CITY OF Thunder Bay
Superior by Nature

Bare Point

Water Treatment Plant & Distribution Subsystem

CORROSION CONTROL PLAN

Environment Division
water
AUTHORITY
Every drop is superior...

Revised
November 16, 2014
TB67(rev11/14)

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EXECUTIVE SUMMARY

The Environment Division Water Authority operates the Bare Point Water Treatment Plant and Distribution Subsystem on behalf of the City of Thunder Bay. In accordance with Schedule 15.1-11 O.Reg170/03 the City of Thunder Bay Corrosion Control Plan was approved on May 16, 2011. The following Corrosion Control Plan (CCP) includes revisions to the original document with consultation and approval from the Ministry of the Environment's Approvals and Licensing Section and is designed to ensure compliance with the regulations.

The purpose of the CCP is to provide an overview of the following:

1. Overview of the Drinking Water System
2. Identification of internal corrosion problems and sources of contamination
3. Assessment of the significance of the contaminants
4. Identification of alternative corrosion control measures and their impacts
5. Preferred measures including rationale
6. Public notifications
7. Monitoring of the effectiveness of the plan
8. Corrosion control implementation

The Bare Point Water Treatment Plant treats approximately 45 million liters of water per day from Lake Superior utilizing a Zeeweed 1000v3 membrane filtration system. Sodium Hypochlorite is used for disinfection in Pre Treatment, Post Treatment, as well as residual maintenance in the Distribution System. The treated water is described as being soft (alkalinity avg. **40 mg/L as CaC03) and the treated water pH averages **7.90. Treated water temperature varies from **1°C in the winter months to **11°C in the summer. The distribution system consists of approximately 719 km of water main with 47% unlined cast, 27% Ductile Iron, 10% PVC, 5% concrete and 1% HDPE. The Municipality does not purchase water from another system. The City of Thunder Bay is both the Owner and Operating Authority of the Drinking Water System.

** 2009 Statistics

LEAD TESTING RESULTS

Using results from the first 5 rounds of testing under schedule 15.1-4 it was determined that the City of Thunder Bay would be required to develop a corrosion control plan. All 5 rounds determined that more than 10% of plumbing samples exceeded the 10 ug/L limit for lead. Below summarizes all 14 rounds of lead sampling from 2008-2014.

Summary of Results of Round 1-14									
Contaminant	Source	Location	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max
Lead ug/L	Lake Superior	Tap	2317	1137	433	283	24.89	<1	1320
Lead ug/L	Lake Superior	Distribution System	316	316	7	7	2.22	<1	41
Lead ug/L Re Sample	Lake Superior	Tap	27	8	10	8	100	<1	240
Lead ug/L Re Sample	Lake Superior	Distribution System	10	10	1	1	10	<1	7

OVERVIEW OF CORRISION CONTROL PLAN

The City of Thunder Bay has approximately 36,732 service lines and there are approximately 8,000 lead service connections. The City of Thunder Bay routinely replaces lead service connections in conjunction with the water main replacement and repair program.

The City of Thunder Bay is planning a phased approach for corrosion control with a focus on reducing the amount of lead service lines and fixtures connected to the distribution system and public education on water quality.

What has been done to date - Public Education, Replacement of Lead Service Lines & Program Evaluation

- Ongoing participation in the Community Lead Sampling Program
- Regular water quality maintenance including watermain flushing and cleaning.
- Ongoing watermain replacement and renewal including the replacement of lead service connections to the property line. Homeowners have the option of making arrangements at any time to replace the service from the property line into the house at their own expense, reducing the number of lead services connected to the distribution system.
- The City will continue to endorse public education, flushing, and the replacement of lead service lines over time.
- Review of ongoing education campaign
- Mail out “Get the Lead Out” information pamphlets, targeting residents with known lead services to property based on existing service records and providing a contact name and number for all lead service replacement inquiries.
- Newspaper insert of “My TBay” with section on lead pipe information – providing contact number with City of Thunder Bay.

- Update City of Thunder Bay website to clarify homeowner responsibilities and City of Thunder Bay responsibilities when replacing lead service line. Provide link to permit applications in Planning Department and link to Priority Lead Water Service Replacement Form.
- Increase person to person communication with respect to lead service replacement and testing.
- Inter-departmental communication to spread the "Get the Lead Out" campaign with Water Meter Shop.
- Provide private plumbing contractors with information pamphlet "Get the Lead Out" to assist in public awareness
- Include TBDHU and MOE in public awareness campaign through risk assessment committee.
- Private plumbing sampling to follow OReg170/03 s. 15.1, along with a third flushed plumbing sample to determine effectiveness of flushing. Homeowner provided with these results.
- Annual review of CCP progress / effectiveness.

2014 Corrosion Control through Chemical Addition

Corrosion control through chemical addition will be considered as a last measure to reduce levels of lead at the tap. This decision will be based on a review of the success in reducing the amount of lead service lines and fixtures connected to the distribution system and the promotion of public awareness on water quality. The final decision to use chemical addition will be based on reviewing the success of lead service line replacement and discussing these results with the local Ministry of Health and Ministry of Environment. The City of Thunder Bay approaches corrosion control with the goal of lead service replacement, which removes lead sources that come into contact with drinking water, as to minimize risk to the safety of the drinking water. This process of lead removal / replacement will take time and cooperation from the public. Based on a review of historical data, the 1996 Chemical Corrosion Control Study as well as the community lead testing program it has been determined that corrosion control by products that will need to be monitored or controlled include lead, copper iron, zinc and manganese.

Utilization of the 1996 corrosion study performed by the City of Thunder Bay in conjunction with the Ministry of Environment and McMaster University determined that the most effective form of chemical corrosion control would be the use of sodium hydroxide. With the expansion of the Bare Point Water Treatment Plant provisions were implemented to include sodium hydroxide and are included in drinking Water Works Permit # 024-021. In order to reduce lead levels within premise plumbing it has been determined that pH adjustment will need to be between 9.0 and 9.6 in order to ensure effectiveness. Since the raw source water pH averages 7.87, the addition of sodium hydroxide does raise concern since the pH will need be increased to 9.0-9.6 to control corrosion. Raising the pH within this range may compromise the effectiveness of the sodium hypochlorite. For this reason, the addition of sodium hydroxide for the purpose of corrosion control will commence in a phased approach. A localized designated area of The City of Thunder Bay – Current River has been selected as a test area.

All homes in this area with known lead services will be issued a lead information pamphlet with the opportunity to request sampling. Baseline lead sampling will occur December 15, 2014 through April 15, 2015 and June 15, 2015 through Oct 15, 2015 for the Current River section of the city. Additional samples to be collected include chlorine residual, alkalinity, temperature, colour, hardness, conductivity, turbidity, copper, iron and microbiological. These will be collected in conjunction with corresponding lead plumbing and distribution samples.

Starting December, 2015 sodium hydroxide will be added to the Current River area at the entry point of Hodder pumping station. The second phase of lead sampling will follow the addition of chemical at the same locations that were sampled prior to the addition – December 15, 2015 through April 15, 2016 and June 15, 2016 through October 15, 2016.

Additional samples for chlorine residual, alkalinity, temperature, colour, hardness, conductivity, turbidity, copper, iron and microbiological will also be collected in conjunction with all lead plumbing and distribution samples taken. Once sampling is complete, results from all rounds will be compared.

1.0 INTRODUCTION AND DRINKING WATER SYSTEM DESCRIPTION

1.1 System Description

Raw water is fed to the plant by gravity through three intake lines approximately one km from the shore line.

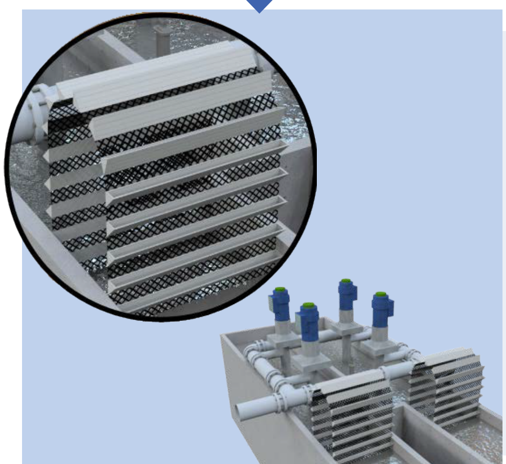
Traveling screens remove debris and particles from the raw water where it enters the plant. After the screens, Sodium Hypochlorite is added to reduce the growth potential and reduce the formation of biofilm. Low lift pumps move this water through a 900mm pipe to the Membrane Filtration building. Here water is pulled through the Zeeweed 1000v3 membrane filtration system using vacuum pressure. After filtration, the water travels to the final stage of the process, the clear well area, where Sodium Hypochlorite is added for primary disinfection. The combination of the clear well and reservoir creates the CT and Log removal required.

Two 2 ML storage reservoirs hold the water before transfer to the distribution system. The Bare Point Water Treatment Plant produces an average of 45 million litres of water per day. The plant has the capacity to produce 113.5 million litres per day.

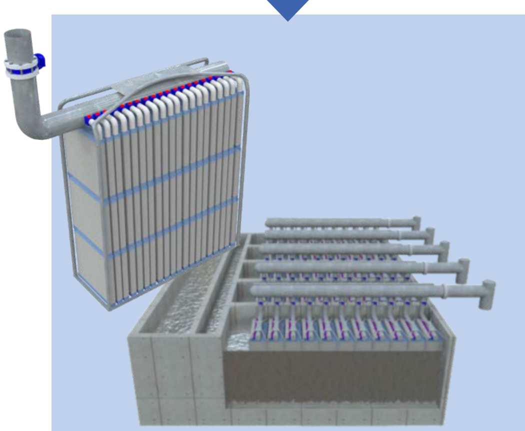
1.1.1 Process Diagram

Lake to Lake approach for Safe Drinking Water

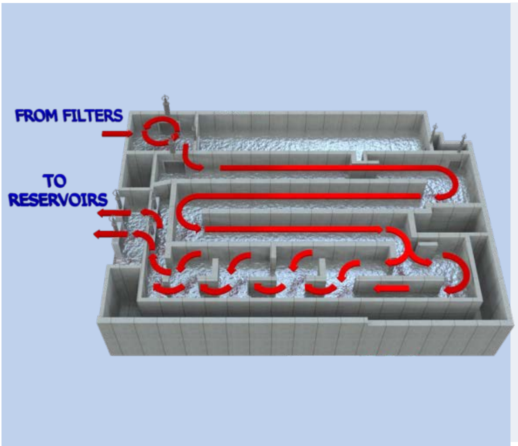
Step 1: Source Water
Our drinking water starts with the world's largest source of fresh water, Lake Superior. The intake for the plant is located nearly 1km from the shoreline and is positioned at a water depth of approximately 18 metres and rests approximately 9 metres above the lake bottom. The depth of the intake protects it from debris entering from the bottom of the lake and from the water surface.



Step 2: Screening
The raw water enters the plant through the intake. Traveling screens remove debris and particles from entering the plant and the raw water is stored briefly in the wet well. The screens are similar to common household window screens, although they are made from stainless steel. Low lift pumps then lift the water through the plant and it is there that sodium hypochlorite is initially added to help discourage biological growth in the plant.

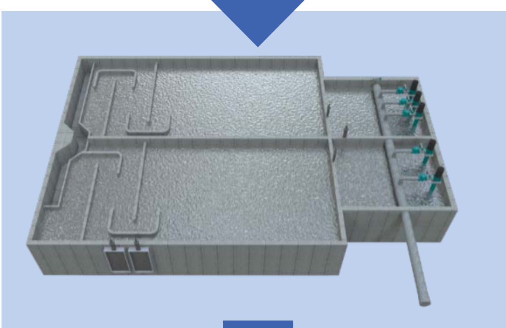


Step 3: Filtration
The water is then pulled through the Zeeweed membrane filtration system using vacuum generated from pumps. Hollow fibre ultrafiltration membranes use gentle suction to filter impurities from the water.



Step 4: Disinfection

The clearwell is used for primary disinfection as described by the Ministry of the Environment. Sodium hypochlorite is added to the water in the clearwell mixing chamber. The clearwell uses a baffling system to allow the sodium hypochlorite to mix with the water. This creates a long contact time or soaking time for the water to mix with the hypochlorite. Contact time is a measurement of the concentration of the sodium hypochlorite multiplied by the time traveled in the clearwell.

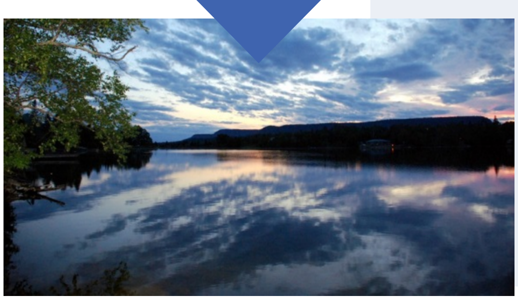


Step 5: Storage

The clean safe disinfected drinking water is then stored at the plant in two underground storage tanks to keep the water cool and fresh awaiting delivery to customers taps. Each reservoir can hold over two million litres of water.

Step 6: Water Delivery

Water is pumped from the storage reservoirs into the distribution system by high lift pumps. Some of the water is delivered directly to customer taps and some delivered to one of five storage reservoirs within the distribution system.



Step 7: Environmental Protection

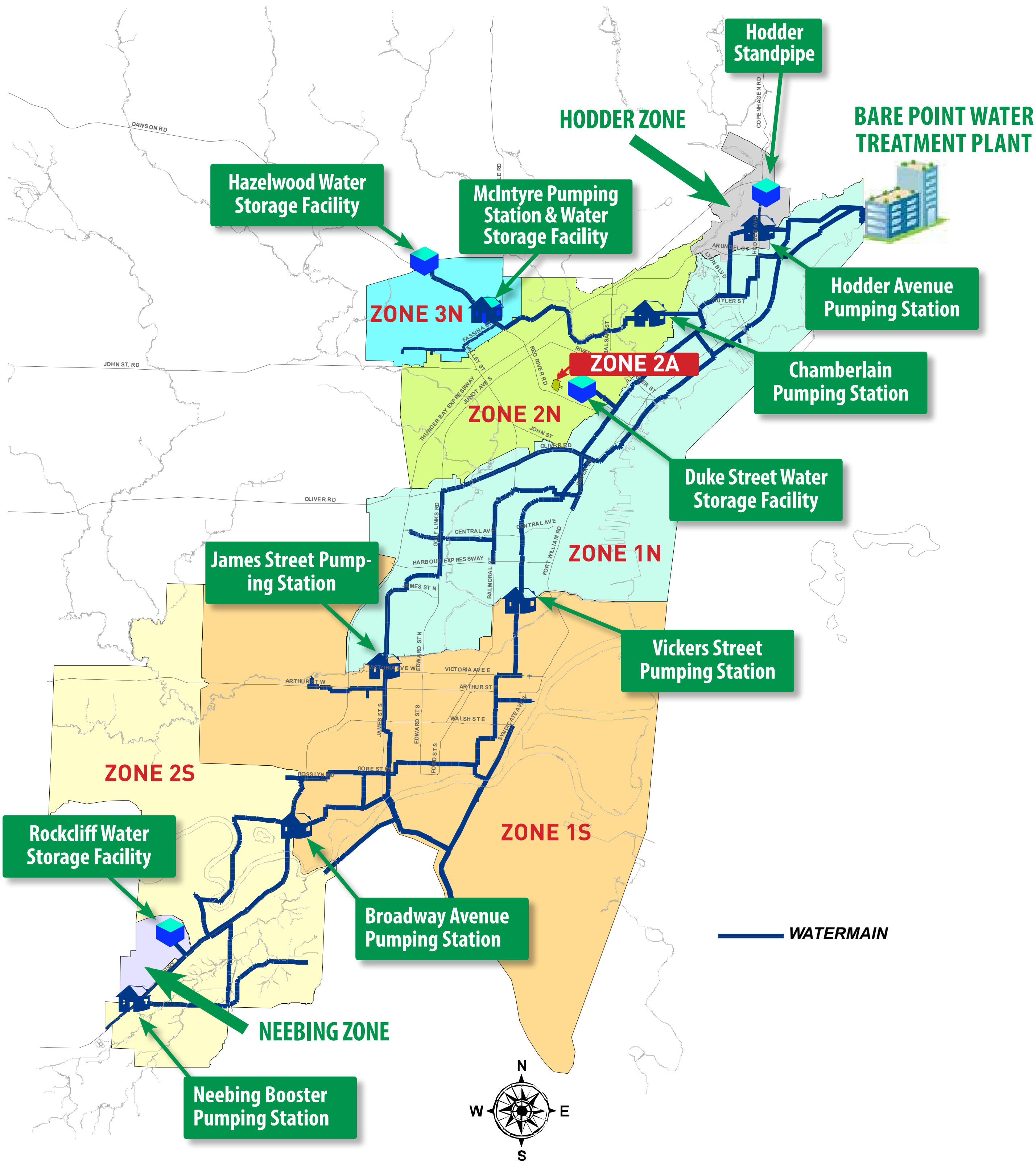
Wastewater from the membrane filtration process is piped to the Atlantic Avenue Water Pollution Control Plant for processing before being returned clean to Lake Superior.

1.1.2 Overview of System Components

The system consists of:

- 1 Water Treatment Plant
- 1 Water Test Area
- 5 Water Storage Facilities
- 8 Water Pumping Stations
- 8 Water Pressure Zones
- 719 Kilometers of Water mains The water distribution pipe system is made up of approximately 47% unlined Cast Iron, 27% Ductile Iron, 10% PVC, 5% concrete, 4% lined Cast Iron, 4% steel, 2% Asbestos Cement and 1% HDPE
- 2,495 Industrial/Commercial/Institutional Service Connections
- 3,402 Fire Hydrants
- 9,212 Valves
- 36,732 Residential Water Service Connections

1.1.3 Distribution System/Pressure Zone



1.1.4 Pressure Zone Description

Thunder Bay's water distribution system is divided into seven pressure zones (see map previous page).High lift pumps move the treated water from the plant into the distribution system. The water storage facilities and pumping stations regulate water pressure within the distribution system. Water can be redirected through the distribution system when needed. The system is made up of the following components:

Standpipe – Above-ground water storage facility providing pressure by water column height

Reservoir – Large volume in-ground water storage facility

Pumping Station – Pumps water from one zone into another zone and can be used to increase water pressure to an area

Water Pressure Zone – Areas where a minimum and maximum water pressure can be expected in water distribution system

Zone 1N

The reservoirs at the Bare Point Water Treatment Plant store water for this zone and pump it into this area as needed. The Duke Street Reservoir also provides water storage for this zone.

Hodder Zone

The Hodder Standpipe stores water for this zone. Water is pumped from the Bare Point Water Treatment Plant to the Hodder pumping station. This station supplies water to the Standpipe as needed. Approximately 165 properties were converted from Zone 1 water pressure zone. The work included relocation of check valves in the distribution system combined with installations of pressure reducing valves and expansion tanks. Original water pressures of 40-50 p.s.i. have been improved to a constant 60 p.s.i.

Zone 2A

The Duke Street Reservoir stores water for this zone. It was added to increase and maintain water pressure for this area.

Zone 2N

The McIntyre Reservoir stores water for this zone. Water is pumped from the Bare Point Water Treatment Plant through the Chamberlain Pumping Station to this zone.

Zone 3N

The Hazelwood Standpipe stores water for this zone. Water is pumped from the Bare Point Water Treatment Plant through the Chamberlain Pumping Station to the McIntyre Reservoir. The McIntyre Pumping station supplies water to the Hazelwood Standpipe.

Zone 1S

The Rockcliff Reservoir stores water for this zone. Water is pumped from the Bare Point Water Treatment Plant through the Vickers and

James Street Pumping Stations filling the Rockcliff Reservoir and supplying water to the area.

Zone 2S

Water is pumped from the Broadway Avenue Pumping Stations to this zone. Water is drawn from the Zone 1S water distribution system, which includes the Rockcliff Reservoir.

Neebing Zone

Water is drawn into this zone from the Zone 2S distribution system. The Neebing Booster Pumping Station increases water pressure for this zone.

1.2 Source Water Supply Information and Characteristics

The Bare Point Water Treatment Plant treats its water from Lake Superior and is a single source system. The following table describes the source water characteristics utilizing 2013 data.

1.2.1 Source Water Characteristics – Lake Superior

Characteristics	Result – 2013 Averages
pH	7.8
Alkalinity (mg/L as CaCO3)	30.7
Conductivity (umho/cm)	97.4
Hardness(mg/L as CaCO3)	42.1
Chloride (mg/L)	1.10
Turbidity NTU	1.0
Color (True)	5.3
Temperature ‘C	5.52
Sodium (Na) Total	2.00
Calcium (Ca) Total	13.88

1.3 Treatment Facility Information and Characteristics

Typical flow rates, rated capacities, chemicals used etc. are listed in Tables 1.3.2 and 1.3.3. A flow diagram is supplied in Figure 1.1.1 under system description. The Bare Point Water Treatment Plant and Distribution Subsystem is operated 24hrs per day 7 days per week.

1.3.1 Overview of Treatment Capacity

Treatment Facility	Source	Rated Capacity (m3/d)	Flow (m3/d)	
			Average	Maximum
Bare Point Water Treatment Plant	Lake Superior	113.5	45	70.45

1.3.2 Treatment Targets

Facility	Sodium Hypochlorite		pH Adjustment		
	Free Chlorine	Target Residual in Treated Water	Chemical	Dose	Target pH
Bare Point Water Treatment Plant	Free	1.4	Sodium Hydroxide	TBD	9-9.6
TBD – To Be Determined					

1.3.3 Overview of Treated Water Quality

Treated water characteristics related to lead release and lead control are summarized in Table 1.3.4. The pH of treated water varied between 7.47 and 8.29 in 2009.

Parameter	Bare Point Water Treatment Plant Point Entry to Distribution System	
	Average	Minimum to Maximum
pH	7.90	7.47 to 8.29
Alkalinity, mg/L as CaCO3	40.7	32 to 44
Temperature °C	4.36	1 to 11
Chlorine Residual, mg/L	1.79	1.61-1.94
Conductivity, µmhos/cm	110	100.1-112
Chloride, mg/L	3.43	3.31-355
Phosphate, mg/L (ortho)	<0.003	<0.003
Nitrite, mg/L	<.02	<.02
Nitrate, mg/L	.355	.339-.390
Sodium (Na) Total	3.41	2.85-3.75
Calcium (Ca) Total	14	11.6-15.2

1.4 Distribution System Information and Characteristics

The distribution subsystem is described in section(s) 1.1.2 to 1.1.4 under system description. A summary of water quality data as sampled during 14 rounds of lead sampling is presented in the executive summary.

An overview of Distribution water quality is presented in Table 1.4.1 below. The results are formulated utilizing data from 2014 quarterly reports.

1.4.1 Overview of Distribution Water Quality

NEEBING BOOSTER STATION								
PARAMETER	1		2		3		4	
	Value	Date	Value	Date	Value	Date	Value	Date
pH	8.29	January 20 2014	8.38	April 23 2014	8.29	July 15 2014	8.32	October 20 2014
Alkalinity mg/L as CaCO3	39	January 20 2014	47.0	April 23 2014	44.4	July 15 2014	48.3	October 20 2014
Temperature °C	10.1	January 20 2014	10.1	April 23 2014	12.0	July 15 2014	13.7	October 20 2014
Chlorine Residual, mg/L	1.13	January 20 2014	1.08	April 23 2014	1.05	July 15 2014	1.14	October 20 2014
Conductivity,µmhos/cm	119	January 20 2014	120	April 23 2014	120	July 15 2014	114	October 20 2014
Nitrite, mg/L	<.02	January 20 2014	<.02	April 23 2014	<.02	July 15 2014	<.02	October 20 2014
Nitrate, mg/L	0.36	January 20 2014	0.394	April 23 2014	0.339	July 15 2014	0.343	October 20 2014
Sodium (Na)	3.31	January 20 2014	3.43	April 23 2014	3.82	July 15 2014	4.07	October 20 2014
Calcium (Ca)	15.2	January 20 2014	16.3	April 23 2014	12.6	July 15 2014	14.5	October 20 2014

1.5 Summary if Current Lead Service Line (LSL) Replacement Program

The City of Thunder Bay has had a lead service line replacement program to assist residents in reducing lead levels in drinking water. The ongoing watermain replacement program renews the piped water infrastructure as part of our asset management program. When watemains are replaced in the distribution system, all lead service connections are replaced to the property line. Homeowners have the option to replace the service from the property line into the house at their expense. The City also has a cleaning and rehabilitation program to line older watermains with a protective coating.

As part of the LSL replacement program and community awareness concerning lead the City of Thunder Bay will endorse the following actions:

- Replacement of lead service connections to the property line as part of the new main rehabilitation program.
- Free sampling for homeowners with known or suspected lead connection at their request.
- Priority replacement of lead service to property line, once private lead portion is replaced.
- Public education / awareness on the impacts of lead in drinking water and options for service replacement via door stuffers, mail out pamphlets, media releases and the City website.

2.0 INDENTIFCATION OF INTERNAL CORROSION CONTROL PROBLEMS AND SORUCES OF CONTAMINATION

2.1 Premise Piping – May 2007 Directors Order

The City of Thunder Bay conducted sampling in twenty homes in response to the Directors Order that had known lead connections. At that time the distribution system was split and fed from two separate sources; Loch Lomond and Lake Superior. Ten samples were taken in each distribution system and for the purposes of the Directors Order and the results were submitted together. The Lake Superior source did not have any samples exceeding 10ug/L and the Loch Lomond source had two samples which exceeded the 10ug/L limit. Currently the City of Thunder Bay's distribution system is fed from Lake Superior and is a single source system.

Results from the lead sampling conducted in response to the Director's Order are presented in Table 2.2. These samples represent lead levels measured at the tap after a 5 minute flush.

2.2 Lead Results, Flushed Samples at Customer Tap and Field Results May 2007

Parameter	Number of Sites	Average	Minimum	Maximum	Number above 10ug/L	Detection Limit
Lead ug/L	20	4.35	<1	15	2	1
Field Lead ug/L	7	<1	<1	1	0	1
Field PH	7	7.93	7.65	8.14	N/A	N/A
Field Alkalinity	7	38.14	22	48	N/A	N/A

2.3 Premise Piping – Schedule 15.1-7

Results from standing samples collected at residential and non-residential plumbing are summarized in Tables 2.3.1 – 2.3.14 and encompass fourteen rounds of testing.

2.3.1 Results Round 1

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	234	117	48	35	29.91	<1	39	y
Lead ug/L	Lake Superior	Distribution System	26	26	1	1	3.85	<1	33	y
Lead ug/L Re-Sample	Lake Superior	Tap	4	2	1	1	50	<1	26	y
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	NA	7	n

2.3.2 Results Round 2

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	228	114	59	39	34.21	<1	396	y
Lead ug/L	Lake Superior	Distribution System	25	25	0	0	0	<1	10	n
Lead ug/L Re-Sample	Lake Superior	Tap	2	1	0	0	0	<1	<1	n
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.3 Results Round 3

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	226	113	44	30	26.54	<1	262	y
Lead ug/L	Lake Superior	Distribution System	22	22	0	0	0	<1	7	n
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.4 Results Round 4

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	228	114	51	34	29.82	<1	1320	y
Lead ug/L	Lake Superior	Distribution System	22	22	0	0	0	<1	4.8	n
Lead ug/L Re-Sample	Lake Superior	Tap	2	1	2	1	100	12.1	240	y
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.5 Results Round 5

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	222	111	28	17	15.31	<1	145	y
Lead ug/L	Lake Superior	Distribution System	27	27	1	1	3.7	<1	14.44	y
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	<1	<1	n

2.3.6 Results Round 6

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	220	110	52	33	30	<1	128	y
Lead ug/L	Lake Superior	Distribution System	20	20	0	0	0	<1	3.7	N
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.7 Results Round 7

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	222	111	24	16	14.41	<1	250	Y
Lead ug/L	Lake Superior	Distribution System	23	23	0	0	0	<1	4.8	N
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.8 Results Round 8

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	220	110	37	22	20	<1	37.5	Y
Lead ug/L	Lake Superior	Distribution System	20	20	1	1	5	<1	41	Y
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	<1	2.1	N

2.3.9 Results Round 9

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	220	110	30	23	21	<1	150	Y
Lead ug/L	Lake Superior	Distribution System	22	22	0	0	0	<1	4.1	N
Lead ug/L Re-Sample	Lake Superior	Tap	6	1	3	3	300	1.7	134	Y
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.10 Results Round 10

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	30	15	6	4	27	<1	40.9	Y
Lead ug/L	Lake Superior	Distribution System	20	20	0	0	0	<1	1.2	N
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	NA	NA	NA	NA	NA	NA	NA	NA

2.3.11 Results Round 11

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	42	21	2	2	9.5	<1	15.2	N
Lead ug/L	Lake Superior	Distribution System	23	23	1	1	4.3	<1	12.2	Y
Lead ug/L Re-Sample	Lake Superior	Tap	4	1	1	1	100	6.4	18.8	Y
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	<1	<1	N

2.3.12 Results Round 12

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	30	15	8	7	47	<1	20.3	Y
Lead ug/L	Lake Superior	Distribution System	20	20	1	1	5	<1	34.0	Y
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	<1	<1	N

2.3.13 Results Round 13

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	66	33	9	5	15	<1	53.5	Y
Lead ug/L	Lake Superior	Distribution System	20	20	1	1	5	<1	38.1	Y
Lead ug/L Re-Sample	Lake Superior	Tap	3	1	0	0	0	1.1	8.7	N
Lead ug/L Re-Sample	Lake Superior	Distribution System	3	3	1	1	33	<1	28.5	Y

2.3.14 Results Round 14

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap	129	43	35	16	37.2	<1	36.9	Y
Lead ug/L	Lake Superior	Distribution System	26	26	1	1	3.8	<1	32.3	Y
Lead ug/L Re-Sample	Lake Superior	Tap	NA	NA	NA	NA	NA	NA	NA	NA
Lead ug/L Re-Sample	Lake Superior	Distribution System	1	1	0	0	0	5.4	5.4	N

In conjunction with round 2 the City of Thunder Bay collected a flushed sample at each of the plumbing sites in order to verify if flushing was a viable option. As shown in Table 2.4.1 the number of sample points with an exceedance dropped 82% when the sample was flushed.

2.4 Results of Round 2 Flushed Sample

CONTAMINANT	SOURCE	LOCATION	Number of individual Samples	Number of Sampling Points	Number of individual Sample Exceedances	Number of Sampling Points with an Exceedance	% of sample points with an Exceedance	Min	Max	Significant (yes/no)
Lead ug/L	Lake Superior	Tap Residential	228	114	8	8	7	<1	18	n

2.5 Water Quality Samples

Between December 2009 and January 2010 a total of 175 homes and commercial buildings were tested for lead in conjunction with routine bacteriological sites. These samples were taken from areas of the city which represent areas of concern ie: dead ends etc. Table 2.5.1 outlines the results and averages of all test sites. These samples were taken after a 5 minute flush and there were no exceedances of the standard. The samples were tested at the Bare Point Water Treatment Plant water test area.

2.5.1 Bacteriological Sampling Sites

Temp ©	pH	Cl2 (mg/L)	Colour (tcu)	Hardness (mg/L)	Alkalinity (mg/L)	Conductivity (ms/ cm)	Turbidity (NTU)	Cu (mg/L)	Iron (mg/L)	Lead (ug/L) (yes/no)
7.36	7.91	1.22	3.63	40.24	27.76	105.88	0.072	<70	0.03	<2

3.0 ASSESSMENT OF SIGNIFICANCE OF CONTAMINANTS AND SOURCES

The finished water from the Bare Point Treatment Plant was monitored from December 2009 to the end of January 2010, to assess any significant sources of contaminants. Daily monitoring of iron, copper, lead and other operational parameters concluded that the treatment plant was not a source of corrosion by-products. The average iron, copper and lead concentrations in the finished water were either non-detectable or below the Ontario Drinking Water Objectives. The metals results are summarized in Table 3.1 below.

3.1 Metals Results

Copper ug/L (average)	Iron ug/L (average)	Lead ug/L (average)
<70	30	<2

Table 3.1 (data collected, T.Cook Chief Operator – Bare Point Water Treatment Plant, December 2009-2010)

4.0 IDENTIFICATION OF ALTERNATE CHEMICAL CORROSION CONTROL MEASURES AND THEIR IMPACTS

The City of Thunder Bay, in conjunction with the Ministry of Environment and Energy (MOEE), conducted a unique two-year Corrosion Study in the fall of 1996, to address metals in the water supply. A small pressure zone was selected for the study, which had a booster pumping station and a water reservoir servicing approximately 600 homes with lead and copper service connections.

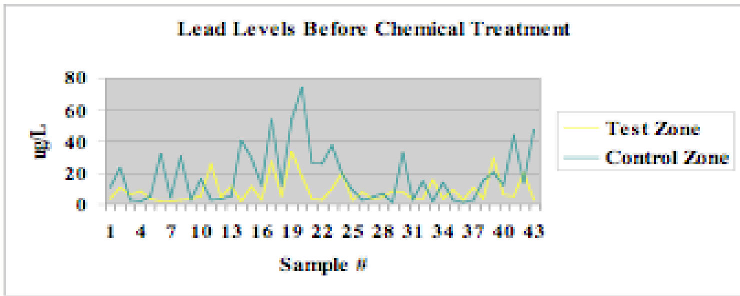
At the time of the study, the City's northward water distribution system was divided into four water zones each with a booster pumping station and three of which have their own reservoir. The smallest, Zone 1A, which was selected for the study, has a 757 litre elevated storage tank and includes a 5.3 million litre per day pumping station which services approximately 600 homes. Zone 1A was an ideal location for the study for the following reasons: low number of consumers; combination of old and new homes with lead and copper connections, the booster pumping station was readily adaptable to act as the treatment plant; no industrial water users; and geographically prepared having an adjacent area with comparative characteristics, which was used as a control group. The most important reason was that we had the support of the 50 consumers, 25 from each area (control and test) who volunteered to participate in the study. The four chemicals selected for the study were as follows, Sodium Silicate, Sodium Hydroxide (caustic soda), Polyphosphates and Zinc Orthophosphate.

The study was conducted over a two-year period to allow for the required three months of chemical dosing per chemical followed by a three month "flush out" period. Daily monitoring of the chemical dosages and plant flows were recorded as well as the pre and post physical characteristics of the water. Sampling locations at the residential homes were selected to ensure that each site selected in the test zone would have a comparable sampling location in the control zone, i.e. age of home, type of connections. Samples collected from these locations were sent to the MOEE Lab in Etobicoke, Ontario for a variety of analyses, some of which is displayed in the report. These samples were taken four times per chemical trial. The first sample was taken two weeks prior to chemical addition, the second was taken one week prior to chemical addition, the third was taken the second-last week of chemical addition and the fourth was taken in the final week of chemical addition. In total the volunteers were required to sample sixteen times over the course of the two-year period. These samples were analyzed for the following, iron, lead, zinc, copper, aluminum, cadmium, and arsenic.

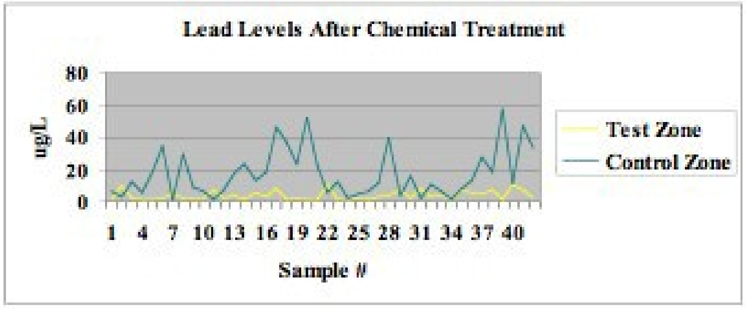
Corrosion control coupons developed and supplied by McMaster University were installed in each zone to monitor the rate of corrosion lead and copper. The corrosion coupon sampling units from McMaster University were housed in locked cabinets which were mounted on the walls of the residents' homes near the water meter. These units were equipped with timers and solenoid valves, which were adjusted to represent the average per capita consumption and timed usage. Each unit had three sets of ten lead/tin solder and copper coupons, which were located in a plexiglass sleeve that could be removed individually by set. The first set was removed after 30 days of the trial period, the second in 60 days and the third in 90 days.

The study concluded that the addition of sodium hydroxide showed the greatest promise of corrosion control. Graphs 1-4 summarize the results.

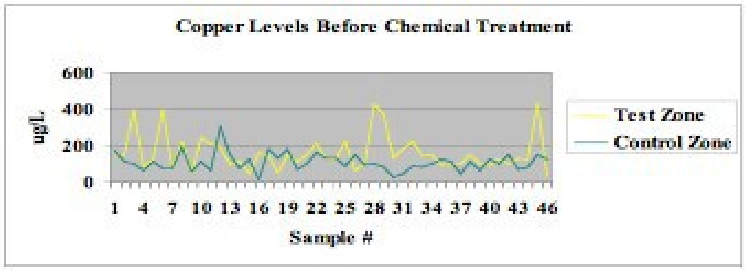
Graph 1



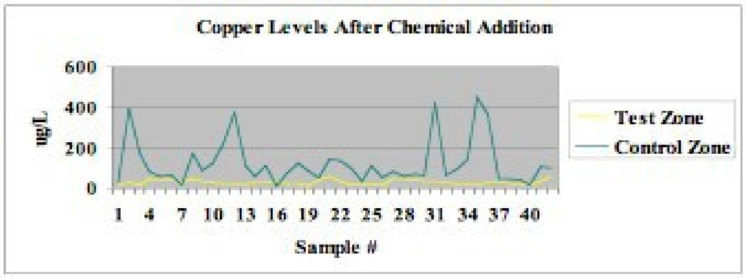
Graph 2



Graph 3



Graph 4



4.1 Chemical Life Cycle Costs

The chemical usage costs from Bare Point WTP are as follows:

It is estimated that approximately 1125L of 50% of Sodium Hydroxide will be required to adjust the pH to 9.3 based on an average daily production of 45 MLD. The approximate daily cost for chemical addition will be $845.45 using 2014 supplier chemical pricing ($0.49 per Kg 50% caustic). This will be an annual operating cost of $308 590.01. Table 4.1.1 details the predicted Life Cycle costs not including chemical costs.

4.2 Life Cycle Costs for Hodder Study and Installation at Bare Point WTP

Equipment	Capacity characteristics	Condition and suggested works	Hodder Study Short term: 2015-2017	Bare Point WTP Long term: 2018-2028	TOTAL
Chemical injection equipment (2 Sodium Hydroxide pumps)	For pH adjustment	Install new peristaltic chem pump at the Hodder station (short term study period) with additional laboratory analysis costs. Install new pump at Bare Point WTP (long term). SCADA programming. Replacement parts for chemical feed system, piping including valves, tubing kits etc. and pump repair (diaphragm kits): $10,000/year.	$50,000	$100,000	$150,000

5.0 IDENTIFICATION OF PREFERRED MEASURE OF CHEMICAL CORROSION CONTROL

Using the lead solubility charts as well as well as historical data it has been determined that the City of Thunder Bay will need to adjust the pH of the distribution system to between 9 and 9.6. The addition of sodium hydroxide has been approved in Drinking Water Works Permit #024-201. The City of Thunder Bay will continue to endorse public education, flushing, and the replacement of lead service lines over time throughout the entire City.

The characteristics of Lake Superior source water make it unique among the Great Lakes. It is a soft water (calcium carbonate hardness = 50 mg/L), low buffering capacity (alkalinity = 45 mg/L as $CaCO_3$) and has a low dissolved inorganic carbon content (about 10 mg/L). The pH of the source water ranges between 7.6 and 7.9.

The initial pipe loop and corrosion coupon trials conducted back in 1996 were good indicator studies that concluded that sodium hydroxide was the agent of choice. In addition the Bare Point Treatment Plant was designed to accommodate the addition of a pH control agent to the finished water if it became necessary. The infrastructure and control systems are in place at the facility.

A formal desktop exercise was not attempted with the Thunder Bay system because historical data and experience showed that some form of chemical control would be necessary. However, the MOE publication Guidance Document for Preparing Corrosion Control Plans for Drinking Water Systems was utilized especially sections 3, 4 and 5. It was realized that analysis of Fig 3-1 “Theoretical Lead Solubility curve vs pH and DIC”, Fig3-2 “Effects of

DIC on Lead” and Fig 4-1 “Saturation pH for Calcium Carbonate Precipitation” would serve as a desktop exercise in determining starting point for sodium hydroxide addition. It was determined from the above mentioned guidance document graphs that Lake Superior treated water would require raising the pH between 9.0 and 9.6. At a DIC level of about 10 mg/L the solubility of lead would be at a minimum value. The guidance document graphs also suggest that the optimal pH for the prevention of calcium precipitation is 8.8. We have not observed calcium precipitation in any bench top tests at the optimal pH range (J.Vukmanich, Lab notes May 2010).

With the above noted comments in mind, bench scale tests were conducted in house at the City’s laboratory. Testing has revealed that for optimal pH adjustment, 7 to 12 mg/L of sodium hydroxide would need to be added to the finished water. A pH vs sodium hydroxide addition titration graph (Table 5.1) has been generated to assist operations staff with the addition.

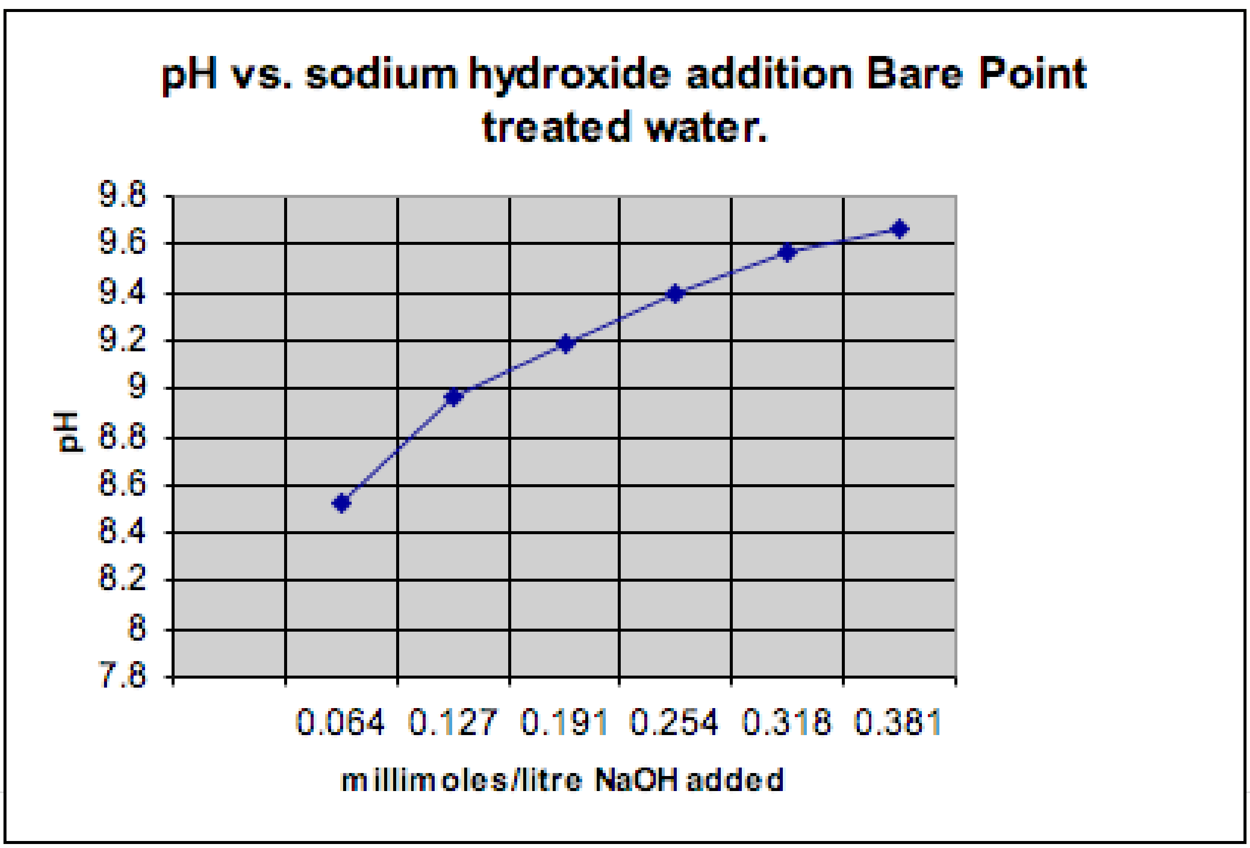
Additional Study – Since the previous study mentioned in this plan involving the MOE, McMaster University – City of Thunder Bay occurred nearly 18 years ago, The City of Thunder Bay will be conducting an additional study. Prior to the addition of sodium hydroxide to the distribution system entirely, residents in the Hodder Zone area of The City of Thunder Bay will be asked to volunteer in a two year sampling study. Residents with confirmed lead service connections in this zone will be identified and asked to have their private plumbing sampled twice per year for two years. The first round of sampling will commence between December 15, 2014 and April 15, 2015 (Winter). The second round of sampling will occur between June 15, 2015 and October 15, 2015 (Summer). Beginning in December 2015, sodium hydroxide will be injected to the Hodder Zone at the Hodder pumping Station. Once the chemical is distributed throughout Hodder Zone, sampling will begin at the same sample locations that were sampled prior to addition. Sampling will commence December 15, 2015 through April 15, 2016 for winter and June 15, 2016 through October 15, 2016 for summer. Parameters listed in Table 7.1 will be tested for all samples taken pre and post chemical addition. These results will be used in addition to the previous study results to determine if the addition of sodium hydroxide poses a risk to the safety of the drinking water. This two year localized study allows the City to assess the impact of raising the pH in the distribution system to a level that may compromise the effectiveness of disinfection. As listed in table 1.2.1 the average pH of raw water entering treatment is 7.80. Raising the pH to a point that effectively reduces corrosion (9.0-9.6) may have an adverse effect on disinfection.

5.1 pH vs. Sodium Hydroxide Results

pH	millimoles NaOH	mg/L NaOH added
8.52	0.06355	2.542
8.97	0.1271	5.084
9.19	0.19065	7.626
9.39	0.2542	10.168
9.57	0.31775	12.71
9.67	0.3813	15.252
9.77	0.44485	17.794
9.87	0.5084	20.336

Table 5.1 (J.Vukmanich Chief Chemist Environment Division-Water Authority May 10, 2010)

5.2 pH vs. Sodium Hydroxide Addition



5.3 Secondary Impacts

As for secondary impacts, the addition of sodium hydroxide will increase the sodium level in Thunder Bay tap water. With reference to the pH vs sodium hydroxide addition curve this increase would be in the range of 4 to 7 mg/L as sodium. The background level of sodium in the finished water after disinfection is about 3 mg/L; therefore the total sodium concentration would not be greater than 10 mg/L. This is well below the health standard of 20 mg/L as stated in the Ontario Drinking Water Objectives (1994).

6.0 PUBLIC NOTIFICATION AND STAKEHOLDER CONSULTATION

Prior to the introduction of sodium hydroxide to any part of the distribution system major stake holders and the public will be notified through a media release.

6.1 Types of media to be contacted

The media release will be mailed major stake holders a minimum of one month prior to the introduction of sodium hydroxide in order for the stakeholders to adjust any process requirements. A copy of the media release will be published in the following areas:

- City of Thunder Bay website
- Thunder Bay Radio Stations
- Thunder Bay Television
- Local Newspapers

7.0 MONITORING CORROSION CONTROL EFFECTIVENESS

Corrosion Control utilizing Sodium Hydroxide for pH adjustment to optimize pH levels in premise piping will require a number of ongoing initiatives. Once results from the study have been analyzed and if the addition of sodium hydroxide to the entire distribution system is the outcome, Table 7.1 outlines the testing and sampling frequency. All testing for the monitoring program will be performed in the Bare Point Water Treatment Plant water test area by certified operators or at ALS Laboratory.

The lead sampling locations will be chosen according to the results as part of the regulatory lead sampling program. A minimum of 10 residential and commercial sites will be chosen based on the worst case results recorded providing the occupants are willing to participate in the program. The residential and commercial sites will be sampled and tested on a monthly basis. Due to confidentiality issues Lead Monitoring Numbers (LM) will be developed for publishing purposes. The Environment Division Water Authority will maintain a data base with corresponding addresses and will be available to the Ministry of Environment upon request.

7.1 Recommended Parameters and Locations for Post Chemical Implementation Monitoring

Parameters	Point of Entry	Distribution Residential and Non- System Residential Taps	Distribution System Dead Ends and Areas of Concern	Parameters
Lead	x	x	x	x
Alkalinity	x	x	x	x
PH*	x	x	x	x
Chlorine Residual*	x	x	x	x
Temperature*	x	x	x	x
Iron		x		x
Sodium		x		x
Turbidity		x		x
Colour		x		x
Microbiological Parameters (coliform,HPC)	x	x		x
* Collected as part of the existing monitoring program				

8.0 CORROSION CONTROL PLAN IMPLEMENTATION

The Corrosion Control project was implemented beginning in 2010. Table 8.1 below shows a Gantt diagram illustrating the major segments of the implementation program and the target dates for completion.

- The development of a public awareness campaign in conjunction with the Thunder Bay District Health Unit.
- The development of an enhanced infrastructure renewal program.
- Two year localized phased study approach involving the Hodder Zone area with injection at the Hodder Pumping Station
- The pH control implementation plan allows for the chemical addition of sodium hydroxide to adjust the pH. If need be, the sodium hydroxide will be added to points in the process stream at the Bare Point Water Treatment Plant (clearwell mixer or the clearwell exit and the distribution header). The commissioning (slow and periodic addition) and the startup phases (continuous addition, controlled pH) of the project will optimize the addition and control for unknown changes in the distribution system

8.1 Corrosion Control Plan Implementation

ID	Task Name	Start	Finish
1	Chemical Addition Design	18/01/2010	28/01/2010
2	Chemical Addition redesign	29/01/2010	11/02/2010
3	Mechanical construction	12/02/2010	25/03/2010
4	Instumentation design	25/01/2010	11/02/2010
5	Instrumentation Equipment Purchasing	12/02/2010	19/03/2010
6	Instrumentation construction	22/03/2010	18/05/2010
7	Community Lead Samplng	06/09/2010	ongoing
8	Lead Reduciton Zone Specialization Flushing Trials	15/06/2011	14/10/2011
9	By-Law Research and Development	01/09/2011	30/11/2011
10	Budget Preparation	01/11/2011	28/02/2012
11	Watermain Flushing	01/06/2011	28/10/2011
12	At the Tap Usage Lead Reduciton Strategies Dev't	01/07/2011	ongoing
13	Service lines/connections Replacement	01/04/2011	ongoing
14	Implementation of At the Tap Strategies	01/07/2011	ongoing
15	Water Quality Maintenance	30/04/2012	31/10/2012
16	Public Education Campaign	29/04/2013	ongoing
17	Evaluating the Success of the public Education and Lead Service Replacement	ongoing	ongoing
18	Addition of 3rd flushed private plumbing sample to Oreg 170 s 15.1 protocol	15/06/2014	15/10/2014
19	Localized phased study for Hodder Zone w/o addition sodium hydroxide	15/12/2014	15/10/2015
20	Localized phased study for Hodder Zone w addition sodium hydroxide	15/12/2015	15/10/2016
21	Documented Annual Review of CCP	15/12/2014	annually