WATER FILTRATION PLANT
RELIABILITY STUDY

FOR

CITY OF MUSKEGON HEIGHTS

JUNE 2014

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Section 1 - Executive Summary

A. Summary

The purpose of this Water Reliability Study is to satisfy the requirements of the Michigan Safe Drinking Water Act. The Act requires that Type 1 water suppliers submit a Reliability Study every five (5) years to determine the adequacy of the system to meet present and projected water demands for the next ten years. The distribution system was analyzed separately by others. The focus of this report is the water supply, treatment and pumping systems.

B. Results

The results indicate that virtually all of the treatment system components are within the design criteria as published by the "Recommended Standards for Water Works, 2012 Edition" by the Great Lakes Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (This document is commonly referred to as the Ten State Standards). The only processes which do not completely conform to Ten States Standards are the settling basins and sludge storage lagoons. For the Settling Basins, the plants rated capacity exceeds the capacity recommended based on the maximum velocity of 0.5 feet per minute in the settling basins. The Water Filtration Plant's (WFP) rated capacity only exceeds recommended design capacity by 5% is considered adequate since the recommendations for detention time and other criteria are met. For the sludge storage lagoons, the minimum recommended operating depth and available freeboard height are not provided, however, the lagoons function as design and are adequate for the WFP.

C. Conclusions

This Water Reliability Study concludes that the City of Muskegon Heights water supply and treatment system components meet the requirements to provide a safe, efficient and reliable water supply to its residential, commercial, industrial and contract customers. The adequacy of the distribution system is being analyzed separately by others.

Currently, the Muskegon Heights Water Filtration Plant treats water for customers located in the Cities of Muskegon Heights and Norton Shores plus Fruitport Township. Recently, the City of Norton Shores and Fruitport Township formed the West Michigan Regional Water Authority.

This new Authority will allow for the two municipalities to jointly bond for the construction of a new pump station, transmission main and other items required to connect the Norton Shores and Fruitport Township Water Systems to the City of Muskegon Water Filtration Plant. The current agreement for Muskegon Heights to provide Norton Shores and Fruitport Township with water expires on April 15, 2015. For the purposes of this report, it is assumed that Norton Shores and Fruitport Township will no longer be customers of the Muskegon Heights Water Filtration Plant after April 15, 2015.

The potential decision for the City of Norton Shores and Fruitport Township to leave will have a great impact on the WFP as these communities currently represent approximately 78% of the population served by the WFP and account for approximately 75% of the water demand. However, as a result of the separate expansions over the years and general layout of the WFP, the treatment rate for the WFP can be reduced without the need for major modification to the WFP.

The WFP consists of six pretreatment trains (a combination of a flocculation basin and corresponding settling basin) with the ability to feed any of the 12 filters individually. With some minor operation changes, any number and combination of pretreatment trains can be operated at one time to maintain the desired treatment rate through each pretreatment train. Based on the recommended design criteria published in Ten States Standards, each pretreatment train has the ability to treat a maximum of 4.2 or 4.6 million gallons per day (MGD) (depending on the specific pretreatment train) and each filter is capable of treating 2.1 million gallons per day. Although the current rated capacity of the WFP greatly exceeds the demand from the City of Muskegon Heights Water System alone, the WFP can be adjusted with minor operational changes to adequately meet the current and future demands of Muskegon Heights alone.

Currently, the WFP is operated in three shifts, 24 hours per day and seven days per week. Due to the expected loss of customer base and resulting decrease in water demand and revenue, it is recommended that the WFP be reduced to operating one shift per day, seven days per week. Although it will take some additional time and effort every day, the conventional filtration treatment processes utilized by the WFP and the design of the WFP, lend themselves to allow for the daily startup and shutdown of the WFP without major operational challenges. The available finished water storage at both the plant site and in the distribution system provide more than enough storage to allow for the intermittent operation of the WFP while still providing adequate storage for the water system demands and required fire flows.

Several project recommendations are presented in a capital improvement list for the WFP. These projects were developed jointly between representatives of the City and HRC based on current needs identified at the WFP. The total estimated cost range for these recommendations is $1,900,000 to $2,300,000. Many of these projects will require engineering assistance and could then be competitively bid. The City should consider putting these projects in an overall capital improvement plan and establish a reasonable time frame to implement the projects.

Section 2 - Purpose

A. General

The purpose of this study is to satisfy the requirements of the Michigan Department of Environmental Quality's Michigan Safe Drinking Water Act (Act 399 of 1976 as amended) and the Rules promulgated pursuant to the Act. Part 12 of the Rules require that Type 1 water suppliers conduct a Water Reliability Study every five (5) years to determine the reliability of the system to meet existing water demands and water demands projected for the next ten years.

The water distribution and storage system condition, reliability and adequacy were analyzed separately by others.

This evaluation focuses on the reliability of the water supply, treatment, pumping and storage capacity including the water storage capacity and condition at the plant site.

A Sanitary Survey of the water filtration plant and distribution system was prepared by the MDEQ in February 2008. HRC has relied upon the Sanitary Survey plus discussions with plant personnel and record drawings for most of the information pertaining to the number and size of the various treatment basins, filters and storage reservoirs.

The treatment system components were analyzed and compared to the design criteria published by the "Recommended Standards for Water Works, 2012 Edition" by the Great Lakes Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (Ten State Standards).

The principal elements of this Water Reliability Study include a study of water supply and treatment plant capabilities for the current and 10-year projected average daily, maximum daily, maximum daily and peak instantaneous demands.

MDEQ generally requires that an approved Water Reliability Study be on file to obtain construction permits for additions and alterations to the water system.

Section 3 - Population and Water Usage

A. Population

Currently, the Muskegon Heights Water Filtration Plant treats water for customers located in the Cities of Muskegon Heights and Norton Shores plus Fruitport Township. Recently, the City of Norton Shores and Fruitport Township formed the West Michigan Regional Water Authority. This new Authority will allow for the two municipalities to jointly bond for the construction of a new pump station, transmission main and other items required to connect the Norton Shores and Fruitport Township Water Systems to the City of Muskegon Water Filtration Plant. The current agreement for Muskegon Heights to provide Norton Shores and Fruitport Township with water expires on April 15, 2015. For the purposes of this report, it is assumed that Norton Shores and Fruitport Township will no longer be customers of the Muskegon Heights Water Filtration Plant after April 15, 2015 but also includes the traditional information for a Reliability Study given the current conditions.

The projected population for each municipality is based on data from the US Census Bureau and the West Michigan Shoreline Regional Development Commission (WMSRDC). According to the WMSRDC Demographic and Economic Projections, Muskegon Heights is projected to have an approximate 0.12% growth rate per year from 2012 to 2024. Norton Shores and Fruitport Township are projected to have similar growth rates. The existing and projected population for each municipality along with the total population served by the Muskegon Heights WFP is shown in the table below.

Table 3-1: Existing and Projected Population Served

Year	Muskegon Heights	Norton Shores	Fruitport Township	Total Population Served
2010[1]	10,856	23,994	13,598	48,448
2014[2]	*10,908*	*24,109*	*13,663*	*48,681*
2015[2]	*10,921*	*24,138*	*13,680*	*10,921*
2024[2]	*11,040*	*24,400*	*13,828*	*11,040*

Notes: 1: Population from the US Census Bureau Statistics
2: The estimated population is based on a 0.12% growth per year

If the Norton Shores and Fruitport Townships continue forward with plans to leave the Muskegon Heights WFP, the total customer base will be reduced from approximately 48,681 to

11,040 or by approximately 78%. If, for some reason, the exodus doesn't occur, the population served would be similar to current conditions since growth in the service area is not expected to be significant.

B. *Water Usage*

Table 3-2 shows the water system demands for the total system (Muskegon Heights, Norton Shores and Fruitport systems) and for the Muskegon Heights system separately for the previous 5 years.

Table 3-2: Total System Water Demands

	Total System Demand (MGD)					Muskegon Heights System Demand (MGD)				
Demand	**2009**	**2010**	**2011**	**2012**	**2013**	**2009**	**2010**	**2011**	**2012**	**2013**
Average Day	5.9	5.5	5.3	5.6	5.2	1.6	1.4	1.4	1.3	1.3
Average Day Maximum Month	9.6	10.0	9.4	10.4	8.7	2.3	2.0	2.1	1.9	1.7

The water system demands for Muskegon Heights Water System have been decreasing for the past 5 years and currently accounts for approximately 25% of the total system demands.

For 2013, the average day flow in the maximum month is 1.3 times the annual average day and the maximum daily demand is 2.5 times the annual average day. A 1.75 peaking factor was used to estimate the peak instantaneous (or maximum hour) system demand.

In 2010, the average daily per capita flow rate for the Muskegon Heights Water System was 128 gallons per capita day (gpcd). To determine the projected future water demands, the average day flow rate of 128 gcpd was multiplied times the projected 2024 population as shown in Table 3-1. Keeping with the 2013 data, the 1.3 and 2.5 factors were used to determine the average day maximum month and maximum daily demands respectively. The 1.75 peaking factor was used to estimate the peak instantaneous demand. Table 3-3 shows the current and future water system demands for Muskegon Heights.

Table 3-3: 2013 Muskegon Heights Water System Demands

Demand	2013	Estimated 2024[2]
Annual Average Day, MGD	1.3	1.4
Average Day Maximum Month, MGD	1.7	2.0
Maximum Daily, MGD	3.2	3.5
Minimum Day Demand, MGD	0.4	0.4
Peak Instantaneous (or Maximum Hour)	5.6[1]	6.1[1]

Notes: 1: Estimated using a peaking factor of 1.75
2: The future water system demands were estimated using the projected 2024 population of Muskegon Heights as shown in Table 3-1

As indicated in Tables 3-3, at the current plant rating of 25.2 MGD, there is ample capacity for the projected future growth in population and flow demands.

Section 4 - Existing Water Supply and Treatment System

A. *Existing System*

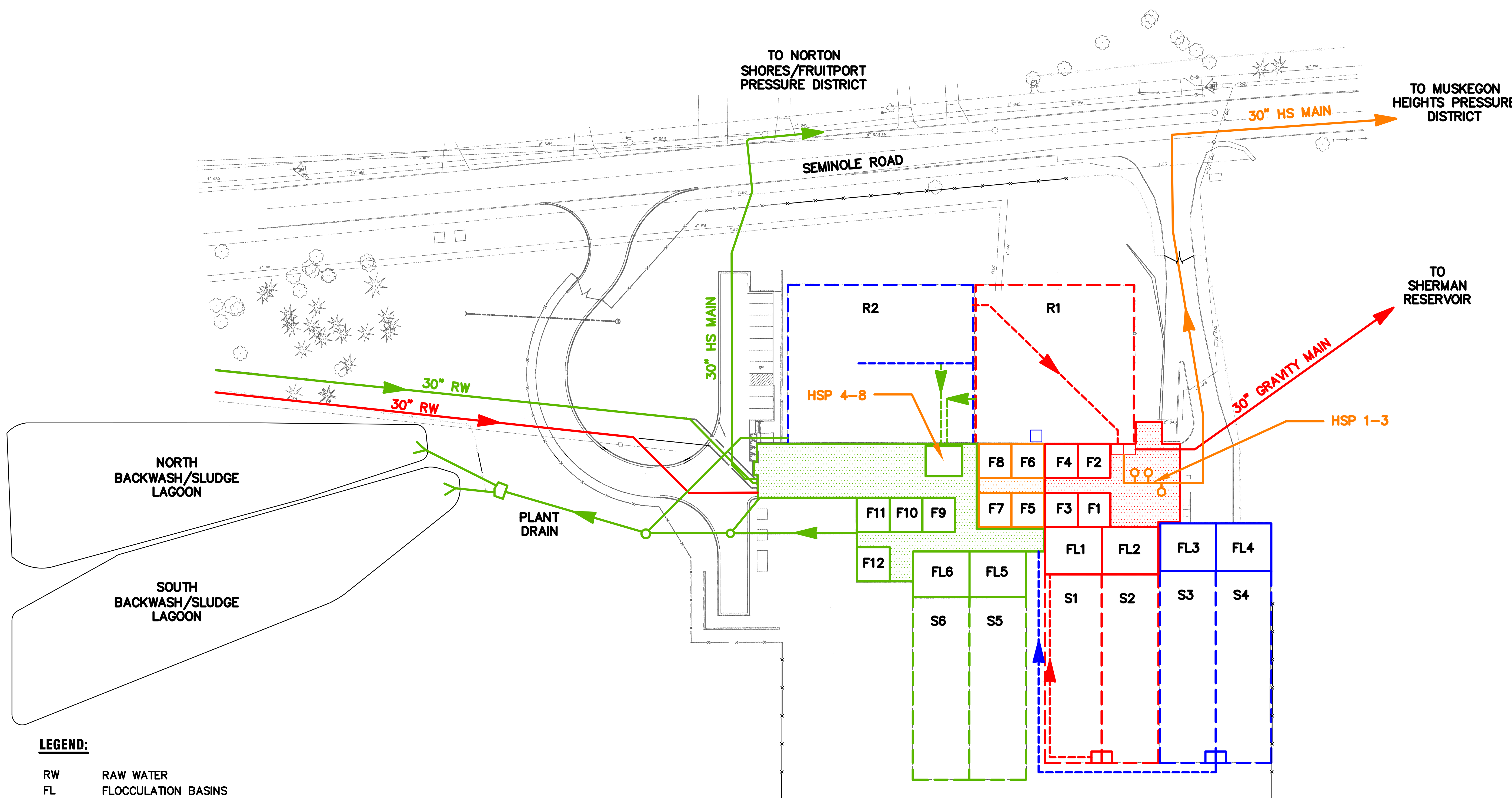
The origin of the Muskegon Heights Water System dates back to 1907 when wells were the source of supply. In 1941 a Water Filtration Plant (WFP) was placed in service using Lake Michigan as the source of supply. The original plant had a rated capacity of 5.7 Million Gallons per Day (MGD). The plant site is on Seminole Road in Norton Shores. In 1965 and 1971 the plant capacity was increased each time by 5.7 MGD. The treatment plant was upgraded in 2002 to the current rated capacity of 25.2 Million Gallons per Day (MGD). Water is currently provided to the cities of Muskegon Heights and Norton Shores as well as Fruitport Township. Water to Norton Shores and Fruitport Township is pumped directly from the WFP and can also be pumped from the Muskegon Heights Distribution System at the Getty Street Elevated Storage Tank. The Norton Shores/Fruitport Water System operates at a pressure approximately 10 psi higher than the City of Muskegon Heights Water System.

A site plan of the facilities at the Water Filtration Plant is shown in Figure 4-1.

1. Source Water and Intakes

Lake Michigan provides an unlimited excellent quality raw water source for the City of Muskegon Heights. A Source Water Assessment completed in 2004 that indicated the intakes are moderately sensitive to potential contaminants. The source water has moderately high susceptibility to potential contamination. These and other climatic conditions of wind and temperature inversions which create problems can be handled by an experienced operating staff.

The plant has two separate intake pipelines into Lake Michigan each with dual intake cribs. The original intake constructed in 1941 is a 30-inch pipe 4,700 feet long with a capacity of 16.8 MGD. A newer 4,800 feet long 42-inch intake with a capacity of 34 MGD was constructed as part of the 2002 expansion project. The total rated capacity of both intakes is 50.8 MGD. Each intake pipe has a single emergency intake/access manhole approximately 1,500 feet from each crib that can be used as a standby emergency intake if the cribs become plugged. Details of the manhole on the 1940 intake are not available, but the pipe extends



LEGEND:

RW	RAW WATER
FL	FLOCCULATION BASINS
S	SETTLING BASINS
F	FILTERS
R	FINISHED WATER RESERVOIRS
HSP	HIGH SERVICE PUMPS
HS	HIGH SERVICE

- 1940 VINTAGE IMPROVEMENTS
- 1965 VINTAGE IMPROVEMENTS
- 1973 VINTAGE IMPROVEMENTS
- 2000 VINTAGE IMPROVEMENTS

FACILITIES SITE PLAN

CITY OF MUSKEGON HEIGHTS
WATER FILTRATION PLANT RELIABILITY STUDY

JOB NO. 20130904	HRC 100 YEARS CONSULTING ENGINEERS SINCE 1915	FIGURE NO.
DATE June 2014		4-1

approximately 8 feet from the buried intake pipe to approximately 2 feet above the lake bottom. The manhole on the 2002 intake extends to 3 feet above the lake bottom and is capped with a blind flange with eye hook for removal. Both manholes are protected with riprap. Each intake crib is equipped with chemical feed lines to control zebra mussel growth.

The intakes were last cleaned in 2012. As part of this work, the 30-inch emergency access manhole intake cover on the older 30-inch intake pipe was replaced. The intakes were made fully operational, including the chemical feed piping, and they were flow tested at that time. The 30-inch intake is currently not in use but should be tested again to ensure the reliability of this intake for future use. Due to the concern regarding sand buildup near the intakes and the emergency access manholes, it is recommended that both intakes be inspected every five years including a flow test to determine the Hazen Williams C value for each intake. Additional inspections and repair work may be necessary if results are not acceptable.

The water plant currently applies chlorine using a sodium hypochlorite solution for zebra mussel control on a seasonal basis, typically when the water temperature is at or above 50 to 51 degrees Fahrenheit, which targets the specific time of the zebra mussel's growth cycle. The City should continue to chlorinate the in-use intakes on a seasonal basis unless additional chemical contact periods are desired or if zebra mussel activity or accumulation is observed during other times of the year.

Phosphate is also fed into carrier water solution to prevent calcium carbonate from precipitating in the carrier line.

2. Low Service Pump Station

The Low Service Pump Station includes six low service pumps. A list of the existing low service pumps is presented in Table 4-1.

Table 4-1: Low Service Pumps

Pump Number	Capacity (MGD)	Design Total Dynamic Head (ft)	Motor Size (HP)	Year Installed	Drive Type
1	7.4	128	250	2000	Variable Frequency
2	4.6	120	100	1988	Constant Speed
3	7.4	128	250	2000	Constant Speed
4	3.7	120	150	2008	Variable Frequency
5	5.4	120	150	1965	Constant Speed
6	8.8[1]	130	250	1974	Constant Speed

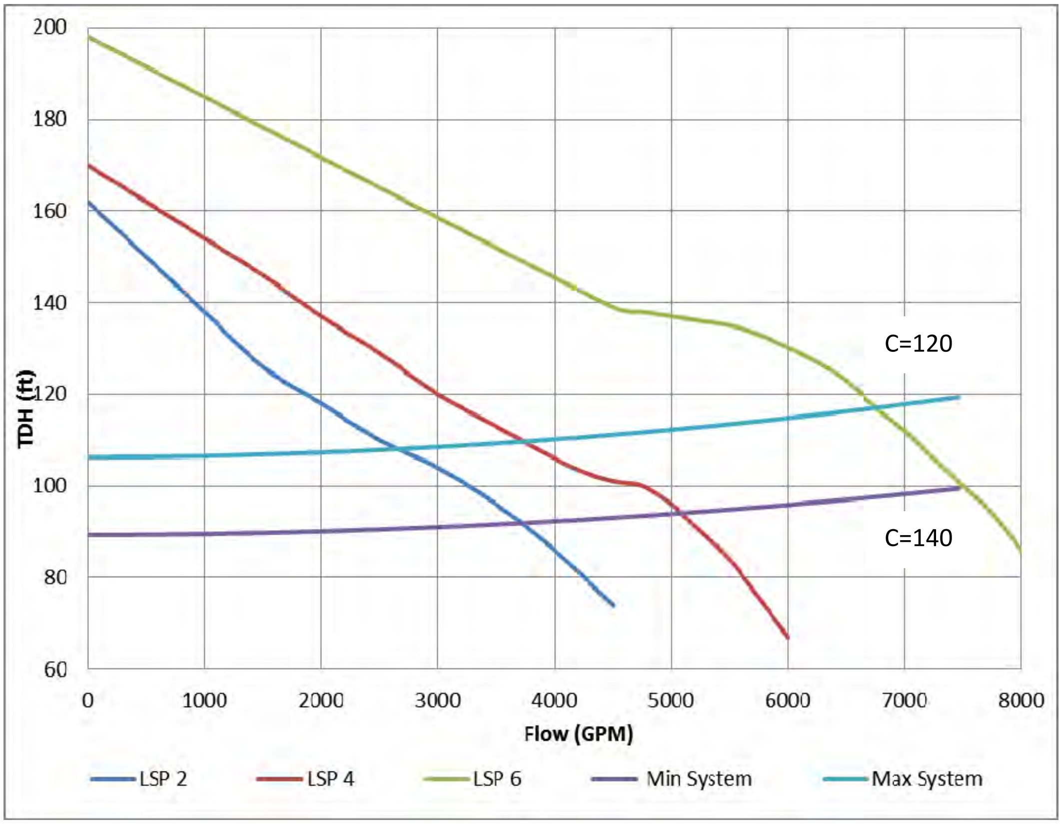
Notes: 1: Low Service Pump No. 6 is currently not in operation due to an issue with the Motor Starter.

The total capacity with all six pumps operating is 33.9 MGD. The firm capacity, which is the pumping capacity with the largest pump out of service, is 25.3 MGD.

There are two 30-inch discharge lines from the low service pump station that convey the raw water to the water plant. A hydraulic analysis of each low service discharge line was performed starting from the low service pumps and ending at the flocculation basins. A system curve was generated for each pipe. Pump curves were only available for Low Service Pumps 2, 4 and 6. It was determined that each line, if operated independently, can provide more than 50% of the low service pumping capacity. The System curves are show in Figure 4-2 below.

Pump selection at the Low Service Pump Station is done by operator preference and primarily to maintain even wear and usage on each pump since the cost of operation is not markedly different between the various pumps. Currently Pump Number 6 is not operational due to an issue with the Soft Starter, which should be replaced.

Figure 4-2 Low Service Pump Curves and System Curves for Pumps Running Independently



3. Rapid Mix and Flocculation Basins

There are two in-line mechanical mixers for mixing pretreatment chemicals prior to flocculation. One is located on each of the two 36-inch raw water lines. Each mixer is capable of provided a velocity gradient of 2500 – 3400 sec^{-1} @ 23 to 70 °F. Chemicals added before the mixers are chlorine and alum. Both mixers are functional although they have been prone to leakage through the shaft seals in the past which is typical with this type of mixer. If these mixers are ever replaced, consideration should be given to a high speed induction type mixer, which is not prone to shaft seal leakage problems. There are no variable speed options on these mixers but this is not considered to be detrimental since rapid mix typically performs well in a high speed, high shear environment.

There are a total of six (6) flocculation basins located at the water filtration plant with a total volume of 0.792 MG. The design capacity of the flocculation basins is 25.2 MGD. At this flow rate the detention time is 45.3 minutes with a flow thru velocity of 0.85 feet per minute (fpm). Ten States Standards recommendation for detention time is 30 minutes and a flow thru velocity between 0.5 and 1.5 fpm. Table 4-2 shows the cross-sectional areas of each basin and the permissible flow rate at the Ten States Standards recommended velocities.

Table 4-2: Flow Rates at Ten States Standards Recommended Velocities Through each Flocculation Basin

Flocculation Basins	Basin Width (Each)	Basin Depth (Each)	Volume	Maximum Flow Rate at Through Flow Velocity	
				0.5 ft/min	1.5 ft/min
	Feet	feet	MG	MGD	MGD
1	43	13.8	0.13	3.2	9.6
2	43	13.8	0.13	3.2	9.6
3	43	13.8	0.14	3.2	9.6
4	43	13.8	0.14	3.2	9.6
5[1]	16.7/44	13.8	0.14	1.2/3.2	3.7/9.8
6[1]	16.7/44	13.8	0.14	1.2/3.2	3.7/9.8

Notes: 1: Internal baffles inside flocculation tanks 5 and 6 create a serpentine flow arrangement thus reducing the cross sectional area carrying the flow inside the tanks. Since this arrangement has not markedly affected flocculation and settling performance it is assumed that their flow rate capacity is not materially affected .

Based on the design capacity of the plant of 25.2 MGD, the flow through velocity is within the Ten States Standards criteria. However based on the anticipated future average flows, these conditions would not be achieved since the flow-through velocities will be less than recommended with all basins in operation. For future conditions, it is recommended that one or two sets of flocculation basins be operated at a time to maintain the velocity and reduce wear on the flocculator mechanisms. The flocculator drives and paddles for Basins have been rebuilt and mechanisms replaced with greased bearings and are in good condition.

According to the previous Sanitary Survey, the area behind the inlet baffle on basins 1 - 4 collects surface scum and is recommended to be cleaned on a regular basis to remove the buildup of this scum.

Flocculation Basins 1 through 4 were drained, inspected and repairs were made in 2011. These repairs included repair of the wall surface of flocculation basins 1 and 2 and repairs of areas of outward leakage from basin 3 as well as repair of the structural expansion joint between the 1940 and 1964 structures.

4. Settling Basins

The plant has a total of six basins with a total volume of 4.34 MG. The design capacity of the settling basins is 25.2 MGD. At this flow rate the detention time is 4.13 hours with a flow thru velocity of 0.52 fpm. Ten States Standards recommendation for detention time is 4 hours and a flow thru velocity of less than 0.5 fpm. Basins 1 through 4 have limited baffling while basins 5 and 6 each have an inlet baffle wall with 105 3-inch diameter holes and four 30-foot long weir troughs on each basin outlet. Table 4-3 shows the width, depth and volume of each basin and the permissible flow rate at the Ten States Standards recommended velocity and detention time.

Table 4-3: Flow Rates at Ten States Standards Recommended Velocities and Detention Time through each Settling Basin

Settling Basin	Basin Width (Each)	Basin Depth (Each)	Volume	Maximum Flow Rate	
				Max Velocity (0.5 ft/min)	Detention Time (4 hours)
	Feet	feet	Million Gallons	MGD	MGD
1	43	17.7	0.70	4.1	4.2
2	43	17.7	0.70	4.1	4.2
3	43	17.7	0.77	4.1	4.6
4	43	17.7	0.77	4.1	4.6
5	44	16.4	0.70	3.9	4.2
6	44	16.4	0.70	3.9	4.2

Some leakage is occurring through the ceiling of Settling Basins 1 through 4. It is planned to cover these basins with a membrane and install drainage pipes on top of the basin to minimize water ponding on the surface of the structure.

Flow-through velocities for the flocculation basins and detention times for both the flocculation and settling basins at design capacity are adequate and within or below the recommended Ten State Standards. A review of plant operating data for 2013 indicates that the plant has maintained pretreatment efficiencies by producing settled water with an average turbidity of 0.54 NTU.

5. Filtration

The plant has a total of twelve filters providing a combined capacity of 25.2 MGD at 3 gpm/sf. Each filter is equipped with rotary surface wash arms. Filters 1 through 4 and 9 through 12 have Leopold underdrains and Filters 5 through 8 have Wheeler stacked ball type underdrains. All twelve filters use a gravel media support system. Filter backwash water is supplied by three 9,750 gpm pumping units. Each filter has a filter to waste line and an on-line turbidity monitor.

Filters 1 through 4 and 9 through 12 have 12-inches of anthracite over 18-inches of sand directly over the media support plate underdrains. Filters 5 through 8 have 6-inches of anthracite over 22 inches of sand with 12-inches of support gravel over the underdrains.

The filters meet Ten State Standards recommendations. Filters 1 and 3 share a common wall with the flocculation basin, however this wall was originally constructed with an internal drained cavity so technically there is a double wall in this location. Filter backwash cycles at the WFP are performed through an automated process. Manual controls are provided at each filter to override or adjust the automation if necessary. Standard operating procedures for manually backwashing a filter are provided and staff is trained to follow the procedures.

The filter control valves were previously controlled with programming and wiring from the valve manufacturer which was no longer supported. This programming and wiring has been eliminated to allow for the plant SCADA system to control all valves. The filter influent valves have recently been replaced but the filter effluent control valves are obsolete and no longer supported by the manufacturer. The filter effluent control valves should be replaced.

During the 2008 Sanitary Survey, many filters were observed to have some mixing of the sand and anthracite media. This appears to be attributed to the gradation of the media. The D90/D10 ratio of anthracite to sand appears to be close to 4 rather than the ideal ratio of 3. When the ratio is this high, too much intermixing of the medias can occur, which could potentially result in poor-quality filtrate. The filter media should continue to be monitored for potential issues but currently the filters are producing quality filtrate.

The previous Sanitary Survey included performance goals for the operation of the filters. These goals along with a summary of the operating data from 2013 are included in the Table 4-4.

Table 4-4: 2013 Filter Operation Data

Criteria	Performance Goals	2013	
		Annual Average	Monthly Averages
Filter Run Time	Up to 200 hours	167 hours	131 - 193 hours
Loading Rate	Less than 3 gpm/sf	1.2 gpm/sf	1.0 - 1.4 gpm/sf
Treated Water Turbidity	Less than 0.05 NTU	0.03 NTU[1]	0.02 - 0.5 NTU[1]
Wash Water Usage (Wash Water Used / Total Water Treated)	Less than 1.5%	3.20%	2.0% - 4.3%

Notes: 1: Turbidity values obtained from combined filter effluent turbidimeter readings.

As shown in the table, the filters consistently operate at or near to these performance goals with exception of the total wash water usage.

Currently, the plant staff backwash the filters when the effluent flow control valve reaches 100% open, even if the head loss through the filter is acceptable and the filter is treating water effectively. Allowing the filter to continue to operate until the filter headloss increases would allow for longer run times and would likely help reduce wash water usage.

The filters are currently operated on a continuous basis with between three to five filters out of service at one time. Even with the three to five filters out of service at any time during the year, the maximum loading rate for the filters was only 2.12 gpm/sf, well below the recommended maximum loading rate of 3 gpm/sf. Based on future water demands, the City may want to consider adjusting the number of filters in service during low demand periods to further reduce wash water usage.

6. Sludge Handling

There are two on-site infiltration lagoons for the disposal of process wastewater. According to the 2008 Sanitary Survey, the combined volume of the two lagoons is 1.89 MG. The usable depth of each lagoon is 3.5 feet with 1.5 feet of free board. Although neither lagoon is strictly in conformance with the recommendations of Ten State Standards (which recommends a minimum usable depth of 5 feet and freeboard of 2 feet), they function as designed. The discharge from these two lagoon cells qualifies for a groundwater permit exemption. The sanitary sewer can also be used to dispose of process wastewater in an emergency. Groundwater disposal has not been a capacity concern since the lagoons are located in an area with significantly well drained soils. Cleaning of the sludge lagoons will be an ongoing O&M expense for the facility.

An analysis of the sludge storage capacity was completed in order to determine the approximate frequency with which the lagoons would reach their capacity based on future flows. The average amount of sludge produced was determined by reviewing at the average daily flow and the amount of Alum added in 2013. Table 3-3 shows the approximate amount of time it would take to fill the lagoons based on both the current annual average flow and at the projected future average flow.

Table 4-5: Time to Fill Sludge Storage Lagoons

Lagoon	Total Volume (MG)	Fill Time (Years) at the Current Annual Average Flow of 5.2 MGD	Fill Time (Years) at the Future Annual Average Flow of 1.4 MGD
North	0.94	4.4	16.3
South	0.95	4.4	16.4
Total	1.89	8.8	32.7

The fill times for the sludge lagoons will increase with the loss of water demand in the future reducing the expense of maintaining the lagoons. However, the lagoons should still be cleaned and monitored to make sure adequate volume of sludge storage is available. The plant spent approximately $140,000 to clean the south lagoon in 2006 and it is anticipated that both lagoons will need to be cleaned in the future. This cleaning project will be included in the Capital Improvement Plan.

7. Treated Water Storage and High Service Pumps

There are two finished water storage reservoirs each with a capacity of 2.0 MG located at the treatment plant. In addition there is 0.5 MG of finished water storage located in the clearwells under the filters for a total finished water storage volume of 4.5 MG at the plant site. The Sherman Avenue Reservoir, located remotely from the plant, provides an additional 1.5 MG of finished water storage capacity for a total finished storage capacity of 6.0 MG.

The Sherman Avenue Reservoir was inspected in 2005 by Dixon Engineering and found to be in good condition. Recently, a retaining wall was built to provide a protective soil cap over the previously exposed east wall and the hatches over the valve chambers were replaced.

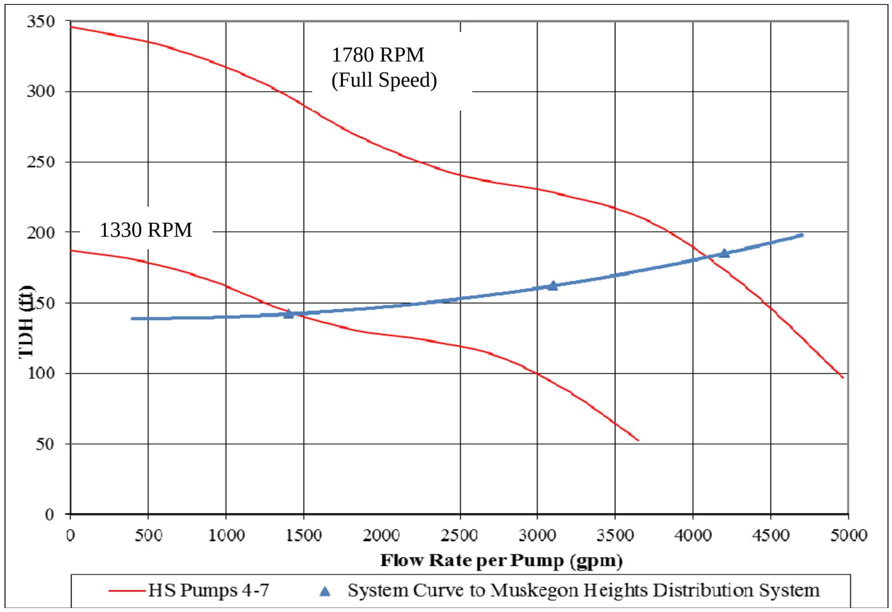
The east and west reservoirs at the plant were also inspected by Dixon Engineering in 2006 and also found to be in good condition. The clearwells were inspected by plant personnel during this past winter and no significant issues were observed.

All tanks should be scheduled for recurring inspections at least once every five years.

There are two High Service Pump Stations at the plant site. High Service Pumps (HSP) No. 1, 2 and 3 are located in the original East High Service Pump Station and pump to the Muskegon Heights Pressure District. The original HSP No. 1 and 2 were installed in 1965. However, no curves are available for these pumps. The West High Service Pump Station was constructed as part of the 2002 plant expansion project. HSP No. 4 through 7 are located in this new pump station and currently pump to the Norton Shores/Fruitport Pressure District. Figure 4-3 shows the pump curve for High Service HSP No. 4 through 7 (which are all identical) operating at full and reduced speeds. Figure 4-3 also includes the system curve developed using the design points of HSP No. 1, 2 and 3. This system curve gives an indication of where HSP No. 4 – 7 would operate if these pumps were connected to the Muskegon Heights Distribution System, which is discussed in Section 5 of this report. A list of all of the existing high service pumps is presented in Table 4-6.

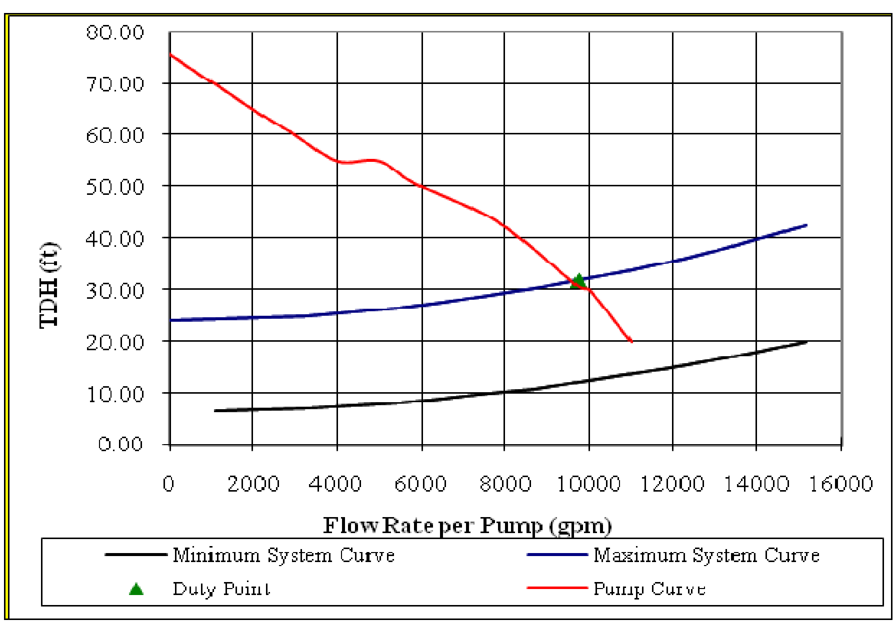
The total capacity of all seven pumping units at the WFP is 32.5 MGD. The firm capacity is 26.5 MGD. The firm capacity of all pumps that can pump from the plant to the Muskegon Heights system (this includes the Sherman Reservoir Pumps) is 11.5 MGD. The firm capacity of all pumps that can pump from the plant to the Norton Shores - Fruitport system (this includes the Getty Booster Pumps) is approximately 15.9 MGD.

Figure 4-3: High Service Pumps No. 4 through 7 Pump Curves



The older East High Service Pump Station includes two backwash water supply pumps and the newer West High Service Pump Station includes one backwash water supply pump for filter washes. A system curve was developed as part of the previous Reliability Study starting from Backwash Pump No. 3 and ending at Filter No. 12 (Worst-case condition). Figure 4-4 shows the backwash system curves and the pump curve.

Figure 4-4: Backwash Pump No. 3 Curve and Backwash System Curves



Based on this analysis, it was found that the Backwash Pump No. 3 can provide 20 GPM/ft^2, which easily meets the Ten States Standards recommendation and should be sufficient for filter bed expansion. Curves are not available for the older backwash pumps.

The Sherman High Service Pump Station is reliant on a low-pressure gravity main that runs from the WFP to the reservoir and is the only source of water for filling the reservoir. This main has been reliable and is not subject to pressure surges or other fluctuations that could cause negative pressure conditions. A control valve at the Sherman Reservoir is utilized to maintain the hydraulic grade line above the surface grade on the transfer line at all times with an adequate factor of safety so that the hydraulic grade line in the pipe never comes close to the surface grade. High Service Pumps are selected so that equipment wear is evened out and to provide adequate turnover of reservoir contents in the case of the Sherman Reservoir.

Table 4-6: High Service Pumps

Pump Number	Location	Pumps to	Capacity (MGD)	Design Total Dynamic Head (ft)	Motor Size (HP)	Year Installed	Drive Type
HSP 1	East HSPS	MH	4.5	162	150	1965	Constant Speed
HSP 2	East HSPS	MH	6.0	185	250	1965	Constant Speed
HSP 3	East HSPS	MH	2.0	142	100	1973	Constant Speed
HSP 4	West HSPS	NS/FP	5.0	210	250	2002	Variable Frequency
HSP 5	West HSPS	NS/FP	5.0	210	250	2002	Variable Frequency
HSP 6	West HSPS	NS/FP	5.0	210	250	2002	Variable Frequency
HSP 7	West HSPS	NS/FP	5.0	210	250	2002	Variable Frequency
SH 1	Sherman Res	MH	3.0	155	100	1965	Constant Speed
SH 2[1]	Sherman Res	MH	6.0	155	200	1940	Constant Speed
SH 3	Sherman Res	MH	2.2	152	75	1965	Constant Speed
SH 4[1]	Sherman Res	MH	4.0	180	150	1940	Constant Speed
GB 1	MH Elev	NS/FP	0.3	48	30	2002	Variable Frequency
GB 2	MH Elev	NS/FP	0.3	48	30	2002	Variable Frequency
GB 3	MH Elev	NS/FP	0.3	48	30	2002	Variable Frequency

Notes: 1: Currently not operational due to valve issues.

8. Chlorine Feed

The WFP switched from chlorine gas to liquid sodium hypochlorite as part of the plant upgrades in 2002. Sodium hypochlorite is stored in two 7,000-gallon storage tanks. Currently only one of the 7,000-gallon storage tanks is filled at a time to reduce the loss of hypochlorite strength over time. There is also a 300-gallon day tank. There are nine positive displacement chemical feed pumps available to feed the solution to twelve different injection points spread throughout the treatment process. The hypochlorite tanks and feed pumps are located in a separate room from other chemicals. Phosphate is fed into all carrier water lines to control calcium carbonate build-up in the feed lines.

C*T is a measure of disinfection effectiveness for the time that the water and disinfectant are in contact, where "C" is the concentration of the disinfectant and "T" is the amount of time the disinfectant is in contact with the water. The C*T for the WFP was calculated in accordance with USEPA Disinfection Profiling and Benchmarking Technical Guidance Manual. The C*T required for the WFP is based on the required 3-log removal (or inactivation) of giardia and 4-log removal (or inactivation) for viruses during the treatment processes. With the conventional treatment process used at the Muskegon Heights WFP, a 2.5-log removal for giardia and 2-log removal for viruses is provided by the treatment processes. The remaining 0.5 log removal for giardia and 2-log removal for viruses required is to be provided with the use of disinfection. Since the WFP uses sodium hypochlorite (chlorine) for disinfectant and sodium hypochlorite is more effective at the inactivation of viruses than giardia, the required C*T is based on the 0.5 log removal of giardia. The C*T required for 0.5 log removal of giardia in water at a pH>9.0 and 0.5 degrees Celsius is 77.0 min-mg/l. Table 4-7 shows the C*T values attributed to each treatment process under conservative conditions. The following conservative conditions were used to determine the C*T provided by the WFP:

- The maximum design flow rate of 25.2 MGD through the WFP and maximum flow rate out of the storage reservoirs of 41.5 MGD. The flow rate out of the storage reservoirs includes 20 MGD to the West High Service Pump Station, 12.5 MGD to the East High Service Pump Station and the rated capacity of the gravity feed to the Sherman High Service Pump Station of 9.0 MGD.
- The volume in the Storage Reservoirs and Filter Clearwells is based on the minimum operating water levels of 3 feet deep in the West Reservoir and 7 feet deep in the East Reservoir. There are three Filter Clearwells each with a north and south part. The south clearwell must flow through the north clearwell to enter the reservoirs. The storage volume for the Filter Clearwells is based on Clearwell No. 1 with a 3 feet deep water level to match the minimum operating water level of the West Reservoir.

- Baffling factors were used to conservatively estimate the actual detention time in each process based on the amount of baffling provided to prevent short circuiting. The baffling factors were determine in accordance with USEPA guidance as described in Table 4-7.

- The minimum yearly chlorine residuals as measured at the rapid mix, applied and plant tap locations.

Table 4-7: Baffling Factors

Baffling Condition	Baffling Factor	Baffling Description
Unbaffled	0.1	None, agitated basin, very low length to width ration, high inlet and outlet velocities
Poor	0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles.
Average	0.5	Baffled inlet or outlet with some intra-basin baffles.
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders.
Perfect (Plug Flow)	1.0	Very high length to width ratio (pipeline flow), perforated inlet, outlet, and intra-basin baffles.

Table 4-8: WFP C*T Calculations

Location	Flow Rate (MGD)	Volume (gallons)	Baffling Factor	Detention Time (min)	Min Chlorine Residual[1] (mg/l)	C*T Attained (min-mg/l)
Rapid Mix/ Influent Piping	25.2	6,300	1.0	0.4	1.92	0.7
Flocculation Basins	25.2	792,000	0.5	22.6	1.92	43.4
Settling Basins	25.2	4,340,000	0.5	124.0	1.50	186.0
Filters (11 of 12 in operation)	25.2	331,000	0.7	13.2	1.50	19.9
Clearwell	8.4	24,684	0.3	1.3	1.36	1.7
Storage Reservoirs	41.5	1,170,000	0.4	16.2	1.36	22.1
				Total C*T Attained		**273.8**
				Required C*T		**77.0**
				% of Required		**356%**

Notes: 1: Minimum Chlorine Residuals obtained from the 2013 Monthly Operating Reports.

Even under the most conservative conditions, the WFP currently achieves a C*T of 273.8 min-mg/l or over 3.5 times the required C*T to provide the required 0.5 log removal of giardia.

As shown in the above table, most of the C*T is attained in the WFP Settling Basins. Based on this calculation, as long as a minimum 0.5 mg/l residual is present in the Settling Basins, the WFP should meet the required C*T values. For both the current and future flow values, WFP should not have issues providing the required C*T values as long as minimum chlorine residuals are maintained through the Settling Basins.

The sodium hypochlorite feed pumps are nearing the end of their useful life and should be replaced. Typical chemical feed pumps have the ability to provide a wide range of flow and care should be taken to select a pump with range of capacity to treat water near the design flow rate and future flow rates without needed to replace the pumps.

9. Coagulant Feed

Liquid alum is stored in two 10,000-gallon storage tanks with a 430-gallon day tank. There are two positive displacement chemical feed pumps each of which have the ability to feed either or both rapid mix unit injection points. The alum storage tanks and feed pumps are located in a room separate from other chemicals. Typically alum is fed at 14 – 20 ppm but if there is a turbidity spike, feed rates can increase to 40 – 50 ppm to account for the higher turbidity.

The alum feed pumps are nearing the end of their useful life and should be replaced. Typical chemical feed pumps have the ability to provide a wide range of flow and care should be taken to select a pump with range of capacity to treat water near the design flow rate and future flow rates without needed to replace the pumps.

The raw water pH consistently exceeds the optimum pH range for alum of 5.5 to 7.8. Failure to operate within this pH range when using alum may result in wasted chemicals. The WFP has tried other chemicals previously and has achieved best treatment results with Alum.

10. Fluoride Feed

The water plant uses liquid Hydrofluosilicic Acid to provide fluoride to its customers. The fluoride compound is stored in a 7,000-gallon tank with a 185-gallon day tank. Fluoride is fed by 2 positive displacement chemical feed pumps each of which have the ability to feed all 3 of the fluoride injection points. There is one injection point for each set of 4 filters. The fluoride storage and pumps are located in a separate room from other chemicals.

Fluoride overfeed protection is currently provided by flow pacing using the SCADA system with a separate hard wired circuit interlock relay connected to the flow meter to provide overfeed protection when there is no flow. Plant tap fluoride residuals are tested every day to ensure proper fluoride residuals are maintained.

The fluoride feed pumps are nearing the end of their useful life and should be replaced. Typical chemical feed pumps have the ability to provide a wide range of flow and care should be taken to select a pump with range of capacity to treat water near the design flow rate and future flow rates without the need to replace the pumps.

11. Phosphate feed

The water plant feeds a food grade Sodium Hexametaphosphate solution to prevent scale accumulation in the chlorine feed lines that run throughout the plant and the intake pipes. The phosphate is delivered in dry bags and the solution is mixed in a drum container which is connected to a chemical feed pump. The phosphate is fed into the sodium hypochlorite carrier water line that runs out to the Low Service Pump Station and eventually to the intakes.

12. Carbon feed

The water plant continues to maintain a carbon feed system which is only used to periodically control taste and odor problems when necessary. The carbon is stored in 40 pound bags in the feeder room and approximately two dozen bags are kept on site. A volumetric feeder is used to put the carbon into a slurry and a small centrifugal pump is used to transport the solution. The carbon slurry is injected into each of the two raw water transmission lines.

In the past, the carbon feeder has been problematic since it uses a very small wetting cone and has periodically plugged up with carbon fines and partially wetted carbon. Additionally, the delivery pump was originally undersized but has been replaced with a higher pressure unit. The carbon system has not been needed in recent years.

13. Plant Piping and Miscellaneous

The plant has two raw water intakes and two raw water transmission lines from the low service station to the water plant which provide adequate reliability. However, there is only a flow meter in the north line which causes a minor bottleneck at this point since the water from the south line must also pass through this meter. The existing pipe configuration and valves allow the flow to go in any direction (flow from the north to south transmission main or south to north transmission main both before or after the flow meter). This arrangement will probably continue to be suitable given the expected decrease in plant demand..

A majority of the paint on the existing piping is in poor to marginal condition. All of the pipes were repainted as part of the last plant upgrade in 2002 and have deteriorated over time. Specifically, the piping in the East Filter Gallery should be prioritized to maintain the integrity of the piping. Piping in other areas of the plant appear to be in marginal condition and the repainting work could be spread out over a few years. When the pipes are repainted, Pipe labels and the paint color schedule should be in accordance with those recommended by Ten States/AWWA.

There are several backflow prevention devices located throughout the plant which have all been tested in accordance with the City's cross connection program. All backflow preventers in the plant are currently tested annually as a minimum.

14. Plant Metering and Controls

SCADA controls have been updated since the last plant expansion. All aspects of the treatment system have the ability to be operated remotely from the control room using the SCADA system and manual controls are also provided. Remote locations such as the Low Service Pump Station, Sherman High Service Pump Station, Getty Booster Station, and the elevated and ground storage tanks can all be monitored and controlled from the water plant. Alarms provided at the WFP and remote locations are adequate in accordance with the 2008 Sanitary Survey.

Each valve throughout the WFP is exercised annually as a minimum to maintain adequate reliability. Records of these activities are being developed to ensure that all valves have been identified and are being exercised and properly maintained.

15. Laboratory

The WFP Laboratory maintains DEQ certification for both Total Coliform and E.Coli, and Heterotrophic Plate Count testing.

The WFP has turbidimeters for each individual filter as well as for each of the combined filter effluent points and other locations throughout the entire treatment process. The turbidimeters are reaching their life expectancy and should be replaced.

All of the lab equipment is calibrated by a contractor in accordance with the equipment manufacturer recommended frequency.

16. Power Reliability

Both the WFP, which includes high service pumping, and the Low Service Pump Station meet the requirements for power reliability. Each location has dual electrical feeds. Each feed line is capable of operating the entire plant or the firm capacity of the Low Service Pump Station. In addition, there is an 800 kW standby power generator at the water plant and a 500 kW standby power generator at the Low Service Pump Station. Each generator is capable of providing 10 MGD of treatment and pumping capacity.

The Sherman Avenue High Service Pump Station is also provided with dual electrical feeds. The City has considered the need to provide a backup generator at the Sherman Avenue High Service Pump Station but since this station already has a dual feed source, is fairly reliable and is essentially a secondary means of pumping water, a generator is not necessary at this location.

Section 5 - Recommendations

A. Plant Operations Recommendation

1. Treatment Capacity

As discussed in Section 2, it is anticipated that after April 15, 2015, Norton Shores and Fruitport Township will no longer be customers of the Muskegon Heights Water Filtration Plant (WFP), thus reducing the average water demands in the future significantly. However, since the WFP consists of six pretreatment trains (combination of the flocculation basin and corresponding settling basin) with the ability to feed any of the 12 filters individually, the treatment rate can be reduced without the need for major modifications to the treatment plant.

The current rated capacity of the WFP significantly exceeds the present and projected 10 year water demands for Muskegon Heights. The current average day demand for the Muskegon Heights water system is 1.4 MGD with a projected 2024 maximum day demand of 3.5 MGD. Table 5-1 below summarizes the data in Tables 4-2 and 4-3 to show the flow range available for each pretreatment train operated together (2 flocculation basins and 2 settling basins in service):

Table 5-1: Pretreatment Train Low and High Flow Rates

Pretreatment Train	Low Flow Rate[1] (MGD)	High Flow Rate[2] (MGD)
1	3.2	4.2
2	3.2	4.2
3	3.2	4.6
4	3.2	4.6
5	1.2	4.2
6	1.2	4.2

Notes: 1: The low flow rate shown is based on the Ten States recommendation of 0.5 fpm through the flocculation tanks. Actual flow rate can be lower since this is generally a rule for flocculation tanks without mixers since they are used to keep the floc suspended during low flows.
2: High flow rate is based on the four hour detention time requirement.

Each filter is capable of treating approximately 2.1 MGD at the design flow rate of 3 gpm/sf.

The WFP is currently operated 24-hours per day 7 days per week. With the expected loss of customer base and resulting decrease in water demand, it is recommended that the WFP be reduced to operating one shift per day. Based on treating water over a period of 6 hours each day and the future water demands shown in Table 3-3, the future average day and maximum day treatment rates would be approximately 5.6 MGD and 14.0 MGD respectively. In order to treat the future maximum daily demand, the WFP would need to operate four pretreatment trains and seven to eight filters.

Based on the current and future water demands, it is recommended that two pretreatment trains and four filters be taken offline for the foreseeable future. Taking these pretreatment trains and filters offline would reduce the maximum capacity from 25.2 MGD to approximately 16.8 MGD, which is still more than sufficient to meet the current and future demands while operating the WFP one shift a day. Taking the pretreatment trains and filters offline would reduce the need to rotate between pretreatment trains and filters required in order to prevent excessive detention times and would also reduce unwarranted wear and tear on mechanical equipment. Taking the pretreatment trains and filters off line for an extended period would require some operations efforts to return them online including disinfection and filtering to waste until desired filter performance is achieved. However, this would still allow for future use if water demand increases or in case of equipment failure.

2. High Service Pumping

Table 4-6 contains the location and capacity of each High Service Pump. There are currently four high service pump stations. Currently, the East High Service Pump Station and Sherman High Service Pump Station are capable of pumping water directly to the Muskegon Heights Distribution System and the West High Service Pump Station and Getty Street Booster Station are capable of pumping to the Norton Shores/Fruitport Distribution Systems.

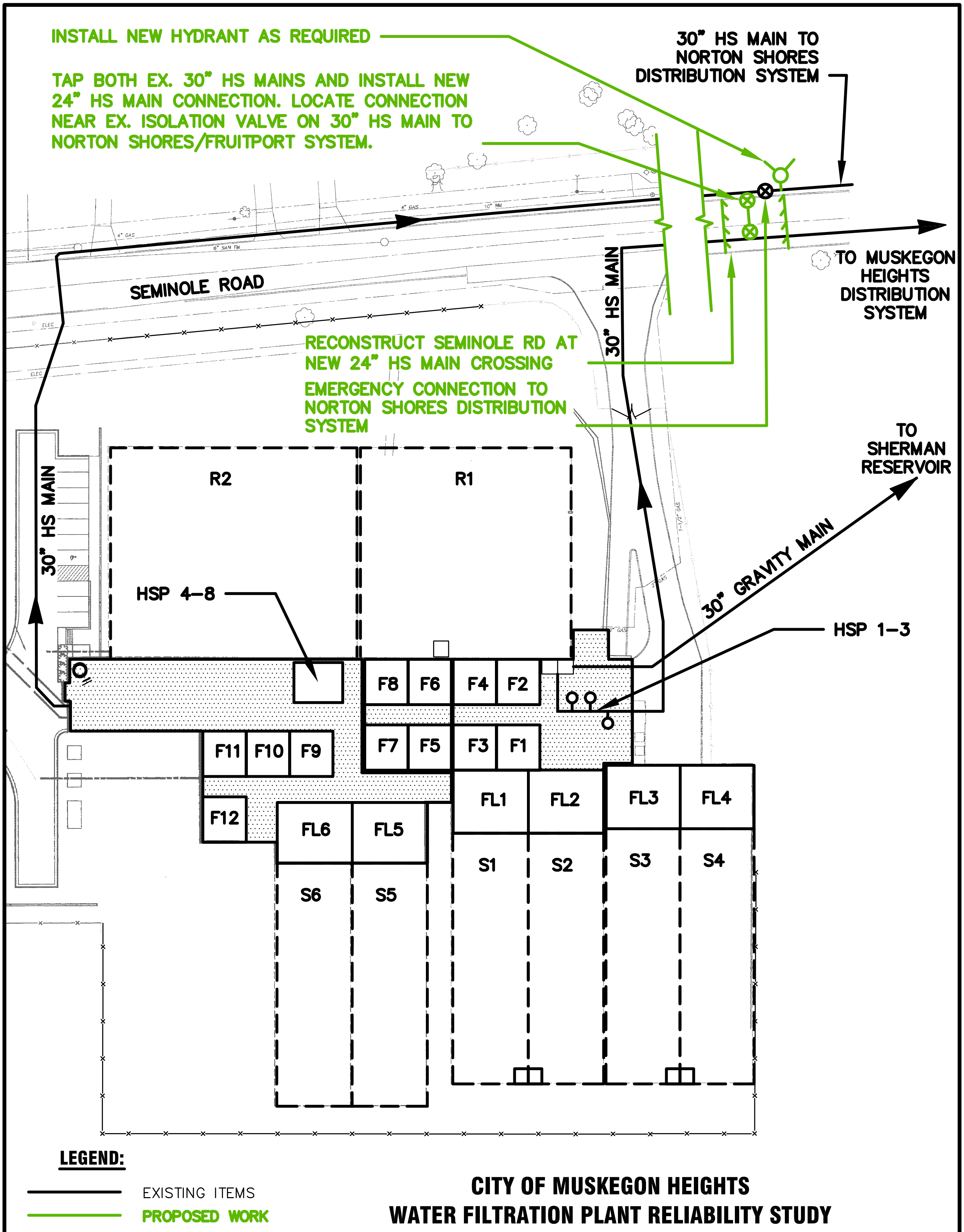
a. Water Filtration Plant West High Service Pump Station Alternative

The West High Service Pump Station was constructed in 2002 and includes High Service Pumps (HSP) 4 through 7. The pumps are in good condition and are controlled with Variable Frequency Drives (VFDs). Once Norton Shores and Fruitport are no longer customers of the WFP, this pump station could be connected to the Muskegon Heights System in order to be utilized. It would be desirable to utilize this pump station because the pumps are in fairly good condition and it would allow for more control of the amount of water pumped since the pumps are controlled with VFDs.

Figure 5-1 shows one option for connecting the West High Service Pump Station to the Muskegon Heights Distribution System. This project would involve tapping both of the existing 30-inch diameter transmission mains leaving the WFP site and installing approximately 30 feet of new 24-inch diameter transmission main across Seminole Rd. The connection should be made near an existing isolation valve on the 30-inch diameter transmission main prior to the connection to the Norton Shores Distribution System. The existing valve could then be used as an emergency connection between Muskegon Heights and Norton Shores Distribution Systems. A hydrant may need to be added to the existing 30-inch diameter transmission main from the Norton Shores Distribution System to allow for flushing the of this section of transmission main depending on the location of the connection.. This project would cost approximately $100,000 to $120,000.

Based on a review of the existing pump curves for HSP No. 4 through 7 and the design points of the existing East High Service Pumps (HSP No. 1 through 3), HSP No. 4 through 7 would be able to provide approximately 2 MGD at 1335 rpm (75% maximum speed) and a maximum of 6 MGD while operating independently to the Muskegon Heights Distribution System (see Figure 4-3). These numbers are estimates and should be confirmed with a model of the distribution system. The West High Service Pumps have sufficient capacity to provide water for both the current and future Muskegon Heights Water System demands.

The connection of the West High Service Pump Station to the Muskegon Heights Distribution System may possibly allow for the Sherman Reservoir to be taken out of service. However, without the Sherman High Service Pump Station and Reservoir, there would only be one means of transmission of water between the plant and the City which would result in a critical reliability. If the Sherman High Service Pump Station and Reservoir were taken out of service, it would leave the 30-inch transmission main as the only connection between the WFP and the City Distribution System. Although this transmission main has been fairly reliable and there are interconnects between the City of Muskegon and Muskegon Heights Distribution Systems which could provide water if the transmission main is out of service, it would still be desirable to maintain the Sherman Reservoir and Pump Station as an additional source of water for the Distribution System.



CITY OF MUSKEGON HEIGHTS
WATER FILTRATION PLANT RELIABILITY STUDY

JOB NO. 20130904	HRC 100 YEARS CONSULTING ENGINEERS SINCE 1915	FIGURE NO.
DATE June 2014		5-1

b. Sherman High Service Pump Station Alternative

If the connection of the West High Service Station is not completed, the Sherman High Service Pump Station is recommended to be operated to provide approximately slightly over half of the City's water demand. The Sherman High Service Pumps would allow water to be pulled from both the WFP Reservoir and the Sherman Reservoir. This will allow the stored water in both reservoirs to be turned over more often than if just the high service pumps at the WFP are used, preventing potential water quality issues when the Sherman pumps are operated. The East High Service Pumps would also be maintained to provide a redundant source of water to the distribution system and to keep circulation through the 30-inch high service main. The Sherman High Service Pumps have sufficient capacity to provide water for both the current and future water system demands.

The electrical systems at the Sherman Pump Station are outdated and should be considered for replacement. The Motor Control Center (MCC) is no longer supported by the manufacturer but refurbished parts are readily available for use. Replacing the low voltage power circuits along with other needed improvements to increase security and maintain reliability of the station are included in the Capital Improvements List.

c. Getty Booster Station

The Getty Booster Station currently serves to provide additional water to the Norton Shores and Fruitport distribution systems as required. The pumps at this station are centrifugal type with 30 HP motors and VFDs. Since they were originally designed to only boost water pressure from the Muskegon Heights distribution system to the Norton Shores/Fruitport system, they cannot generate a high enough operating pressure to be used to pump from either reservoir into the Getty Elevated Storage Tank. It may be possible to modify the existing pump impeller and install a larger motor operating at a higher speed to generate enough pressure to operate at the Sherman High Service Pump Station. However, considering the additional cost required to modify and relocate the pumps, it is recommended to purchase a new, appropriately designed pump rather than spend additional money to modify the existing pumps or pump station. This existing pump station may have some value on the used equipment market but doesn't provide much worth to the City for its existing uses.

The Booster Station also includes an 80 KW natural gas powered generator with a 150 amp transfer switch. This generator is not large enough to operate the pumps at the Sherman High Service Pump Station. However, it is in good condition and could be relocated to provide backup power to another City owned property or sold.

3. Water Storage

A summary of the available treated water storage capacity is shown in Table 5-2 below:

Table 5-2: Treated Water Storage Capacity

Location	Volume (MG)
North Filter Clearwells 1-3	0.3
South Filter Clearwells 1-3	0.2
WFP East Reservoir	2.0
WFP West Reservoir	2.0
Sherman Reservoir	1.5
Getty Elevated Storage Tank	0.75
Total	**6.75**

The Muskegon Heights Water System has a total of 6.75 million gallons of storage including 4.5 million gallons at the WFP and 2.25 million gallons in the distribution system. This amount of water accounts for almost two times the future maximum day water demand. This amount of storage could be excessive for normal operation and reducing the storage volume or possibly operating at lower water levels in the reservoirs should be considered to prevent possible water quality deterioration issues. Poor water circulation and long detention times can lead to loss of disinfectant residual, microbial growth, formation of disinfectant byproducts, taste and odor problems, and other water quality problems. Operating at a lower elevation or removing one cell from service is one possibility to reduce the overall detention times.

As discussed above, if the West High Service Pump Station is connected to the Muskegon Heights Distribution System, the Sherman Reservoir could potentially be taken out of service. This would reduce the storage available by 1.5 million gallons to a total 5.25 million gallons.

If the West High Service Pump Station is not connected to the Muskegon Heights Distribution System, the WFP East and West Reservoir operating water levels could be maintained below the maximum level except during periods of high demands. Each Reservoir has an approximate operating range of 13.5 feet with minimum operating water levels in the East and West Reservoir of 7 feet and 3 feet, respectively. For every foot the operating level is lowered in the reservoirs, the total storage capacity is reduced by approximately 0.22 million gallons. The total storage at the minimum operating level is approximately 1.17 million gallons. Maintaining the water level at approximately half of the usable storage volume would reduce the total storage capacity by approximately 1.5 million gallons but would increase energy usage for high service pumping. Since the future estimated average system demand is 1.4 MGD, this would still leave a 24 hours of usable storage available at the WFP along with the storage available in the distribution system. Another option is to remove one of the plant reservoirs while maintaining the other at current levels. It is also possible to isolate the filter clearwells which are not in operation. Several options are available for plant staff to consider moving forward.

4. Staffing

The Michigan Safe Drinking Water Act requires an operator with F-1 License to operate a Treatment Plant with a rated capacity of greater than 5.0 MGD or serving a population greater than 20,000. In addition, a properly certified shift operator must be onsite and in charge when the operator in charge is not present. All shift operators require at least and F-4 certification. The Muskegon Heights WFP currently employs one part time superintendent with an F-1 license, three operators with F-3 licenses and three operators with F-4 licenses. The City has had a difficult time employing a full time F-1 operator due to the limited number of operators that possess this classification.

If the City of Norton Shores and Fruitport Township proceed with plans to leave the WFP, the total population served will drop below the 20,000 population limit the Michigan Safe Drinking Water Act requires for an operator with an F-1 License. While the rated capacity of the treatment plant will remain over 5.0 MGD, the population will be within the 4,000 to 20,000 person limit required to allow for an operator with an F-2 License to operate the WFP. The City should appeal to MDEQ to have the operator certification for its plant reduced to F-2. This may require that the plant capacity be de-rated but some capacity should be retained to allow for less than full day operation and to avoid overtime staffing of the plant. The de-rated capacity could be maintained for future use but may require some negotiation with MDEQ.

The MDEQ is currently drafting a revised interpretation for required operations oversight at community water supplies. This interpretation states that for interim operation, as is the current case with the WFP, when an operator in charge (OIC) (or superintendent) is no longer available, it is allowable for the Michigan Department of Environmental Quality to provide the WFP time to recruit a replacement or promote a staff member to fill the OIC position. During this interim period, the supply must retain a temporary OIC certified at the appropriate level to visit the WFP at least five days per week and be responsible for its daily operation. The WFP will be required to have a full time OIC on staff or agreement for contract operation within 6 months unless a current staff member is desired for the position. The current staff member must be eligible to take the proper licensing exam and must be registered to sit for the next available exam.

This revised interpretation also includes penalties in an OIC is not hired in the required timeframe. The Stage 1 Disinfectants and Disinfection Byproducts Rule requires water supplies that disinfect to have proper certified operator oversight. A supply that fails to do so is in violation of federal requirements and incurs a Tier 2 Treatment Technique violation. For tracking and reporting purposes, the violation shall be entered in SDWIS as a Type 12 violation and will be subject to EPA reporting. These violations would result in a required public notice and financial penalties of $1,000 per day up to a maximum $5,000.

The U.S. Environmental Protection Agency (EPA) Community Water Supply (CWS) Survey performed in 2006 provides a detailed look at the most important operational and financial characteristics for over 1,300 community water supplies. Part of this survey includes a look into average staffing levels for water supplies based on primary water source and ownership based on the population served. Table 5-3 summarizes the pertinent data for staffing levels at the WFP from this EPA CWS survey for surface water systems.

Table 5-3: 2006 EPA CWS Survey Data

	Average Staffing Levels		**Average Wage[1]**	
	3,301 – 10,000	**10,001 – 50,000**	**3,301 – 10,000**	**10,001 – 50,000**
Managers	1.2	1.9	$69,690	$78,560
Treatment Plant Operators	2.7	5.6	$45,110	$48,910
Distribution System Operators	3.6	7.9	$42,830	$47,640
Total	7.5	15.4	$359,610	$799,520

Notes: 1: Average wage adjusted from reported 2006 values to 2014 dollars based on an average 2.5% cost of living increase. The average wages shown do not include benefits.

Based on the future population to be served by the WFP after the customer shift, industry average staffing levels would indicate between 4 through 7.5 full time equivalent staff. The WFP currently has 6 treatment plant operators on staff with an average wage of $42,200 and one part time superintendent. Based on this comparison, the plant operations staffing levels appear to be in line with comparable communities with the exception of at least one full time manager/superintendent. If the WFP is reduced to operating one shift per day as recommended, the City may consider reducing operations staff but it should be noted that many of the same tasks required to operate the WFP will remain and additional WFP startup and shut down activities will be required. In any case, a full time superintendent (OIC) with the appropriate licensing classification should be hired to manage the plant in order to meet MDEQ requirements.

B. Capital Improvement Project Recommendations

Table 5-3 includes a list of Capital Improvement Projects developed jointly by the City and HRC through ongoing discussions regarding near term needs. An approximate project cost range was determined based on previous vendor quotes for similar work as well as current experience and quotes. In some cases, there is very limited information and so these costs should be considered very preliminary in nature and thus significant contingencies have been included by expanding the potential cost range for each item. Another reason for the large cost range is that the expected time frame for each project is unknown and project costs could climb significantly.

Table 5-4: Capital Improvement Project Recommendations

No.	Capital Improvement Project	Project Cost Range
1	Inspect North and South Intakes	$50,000 - $80,000
2	Replace Soft Start on LSP # 6	$18,000 - $20,000
3	Replace all plant turbidimeters	$80,000 - $100,000
4	Sherman pump valve refurbishment	$14,000 - $20,000
5	Connect West High Service Pump Station to Muskegon Hts. System	$100,000 - $120,000
6	Replace Filter Effluent Valve Actuators on all filters	$120,000 - $140,000
7	Revise hot water heat piping system for added efficiency and add small boiler for low heat usage months.	$50,000 - $70,000
8	Re-paint plant piping	$120,000 - $140,000
9	Clean North Sludge Lagoon	$100,000 - $130,000
10	Add Meter to Filter Backwash Pumps 1 &2	$10,000 - $15,000
11	Add Mag Meter to 30" from LSP	$25,000 - $30,000
12	Replace Chemical Feed Pumps	$50,000 - $60,000
13	Install membrane and drains over the top of Settling Basins 3&4	$282,000 - $340,000
14	Replace three 30"x30" sluice gates in East High Service Pump Station Suction Well	$30,000 - $40,000
15	Security and misc. improvements at Sherman Pump Station	$60,000 - $80,000
16	Replace roof at Sherman Pump Station	$70,000 - $80,000
17	Replace low voltage power feed and circuits at Sherman Pump Station	$25,000 - $34,000
18	Replace media (18/12) in Filters 5-8	$136,000 - $170,000
19	Replace surface wash piping and arms in Filters 1-8	$360,000 - $395,000
20	Refurbish 20-inch backwash water supply valve	$3,000 - $5,000
21	Inspect clearwells under Filters 5-8	$8,000 - $15,000
22	Replace meter head on backwash water supply meter and connect to SCADA	$5,000 - $10,000
23	Relocate/modify exist chlorine monorail over HS Pumps 1&2	$14,000 - $23,000
24	Install monorail over HS Pump 3	$12,000 - $14,000
25	Replace media (18/12) in Filters 5-8	$136,000 - $170,000
	Rounded Totals	**$1,900,000 - $2,300,000**

Most of the basis for the projects above has been explained within the report or are fairly obvious. Several of the projects are recommended to provide improved operation or to address the age of the equipment so that it can continue to remain viable for the foreseeable future.

Some of the projects could be paid for through energy cost savings such as the seasonal boiler installation, which would save significantly on natural gas usage. Currently, quotes have been received for projects 1 through 4 and these projects are scheduled to be completed this year. An explanation of most of the projects and their rationale for inclusion is as follows:

- Project 1 is necessary to determine the current condition of both intakes and identify any issues and corrective actions needed to maintain reliability.
- Project 3 involves replacing the turbidimeters located throughout the WFP. The existing turbidimeters are nearing the end of their service life and are in need of replacement to maintain reliability,
- Project 4 includes the repairs to non-operational valves at the Sherman Pump Station.
- Project 5 allows for the West High Service Pump Station to deliver water to the Muskegon Heights Distribution System as discussed above.
- Project 6 includes replacement of non-supported filter effluent control valves. All of the filter valves are included as part of this project and while all the valves should be replaced, this project may be done over a couple of years as money is available.
- Project 7 addresses the building heating system and should lead to lower operational costs for the building heating system.
- Project 8 includes the repainting of all of the plant piping to maintain service. The piping in the East Filter Gallery is in poor condition and should be prioritized to maintain the integrity of the piping.
- Project 10 addresses the metering of Backwash Pumps 1 and 2. This project will allow more control over the filter backwash process.
- Project 11 increase the reliability of the plant flow monitoring in case of a failure of the existing flow meter.
- Projects 14 addresses the operational status of some of the older sluice gates between the reservoirs and the East High Service Pump Station so that isolation of the reservoirs can be performed.
- Projects 15, 16 and 17 will address deficiencies at the Sherman High Service Pump Station. These projects include increasing security by adding a key card system similar to that used at the WFP, replacing the roof which has started leaking, modifying the roof drainage to meet code, replacing overhead doors and operators, and replacing outdated lighting and unit heaters.

- Project 18 is recommended since the original media from the 1960’s is still present in these filters. The filter underdrains should be inspected at the time the media is removed and a decision could be made as to whether underdrains replacement is necessary at that time. A plastic media underdrain with integral media support system (similar to filters 9-12) could be utilized if the underdrains are replaced so that the filters are similar and backwashing characteristics are also similar. It is not recommended that an air-wash system be incorporated for these filters since it would be very costly to implement and it would not be desirable to have air wash on only four of the 12 filters at the WFP. The merits of an air water wash system may also be questionable since the raw water supply is of very low turbidity.
- Project 21 is necessary since the clearwells have not been inspected in several years.
- Projects 23 and 24 will improve the maintenance access for High Service Pumps 1 through 3 by providing a monorail for removal of pumps and motors. Access to these pumps is currently very difficult.