.70 MGD, based on all four filters being in service. A more detailed description of the individual components of the Pilchuck River supply system is contained in **Section 2** of this report and in the technical memorandum in **Appendix B**.

Near-Term Capital Improvements and Operational Changes

MSA's April 29, 2008 technical memorandum titled "Near-Term Water Treatment Plant Evaluation for Compliance with State of Washington Treatment Optimization Program Performance Goals", analyzed data from 2004 through 2007 to determine if the Pilchuck WTP is achieving the State of Washington's Treatment Optimization Program (TOP) Performance Goals. A copy of this technical memorandum is included in **Appendix A**. The data analysis was combined with information obtained during site visits to identify near-term operational modifications and capital improvements to achieve compliance with those goals.

The State of Washington has established model treatment performance goals for water treatment facilities within three categories: turbidity monitoring, filtration performance, and disinfection. The goals are as follows:

Turbidity Monitoring Goals:

- Goal #1 – Monitor raw water turbidity at least every four hours
- Goal #2 – Continuously record effluent turbidity for each filter
- Goal #3 – Continuously record combined filter effluent (CFE) turbidity

Filtration Goals:

- Goal #1 – Maintain maximum daily CFE turbidity less than 0.1 NTU (Nephelometric Turbidity Units) 95 percent of the time that the plant operates
- Goal #2 – Achieve filter effluent turbidity less than 0.1 NTU within 15 minutes of placing a filter into operation
- Goal #3 – Maintain CFE turbidity at or below 0.3 NTU at all times
- Goal #4 – Backwash filters before breakthrough
- Goal #5 – Changes in raw water turbidity do not affect filtered water turbidity

Disinfection Goal:

- Goal #1 – Achieve regulatory requirement for CT values at all times

These goals are based on the relevant portion of WAC 246-290 Part 6, Subpart B. Some of the goals, such as the disinfection goal, are simply a reiteration of the regulatory requirements. Therefore, failure to achieve that goal would constitute a failure to comply with regulatory requirements. However, other goals are more restrictive than the regulatory requirements delineated in the administrative code. For example, Filtration Goal #1 is to the maintain maximum daily CFE turbidity less than 0.1 NTU 95 percent of the time that the plant operates while the regulatory requirement is to maintain the CFE below 0.3 NTU 95 percent of the time. In this case, the WTP may be meeting the regulatory requirement even if it fails to achieve the goal.

The City is currently achieving Turbidity Monitoring Goals #1 and #2, but must relocate the sampling point for CFE to fully meet Turbidity Monitoring Goal #3. The City met Filtration Goals #3 and #4 during 2007 and should be capable of continuing to meet these goals without modification to the process or operations.

The City does not consistently meet Filtration Goal #2: filter effluent turbidity after backwashing decreases below 0.1 NTU within 15 minutes of operation. This goal has been met less than 50 percent of the time. Because of this fact, the City has prioritized installation of a filter-to-waste system, which is expected to be completed in the first half of 2009. A filter-to-waste system will not completely achieve this goal, but it will prevent the high turbidity spike that occurs when a filter is returned to service immediately after backwashing from being introduced into the distribution system.

To consistently achieve Filtration Goal #2, the City should consider extending the backwash cycle by introducing a thirty minute delay between completing the backwash cycle and returning the filters to service. Extending the backwash cycle will reduce the time available for production. To counter the adverse impact that this change will have on production, the City has prioritized the installation of automated shutdown capability, which is expected to be completed in the first half of 2009. Once installed, the automated shutdown capability will allow the plant to operate for more than eight hours per day. The increased period of operation will reduce the adverse impact on production time caused by introducing a delay into the backwash cycle.

The City does not meet Filtration Goal #1. Placing the fourth filter back in service may help achieve this goal. Modifications to the flocculation tank outlet weir, which would reduce damage to the floc that is currently generated by excessive velocity and excessive fall, may also help achieve this goal. Once the fourth filter is placed back in service, a comparison of the plant performance (with all four filters in operation) to the TOP performance goals will clarify whether modifications to the flocculation tank outlet weir should be considered for near-term improvements or should be considered as part of the long-term changes to the facility.

The City is not meeting Filtration Goal #5 and it may be difficult to do so unless improvements are implemented to add a sedimentation basin, thereby converting the plant from a direct filtration facility to a conventional treatment facility.

The City is currently meeting the disinfection goal of achieving CT compliance for water supplied through the finished water transmission main, including all customers directly served from the main. However, the disinfection goal is not met for potable water supply to the WTP facility itself and for the lead WTP operator's home, due to the close proximity of these two services to the point of disinfection at the WTP. Both of these services receive water from the WTP potable water system and not from the finished water transmission main. To achieve the disinfection goal for service to the WTP and the lead WTP operator's home, improvements are required to increase contact volume prior to the WTP and the lead WTP operator's home. In the interim, the City has labeled all water faucets in the WTP as not for potable use and has provided bottled water for the operators.

Long-Term Capital Improvements

MSA's technical memorandum titled "Long-Term Water Treatment Plant Evaluation and Capital Improvements" evaluated the condition of each component of the Pilchuck WTP facility to determine required long-term capital improvements to keep the plant in operation for the next 20 years at its original design capacity. The technical memorandum also analyzed the capacity limitations of the plant to determine long-term capital improvements that would allow for operation at an increased capacity, up to the City's water rights.

Existing Capacity

The City's water rights on the Pilchuck River at Pilchuck River Dam No. 2 are 2.68 MGD on an annual basis and 3.23 MGD on a maximum instantaneous basis. The WTP is currently operating with three of four filters and a maximum capacity of approximately 1.3 MGD. When Filter No. 4 is returned to service, the WTP will be capable of operating at a maximum capacity of approximately 1.7 MGD. This is less than the original design capacity of 2.16 MGD, due to an apparent hydraulic capacity limitation through the filters. The capital improvements needed to operate the Pilchuck WTP at the original design capacity and at an expanded capacity capable of treating the full water rights, as detailed in the technical memorandum, are summarized below.

Long-Term Capital Improvements for Operation at Original Design Capacity

The following is a summary of recommended improvements that would enable the Pilchuck WTP to produce treated water at its original design capacity of 2.16 MGD for the next 20 years. **Table 6-1** provides an opinion of probable project costs for the improvements. It is assumed that improvements to the transmission main system will not be required in the next 20 years, as discussed in **Section 7**.

Structural upgrades to the WTP building are required to ensure that the facility continues to operate should a code level seismic or snow event occur in the next 20 years. Structural upgrades to handle a code level seismic event are also required for the 0.5 MG steel backwash reservoir. The reservoir should also be recoated as part of that work.

The City should install a supervisory control and data acquisition (SCADA) system to improve remote control and monitoring of the plant. This work should include detailed data logging for preparing reports that are required by DOH and reports that would be beneficial to City managers. The logs of detailed data would also assist in troubleshooting long-term issues, such as the apparent hydraulic capacity limitation on the filters, and formulating solutions to improve plant operation.

Electrical and controls upgrades are needed to replace aging equipment and to enable the plant to operate for another 20 years. Upgrades to the water system telemetry system are also needed to integrate the proposed SCADA system with the existing telemetry facilities at the City's Water Shop.

Table 6-1
Capital Improvements for Operation at Original Design Capacity of 2.16 MGD

Capital Improvement	Opinion of Project Costs[1]
Fish Screens	$392,000
Dam Weir and Fish Ladder	$1,750,000
Implement Modulation of Influent Valve	$58,000
Modify Flocculation Tank Outlet Weir	$12,000
WTP Building Structural Upgrades	$52,000
Backwash Tank Structural & Recoating	$180,000
Replace WTP Electric Service Equipment	$35,000
Replace WTP MCC	$46,000
Upgrade Filter Control Panel	$9,000
Replace WTP Control Panel	$115,000
Upgrade Water System Telemetry	$115,000
Implement Water SCADA System	$92,000
WTP Lighting Improvements	$9,000
WTP Instrumentation Replacements	$12,000
Effluent Pumps	$400,000
Total - Opinion of Project Cost (2.16 MGD Capacity)	**$3,277,000**
Total - Opinion of Project Cost (1.7 MGD Capacity)[2]	**$2,877,000**

1. Opinion of project costs includes construction and engineering costs in 2008 dollars.
2. Cost without effluent pumps, which are assumed to be required for 2.16 MGD capacity only.

The existing intake facility should be upgraded with new stationary fish screens capable of meeting all current fish screen criteria while passing either 3.3 cfs (2.16 MGD), if the WTP is to be operated at the original design capacity, or 5 cfs (3.23 MGD), if the plant is to be operated at the City's maximum instantaneous water right.

The current fish ladder is not able to meet specific criteria due to the current design of the bottom three pools. A more serious problem, however, is the accumulation of debris in the fishway, which may regularly obstruct a portion of the adult Coho migration and the entire upriver adult steelhead migration. With the May 2007 listing of the Puget Sound Steelhead as a "threatened" species under the Endangered Species Act, there is likely to be increased scrutiny of all structures within Puget Sound that adversely impact steelhead survival. As a result, it appears likely that major modifications to the fishway will be required if the City is to operate the structure for another 20 years. The opinion of probable project cost in **Table 6-1** is provided solely for use in the cost model of this study. It must be emphasized that there is no consensus at present on what modifications will be required or what the preferred alternative will be. It is therefore recommended that a separate study be conducted on the fishway structure to determine the preferred option. The result of that study may alter the opinion of probable construction costs presented in the table.

The WTP influent control valve should be replaced with a smaller valve to allow for modulation of the influent when a filter is removed from service for backwashing. Modifications to the influent controls will also be required. The outlet weir from the flocculation tank should be modified to reduce the velocity of the water over the weir and to reduce the height of the drop that the flocculated water experiences when falling over the weir, which currently causes damage to the floc.

To operate at the plant's original design capacity of 2.16 MGD, it will be necessary to overcome the apparent hydraulic capacity limitation through the filters. The City must first collect sufficient data to verify and quantify the hydraulic capacity limitation through the filters. If there is a hydraulic limitation, the data should be used to determine the cause of the limitation and to investigate whether minor operational changes would be sufficient to overcome the limitation to operate the filters at their original design capacity. If minor operational changes are not sufficient to achieve the 2.16 MGD design flow of the existing plant, it will be necessary to install filter effluent pumps similar to the filter-to-waste pumps planned for installation in 2009. Filter effluent pumps will enable a higher rate of flow through the filters by forcing the treated water out of the plant via pumping as opposed to the existing plant configuration where treated water flows by gravity out of the plant.

Long-Term Capital Improvement Options for Operation at Expanded Capacity

Three options for expanding the treatment capacity of the filtration process at the existing Pilchuck WTP were identified and evaluated. The options were evaluated on the basis of producing treated water at 3.23 MGD to fully utilize the City's maximum instantaneous water right for the Pilchuck River source. A brief discussion of each option is provided below. A more detailed discussion of the options is contained in the technical memorandum in **Appendix B**. **Table 6-2**, which follows the discussion of the three options below, provides a summary of capital improvements and associated cost estimates for each of the options. The table also includes the capital improvements in **Table 6-1**, which are necessary for the long-term operation of the WTP. The cost estimates below and in **Table 6-2** are preliminary planning level estimates that include all project costs (construction, surveying, field investigations, engineering and contingencies), but do not include costs associated with transmission main improvements, which are presented in **Section 7** of this report.

Option 1 – Converting from Direct Filtration to Conventional Treatment

This option will allow the plant to operate at an expanded capacity of 3.23 MGD by installing a sedimentation basin before the filters, thereby converting the plant from a direct filtration facility to a conventional treatment facility. A sedimentation basin would allow heavy particles to settle out, thereby reducing turbidity prior to the water entering the filters. This would enable continuous operation of the WTP during high turbidity events and allow a higher rate through the filters to achieve the desired expanded capacity of the plant. The sedimentation unit would consist of a concrete basin incorporating rapid mixing, coagulation, flocculation and sedimentation with enhanced settling capabilities through use of tube or plate settlers. Filter effluent pumps would need to be installed on the filter effluent piping to overcome the existing apparent hydraulic capacity limitation of the filters. The addition of a sedimentation basin and filter effluent pumps would allow the filters to operate at the increased rate of 4.5 gpm/ft^2, which is required to supply water at the maximum instantaneous water rights rate of 3.23 MGD. The preliminary opinion of cost for a sedimentation basin and filter effluent improvements is approximately $2.17 million. The total cost of all improvements related to this option is shown in **Table 6-2**.

Option 2 – Replace Pilchuck River Intake with New Riverbank Filtration Intake

Replacing the existing river intake system with a new riverbank filtration intake system, located between the WTP and Pilchuck River, would reduce turbidity, enable continuous operation of the WTP during high turbidity events, and enable the WTP filters to operate at a higher rate to achieve the desired expanded capacity of the plant. Riverbank filtration (RBF) is a natural filtration method of withdrawing water from a surface water source by causing it to infiltrate into a local groundwater aquifer, thereby providing removal of suspended solids and reduction of turbidity. A RBF system typically consists of a series of boreholes located a short distance from and parallel to the bank of a surface water source. As water is pumped at the boreholes, the surface water is induced and infiltrates through the riverbed to the aquifer.

RBF is only appropriate if the hydrogeological conditions adjacent to the surface water source are favorable, where the surface water source is hydraulically connected to a nearby aquifer through permeable, unconsolidated deposits that form the riverbed. Review of limited available data indicates the subsurface conditions near the Pilchuck WTP site are most likely suitable for a RBF system and that the static water level is approximately 12 feet below the ground surface. However, a field investigation with exploratory test drilling and aquifer pumping tests would be required to determine the suitability of the site prior to implementation of a RBF intake system.

The advantage of a RBF intake system over the existing intake system, which would remain for the conventional treatment facility under Option 1, is that it would avoid the capital and operating costs for constructing and maintaining fish screens and a fish passageway. A RBF intake system would also avoid future costs and challenges associated with maintaining the dam on the Pilchuck River. Furthermore, costs to upgrade or replace the raw water pipeline between the Pilchuck River intake and the WTP would be avoided with a RBF intake system.

Like the conventional treatment option, filter effluent pumps would be required on the filter effluent piping to overcome the existing apparent hydraulic capacity limitation of the filters to enable the WTP to operate at an expanded capacity. The preliminary opinion of cost for a RBF system at the Pilchuck WTP site is approximately $3.41 million. This also includes the cost of installing filter effluent pumps to overcome the hydraulic capacity limitations of the filters. The total cost of all improvements related to this option is shown in **Table 6-2**.

Option 3 – Replace Existing Filters with New Membrane Filtration

Replacing the existing filters with a new membrane filtration system would produce treated water at a higher rate to achieve the desired expanded capacity of the plant. Membrane filtration will enable the plant to operate through most, if not all high turbidity events, but will require more frequent flushing of filters during those events. Membrane filtration utilizes a semi-permeable membrane for the separation of suspended and dissolved solids from the water and is also capable of removing many microorganisms. Membrane filtration has become an increasingly popular filtration alternative throughout the United States and in the Pacific Northwest. As the technology has matured, the costs for new construction are increasingly competitive with conventional filtration.

The implementation of membrane filtration at the Pilchuck WTP would likely involve removal of the four steel filter bays and installation of a pressure membrane system. A pretreatment system may be required to remove excessive suspended solids and other constituents that would foul the membrane surface. A pilot study would be required to determine the design parameters for a membrane system and whether pretreatment would be required. If pretreatment is necessary, the pilot study would help determine if the existing flocculation system is sufficient or if a new system is required. The preliminary opinion of cost for a membrane system at the Pilchuck WTP site is approximately $3.8 million, which includes the cost of a pilot study and assumes the existing flocculation system can be used for pretreatment. The total cost of all improvements related to this option is shown in **Table 6-2**.

Table 6-2
Capital Improvement Options for Operation at Expanded Capacity of 3.23 MGD

	Opinion of Project Costs[1]		
Capital Improvements	**Option 1 Conventional (3.23 MGD)**	**Option 2 RBF Intake (3.23 MGD)**	**Option 3 Membrane (3.23 MGD)**
Fish Screens	$392,000	N/A	$392,000
Dam Weir and Fish Ladder [2]	$1,750,000	$460,000	$1,750,000
Implement Modulation of Influent Valve	$58,000	$58,000	$58,000
Modify Flocculation Tank Outlet Weir	N/A	$12,000	N/A
WTP Building Structural Upgrades	$52,000	$52,000	$52,000
Backwash Tank Structural & Recoating	$180,000	$180,000	$180,000
Replace WTP Electric Service Equipment	$35,000	$35,000	$35,000
Replace WTP MCC	$46,000	$46,000	N/A
Upgrade Filter Control Panel	$9,000	$9,000	N/A
Replace WTP Control Panel	$115,000	$115,000	N/A
Upgrade Water System Telemetry	$115,000	$115,000	$115,000
Implement Water SCADA System	$92,000	$92,000	$92,000
WTP Lighting Improvements	$9,000	$9,000	$9,000
WTP Instrumentation Replacements	$12,000	$12,000	N/A
Option 1 Treatment Improvements	$2,170,000	N/A	N/A
Option 2 Treatment Improvements	N/A	$3,410,000	N/A
Option 3 Treatment Improvements	N/A	N/A	$3,800,000
Total - Opinion of Project Costs[3]	**$5,035,000**	**$4,605,000**	**$6,483,000**

1. Opinion of project costs includes construction and engineering costs in 2008 dollars.
2. Decommissioning costs of dam weir, fish ladder and intake structure shown for Option 2.
3. Total costs do not include finished water transmission main replacement or finished water pump station.

Operations and Maintenance Cost Estimates

Operations and maintenance (O&M) costs were estimated for the three capital improvement options presented above, based on an expanded operation of the WTP at 3.23 MGD. O&M costs were also estimated for the existing WTP operating at its original design capacity, based on the proposed improvements presented in **Table 6-1**. A summary of the O&M cost estimates are presented below in **Table 6-3**.

Table 6-3
Operations and Maintenance Cost Estimates

Description (peak capacity of facility)	Annual O&M Estimated Costs[1]
Existing WTP with Improvements (2.16 MGD)	$440,000
Option 1 - Conventional WTP (3.23 MGD)	$515,000
Option 2 - Riverbank Filtration Intake (3.23 MGD)	$500,000
Option 3 - Membrane Filtration (3.23 MGD)	$490,000

1. Estimated O&M costs in 2008 dollars.
Estimated O&M costs based on average annual production = peak capacity/2.4 peaking factor.

Long-Term Staffing Evaluation

The City of Snohomish currently employs two full-time operators for the Pilchuck WTP. Prior to June 2006, the plant was operated in automatic mode without operators present. Since June 2006, the WTP has been operated only when a certified operator is present at the facility. This restriction was imposed by DOH and will remain in effect until the City completes installation of both filter-to-waste improvements and a control system capable of automatically shutting down the WTP. As a result of the restrictions imposed by DOH, the plant is currently operated for a maximum of eight hours per day.

The two operators currently work alternate weekends and alternate Mondays and Wednesdays. This schedule allows the plant to be operated for one eight hour shift seven days per week. The schedule provides for three days each week (Tuesday, Thursday and Friday) when two operators are present and four days per week when only one operator is present. Thus, two operators are present up to 43 percent of the time that the plant is operated. Accounting for vacation, sick leave, City meetings and continuing education to maintain certification, the frequency of two operators being present at the plant is commonly less than this.

Certain maintenance and repair activities require the presence of two operators. Other maintenance and repair activities can be carried out by one operator, but only when the plant is running in a steady-state condition that does not require the close attention of that operator. When raw water quality is changing due to weather conditions in the catchment, a single operator may need to focus on making adjustments to the plant operation to ensure high quality finished water. Therefore, it is difficult for two operators working under the existing schedule to ensure that all required preventative maintenance activities and repairs are conducted in a timely manner.

A brief analysis of staffing plans for water treatment facilities in the region was conducted. The analysis began with a review of existing data and reports. This existing data was augmented by discussions with municipalities of a similar size to the City of Snohomish. The goal was to assess the various staffing plans used in the region and to recommend a staffing level for the Pilchuck WTP that will allow for operation of the facility for more than eight hours per day and do so in a manner that is economical, yet provides sufficient staffing to ensure that maintenance and repair activities can be carried out in a timely manner.

There are two primary determinants for required staffing levels. The first is the number of hours per day that the plant is operated. The second is whether the plant is always staffed when in operation or is operated in automatic mode, without staff present, during one or more of the evening and night shifts.

A number of plants in the region are operated only when staff is present at the facility and are operated seven days per week with the number of hours per day varying from 16 to 24. Most of these plants operate less than 24 hours per day during low demand periods and only operate 24/7 during the few weeks of high demand that normally occurs during the summer. Staffing levels are based on a 16 or 20 hour per day schedule and staff are paid overtime when it is necessary to operate the facility 24 hours per day.

Staffing levels at facilities that operate 16 hours per day or more, while maintaining staff at the plant whenever water is produced, vary depending upon the organization of the staff, the shift schedule employed, the ability to share resources among treatment and distribution staff, and whether some activities are outsourced. Staffing levels at these facilities range from five to nine people. The production capacity at all these facilities is much larger than the Pilchuck WTP, varying from 12 to 21 MGD.

For smaller facilities, in the range of 2 to 4 MGD, maintaining a staff of five or more people may increase the unit cost of production to prohibitive levels. Therefore, for facilities similar in size to the Pilchuck WTP, it is more common to staff the plant for only one shift per day. All plants of this size that are operated for more than eight hours per day have been equipped with automated controls systems to annunciate alarm conditions to an on-call operator and to shut the plant down automatically, if necessary. Some facilities have the ability for the on-call operator to remotely troubleshoot and control the facility using a laptop computer and an Internet connection that includes a control program which mirrors the computer-based control program located at the WTP. The installation of such a high-level supervisory control and data acquisition (SCADA) system can significantly reduce staffing requirements.

Staffing levels at these smaller, automated facilities are typically two to three full-time operators. Where possible, these smaller plants have two full-time operators and share an additional operator with another facility operated by the same authority, either another water treatment plant, a wastewater treatment plant, or the distribution system. This provides an average staffing level of approximately 2.5 full-time equivalents (FTE). Where this is not possible, smaller plants operating more than eight hours per day employ either two or three full-time operators. With two full-time operators, they typically employ a schedule similar to that already used by the City for the Pilchuck WTP.

Plants with three full-time operators, or two full-time operators and one shared operator, have more flexibility with scheduling and can ensure that at least two operators are at the facility for five shifts per week. Two operators work the day shift Monday through Friday. The third operator works the day shifts during the weekend and is on call throughout the week. The on-call operator receives compensatory time for weekend and call-out duties and only works up to three days during the week, up to a total of 40 hours. The responsibility for weekend and on-call status rotates among the three operators.

Plants with more than two operators generate less stress on plant staff and can continue normal operation without excessive overtime payments should one of the operators experience an extended illness or quit before a replacement is hired. They are also less likely to develop a backlog of repairs and maintenance.

It is recommended that the City consider increasing the number of staff at the Pilchuck WTP to 2.5 FTE by investigating the option of sharing one operator between the distribution system and the treatment plant. If there is spare capacity in the distribution system staff, one of the operators could be trained and certified to operate the WTP. If the distribution system staff does not have spare capacity, the City should consider hiring one operator to split duties among treatment and distribution.

General

This section presents the results of the evaluation of the City's finished water transmission main, which delivers treated water to a portion of the City's customers from the Pilchuck River water treatment plant. A schematic of the transmission main is shown in **Figure 2-1** from **Section 2**.

Background

The first transmission main that supplied water to the City was a 12-inch wood stave pipe that was constructed in 1912. In 1931 the 12-inch wood stave pipe was replaced with larger wood stave pipe ranging in sizes of 14, 16, and 18-inch diameter. The current transmission main was constructed in 1981 at the same time as the current Pilchuck River Water Treatment Plant (WTP). A more detailed description of the existing transmission main follows.

Existing Transmission Main Description

The 14.6-mile long transmission main carries treated water from the City's WTP to Reservoirs No. 1 and No. 2, which serve the City's 222 Zone. The transmission main also serves approximately 93 customers spread out along the length of the main that are directly connected to this main. The transmission main consists of approximately 33,000 feet (6.2 miles) of 18-inch asbestos cement (AC) pipe from the clearwell at the WTP to approximately Creswell Road and approximately 44,000 feet (8.3 miles) of 12-inch Permastran pipe from approximately Creswell Road to the site of the Reservoirs No. 1 and No. 2. Permastran is a fiberglass composite pipe with a PVC inner core that is wrapped with fiberglass and bonded with epoxy resin. The 12-inch Permastran pipe connects into a 14-inch pipe of unknown material that extends approximately 500 feet across the reservoir site and connects into the two reservoirs. The transmission main system also includes pressure reducing valves, air relief valves and isolation valves along the length of the main. Three fire hydrants, as described later in this section, are also connected to the transmission main. A more detailed description of the pressure reducing valves follows.

Pressure Reducing Valve Stations

The difference in elevation of the water surface in the WTP clearwell (approximately 442 feet maximum) and Reservoirs No. 1 and No. 2 (approximately 220 feet maximum) is significant enough that pressure reducing valve (PRV) stations were installed at four locations along the transmission main in 1981 to maintain a safe range of pressures along the entire length of the transmission main. Only the lower two PRV stations, PRV #1 and PRV #2, remain in service today. The other two PRV stations, PRV #3 and PRV #4, still exist, but the pressure reducing valve has been disabled in each, thereby allowing water to pass through without reducing the pressure. This was likely accomplished to provide higher pressures to customers downstream of these two stations and recognizing that the increase in pressures without the stations is moderate and doesn't justify the need to reduce pressures in these sections of the transmission main. Increasing pressures in the transmission main may have also been accomplished to provide adequate pressure to some of the transmission main customers that have long service lines and are located at elevations above the transmission main. **Table 7-1** summarizes information for the PRV stations, based on information provided by the City and pressure data provided by the local Cla-Val representative, GC Systems, from their most recent on-site maintenance visit in March 2008.

Table 7-1
Transmission Main PRV Station Data

PRV Station Name & Location (status)	Valve Size (inches)	Valve Manufacturer & Model	Valve Elv (feet)[1]	Inlet Pressure (psi)[2]	Existing Valve Set Points	
					(psi)[2]	(feet H.E.)
PRV #4 - OK Mill & Creswell (Inactive)	3	Cla-Val 90DG-01ABCS	305	58	58	439
	12	Cla-Val 90DG-01ABCS	305	58	58	439
PRV #3 - OK Mill & Newberg (Inactive)	3	Cla-Val 90G-01AS	270	70	70	432
	12	Cla-Val 90G-01AB	270	70	70	432
PRV #2 - OK Mill & 147th/Machias (Active)	3	Cla-Val 90G-01AS	140	130	85	336
	12	Cla-Val 90G-01AB	140	130	80	325
PRV #1 - Machias & Debuque (Active)	3	Cla-Val 90G-01AS	65	96	85	261
	12	Cla-Val 90G-01AB	65	96	80	250

1. Valve elevation data is approximate.
2. Inlet pressures and valve set point pressures measured by GC Systems on 3/19/08.

Transmission Main Operation

Treated water flows by gravity through the transmission main from the clearwell at the WTP to the City's Reservoirs No. 1 and No. 2 in the 222 Zone. An electronically operated flow control valve located on the reservoir site near the end of the transmission main enables the WTP operator to remotely set the amount of supply to be provided to the system from the WTP. The remote control capability has been in place since 1991 when the telemetry system was installed. A brief summary of steps followed daily by the operator for the typical operation of the transmission main includes the following:

1. At the beginning of the day, the operator estimates water demand for the day, or the period that the WTP is expected to run.
2. The operator calculates the production rate of the WTP, based on the current level of the 222 Zone reservoirs and demand estimates for the 222 Zone and transmission main customers.
3. The operator sets the WTP production rate at the RTU (remote telemetry unit) in the plant, which sends a signal to the RTU at the 222 Zone reservoir site near the end of the transmission main. Once set, the flow control valve opens to supply water to the 222 Zone at a steady flow rate.

The WTP is shut down if the 222 Zone reservoirs become too full, but this situation seldom occurs. The WTP operator is made continuously aware of the level of the two 222 Zone reservoirs from the accurate level data being transmitted back to the WTP and automated alarms that are sounded when the reservoirs approach their full levels. This is accomplished with an electronic level sensor at the 1.5 MG Reservoir #1. The level of the 5.0 MG Reservoir #2 fluctuates with the level of Reservoir #1, since they are connected to each other.

Maintenance

Maintenance required for the transmission main has been minimal. Current City staff recalls two pipe repairs in the past. A small leak repaired by the City was found to be from a very small fracture in the Permastran pipe, located between PRV Stations #1 and #2. A repair at another location was required after a contractor accidently fractured the pipe while excavating in the area of the main. City records also show a repair in November 1985 of approximately 140 feet of 12-inch Permastran pipe that was damaged when the road washed out approximately 1.5 miles east of the Pilchuck Bridge near Price Road. About 1,900 feet southeast of Price Road, approximately 400 feet of Permastran pipe was replaced with 12-inch ductile iron pipe in 1997 to relocate the main from the south side of OK Mill Road to the north side, due to a slide caused from a snow storm. The City regularly maintains the controls valves within the transmission main PRV stations to ensure continued reliable operation. Maintenance on the control valves was most recently completed in March 2008 by GC Systems.

Pipe Material

The transmission main consists of two different pipe materials and sizes, as described above. The upper portion of the transmission main starting at the WTP consists of 18-inch asbestos cement (AC) pipe and the lower portion consists of 12-inch Permastran pipe.

AC pipe is composed of a dense homogeneous matrix of inert materials that are resistant to rust and corrosion, due to its non-metallic construction that prevents attack by electrolysis or stray electrical currents. However, the structural stability and life of AC pipe is affected by a number of factors, including quality of original pipe manufacture, quality of original installation, characteristics of the surrounding soil, and the characteristics of the water being transported by the pipe (pH, hardness, and alkalinity). According to project documents from the design of the transmission main, the AC pipe was seal coat lined on the interior to prevent attack on the cement by potentially aggressive water. Project documents also indicate that the AC pipe had to meet the specifications of AWWA C402, which required that the pipe was manufactured to withstand an internal hydrostatic test pressure of at least 300 psi. Although the project documents do not specify the working pressure class of the installed pipe, it is likely one of three working pressure classes of 100, 150, or 200 psi. The internal diameter of the pipe is18 inches according to AWWA C402.

Permastran is a fiberglass composite pipe composed of an inner core of PVC overwrapped with continuous roving fiberglass bonded with epoxy resin. The fiberglass and epoxy resin provide Permastran with its hydrostatic strength and external corrosion protection while the

PVC core provides a corrosion resistant, watertight internal core. According to project documents from the design of the transmission main, the Permastran pipe has an internal diameter of approximately 12.55 inches and is rated for a maximum operating pressure of 350 psi.

Pressure Analysis

Pressures were calculated along the transmission main to provide a general understanding of the magnitude of pressures and to provide a comparison to the pressure rating of the two pipe materials. The pressures were calculated based on static conditions to identify maximum operating pressures during normal conditions. Potential surge pressures, which could occur during abnormal operating conditions from a sudden increase or decrease in flow rate, were not determined and are beyond the scope of this project. **Table 7-2** below provides a summary of minimum and maximum pressures within each section of the transmission main shown. A discussion of the results of the pressure analysis follows.

Table 7-2
Transmission Main Static Pressure Summary

Pipe Section	Pipe Size & Material	Hydraulic Elevation (feet)	Minimum Pressure (psi)	Maximum Pressure (psi)
WTP - PRV #4	18" AC	442	at clearwell	55
PRV #4 - PRV #2	12" Permastran	442	53	130
PRV #2 - PRV #1	12" Permastran	330	80	112
PRV #1 - Reservoirs	12" Permastran	255	65	95

Pressures shown are based on maximum static conditions with WTP clearwell level at 442 feet.

AC Pipe Section

The upper section of the transmission main consisting of the 18-inch AC pipe operates at the same hydraulic elevation throughout, since it is upstream of all PRV stations. During maximum static pressure conditions when the WTP clearwell is operating at 442 feet, a maximum pressure of approximately 55 psi occurs at the lowest elevation along the main, where the elevation is approximately 315 feet at the end of the AC pipe section near the inactive PRV Station #4. This maximum pressure is conservatively within the pressure rating of the AC pipe.

Permastran Pipe Section

The lower section of the transmission main consisting of the 12-inch Permastran pipe operates at three different hydraulic elevations due to the two active PRV stations (#1 and #2) that reduce the pressure of the water as it passes through the stations. The hydraulic elevation of the upper portion of the Permastran pipe section between PRV Station #4 and PRV Station #2 (PRV Station #3 is inactive) is set by the WTP clearwell level during static conditions. The static pressure in this section varies from approximately 53 psi at Connors Road to 130 psi at the Anderson Creek crossing near PRV Station #2.

The hydraulic elevation of the section between PRV Station #2 and PRV Station #1 is established by the pressure setting of PRV Station #2, which is approximately 80 psi, resulting in a hydraulic elevation of 330 feet. The static pressure in this section of Permastran pipe varies from approximately 80 psi at PRV Station #2 to approximately 112 psi at PRV Station #1.

The hydraulic elevation of the section between PRV Station #1 and City's 222 Zone reservoirs near the end of the main is established by the pressure setting of PRV Station #1, which is approximately 80 psi, resulting in a hydraulic elevation of 255 feet. The static pressure in this section of Permastran pipe varies from approximately 65 psi at Maple Avenue to approximately 95 psi near Three Lakes Road. The maximum pressures in the Permastran pipe sections are conservatively within the pressure rating of the pipe.

Capacity Analysis

Design Capacity

The current transmission main was originally sized and designed to match the design capacity of the WTP, which is 2.16 MGD or 1,500 gpm. The current operating capacity of the WTP is less than 2.16 MGD, as discussed in other sections of this study.

Calculated Flow Capacity

A hydraulic evaluation of the existing transmission main was performed to determine the maximum capacity of the main, based on three different scenarios, as shown in **Table 7-3**.

Table 7-3
Transmission Main Capacity Analysis Summary

Description / Purpose	Maximum Capacity		Maximum Velocity (ft/sec)[1]	Total Head Loss (feet)	Supply Head (feet)	Limiting Factor
	(MGD)	(gpm)				
Scenario #1 - Existing System / No Improvements						
- Supply from Clearwell	2.29	1,590	4.1	221	440	Clearwell elevation
Scenario #2 - Proposed Improvements / Minimize Improvement Costs						
- Supply from Backwash Tank	2.44	1,694	4.4	249	468	Backwash tank elevation
Scenario #3 - Proposed Improvements / Maximize Water Rights						
- Supply from Proposed Pumps	3.23	2,243	5.8	418	640	Pumping required

1. Maximum velocity occurred in 12-inch Permastran pipe for all analyses.

All three scenarios are based on the existing transmission system with the current pipe in place and estimates of internal pipeline roughness. The current capacity of the transmission main is established by the water surface elevations of the clearwell and 222 Zone reservoirs, the length, internal diameter and internal roughness of the different sections of the pipeline, and the friction losses from control valves, flow meters, gate valves and pipe bends. The ability to increase the flow rate in the current transmission main is primarily limited to increasing the supply head at the pipeline entrance at the WTP, based on the approach that the current transmission main will remain in service for a number of years and continue to supply water into the 222 Zone. The two analysis scenarios with proposed improvements (Scenario #2 and #3) follow this approach to increasing the flow capability of the transmission main, as shown in **Table 7-3**.

Scenario #1

The results of the capacity analysis of the existing transmission main, as currently configured with the existing clearwell, indicates that the main can deliver treated water at a maximum rate of approximately 2.29 MGD or 1,590 gpm, which is very close to the original design capacity of the transmission main. Although the transmission main is capable of delivering water at this rate, this rate cannot be sustained for very long due to the small size of the existing clearwell and the existing capacity limitations of the WTP.

Scenario #2

Since the flow capacity of the existing transmission main as currently configured is limited by the set elevation of the existing clearwell, increasing the head of the supply source would increase the flow rate in the existing transmission main. The first approach evaluated to accomplish this is based on a minimum level of improvements that would enable the transmission main to be supplied by the 0.5 MG backwash tank, which operates at a higher head than the clearwell, as shown in **Table 7-3**. The results of the capacity analysis for this scenario indicates that the main would be capable of delivering treated water at a maximum rate of approximately 2.44 MGD or 1,694 gpm, which isn't much more than the capacity of the main with its current configuration.

Scenario #3

The analysis for the third scenario was performed to determine if the current transmission main is capable of delivering treated water at a rate that is equal to the maximum instantaneous water right of the Pilchuck River source (3.23 MGD). This is based on the approach of full utilization of the certificated water right and expansion of the WTP to treat water at a higher rate. The results of the capacity analysis for this scenario indicates that the main could deliver treated water at 3.23 MGD, only if proposed improvements (i.e., pumping) were in place to increase the supply head from the current level of 440 feet, as established by the clearwell water level, to approximately 640 feet. Increasing the supply head by approximately 200 feet would require the addition of booster pumps and related improvements. Based on this supply rate, the maximum velocity within the transmission main would be approximately 5.8 feet per second in the 12-inch Permastran pipe section, which is within the acceptable range of velocities for the design and operation of transmission mains. Further discussion of proposed improvements to increase the capacity of the Pilchuck River source is contained in **Section 8**.

Increasing the supply head by approximately 200 feet will result in a static pressure increase of approximately 87 psi. This would increase the static pressure from approximately 130 psi to 217 psi near the upstream side of PRV #2, which is the location of the transmission main that has the highest pressure. While this is still within the pressure rating of the Permastran pipe, the increase in pressure alone may be enough to cause further leakage or other problems within both sections of AC pipe and Permastran pipe. Increasing the supply head would also require installation of individual pressure reducing valves on all transmission main service connections between the WTP and PRV #2 to prevent potential problems that could occur within the plumbing systems of transmission main customers.

Leakage Analysis

A leakage analysis was performed to estimate the magnitude of potential leakage that may be occurring in the transmission main. Because leaks in pipelines are often directly associated with the structural integrity of the pipe material and pipe joints, this analysis provides a non-destructive means of assessing the condition of the transmission main.

The transmission system includes a flow meter near the end of the transmission main that records the flow rate and total volume of water being discharged into the 222 Zone reservoirs. Since a flow meter is not installed at the upper end of the transmission main on the WTP site, a leakage analysis that utilizes data from flow meters at each end of the transmission main was not possible. Instead, the method carried out for the leakage analysis is described below.

1. The WTP was shut down and the flow control valve at the lower end of the transmission main was completely closed, preventing water from exiting the transmission main during the 3-day test period.
2. The water level in the 0.5 MG backwash tank was recorded at the beginning of the test after the tank was filled. The water in the tank was used during the test period to provide water supply to customers that are served directly off the transmission main.
3. At the end of the 3-day test period, the water level in the 0.5 MG backwash tank was recorded again.
4. The amount of water used during the test period was calculated from the difference in the two tank level readings. This volume was compared to the amount of water that the transmission main customers typically use during a 3-day period. The difference between the two numbers represents unaccounted-for water, which is assumed to be from leakage in the transmission main.

The results of the leakage analysis indicated that approximately 114,000 gallons of water was supplied from the backwash tank during the 3-day period and approximately 47,400 gallons of water was used by the transmission main customers. The difference between the two values is 66,600 gallons, which results in a leakage rate of approximately 15 gpm. This leakage rate, when converted to an average annual amount, represents approximately 12 percent of the total amount of water supplied by the WTP in 2007.

While 12 percent leakage is consistent with the amount of unaccounted-for water in most water systems, it is recommended that the City retain the services of a professional leak detection company to conduct periodic leak detection on the transmission main in the future. Leaks identified should be repaired when found to conserve water and make it available to customers of the system. Leak detection performed in the field has been conducted in the past for the transmission main.

Transmission Main Alignment

The transmission main alignment is shown in **Figure 2-1** from **Section 2** of this report. The transmission main is located in public right-of-way at locations that follow public roads, easements where it crosses private property, and within City owned property at the WTP and 222 Zone reservoir sites. The City has easement documents for the transmission main, but it is not known if City records include all easement documents for the transmission main. It is recommended that the City conduct a comprehensive review of the easement documents to determine the completeness of the documents, rights granted by the easement documents, and conditions imposed by the documents. The pipeline corridor and associated easements are a valuable asset that the City owns and should be well documented in the event that the City decides to abandon or relocate the WTP in the future.

Transmission Main Customer Connections

Approximately 93 customers are directly connected to the transmission main for their water supply. The transmission main customers include approximately 86 single family residential users, two multi-family residential users (Machias Mobile Manor and Green Velvet Water System), three commercial users (Machias Nursery, Forest Glade Community Church, and Snohomish Fire District No. 8), one park (Machias Station Trailhead), and one school (Machias Elementary School). The transmission main customers are mostly spread out along the main with some areas containing clusters of customers, as shown in **Figure 2-1** from **Section 2** of this report. Several of the customers are set back from the main and have long service lines, with the longest being approximately ¼ mile long. Some of the customers with long service lines are located at elevations higher than the transmission main, up to 30 feet higher. As a result, the water pressure at the end of the service line may become low if adequate pressure isn't maintained in the transmission main.

The City has not allowed new service connections to the transmission main since the passage of Resolution No. 580 in October 1984. In some cases, the City has transferred customers to the Snohomish County PUD (PUD) as the PUD has expanded water service to several areas adjacent to the transmission main.

Fire Hydrants

The existing transmission main has three fire hydrants that are owned and maintained by the City. One hydrant is located at Machias Elementary School (231 - 147th Avenue SE) and two hydrants are located near Lake Stevens Fire Station 83 (13717 Division Street). Other fire hydrants located near the transmission main along Machias Road are part of the PUD's water system that is located nearby. Although a few fire hydrants are connected to the transmission main, the original design of the main did not intend for it to provide fire flow. Therefore, the City does not allow the installation of new fire hydrants on the transmission main.

Capital Improvements

Improvements to the transmission system have not been required since it was installed in 1981, other than a few maintenance related improvements, as discussed earlier in this section. The transmission main has functioned reliably and there are no immediate plans for replacement of it. Like all capital facilities, the transmission main will eventually reach the end of its service life and will need to be replaced, or rehabilitated at a minimum.

The existing transmission main is 27 years old. The remaining useful service life of the main is difficult to predict, but providing an estimate is prudent in the long-term planning of the City's water supply system. AC water mains are much more common in water systems than Permastran water mains. AC water mains typically have a service life of approximately 30 to 60 years, but the service life is affected by a number of factors as discussed above under Pipe Materials. Since Permastran pipe is not commonly used in water systems, limited data is available to determine the typical service life of this pipe material. For the purpose of this study, an average service life of 50 years is assumed for both pipe materials. Based on this, the remaining service life of the transmission mains is assumed to be approximately 23 years, at which time improvements to replace or rehabilitate will be required.

Determining the cost of replacement of the transmission main depends on a number of factors, including the size and material of the new main, new pipeline alignment and related length, and method of construction. As an alternative to pipeline replacement, pipeline rehabilitation through relining of the existing transmission main is possible. However, since relining results in a reduced internal diameter of the pipe, flow capacity would be reduced. Therefore, relining would have to be limited to a portion of the transmission main, so that the remaining portion of the transmission main could be replaced with larger diameter pipe to increase the flow capacity of the transmission system and offset the reduction in flow capacity from relining. An example to this approach would involve relining the section of 18-inch diameter AC pipe and replacing the section of 12-inch diameter Permastran pipe with larger diameter pipe.

Based on a conservative approach for planning purposes, a cost estimate was prepared for replacement of the entire transmission main, as shown in **Table 7-4**. The estimated project costs shown includes all project related costs (surveying, engineering, permits, construction, administration, etc.) for installation of a new 16-inch diameter ductile iron (DI) water main, based on the same length as the existing transmission main. Included in the cost estimate is the replacement of the two active PRV stations (PRV #1 and PRV #2).

Table 7-4
Transmission Main Planning Level Replacement Cost Estimate

Pipe Section	Approx. Length (feet)	Existing Pipe Size & Material	Proposed Pipe Size & Material	Estimated Project Cost (2008 $$)
WTP - PRV #4	32,800	18" AC	16" DI	$7,700,000
PRV #4 - PRV #2	16,100	12" Permastran	16" DI	$3,800,000
PRV #2 - PRV #1	13,600	12" Permastran	16" DI	$3,200,000
PRV #1 - Reservoirs	14,200	12" Permastran	16" DI	$3,300,000
Totals	**76,700**			**$18,000,000**

The proposed 16-inch transmission main is sized to convey 3.23 MGD, the maximum instantaneous water right of the Pilchuck River source. Replacing the 12-inch Permastran pipe with larger 16-inch DI pipe will significantly reduce the head loss in the transmission main, enabling the increased flow rate of 3.23 MGD to be conveyed from the existing clearwell without the need to implement pumping improvements, which are discussed above under the Capacity Analysis section.

While it appears the transmission main will function sufficiently for the next 20 years, it is recommended that the following improvements be implemented in the near-term:

- Install a flow meter near the upper end of the transmission main on the WTP site and provide the necessary SCADA equipment to enable real-time data logging that would provide advance notification in the event of a leak by continuously analyzing the flow rate data from the existing meter at the lower end of the transmission main and the proposed meter at the upper end of the main.
- Remove the control valves from the inactive PRV stations (#3 and #4) and replace with straight pipe sections to eliminate the head loss and potential maintenance of the control valves.

If the City decides to operate the WTP beyond 20 years, replacement of the entire transmission main should be planned for implementation soon after the 20-year planning period. If the capacity of the WTP is expanded beyond the original design capacity of 2.16 MGD, the 12-inch Permastran pipe portion of the transmission main will need to be replaced with larger transmission main or pumping at the WTP will be required.

In other words, replacement of the existing transmission main will be triggered by one of the following factors:

- Due to capacity - if WTP capacity is increased beyond 2.16 MGD and pumping is not implemented at the WTP.
- Due to age - when existing main reaches the end of its useful service life.

SECTION 8

General

This section identifies potential water supply alternatives for meeting the water supply needs of the City of Snohomish for the next 20 years. This section also presents options for providing water service to the City's customers that have direct service connections to the finished water transmission main. Conceptual, planning level cost estimates were prepared for capital and operating costs of each alternative and are presented at the end of this section. **Section 9** that follows presents a financial analysis of the alternatives and **Section 10** provides an evaluation of the alternatives.

A total of 11 water supply alternatives have been identified as part of this study and are listed below. This list includes the supply options identified in **Section 6** that relate to the City's existing water treatment plant (WTP). A number has been assigned to each alternative as a unique identifier and is not intended to represent ranking or priority. The maximum capacity of each alternative that utilizes the City's water rights is shown in parenthesis with units of million gallons per day (MGD). The 1.7 MGD capacity reflects the current capacity of the WTP, which is operating at a rate that is less than the 2.16 MGD original design capacity of the plant. The 3.23 MGD capacity reflects the maximum instantaneous water right amount, as recorded on the City's water right certificate for the Pilchuck River source.

- Alternative 1 – Existing Direct Filtration WTP (1.7 MGD)
- Alternative 2 – Riverbank Filtration Intake at Existing WTP (1.7 MGD)
- Alternative 3 – Existing Direct Filtration WTP Upgraded (2.16 MGD)
- Alternative 4 – Riverbank Filtration Intake at Existing WTP Upgraded (2.16 MGD)
- Alternative 5 – Expanded WTP with Conventional Treatment (3.23 MGD)
- Alternative 6 - Riverbank Filtration Intake at Existing WTP Expanded (3.23 MGD)
- Alternative 7 – Membrane Filters at Existing WTP Expanded (3.23 MGD)
- Alternative 8 – New WTP Downstream with Surface Water Intake (3.23 MGD)
- Alternative 9 – New WTP Downstream with Riverbank Filtration Intake (3.23 MGD)
- Alternative 10 – New Groundwater Wells Near City (3.23 MGD)
- Alternative 11 – Everett Supply Entire System

Key Issues

Several key issues to be considered during the decision making process for the City's future water supply have been identified. The list below is not intended to be comprehensive of all issues, but is being provided to highlight those that are deemed to be most important.

- Cost of Water Supply – This includes existing and future costs during the 20-year planning horizon of this study and takes into account capital costs, operations and maintenance costs, and depreciation costs.
- Transmission Main Future Replacement Costs – The 15-mile long transmission main that carries water from the Pilchuck WTP to customers within the City will eventually reach the end of its useful service life and need replacing. The cost to replace this long pipeline will be significant. It is estimated that the existing transmission main will remain in service throughout the duration of the 20-year planning period of this study, but is expected to need replacement shortly after the end of the 20-year period, as discussed in **Section 7** of this report.
- Water Service to Transmission Main Customers – The City provides water service to approximately 93 customers that are directly connected to the transmission main and supplied with treated water from the City's Pilchuck WTP. Some of the water supply alternatives involve abandonment of the Pilchuck WTP in its existing location, which would leave the transmission main customers without supply, thereby requiring another means of supplying the 93 customers. Options to serve the transmission main customers are presented below in this section of the report.
- Water Rights – The City has certificated water rights for an amount that is more than current demands, but less than future demands. A court case underway at the time of this writing may result in an outcome that will impact water rights held by municipal water suppliers like the City of Snohomish. The process for changes to an existing water right or securing a new water right is becoming more complex and requires the involvement of attorneys that specialize in water rights, due to many competing interests for water, environmental issues, and the frequently changing regulatory requirements. A summary of the City's water rights is presented in **Section 3**.
- Dam, Intake and Fish Ladder – The City's water source is diverted from the Pilchuck River with an intake structure and dam on the river, which also includes a fish ladder. Improvements to the existing fish screens on the intake structure are required to protect juvenile fish. It is likely that improvements to the fish ladder will also be required within the next 20 years. Prior to construction of improvement projects at the diversion site, it is recommended that an assessment of the dam be conducted so that improvements to the dam, if required, are coordinated with other improvements on the river. With the frequently changing regulatory requirements and increasing need to protect fish, the amount of required improvements to maintain the diversion on the Pilchuck River will likely increase during the next 20 years, but is difficult to predict at this time.

Options for Water Service to Transmission Main Customers

As stated above, providing water service to the transmission main customers is a key issue to be considered when evaluating water supply alternatives, since some of the alternatives involve abandonment of the Pilchuck WTP, which is the source of water supply to the transmission main customers. This section reviews different options to provide water service to transmission main customers in the event that the City abandons the Pilchuck WTP.

Background

Approximately 93 of the City's water customers are directly served from the transmission main and supplied with treated water from the City's Pilchuck WTP. The transmission main customers are mostly spread out along the 15-mile long main with some areas containing clusters of customers, as shown in Figure 2-1 from **Section 2** of this report. More information on the transmission main customers is contained in **Section 7** of this report.

The City has not allowed new service connections to the transmission main since the passage of Resolution No. 580 in October 1984. In some cases, the City has transferred customers to the Snohomish County PUD (PUD) as the PUD has expanded water service to several areas adjacent to the transmission main.

Prior Legal Opinions

In 1979, the City conducted legal research into its rights and liabilities with respect to terminating water service to its transmission main customers. The City Attorney issued an opinion in a letter, dated August 30, 1979, which explained that the City would likely be subject to substantial damages if it terminated water services to certain customers that had perpetual long-term agreements in place. The letter also indicated that it would be difficult to discontinue water service even if there were no agreement in place, since an implied contract with the City might be proven by a transmission main customer. The City should consider updating its legal review to confirm its rights and obligations with respect to these services, which would also be useful when deciding on water supply alternatives. For the purposes of this study, it is assumed that the City is obligated to provide replacement or alternate water service if the WTP and transmission main are abandoned, or if the City desires to otherwise discontinue providing water service directly from the transmission main.

Future Water Service Options for Transmission Main Customers

The following are options for providing water service to the transmission main customers for the next 20 years, in the event that the water supply alternative selected by the City involves abandonment of the Pilchuck WTP (Alternatives 8-11). It is assumed that the existing transmission main will be in sufficient condition to remain in service during the 20-year planning period.

A. Supply PUD Water through Transmission Main to All Customers – The City would purchase PUD water and supply it through the existing transmission main to all 93 customers. This would require a new connection to the PUD's water system, likely near the intersection of Robe Menzel Road and North Carpenter Road. Improvements would consist of approximately 1,000 feet of 12-inch water main extended from the PUD's Lake Roesiger system to the City's transmission main, including installation of a supply station vault with a flow meter and control valve. Due to the low demand of the transmission main customers, operating the transmission main for just these customers may impose water quality challenges for the City. For the purpose of this study, this is the assumed option of choice during the planning period of this study.

However, it is important to realize that at some time in the future when the transmission main requires replacement, the likely scenario will be to abandon the transmission main, due to the significant costs to replace the 15-mile long pipeline. At that time, supply to the transmission main customers would need to be provided by one of the other options below or another option that may present itself in the future.

B. Transfer Transmission Main and All Customers to PUD – The City would release all interest in the transmission main and all 93 customers being served by it under this option. The PUD would take ownership of the transmission main and become the water provider for the transmission main customers. For the water supply alternatives that include a WTP at the site of the City's existing Pilchuck WTP, the transmission main would carry City produced water, which would be purchased by the PUD for those customers that the PUD keeps connected to the transmission main. For the water supply alternatives that do not include a WTP at the site of the City's existing Pilchuck WTP, the PUD would have several options to serve the transmission main customers. These include supplying PUD water through the transmission main by connecting the Lake Roesiger system to the transmission main, removing customers from the transmission main and connecting them to nearby PUD mains where applicable, or placing transmission main customers on individual private wells.

C. Transfer Some Customers to PUD and Place Others on Private Wells – This option would remove all customers from the transmission main and provide an alternative source of supply. The PUD's distribution system is very close to many of the transmission main customers, especially along the Machias Road. Approximately half of the transmission main customers are located in this area and could be transferred to the PUD with a minimum amount of water main extensions to connect the customers to the PUD's existing distribution system. The remaining transmission main customers are mostly spread out along the transmission main between approximately 147th Ave SE/OK Mill Road and near the Pilchuck WTP. Since the PUD's distribution system is too far away to connect most of these customers, they would be placed on individual private wells. Further discussion of private wells is included in the option that follows.

D. Place All Customers on Private Wells – This option would remove all customers from the transmission main and place them on individual private wells. Transferring customers from a public water system to individual private wells is not a common practice and carries several issues that will need to be investigated. It would involve conducting groundwater explorations to determine the adequacy of groundwater for each well site, legal review related to the transfer of customers, regulatory review, and a cost analysis.

Initial discussions with the PUD about some of the options above have taken place in recent years, but have not progressed to the next level. It is recommended that the City continue discussions with the PUD and initiate a study to further analyze the above options and develop a plan that can be implemented with certainty. Without a solid plan in place to provide water service to the transmission main customers on a long-term basis, the ability of the City to pursue its preferred choice of water supply alternative could be challenging and costly.

Description of Water Supply Alternatives

General

A description of each water supply alternative identified and evaluated as part of this study is provided below. Within the heading of each, the maximum capacity of each alternative that utilizes the City's water rights is shown in parenthesis with units of million gallons per day (MGD). A number has been assigned to each alternative as a unique identifier and is not intended to represent ranking, priority, evaluation results, or recommendations.

Distribution System Pump Station Improvement

All alternatives (Alternatives 1 through 10) that utilize the City's own water source include a proposed pump station within the City's distribution system to pump water from the City's 222 Zone reservoirs to the 358 Zone reservoir, thereby allowing more of the City's own source to be used and reducing the amount of water purchased from Everett.

Transmission Main Assumptions

It is assumed that the existing finished water transmission main will remain in service during the 20-year planning period, based on the evaluation presented in **Section 7**. However, it is expected that the transmission main will require replacement soon after the end of the 20-year planning period. The transmission main is needed for Alternatives 1through 7, where the source of supply originates at the same location as the existing Pilchuck WTP.

Property Acquisition Assumptions

It is assumed that the supply facilities for Alternatives 8 through 10 will be located within the City limits, possibly on property currently owned by the City. It is also assumed that costs related to property acquisition for these alternatives will be offset by the proceeds from the assumed sale of the City's property at the current water treatment plant site. Therefore, property acquisition costs are not included in the costs estimates for the supply alternatives.

Everett Supply Assumptions

It is assumed that the City's existing Everett meter stations will remain in service during the planning period, since Everett water is needed now and in the future to serve the City's higher elevation pressure zones (368 and 418 Zones). Everett water will also be required in the future during peak demand periods to supplement supply to the City's other pressure zones (222, 345, and 358 Zones) from the City's own source, which by itself will not have enough capacity to meet the increased demands, unless additional water rights are obtained by the City. The need for Everett water to supplement supply to these pressure zones, or the need for additional water rights, will occur when the peak demand of these pressure zones exceeds the City's current water rights of 3.23 MGD. Based on the demand projections in **Section 4**, this is expected to occur near the end of the 20-year planning period. If the City implements one of the first four alternatives with a capacity that is less than the City's 3.23 MGD water rights, Everett supply will be needed sooner to supplement the City's own source during peak demand periods.

Alternative 1 – Existing Direct Filtration WTP (1.7 MGD)

This alternative is essentially the existing direct filtration WTP and Pilchuck River surface water intake system, which has a current maximum capacity of 1.7 MGD. Recommended improvements to enable this facility to produce water for the next 20 years are described in **Section 6**.

Alternative 2 – Riverbank Filtration Intake at Existing WTP (1.7 MGD)

This alternative is based on the existing direct filtration WTP and a proposed riverbank filtration intake system on the Pilchuck River adjacent to the plant. This alternative would eliminate the need for the existing Pilchuck River dam and surface water intake system, which would be decommissioned upon completion of the riverbank filtration intake improvements. The recommended improvements for the existing WTP in Alternative 1 are the same for this alternative, except for those related to the dam and surface water intake system. The maximum capacity of this alternative would be the same as the existing plant, which is 1.7 MGD.

Alternative 3 – Existing Direct Filtration WTP Upgraded (2.16 MGD)

This alternative is the same as Alternative 1, but includes effluent pumps, which are assumed to be required to achieve the original design capacity of the plant of 2.16 MGD. The need for effluent pumps is discussed with the other long-term capital improvements for the existing plant in **Section 6**.

Alternative 4 – Riverbank Filtration Intake at Existing WTP Upgraded (2.16 MGD)

This alternative is the same as Alternative 2, but includes effluent pumps, which are assumed to be required to achieve the original design capacity of the plant of 2.16 MGD. The need for effluent pumps is discussed with the other long-term capital improvements for the existing plant in **Section 6**.

Alternative 5 – Expanded WTP with Conventional Treatment (3.23 MGD)

This alternative is based on converting the existing direct filtration WTP to a conventional WTP by installing a sedimentation basin before the filters. The alternative utilizes the existing Pilchuck River surface water intake system. This alternative also includes a finished water pump station at the WTP site, which would be required to supply water through the existing transmission main at a maximum rate of 3.23 MGD. A more detailed description of the recommended improvements for this alternative is included in **Section 6** for the Option 1 capital improvement.

Alternative 6 - Riverbank Filtration Intake at Existing WTP Expanded (3.23 MGD)

This alternative is similar to Alternative 2, but includes a finished water pump station at the WTP site, which would be required to supply water through the existing transmission main at a maximum rate of 3.23 MGD. A more detailed description of the recommended improvements for this alternative is included in **Section 6** for the Option 2 capital improvement.

Alternative 7 – Membrane Filters at Existing WTP Expanded (3.23 MGD)

This alternative is based on replacing the existing filters with a new membrane filtration system and utilizing the existing Pilchuck River surface water intake system. This alternative also includes a finished water pump station at the WTP site, which would be required to supply water through the existing transmission main at a maximum rate of 3.23 MGD. A more detailed description of the recommended improvements for this alternative is included in **Section 6** for the Option 3 capital improvement.

Alternative 8 – New WTP Downstream with Surface Water Intake (3.23 MGD)

This alternative is based on a new conventional WTP and surface water intake system located downstream on the Pilchuck River at a location within or near the City. This alternative would eliminate the need for the existing Pilchuck River WTP, dam and surface water intake system, which would be decommissioned upon completion of the new plant. For the purpose of this study, it is assumed the City's existing 93 customers that are served directly off of the transmission main would continue to be served the same way, but with water purchased from the PUD and supplied into the transmission main. The maximum capacity of this alternative would be 3.23 MGD, utilizing the City's full water right. An application to change the point of withdrawal for the City's existing water right would need to be submitted to Ecology for this alternative.

Alternative 9 – New WTP Downstream with Riverbank Filtration Intake (3.23 MGD)

This alternative is the same as Alternative 8, but includes a riverbank intake system instead of a surface water intake system.

Alternative 10 – New Groundwater Wells Near City (3.23 MGD)

This alternative is based on drilling groundwater wells within or near the City and constructing improvements necessary to fully utilize the City's water rights. It is assumed that up to five wells would be required to produce up to 3.23 MG of water for the City and that treatment would be required. Like Alternatives 8 and 9, this alternative would eliminate the need for the existing Pilchuck River WTP, dam and surface water intake system, which would be decommissioned upon completion of the groundwater well system. For the purpose of this study, it is assumed the City's existing 93 customers that are served directly off of the transmission main would continue to be served the same way, but with water purchased from the PUD and supplied into the transmission main. Similar to the prior two alternatives, an application to change the type and location of withdrawal for the City's existing water right would need to be submitted to Ecology for this alternative.

The March 1999 Source of Supply Evaluation for the City of Snohomish assessed groundwater as a possible source of supply for the City. The assessment found that the availability of a groundwater source was plausible, but a more in-depth analysis would be required to fully understand the geology of the area around the City. A groundwater source commonly contains levels of iron and manganese that are higher than drinking water standards allow. Therefore, it is assumed for the purpose of this study that treatment will be required for a groundwater source.

Alternative 11 – Everett Supply Entire System

This alternative is based on the City utilizing the five existing Everett meter stations to supply the entire water system. This alternative would require a proposed pressure reducing station with control capabilities to supply the 222 Zone with Everett water and maintain adequate levels in the City's two 222 Zone reservoirs. Like Alternatives 8, 9 and 10, this alternative would eliminate the need for the existing Pilchuck River WTP, dam and surface water intake system, which would be decommissioned. For the purpose of this study, it is assumed the City's existing 93 customers that are served directly off the transmission main would continue to be served the same way, but with water purchased from the PUD and supplied into the transmission main. It is expected that at some time in the future all customers would be removed from the transmission main and served from another source so the transmission main can be decommissioned and abandoned.

Cost Estimates of Water Supply Alternatives

Planning level costs were estimated for the alternatives for both capital costs and annual operations and maintenance (O&M) costs, both presented in 2008 dollars. The capital cost estimates include all project costs, which consist of design, construction, administration, permitting, and sales tax.

A summary of the capital cost estimates for the water supply alternatives is presented in **Table 8-1**. The summary of O&M cost estimates for the alternatives is presented in **Table 8-2**. Projected O&M cost estimates for the alternatives is shown in **Table 8-3**. While **Table 8-2** presents a comparison of O&M costs of the alternatives specifically for the "Average Supply" quantities shown, **Table 8-3** illustrates projected O&M costs for total system demands estimated for each year shown. In other words, **Table 8-3** includes O&M costs for the portion of supply from each alternative and O&M costs for the portion of supply from Everett, since some supply from Everett is needed for all of the alternatives. The cost estimates in these tables are used in **Section 9** to develop present value costs for the alternatives and to assist in the financial analysis portion of this study.

Table 8-1
Planning Level Capital Cost Estimates

Water Supply Alternative		Max Capacity (MGD)	Planning Level Capital Cost Estimate 2008 $$ Supply Facility	Other Improvements (see below)		Total Project Cost
1	Existing Direct Filtration WTP	1.7	$2,877,000	a	$900,000	$3,777,000
2	RBF Intake at Existing WTP	1.7	$4,205,000	a, d	$1,380,000	$5,585,000
3	Existing Direct Filtration WTP Upgraded	2.16	$3,277,000	a	$900,000	$4,177,000
4	RBF Intake at Existing WTP Upgraded	2.16	$4,500,000	a, d	$1,380,000	$5,880,000
5	Expanded WTP with Conventional Treatment	3.23	$5,035,000	a, b	$1,500,000	$6,535,000
6	RBF Intake at Existing WTP Expanded	3.23	$4,605,000	a, b, d	$1,980,000	$6,585,000
7	Membrane Filters at Existing WTP Expanded	3.23	$6,483,000	a, b	$1,500,000	$7,983,000
8	New WTP Downstream w/Surface Intake	3.23	$8,700,000	a, c, e	$2,460,000	$11,160,000
9	New WTP Downstream w/RBF Intake	3.23	$8,400,000	a, c, e	$2,460,000	$10,860,000
10	New Groundwater Wells Near City	3.23	$11,000,000	a, c, e	$2,460,000	$13,460,000
11	Everett Supply Entire System	Existing meter stations		c, e, f	$1,860,000	$1,860,000

Related Improvements Required for Alternatives Above:		Capital Cost
a	Distribution system pump station (222 to 358 Zone) to expand use of City source	$900,000
b	Finished water pump station at WTP if using existing transmission main	$600,000
c	Alternative supply to all transmission main customers from PUD	$610,000
d	Decommissioning of dam, intake and fish ladder	$480,000
e	Decommissioning of dam, intake, fish ladder and existing WTP	$950,000
f	222 Zone PRV/control station to supply entire system with Everett water	$300,000

Notes:

- WTP = water treatment plant, RBF = riverbank filtration.
- Transmission main replacement assumed to be required beyond 20-year planning period; costs not included above.
- Everett supply required for all alternatives to serve high pressure zones and meet future peak system demands.

Table 8-2
Alternatives O&M Cost Comparison

Water Supply Alternative	Max Capacity (MGD)	Average Supply (MGD)	Planning Level O&M Cost Estimate 2008 $$ Supply Facility	Other Improvements (see below)		Total Annual O&M Cost
1 Existing Direct Filtration WTP	1.7	0.71	$410,000	a	$3,000	$413,000
2 RBF Intake at Existing WTP	1.7	0.71	$400,000	a, d	$3,000	$403,000
3 Existing Direct Filtration WTP Upgraded	2.16	0.90	$440,000	a	$7,000	$447,000
4 RBF Intake at Existing WTP Upgraded	2.16	0.90	$430,000	a, d	$7,000	$437,000
5 Expanded WTP with Conventional Treatment	3.23	1.35	$515,000	a, b	$16,000	$531,000
6 RBF Intake at Existing WTP Expanded	3.23	1.35	$500,000	a, b, d	$16,000	$516,000
7 Membrane Filters at Existing WTP Expanded	3.23	1.35	$490,000	a, b	$16,000	$506,000
8 New WTP Downstream w/Surface Intake	3.23	1.35	$555,000	a, c, e	$32,000	$587,000
9 New WTP Downstream w/RBF Intake	3.23	1.35	$540,000	a, c, e	$32,000	$572,000
10 New Groundwater Wells Near City	3.23	1.35	$450,000	a, c, e	$32,000	$482,000
11 Everett Supply Entire System	n/a	1.35	$470,000	c, e, f	$22,000	$492,000

Related Improvements Required for Alternatives Above:		O&M Cost
$a_{1.7}$	Distribution system pump station (222 to 358 Zone) to expand use of City source	$3,000
$a_{2.16}$	Distribution system pump station (222 to 358 Zone) to expand use of City source	$7,000
$a_{3.23}$	Distribution system pump station (222 to 358 Zone) to expand use of City source	$16,000
b	Finished water pump station at WTP if using existing transmission main	$0
c	Alternative supply to all transmission main customers from PUD	$16,000
d	Decommissioning of dam, intake and fish ladder	$0
e	Decommissioning of dam, intake, fish ladder and existing WTP	$0
f	222 Zone PRV/control station & five metered stations	$6,000

Notes:

- Annual costs shown are based on "Average Supply" quantities shown and do not represent 2008 demand levels.
- WTP = water treatment plant, RBF = riverbank filtration.
- "Average Supply" based on "Max Capacity" and City's 2.4 peak day demand/average day demand peaking factor.
- Assumes City continues service to transmission main customers for next 20 years.
- Alternative 11 O&M cost estimate for "Supply Facility" portion is based on Everett's 2008 rates for wholesale water purchased.
- Everett supply required for all alternatives to serve high pressure zones and meet future peak system demands.

Table 8-3
Alternatives O&M Cost Projections

Water Supply Alternative	Max Capacity (MGD)	System-Wide Water Supply Total Annual O&M Cost Projections 2008	2018	2028
1 Existing Direct Filtration WTP	1.7	$553,000	$1,115,037	$1,915,924
2 RBF Intake at Existing WTP	1.7	$543,000	$1,101,598	$1,897,863
3 Existing Direct Filtration WTP Upgraded	2.16	$517,000	$1,010,731	$1,757,332
4 RBF Intake at Existing WTP Upgraded	2.16	$507,000	$997,291	$1,739,271
5 Expanded WTP with Conventional Treatment	3.23	$503,000	$842,519	$1,363,178
6 RBF Intake at Existing WTP Expanded	3.23	$489,000	$822,360	$1,336,086
7 Membrane Filters at Existing WTP Expanded	3.23	$481,000	$808,921	$1,318,025
8 New WTP Downstream w/Surface Intake	3.23	$554,000	$917,778	$1,473,351
9 New WTP Downstream w/RBF Intake	3.23	$542,000	$897,620	$1,437,228
10 New Groundwater Wells Near City	3.23	$464,000	$783,387	$1,274,678
11 Everett Supply Entire System	n/a	$380,000	$1,130,000	$2,020,000

MSA

SECTION 9

General

This section presents the economic and financial analysis of the 11 alternatives presented in **Section 8.** The financial analyses include identification of the full lifecycle costs of each alternative and ranking based on the net present value (NPV) of each alternative, a financial forecast to calculate the annual cash flow needs of each alternative and the resulting bimonthly rate impact, a system connection charge update that includes the addition of future capital costs and capacity increases, and finally a summary of potential funding sources for the alternative that will be pursued by the City.

Net Present Value

Each of the 11 alternatives presents a unique combination of operations and maintenance (O&M) expenses, capital costs, and varying levels of both City water system capacity and City of Everett water. NPV is a standard method for using the time value of money to appraise long-term project costs. A NPV comparison cannot, and is not intended to, present the entire basis for decision-making because costs are ultimately borne by customers through utility rates and charges, which can have a complex relationship to capital and operating costs.

The key assumptions used in the development of the net present value calculations are as follows:

1. Capital cost projections based on 20-year planning period, except for replacement of transmission main, which were provided in 2008 dollars and escalated by 6% annually in near-term.
2. Transmission main replacement assumed to take place in 2031 for $18 million in 2008 dollars under Alternatives 1-7, which utilize the existing water treatment plant (WTP) site.
3. Alternatives 8-11 include the capital cost of alternative water supply of PUD purchased water to all transmission main customers.
4. O&M estimates based on average cost per million gallons of supply in 2008 dollars, escalated thereafter by 3% annually.
5. Discount rate of 5% used. [Essentially, the discount rate helps compare side-by-side alternatives that have differing tradeoffs between upfront capital costs and ongoing operating costs.]
6. Everett is assumed to continue to supply the City's 368 Zone and 418 Zone in all alternatives, and will continue to provide additional supply whenever the City's own source of supply cannot meet City demands.
7. Everett wholesale water rates per million gallons are per Everett ordinance through 2012, and projected thereafter by a combination of methods that result in an average annual increase of 4.3%.

Net Present Value Results

Table 9-1 presents the results of the NPV portion of the analysis. The first column of costs shows the total NPV without considering the replacement of the transmission main. The second column of costs shows the total NPV including full replacement of the transmission main in year 2031.

Table 9-1
Water Supply Alternatives Net Present Value Comparison

2009 Net Present Value Summary (2010-2039 Costs)		Without Transmission Main Replacement	With Transmission Main Replacement
1	Existing Direct Filtration WTP	$24,886,776	$39,378,307
2	RBF Intake at Existing WTP	$26,641,809	$41,133,341
3	Existing Direct Filtration WTP Upgraded	$23,528,687	$38,020,218
4	RBF Intake at Existing WTP Upgraded	$25,170,019	$39,661,550
5	Expanded WTP with Conventional Treatment	$22,323,255	$36,814,786
6	RBF Intake at Existing WTP Expanded	$22,091,018	$36,582,549
7	Membrane Filters at Existing WTP Expanded	$23,413,956	$37,905,487
8	New WTP Downstream w/Surface Intake	$28,400,708	$28,400,708
9	New WTP Downstream w/RBF Intake	$27,789,464	$27,789,464
10	New Groundwater Wells Near City	$28,886,652	$28,886,652
11	Everett Supply Entire System	$23,603,165	$23,603,165

In order to acknowledge the variables that are difficult to capture in NPV calculations, it is imperative that the City's own source alternatives (1-10) are first compared to one another. Not only is it difficult to weigh the benefits of the City's water autonomy in economic terms, but the Everett wholesale rate that forms much of the basis for the NPV of alternative 11 is based on an assumed rate escalation factor of 4% annually after 2018 and is highly sensitive to this assumption. If the Everett average annual wholesale rate were to increase instead by 6.4% annually after 2018, the NPV of Alternative 11 would be nearly identical to that of Alternative 9.

Most of the supply alternatives at the existing WTP site (1-7) would be superior economic decisions if the transmission main did not require replacement, as shown in column of **Table 9-1** titled "Without Transmission Main Replacement". This is placed alongside the column titled "With Transmission Main Replacement" to illustrate that replacement of this main, if indeed necessary around 2031, should have a bearing on the comparison as it presents a large capital obligation at the end of the planning period that would be avoided with Alternatives 8-10.

Alternative 11, which assumes 100% of water supply is received from Everett and no supply from the City's own source, should be assessed relative to the most affordable City alternatives after the latter are holistically evaluated.

Financial Forecast

The financial forecast developed for each alternative is intended to identify the monthly rate impact over a period of 25 years to the average single family customer. In this study, the average single family customer is defined as a customer with a 5/8" meter that uses 1,400 cubic feet of water per bimonthly period. The key factors used to develop the financial forecast include the following:

1. The analytical rate module developed in 2007 for the City was used as a baseline for the rate comparison. Only information essential to the comparison of rate alternatives was updated. This includes the costs titled "treatment" in the City's budget, the cost of water purchased from Everett, and the amount of assumed debt financing and corresponding debt service.
2. Revenue bond debt (5.0%, 20 years, 2% issuance costs) is assumed to fund all capital projects. No grants or low-interest loans are assumed.
3. Alternatives 1-7 include the assumption of transmission main replacement in the year 2031, and the corresponding debt service of approximately $3.5 million associated with this project is clearly detectable in the year 2033 rate under those alternatives.
4. Design of water supply alternative improvements is assumed to occur in 2010, and construction is assumed to occur in 2011 and 2012.

Other factors that come into play with respect to rates include the timing of other capital projects for expansion and replacement and the rate/extent that the City replaces Everett water supply with its own.

Financial Forecast Results

Table 9-2 depicts a rate projection under each of the 11 alternatives, beginning with the bimonthly charge that would be paid by a single family home that uses 1,400 cubic feet in a bimonthly cycle. The rate projection begins in 2009, assuming current rates, and thereafter incorporates debt service, operating costs which account for the alternative-specific combination of Everett and City water at growing City demand, and slightly different system connection charge revenue under each of the alternatives. All other costs are consistent with the rate analysis completed in 2007 with 2007 budget information. Please refer to the 2007 study documentation for more information on those study assumptions that remain constant for all alternatives.

Table 9-2
Water Supply Alternatives Rate Impact Projection Comparison

Single Family Residential Bimonthly Sample Bills (5/8" meter with 14 ccf of usage in a bimonthly period)							
Alt.	2009	2011	2013	2018	2023	2028	2033
1	$66.10	$69.59	$88.55	$100.49	$118.72	$140.81	$298.17
2	$66.10	$73.54	$94.87	$106.39	$124.21	$145.91	$304.72
3	$66.10	$70.45	$87.35	$98.33	$115.87	$137.19	$294.76
4	$66.10	$74.19	$93.29	$103.87	$121.03	$141.97	$300.64
5	$66.10	$75.63	$91.33	$99.95	$115.10	$133.51	$291.63
6	$66.10	$75.74	$91.02	$99.54	$114.59	$132.87	$291.00
7	$66.10	$78.82	$95.89	$104.05	$118.76	$136.71	$295.62
8	$66.10	$85.78	$110.96	$119.05	$132.14	$150.45	$152.48
9	$66.10	$85.13	$108.79	$116.82	$131.26	$149.13	$150.91
10	$66.10	$90.77	$119.45	$125.58	$135.39	$151.40	$152.77
11	$66.10	$69.41	$79.42	$94.04	$113.45	$137.45	$148.77

It must be noted that these rate projections are for comparison purposes only, and do not represent policy recommendations. More up-to-date information would be required to implement an actual rate increase, and rates would be set only for the near term. The dollar amounts of rate projections are tenuous at best beyond 5 years.

These rate projections are useful in assessing the relative pace and final level of increases required to annually pay for the debt service and operating costs that are unique to each alternative. Alternatives that require significant debt service to complete construction projects will show immediate rate impacts, but may be less expensive to operate in the long term.

Ultimately, there are subjective criteria and further information that must be weighed externally to the financial and economic analysis. Construction of a water supply facility that eliminates nearly all of the City's dependence on Everett water may be desirable from a risk perspective. Some of the alternatives may be likelier to be eligible for low-interest loans and grants than others, and any such funding availability may weigh into a comparison between City source alternatives (1-10) and the Everett alternative (11). Water supply expansion to utilize all water rights under Alternatives 5-10 may prove costlier than current estimates in an ever-changing litigation environment.

System Connection Charge Analysis

Included as a part of the economic and financial analysis is an update of the City's existing water system connection charges. Connection charges are imposed on new development or expanded connection to the system as a condition of service. The charge represents a prorated share of the cost of providing system capacity. Unlike setting water utility rates, system connection charges must be calculated based on the intent and structure identified in the Revised Code of Washington (RCW) for Cities and Towns 35.92.025.

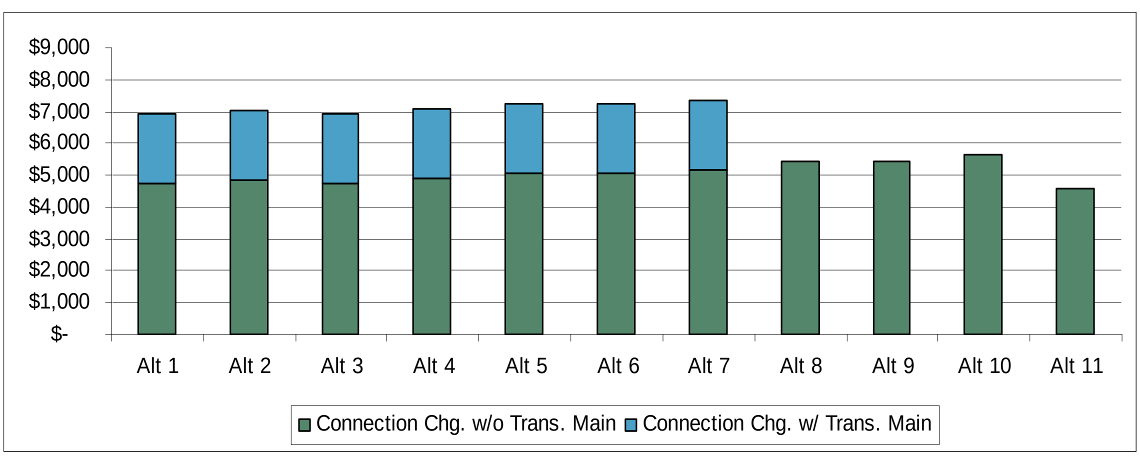
The methodology used to provide a cursory update of the City's water system connection charges is as follows:

1. Original cost of existing water system assets was determined (end of year 2004 most recent asset listing available).
2. Distribution mains were deducted from asset listing and replaced with comprehensive inventory provided by City.
3. Included 10 years of interest
4. Deducted value of facilities donated or granted.
5. Deducted provision for depreciation (assets replaced by future projects)
6. Included all future capital identified by each alternative in this study
7. Total water right capacity (3.23 MGD) used as basis for equivalent unit valuation (7,319 total equivalent residential unit capacity)

System Connection Charge Results

The results of the analysis indicate the system connection charge for the 11 alternatives ranges from approximately $4,700 to $5,600 without the replacement of the transmission main included, as shown in **Table 9-3**. An additional $2,179 is added to the connection charge when the replacement of the transmission main is included (Alternatives 1-7) resulting in a connection charge in the range of approximately $6,900 to $7,350. Alternatives 8–11 are not subject to the transmission line replacement cost and range from approximately $4,600 to $5,650.

Table 9-3
Water Supply Alternatives System Connection Charge Comparison



The City's current connection charges, which consists of a capital facilities charge and a utility connection charge, total $2,580. It is apparent from the connection charge update that the City's current charge is below the calculated value of the water facilities identified. It is recommended that the City complete this connection charge calculation when the City moves forward with a selected alternative. Completion of the analysis should include identifying the additional assets from 2004 – 2008 and include the future capital costs associated with the alternative selected. Future capital costs should be included in an approved capital plan, such as the City's Comprehensive Water System Plan.

Washington State Funding Programs

A number of funding programs in Washington State offer financial assistance for construction projects that benevolently affect water quality and the environment. Eligibility for each of these programs may vary depending on the alternative presented. The availability of funds in each of the programs is in constant flux. Recent federal activity indicates that infrastructure money may become available in the near future, including funds for water projects.

A matrix summarizing various funding programs in the state of Washington is included in **Appendix D**, and includes a general description of eligibility criteria and program summaries for a number of agencies that can be utilized as a starting point towards an assessment of funding availability. Each government funding agency distributes funding in a competitive fashion, and it is hard to predict the manner in which it will be distributed.

Upon selection of a water supply alternative, it would be useful to contact a Public Works Board representative to explore the availability of a "technical team" that can assist the City in assessing the availability of funding from various agencies. Terry Dale, in Client Services, is available at (360) 725-3155 to address City questions about such assistance.

General

This section presents an evaluation of the water supply alternatives for meeting the water supply needs of the City of Snohomish for the next 20 years. The planning level cost estimate data in **Section 8** and the financial data in **Section 9** were utilized in the evaluation of alternatives.

Summary of Water Supply Alternatives

The following water supply alternatives, which are described in **Section 8**, were evaluated using criteria developed for this study.

- Alternative 1 – Existing Direct Filtration WTP (1.7 MGD)
- Alternative 2 – Riverbank Filtration Intake at Existing WTP (1.7 MGD)
- Alternative 3 – Existing Direct Filtration WTP Upgraded (2.16 MGD)
- Alternative 4 – Riverbank Filtration Intake at Existing WTP Upgraded (2.16 MGD)
- Alternative 5 – Expanded WTP with Conventional Treatment (3.23 MGD)
- Alternative 6 – Riverbank Filtration Intake at Existing WTP Expanded (3.23 MGD)
- Alternative 7 – Membrane Filters at Existing WTP Expanded (3.23 MGD)
- Alternative 8 – New WTP Downstream with Surface Water Intake (3.23 MGD)
- Alternative 9 – New WTP Downstream with Riverbank Filtration Intake (3.23 MGD)
- Alternative 10 – New Groundwater Wells Near City (3.23 MGD)
- Alternative 11 – Everett Supply Entire System

Key Issues and Assumptions

The key issues and assumptions identified and documented in **Section 8** were considered in the evaluation of water supply alternatives. A summary of the key issues and assumptions is provided below.

Key Issues

- <u>Cost of Water Supply</u> – Existing and future costs, including both capital and annual operations and maintenance (O&M) costs. Cost information is presented in **Section 8** and **Section 9**.
- <u>Transmission Main Future Replacement Costs</u> - The 15-mile long transmission main that carries treated water from the Pilchuck River WTP to customers within the City will eventually reach the end of its useful service life and need replacing. The cost to replace this long pipeline will be significant, as discussed in **Section 7** of this report.

- Water Service to Transmission Main Customers – The City provides water service to approximately 93 customers that are directly connected to the transmission main and supplied with treated water from the City's Pilchuck River WTP. The City will need to make arrangements for an alternative method of providing water service to these customers if the Pilchuck River WTP is abandoned in the future. Options to serve these customers have been identified and are described in **Section 8**.
- Water Rights – The City has sufficient water rights for its Pilchuck source to meet current demands, but not enough to meet the future demands of the entire water system, requiring either additional water rights or continued purchases of Everett water supply. A court case underway at the time of this writing may result in an outcome that will impact water rights held by municipal water suppliers like the City of Snohomish. The City's water rights are summarized in **Section 3**.
- Dam, Intake and Fish Ladder – The City's diversion on the Pilchuck River, which includes an intake structure, dam, and fish ladder, is in need of improvements. The amount of required improvements to maintain the diversion on the Pilchuck River will likely increase during the next 20 years, due to the frequently changing regulatory requirements and the increasing need to protect fish. A description of the current diversion system and improvement needs is included in the technical memorandum in **Appendix B**.

Assumptions

- Transmission Main – It is assumed that the existing finished water transmission main, which is needed for Alternatives 1 through 7, will remain in service during the 20-year planning period, but will eventually need to be replaced. For the purpose of this study, it is assumed that replacement will occur soon after the end of the 20-year planning period.
- Distribution System Pump Station - It is assumed that all supply alternatives utilizing the City's own source will include a pump station within the distribution system to enable more of the City's own source to be used by pressure zones other than the 222 Zone.
- Property Acquisition Costs – It is assumed that the supply facilities for Alternatives 8 through 10 will be located within the City limits, possibly on property currently owned by the City. It is also assumed that costs related to property acquisition for these alternatives will be offset by the proceeds from the assumed sale of the City's property at the current WTP site. Therefore, property acquisition costs are not included in the costs estimates for the supply alternatives.
- Everett Supply - It is assumed that the City will continue to purchase water from Everett throughout the planning period for all supply alternatives, since Everett water is needed to serve the City's higher elevation pressure zones (368 and 418 Zones) and to meet the increased demands of the system in the future.

Evaluation of Water Supply Alternatives

Evaluation Criteria

The water supply alternatives were evaluated using criteria presented and discussed below.

- Capital Costs – This criteria includes all project costs associated with capital improvements for the supply alternatives, as described in **Section 8**.
- Operations and Maintenance Costs – This criteria includes all annual costs associated with the operations and maintenance of the supply alternatives, as described in **Section 8**.
- Complexity of Operations and Maintenance – This criteria considers the complexity of the day-to-day O&M requirements of the alternatives and potential O&M issues.
- Supply Redundancy – This criteria considers the ability of each alternative, when combined with the existing supply from Everett, to provide the City with a redundant source of supply.
- Risks – This criteria considers potential risks associated with each alternative. Some example elements of risk include the following:
    - Water rights legal outcome, ability to acquire more, and cost to maintain
    - Future Pilchuck River flows (may be less than current flows)
    - Hydrogeology of river bank (may not be suitable for riverbank filtration)
    - Hydrogeology near City (may not be suitable for groundwater wells)
    - Downstream surface water intake on Pilchuck River (may not be allowed)
    - Transmission main reliability (may require early replacement)
    - Transmission main customers (service obligations, costs, service options)
    - Future Everett rate increases (may be more than estimated)
    - Future regulatory requirements (may restrict use of Pilchuck River source, require improvements, and add costs to maintain diversion system)
- Protected Watershed – This criteria considers the existing watershed of the City's Pilchuck source, Everett's source, and the anticipated level of protection of the downstream alternatives (Alternatives 8 through 10).
- Other Criteria – The criteria listed above are the primary criteria used in the evaluation of alternatives. Other criteria considered, but with less of an influence on the evaluation, include: supply ownership/independence, avoid facilities within the river, full utilization of water rights, revenue from transmission main customers, and minimizing unknowns.

Evaluation Results

The water supply alternatives were evaluated and scored by City staff, which resulted in a list of alternatives ranked from lowest to highest. The evaluation was based on a matrix of weighted criteria that was developed by City staff, utilizing elements of an initial matrix developed by MSA and the technical information provided within this study. The matrix used to evaluate the alternatives is included in **Appendix E**.

The results of the evaluation ranked Alternative 11 (Everett Supply Entire System) the highest among all alternatives and substantially higher than the others. Costs are most important to the City among all criteria, both near-term capital costs and ongoing O&M costs. As a result, the City assigned 30 percent of the total weighting to capital costs and 20 percent to O&M costs. The Everett supply alternative has the lowest near-term capital costs among all alternatives and annual O&M costs that are comparable to the other alternatives. The Everett supply alternative also has the least impact on customer rates, especially in the future when the transmission main will need to be replaced for Alternatives 1 through 7.

Recommended Next Steps

Based on the results of the evaluation and intent to pursue the all Everett supply alternative, it is recommended that the City plan for the following next steps:

1. Initiate discussions with the regulatory agencies on decommissioning of the dam, intake structure, fish ladder, and water treatment plant.
2. Pursue funding programs that would offer favorable grants and low interest loans for removal of the diversion system from the Pilchuck River.
3. Conduct a study to research and investigate property records along the transmission main alignment to locate and document all easements, rights granted by the easements, and conditions imposed by the easements. The pipeline corridor and associated easements are a valuable asset that the City owns and should be well documented prior to pipeline abandonment and negotiation with others.
4. Initiate discussions with Snohomish County PUD regarding interim supply to transmission main customers, transfer of transmission main customers to the PUD's water system, and potential purchase of the transmission main and its easements.
5. Develop a plan to provide an alternative supply of water to approximately 93 City customers that are directly connected to the transmission main and a follow-up plan to decommission the transmission main. Options to serve the transmission main customers have been identified and are described in **Section 8**.
6. Conduct a study of the City's existing water rights that includes a valuation of the water rights and a marketing plan for a potential sale of the water rights.
7. Initiate design of capital improvements to provide the capability to supply the entire system with water from Everett. This includes decommissioning the City's Pilchuck River supply facilities, a new pressure reducing station with reservoir level control capabilities to supply the 222 Zone with Everett water, and a new intertie with the PUD's Lake Roesiger system to provide interim supply to the transmission main customers until a long-term solution is identified.

MSA

APPENDIX A

MSA
Murray, Smith & Associates, Inc.
Engineers/Planners
2707 Colby Avenue, Suite 1110 ▪ Everett, WA 97201-3566 ▪ PHONE 425.252.9003 ▪ TOLL-FREE 888.252.9003 ▪ FAX 425.252.8853

TECHNICAL MEMORANDUM

DATE: April 29, 2008

TO: Andy Sics, P.E, City of Snohomish

FROM: Andrew Szatkowski, P.E.
Thomas C. Lindberg, P.E.
Murray, Smith & Associates, Inc.

THOMAS C. LINDBERG
STATE OF WASHINGTON
30499
REGISTERED PROFESSIONAL ENGINEER
EXPIRES 7/27/08
SIGNED: 4/29/08

RE: Near-Term Water Treatment Plant Evaluation for Compliance with State of Washington Treatment Optimization Program Performance Goals

---

Introduction

Murray, Smith & Associates, Inc. (MSA) was authorized by the City of Snohomish in October 2007 to evaluate the City's existing water supply facilities (water treatment plant, Pilchuck River diversion structure, and finished water transmission main) and alternative sources of water for long-term supply to the City. The overall work program for this project consists of the following major elements:

- Determine near-term operational modifications and capital improvements at the water treatment plant to achieve compliance with current laws and regulations, and with the State's Treatment Optimization Program (TOP) performance goals for water treatment plants.
- Determine operational modifications and capital improvements needed to extend the water treatment plant's service life for another 20 years while maintaining compliance with laws, regulations and the optimization goals the City adopts.
- Develop and evaluate alternatives that will allow the City to utilize existing water rights to the maximum extent possible and reduce the purchase of water from Everett to a minimum.

- Evaluate the condition of the City's finished water transmission main from the treatment plant to the City, and make recommendations regarding capital improvements and operational modifications needed to ensure another 20 years of service life.
- Evaluate all supply alternatives available to the City, including supply options for the approximately 100 customers currently served from the City's finished water transmission main.
- Estimate capital and operating costs for all the alternatives developed, calculate net present value costs and determine the impacts of each alternative on utility rates and charges.

This technical memorandum is the first deliverable from the work program in fulfillment of the first major work element of this project: identification of near-term operational modifications and capital improvements at the water treatment plant to achieve compliance with the State's TOP performance goals.

Background

The City of Snohomish supplies drinking water to customers from two sources. The City purchases treated water from the City of Everett regional water system for supply to the City's 345-foot, 358-foot, 368-foot, and 418-foot pressure zones. The City also owns and operates a diversion on the Pilchuck River, along with a water treatment plant and finished water transmission main for supply to the City's 222-foot pressure zone.

The diversion consists of a concrete weir approximately ten feet high, a fish ladder and an intake structure. The diversion is located at River Mile 26.3 on the Pilchuck River. The intake is equipped with a traveling screen and a pump to clean the screen. Flow from the intake to the water treatment plant is by gravity.

The water treatment plant (WTP) is a direct filtration package plant built in 1981. The plant is equipped to feed coagulant and polymer prior to flocculation, and soda ash and chlorine for post-filtration pH adjustment and disinfection. Four filters with a total area of 500 ft^2 provide for up to 1,500 gpm filtration, the nominal treatment capacity of the plant.

The finished water transmission main, which is approximately 16 miles long, consists of 18-inch diameter AC water main and 12-inch diameter Permastran water main that was constructed in 1981. Approximately 100 customers spread out along the length of the finished water transmission main are served directly off this main.

The WTP is currently operated under restrictions that were imposed by the State of Washington Department of Health (DOH) in June 2006. These restrictions resulted from a sanitary survey of the City's water system conducted by the DOH Office of Drinking Water and a Comprehensive Performance Evaluation of the City's water treatment plant conducted by The Cadmus Group, an outside consultant contracted by DOH. The survey and evaluation identified a list of administrative, operational, and capital improvements needed at the City's water treatment plant.

At least one of the restrictions imposed at that time has been removed because the conditions that required the restriction have been resolved. Some of the restrictions remain. One of the existing restrictions requires that the plant be operated only when an appropriately certified operator is present at the WTP. As a result, the plant is only operated eight hours per day, requiring the City to purchase more water from the City of Everett. This restriction will remain until the WTP has filter-to-waste in place and plant controls are upgraded to include automated shut-down when particle removal or disinfection criteria are not being met.

Comparison of WTP Performance with TOP Performance Goals

The State of Washington has established requirements for treatment of surface water for public water supplies. These requirements are detailed in the Washington Administrative Code, WAC 246-290 Part 6. Subpart B of Part 6 addresses the requirements for filtered systems.

In addition to requiring strict adherence to the regulatory requirements, the State encourages all public water systems to adopt performance goals that exceed the regulatory requirements, then optimize plant operation to achieve those goals. Adoption of performance goals that exceed regulatory requirements is voluntary. The State provides assistance in optimizing performance to achieve the goals, but there are no consequences or repercussions for not achieving the goals.

The State's Treatment Optimization Program has established model treatment performance goals within three categories: turbidity monitoring, filtration performance, and disinfection. These goals are based on the relevant portion of WAC 246-290 Part 6, Subpart B; however, some of the goals are more restrictive than the requirements delineated in the administrative code. It is the opinion of the State that the TOP performance goals are achievable for treatment plants that have been properly designed and operated.

The TOP performance goals for each of the three categories are discussed below along with a brief description of whether the City's WTP facility has achieved those goals. The Cadmus Group recommended in 2004 that the City of Snohomish adopt the State's TOP performance goals or an alternative set of similar performance goals that are modeled after the State's goals. The City has posted the State's TOP performance goals at the WTP and is evaluating changes to the treatment process and operating procedures that may assist in achieving these goals.

Turbidity Monitoring Performance Goals

The State of Washington has established three TOP performance goals for turbidity monitoring.

Turbidity Monitoring Goal #1 – Monitor raw water turbidity at least every four hours

The City has a Hach 1720C turbidimeter that continuously monitors raw water turbidity. The City is meeting this goal at present and should be capable of doing so by maintaining the turbidimeter in a properly calibrated condition and by recording the raw water turbidity at the required interval at all times when the WTP is operating.

Turbidity Monitoring Goal #2 – Continuously record effluent turbidity for each filter

The City has installed four US Filter TMS 561 turbidimeters, one for each of the filters and all four have been wired to a four-pen chart recorder that continuously records effluent turbidity. The City is meeting this goal at present and should be capable of doing so without further modification of plant equipment or operations.

Turbidity Monitoring Goal #3 – Continuously record combined filter effluent (CFE) turbidity

The City has a Hach 1720C turbidimeter that continuously monitors combined filter turbidity. This unit is wired to a single-pen chart recorder that continuously records effluent turbidity. However, there is at present an issue regarding the lack of a representative CFE sample.

WAC 246-290-664 requires that the WTP facility "Continuously monitor turbidity on representative samples from each individual filter unit and from the system's combined filter effluent, prior to clearwell storage." At the WTP, the sample point for each individual filter turbidimeter is the outlet pipe from which all filter effluent leaves the filter. This fulfills the State's requirement regarding a "representative sample" for individual filter effluent values. However, the CFE sample does not currently constitute a "representative sample." This is due to the location from which the CFE samples are drawn, as discussed below.

Currently, a sample is drawn from each filter and the samples are combined for the CFE monitoring. Individual filter samples are drawn from the head loss sight tube for each filter. The site tubes are connected to ports in the underdrains of the filters. This sample port arrangement is fine for measuring pressure in the underdrain or head loss through the filter, but it is not acceptable for sampling the filter effluent in the underdrain for two reasons. First, the individual filter samples are drawn from tee's that were cut into the sight tubes fairly high in the sight tube. When head loss through the filter exceeds approximately three feet, the water level in the sight tube falls below the location of the tee and that filter no longer contributes a sample to the CFE sample. Second, even when the water level in the sight tube is above the elevation of the tee, the small flow drawn through the sample port in the underdrain only reflects the filter effluent quality in the immediate vicinity of the sample port. If breakthrough occurs in an area of the filter other than the location of this port, the high turbidity water could easily exit the filter through the filter effluent piping without an increase in turbidity registering in the CFE sample.

Therefore, to comply with the State requirement for a representative sample, the sample point for the CFE sample must be relocated. The best location to obtain a representative sample of CFE is at the combined filter effluent piping before it penetrates the floor slab inside the WTP. The City should install a tap in the vertically oriented 90 degree bend in the CFE piping just above the floor slab and draw all the water for CFE monitoring from this single sample point.

Filtration Performance Goals

Data from 2004 through 2007 were analyzed to determine if the WTP has achieved these goals. The data for the early part of this period may not be representative of current plant performance because the turbidity performance requirements delineated in WAC 246-290-660 changed during this period and plant operations have been modified somewhat since DOH imposed restrictions on the WTP facility in June 2006.

Prior to January 14, 2005, the regulations required that the maximum daily CFE turbidity be less than 0.5 NTU 95 percent of the time and never exceed 5.0 NTU. After that date, the requirements were reduced to less than 0.3 NTU 95 percent of the time and never exceed 1.0 NTU. From 2004 through 2006, the finished water turbidity at the WTP was below 0.24 NTU 95 percent of the time. The 95^{th} percentile varied slightly during the 3-year period: 0.28 NTU in 2004, 0.22 NTU in 2005, and 0.24 NTU in 2006. The higher value for the 95^{th} percentile in 2004 reflects the higher turbidity values that were allowed by the regulations until January 14, 2005. The 95^{th} percentile for 2007 was 0.26 NTU.

In 2004, the maximum combined filter effluent was greater than 0.3 NTU on eleven days and the maximum CFE recorded that year was 2.4 NTU. This reflects the operation of the facility to meet the less stringent regulatory requirements in effect at that time. The maximum combined filter effluent exceeded 0.3 NTU twice in 2005 and the maximum recorded CFE value for that year was 0.32 NTU. In 2006, the maximum combined filter effluent exceeded 0.3 NTU only once when the value was 1.22 NTU. In 2007, the maximum combined filter effluent never exceeded 0.3 NTU.

The State of Washington has established five TOP performance goals for turbidity removal by filtration.

Filtration Goal #1 – 95^{th} Percentile for CFE turbidity less than 0.1 NTU

The first filtration performance goal is to maintain a filtered water turbidity of less than 0.1 NTU 95 percent of the time. This is based on the maximum CFE turbidity measured each day that the plant is in operation. For plants that do not have filter-to-waste, the first 15 minutes after backwash is excluded for determining the maximum daily value. This goal is more restrictive than the regulations, which require CFE turbidity to be less than 0.3 NTU 95 percent of the time.

As noted above, the 95th percentile for CFE turbidity varied slightly over the four year period from 2004 through 2007 as follows: 0.28 NTU in 2004, 0.22 NTU in 2005, 0.24 NTU in 2006; and 0.26 NTU in 2007. For 2004, only 68 percent of maximum daily CFE values were less than 0.1 NTU. For 2005 through 2007, the corresponding figures were 74 percent, 73 percent, and 69 percent, respectively. Filtration Goal #1 was not achieved in the period 2004 through 2007. However, the WTP is meeting the regulatory requirements for this filtration measure.

Filtration Goal #2 – Turbidity Less Than 0.1 NTU within 15 Minutes of Operation

The second filtration performance goal is to achieve a filter effluent turbidity below 0.1 NTU within 15 minutes of placing the filter into production. This applies to operation after backwashing and when the WTP is initially placed in service after it has been shut down, which is common for plants that do not operate continuously 24 hours a day, 7 days a week.

The Cadmus Group reported in 2006 that the WTP did not achieve 0.1NTU within 15 minutes of placing the filters into production when they conducted their Comprehensive Performance Evaluation (CPE) that year. However, it was observed on November 20, 2007 that the filters did achieve this goal after backwashing on that day.

To clarify whether this goal is being achieved, twenty circular charts of filter effluent turbidity from 2007 were reviewed. The charts were a random assortment of days from the months of April, May, June, July, and September. Each chart covered a period of 3 to 4 days. Backwash cycles were most often performed in the morning when the plant was first started. Typically, all three filters were backwashed sequentially and were backwashed for the same period of time. On some days, the filter effluent turbidity chart recorder was not turned on at the start of the day. Instead, the recorder was turned on after backwashing of the filters had already been initiated. The data from these days were not used in this analysis. On several days, the charts had only two pens in operation instead of three. The lead WTP operator has confirmed that the operators occasionally have trouble with the chart recorder pens.

The circular charts provided were black and white. Without different pen colors to identify each filter, there was difficulty differentiating the individual filter effluent turbidities where the values overlapped. Most days required interpretation to identify exactly where each filter was within the backwash cycle because of overlapping lines during backwash.

Eighty-eight backwash cycles were analyzed. Of these, only forty-one appeared to have achieved a filter effluent turbidity of 0.1 NTU within 15 minutes of being returned to service after backwashing. Thus, based on these data, it appears that the WTP is only meeting Filtration Goal No. 2 about half the time. The time required to achieve filter effluent turbidity of 0.1 NTU after backwashing ranged from 5 to 35 minutes, with the average being 17 minutes. The spring months of April and May had a higher percentage of days that met the goal than did the summer months of June, July and August. The circular charts do not identify which filter is represented by which pen, therefore it is not possible to determine if one filter is operating better than another.

Filtration Goal #3 – CFE Turbidity Never Exceeds 0.3 NTU

The third filtration performance goal is to maintain filtered water turbidity at 0.3 NTU or less at all times. This goal is more restrictive that the regulatory requirement to maintain CFE turbidity less than 0.3 NTU 95 percent of the time and to never exceed CFE turbidity of 1.0 NTU.

This goal was not achieved during 2004 when the regulatory requirements were not as stringent as current requirements and CFE turbidity exceeded 0.3 NTU eleven times. CFE turbidity exceeded 0.3 NTU twice during 2005 and once during 2006. CFE did not exceed 0.3 NTU during 2007. Therefore, it appears that current equipment and operation should allow operators to continue to achieve this goal in the future.

Filtration Goal #4 – Backwash filters before breakthrough

The fourth filtration performance goal is to backwash filters prior to breakthrough. During the period 2004 through 2006, the filters were, for the most part, removed from service prior to breakthrough or as breakthrough was being detected through turbidity increases. However, backwashing prior to breakthrough was not consistently achieved during those years. Now that all filters have functioning turbidimeters, this goal should be achievable.

Filtration Goal #5 – Raw Water Turbidity Changes Do Not Affect Filtered Water Turbidity

The fifth filtration performance goal is that filtered water turbidity should not be affected by changes in raw water turbidity. Review and analysis of the data from 2004 through 2006 indicate there is a correlation between raw water turbidity and maximum daily CFE turbidity. This goal is more readily achieved with conventional filtration, which includes a sedimentation basin, than with the City's WTP that utilizes direct filtration. Therefore, it is not surprising that the plant has not achieved this goal and it is possible that this plant may not be capable of achieving this goal as long as it is operated as a direct filtration facility.

Disinfection Performance Goal

The Treatment Optimization Program has one goal for disinfection: to achieve the regulatory requirement for CT values at all times. Another way of stating this is that the plant must maintain an Inactivation Ratio (IR) of 1.0 or greater at all times.

The following provides a brief summary of CT calculations performed by others in the past. DOH approved a CT calculation for the City's WTP on September 23, 1993, but currently considers this CT calculation invalid. DOH invalidated this CT calculation after a Sanitary Survey in May 2005 determined that at least one customer within the vicinity of the WTP was located closer than the first customer served by the WTP that was used in the 1993 calculation. Since the 2005 Sanitary Survey, DOH has been under the impression that customers in the vicinity of the WTP are connected to the transmission main. This appears to be the basis of DOH's decision to invalidate the previously approved CT calculations.

At the present time, DOH is expecting CT compliance to be met for two separate supply areas that receive water from the WTP. The first is the supply of treated water through the transmission main from the WTP to the City's 222 Zone reservoirs, including service to approximately 100 customers that are located along the transmission main. The second includes the supply of treated water to the WTP and the nearby City-owned house, which is occupied by the lead WTP operator. Supply of treated water to the WTP is used for surface washing during backwash, chemical feed systems, the lavatory, and laboratory sinks. Water supply to the WTP and operator's house is accomplished with two pumps, which draw treated water directly from the clearwell, and a hydropneumatic tank, which maintains pressure at the WTP between approximately 40 and 60 psi.

DOH is requiring that sufficient CT be achieved for supply to the transmission main customers, the WTP, and the nearby lead operator's house. Neither the WTP nor the lead operator's house has sufficient contact time to meet the disinfection requirement. It is anticipated that DOH will require improvements, as necessary, to meet the CT requirements for all of these. Subsequently, the WTP operators will need to report two separate CT calculations: one for the first customer on the transmission main and one for supply to the WTP and lead WTP operator's house.

The CT analysis that was approved by DOH on September 23, 1993 and recently invalidated was for the transmission main only. The calculation was based on the first customer being 6,515 feet from the point where the finished water transmission main exits the clearwell. This represents a contact volume of approximately 86,100 gallons, based on the 18-inch diameter pipe. EarthTech conducted a CT analysis for the City in 2005. According to a memo from EarthTech to the City, dated March 21, 2005, EarthTech was instructed by the City Engineer to base that analysis on a distance of 5,500 linear feet to the first customer.

The first customer on the transmission main is located at 3124 Robe-Menzel Road, according to City records. Based on our review of the stationing used in the 1967 design drawings for the replacement of the upper 5.8 miles of transmission main, this customer is located approximately 6,515 feet from the WTP. Therefore, it appears that the CT calculation that the City has used since 1993 for the transmission main is valid and does not need to be altered. If the City has data indicating that the first customer is less than 6,515 feet from the WTP clearwell, then DOH must be informed and a new calculation for contact time along the transmission main must be submitted for DOH to review and approve.

DOH will require that an inactivation ratio of 1.0 be achieved at all times for the WTP operator's house and likely for the WTP as well. There appears to be sufficient space on the

WTP site to install a length of large diameter pipe that will provide sufficient contact time for treated water that is supplied to the WTP and the operator's house.

Summary of WTP Achievement of TOP Performance Goals

The following summarizes the discussion above regarding the WTP's current status in achieving the TOP performance goals.

Turbidity Monitoring Goal #1 – Monitor raw water turbidity at least every four hours

Yes, this goal is currently being met.

Turbidity Monitoring Goal #2 – Continuously record effluent turbidity for each filter

Yes, this goal is currently being met.

Turbidity Monitoring Goal #3 – Continuously record combined filter effluent (CFE) turbidity

Yes, this goal is currently being met. However, the CFE sampling point must be relocated to ensure a representative sample.

Filtration Goal #1 – 95th Percentile for CFE turbidity less than 0.1 NTU

No, this goal is not being met at the time of this writing. The 95th percentile for maximum daily CFE values was approximately 0.24 NTU for the three year period 2005 through 2007. For the year 2007 only, the 95th percentile was 0.26 NTU. For the three year period 2005 through 2007, only 71 percent of the maximum daily CFE values were less than 0.1 NTU.

Filtration Goal #2 – Turbidity Less Than 0.1 NTU within 15 Minutes of Operation

Based on the available data, it appears that this goal is not being met on a consistent basis. Filter effluent turbidity is less than 0.1 NTU within 15 minutes of operation in less than fifty percent of the data reviewed.

Filtration Goal #3 – CFE Turbidity Never Exceeds 0.3 NTU

This goal was not achieved in 2005 through 2006. However, it was achieved in 2007 and it can continue to be achieved without changes to equipment or operations.

Filtration Goal #4 – Backwash filters before breakthrough

Yes, this goal is currently being met.

Filtration Goal #5 – Raw Water Turbidity Changes Do Not Affect Filtered Water Turbidity

No, this goal is not being met at the time of this writing.

Disinfection Goal – Achieve Regulatory Requirement for CT Values at All Times

This goal is partially being met. The goal is being met for all customers on the transmission main. However, the goal is not being met for treated water that is supplied to the WTP and the nearby lead WTP operator's house.

Proposed Improvements to Existing Water Treatment Plant Facility

Modifications to Existing Facilities

Modifications Previously Identified by DOH

Filter-to-Waste: In accordance with the DOH requirements as delineated in the June 2006 memorandum from DOH to the City, the City must install filter-to-waste piping. This project is currently underway and is scheduled to be completed in 2008. Although this will not directly improve the City's ability to meet any of the performance goals, it will prevent filtered water with the initial spike of high turbidity when a filter is returned to service after backwashing from entering the distribution system. Installation of these improvements is particularly important given the fact that the WTP is only achieving Filtration Goal #2 less than fifty percent of the time.

Automated Shutdown: If the City intends to operate the plant without the operators present at the facility, an automated shutdown capability must be installed. This is in accordance with the June 2006 memorandum from DOH. Automated shutdown capability may only have a marginal impact on the ability of the operators to achieve the TOP performance goals. The primary benefit of an automated shutdown system would be to maximize the use of the facility since it would allow production at times when an operator is not present. This improvement is currently under design and is scheduled to be completed in 2008. Upon completion of this improvement and work necessary to place the fourth filter back in service, which is described below, the WTP will be capable of producing more treated water than in the past.

Modifications to Achieve Turbidity Monitoring Goals

The only turbidity monitoring issue is the lack of a representative sample for the CFE turbidity measurement, as discussed earlier in this memorandum. It is recommended that the CFE sampling point be relocated to the vertically oriented 90 degree bend in the CFE piping to ensure a representative sample. Upon completion of this improvement, all turbidity monitoring goals will be fully achieved.

Modifications to Achieve Filtration Goals

Placing the fourth filter back in service may help in achieving Filtration Goal #1 and in maintaining compliance with Filtration Goals #3 and #4. Currently there are only three filters in service. When one of the three operating filters is taken out of service to backwash, the remaining two filters experience a 50 percent increase in influent rate. This "bumping" of the filters can shear the solids retained in the filter bed causing turbidity spikes, premature breakthrough, and reduced filter run times. With four filters in service, the increase in influent rate will be reduced to 33 percent.

In addition, with four filters in service, the rate through each filter will be reduced at all flow rates at which the plant is operated. Given the fact that the WTP is a direct filtration facility with marginal flocculation, reducing the rate through the filters may help with achieving the performance goals. Based on the data from 2007, the three filters in operation were operated at rates as high as 2.5 gpm/ft^2 and as low as 0.9 gpm/ft^2 with a median value of 1.8 gpm/ft^2. If the plant were operated at the same rates as it were in 2007 with all four filters online, the corresponding values would be: a maximum rate of 1.9 gpm/ft^2, a minimum rate of 0.7 gpm/ft^2, and a median value of 1.4 gpm/ft^2. Therefore, returning the fourth filter to service should be considered a priority.

Modifying the controls to allow for automatic modulation of influent when a filter is taken out of service for backwash would completely eliminate the problem of filter "bumping," which would assist in achieving filtration goals. However, the influent control valve is an 18-inch butterfly valve, which is rather large for modulating flows less than 1,500 gpm with any precision. Therefore, implementing reasonably precise automatic flow modulation for backwash may involve more than simply changing the controls; it may also require modifications to the influent piping to install a smaller influent control valve. The cost for this work may not be in line with the potential benefit, at least for short-term operation of the WTP.

There is evidence that particle counters detect nascent breakthrough up to several hours before the turbidity increase is detected by turbidimeters. This could assist with achieving Filtration Goal #5. However, installation of particle counters at this facility to achieve this goal in the short-term is not considered necessary or cost effective given that the operators appear to have achieved this goal during 2007 without particle counters.

The existing floc basin outlet weir is poorly designed as it shears the floc, damaging it before the water enters the filters. Modifications to the floc basin outlet could reduce the damage to the floc. However, these modifications may not be required for near-term improvements. Improvements in filter performance that may be achieved by returning the fourth filter to service and making minor operational changes may have a greater impact than modifying the floc basin outlet weir. Once these other changes have been implemented, comparison of the plant performance to the goals will clarify whether this modification should be considered for near-term improvements or should be considered as part of the long-term changes to the facility.

Modifications to Achieve the Disinfection Goal

As previously discussed, although the disinfection goal is being met for customers along the finished water transmission main, it is not being met for treated water supplied to the WTP and the nearby lead WTP operator's house. This goal can only be met for the WTP and lead WTP operator's house by increasing the contact time of the disinfectant, chlorine. It is recommended that this be accomplished by installing a sufficient length of large diameter pipe on the WTP site. This section of large diameter pipe should be designed to provide sufficient contact volume to achieve the required CT before the water is consumed at the WTP and conveyed to the lead WTP operator's house.

Modifications to Existing Operation

Increased frequency of jar testing could assist in achieving the filtration goal of a maximum daily CFE turbidity of less than 0.1 NTU 95 percent of the time. It may also increase filter run times, which would increase plant efficiency. Production data from 2004 through 2006 show a production efficiency of approximately 90 percent prior to DOH's imposition of restrictions on operation in 2006. After that time, the efficiency decreased to about 87 percent.

Currently, there are only three days per week when both operators are present. The operators have maintenance duties at the WTP, in addition to their duties monitoring plant performance. Increased jar testing is more likely on those days when both operators are present.

More frequent backwashing when raw water turbidity is high may help reduce the value of the 95^{th} percentile for maximum daily CFE turbidity. However, this would reduce the filter run time and reduce the production efficiency, which is already low.

Allowing the filters to rest between backwash and the resumption of filtration may improve performance with respect to Filtration Goal #2, achieving less than 0.1 NTU within 15 minutes of placing the filters into service. Studies have shown that a brief "resting" period after backwashing can decrease the magnitude and duration of the initial turbidity spike. In one study (reported in "Controlling the Initial Turbidity Spike," Opflow, Vol 31 No 10, October 2005) a filter returned to service without delay had an initial turbidity spike of 0.17 NTU and the turbidity was 0.13 after fifteen minutes. In contrast, three filters for which filtration was delayed by 46 to 144 minutes all had an initial turbidity spike of less than 0.1 NTU.

The theory behind allowing the filter to rest is that the delay allows the filter media to settle and compact and may allow particles that become detached during backwash, but remain within the filter bed, to reattach to filter media before filtration resumes. Also, any floc that remains in the filter bed above the media has time to settle on the top of the media. All these factors appear to reduce the magnitude of the spike and could help the filters at the Pilchuck

WTP consistently achieve less than 0.1 NTU within fifteen minutes of being returned to service.

There is a limit to how long a filter can be left out of service after backwashing before water quality begins to decrease due to bacteriological activity. Some water treatment plants report leaving filters out of service after backwashing for up to 48 hours, although this may not be advisable without prechlorination. The lead operator at the Pilchuck WTP reported that DOH will not allow the Pilchuck WTP to backwash at the end of a shift and return the filters to service at the start of the next shift without backwashing again.

With the plant operating only eight hours per day, backwashing all filters at the start of the day and allowing a minimum of thirty minutes of delay before returning the filters to service would greatly reduce the amount of time available for production. However, when automated shutdown capabilities are implemented and the plant can operate for more than eight hours per day, introducing a delay period into the backwash cycle could assist the WTP in consistently achieving Filtration Goal #2.

Summary

The City is currently complying with Turbidity Monitoring Goal #1 (Monitor raw water turbidity at least every four hours) and Turbidity Monitoring Goal #2 (Continuously record effluent turbidity for each filter) but must relocate the sampling point for combined filter effluent (CFE) to fully meet Turbidity Monitoring Goal #3 (Continuously record CFE turbidity).

The City met Filtration Goal #3 (CFE Turbidity Never Exceeds 0.3 NTU) and Filtration Goal #4 (Backwash filters before breakthrough) during 2007 and should be capable of continuing to meet these goals without modification to the process or operations.

The City does not consistently meet Filtration Goal #2 (Turbidity Less Than 0.1 NTU within 15 Minutes of Operation). The filter effluent turbidity after backwashing drops below 0.1 NTU within 15 minutes of operation less than fifty percent of the time. The City should prioritize installation of a filter-to-waste system, which is currently under design at the time of this writing. In addition, introducing a delay between completing the backwash and returning the filters to service could help the City consistently achieve this goal. If DOH will not allow backwashing at the end of the day without backwashing the filters again at the start of the next day, then it may be advisable to wait until the automated shutdown capability is installed and the plant can operate for more than eight hours per day to introduce a delay in the backwash cycle.

The City does not consistently meet Filtration Goal #1 (95th Percentile for CFE turbidity less than 0.1 NTU). Placing the fourth filter back in service may help in achieving this goal, or at least come closer to the goal, by reducing the rate through the filters at all operating flow rates. Modifications to the floc basin outlet could reduce the damage to the floc and also help achieve this goal. Once the fourth filter has been returned to service, comparison of the plant performance to the goals will clarify whether modification of the floc basin outlet weir should be considered for near-term improvements or should be considered as part of the long-term changes to the facility.

The City is not meeting Filtration Goal #5 (Raw Water Turbidity Changes Do Not Affect Filtered Water Turbidity), and it may be difficult to do so as long as the plant is operated as a direct filtration facility (i.e., without a sedimentation basin).

The City is currently meeting the disinfection goal for all customers on the finished water transmission main. DOH currently considers the City's existing calculation of the inactivation ratio (IR) for the finished water transmission main as "invalid" due to an apparent misunderstanding regarding the location of the first customer. DOH invalidated the existing calculation of the inactivation ratio for the finished water transmission main on the understanding that the lead WTP operator's home was served from that main rather than a separate distribution system. The City must initiate official communication with DOH to clarify that the existing calculation of inactivation ratio for the first customer on the finished water transmission main is correct, but that a separate calculation must be developed for determining IR for the WTP and the lead WTP operator's home. In addition, the City must install sufficient contact volume at the WTP to ensure that the required IR is achieved for the WTP and the lead WTP operator's home.

APPENDIX B

Murray, Smith & Associates, Inc.
Engineers/Planners
2707 Colby Avenue, Suite 1110 ■ Everett, WA 98201-3566 ■ PHONE 425.252.9003 ■ FAX 425.252.8853

TECHNICAL MEMORANDUM

DATE: February 12, 2009

PROJECT: Water Treatment Plant & Water Supply Study

TO: Andy Sics, P.E, City of Snohomish

FROM: Andrew Szatkowski, P.E.
Thomas C. Lindberg, P.E.
Murray, Smith & Associates, Inc.

RE: Long-Term Water Treatment Plant Evaluation and Capital Improvements

---

Introduction

Murray, Smith & Associates, Inc. (MSA) was authorized by the City of Snohomish in October 2007 to evaluate the City's existing water supply facilities and alternative sources of water for long-term supply to the City. The City's existing water supply facilities consist of the Pilchuck River diversion structure, the Pilchuck River water treatment plant, and a finished water transmission main to deliver the treated water from the Pilchuck facilities to the City. The overall work program for this project consists of the following major elements:

1. Determine near-term operational modifications and capital improvements at the water treatment plant to achieve compliance with current laws and regulations, and with the State's Treatment Optimization Program (TOP) performance goals for water treatment plants.
2. Determine operational modifications and capital improvements needed to extend the water treatment plant's service life for another 20 years while maintaining compliance with laws, regulations and the optimization goals the City adopts.

   Develop and evaluate alternative improvements at the water treatment plant that will allow the City to utilize existing water rights to the maximum extent possible and reduce the purchase of water from Everett to a minimum.
3. Evaluate the condition of the City's finished water transmission main from the treatment plant to the City, and make recommendations regarding capital

improvements and operational modifications needed to ensure another 20 years of service life.

4. Evaluate all supply alternatives available to the City, including supply options for the approximately 100 customers currently served from the City's finished water transmission main.
5. Estimate capital and operating costs for all the alternatives developed, calculate net present value costs and determine the impacts of each alternative on utility rates and charges.

The results of the first work element listed above are documented in the technical memorandum, "Near-Term Water Treatment Plant Evaluation for Compliance with State of Washington Treatment Optimization Program Performance Goals." The second and third work elements listed above are the focus of this technical memorandum, which is the second deliverable from the overall work program described above. The scenarios and associated costs developed in these two technical memoranda will be included in the overall project report with the remaining work elements.

The scope of work for the analysis and reporting in this technical memorandum is detailed within the project's scope of work under the following major work items for Task 6 – Water Treatment Plant Evaluation:

6.3 Capacity Analysis
6.4 Chlorine Contact Analysis
6.5 Capital Improvements

Background

The City of Snohomish supplies drinking water to customers from two sources. The City owns and operates a diversion on the Pilchuck River, along with a water treatment plant and finished water transmission main for supply to the City's 222-foot pressure zone. The City also purchases treated water from the City of Everett regional water system for supply to the City's 345-foot, 358-foot, 368-foot, and 418-foot pressure zones.

The diversion consists of a concrete weir approximately ten feet high, a fish ladder and an intake structure. The diversion is located at River Mile 26.3 on the Pilchuck River. The intake is equipped with a traveling screen and a pump to clean the screen. Flow from the intake to the water treatment plant is by gravity.

The water treatment plant (WTP) is a direct filtration package plant built in 1981. Figure 1 (see attached) shows a simplified schematic of the plant excluding chemical feed systems. The plant is equipped to feed coagulant and polymer prior to flocculation, and soda ash and gas chlorine for post-filtration pH adjustment and disinfection, respectively. Four filters with a total area of 500 ft^2 provide for up to 1,500 gpm filtration, the original design treatment capacity of the plant.

The finished water transmission main, which is approximately 15 miles long, consists of 18-inch diameter AC water main and 12-inch diameter Permastran water main that was constructed in 1981. Approximately 93 customers spread out along the length of the finished water transmission main are served directly off this main.

The WTP is currently operated under restrictions that were imposed by the State of Washington Department of Health (DOH) in June 2006. These restrictions resulted from a sanitary survey of the City's water system conducted by the DOH Office of Drinking Water and a Comprehensive Performance Evaluation of the City's water treatment plant conducted by The Cadmus Group, an outside consultant contracted by DOH. The survey and evaluation identified a list of administrative, operational, and capital improvements needed at the City's water treatment plant.

At least one of the restrictions imposed at that time has been removed because the conditions that required the restriction have been resolved. Some of the restrictions remain. One of the existing restrictions requires that the plant be operated only when an appropriately certified operator is present at the WTP. As a result, the plant is only operated eight hours per day, requiring the City to purchase more water from the City of Everett. This restriction will remain until the WTP has filter-to-waste in place and plant controls are upgraded to include automated shut-down when particle removal or disinfection criteria are not being met.

Dam, Intake Structure and Fish Screen Assessment

Background and Condition Assessment of Pilchuck River Dam No. 2

The City owns and operates the diversion on the Pilchuck River. The diversion consists of a reinforced concrete weir with a concrete ogee spillway, a fish ladder and an intake structure. The weir, spillway and fish ladder are discussed in this section and the intake structure is discussed below.

The existing dam was constructed in 1932 and the fish ladder was added in 1947. The dam is officially known as the Pilchuck River Dam No. 2 since it is a replacement of a dam built in 1911 at a location north of the existing dam. The dam is located at a slight bend in the river. The intake structure is located on the north end of the weir along the outside of the bend and the fish ladder is located at the south end of the weir, along the inside of the bend. This arrangement is not ideal. The location of the ladder results in less flow through the ladder at low flow conditions and in greater gravel and sediment accumulation in the ladder at high flow conditions than would be the case if the ladder were located on the north end of the weir along the outside of the meander bend.

The elevation of the crest of the dam spillway is 455 feet above sea level, about 12 feet above the elevation of the river bed. The low height of the dam generates only a small pool behind the weir (approximately 3,000 square feet of surface area), so the structure operates as a run-of-river diversion. The dam is approximately 20 feet thick at the base, approximately 5 feet thick at the crest and approximately 70 feet across the spillway.

In 1985, an inspection revealed extensive erosion of the concrete surface along the weir crest and throughout the fish ladder as well as undermining of the subgrade beneath the dam, spillway and fish ladder. Emergency repairs were carried out to place concrete beneath the structure to prevent further undermining. Repairs to the concrete of the weir, spillway and fish ladder were completed in 1987.

In 1994, improvements were made to the fish ladder. The lowermost weir of the fish ladder was modified to increase flow through the ladder at low-water stages and a debris trap was installed to protect the ladder from excess sediment during high-water stages. In 2003, a flashboard was added to the debris trap to further reduce the amount of debris entering the ladder.

The primary maintenance requirement of the dam is periodic cleaning of the fish ladder several times each year. Debris is removed as necessary throughout the year as high flows deposit debris in the ladder. In addition, the City cleans the ladder of all debris in August prior to the upriver migration of Chinook.

The scope of work for this study focuses on condition and capacity assessments of the water treatment plant structures and unit processes, starting with the intake and continuing through chlorine contact. Detailed assessment of the dam structure itself was not included in this scope. Based on a cursory field investigation of the dam and a review of available documents, and given the repairs that were effected on the dam in the 1980's and the repairs and upgrades effected on the fish ladder in 1994, it is advisable that a complete condition assessment and structural analysis be conducted on the dam structure in the near future. This will require dewatering the pool behind the structure and removing debris from the fish ladder to thoroughly inspect the entire structure and the riverbed adjacent to the structure.

Regulatory Assessment of Pilchuck River Dam No. 2

The City of Snohomish Endangered Species Act (ESA) Response Planning document prepared in May 2004 concluded that the Pilchuck River Dam No. 2 is probably a minor obstacle to the upriver migration of adult Chinook. The report also concluded that the dam is probably a greater obstacle to upriver adult Coho migration and may especially obstruct upriver adult steelhead migration. This is primarily because Chinook migrate upriver after the ladder is cleaned every August and before high-water stages once again deposit debris while Coho migration extends into the flood season and steelhead migration extends throughout much of the flood season. Steelhead were listed as threatened in the Puget Sound Evolutionarily Significant Unit (ESU) in May of 2007. The Pilchuck River is within the Puget Sound ESU. The dam also poses a threat to juvenile salmon. Juvenile salmon seeking to migrate upstream in the late spring and summer in search of cooler water are probably unable to pass through the ladder.

The State of Washington Fisheries Code requires that every dam be provided with a durable and effective structure that allows for the passage of fish. The code also requires the owner to maintain the fish passage structure such that fish can freely and effectively pass at all times. Fish ladder design criteria are aimed at providing conditions that allow fish to pass upstream, resting as necessary in the pools of the ladder. A primary limitation of the pool and weir type fishway is the narrow range of operating flow. The minimum depth of flow over the weirs commonly determines the lower limit of acceptable flow through a fishway. That minimum depth for fish passage is commonly 0.25 feet. The upper limit of flow is determined by the ability of the fishway pools to dissipate the energy from the water flowing into the pools.

The discussion below describes the design criteria that have been developed to create conditions conducive to passing all salmonid species upstream with minimal delay and injury and assesses how well the existing fishway meets those criteria. The Pilchuck River Fish Ladder consists of eight full time operational weirs with three additional orifices capable of operating as weirs with the addition of stoplogs that can be inserted into the ladder during high flows.

The recommended maximum head differential (RHD) between pools is 12 inches. This is based on allowing the passage of most adult salmonid species and adult trout. Most, but not all of the pools in the Pilchuck fish ladder meet this criterion. Of the eight weirs that operate year round, two of the weirs exceed the RHD between pools. The two pools are located at the base of the ladder and referred to as weirs 9 and 11, with weir 11 being the last pool before the fish ladder discharges into the Pilchuck River below the dam. The pools exceed the recommended head differential by 0.3 and 1.25 feet respectively.

A key criteria for fish passage is the Energy Dissipation Factor (EDF) which is a function of the difference in water surface elevations between adjoining pools, the dimensions of the receiving pool and the flow through the fishway. The maximum amount of flow through a fishway that does not exceed the EDF is the Fishway Hydraulic Capacity (FHC). The existing fishway as configured has a FHD of 8.8 cfs.

Typical minimum fishway pool depths for weir, pool and vertical slot fishways varies from 3 to 8 feet. The minimum depth required is based on experience and depends on the scale of river. When the flow through the Pilchuck fishway is at the existing FHC of 8.8 cfs, the pool depths within the fish ladder range between 3.6 to 5.6 feet deep. Deeper pools may be recommended as the increased pool volumes would reduce the Energy Dissipation Factor.

A minimum freeboard of 3 feet is required to prevent or deter fish from jumping out of the fish ladder structure. From analysis of the structure, weirs 3 through 7 and weir 10 will meet the requirements as long as flows remain below 11.5 cfs. With flows higher than 11.5 cfs, weir 7 does not meet the 3-foot freeboard requirement. Weir 8 does not meet the freeboard requirement at any flow rate as the retaining wall separating the river flow from the fish ladder is too low. The retaining wall is at an elevation of 453 feet, while the top of weir 8 is at an elevation of 451 feet. Weir 9 meets the freeboard requirement as long as the flow remains below 2.2 cfs. Any flow greater than 2.2 cfs will exceed the freeboard limit due to the low elevation of the retaining wall.

However, the greatest problem with the Pilchuck Dam No. 2 fishway appears to be the accumulation of debris in the fishway, which may regularly obstruct at least a portion of the adult Coho migration and the entire upriver adult steelhead migration. In discussions with WDFW staff and consultants familiar with the dam and fishway, the consensus appears to be that major modifications will be required if the City is to operate the structure for another twenty years. There is, however, no consensus at present on what modifications will be required to ensure a durable and effective structure that allows for the passage of fish. WDFW staff expressed the opinion that the fishway should be moved to the right bank. A consultant familiar with the site indicated that there are significant challenges to moving the fishway and stated that it may be preferable to modify the existing structure where it currently exists on the left bank. Clearly, additional and detailed analysis of the fishway structure is required to determine the preferred option for long-term operation.

Regulatory Assessment of Pilchuck River Intake Structure and Fish Screen

Environmental regulations promulgated to protect threatened and endangered species of anadromous fish that populate the Pilchuck River include specific requirements for river intakes and diversions to avoid the potential "take" of these species, particularly juvenile fish. Important features of an acceptable fish screening system on an intake system include:

- An approach velocity at or below the maximum;
- A sweeping velocity at the face of the screen to ensure that juvenile fish are not trapped in front of the intake;
- A screen opening size less than the maximum;
- A hydraulic gradient to route juvenile fish from between the trash rack and screen to safety where trash racks are used.

For streams and rivers in which the velocity of water past the intake structure is greater than 0.4 feet per second (fps), the maximum approach velocity for an intake structure with an automatic screen cleaning system is 0.4 fps. If flow past the structure is less than 0.4 fps, then the maximum approach velocity is 0.33 fps. If there is no automatic screen cleaning system, the maximum approach velocity is 0.2 fps. For intakes drawing more than 3 cfs, an automatic screen cleaning system is required. The existing treatment capacity for the Pilchuck WTP is approximately 3.3 cfs; therefore, an automatic screen cleaning system is required for this intake for the existing capacity and for any proposed expanded capacity up to the City's water right. Under most flow conditions, the velocity past the structure is greater than 0.4 fps. However, for low flow conditions, it is possible that the ambient velocity is less than 0.4 fps. Therefore, the maximum approach velocity for the Pilchuck intake may be as low as 0.33 fps.

The sweeping velocity at the face of the screen must be at least equal to the approach velocity. When screens are mounted on the exterior of an intake structure, the sweeping velocity must be sufficiently high to ensure that juvenile fish are not exposed to the screen for a period of time exceeding 60 seconds. The maximum width of a fixed screen on the face of the Pilchuck structure would be 8 feet. Sweeping velocities greater than 0.13 fps would ensure that the fish are exposed to the screen for less than 60 seconds. It is possible that the sweeping velocity at the Pilchuck intake under very low flow conditions may approach this low value.

When the screen is located on the inside of a structure, there must be a bypass system that facilitates return of the fish back to the main river channel with a minimum of risk or delay. The traveling screen on the City's existing intake structure is located inside an interior bay without the required bypass system.

The maximum opening size for fish screens depends upon the material of the fish screen. For perforated plate and woven wire mesh screens, the maximum opening size is 3/32-inch (2.38 mm). For profile bar screens (steel bars welded parallel to each other on a structural backing), the maximum opening is 0.069-inch (1.75 mm).

At the City's existing intake, the approach velocity is less than 0.4 fps. However, the traveling screen is located inside an interior bay which does not have the required bypass system to facilitate safe removal of fish from the bay to the river. In addition, the existing traveling screen opening size of 1/8-inch (3.18 mm) is greater than the maximum allowable opening size of 3/32-inch (2.38 mm). Also, there are holes in the screen significantly larger than the nominal mesh size where the mesh has been damaged. Finally, the mesh has become misaligned within the brackets: on one side, there appears to be a gap between the mesh and the sidewall bracket because the screen has compressed and bunched up within the sidewall bracket on the other side.

Condition and Capacity Assessment of Pilchuck River Intake Structure and Fish Screen

The intake structure was constructed in 1932 at the same time as the dam. The intake structure appears sound. The portion of the concrete structure that is visible without dewatering the small pool behind the weir appears to be in good condition.

The intake structure has two openings to the Pilchuck River, each approximately 8 feet wide by 10 feet high. There is no trash rack on the outside of the structure in front of these openings. Inside the structure, there is a single traveling screen inside a small bay. The screen can be isolated by slide gates, which are located on either side of the traveling screen bay. The raw water passes through the screen and enters an interior bay. The screened water exits the interior bay and flows by gravity through a raw water pipeline to the WTP. A submersible pump is also located in the interior bay and is used to backwash the screen when the screen is clogged.

The traveling screen is in very poor condition and does not meet current fish protection criteria. The submersible pump that cleans the traveling screen is currently functioning well, according to the WTP operators. However, this pump will need to be replaced, even if a hydraulic screen cleaning system is installed on a new fixed screen because the existing pump does not produce a sufficient volume of water at sufficiently high pressure to operate a hydraulic cleaning system for a fixed screen. The 8-foot by 10-foot openings on the exterior of the intake structure are of adequate size to draw up to the City's maximum water right of 5 cfs into the intake without exceeding the maximum approach velocity of 0.4 fps.

To meet all of the current fish protection criteria, it will be necessary to replace the existing traveling screen with a fixed screen located on the exterior face of the structure. Such a modification would locate the screen at the diversion entrance, which avoids the need for installing a bypass system and allows the river's natural flow to provide the required sweeping velocity. It may be necessary to attach trash racks to the exterior of the intake to protect the fixed screen. A new automatic screen cleaning system will be required. Options include: mechanical brush cleaning, water nozzles, and air burst.

There is ample space within the two openings to the Pilchuck River to install at least 12.5 square feet of screen to ensure that the approach velocity remains less than 0.4 fps while drawing 5 cfs through the screens. However, as noted above, the approach velocity must be less than the sweeping velocity and the sweeping velocity at this diversion under very low conditions is likely less than 0.4 fps. Therefore, the screen size may be determined by the low sweeping velocity. This may require "oversizing" the screens to maintain an approach velocity as low as 0.1 fps. Fortunately, there appears to be sufficient opening to install such oversized screens.

Raw Water Transmission Line Capacity Assessment

The existing raw water transmission line from the intake structure at the Pilchuck River to the WTP consists of approximately 1,900 feet of 18-inch diameter asbestos cement pipe. Hydraulic calculations indicate that the current treatment plant design capacity of 2.16 mgd is close to the maximum rate that can flow by gravity through the raw water transmission line when the water surface behind the dam is at its minimum level. This is based on the current configuration of the flocculation tank, which is at the receiving end of the raw water supply pipeline.

Figure 1 is a simplified schematic of the existing water treatment process, as shown in hydraulic profile. The water surface in the flocculation tank is approximately 1.0 to 2.3 feet below the elevation of the dam weir. The total head loss through the raw water pipeline from the intake to the WTP at a flow of 3.23 mgd, the City's instantaneous water right amount, would be approximately double the headloss when flowing at 2.16 mgd. The normal maximum water surface in the flocculation tank shown in Figure 1 occurs when the plant is operating near the existing design capacity of 2.16 mgd. At higher flow rates, the water surface in the flocculation tank will rise, approaching the flocculation tank overflow level and reducing the head available for gravity flow from the dam. When the water surface behind the dam is at low levels, the head available for gravity flow appears to be insufficient to transmit the City's instantaneous water right amount of 3.23 mgd to the existing flocculation tank. Therefore, it appears that gravity flow of 3.23 mgd is not possible with the existing raw water transmission line and current WTP configuration.

There is approximately 2.9 feet of elevation between the minimum water surface in the flocculation tank and the water surface in the filters. Therefore, when the water surface behind the dam is at its minimum, it appears that there is sufficient head available from the dam to the filters to supply 3.23 mgd by gravity, only if the existing flocculation tank is replaced with a newly designed pre-filtration treatment system. The flocculation tank capacity assessment, presented below, concludes that the existing tank cannot treat more than the existing design capacity of 2.16 mgd. Therefore, the only option that will allow for gravity flow of up to 3.23 mgd from the dam to the plant is replacement of the existing flocculation tank. A new basin combining rapid mix, flocculation and sedimentation, if carefully designed and precisely constructed, could ensure that the water surface in the rapid mix basin is low enough to allow for gravity flow from the dam at 3.23 mgd, but high enough to provide for gravity flow from the sedimentation basin to the filters at that rate. Figure 3 (see attached) is a simplified water treatment process schematic illustrating the expected hydraulic profile through the plant if the plant were modified to treat 3.23 mgd in a conventional treatment process.

Pilchuck Water Treatment Plant Condition and Capacity Assessment

Rapid Mix and Flocculation Tank Condition Assessment

The coagulation and flocculation tank was installed when the WTP was constructed. The tank was inspected by Liquivision Technology in January 2007. Their report does not comment on the condition of the coating beneath the water surface because high turbidity in the tank prevented inspection and photographing of those surfaces. According to the WTP operators, when the plant has not been operating for a few days, the turbidity in the tank is low enough to see the interior surfaces of the tank. The operators report that no significant corrosion has been observed under these conditions.

Based on the Liquivision report, a visual inspection of the tank by MSA in November 2007, and comments by the operators regarding the interior wall coating, the tank appears to be structurally sound and the coating system does not appear to have failed on any of the surfaces observed by MSA, Liquivision and the operators. It appears that the tank can continue to function for another 20 years without significant rehabilitation or recoating work.

Rapid Mix and Flocculation Tank Capacity Assessment

The flocculation tank has three compartments, but only one of the compartments has a low-speed mixer that generates a velocity gradient for flocculation. The volume of the flocculation tank is approximately 42,000 gallons when the flow through the tank is about 550 gpm and approximately 42,800 gallons when the flow through the tank is at the treatment plant's design capacity of 2.16 mgd (1,500 gpm). At the WTP's design capacity, the total detention time is approximately 28 minutes.

The first compartment has a mixer that operates at 30 rpm. Although the shop drawings available for review do not show interior walls within the first chamber, it appears that this mixer is isolated from the bulk of the first chamber by walls. It is presumed that the intent of this mixer is to provide rapid mixing of the chemicals. The extent of the hydraulic connection between this rapid mix zone and the remainder of the first chamber is not known, so it is unclear if there is a velocity gradient within the first chamber. The second compartment has a mixer that operates at 1.6 rpm. The third chamber has no mixer.

If there is sufficient hydraulic connection between the first chamber and the rapid mix section of that chamber, there could be a velocity gradient within the flocculation portion of the first chamber that is greater than the velocity gradient in the second chamber. With no mixing in the third chamber, there would be a decreasing velocity gradient from the first chamber through to the third chamber and the tank would operate as a 3-stage tapered flocculation unit. However, this is a best case scenario and there are no data or drawings to support this supposition. If there is little or no velocity gradient in the first chamber, then this chamber may not be contributing significantly to floc formation. If that is the case, then the tank volume should be derated and the effective flocculation time at nominal capacity would be approximately 18 minutes.

There is a note on the shop drawing available for review that states that the velocities in the conduits transferring water between the chambers may be too high, causing damage to the floc. It has been noted in previous plant assessments by others that the outlet weir also damages the floc because of the high velocity across the weir and the length of the fall from the weir. At the nominal design capacity, the velocity across the outlet weir is about 2.2 fps. Given the apparent damage to the floc and the uncertainty regarding the effective flocculation volume, it appears that the flocculation provided by this tank is barely adequate for operation at the original design capacity of 2.16 mgd. If the plant is to be operated for another 20 years at the existing design capacity, the outlet weir from the flocculation tank should be modified to reduce the damage to the floc that is currently generated by excessive velocity and excessive fall.

If the plant were operated at the City's maximum instantaneous water right of 3.23 mgd, the total detention time in the flocculation tank would be approximately 19 minutes, the effective flocculation time could be as low as 13 minutes, and the velocity across the outlet weir would be about 2.6 fps. For truly tapered flocculation in a conventional treatment facility, 19 minutes total flocculation time might be adequate and 13 minutes would be outside the recommended lower limit. Considering that this is a direct filtration facility, that the effective flocculation time is probably lower than the nominal time, and that the tank's design clearly damages the floc, 2.16 mgd should be considered the upper limit of treatment capacity for this flocculation tank.

Filter Condition Assessment

The four filters and associated piping and valves were installed when the WTP was constructed in 1981. Filter No. 4 has been offline since August 2005 when cracks in the steel basin were discovered. The filter media and support gravel were removed and the cracks were repaired, however, the filter has been left offline since the repairs were completed. The City has been investigating the installation of filter-to-waste piping in all four filters for some time. At the time of this writing, filter-to-waste piping improvements and improvements to

Filter No. 4 are under design. The current plan is to complete the installation of filter-to-waste piping and reinstall media in all four filters.

The new filter media and support gravel that will be installed in the filters after the filter-to-waste system is constructed meet the same specifications as the media and gravel that were originally installed in the filters. The configuration of the filter layers is as follows:

- 16-inches of anthracite coal, 0.6 to 0.8 mm effective size
- 9-inches of silica sand, 0.45 to 0.55 mm effective size
- 4-inches of ¼" x No. 10 gravel
- 4-inches of ½" x ¼" gravel
- 4-inches of ¾" x ½" gravel
- 4-inches of 1-½" x ¾" gravel

Filter Capacity Assessment

Currently, the filtration treatment capacity limitation is due to the fact that the Pilchuck WTP is a direct filtration facility. Direct filtration filters cannot be operated at rates higher than 3 gpm/ft^2. With a total of 500 ft^2 of filter area among the four filters, this equates to a treatment capacity of 1,500 gpm or 2.16 mgd.

If the plant were converted to a conventional treatment facility by adding a properly designed and operated sedimentation basin prior to the filters, the filters could potentially operate at rates higher than 3 gpm/ft^2. Filters in a conventional filtration facility that have a media profile similar to those in the Pilchuck WTP can operate effectively at rates up to 5 gpm/ft^2. With a total of 500 ft^2 of filter area among the four Pilchuck WTP filters and a water right of 5 cfs, the filtration rate required to treat the full water right would be 4.5 gpm/ft^2, which is within the operating rate for a conventional filtration facility.

There does, however, appear to be a hydraulic limitation of the filters. The water treatment operators have stated that when the plant is operated at or near the design capacity of 2.16 mgd, the filters are incapable of passing water at the rate of 3 gpm/ft^2. This problem has been noted when the City's fire department takes large volumes of water from the distribution system. This causes a rapid drop in the clearwell level at the WTP. When the influent valve responds by opening fully, the filters are unable to pass the full design rate through the filters. The water surface in the filters increases until some of the water spills over the backwash wastewater troughs. The influent rate during these events is not known. Also unknown is the portion of the influent that passes through the filters and the portion that flows over the backwash wastewater troughs. At present, it is not entirely clear what causes the hydraulic capacity limitation. There was no testing done to assess this potential problem during site visits to the WTP because the issue was not raised until after site visits had been conducted. A desk study of the available data has been conducted.

Based on the data from 2007, the filters are operated at rates as high as 2.5 gpm/ft^2 and as low as 0.9 gpm/ft^2 with a median value of 1.8 gpm/ft^2. The highest rates are in the months of

July through September. On September 2, 2007, the plant was operated at a maximum rate of 2.5 gpm/ft^2 and the average rate during the seven hours the plant was operated that day was 2.4 gpm/ft^2. The operators have not reported any problems with hydraulic limitations during those days when the plant was operated up to 2.5 gpm/ft^2, but they do believe that this is about the maximum they can operate the plant without experiencing hydraulic overload of the filters. Based on this, it appears that the current hydraulic limitation of the filters limits the WTP capacity to approximately 1.7 mgd when all four filters are operating.

One potential explanation for hydraulic overload of the filters is that the influent valve may have opened to a point that provided more than 3 gpm/ft^2. With only three filters online, rates above 1,200 gpm would exceed this value. Before Filter No. 4 was taken offline, rates above 1,500 gpm would exceed this value.

Another possible explanation is that this occurs when the clearwell level drops low enough to briefly expose the crown of the combined filter effluent line in the clearwell before the influent valve responds. This could allow air to enter the combined filter effluent line, generating an air blockage that increases head loss through the effluent piping. Alternatively, exposing the effluent pipe in the clearwell could allow enough air to enter the combined filter effluent pipe to greatly reduce the driving head. However, either of these causes should have effects on hydraulic performance that linger after the influent rate is reduced.

Data on water surface elevations for the plant do indicate that the filtration driving head is low when the plant is operated in automatic mode. In automatic mode, the minimum clearwell level is 4.62 feet which provides a maximum driving head of 9 feet. This is a fairly low driving head for granular media filtration, particularly for direct filtration where the solids loading on the filters is higher than conventional treatment. The operation and maintenance manual for the Pilchuck WTP, provided by the package plant manufacturer, states that the plant should be backwashed whenever the head loss across the filter equals 8 feet. With only 9 feet of total driving head and several feet of head loss through effluent piping and valves, a filter bed head loss of 8 feet is clearly unattainable. Therefore, it appears that the most plausible explanation for the hydraulic limitation of the filters is the low driving head available between the water surface in the filters and the clearwell.

To assist in confirming this analysis, further field testing is advisable. Such field testing would determine whether the filters can be operated by gravity at the nominal design rate of 3 gpm/ft^2 with minor modifications, such as changes in operating levels. Installation of a headloss transmitter on at least one operational filter and the logging of headloss data, along with data on flow rate, turbidity and filter run time, would assist in determining whether there is indeed a hydraulic limitation, the cause of the limitation, and whether changes in operational levels would be sufficient to overcome the limitation. It would also assist in determining if the filters need significant modification to operate at rates up to 4.5 gpm/ft^2 so as to maximize the use of the City's water right.

If it is determined that gravity flow to the clearwell at the higher rate necessary to treat the City's full water right is not possible, the filters could still be operated at that higher rate by adding small pumps from each filter to the backwash water tank, similar to the system being installed for the filter to waste. Under this scenario, the filter effluent would be pumped directly to the backwash tank, rather than flow by gravity to the clearwell. The backwash tank alone would maintain the level in the clearwell to supply the transmission main. The pumps that currently pump from the clearwell to the backwash tank would no longer be needed. Figure 3 (see attached) is a simplified water treatment process schematic illustrating the expected hydraulic profile through the plant for a WTP modified to treat 3.23 mgd in a conventional treatment process. The figure includes the pumps required to lift the filter effluent to the backwash tank. Figure 2 (see attached) is a simplified water treatment process schematic illustrating the expected hydraulic profile through the plant for the WTP modified for conventional treatment but continuing to treat at the original design capacity of 2.16 mgd. In this figure, there are no filter effluent pumps as it is assumed that the original design treatment capacity can be achieved without pumping.

Modulation of Filter Influent

Currently the influent valve cannot be modulated to reduce the flow rate into the WTP when a filter is taken offline for backwashing. At present, there are three of four filters in service. When one of the three operating filters is taken out of service to backwash, the remaining two filters experience a 50 percent increase in influent rate. This "bumping" of the filters can shear the solids retained in the filter bed causing premature breakthrough, reducing the filter run times. When the fourth filter is brought back online after installation of the filter-to-waste system, the increase in influent rate will be reduced to 33 percent. If the hydraulic capacity limitation is overcome allowing for instantaneous flows of 2.16 mgd through the WTP, it is critical that the influent valve modulates whenever a filter is taken offline.

Modifying the controls to allow for automatic modulation of influent when a filter is taken out of service for backwash would completely eliminate the problem of filter "bumping." However, the existing influent control valve is an 18-inch butterfly valve, which is rather large for modulating flows less than 1,500 gpm with any precision. Therefore, implementing reasonably precise automatic flow modulation for backwash may involve more than simply changing the controls; it may also require modifications to the influent piping to install a smaller influent control valve.

Chemical Feed Systems

The chemical alum, which is used as a coagulant to bind together very fine suspended particles into larger particles to improve filtration, is stored in a 5,000 gallon tank. Prior to August 2005, when the plant was operated 24 hours per day and there were four filters online, operators had the tank refilled two or three time per year. If the plant were to run at its design capacity of 2.16 mgd for 24 hours per day, the tank would need to be refilled about seven to nine times per year. If the plant were to run at the full water right amount of 3.23 mgd for 24 hours per day, the tank would need to be refilled monthly. For operation at 2.16 mgd, the addition of a second alum tank may be advisable to reduce the frequency of deliveries, although it is not critical unless the plant is operated for 24 hours per day at that rate. For operation at 3.23 mgd, the addition of a second alum tank is necessary.

The chemical soda ash, which is used for pH adjustment, is stored in a feed hopper that holds 150 to 175 pounds of dry soda ash. When the WTP was operated 24 hours per day with four filters, the operators added three to four bags per day. Since the hopper only holds about three bags, they would add one or two bags each shift. However, the plant was not operated at 2.16 mgd. If the WTP were operated at 2.16 mgd for 24 hours per day, operators would need to add three to four bags every shift. Therefore, it is advisable to modify the soda ash feed system if the plant will be operated 24 hours per day at 2.16 mgd. If the capacity is increased to 3.23 mgd and operated 24 hours per day, an improved soda ash storage and feed system will be necessary. Otherwise the operators would be required to manually add one-third of a soda ash pallet each day to the hopper.

Wastewater Pond Capacity

The WTP site has a single wastewater pond for disposal of backwash effluent. Originally the pond was designed and constructed as two separate ponds. At some point, the south ends of the ponds were joined by breaching the berm between them to create the existing single pond. Annually, operators remove the solids from the pond and place them in a solids drying area on the west side of the WTP site. The solids remain in that location for one year for dewatering. They are then moved to a City-owned site where they are spread. Currently, whenever the filters are backwashed, the pond fills, but the water level always drops before the next backwashing.

The water treatment operator reports that there have been no capacity limitations with the wastewater ponds during his tenure at the facility, even when the plant was operated on a 24 hour per day schedule. However, this was without a filter-to-waste system. Once the filter-to-waste system is installed, the total loading on the pond will increase. Therefore, even if the plant capacity is not increased but the plant is operated closer to that capacity for 24 hours per day, it is likely that the existing pond will have insufficient storage capacity.

There is additional area available on the site for expanding the wastewater facilities, if necessary. Apparently, the property line for the WTP site is about 40 feet west of the current location of the western fence line. Expanding the available area would require relocation of the fence and some tree removal. As an alternative to expanding the pond area, the invert of the existing pond could be lowered to provide additional capacity.

Chlorine Contact Analysis

The City is currently meeting the disinfection goal of achieving CT compliance for water supplied through the finished water transmission main, including all customers directly served from the main. However, the disinfection goal is not met for potable water supply to the WTP facility itself and for the lead WTP operator’s home, due to the close proximity of these two services to the point of disinfection at the WTP. Both of these services receive water from the WTP potable water system and not from the finished water transmission main. To achieve the disinfection goal for service to the WTP and the lead WTP operator’s home, improvements are required to increase contact volume prior to the WTP and the lead

WTP operator's home. A summary of the chlorine contact analysis performed for the first customer on the transmission main and separately for the operator's house is shown below in Table 1.

Table 1
Chlorine Contact Analysis

Description	2007 Existing System	
	Transmission Main Customer	**Operator's House**
Input Data:		
Peak Hour Flow (gpm)	925	15
Water Temp (^{o}C)	4	4
pH	7.3	7.3
Chlorine Residual, C (mg/l)	1.2	1.2
First Customer Location	3124 Robe-Menzel Rd	Operator's House
Length of Pipe (ft)	6,515	1,940
Diameter of Pipe (in)	18.0	1.0
Calculations:		
Chlorine Contact Volume (gal)	86,128	79
Contact Time calculated, T (min)	93.1	5.3
CT calculated, CxT	111.7	6.3
CT Required (1-log inactivation)	65.6	65.6
Contact Time Required, T (min)	54.6	54.6
Inactivation Ration, IR	1.70	0.10
Results: Pass/Fail (IR Required >= 1)	Pass	Fail

Peak Hour Flow is from peak in 2007 for Transmission Main Customer and estimated for Operator's House.
Temperature and pH represent maximum CT requirement in 2007 (1/15/07), chlorine residual from 2007 average.

The first customer on the transmission main is located approximately 6,515 feet from the clearwell, which equates to a chlorine contact volume of approximately 86,100 gallons for the existing 18-inch diameter transmission main. If water was supplied through the transmission main at the WTP original design flow rate of 2.16 mgd, the contact time would be approximately 57 minutes. If water was supplied through the transmission main at a rate equal to the City's maximum instantaneous water right of 3.23 mgd, the contact time would be approximately 38 minutes.

Based on an analysis of the data for finished water pH, temperature and chlorine residual for 2004 through 2007, the WTP could operate at a rate of 2.16 mgd throughout the entire year and achieve the required inactivation ratio (IR) of at least 1.0 without significantly altering operations. Using the data from 2007 for finished water temperature, pH and chlorine residual, there were only nine days that the plant would have failed to achieve an inactivation ratio of at least 1.0 had the plant been operated at 2.16 mgd. On all of those days, if the residual had been raised slightly, to 1.2 mg/l, the IR would have been greater than 1.0 at the flow rate of 2.16 mgd. It is important to emphasize that the plant did meet disinfection requirements on all of those days; the IR achieved was greater than 2.0 for all nine days because the plant was being operated at or below one-half the plant's original design capacity. These data demonstrate that by simply maintaining a consistent chlorine residual of 1.2 mg/l during those periods when temperature is low, even when the finished water pH is high, the plant could be operated at 2.16 mgd while meeting disinfection requirements.

At a rate of 3.23 mgd, an inactivation ratio of 1.0 can be achieved about eight months out of the year without significantly altering operations other than consistently maintaining a residual of 1.4 mg/l on days when the temperature is low and the pH is high. However, simply maintaining a consistently high chlorine residual would be insufficient for achieving an inactivation ratio of 1.0 throughout much of the period from November through February. During those months, operating at 3.23 mgd would require both a very high residual and a low pH. However, operation at the peak rate of 3.23 mgd would likely be limited to the summer months when demands are high. Rather than increase the residual, the City could install a CT pipe improvement at the service connection of the first customer or transfer the first customer to another water source, if applicable. The second customer on the transmission main is located approximately 11,200 feet from the WTP clearwell, which significantly reduces the challenges of meeting the CT requirements at the higher WTP production rates.

Summary of Pilchuck WTP Capacity Limitations

The intake structure, with appropriate modifications to the fish screen, can operate at the City's maximum instantaneous water right of 3.23 mgd. Head loss through the existing raw water line at a flow rate of 3.23 mgd would be too high to supply the existing flocculation tank as it is currently configured. However, there does appear to be sufficient head to convey 3.23 mgd by gravity through the existing raw water line to a properly located basin incorporating rapid mix, coagulation, flocculation and sedimentation between the intake and the existing filters. The capacity of the existing 18-inch diameter raw water line, based on the current configuration with the existing flocculation tank, is approximately 2.16 mgd, which is the original design capacity of the WTP.

The flocculation tank is not capable of treating 3.23 mgd for direct filtration. The tank's original design capacity of 2.16 mgd is the upper limit of what the tank can effectively treat. Due to the poorly designed effluent weir, 2.16 mgd may in fact be outside the limit of the tank's effective treatment capacity for direct filtration.

The filters cannot treat 3.23 mgd as long as the plant is operated as a direct filtration facility. To operate the four existing filters at 3.23 mgd, the WTP needs to be upgraded to conventional treatment by adding a sedimentation unit before the filters. However, there appears to be a hydraulic capacity limitation that prevents the filters from operating at their original design capacity of 2.16 mgd. The driving head for the filters is low for direct filtration. Minor modifications to clearwell operating levels may allow the filters to operate at 2.16 mgd by gravity. Filter effluent pumps would likely be required to operate the filters at 3.23 mgd.

The alum tank is sufficiently sized for operation of the WTP at 2.16 mgd for 24 hours per day. However, additional alum storage would be necessary to operate at 3.23 mgd for 24 hours per day. The soda ash feed system is acceptable for operation at 2.16 mgd, although if the plant were to run at that rate 24 hours per day, a larger hopper is recommended. For operation at 3.23 mgd for 24 hours per day, an alternative pH adjustment system will be needed to prevent the operators from having to manually handle the large volume of soda ash that will be consumed at that treatment capacity.

The backwash wastewater pond will need to be expanded if the plant capacity is increased to 3.23 mgd. It is likely that the pond will also need additional capacity after the filter-to-waste system is installed if the WTP is operated close to its original design capacity of 2.16 mgd for 24 hours per day.

The existing chlorine contact volume is sufficient for treatment of an instantaneous rate of 2.16 mgd throughout the year as long as careful attention is paid to the chlorine residual and the finished water pH when the water temperature is below 7ºC. For disinfection at an expanded plant capacity of 3.23 mgd when the temperature is between 10 ºC and 15 ºC, an IR of 1.0 could be achieved with a residual of 1.2 mg/l as long as the finished water pH is closely monitored. Between 7ºC and 10 ºC, the pH would need to be carefully controlled while maintaining a consistent residual of approximately 1.4 mg/l. Below 7 ºC, it will be difficult to achieve an IR of 1.0 for 3.23 mgd without adding additional chlorine contact volume for the system, or on a smaller scale, adding additional chlorine contact volume for the first customer on the transmission main.

Pilchuck Water Treatment Plant Structural Assessment

A structural assessment of the WTP building and the 0.5 MG steel backwash water tank was conducted by Peterson Structural Engineers, a subconsultant to MSA for this project. The results of the structural assessment indicate that both structures will require structural upgrades to ensure reliable service over the next 20 years. Refer to the attached technical memorandum that documents the structural assessment.

Assessment of Electrical, Instrumentation and Controls Systems

An electrical, instrumentation and control assessment of the WTP facilities was conducted by Casne Engineering, a subconsultant to MSA for this project. The results of this assessment are documented below.

Electrical Service at the Intake Structure

A small electrical service is located at the Pilchuck River intake structure with transformers overhead and service conduit that runs underground and into the open structure. The electrical equipment is original and will need to be upgraded to provide sufficient power for the high pressure pumps that will be needed for automatic cleaning of the proposed fish screens. A small telemetry cabinet currently transmits alarms. This cabinet, which is tone telemetry over phone, will need to be upgraded for long-term operation of the intake facility.

Electrical Service and Motors Control at the Water Treatment Plant

The WTP is currently provided with a 200-amp, 480-volt three-phase service consisting of overhead transformers, an outdoor 200-amp fused disconnect, and an indoor 200-amp manual transfer switch. This equipment was installed in 1981 when the WTP was constructed. The major loads are for backwashing, and have not grown. The planned addition of pumps for filter-to-waste will bring the maximum demand on the electrical service close to the full capacity of the service equipment. Any additional loads above and beyond the filter-to-waste pumps will likely require an increase of the electrical service size to 400 Amps and the replacement of the existing service equipment. Even if the service is not increased, replacement of the existing service equipment is recommended since the equipment is over 25 years old and is near the end of its useful life. Replacement parts for the existing equipment will be increasingly difficult to obtain.

The motor control center (MCC), which is rated at 600 amps, is located indoors and is in good condition with a mix of circuit breakers and combination fill voltage starters. With replacement of the service equipment, the utility will require the installation of soft starters for the 40 HP backwash pumps. The existing MCC could perhaps last another 20 years, but replacement parts will be increasingly difficult to obtain.

Lighting at the Water Treatment Plant

There is need for additional lighting under the filter platform and on the east side of the flocculation tank. Also, the existing lighting fixtures will soon start experiencing ballast failures. The fluorescent fixtures should be replaced with more efficient T8 fluorescent fixtures.

Water Treatment Plant Instrumentation

Some of the instruments at the WTP have been upgraded recently. However, some instruments remain from the initial construction or were installed during the early years of operation. It is recommended that the older instruments be replaced if the WTP is to operate for another 20 years. The raw water turbidimeter is a Hach 1720 C that will likely need replacement sometime during the next 20 years. The four filter effluent turbidimeters and the combined filter effluent turbidimeter are all US Filter TMS 561 units of recent manufacture.

Water Treatment Plant Controls

The plant was designed with a custom Plant Control Panel (PCP) and a pre-engineered Filter Control Panel (FCP). The FCP controls the filter flows, level and differential pressure, and provides for initiation of backwash, control of the backwash cycle and returning the filter to service. The FCP was originally provided with a cycle timer, which has been upgraded to a small PLC controller. The FCP will require some upgrades for extended life.

The PCP displays and controls the level of the clearwell tank, indicates and totalizes raw water flow, controls chlorination and the feed of other chemical, displays and controls the backwash tank level, controls the potable water system pumps, records raw and finished water turbidity, and monitors air pressure for filter valve control. It is a hardwired panel consisting of control switches, indicators and chart recorders. Some of the indicators have been upgraded to electronic, but most of the power supplies for instruments, timers, annunciators, control relays, and wiring are original equipment. The PCP has exceeded its useful life by component replacement and with loss of function. The PCP will require replacement if the plant is to operate for another 20 years.

SCADA System

Supervisory control and data acquisition (SCADA) systems are used by most municipalities for remote monitoring and supervisory control of water treatment facilities. The Pilchuck WTP does not have such a system. Installation of a SCADA system would greatly assist the operators as well as those who provide technical assistance to the operations staff. SCADA systems allow the operator to remotely determine the cause of many alarms and, when appropriate, resolve the problem remotely. When combined with data logging, a SCADA system also assists in preparing reports; both those reports required by the State and reports that may be helpful to City managers. Finally, the data logging capability assists in troubleshooting long-term problems that may arise. It is recommended that a small SCADA system be tied into the information from the telemetry system and the plant PLCs. The SCADA system would likely be located at the WTP, but could be accessed from other City locations through the City's telemetry system.

Water System Telemetry

The Pilchuck WTP provides treated water to Reservoirs 1 and 2 in the City's 222-foot pressure zone. These reservoirs are the terminal reservoirs for the finished water transmission line. The reservoirs have a remote telemetry unit (RTU) that communicates back to the WTP to discontinue supply from the WTP when the reservoirs are full. The chlorine room at the site of the reservoirs also has an RTU. Another RTU resides at the water shop on 1st Street. All the RTUs are based on Rugid 256 equipment and communicate over leased telephone lines. The key information monitored by the system is finished water transmission line flow rate, reservoir level and backwash tank level. The telemetry system uses older equipment that should be upgraded. Since this memorandum focuses on the WTP, only the cost for upgrading the terminal reservoir RTU is included in the capital cost analysis. However, all the water system RTUs should be upgraded at the same time.

Options for Capacity Expansion at the Existing Pilchuck WTP

Three options for expanding the treatment capacity of the filtration process at the existing Pilchuck WTP have been identified.

- Option 1 - Converting from Direct Filtration to Conventional Treatment: Using the existing river intake and the existing rapid sand filters, upgrade from the existing treatment process of direct filtration with coagulation and flocculation to conventional treatment by adding sedimentation to the treatment process.

- Option 2 - New Riverbank Filtration Intake: Replace the existing river intake system with a new riverbank filtration intake system and increase the rate of the existing rapid sand filters from the direct filtration rate of 3 gpm/ft^2 to 4.5 gpm/ft$^{2.}$

- Option 3 – New Membrane Filtration: Replace the existing rapid sand filters with a new membrane filtration system that includes coagulation and flocculation prior to membrane filtration.

The capacity of the existing plant could be expanded from 2.16 mgd to 3.23 mgd by adding sedimentation to the process and increasing the rate of the filters from 3 gpm/ft^2 to 4.5 gpm/ft^2. Alternatively, the existing plant could be converted to membrane technology as part of a program to expand the plant to 3.23 mgd.

Option 1 - Converting from Direct Filtration to Conventional Treatment

Converting the existing WTP from direct filtration to conventional treatment involves adding a sedimentation basin before the filters to allow heavy particles to settle out, thereby reducing the turbidity of the water prior to it entering the filters. A conventional treatment system would allow for operation of the facility during high turbidity events, which currently requires the existing WTP to be shutdown. It would also allow for increasing the treatment capacity of the filters by raising their rated throughput from 3 gpm/ft^2 to 4.5 gpm/ft^2. This would increase the treatment capacity for filtration to 3.23 mgd. Further analysis and field testing will be required to determine whether the filters can operate at this rate by gravity flow or if pumps would be needed to achieve this throughput. Based on the data available at this time, it appears that pumps will be required for rates above 3 gpm/ft^2.

Figure 2 shows the water treatment process schematic and expected hydraulic profile through the plant if the plant were modified to operate as a conventional treatment plant at the existing design rate of 2.16 mgd. This figure shows the filter to waste pumps that are expected to be added soon. The figure does not show filter effluent pumps as it assumes that the filters can operate at their nominal design capacity of 3 gpm/ft^2 without being hydraulically limited.

Figure 3 shows the water treatment process schematic and the expected hydraulic profile through the plant for a WTP modified to treat 3.23 mgd in a conventional treatment process. This figure includes pumps required to lift the filter effluent to the backwash tank as it is assumed that there is a hydraulic capacity limitation that would prevent gravity operation at the higher filtration rate of 4.5 gpm/ft^2. The pumps that currently pump from the clearwell to the backwash tank are not shown as they would no longer be needed.

A concrete sedimentation basin incorporating rapid mixing, coagulation, flocculation and sedimentation with enhanced settling capabilities through use of tube settlers or Lamella plates could be located east of the access drive to the backwash basins, between the access drive and the fence along the east side of the property. With proper design of the water surface in the basins, raw water could flow by gravity at a rate of up to 3.23 mgd to the rapid mix basin and the settled water could flow by gravity to the filters.

To provide sufficient depth in the sedimentation basin to operate the basin at a surface overflow rate of 1.5 gpm/ft^2, it will be necessary to pump the solids from the sedimentation basin sump or to lower the invert of the wastewater ponds to allow for gravity flow from the sump. To allow for gravity flow from the sedimentation basin sump without lowering the wastewater pond invert would require a shallower sedimentation basin which would decrease the surface overflow rate of 1.0 gpm/ft^2, greatly increasing the overall footprint for the basin. Increasing the depth of the wastewater basins is likely the better option since this would also increase the volume of wastewater storage which may be necessary if the plant capacity is increased.

As noted in the analysis of electrical systems at the WTP, the addition of pumps for the filter-to-waste improvements that are planned for 2008 will bring the maximum demand on the electrical service close to the full capacity of the service equipment. Installation of a new basin for rapid mixing, flocculation and sedimentation would likely require an increase of the electrical service size to 400 Amps and the replacement of the existing service equipment.

The preliminary opinion of cost for a concrete basin incorporating rapid mixing, coagulation, flocculation and sedimentation with enhanced settling capabilities at the Pilchuck WTP site is approximately $2.17 million. This is a conceptual, planning-level estimate of the total project cost including construction, contingencies, surveying, field investigations and engineering. It also includes the cost of installing filter effluent pumps to overcome the hydraulic capacity limitations of the filters, but does not include the costs for a finished water pump station, which would be required to supply 3.23 mgd through the existing transmission main.

Option 2 - New Riverbank Filtration Intake

Riverbank filtration (RBF) is a method of withdrawing water from a surface water source while also providing some level of pretreatment at the intake. The primary surface water contaminants attenuated with a properly designed RBF system are turbidity and biological contaminants. Typically, RBF systems are constructed in unconsolidated, alluvial aquifers adjacent to the surface water source. This process can only be applied where the hydrogeological conditions adjacent to the surface source are favorable. A properly designed RBF system creates a hydraulic gradient from the riverbed toward the intake screens inducing the surface water to infiltrate from the riverbed into the surrounding aquifer. This process provides some removal of suspended solids, reducing the turbidity of the water and also reducing the variability in raw water turbidity.

The water from a RBF intake is a mixture of groundwater and surface water filtered through the porous media separating the screens from the river bed. The precise mix of surface water and groundwater will vary depending upon the local hydrology and hydrogeology as well as the design of the intake. The mix may also vary throughout the year if the surface water source at that location alternates between recharging the local aquifer and receiving discharge from the aquifer.

An RBF intake can be a large diameter vertical collector well or a large, circular caisson with horizontally oriented screens extending laterally from the central caisson. For horizontal collector well systems, some of the laterals typically extend toward the surface water source and may even extend beneath the source. Laterals may or may not extend away from the surface source, depending upon hydrology, hydrogeology and the desired intake capacity.

Only limited data are available for analysis of the subsurface conditions near the Pilchuck WTP site. Most of the available data are from nearby domestic wells. Such wells are typically drilled to shallow depths and the well logs from such drilling often do not record the hydrogeology encountered in great detail, or even very accurately. Review of the available data suggests that permeable alluvial deposits do exist in the vicinity of the WTP and that the static water level is about 12 feet below ground surface.

For the planning level estimate prepared in this study, it is assumed that an RBF system capable of producing the desired capacity would consist of a central caisson collector well approximately 50 feet below ground surface with screens extending laterally toward the nearby Pilchuck River. The prospective site is west of the clearwell near the location previously identified for a second reservoir. To determine if this is a suitable site, exploratory test drilling and aquifer pumping tests would be needed. These tests would generate information about the aquifer properties necessary to prepare a preliminary design, to refine cost estimates and to prepare a final design if the aquifer properties appear promising.

The preliminary opinion of cost for a riverbank filtration intake at the Pilchuck WTP site is approximately $3.41 million. This is a conceptual, planning-level estimate of the total project cost including construction, contingencies, field investigations and engineering. It also includes the cost of installing filter effluent pumps to overcome the hydraulic capacity limitations of the filters, but does not include the costs for a finished water pump station, which would be required to supply 3.23 mgd through the existing transmission main. A detailed field investigation program would help refine this project cost estimate. Field investigations would generate the data needed for preliminary design and could possibly determine that the cost would be lower than anticipated by this planning-level estimate. Based on this planning level estimate, it appears that although RBF might improve raw water quality enough to uprate the filters to treat the City's full water right, the cost for an RFB intake is significantly greater than the cost for converting the WTP to conventional treatment.

However, riverbank filtration should still be considered when examining source alternatives. If it is determined that the City's full water right can be transferred downstream to a location within the city limits, a RBF intake could be considered a viable alternative to conventional surface intakes. This is due to the following factors.

1. Typically, the most favorable deposits for RBF systems are found in alluvial valleys. The wider the alluvial valley and the lower the slope of the valley, the greater the likelihood of finding favorable deposits. The downstream location within the City limits meets these latter conditions more closely than does the site of the existing WTP.

2. A new conventional surface intake at the prospective downstream site will have a significant cost, perhaps in the same range as RBF. However, unlike a conventional surface intake, RBF avoids instream work that could streamline permitting for an intake at the prospective downstream site.

3. RBF avoids the capital and operating cost for constructing and maintaining fish screens and a fish passageway associated with a conventional surface water intake.

4. Surface water quality will likely be more degraded at the prospective downstream site than at the existing Pilchuck Dam No. 2 intake location. Thus, the reduction in turbidity and water temperature provided by a RBF intake could be more beneficial at a downstream location than at the upper Pilchuck facility.

Option 3 - New Membrane Filtration

Membrane filtration systems have hollow fiber membranes that are used to separate particles from the water. The membranes have small pores, on the order of 0.1 micrometers (μm) or less, that allows water to pass through the membrane while retaining particles larger than about 1.0 μm. The membranes are formed into hollow fibers bundled together longitudinally. The fiber bundles can be encased into a pressure vessel or submerged in a basin. Pressure membranes operate with the unfiltered water pumped through the inside of the hollow fiber. Particles are retained on the inside of the hollow fiber while filtered water passes through the pores to the outside of the fiber. Submerged, or "vacuum," membranes operate with the unfiltered water on the outside of the fiber. Particles are retained on the outside of the fiber while filtered water passes through the pores to the inside of the hollow fiber under the pressure differential provided by a vacuum applied to the inside of the hollow fiber.

Membrane systems normally require minimal chemical addition for treatment and provide high quality drinking water and operational simplicity within a relatively small footprint. Membranes do, however, require periodic chemical cleaning and packaged membrane systems include the equipment for such cleaning.

Membrane filtration has become an increasingly popular filtration alternative throughout the United States and in the Pacific Northwest. As the technology has matured, the costs for new construction are increasingly competitive with conventional filtration. In spite of this fact, the costs associated with converting the Pilchuck WTP from direct filtration to membrane filtration are significantly higher than the cost for converting the plant to conventional filtration.

For retrofitting an existing rapid sand filtration plant for membrane filtration, it is common to use submerged membranes located inside the existing filter bays if the filter bays are concrete. This generally results in a lower capital cost than retrofitting with pressure membranes. In the case of the Pilchuck WTP, the preferred option is to remove the steel filter bays from the rapid sand package plant and install pressure membranes. This is because pressure membrane filters tend to have a smaller footprint than do submerged membranes and because the plant's existing steel filter bays may not be readily retrofitted to accommodate the submerged membrane technology. There are several pressure membrane filtration systems on the market today that may be appropriate for the Pilchuck WTP.

Membrane filters provide an absolute barrier to *Giardia* and *Cryptosporidium*, thus ensuring compliance with current and future regulations. However, membranes are not capable of removing dissolved organic material – such as total organic carbon (TOC) or color – unless a coagulant is used to create a filterable floc. In some systems, it is necessary to continue to coagulate the raw water prior to filtration even if membranes are installed to produce water with low disinfection by-products and consistently low and stable chlorine demand. Also, to protect the membranes from fouling, it is sometimes necessary to oxidize insoluble iron and manganese compounds prior to membrane filtration.

The quality of the raw water from the Pilchuck River is fairly good. No TOC data have been made available for review; however, the low level of total trihalomethanes (TTHMs) reported is an indication that raw water TOC is low. Color has been consistently below the maximum contaminant level (MCL). The data indicate fairly low iron and manganese concentrations in the raw water as well. These data indicate that the raw water quality at the Pilchuck WTP may be good enough for pressure membrane filtration without pre-treatment. However, this must be confirmed through laboratory testing of raw water samples in accordance with the various membrane manufacturers recommendations. If pretreatment is deemed necessary, such testing would help determine whether the existing flocculation tank provides sufficient flocculation time for the higher treatment rate of 3.23 mgd or whether a new coagulation and flocculation system must be installed.

A pilot study to determine the design parameters for full-scale performance would be required if the City were to decide to implement pressure membrane technology at the Pilchuck WTP. Proper engineering design would be required to successfully integrate membrane technology into the existing Pilchuck WTP's treatment process and to identify locations for all of the required ancillary equipment. Membrane technologies generally require large capital investments and costly periodic membrane replacements. These additional costs may make this alternative substantially less attractive compared to the alternative of expanded rapid sand treatment by upgrading the plant to conventional treatment.

Retrofitting the existing plant with pressure membrane technology to achieve an expanded capacity of 3.23 mgd would require a footprint of approximately 37 feet wide by 54 feet long. Sufficient space is available in the existing structure if the filters and existing flocculation tank are removed. If the existing flocculation tank remains, it will be more difficult to fit pressure membrane treatment into the existing structure.

The preliminary opinion of cost for such a membrane system is estimated at approximately $3.8 million. This is a conceptual, planning-level estimate and includes construction, contingencies, pilot testing of membrane systems and engineering. Further consideration of membrane filtration for expansion of the Pilchuck WTP is not warranted at this time based on this planning level cost estimate. However, membranes should still be considered when examining source alternatives. If it is determined that the City's full water right can be transferred downstream to a location within the city limits, membranes should be considered as a viable option for treatment of the water at that location.

Conclusions and Recommendations

Water Rights and Existing WTP Capacity

The City's water rights on the Pilchuck River at Pilchuck River Dam No. 2 are 2.68 mgd on an annual basis with a maximum instantaneous rate of 3.23 mgd. The WTP is currently running at a maximum capacity of approximately 1.3 mgd. When Filter No. 4 is returned to service, the WTP capacity will be approximately 1.7 mgd. This is less than the original design capacity of 2.16 mgd, due to an apparent hydraulic capacity limitation through the filters. The capital improvements needed to operate the Pilchuck WTP at the original design capacity are summarized below.

Dam and Fish Ladder

The consensus among WDFW staff and consultants familiar with the fish ladder is that modifications will be required at some point if the City is to operate the dam for the next twenty years. This study did not include a detailed condition assessment and structural analysis of the dam structure nor did it include a detailed analysis of the alternatives for modifying the fish ladder to ensure a durable and effective structure that allows for the passage of fish. It is recommended that the City conduct a separate study to obtain a comprehensive understanding of the existing dam condition and to identify alternatives for improving the fishway. The assessment of the dam will require dewatering the pool behind the structure and removing debris from the fish ladder to thoroughly inspect the entire structure and the riverbed adjacent to the structure. The assessment of the fish ladder will require detailed analysis of alternatives, including moving the fishway to the right bank and options for improving the fishway in place on the left bank.

Recommended Capital Improvements for Operation at Original Design Capacity

The following provides recommendations for improvements that would enable the WTP to produce treated water at its original design capacity of 2.16 mgd. An opinion of probable project costs including construction costs, a construction contingency and engineering costs, is provided for each improvement in Table 2. The dam weir and fish ladder cost estimate may be refined by a study to obtain a comprehensive understanding of the existing dam condition, to develop alternatives for improving the fishway, and to identify the preferred fishway improvement alternative.

Table 2
Opinion of Probable Project Costs for Improvements to
Operate the Pilchuck WTP at Original Design Capacity of 2.16 MGD

Capital Improvement	Opinion of Project Costs[1]
Fish Screens	$392,000
Dam Weir and Fish Ladder	$1,750,000
Implement Modulation of Influent Valve	$58,000
Modify Flocculation Tank Outlet Weir	$12,000
WTP Building Structural Upgrades	$52,000
Backwash Tank Structural & Recoating	$180,000
Replace WTP Electric Service Equipment	$35,000
Replace WTP MCC	$46,000
Upgrade Filter Control Panel	$9,000
Replace WTP Control Panel	$115,000
Upgrade Water System Telemetry	$115,000
Implement Water SCADA System	$92,000
WTP Lighting Improvements	$9,000
WTP Instrumentation Replacements	$12,000
Effluent Pumps	$400,000
Total - Opinion of Project Cost (2.16 MGD Capacity)	**$3,277,000**
Total - Opinion of Project Cost (1.7 MGD Capacity)[2]	**$2,877,000**

1. Opinion of project costs includes construction and engineering costs in 2008 dollars.
2. Cost without effluent pumps, which are assumed to be required for 2.16 MGD capacity only.

Structural upgrades to the WTP building are required to ensure that the facility continues to operate should a code level seismic or snow event occur in the next 20 years. Structural upgrades to handle a code level seismic event are also required for the 0.5 MG steel backwash reservoir. The reservoir should be recoated as part of that work. The cost shown for backwash reservoir upgrades includes a contingency for lead abatement in the event that the existing backwash reservoir coating is found to contain lead.

The City should install a supervisory control and data acquisition (SCADA) system to improve remote control and monitoring of the plant. This work should include data logging for preparing reports that are required by the State and reports that would be beneficial to City managers. The data logged would also assist in troubleshooting long-term issues, such as the apparent hydraulic capacity limitation on the filters.

Electrical and controls upgrades are needed to operate the plant for another 20 years. The costs shown in Table 2 for upgrading the water system telemetry system and implementing a SCADA system assume that the improvements will also include upgrades to and communication with the existing telemetry facilities at the City's Water Shop.

The existing intake facility should be upgraded with new stationary fish screens. The screens should be capable of meeting all current fish screen criteria while passing either 3.3 cfs, if the WTP is to be operated at the existing plant capacity, or 5 cfs if the plant is to be operated at the City's maximum instantaneous water right. The opinion of cost presented herein include upgrades to the electrical service at the intake, a new RTU and modifications to the intake MCC to handle screen cleaning pumps.

The current fish ladder is not able to meet specific criteria due to the current design of the bottom three pools. A more serious problem is the accumulation of debris in the fishway which may regularly obstruct a portion of the adult Coho migration and possibly the entire upriver adult steelhead migration. With the May 2007 listing of the Puget Sound Steelhead, there is likely to be increased scrutiny of all structures within the Puget Sound Steelhead ESU that adversely impact steelhead survival. As a result, it appears likely that major modifications to the fishway will be required if the City is to operate the structure for another twenty years. The opinion of probable project cost presented below is provided solely for use in the cost model of this study. It must be emphasized that there is no consensus at present on what modifications will be required or what the preferred alternative will be. It is therefore recommended that a separate study be conducted on the fishway structure to determine the preferred option. The result of that study may alter the opinion of probable construction cost presented below.

The WTP influent control valve should be replaced with a smaller valve to allow for modulation of the influent when a filter is removed from service for backwashing. Modifications to the influent controls will also be required.

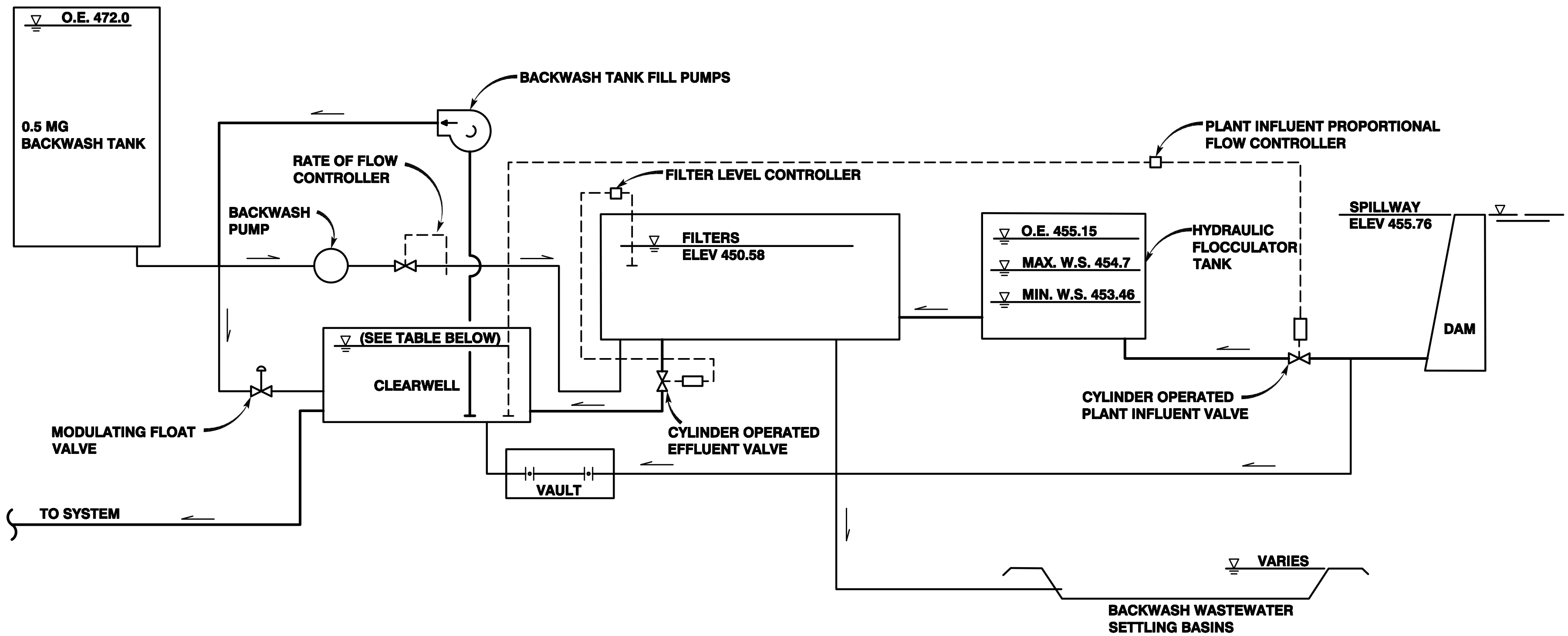
The outlet weir from the flocculation tank should be modified to reduce the velocity of the water over the weir and to reduce the height of the drop that the flocculated water experiences when falling over the weir.

To operate the plant at the original design capacity of 2.16 mgd, it will be necessary to overcome the apparent hydraulic capacity limitation through the filters. To do this, the City must first collect sufficient data to verify and quantify the hydraulic capacity limitation. The City should install a headloss transmitter on at least one operational filter. Time-stamped data on headloss, flow rate, filter effluent turbidity and filter run time should be logged. These data can be used to determine whether there is indeed a hydraulic limitation through the filters. If there is a hydraulic limitation, the data should be used to determine the cause of the limitation and to investigate whether minor operational changes, such as reduced clearwell level, would be sufficient to overcome the limitation to operate the filters at 3 gpm/ft^2. If modifying the clearwell operating level is insufficient to achieve the 2.16 mgd design flow of the existing plant, it will be necessary to install filter effluent pumps similar to the filter-to-waste pumps that are planned for installation in 2008.

This technical memorandum identifies recommended improvements to the existing WTP and intake facility on the Pilchuck River. It does not include an evaluation of the City's finished water transmission main and related recommended improvements, which will be addressed separately in the overall project report. Therefore, additional improvements related to the finished water transmission main may be required for long-term supply from the Pilchuck River source and to convey treated water at an increased rate equal to the City's instantaneous water right of 3.23 mgd.

Attachments:

- Figure 1 – Existing Water Treatment Process Schematic
- Figure 2 – Plant Process Schematic for Conventional Treatment (2.16 MGD)
- Figure 3 – Plant Process Schematic for Conventional Treatment (3.23 MGD)
- City of Snohomish WTP Evaluation – Structural Assessment, dated 4/2/08



CLEARWELL OPERATING LEVELS

INFLUENT VALVE CLOSED	ELEV 442.0
INFLUENT VALVE FULL OPEN	ELEV 440.5
MOD. FLOAT VALVE CLOSE	ELEV 439.4
MOD. FLOAT VALVE OPEN	ELEV 438.5

NOTE: CLEARWELL OPERATING LEVELS OBTAINED FROM 1980 DESIGN DRAWINGS. WATER TREATMENT PLANT OPERATORS INDICATE THAT MINIMUM CLEARWELL LEVEL IN AUTOMATIC MODE IS 441.6 FEET.

SCALE: NTS

FIGURE 1

CITY OF SNOHOMISH

SNOHOMISH WASHINGTON

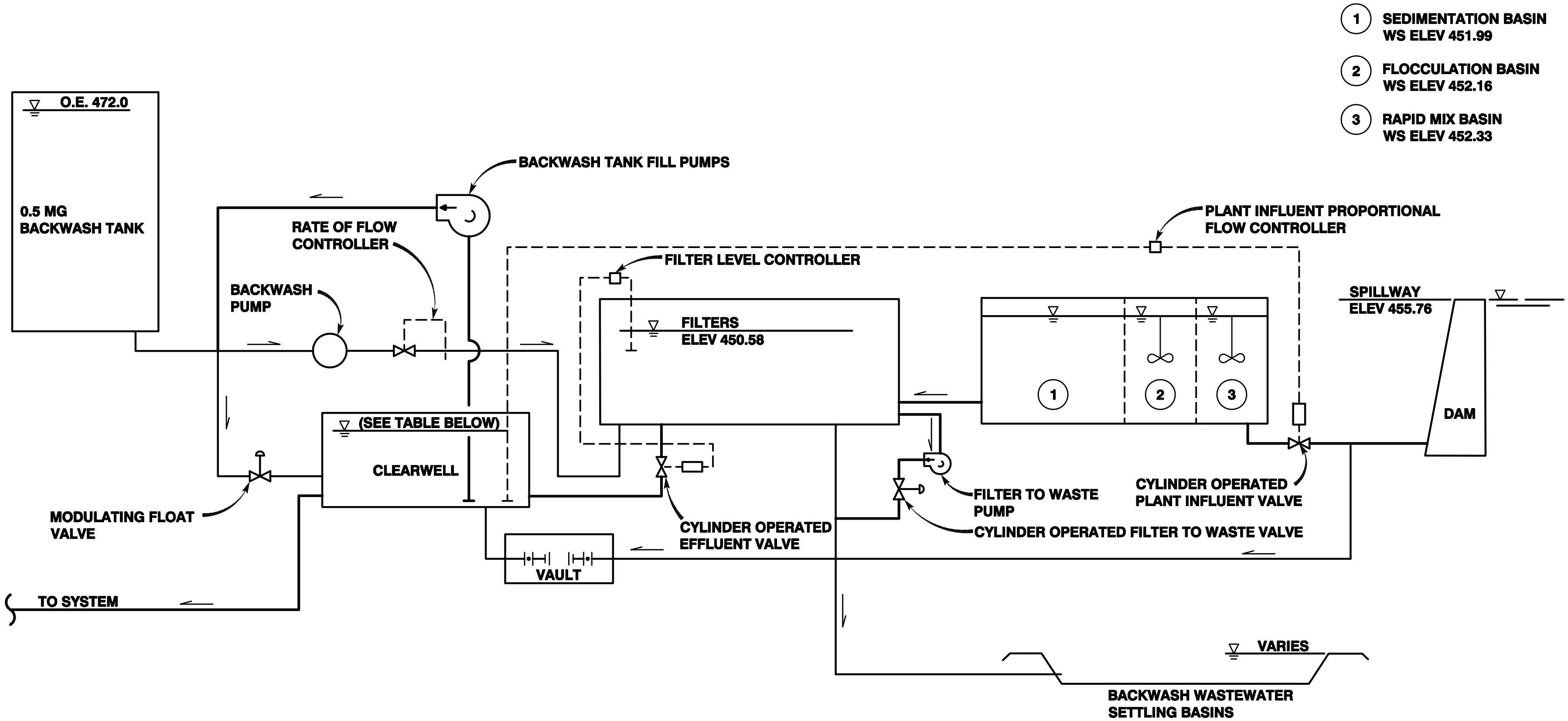
EXISTING WATER TREATMENT PROCESS SCHEMATIC

AUGUST 2008

MSA Murray, Smith & Associates, Inc. Engineers/Planners

07-0900.103

G:\07\0900\103 - WTP & Trans Main Evaluation\CAD\07-0900-103-OR-FIG-2.dwg FIGURE 2 8/8/08 13:56 (MBE)



CLEARWELL OPERATING LEVELS

INFLUENT VALVE CLOSED	SEE NOTE 1 BELOW
INFLUENT VALVE FULL OPEN	SEE NOTE 1 BELOW
MOD. FLOAT VALVE CLOSE	ELEV 439.4
MOD. FLOAT VALVE OPEN	ELEV 438.5

NOTES:

1. INFLUENT VALVE OPERATING LEVELS MAY REQUIRE MODIFICATION TO ELIMINATE POSSIBLE EXISTING HYDRAULIC LIMITATION.

2. MODULATING FLOAT VALVE OPERATING LEVELS OBTAINED FROM 1980 DESIGN DRAWINGS.

SCALE: NTS

FIGURE 2

CITY OF SNOHOMISH

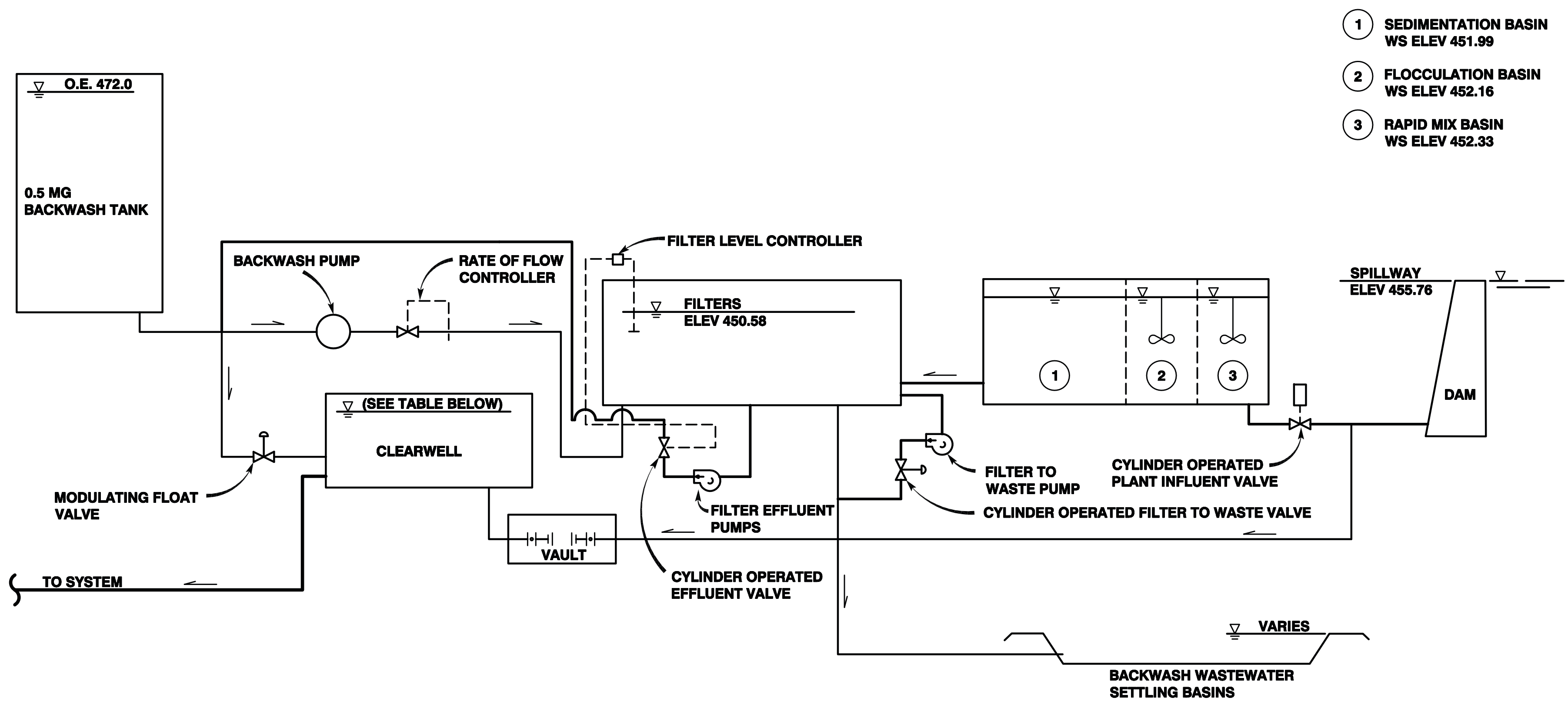
SNOHOMISH WASHINGTON

PLANT PROCESS SCHEMATIC FOR CONVENTIONAL TREATMENT (2.16 MGD)

AUGUST 2008

MSA Murray, Smith & Associates, Inc. Engineers/Planners

07-0900.103



CLEARWELL OPERATING LEVELS

MOD. FLOAT VALVE CLOSE	ELEV 439.4
MOD. FLOAT VALVE OPEN	ELEV 438.5

NOTE: MODULATING FLOAT VALVE OPERATING LEVELS OBTAINED FROM 1980 DESIGN DRAWINGS.

SCALE: NTS

FIGURE 3

SNOHOMISH WASHINGTON

CITY OF SNOHOMISH

PLANT PROCESS SCHEMATIC FOR CONVENTIONAL TREATMENT (3.23 MGD)

AUGUST 2008

MSA Murray, Smith & Associates, Inc. Engineers/Planners

07-0900.103

Peterson Structural Engineers, Inc.

consulting structural engineers

Charles Gary Peterson, P.E.
Erik W.B. Peterson, P.E.
Travis G. McFeron, P.E.

5319 sw westgate drive, suite 215
portland, oregon 97221
503/292-1635
fax: 503/292-9846

Andy Szatkowski
Murray, Smith & Associates
121 SW Salmon St., Suite 900
Portland OR 97204

4/2/08

File: Pse\07-200-01

Re: City of Snohomish WTP Evaluation – Structural Assessment

Dear Andy:

The following is a memorandum generated to provide a structural assessment of the existing 0.5 million gallon (MG) ground supported steel reservoir and metal treatment plant building at the City of Snohomish Water Treatment Plant. Our firm has reviewed multiple documents provided by MSA relating to the original construction and subsequent investigations. Our firm also performed a site visit on 11/20/07 to view the existing structures.

Based on our understanding the existing subject structures were constructed in the early 1980's and have been in service since that time. The provided documents also show that recent geotechnical, planning and reservoir inspections have been performed with reports submitted to the City. The purpose of these reports appears to have been for a proposed second reservoir on the site and a condition report of the existing steel reservoir.

At the time of our site visit the steel reservoir was in operation at a level well below its maximum water height. The treatment plant was also in operation. In attendance at our site visit, along with you, were members of the City staff and treatment plant operators.

The purpose of our investigation is to determine the condition and the gravity and lateral load capacity of the two subject structures. Along with our visual observations we have analyzed the structures applying current 2006 International Building Code (IBC) loads. From this analysis and review of provided documents we have generated an assessment of the structural condition as well as load capacity of each structure. Upgrade recommendations and cost opinions follow.

0.5MG Backwash Reservoir

Documents we were provided related to the construction of the 0.5MG welded steel reservoir (Photograph #1) include four sheets of general construction details by Straam Engineers dated October 1980. In addition, five sheets of reservoir shop drawings by Reliable Steel Fabricators Inc. dated February 4th, 1981 were reviewed for the actual reservoir construction. To date, no original calculations for the reservoir have been received or reviewed. We noted that both sets of documents have ringwall foundation details which were almost identical with the exception of the reservoir anchors which were shown only on the shop drawings.

Additional documents reviewed in relation to this structure were an internal/external assessment by Liquivision Technology dated 1/13/07 and a storage tank study by Earth Tech, Inc. dated August 2005. The latter document included repair recommendations for the existing reservoir and a site geotechnical report.

The dimensions and materials shown in the construction drawings are assumed to be consistent with the as-built conditions. The reservoir is 53'-10" in diameter and 32'-3 ½" in height at the shell. The shell plate thicknesses vary from 11/32" to 1/4". The roof plate is 3/16" thick and the floor plate is 1/4" thick. The roof is supported by a single center column with C shape roof joists. The concrete ringwall foundation is 1'-4" wide by 2'-6" deep and is reinforced by (8) #5 bars with #5 stirrups @ 12" o.c. The subgrade of the reservoir consists of 2" class B asphalt and 6" crushed rock. The floor does not appear to be sloped for drainage.

Our visual observation of the reservoir revealed conditions similar to those noted in the January 13th, 2007 report by Liquivision. The exterior coating of the shell plates have numerous rust spots (Photograph #2) and the exterior coating on the roof has degraded extensively (Photograph #3) above the primer coat (a condition Liquivision refers to as "chalking"). Typical rust areas, such as around bolt holes and hatches, were more heavily damaged than the field of the shell plates but there also were areas of rust and damaged coating.

The condition of the roof plates shows areas of local plate buckling which has caused a number of depressed areas which are subject to ponding. An extensive buildup of moss and other organics on both the roof plates (Photograph #4) and the roof access ladder (Photograph #5) have resulted in a dangerously slippery condition.

The condition of the steel anchors and exposed portions of the ringwall appears to be good with no appreciable concrete spalling (Photograph #6). The condition of the plate seam welds in all areas appears to be good and no evidence of leakage in the accessible areas was found.

The interior coating above the maximum waterline and on the underside of the roof plates and joists was found to be heavily stained and rusted. The visible areas below maximum waterline were observed to be consistent with the conclusions found in the Liquivision report. Please note that because of the buildup of condensation inside typical reservoirs it is common for steel above the waterline to be more heavily corroded than coated steel below the waterline.

<u>Structural Analysis</u>

We have performed a gravity and lateral load analysis of the existing reservoir based on current IBC and AWWA applicable codes. For gravity live load we applied 25psf snow load to the roof system which is based on the 1975 SEAW "Snow Load Analysis for Washington". For lateral loads we applied IBC simplified wind loads and USGS local seismic accelerations using an assumed site class D. The Earth Tech geotechnical report recommended a site soil bearing pressure of 6,000psf and the report also confirmed other geotechnical assumptions made during our analysis.

The results of our analyses indicate that for gravity loads, the reservoir system and foundation has adequate capacity to support the aforementioned dead and live loads. The concrete ringwall width imparts approximately 2,300psf of soil pressure which is higher than a code allowed assumption for site class D but is well within the criterion supplied by Earth Tech. We did not observe any evidence of foundation settlement and therefore assume the site preparation was adequate for the loads and foundation size. Application of hydrostatic and seismically induced hydrodynamic loads to the shell plates revealed they are also adequately sized to resist current code loads.

A common area of insufficiency in steel reservoirs from this era relates to issues stemming from seismic and wind loads applied to the existing anchorage. The results of our analysis in this area revealed insufficient capacity in the anchorage of the reservoir relating to resisting sliding forces. The geometry of the reservoir is such that global overturning is not a concern and thus the reservoir would be stable under current code loads without anchorage.

The resistance of sliding forces is critical because, if not considered or resisted, the reservoir could slide off its foundation and/or shear the inlet/outlet piping. The configuration of the subject anchors is a steel strap common from this era (Photograph #7) which has no direct contact with the floor plates. During a sliding condition the reservoir must move laterally to either engage the strap base or elongate the bent strap into full tension. In this application the structure would have to move 1" to 2" before engaging an anchor. It is unknown if the reservoir piping has adequate flexibility to allow for this much movement but it is assumed that some amount of lateral translation will result in pipe damage and a potential loss of reservoir contents.

If a seismic event causes structure sliding and the existing anchors are fully engaged, our analysis shows that the anchor embedment and foundation size are insufficient to support the loads from the structure. Current American Concrete Institute (ACI) anchorage requirements call for a larger and more heavily reinforced mass of concrete around the anchors to prevent them from tearing out of the ringwall concrete.

Please note that sliding resistance, in some steel reservoirs, is attained by passive soil resistance within a conical base. For this to occur the floor of the reservoir needs to be radially sloped down from the center and the void beneath filled with competent compacted fill. In the subject structure none of the construction documents indicate anything other than a flat bottom. Friction forces between the floor plates and subgrade are by code not allowed to be considered in sliding resistance.

Recommendations

Based on our review and analysis of the 0.5MG steel reservoir we feel the following items need to be addressed or upgraded:

- Replacement of all interior and exterior coatings
- Replacement of safety climb system, seals & screens (per Liquivision)
- Upgrade/replace foundation and anchorage

It is important to note that repair and replacement of coatings can have a wide range of performance versus cost considerations. The 2005 report by Earth Tech accurately outlines these options and we agree with their recommendations. We recommend updating their estimate to $75,000 for coating costs alone. Also note in the Earth Tech report the consideration for lead paint which, if it exists on the existing structure, could add $80,000 to the recoating costs.

Upgrade to the anchorage of the structure is also a fairly expensive proposition. The exterior of the ringwall would have to be exposed and added to with an additional ring of thickened concrete dowelled to the existing concrete. Shear tabs and extensions would have to welded to the existing shell and floor plates. The welding associated with the shear tab installation will likely damage existing coatings (including the interior) so recoating costs should be associated with this upgrade. It is our opinion the construction costs associated with upgrading the structure anchorage will likely be between $15,000 and $20,000. Engineering and construction documents for the anchorage upgrade would cost approximately $4,000.

Treatment Plant Building

Documents we were provided related to the construction of the treatment plant building (Photograph #8) include eleven sheets of general construction details by Straam Engineers dated October 1980. In addition, nine sheets of non-specific steel building detail drawings by Kirby Building Systems (drawing dates vary, all in the mid 1970's) were reviewed for the building construction. To date, no original calculations for either the building foundation or the building itself have been received or reviewed. Please note that the steel building drawings are not specific to the subject project and contain differing specifications for a range of building sizes.

The configuration of the treatment plant building consists of a 3'-0" tall stemwall around a slab on grade which is 30" below exterior grade. The main building dimensions are 70' by 45' in plan with a 10'-8" by 30'-9" laboratory room extended off the south wall. The main building has portions of a proprietary steel building (assumed to be by Kirby) which is mounted atop the perimeter stem wall. The lab room is single story masonry with an 8" thick cast in place concrete roof.

The overall construction of building system is atypical in a number of areas and is not well documented in the construction documents. It appears that portions of the steel building were ordered specifically from Kirby and that other portions were custom assembled from various sections of cold-formed steel. Generally, the building departs from standard building methods in several important ways.

The first curious aspect of the building is that the roof slopes in the direction of the long building dimension rather than the short building dimension. The roof system consists of metal Z-purlins spanning between either free span girders (assumed to be Kirby specifications) or the aforementioned cold-formed framing. The north wall and interior supports are girders (Photographs #9 & #10) and the north wall is cold-formed steel. It is interesting to note that the interior girder is not centered in the 45' building plan but is actually 5'-0" north of center. There was no obvious reason observed for constructing the building in this fashion. The south wall of the building uses a combination cold-formed C-sections and Z-purlins (Photograph #11) constructed in an unconventional configuration which does not appear to have been engineered. Bolted connections in this area are fairly light and bearing on the thin cold-formed steel webs (Photographs #12, #13 & #14).

The lateral load system of the building is a partial system and appears to lack a complete load path. In the north bay of the building, the section between steel girders, diagonal cable braces are installed in the walls and ceiling (Photograph #10) areas and are detailed similar to steel buildings typical of the construction era. Some of the cables appeared to be hanging somewhat slack which reduces or negates their effectiveness in a lateral load event. In the south bay of the building, the section between the interior girder and south wall, there is no cable bracing and very little in the way of a lateral load resisting system. The same is true for both the north and south walls.

By all appearances, the building was originally ordered as a single bay 70' by 20' system and extra material was ordered and installed to complete the additional 25' in width. In particular the construction of the south wall matches no generally accepted construction convention. The original design placement of the CMU lab room appears to allow for the girder frame system so it is not clear why the change in support systems was used.

Structural Analysis

We have performed a gravity and lateral load analysis of the existing steel building based on the current IBC applicable code. For gravity live load we applied 25psf snow load to the roof system. For lateral loads we applied IBC simplified wind loads and USGS local seismic accelerations using an assumed site class D.

For gravity loads in the north bay the steel roofing, Z-purlins and west wall steel girder appears to be adequate to support the applied roof loads. The typical combined strip footing/floor slab is sufficiently large to adequately support the column loads from the steel girders. In the south bay, application of the roof snow load slightly overstressed the Z-purlins (based on an assumed steel grade) and is subject to deflections which may appear uncomfortably high during a code level snow event. The interior girder appears to have been originally sized for a 20' bay spacing so the additional 5' of tributary width causes an overstressed condition in the girder and center bolted connection.

On the south wall the framing members are nominally able to support roof loads but the bolted bearing connections are overstressed and may fail under a code level snow event. Crushing of cold-formed webs or tear out of the bolts could potentially result in partial roof collapse in the south bay.

As previously mentioned, the north bay of the steel building has typical cable bracing and wall girts which can act as a fairly effective lateral resisting system. Analysis shows that if all components are well secured and cables are tight, the portions of the building with bracing will likely perform well under a code level lateral event oriented in the north/south direction. The south bay and north and south walls, lacking bracing or diaphragms, obtain some lateral support only from the steel siding/roofing connections which, particularly in the walls, are insufficient to support a code level lateral load event. Please note that while the CMU lab room wall is in line with the south wall of the steel building there is insufficient connectivity between the two elements to transfer loads to the stiffer CMU element.

It is our opinion that should a code level lateral event occur, regardless of load orientation, we feel it likely that building elements may be damaged and the possibility of partial collapse damage exists. Because of the unconventional framing of the south wall upgrading this system will likely entail overall redesign and reconstruction of this primary element.

The CMU laboratory room acts, in this system, as a stand alone self supporting element. Based on our review of the provided construction documents and structural analysis of the room we feel that, while not detailed to current code requirements, the lab room has sufficient capacity to support code level gravity and seismic loads. The concrete roof slab has positive connection to the CMU walls and, while not clearly stated in the construction drawings, we assume positive connection to the foundation. We did note during our site visit that the concrete roof has some cracking and leakage issues but we do not attribute the cracks to flexural overstress.

Recommendations

Based on our review and analysis of the steel treatment plant building we recommend the following items need to be addressed or upgraded:

- Adjust/repair cable bracing connections in the north bay
- Redesign and replace or upgrade south bay roof system
- Redesign and replace or upgrade the north and south wall lateral systems
- Upgrade interior girder system to support code level gravity loads
- Inject or repair roof cracks in the laboratory room

As previously mentioned the south bay of the steel building, which encompasses approximately 56% of the building plan area, lacks a conventional lateral load resisting system. We feel it likely that if the wall system is sufficiently redesigned and replaced, additional bracing may be added to the roof system which would be connected to the existing interior steel girder. We feel that there is no reasonable way to upgrade or infill the existing south wall because primary lateral chords and boundary elements needed for bracing connections need to be located where insufficient framing members currently exist.

We feel it likely that shoring the roof and replacing the wall system would be the most economical approach.

Based only on the supposition of a replacement south wall system and upgrade to the north wall, we offer a range of cost opinions to construct the recommended repair. Assuming either the installation of a conventional metal stud/diaphragm system or a braced free span girder system we opine the repair construction cost will be in the range of $30,000 to $40,000. If allowed to perform an actual design for the building upgrades we would be able to provide a more accurate cost opinion. Engineering and generation of construction documents for building upgrades would likely cost $10,000 to $12,000.

Dam Structure

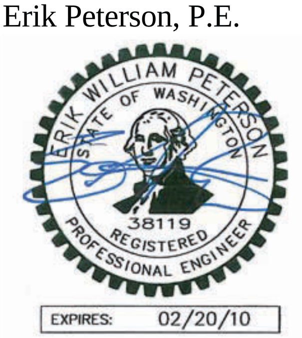
During our site visit we were asked to view the existing dam and diversion structure. At the time of our site visit the dam and diversion structure were not dewatered and thus our observations were limited to the concrete visible above the water line. Because of scope limitations we are only able to offer the following limited observations and recommendations:

The condition of the various portions of concrete, constructed at different times, showed various levels of wear. We understand that emergency repairs were performed a few years ago on underwater portions of the dam structure but we were unable to view the conditions of the repairs at the time of our site visit. A few local areas of spalled concrete were noted but not thoroughly investigated. We recommend the City dewater the facility to allow for a full inspection of the structure. From this a structural analysis may be performed to provide an appropriate response to this portion of the project.

Structural Assessment Summary

Based on the fact that the two primary subject structures were constructed almost three decades ago it is not unexpected that insufficiencies relating to current building codes exist. Given the fact that the structures serve a water system which is connected to fire suppression the reservoir and building are classified as "significant structures". It is therefore important that these structures remain operational during all climatic and geologic events. If the City performs the recommended upgrades we feel it likely that the building and steel reservoir would be fit to serve the City 20 years or more.

Respectfully Submitted,
Erik Peterson, P.E.



Submitted via e-mail: Andrew Szatkowski [as@msa-ep.com]

Photograph #1 – 0.5MG Welded Steel Reservoir

Photograph #2 – Rust on reservoir shell plates

Photograph #3 – Degraded roof coating (primer coat is red)

Photograph #4 – Buildup of organics around ladder and access hatch

Photograph #5 – Roof access ladder

Photograph #6 – Reservoir ringwall foundation and anchors

Photograph #7 – Reservoir strap anchor

Photograph #8 – Treatment Plant Building


Photograph #9 – North wall support girder and cable bracing


Photograph #10 – North wall and interior support girders (note cable bracing in north bay)

Photograph #11 – South wall cold-formed steel construction

Photograph #12 – South wall cold-formed steel connections

Photograph #13 – South wall cold-formed steel connections

Photograph #14 – South wall cold-formed steel connections

APPENDIX C

CERTIFICATE OF WATER RIGHT

[X] Surface Water

[ ] Ground Water

CERTIFICATE NUMBER	PERMIT NUMBER	APPLICATION NUMBER	PRIORITY DATE
S1-00500C	1887	3571	December 9, 1931

NAME			
CITY OF SNOHOMISH			
ADDRESS (STREET)	(CITY)	(STATE)	(ZIP CODE)
1009 1st Street	Snohomish	Washington	98290

This is to certify that the herein named applicant has made proof to the satisfaction of the Department of Ecology of a right to the use of the public waters of the State of Washington as herein defined, and under and specifically subject to the provisions contained in the Permit issued by the Department of Ecology, and that said right to the use of said waters has been perfected in accordance with the laws of the State of Washington, and is hereby confirmed by the Department of Ecology and entered of record as shown

PUBLIC WATER TO BE APPROPRIATED

SOURCE: Pilchuck River

TRIBUTARY OF (IF SURFACE WATERS): Snohomish River

MAXIMUM CUBIC FEET PER SECOND	MAXIMUM GALLONS PER MINUTE	MAXIMUM ACRE-FEET PER YEAR
5.0 cubic feet per second		3000 acre-feet per year

QUANTITY, TYPE OF USE, PERIOD OF USE: Municipal Supply - continuous use

LOCATION OF DIVERSION/WITHDRAWAL

APPROXIMATE LOCATION OF DIVERSION/WITHDRAWAL: 1,976 feet south 20°15'45" west from northeast corner of Section 9 being within NE¼ of Section 9

LOCATED WITHIN (SMALLEST LEGAL SUBDIVISION)	SECTION	TOWNSHIP N.	RANGE, (E. OR W.) W.M.	W.R.I.A.	COUNTY
NE¼SE¼NE¼	9	29	7E		Snohomish

RECORDED PLATTED PROPERTY

LOT	BLOCK	OF (GIVE NAME OF PLAT OR ADDITION)

LEGAL DESCRIPTION OF PROPERTY WATER TO BE USED ON

Area served by the City of Snohomish.

OFFICIAL RECORDS
RECORDED
VOL. OF
MAR 12 AM 9 '34
HENRY R. WHALEN, AUDITOR
SNOHOMISH COUNTY, WASH.
DEPUTY

PROVISIONS

Nothing in this certificate shall be construed as excusing the certificate holder from compliance with any applicable federal, state, or local statutes, ordinances, or regulations including those administered by local agencies under the Shoreline Management Act of 1971.

The entire opening of the diversion intake shall be tightly screened at all times with wire mesh having openings with dimensions not greater than 0.125 (1/8) inch. Water approach velocity to the screen shall be less than 1 foot per second and approaching 0.5 foot per second, as measured one foot in front of the screen.

7331646

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, except as provided in RCW 90.03.380, 90.03.390, and 90.44.020

This certificate of water right is specifically subject to relinquishment for nonuse of water as provided in RCW 90.14.180.

Given under my hand and the seal of this office at Olympia, Washington, this 28th *day of* February, *19* 74.

JOHN A. BIGGS, *Director*
Department of Ecology

by [signature]
R. JERRY BOLLEN, Assistant Director

ENG. DATA OK [initials]

FOR COUNTY USE ONLY

VOL. 760 PAGE 297

OFFICIAL RECORDS

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
WATER RIGHT CLAIMS REGISTRATION

WATER RIGHT CLAIM

RECEIVED DEC 2? 1973

1. NAME: CITY OF SNOHOMISH

ADDRESS: 1009 1st Street

Snohomish, Washington ZIP CODE 98290

XC: City Atty.
ORG. City Clerk

2. SOURCE FROM WHICH THE RIGHT TO TAKE AND MAKE USE OF WATER IS CLAIMED: Surface (SURFACE OR GROUND WATER)

W.R.I.A. 07 (LEAVE BLANK)

A. IF GROUND WATER, THE SOURCE IS

B. IF SURFACE WATER, THE SOURCE IS Pilchuck River

3. THE QUANTITIES OF WATER AND TIMES OF USE CLAIMED:

A. QUANTITY OF WATER CLAIMED 2.5 cfs. PRESENTLY USED 2.5 cfs.
(CUBIC FEET PER SECOND OR GALLONS PER MINUTE)

B. ANNUAL QUANTITY CLAIMED PRESENTLY USED
(ACRE FEET PER YEAR)

C. IF FOR IRRIGATION, ACRES CLAIMED PRESENTLY IRRIGATED

D. TIME(S) DURING EACH YEAR WHEN WATER IS USED: Continuous

4. DATE OF FIRST PUTTING WATER TO USE: MONTH YEAR 1890

5. LOCATION OF THE POINT(S) OF DIVERSION/WITHDRAWAL: 1,976 FEET S20°15'45"W AND

FEET FROM THE NE CORNER OF SECTION 9

BEING WITHIN NE 1/4 OF SECTION 9, T. 29 N., R. 7 (E.) W.M.

IF THIS IS WITHIN THE LIMITS OF A RECORDED PLATTED PROPERTY, LOT BLOCK OF

(GIVE NAME OF PLAT OR ADDITION)

6. LEGAL DESCRIPTION OF LANDS ON WHICH THE WATER IS USED:

Section 7,8,9,17,18,19 in Township 29 North, Range 7 East

Section 14,15,16,20,21,22,23,24,28,29,32 in Township 29 North, Range 6 East

Section 5,7,8,9,17,18,19 in Township 28 North, Range 6 East

Section 1,12,13,14,24 in Township 28 North, Range 5 East

COUNTY SNOHOMISH

7. PURPOSE(S) FOR WHICH WATER IS USED: Municipal

8. THE LEGAL DOCTRINE(S) UPON WHICH THE RIGHT OF CLAIM IS BASED: Appropriation

THE FILING OF A STATEMENT OF CLAIM DOES NOT CONSTITUTE AN ADJUDICATION OF ANY CLAIM TO THE RIGHT TO USE OF WATERS AS BETWEEN THE WATER USE CLAIMANT AND THE STATE OR AS BETWEEN ONE OR MORE WATER USE CLAIMANTS AND ANOTHER OR OTHERS. THIS ACKNOWLEDGEMENT CONSTITUTES RECEIPT FOR THE FILING FEE.

DATE RETURNED — THIS HAS BEEN ASSIGNED WATER RIGHT CLAIM REGISTRY NO.

DEC 10 1973 — 043262

DIRECTOR DEPARTMENT OF ECOLOGY

I HEREBY SWEAR THAT THE ABOVE INFORMATION IS TRUE AND ACCURATE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

X Richard J. Thompson, City Atty

DATE October 15, 1973

IF CLAIM FILED BY DESIGNATED REPRESENTATIVE, PRINT OR TYPE FULL NAME AND MAILING ADDRESS OF AGENT BELOW.

Richard J. Thompson
City Attorney
108 Union Avenue
Snohomish, WA 98290

☐ ADDITIONAL INFORMATION RELATING TO WATER QUALITY AND/OR WELL CONSTRUCTION IS AVAILABLE

RETURN ALL THREE COPIES WITH CARBONS INTACT, ALONG WITH YOUR FEE TO:
DEPARTMENT OF ECOLOGY
WATER RIGHT CLAIMS REGISTRATION
OLYMPIA, WASHINGTON 98504

MSA

APPENDIX D

Snohomish Water Supply Alternative Financing Matrix
Washington State Financing

Name of Resource	General Eligibility Requirements	Name of Financing Program(s)	Eligible Uses	Funds Available	Type of Product	Funding Cycle	Fees	Interest Rate Range	Compliance and Regulatory Requirement	Payment Terms	Contact Name	Address	Phone Number	Email Address	Website
Rural Community Assistance Corporation (RCAC)	Eligibility: Non-profits, public agencies, tribal governments Pop Limit: 50,000 (10,000 for USDA Guaranteed loans) Projects: Water, wastewater, solid waste, storm water serving low-income rural communities	Feasibility Report	Preliminary Engineering Reports/ Environmental Reports	$ 50,000	Promissory Note	1 Year	1%	Around 5%	Must have Technical Assistance to extent needed, either from RCAC or another acceptable TA source	Entity must agree to repay loan, on extended terms if the project does not proceed	Lucy Shelby RDS Loan Officer	1020 SW Taylor Suite 380 Portland, OR 97205	(503) 228-1672	lshelby@rcac.org	www.rcac.org/
		Predevelopment	Engineering, Legal Bond Counsel Costs	$ 250,000	Promissory Note	1 Year	1%	Around 5%	Letter of Conditions from long-term funding source						
		Construction	Construction	$ 1,000,000	Promissory Note	1+ Year	1%	Around 5%	Commitment Letter for interim financing from other funding source indicating take-out provision	Loan Term corresponding with construction period for loan					
		Long-term loans	Must meet requirements of USDA Rural Utilities Service Water and Waste Disposal Guaranteed Loan Program, such as eligible loan purpose, eligible entity *(Generally intermediate terms loans for system or facility improvements)*	Not given	Loan	10-20 Year Term	1% loan fee 1% guarantee fee on guaranteed portion of loan (generally 90%)	2-3% over short-term loans	Cannot be used for public body applicants who would issue tax exempt obligations as security.	Applicant must demonstrate repayment ability and security for the loan					
Washington State Public Works Board Public Works Trust Fund	Counties, Cities and special purpose districts Often focuses on Distressed Jurisdictions located in a non-metropolitan area	Construction Loan Program	Construction	$20 Million per jurisdiction per biennium	Loan	Annual Applications Due May 2010	None	.25%-2%	Local Match 10%-15% with interest rate of 1% and 0.5% respectively	Life of the project or 20 year Maxium	Kelley Snyder Executive Director	711 Capital Way Suite 102 Olympia, WA 98504	(360) 586-4120	kelly.snyder@pwb.wa.gov	www.pwb.wa.gov
		Pre-Construction Loan Program	Preliminary Engineering Reports/ Environmental Reports	$1 Million per jurisdiction per biennium	Loan	On-going pending availability of funds	None	.25%-2%	0-5% Match required	5 Year maximum or 20 years with proof of construction financing					
		The Public Works Planning Loan Program	To provide financial assistance for the preparation of long-term Capital Facilities Plans or Comprehensive System Plans	$100,000 per jurisdiction per biennium	Grant	On-going pending availability of funds	None	0%	No local match required	6 Years					
		Emergency Loan Prgram	To fund public works emergencies and reimburse costs associated with emergency funding	$500,000 per jurisdiction per biennium	Loan	On-going pending availability of funds	None	3%	No Match required	Life of the project or 20 year Maxium					
		Technical Assistance	To prepare and monitor capital improvement programs	$ 50,000	Grant										
State of Washington Community Trade and Economic Development (CTED)	Open to Washington State small cities (less than 50,000) and counties (less than 200,000) Principally for low and moderate income persons.	Planning Only Grant Program	Applications for funds must meet one of the following program priorities: Addressses a public health and safety issue Assists communities in planning that principally LMI persons Completes a necessary and specific step in a broader community development strategy	$24,000 per single applicant ($400,000 total). If all priorities are met, $35,000 may be available	Grant	Applications will be accepted November 1, 2008-October 31, 2009 until all funds are awarded.	None	None	Cities and Counties only. No districts, agencies, councils, not for profits are allowed to apply.	None	Julie Baker Project Manager		(360) 725-3010	julieb@cted.wa.gov	
		General Purpose Grant Program	Examples of eligible General Purpose Grant activities include: Public facilities, such as water, wastewater, storm sewer and streets Community Facilities Housing Rehabilitations Economic development, such as revolving loan funds, infrastructure…. Projects in support of new housing construction	Maximum loan per jurisdiction is $1 Million Appoximately $11.5 million is available	Grant	Applications due November 20. Notification in March.	None		Cities and Counties only. No districts, agencies, councils, not for profits are allowed to apply.	None					
USDA Rural Development Programs (Rural Utilities)	Rural Communities with a population of 10,000 or less	Direct Loans	Funds are available to public entities such as municipalities, counties, special purpose districts, and indian tribes. In addition, funds may be made available to corp. on a not-for-profit basis.			Yearly 40 Year Max Term or the life of the project	1%	Adjusted quarterly	Priority is given to public entities, in areas with less than 5,500 people	Interest rates are adjusted quarterly and may obtained from any Rural Development office.		USDA Rural Development Water and Environmental Programs STOP 1548 Washington, DC 20250-1548	(202 690-2670		www.usda.gov/rus/water/index.htm
		Guaranteed Loans	Available for the same purpose as direct loans	90% on any loss of interest and principal on the loan	Guaranteed Loans through private banks	Yearly?	??		Normally, guarantees do not exceed 90% on any loss of interest and principal on the loan.	Based on private loans terms					
		Water and Waste Disposal Grants	Same as for direct loans	Up to 75% of eligible project costs	Grants	Yearly	n/a		Completed Application	25% funded by entity					
		Emergency Community Water Assistance Grants	To make emergency repairs or to fix a dramatic drop in water quality	$150,000-$500,000	Grants	Yearly	??		Grants can be made in rural areas and cities or towns with a population not in excess of 10,000 and a median household income of 100 percent of a State's non-metropolitan median household income. Grants may be made for 100 percent of project costs.	No repayment					
		Technical Assistance and Training Grants	Same as for direct loans	$50,000	Grants	Yearly	??			No repayment					
Community Development Block Grant (CDBG)	Non-Entitlement cities or towns with fewer than 50,000 people Non-Entitlement counties with fewer than 200,000 people	General Purpose Grant Program	Final Design and construction of domestic wastewater, side sewer connections, drinking water, stormwater, roads, streets, bridge, and housing rehabilitation projects.	Up to $1.5 million for projects over $10 million	Grants	Applications due November 20. Notification in March.	None	None	Projects must mutually benefit low to moderate-income people in non-entitlement cities and counties	No match required, but local contribution and gap financing preferred	Kaaren Roe		(360) 725-3018	kaarenr@cted.wa.gov	www.hud.gov/offices/cpd/communitydevelopment/programs
		Imminent Threat Grant Program	Repair water, sewer and drainage facility damages that pose an immediate, urgent threat to public health and safety A formal disaster must be declared Project must be ineligible for emergency funds from the Public Works Trust Funds	Reimbursement funds	Grants as reimbursement	Applications accepted year round		None	Only eligible costs incurred after an emergency is formally declared can be reimbursed						
Community Economic Revitalization Board (CERB)	State of Washington Supports proposed projects that support the creation or rentention of jobs in infastructure development	Construction Program	Provides funding assistance to economically disadvantaged communities statewide to foster the creation and/or retention of jobs by industry.	Up to $1 million per year	Grants	2 Year Budget Cycle	None	10% Max	25% Local Match	A per-project grant maximum of 80% of the total request or $300,000 (whichever is less)	Matthew Ojennus		(360) 725-4047	matthewo@cted.wa.gov	
		Rural Construction Program		Up to $1 million per year	Loans	Yearly	None	6% Max	25% Local Match	A per-project grant maximum of 80% of the total request or $500,000 (whichever is less)					
		Local Infrastructure Financing Tool (LIFT)		Up to $1 million per year	Tax revenue that can be used to pay back public finance bonds	Yearly	N/A	N/A	Competitive process--only $2.5 million is available per year	Available online--to comply with bond repayment schedule			(360) 725-4047	cerblift@cted.wa.gov	
		Job Development Fund Program		Up to $1 million per year	Loans	Yearly	None	6% Max	25% Local Match						
		Rural Feasibility Study		$50,000	Grants	2 Year Budget Cycle	None	None	50% Matching Program	None					
Drinking Water State Revolving Fund	Counties, Cities and special purpose districts Capital Improvement Projects	Drinking Water State Revolving Fund Loan	The DWSRF is a federal/state partnership program whose purpose is to provide loans to public water systems for capital improvements aimed at increasing public health protection and,provide a source of funds for other Safe Drinking Water Act activities.	$4 million per jurisdiction	Loan	It is likely the program will receive federal Economic Recovery funding for drinking water loans. To prepare for receipt of these funds, they are postponing the regular Drinking Water State Revolving Fund (DWSRF) loan deadline until fall 2009. As more information becomes available on the Economic Recovery drinking water loan funding it will be posted to their web site.	1%	0%-1.5% (Linked with local income level)		20 Year Terms	Kitty Weisman	Washington State Department of Health Office of Drinking Water 243 Israel Road SE Tumwater, Washington 98501	(360) 236-3116		www.doh.wa.gov/ehp/dw/OUr_Main_Pages/dwsrf.htm
Washington State Pollution Control Revolving Fund	Counties, Cities and special purpose districts Capital Improvement Projects	State Pollution Control Revolving Fund Loan	Low interest loans will fund high priority water quality projects that will protect and improve the water quality in Washington statewide.	Current Projects range from $500,000 to $12 million	Loan	Applications Accepted Sept-Oct 31	1%	0%-3.1% (Linked with local income level)	The State Revolving Fund (SRF) state rule requires Ecology to distribute money according to the following category allocations: 80 percent of the fund is to be used for water pollution control facilities; 20 percent of the fund is reserved for nonpoint source pollution control and for comprehensive estuary conservation and management. Unless the demand for funds is limited, not more than 50 percent of each funding category allocation can be awarded to any one applicant.	Yearly 5-20 Year Term or the life of the project	n/a	Department of Ecology Water Quality Program P.O. Box 47600 Olympia, WA 98504-7600			http://www.ecy.wa.gov/pubs/0710057.pdf

APPENDIX E

CITY OF SNOHOMISH
WATER SUPPLY STUDY

ALTERNATIVE EVALUATION MATRIX

		Water Supply Alternatives *Without* Transmission Line Replacement										
		1	2	3	4	5	6	7	8	9	10	11
Selection Criteria	*Wt*	Existing 1.7 MGD	RBF 1.7 MGD	Existing 2.16 MGD	RBF 2.16 MGD	Expand 3.23 MGD	RBF 3.23 MGD	MBR 3.23 MGD	Down Strm Surface	Down Strm RBF	Down Strm Wells	Everett Entire System
Capital Costs (1)	30%	4.9	3.3	4.5	3.2	2.8	2.8	2.3	1.7	1.7	1.4	10.0
O&M Costs 2028	20%	6.6	6.7	7.3	7.3	9.3	9.5	9.7	8.6	8.9	10.0	6.3
Complexity of O&M	10%	6.0	8.0	6.0	8.0	6.0	8.0	8.0	6.0	8.0	9.0	10.0
Redundant Supply	15%	8.0	8.0	9.0	9.0	10.0	10.0	10.0	10.0	10.0	10.0	3.0
Potential Risk	15%	8.0	7.0	8.0	7.0	5.0	5.0	5.0	4.0	4.0	2.0	9.0
Watershed Protection	10%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	7.0	7.0	10.0
TOTALS	**100%**	**6.6**	**6.2**	**6.7**	**6.4**	**6.4**	**6.6**	**6.5**	**5.5**	**5.9**	**5.8**	**8.1**

(1) Capital Costs do not include cost to replace the transmission line.

		Water Supply Alternatives With Transmission Line Replacement										
		1*	2*	3*	4*	5*	6*	7*	8	9	10	11
Selection Criteria	Wt	Existing 1.7 MGD	RBF 1.7 MGD	Existing 2.16 MGD	RBF 2.16 MGD	Expand 3.23 MGD	RBF 3.23 MGD	MBR 3.23 MGD	Down Strm Surface	Down Strm RBF	Down Strm Wells	Everett Entire System
Capital Costs	30%	4.3	3.9	4.2	3.9	3.8	3.8	3.6	5.0	5.1	4.4	10.0
O&M Costs 2028	20%	6.6	6.7	7.3	7.3	9.3	9.5	9.7	8.6	8.9	10.0	6.3
Complexity of O&M	10%	6.0	8.0	6.0	8.0	6.0	8.0	8.0	6.0	8.0	9.0	10.0
Redundant Supply	15%	8.0	8.0	9.0	9.0	10.0	10.0	10.0	10.0	10.0	10.0	3.0
Potential Risk	15%	8.0	7.0	8.0	7.0	5.0	5.0	5.0	4.0	4.0	2.0	9.0
Watershed Protection	10%	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	7.0	7.0	10.0
TOTALS	**100%**	**6.4**	**6.4**	**6.7**	**6.6**	**6.7**	**6.9**	**6.9**	**6.5**	**6.9**	**6.7**	**8.1**

Alternatives 1 through 7 involve Transmission Main Replacement (15-mile long) estimated in approximately 2031 for $18 Million (in 2008 dollars).

Alternative 8 through 11 involve Sliplining PUD Main estimated for $7.4 Million (in 2008 dollars).

MSA