City of Kalamazoo Public Water Supply System

Lead and Copper Program

Report

Prepared by the Department of Public Services

December 2016

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City of Kalamazoo Public Water Supply System Lead and Copper Program – Report

Executive Summary

A detailed report has been prepared to educate policy and decision makers, customers and the public at large on matters relating to regulatory compliance, level of service and the future direction of the lead and copper program. Data and information contained herein demonstrates that the City of Kalamazoo Public Water Supply System is compliant and adherent to all federal and state drinking water regulations with respect to the Safe Drinking Water Act – Lead and Copper Rule (SWDA-LCR).

There are presently 2,917 known lead service lines (November 16, 2016) which serve to connect customers to the water main. These service lines are owned and maintained by the City of Kalamazoo from the connection at the water main to the location of the customer water meter. In addition to the known lead service lines there are 7,308 undefined service lines (November 16, 2016). These undefined service lines could be lead, galvanized, cast iron, or copper. Efforts taken and planned to define the material of the undefined service lines are discussed within the report.

The City of Kalamazoo Public Water Supply System feeds sodium hexa-metaphosphate into the system at source water stations for the purpose of iron sequestration. The sodium hexa-metaphosphate breaks down into ortho-phosphate within the distribution system and provides the secondary benefit of corrosion control. The City of Kalamazoo contracted with Tetra-Tech to perform a desktop corrosion control chemical analysis. Tetra-Tech's draft report and recommendations to the City of Kalamazoo are contained within this report as an attachment. Tetra-Tech will be issuing a final report following a complete second set of sampling data which was transmitted in November. The initial data set and corresponding assumptions indicates that improvements could be made in regards to both iron sequestration and corrosion control within a few of the pressure districts. Further testing and analysis may include bench, coupon and pilot scale as well as dynamic modeling to confirm assumptions before any changes are made to the current chemical feed systems.

During 2016 the level of service related to the lead and copper program was increased. Efforts related to public education and outreach were enhanced to include the creation of a lead and copper hotline; where customers can call to schedule free water testing, receive point of use filters and be connected to educational information concerning lead in drinking water. An educational video was also created to help educate the public on concerns with lead in drinking water. Additionally, the Department of Public Services ramped up lead service line replacements in

coordination with street construction and in response to acute results above the action level in accordance with our Departmental policy (figure 6).

As we plan towards the future there are many alternatives and pathways that may be chosen to determine lead service line replacement strategies. In the near term budgets have been increased (proposed) to increase the annual replacement capacity. Under the current SDWA-LCR the City of Kalamazoo Public Water Supply System is not required to replace the lead service lines. However, any changes to federal and/or state law may influence replacement requirements. Additionally, best management practices and the implementation of asset management practices would compel replacement in coordination with any street or utility project.

Respectfully,

James J. Baker

James J. Baker, PE
Public Services Director & City Engineer

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PUBLIC WATER SUPPLY SYSTEM

LEAD AND COPPER PROGRAM

DECEMBER 2016

INTRODUCTION

Background

Lead and Copper Program Project Team

In Spring 2016, a Lead and Copper Program Project Team was formed to represent all entities involved with meeting the regulatory compliance of the mandated U.S. Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA) Lead and Copper Rule (LCR), and to address the public concern associated with lead in drinking water after the highly publicized Flint Water crisis.

The project team members are listed in Attachment A and represent the Public Services Director's Office, Public Services Water Resources Division, Public Services Wastewater Division (Laboratory), and Information Technology (IT). Several other staff significantly contributed to the Lead and Copper Project by assisting with production of an educational video, records research, mapping, and providing information regarding property and historic records, notably the City Manager's Office, City Clerk's Office, IT, and the Management Services Department (Treasury Division).

Scope and Primary Purpose of Report

In July 2016, a meeting was held between representatives of the City Manager's Office and the new Lead and Copper Project Team to discuss the City's Lead and Copper Program (LCP). This summary report is primarily intended to respond to the request by the City Manager's Office to provide additional information regarding the specifics of the City's LCP, about the issue of lead in drinking water in general, and to enhance public outreach efforts regarding the issue. Since lead is the primary concern and issue associated with the City's LCP, this report will focus on lead specifically and only discuss copper when relevant to compliance or other issues of concern.

This report is not intended to be a technical or an exhaustive report on the subject matter but is rather designed to provide an overview of the pertinent elements of the lead issue as it pertains to its presence in drinking water. In selected circumstances, references will be provided to direct the

reader to a more detailed review of the subject manner as appropriate. For example, there are numerous sources (e.g. Kalamazoo County Health or otherwise cited) to obtain additional and detailed information about the health effects of elevated lead exposure that are beyond the scope of this report. Attachment B contains selected general educational information regarding the issue of lead in drinking water.

Natural Sources and Common Uses of Lead

Lead is a naturally occurring element found in the Earth's crust. It is usually found in combination with two or more other elements to form lead compounds and is rarely found as a metal. Most lead used by industry comes from mined ores or from recycled scrap metal or batteries. In the U.S., lead is mined primarily in Alaska and Missouri.

Historically, use of lead was popular since it is resistant to corrosion, easily molded and shaped and combines with other metals to form alloys. Because of these properties, lead and lead alloys are commonly found in pipes, storage batteries, weights, shot and ammunition, cable covers, and sheets used to shield us from radiation. Lead compounds are also used as a pigment in paints, dyes, ceramic glazes, and in caulk. Although paint containing more than 0.05% lead (by weight of dried product) was banned for residential use in the United States in 1978 by the U.S. Consumer Product Safety Commission, lead painted walls (i.e. chips/dust from them) remain a significant source of lead exposure for children. Lead was also used as an additive in gasoline to increase octane ratings until eventually phased out in the 1980s and banned for use in gasoline for motor vehicles in 1996. In the U.S., lead water main pipes were used in water systems mostly in the late 1800s to the 1940s but still exist today, much of which are located in the Northeast and the Midwest.

Health Effects and Exposure to Elevated Lead and Copper Levels

Lead is known to be harmful to human health if inhaled or ingested. The degree of harm depends upon the level of exposure. Pathways of lead exposure include the air, soil, dust, food, and water. Elevated lead exposure can cause damage to the brain, red blood cells, and kidneys, especially for young children and pregnant women. Children's smaller body volumes make them more susceptible and these effects are concentrated in brain cells. Elevated copper levels can cause stomach and intestinal distress, liver or kidney damage, and complications of Wilson's disease in genetically predisposed people. Information discussing environmental sources and exposures to lead can be found in many sources, including "Public Health Statement for Lead" by the Agency for Toxic Substances & Disease Registry (ATSDR), 2007, CAS# 74399-92-1, and on the Kalamazoo County website in the Health and Community Services Department section.

Source of Lead and Copper in Drinking Water

In general, very little lead is found in lakes, rivers, or groundwater used to supply the public with drinking water. More than 99% of all publically supplied drinking water contains less than 0.005 parts per million (ppm) or 5 parts per billion (ppb) of lead.

There is no detectable lead in the Kalamazoo Public Water Supply System (PWSS) when it leaves our Water Pumping Stations (WPSs). However, since water is naturally *corrosive,* small amounts

of lead can dissolve into your drinking water if your water sits for several hours in plumbing fixtures or service lines that contain lead. Lead levels in drinking water are likely to be highest:

- In homes with lead service lines connecting the water main to the house;
- In homes with lead indoor plumbing (more common in 1930s and 1940s). However, lead levels decrease as a building ages since over time, because mineral deposits form a coating that insulates the water from the solder;
- In homes that have copper plumbing with lead solder (typically before homes built before 1988);
- In homes that have brass fixtures that can contain up to eight percent lead.

Faucets and fixtures made with brass or chrome-plated brass with lead solder used in homes and businesses contained significant amounts of lead until approximately 1986 when the Amendments to the Safe Drinking Water Act (SDWA) significantly reduced the maximum allowable lead content in pipes, pipe fittings, plumbing fittings, and fixtures. Consequently, homes built before 1986 are more likely to have lead pipes, fixtures, and solder. On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total lead exposure in young children.

In summary, lead exposure from drinking water is caused by lead containing materials used in pipes, fixtures. The corrosive properties of water are the primary factor in determining whether lead and/or copper are likely to leach out of those metal pipes and/or solder and into the water. The general issue of corrosion control and its specific impact on the Kalamazoo Public Water Supply System is discussed in a later section.

History of the Kalamazoo Water System Piping

The City of Kalamazoo (City) water system formally began in 1869 by authorization of the "Committee of Fire and Water" and three Kalamazoo village trustees. It was decided then that groundwater was preferred over surface water for drinking water because of its relative purity. Prior to 1866, water pipes used in Kalamazoo were made of hollowed-out wood (see insert below). Subsequently, cast iron main eventually replaced the wooden ones and were used until 1962 when the City specified the use of ductile iron main pipes because of its greater flexibility which resulted in higher production installation rates and decreased breakage. Ductile pipe is still used and is the preferred choice today. In the U.S., the material types of main buried in the ground from largest percentage to lowest percentage are cast iron, ductile iron, concrete and lined concrete, PVC, and steel. The document "The Kalamazoo Water System A Centennial Survey 1881-1981" (Ruth G. Allen, 1981) provides a thorough and interesting source of historic information about Kalamazoo's water system.

Abandoned wooden water main – hollowed out logs circa 1851. Retrieved from the intersection of E. Michigan and Pitcher Street, downtown Kalamazoo, 2001.

There is significantly more written documentation regarding water *main* pipe (water system distribution pipe) type than there is regarding water *service* pipe type (from the main to the home). Consequently, there is greater certainty of material types for water main pipe than for the type of pipe used as water service pipe. This fact is not unique to Kalamazoo, but rather common nationwide according to studies conducted by the American Water Works Association. For example, according to Jane McDonagh, Public Services Records Supervisor (2016), Kalamazoo has records dating back to the 1860s for water main.

Historically, recorded information about other water asset information focused primarily on water meters and services since the reading of meters produced revenue, the "cash registers" of the utility. It is documented that in 1884, the City Commissioners authorized an ordinance to allow for the attachment of meters to water pipes of "large consumers" such as manufactures, distillers, and hotels. This was driven by the fact that a significant quantity of water was being wasted. House-to-house inspections and residential meter installations were also performed to address the continued problem of increased pumpage but lower revenue. In 1926, a new policy was implemented that all meters would remain on the property of the city. In the mid-1970's, a meter improvement program was implemented to replace inaccurate meters, install remote meters, and measure the water use in cubic meters. Unfortunately, information regarding service lines – such as material type, diameter, and installation dates - was not routinely documented and thousands are categorized as "undefined" today.

However, we do know from historic research that in Kalamazoo lead service pipes were most likely used from approximately 1900 to 1950. Furthermore, the time periods when lead was used the most was 1900 – 1914 and 1918 – 1930, excluding the World War I period when lead was used primarily for bullets and galvanized pipe was used (James Baker, P.E., Public Services Department Director, 2016). Reportedly, approximately 67% of the population growth occurred between 1900 and 1910. Lead was used primarily due to its durability, flexibility and cost-effectiveness. Nationally since World War II, copper has been the most common material for consumer plumbing because its ease of installation, lower cost, and corrosion resistance. Kalamazoo's records support the fact that in the 1950s and early 1960s, lead and galvanized metal pipe was replaced by copper that has since been the primary material used for water services. Historically, the selection of water service material type seems to have been largely dictated by cost, availability, and convenience.

KALAMAZOO'S WATER UTILITY ASSETS

History

In the early days of the water system, records of water related assets were recorded in various methods and not in a systematic system. Written records were made and kept in several ways and for different reasons. There was no "asset management system," or Safe Drinking Water Act – let alone a Lead and Copper Rule. Records were primarily kept for material and costing records, engineering and /project management. It was not until meters were used and revenue was collected for water use that a more systematic and thorough water related record system began to be used (see previous discussion).

The first electronic system that the City used that stored water utility billing information was in the 1980s and had various iterations and titles, including "Water Information System," "Water Information Network," "Utility Billing System, " and "Integrated Financial Information System" (IFIS). In the late 1980s, "NCC" was launched and was the primary database that stored water billing information. Hansen utility software was used for a brief period of time in the 1990s for hydrants but was primarily used for sanitary sewer assets. As noted earlier, information regarding meters was the primary focus in all of these systems due to revenue collection/billing information. BS&A is the current software system used for water meters and billing information.

Lucity Software Database

It wasn't until approximately 2005 that the Department of Public Services began using the specific utility asset management system "Lucity" – primarily for work order generation for maintenance of service lines. Lucity is the current software database used for utility assets and its database and use has been significantly expanded the last couple of years. For example, all water assets including hydrants, gate valves, water main, and services are entered into Lucity and are continually being updated. Lucity is the source of information for the water service asset information discussed below and presented herein.

The Department of Public Services holds approximately 26,000 water service cards dating back to 1958 that were filled out during the installation of a water service. These cards have been matched up to the "undefined" services to correlate any data that would assist in identifying the undefined services to a specific material type. The services were then updated in our Lucity Software System. Currently, these service cards hold valuable information such as the tap and installation dates, and city or township that specific addresses are located. The data on these service cards, together with additional data such as pressure district and map number, will need to be entered into the Lucity system. The maps drawn on the back of these cards are also useful and will be scanned and attached in Lucity, securing all of our service records to date.

Lead Services - Spatial Distribution and Areal Differentiation

Figure 1 illustrates that there are 2,917 *known* lead services or approximately 6.3 % of the 46,401 total water services. In addition, there are 7,308 services or approximately 15.7 % that have

undefined material types (no information identifying material type and sometimes date of installation). Thus, approximately 78% of the total water services are known to *not* contain lead.

Figure 2 shows the distribution of known lead services by neighborhood, including Kalamazoo Township "East," and Kalamazoo Township "West." Figure 3 is a "heat map" illustrating the density of known lead services. As can be seen by both Figure 2 and Figure 3, the highest density of known lead services are in Kalamazoo Township East and in Edison with 25.34% and 20.44% of the total, respectively. The next highest by neighborhood are Northside (11.7%), Kalamazoo Township West (9.71%), and CBD and Vine (9.18%). The remaining neighborhoods range from 0.54% to 4.17% of the total known lead services.

Figure 4 is a heat density map of the undefined water service material type locations. Again, one can draw some preliminary indications of the likelihood if a currently undefined service is likely to be lead or not by comparing the densities of known lead service areas (Figure 3) with those of undefined service types. Staff continues to decrease the number of undefined services by making these types of comparisons, continuing laborious research, database QA/QC, data categorization, and database queries that target areas to perform field verifications and water quality monitoring.

The uncertainty of when specifically the City discontinued the use of lead services and galvanized pipe and began using copper prevents us from using just the date of installation to accurately determine what material was used at that time. We are confident that the date range of lead use was between the late 1800s to 1950. An example of using the database inputs to help determine whether lead services exist is the Burke Acres neighborhood. Since the water mains were installed in 1951-1955 and Lucity lists all services to be copper, a fair conclusion could be made that lead was not being installed in the 1950s. Furthermore, water main was installed in 1936 on Paterson Street and the Lucity database indicates that many services were lead or undefined. Subsequently, one could assume that a higher percentage of the undefined services on Paterson Street are lead. However, some of these services have been renewed (replaced) with copper even prior to the Lead and Copper Rule (LCR) that was initiated in 1992. For these reasons, visual inspection is necessary to document the current material type of those services categorized as undefined. Further research will need to be performed to identify the undefined services. Such steps include researching dates of water main installation, construction periods of neighborhoods, vacated streets, and empty lots (home and businesses that have been demolished). This process should result in a continual decrease in undefined services and an increase in known lead services. Progress of this research and field verifications will be provided in subsequent status reports.

REGULATORY COMPLIANCE

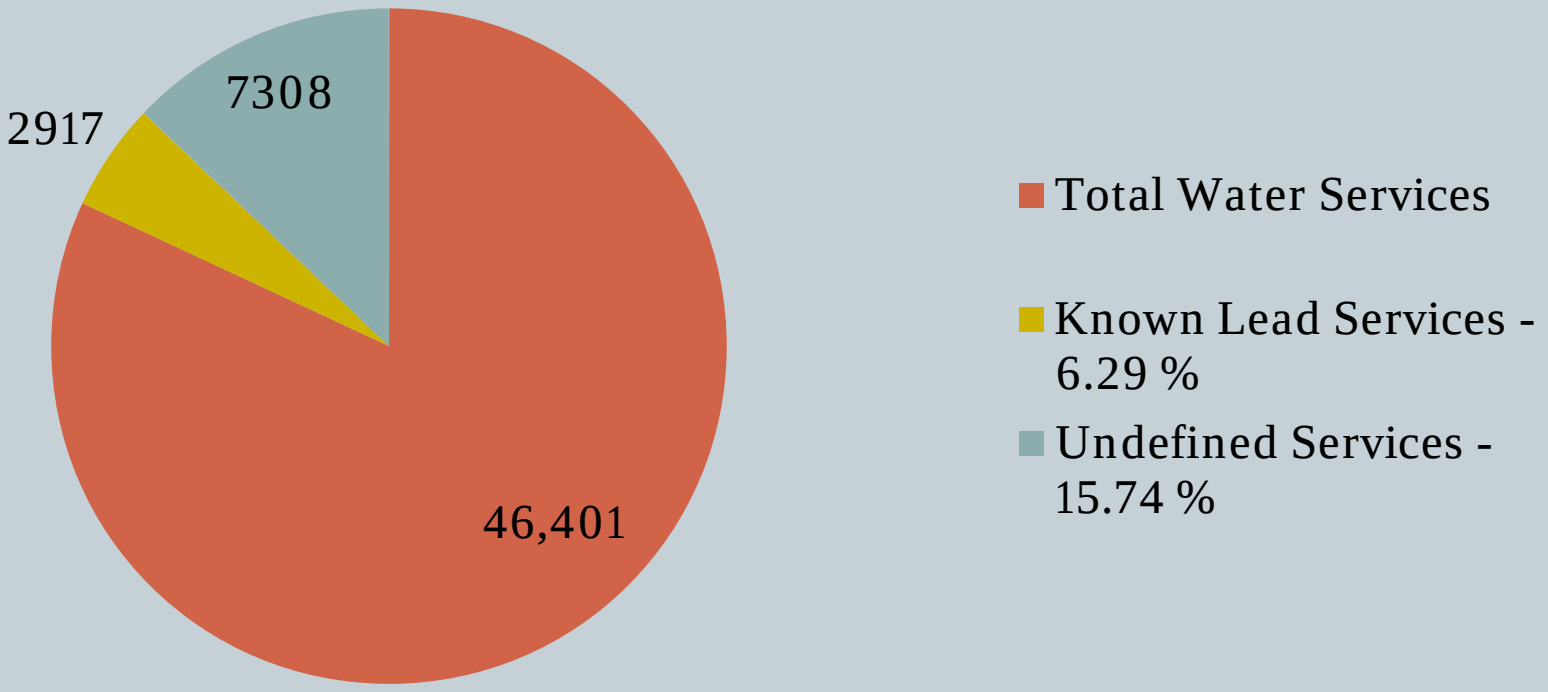
Safe Drinking Water Act

The federal Safe Drinking Water Act (SDWA) was enacted in 1974 and governs regulation of drinking water in the United States. The SDWA authorizes the U.S. Environmental Protection Agency (EPA) to establish standards to protect tap water and requires all owners or operators of public water systems to comply with primary health-related standards. SDWA has been amended

City of Kalamazoo Public Water Supply System

Figure 1

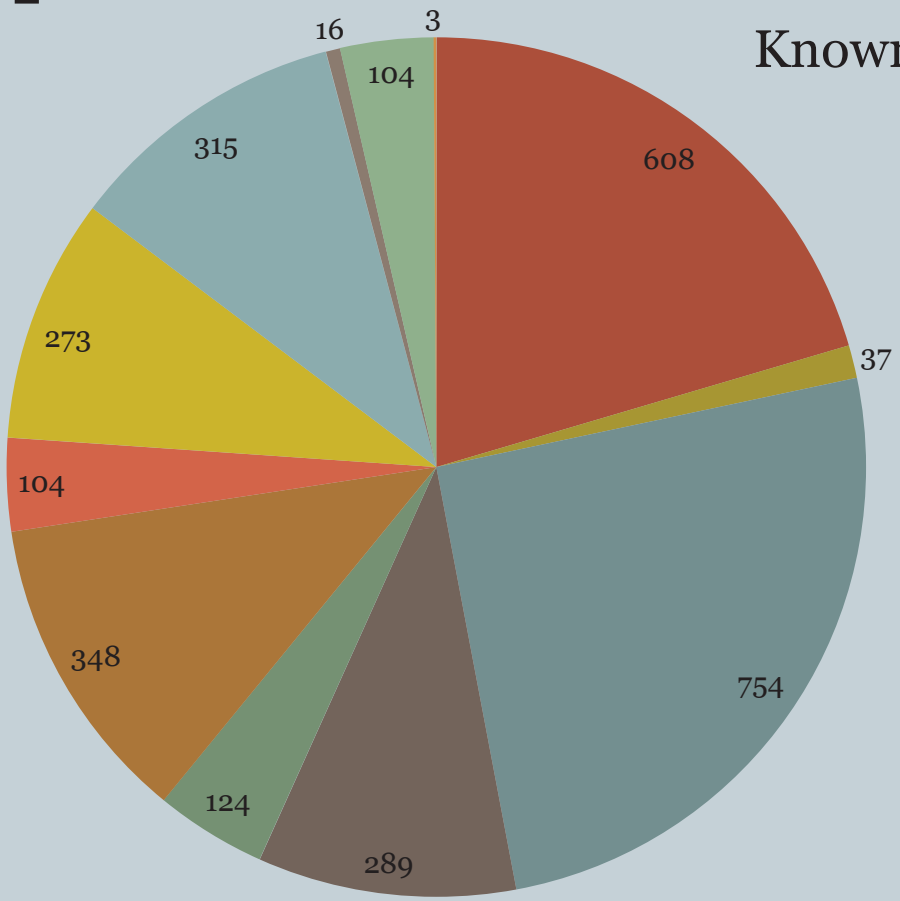
Total Water Services



Data provided as of November 16, 2016

City of Kalamazoo Public Water Supply System

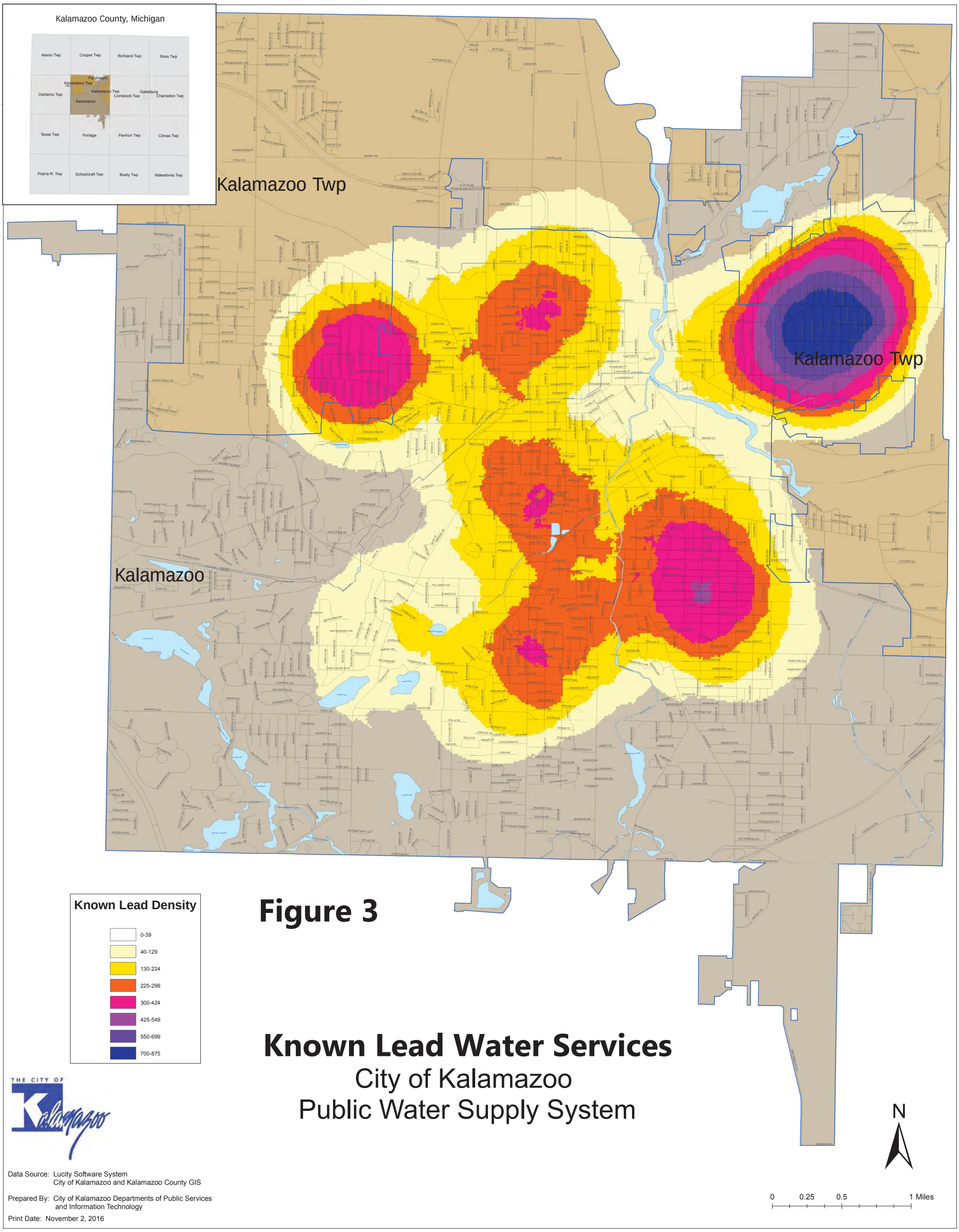
Figure 2



Known lead - defined by neighborhoods

- EDISON - 20.44 %
- MILWOOD - 1.24%
- KAL TWP EAST - 25.34%
- KAL TWP WEST - 9.71%
- EAST SIDE & BURKE ACRES - 4.17%
- NORTHSIDE - 11.70%
- FAIRMONT,STUART,W MAIN HILL - 3.50%
- CBD & VINE - 9.18%
- S SIDE & WSTNDGE HILL & S WSTNDGE - 1.59%
- COLONY, OAKWOOD, HIL-N-BROOK, PVH - 0.54%
- OAKLAND & WINCHELL - 3.50%
- KNOLLWOOD, ARCADIA, WESTWOOD - 1.10%

Data provided as of November 16, 2016



Data Source: Lucity Software System
City of Kalamazoo and Kalamazoo County GIS

Prepared By: City of Kalamazoo Departments of Public Services and Information Technology

Print Date: November 2, 2016

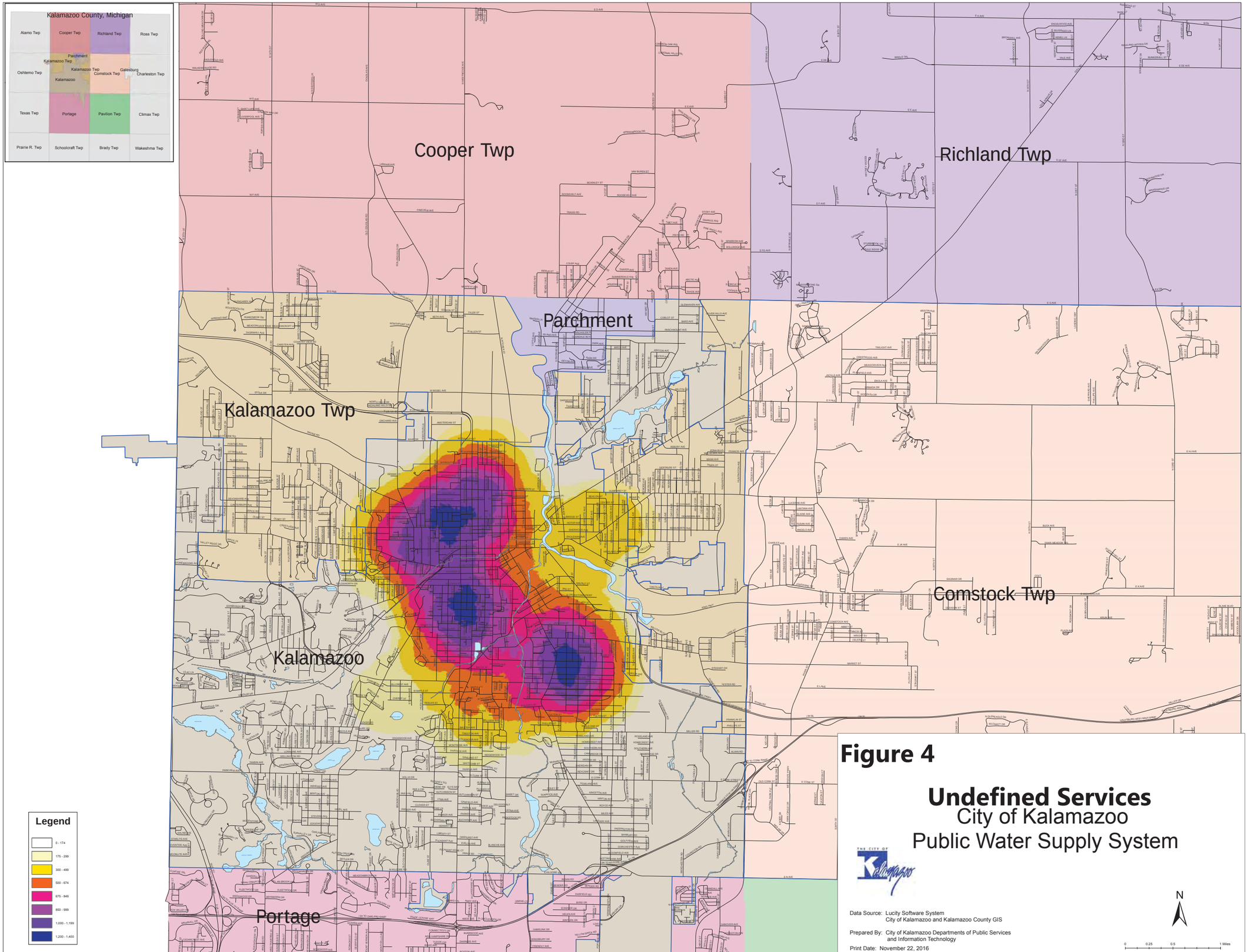


Figure 4

Undefined Services

City of Kalamazoo
Public Water Supply System

Data Source: Lucity Software System
City of Kalamazoo and Kalamazoo County GIS

Prepared By: City of Kalamazoo Departments of Public Services and Information Technology

Print Date: November 22, 2016

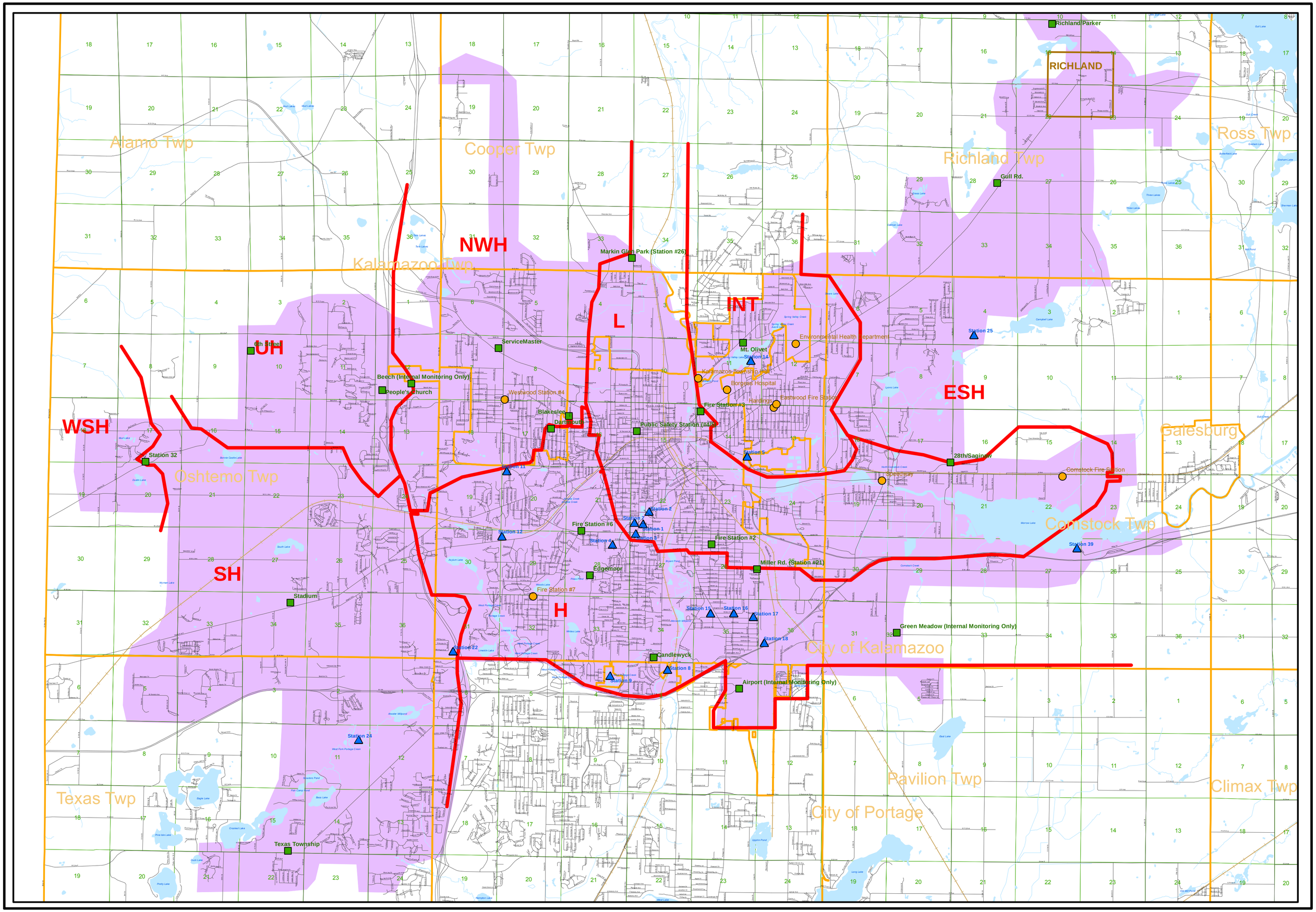


Figure 5
Water Distribution System Sampling Locations

Legend
- Distribution System - Corrosion Control
- Distribution System - Bacteriological and/or Corrosion Control
- Water Pumping Station - Bacteriological and Corrosion Control
- Pressure District Boundary
- Water Distribution System Boundary

NORTH

0 1250 2500 5000 7500 10000 Feet

November 2016

THE CITY OF Kalamazoo
Department of Public Services
Environmental Services Division

multiple times since its enactment, most recently in 2015. Michigan enacted the state SDWA (PA 399) in 1976 that establishes state authority for regulating drinking water supplies in Michigan. It also provides the statutory basis for the EPA's delegation to the Michigan Department of Environmental Quality (MDEQ) to implement the federal SDWA.

The SDWA sets upper limits or maximum contaminant levels (MCLs) for most substances it regulates in a utility's drinking water system. These MCLs are set at levels designed to protect the health of customers. For most contaminants, testing takes place at the PWSS Water Pumping Stations (WPSs) and/or in numerous carefully selected locations across its distribution system (See Figure 5).

Lead and Copper Rule

In 1991, revisions included the "Lead and Copper Rule" (LCR) with the purpose of protecting public health by minimizing lead (Pb) and copper (Cu) levels in drinking water. The goal of the LCR is to provide maximum human health protection by reducing lead and copper levels at consumers' taps to as close to the Maximum Contaminant Level Goals (MCLG) as is feasible. The MCLG for lead in water is 0 mg/l (ppm). To accomplish this goal, the LCR establishes requirements for community water systems and non-transient non-community water systems to conduct periodic monitoring at customer taps for lead and copper (Lead and Copper Monitoring Program), and conduct water quality parameter monitoring within its distribution system for indications of water corrosion potential and associated appropriate corrosion control, if warranted.

Lead is different from most contaminants monitored because it's not commonly found in a water utility's source water or its distribution system. Instead, lead usually dissolves into drinking water after the water has entered the customer's property. EPA has set an action level (AL) of 0.015 milligrams/Liter (mg/L) or 15 parts per billion (ppb) for lead and 1.3 mg/L (1300 ppb) for copper, based on 90th percentile level of tap water samples. See Attachment C for a discussion on how the 90th percentile is calculated. The ALs are designed to measure a utility's effectiveness in controlling the *corrosiveness* of drinking water so that these metals don't easily dissolve into it. Corrosion control is discussed specifically in the following section. Large water systems, defined as those serving over 50,000 people, were required to have optimal corrosion control treatment by 1997 if needed. Currently, EPA is in the process of reviewing and revising the LCR through its established rulemaking procedures.

Triggers for Additional Requirements

If results of the Lead and Copper Monitoring Program sampling determine that the 90th percentile is at or above the Action Level of 15 ppb for lead or 1300 ppb for copper, it is not considered a violation of the LCP; however, it can trigger other/additional requirements. These extra requirements may include: additional water quality parameters monitoring and frequency; source water monitoring and source water treatment; corrosion control treatment; public education; and lead service line replacement. See Attachment D for the "EPA Lead and Copper Rule: A Quick Reference Guide." For example, the District of Columbia Water and Sewer Authority historically have had more than 10 percent of the homes sampled have lead levels in water above the EPA

action levels. Consequently, they have been required to implement a public education program, make changes to their water treatment process to improve the corrosion control, collect an additional number of samples, and replace seven (7) percent of the lead water service lines in the DC each year for as long as the lead in water problem persists.

Requirements for Kalamazoo PWSS

Since the Kalamazoo PWSS serves over 100,000 people, it is considered a large water system that would be required to collect 100 lead and copper samples (50 each) on an annual basis. However, it is placed on a reduced triennial monitoring program of 50 samples (25 each) because the 90th percentile has not exceeded the ALs of lead or copper for two consecutive 6-month monitoring period sampling events; it never has to date. Additionally, in 2016, our PWSS was required by MDEQ to increase the number of water quality sampling locations, number of water quality parameters, and total number of water quality samples within the distribution system (MDEQ correspondence provided in Attachment E).

Due to the City not having exceeded the ALs in any of its previous eight sampling events, the City is *not* required to: implement a public education program regarding lead health effects, sources, and steps to minimize its exposure; implement a corrosion control treatment; or conduct a lead water service replacement program. However, the City does voluntarily implement public education efforts (discussed in a later section), continue to add sodium hexa-metaphosphate as a sequestering agent for iron with a secondary benefit of corrosion control, and replaces lead services in a methodical and consistent basis.

Corrosion Control

The primary strategy of the LCR is to reduce the corrosivity of water since lead and copper enter the water supply mainly from corrosion of lead and copper contained in plumbing materials. Most utilities have no or low levels of lead and copper in the water distribution system. However, water that is itself corrosive can cause the leaching of metals from the pipes into the water. As discussed previously, negative health effects can result from internal corrosion of lead, copper alloys and solder, and copper plumbing.

In June 2016, the City received a letter from MDEQ requiring additional water quality monitoring for further corrosion control evaluation, including: Starting on July 1, 2016, pH, alkalinity, orthophosphate dosage rate and orthophosphate residual, measurements of chloride and sulfate, and daily orthophosphate residual readings at each water pumping station in operation during the two-week monitoring period; and orthophosphate residual readings at bacteria sampling locations in the distribution system. Also, starting August, 2016, sampling of pH, alkalinity, and orthophosphate residual at 25 sites within the distribution system at least two times during a six month period was required. The first set of was collected on August 16, 2016. All data collected in a month can be submitted with that month's routine Monthly Operations Report. A copy of this letter is provided in Attachment E. Figure 5 shows sampling locations within the water distribution system, including the required corrosion control parameters.

The City has retained Tetra Tech to perform a desktop analysis and review the current corrosion control program to evaluate whether there would be a cost benefit to implement modifications for

its enhancement. A draft report has been provided to the City by Tetra Tech and revisions are currently being made based on City review and the availability of additional water quality data. This on-going Tetra Tech report is titled “Desktop Corrosion Control Analysis.”

As reported in the draft report, corrosion of lead and release of soluble lead compounds into solution is thought to originate when the metal is oxidized, usually in the presence of dissolved oxygen and chlorine to the +2 state. According to Tetra Tech, the degree of oxidation and release of soluble lead is dependent upon the pH, the concentration of oxidants and the complexation of the Pb^{+2}ion with various anions and ligands in the water. The geochemistry of groundwater and how it affects the ability of metals is complex.

Kalamazoo’s groundwater source in general has elevated levels of iron, manganese, and hardness (CaCo3). Although these levels typically exceed the secondary maximum contaminant levels (SMCLs), they pose largely aesthetic issues in nature and are not health related action levels. Kalamazoo has been adding sodium hexametaphosphate to its water supply since 1956 to serve as a sequestering agent primarily for iron, and secondarily for manganese and calcium. It helps prevent possible color, particulate, taste, and staining issues in the water distribution system. Eventually, the sodium hexametaphosphate degrades into an orthophosphate compound, providing some benefit of corrosion control. The water quality data collected to date provides confirmation that a suitable range of orthophosphate exists in the water distribution system for corrosion control purposes. However, additional evaluation and analysis will determine whether pH adjustment, changes in sodium hexametaphosphate application rates, or use of an orthophosphate blend would be beneficial.

There are various methods for measuring the corrosion potential of water, such as the Langelier Saturation Index, Calcium Carbonate Precipitation Potential, and the Larson-Skold Index. It is not within the scope of this report to discuss these in detail. However, it is important to mention that a higher potential for scaling may warrant the further addition of a sequestrant such as a polyphosphate, reducing the pH, or softening to prevent scaling. However as Treta Tech points out, slight precipitation of calcium carbonate can serve as a protective scale in water distribution pipes and has been associated with reduced corrosion complaints.

The corrosivity of water can be reduced by improving/modifying certain water quality characteristics. According to Tetra Tech, the water quality factors that have the greatest effect on lead and copper corrosion are pH, dissolved inorganic carbonate (DIC), orthophosphate concentration, alkalinity, buffer intensity, and dissolved oxygen. In addition, chlorine residual are also important considerations for copper corrosion since the City adds chlorine at each of its water pumping stations as a disinfectant. A common strategy to optimize corrosion control is to add orthophosphate directly to the water distribution system. “When orthophosphate is added to the water sparingly, soluble lead hydroxyphospahte compounds can form to limit the solubility of lead in equilibrium with the passivation film” (Tetra Tech, 2016).

The City’s PWSS is complex since it is hydraulically sectioned into eight different pressure service districts with water being connected between them by a series of booster pumping stations and pressure reducing (bleeder) stations. Consequently, it is a challenge to analyze a water system that is always dynamic and results in multiple combinations of mixing zones depending on what

stations are operating. The city will evaluate any recommendations made by Tetra Tech in their final report and weigh the cost-benefit of modifying its current practices and altering its chemistry of the water in its distribution system to improve its corrosion control program. The final report will also consider their review and analysis of all of the additional water quality monitoring that was collected subsequent to the first draft, contained in Attachment F. Figure 5 shows all of the sampling locations associated with the water quality monitoring program, and illustrates the boundaries of the pressure service districts.

2016 Source Water Monitoring Program

As mentioned previously, the City is currently on a water system-wide tap monitoring program for lead and copper once during a three-year compliance period (tri-annually). It requires a minimum of 25 lead samples and 25 copper samples from Tier 1 sites – single family residence with lead service lines; copper plumbing with lead solder installed after 1982 and before 1989; or interior lead plumbing. At least 50 percent of the sampling sites must have lead service. The City decided to perform the three-year monitoring in 2016, one year early from the required set due in 2017. In May 2016, the City received a letter from MDEQ (contained in Attachment E) that provided revised sampling instructions for water quality monitoring.

Note that these requirements to sample for lead and copper at the tap are separate than those required within the distribution system for the corrosion potential and control. Water quality monitoring includes sample parameters for water quality samples as follows:

Water pumping stations (Bi-Monthly) - pH, hardness, iron, sodium hexa-metaphosphate, orthophosphate (also daily - new for 2016), and alkalinity, chloride, sulfate (new for 2016);

Water Distribution System – 25 sites quarterly for pH, alkalinity, and orthophosphate, coordinated with required disinfection by-product sampling, added nine new sampling locations.

Sampling Data Sets for 90th Percentile for Lead and Copper in Tap Water

The City has collected nine formal sample data sets for and since the implementation of the LCR: 1992/93, 1996, 1999, 2002, 2005, 2008, 2011, 2014, and 2016. As mentioned earlier, the City was placed on a standard 3-year monitoring schedule for lead and copper. For all data sets up until 2016, sampling kits were delivered to higher risk homes that included directions on how to take the sample. In 2016, all samples were collected by a water licensed City Supervisor and tested by a state-certified laboratory.

2016 Lead and Copper Sampling Protocol

EPA requires that samples for lead be taken from inside the homes at either the kitchen or bathroom taps. A minimum of 25 samples for lead and 25 samples for copper for the 90th percentile, and numerous more in response to customer requests, were collected from customer residences under a certain set of conditions, including:

- These tests must be taken in homes likely to have the highest concentration of lead. That includes houses with lead service lines and houses with copper plumbing built just before lead-based solder was outlawed in the late 1980s.

- In the case for copper sampling, all internal copper plumbing installed after 1982 and before 1989 was verified by the homeowner by solicited mailed letters that included a written survey form and an optional Survey Monkey internet questionnaire.
- All samples were coordinated by laboratory staff and scheduled by the Public Services Accounts coordinator/Secretary.
- Verification that the water was not used and sat in the pipes for a minimum of six hours.
- The faucet was not connected to a home treatment device (e.g. filter, softener).
- The samples were collected from a cold water kitchen or bathroom tap.
- Samples were collected in 1 Liter bottles, acidified with metals grade nitric acid and delivered to a certified lab for analysis the same or next day.
- A report of the sample results were sent to the homeowner within 30 days of receiving the results.
- A lead and copper sampling record and service material verification was performed by certified staff.
- A laboratory chain-of-custody was used to track the sample analysis process.
- City sent letters with lab result and additional lead information to each home owner.

As required, the City solicited sampling participation from all of the previous homeowners that participated in the lead and copper sampling triennial program. The City also solicited additional residents to participate in the program. These extra locations were selected by knowledge of lead service lines from service cards/trouble reports, and institutional knowledge by comparison of dates of service hook-ups with materials used during that time period. Door hangers were used in the selected areas to request participation. On-site inspections were provided for those responding to the door hanger requests to confirm that their services did meet the sampling program criteria. See Attachment H for examples of customer correspondence.

In addition, the city continued to offer free samples to residents that requested that their water be sampled due to lead concerns. Figure 6 illustrates the communication, decision-making, and documentation process used when sampling is conducted for lead and copper. All samples were collected, analyzed, and a report provided at no charge to the customer. The information was then compared/verified and entered in our Lucity database system.

2016 Lead and Copper Program Sampling

In 2016, a total of 563 locations were sampled, with two samples collected at each location. The first sample or first draw was collected after the six-hour minimum stagnant period. The second sample, or second draw, was collected after the faucet has been momentarily run so that a comparison can be made of the stagnant and “fresh” water. The City voluntarily collected the lead and copper monitoring data set one year early of the requirement due to the public concern expressed over the Flint water system lead problem. To minimize questions of sample quality, we had a water-certified City employee collect every sample at the residences to better ensure that sample integrity protocol was followed. Our personnel collected samples from 148 locations for the water monitoring program alone. Of these 148 locations, 76 lead samples and 72 copper samples were collected.

The action level of 0.015 mg/L (15 ppb) and 1.3 mg/L (1300 ppb) for copper is based on the 90th percentile level of water samples. It is important to understand that the reporting level represents the 90th percentile of all samples collected, meaning that 90% of the samples were at or below the reported number for lead and for copper. Attachment C provides a detailed explanation of how the 90th percentile is calculated. It is important to note that if the 90th percentile exceeds the Action Level, it is not considered a violation but instead triggers additional requirements, including added water quality monitoring, corrosion control treatment, additional source water monitoring or treatment, public education, and lead service line replacement. To be pro-active, the City actually performs all of these measures anyway to ensure it has a comprehensive and effective program.

Point of use water filters, meeting National Sanitation Foundation (NSF) certification and lead removal efficiencies of 99%, were provided to home owners with identified higher risks, such as those with a higher lead and children in home. A total of 15 filters were provided for water customers that had lead ranging from 3 to 48 ppb at no charge to the customer. Figure 6 illustrates the sampling process from initial customer inquiry through the sampling result.

Sampling Results

Figures 7 and 8 illustrate the sampling locations and the results for all of the respective lead and copper sampling performed for the 2016 monitoring program.

The 2016 round of Lead and Copper Monitoring 90th percentile results have been determined to be 4 parts per billion (ppb) for lead and 896 ppb for copper – significantly lower than the 13 ppb lead and 1200 ppb for copper reported in 2014, and well below the EPA's action levels (ALs) of 15 ppb for lead and 1300 ppb for copper. In 2016, 2.7 percent of the lead samples and 2.0 percent of the copper samples were above the ALs resulting in the lowest 90th percentile since samples have been collected.

For the eight prior sample years (1992-2014), 4.5% of the lead results and 2.5% of the copper samples were above the action levels when customers sampled their own home water. The 90th percentile results of the City's lead and copper monitoring has not exceeded the action levels for any of the nine sampling events. Table 1 shows the 90th percentile results for each of the nine lead and copper monitoring years.

Notable changes in 2016 were that 148 homes were sampled for the 2016 lead and copper monitoring program (up from 59 in 2014) which resulted in a better overall representation of the water system. One can indicate that both these factors contributed to more representative numbers than in years past.

TABLE 1

Results of all LPC Water Quality Monitoring (In ug/L or PPB) 90th Percentile									
	Lead		Copper		Total # of Samples		# Of Lead Samples		# Of Copper Samples
1992(Jan-June)	7.4		634		118		60		58
1992(July-Dec)	6.97		592		102		~50		~50
1996	5.7		501		64		39		25
1999	9		700		54		28		26
2002	9		634		50		25		25
2005	7		800		60		34		26
2008	9		681		50		25		25
2011	6		734		53		26		27
2014	13		1200		59		30		29
2016	4		896		148		76		72

An additional 415 locations were sampled in 2016 that were not part of the 2016 monitoring program – primarily customers that requested to have their water sampled - totaling 563 locations. Again, all samples were collected by a water certified City employee instead of relying on homeowners as had been done in previous years.

The City's pro-active Lead and Copper Program continues to fully comply with the federal and state Safe Drinking Water Act Lead and Copper Rule by not only the water quality monitoring, but also an effective corrosion control program that minimizes the likelihood that lead can leach into the water supply, a lead water service replacement program, and a public education program.

LEAD WATER SERVICE REPLACEMENT

Pre-1992 Lead Service Removals

Lead services were replaced by state water distribution licensed personnel primarily upon discovery during restoration street projects, and repairs to service line breaks. It is estimated that approximately 300 lead water services – street and/or yard-side were removed prior to 1992 when the LCR was implemented.

Post-1992 Lead Service Removals

Since the implementation of the Lead and Copper Rule in 1992, lead services have been replaced by state water distribution licensed personnel upon discovery during restoration street projects, repairs to service line breaks, response to results found from the federal and state mandated Tri-Annual Lead and Copper Monitoring Program, other lead sampling analytical results from customer requests, and physical verification at homes.

In addition, lead service removal is given a priority if a home with a lead service is on a street with a scheduled construction project (to avoid multiple dig ups/road disturbances), and in neighborhoods with a known high density of lead services.

Based on internal documentation and institutional knowledge, it is estimated that a total of approximately 1600 lead services have been replaced. Most municipalities take responsibility from the water main to the curb valve. The City of Kalamazoo is responsible up to and including the water meter. Having said this, we refer our water services to have both a street side and yard side. The street service is from the water main (corporation valve) to the curb valve (curb stop). The yard service is from the curb valve to the meter. Historically, lead has been removed and replaced from either the street side, yard side, or both. The estimation of 1600 replaced services constitutes a partial or full replacement.

2016 Lead Service Removals

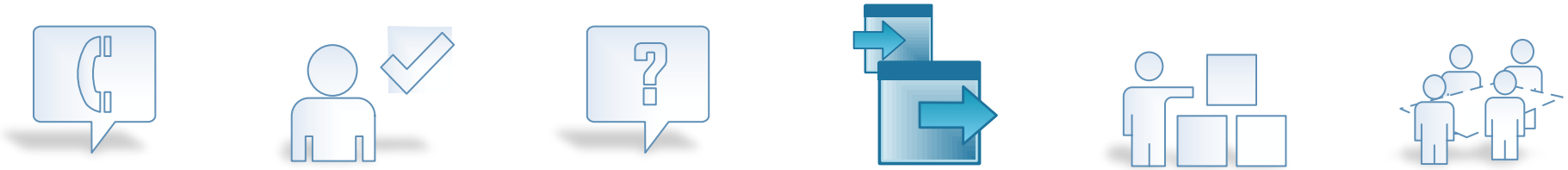
A total of 120 lead water services were removed in 2016 through November 17th (see Figure 9). During various times of the year, one to two crews were working on lead service removals when other higher priority work did not take precedent (e.g. main breaks, service repairs). Services are composed of lead, galvanized, and cast iron material, or a variety of their combinations.

In summary, it is estimated that approximately 2,020 lead water services – street and/or yard-side have been removed. For the last several years, the entire section of lead service – both street and yard side were removed when encountered. Attachment I contains the lead service replacement procedure.

Methodology for Lead Service Removals

Pulling Method

Lead water service replacements on the street service side are conducted as follows: Expose the street service at the water main and disconnect the cooperation stop and turn corporation off; while old line is connected to the cable, push cable inside of lead service and pull lead out while whole new copper follows old lead out; install new brass curb stop and copper adapter to the corporation stop at water main.



Customer Inquiry	Response from COK Staff	If the Material Type is Lead	Sampling Process	The Lab	The Results
• Customer request Water Sampling; • **May have been contacted by COK Lead Team to request sampling** • Home owners are contacted by COK Staff within two business days.	• Contacts customer within two business days • Logs Information • Identifies Pipe Type • Identifies if children are in the home	• If lead services, the home is prioritized • If the home has young children, sampling and analysis turnaround is prioritized • Staff Schedules date and time of sampling with instructions: 6 – 8 hours prior to sampling No Flushing No water Running	• Staff Prepares for sampling visit • Preps Sample • Goes to home • Collects sample • Deliver to Lab	• Samples are dropped to independent lab immediately • Results are sent to [Lab] Programs Manager electronically	• Results are reviewed by Programs Manager. • Staff shares findings with homeowners within 30 days of sample • See below for response based on results

Action in homes With Children

- Results 0 – 4 ppb: results of the sampling are mailed to customer placed on lead replacement schedule.
- Results 5 – 9 ppb: Programs Manager contacts via phone and mails results to customer The customer is offered a filter. Placed on lead replacement schedule.
- Results 10 - 14 ppb: Programs Manager contacts via phone and mails results to customer The customer is offered a filter. Prioritized on lead replacement schedule.
- Results ≥15 ppb: Programs Manager contacts via phone and mails results to customer The customer is offered a filter. Lead removal is immediate.

Action in homes Without Children

- Results 0 – 7 ppb: results of the sampling are mailed to customer placed on lead replacement schedule
- Results 8 – 9 ppb: Programs Manager contacts via phone and mails results to customer. The customer is offered a filter. Placed on lead replacement schedule.
- Results 10 - 14 ppb: Programs Manager contacts via phone and mails results to customer The customer is offered a filter. Prioritized on lead replacement schedule
- Results ≥15 ppb: Programs Manager contacts via phone and mails results to customer The customer is offered a filter. Lead removal is immediate

Figure 6

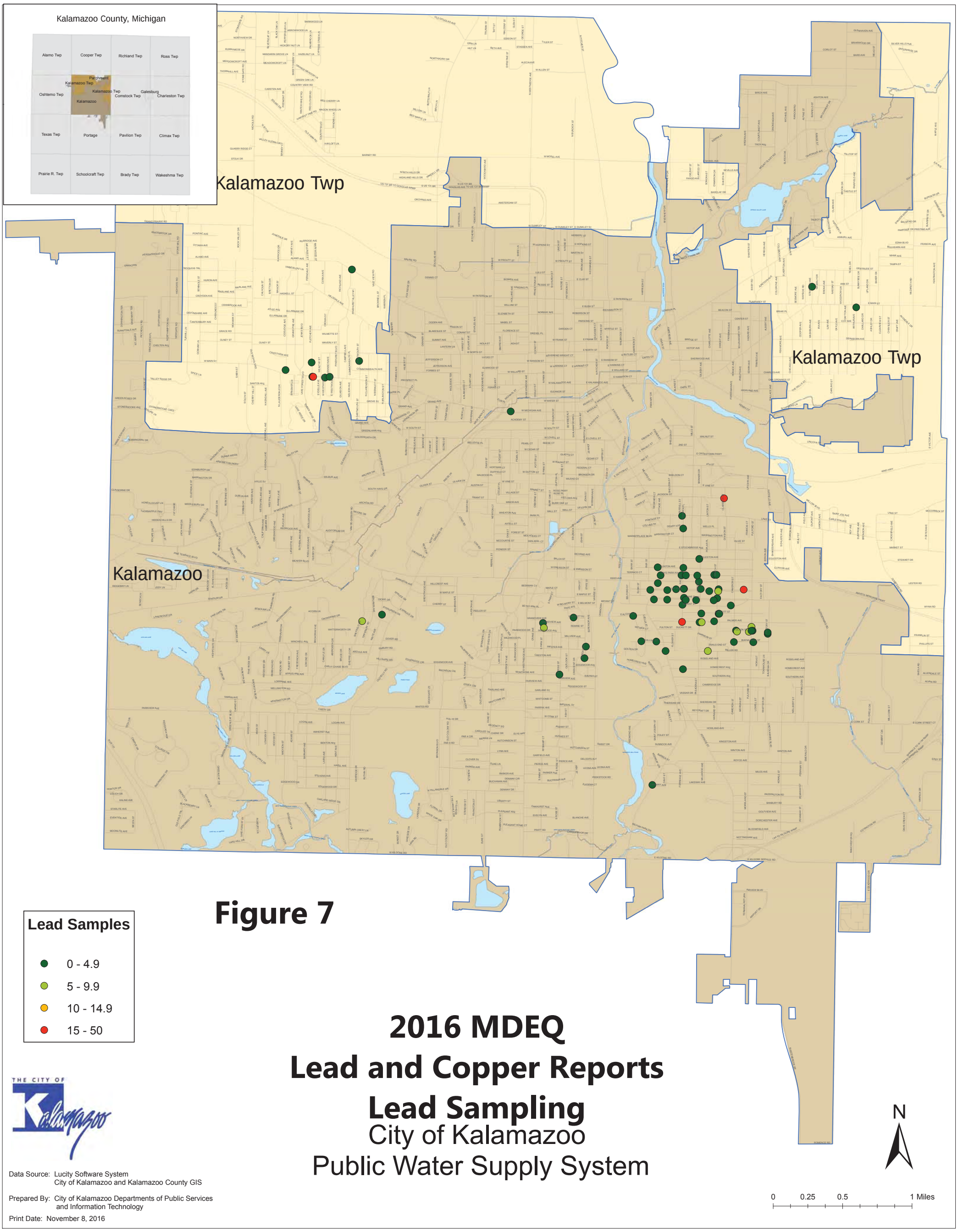


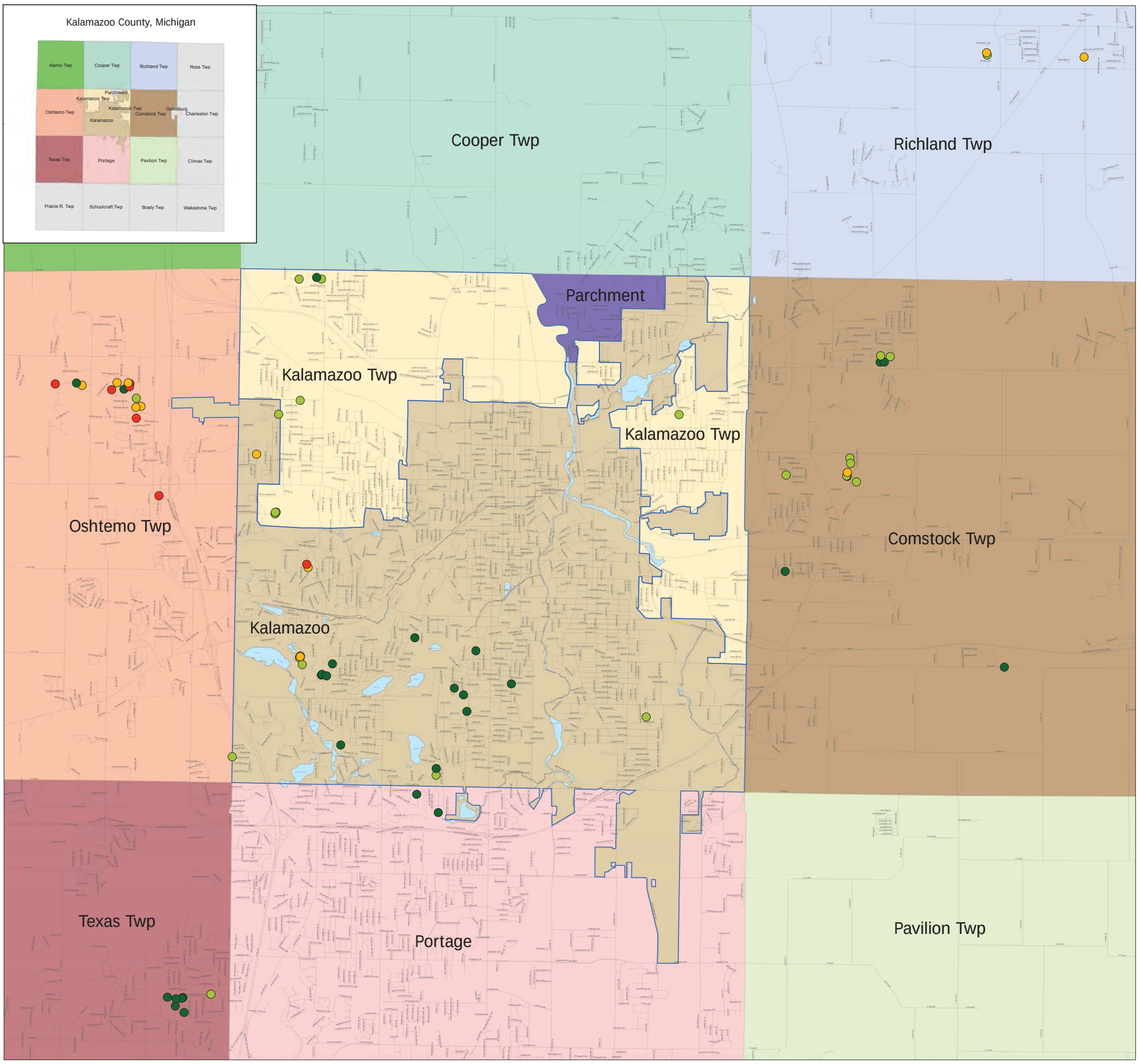
Figure 7

2016 MDEQ
Lead and Copper Reports
Lead Sampling
City of Kalamazoo
Public Water Supply System

Data Source: Lucity Software System
City of Kalamazoo and Kalamazoo County GIS

Prepared By: City of Kalamazoo Departments of Public Services and Information Technology

Print Date: November 8, 2016



Results

- 0-350
- 351-700
- 701-1000
- 1001-1300

Figure 8

2016 MDEQ
Lead and Copper Reports
Copper Sampling

City of Kalamazoo
Public Water Supply System

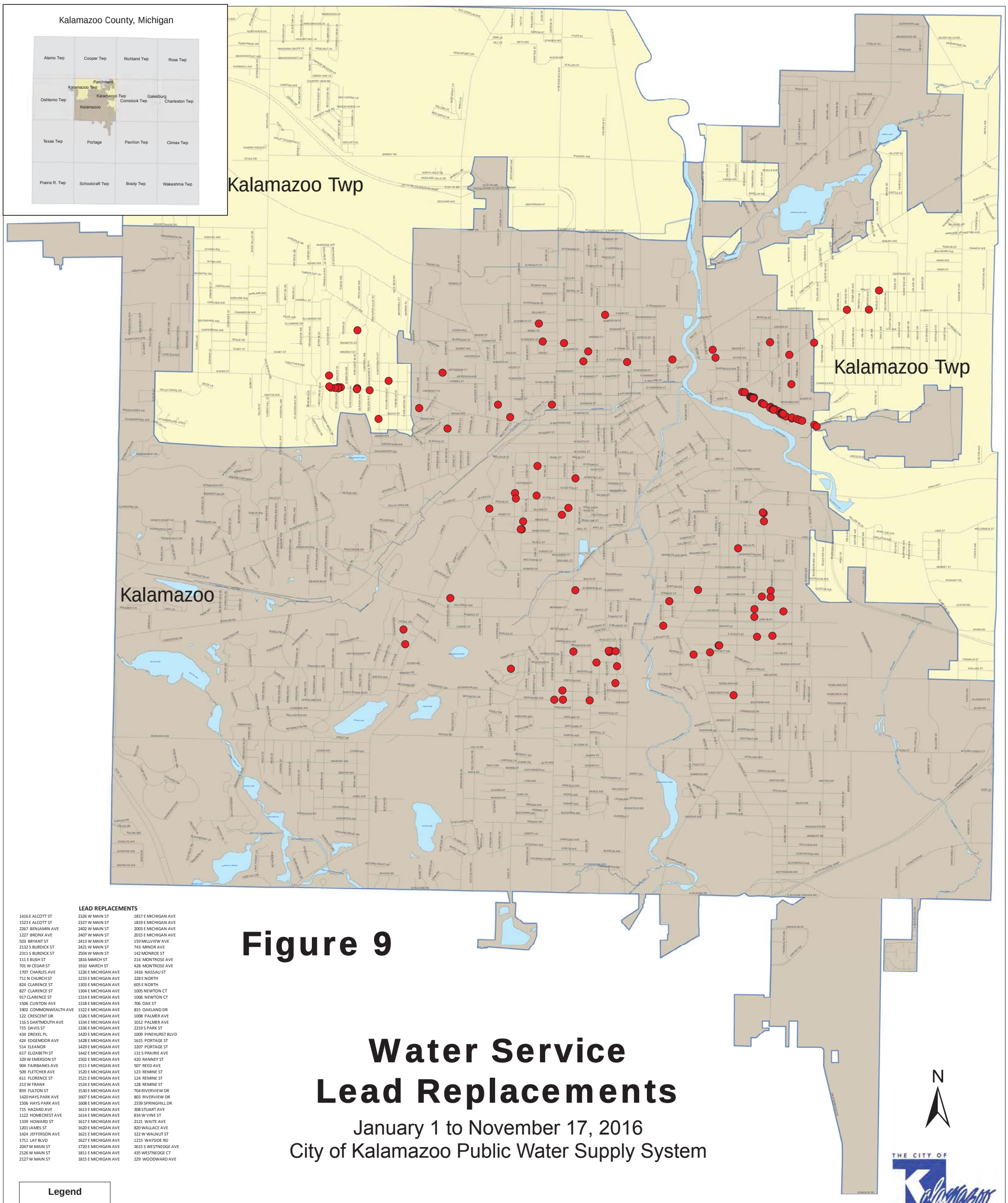
N

0 0.5 1 2 Miles

Data Source: Lucity Software System
City of Kalamazoo and Kalamazoo County GIS

Prepared By: City of Kalamazoo Departments of Public Services and Information Technology

Print Date: November 8, 2016



LEAD REPLACEMENTS

1416 E ALCOTT ST	2326 W MAIN ST	1817 E MICHIGAN AVE
1523 E ALCOTT ST	2327 W MAIN ST	1819 E MICHIGAN AVE
2267 BENJAMIN AVE	2402 W MAIN ST	2003 E MICHIGAN AVE
1227 BRONX AVE	2407 W MAIN ST	2015 E MICHIGAN AVE
503 BRYANT ST	2413 W MAIN ST	159 MILLVIEW AVE
2132 S BURDICK ST	2421 W MAIN ST	743 MINOR AVE
2311 S BURDICK ST	2504 W MAIN ST	142 MONROE ST
111 E BUSH ST	1816 MARCH ST	214 MONTROSE AVE
701 W CEDAR ST	1910 MARCH ST	428 MONTROSE AVE
1707 CHARLES AVE	1226 E MICHIGAN AVE	1416 NASSAU ST
711 N CHURCH ST	1233 E MICHIGAN AVE	228 E NORTH
824 CLARENCE ST	1303 E MICHIGAN AVE	605 E NORTH
827 CLARENCE ST	1304 E MICHIGAN AVE	1005 NEWTON CT
917 CLARENCE ST	1314 E MICHIGAN AVE	1006 NEWTON CT
1506 CLINTON AVE	1318 E MICHIGAN AVE	706 OAK ST
1902 COMMONWEALTH AVE	1322 E MICHIGAN AVE	815 OAKLAND DR
122 CRESCENT DR	1326 E MICHIGAN AVE	1008 PALMER AVE
116 S DARTMOUTH AVE	1334 E MICHIGAN AVE	1012 PALMER AVE
715 DAVIS ST	1336 E MICHIGAN AVE	2219 S PARK ST
434 DREXEL PL	1420 E MICHIGAN AVE	1009 PINEHURST BLVD
424 EDGEMOOR AVE	1428 E MICHIGAN AVE	1615 PORTAGE ST
514 ELEANOR	1429 E MICHIGAN AVE	2207 PORTAGE ST
617 ELIZABETH ST	1442 E MICHIGAN AVE	131 S PRAIRIE AVE
329 W EMERSON ST	1502 E MICHIGAN AVE	420 RANNEY ST
904 FAIRBANKS AVE	1511 E MICHIGAN AVE	507 REED AVE
509 FLETCHER AVE	1520 E MICHIGAN AVE	123 REMINE ST
611 FLORENCE ST	1521 E MICHIGAN AVE	124 REMINE ST
213 W FRANK	1524 E MICHIGAN AVE	128 REMINE ST
859 FULTON ST	1530 E MICHIGAN AVE	704 RIVERVIEW DR
1420 HAYS PARK AVE	1607 E MICHIGAN AVE	803 RIVERVIEW DR
1506 HAYS PARK AVE	1608 E MICHIGAN AVE	2339 SPRINGHILL DR
715 HAZARD AVE	1613 E MICHIGAN AVE	308 STUART AVE
1122 HOMECREST AVE	1614 E MICHIGAN AVE	834 W VINE ST
1339 HOWARD ST	1617 E MICHIGAN AVE	2121 WAITE AVE
1201 JAMES ST	1620 E MICHIGAN AVE	820 WALLACE AVE
1424 JEFFERSON AVE	1621 E MICHIGAN AVE	322 W WALNUT ST
1711 LAY BLVD	1627 E MICHIGAN AVE	1215 WAYSIDE RD
2047 W MAIN ST	1720 E MICHIGAN AVE	2615 S WESTNEDGE AVE
2126 W MAIN ST	1811 E MICHIGAN AVE	435 WESTNEDGE CT
2127 W MAIN ST	1815 E MICHIGAN AVE	229 WOODWARD AVE

Figure 9

Water Service Lead Replacements

January 1 to November 17, 2016

City of Kalamazoo Public Water Supply System

Legend

Lead Replacements

Data Source: Lucity Software System
City of Kalamazoo and Kalamazoo County GIS

Prepared By: City of Kalamazoo Departments of Public Services and Information Technology

Print Date: November 21, 2016

A lead service with multiple lines, 2016.

Lead water service replacements on the yard side are conducted as follows: Locate utilities and expose the curb box; cut service line on the yard side of curb box; disconnect the service inside of the basement at the meter and valve; push cable inside of lead pipe until it shows up outside where the service was cut; place “Chinese finger” over the lead pipe and use the cable and Chinese finger together to pull the lead service out; attach a new copper line behind the lead service until it shows up in the hole by the curb box.

Non-Pulling Method

When the lead service cannot be readily pulled, an underground piercing tool (missile) driven by air is typically used. From the street side, a missile is shot from the curb stop hole to the hole where the water main is exposed. The hole would then be replaced by pulling the cable through, followed by the new copper pipe.

From the yard side, the missile is shot from a hole in the basement wall out to a hole at the exposed curb stop. The hose would be replaced by pulling the cable through the wall with the copper piping attached.

Directional Bore

Another option is to use a directional boring machine that is hydraulically or mechanically driven. From the street side, the hole at the curb stop is used to directionally bore towards the water main. Subsequently, the boring tool is pulled back toward the curb stop.

From the yard side, a directional bore is driven through the curb stop hole toward the basement wall. An adapter on the boring tool is used to make a hole in the wall which allows for the copper pipe to be pulled through to the curb stop, along with the tooling.

Current Strategy to Minimize Risk to Health

Once lead services are defined/confirmed, it is noted in the Lucity database and targeted for replacement.

For homes with children, the customer is offered a filter if the lead results are 5 ppb or higher. If the result is 10-14 ppb, the lead service replacement is given a priority on the schedule. If the result is ≥15, the lead service is removed as soon as possible (usually within two weeks).

For homes without children, the customer is offered a filter if the lead result is 8 ppb or higher.

If the result is 10-14 ppb, the lead service replacement is given a priority on the schedule. If the result is ≥15, the lead service is removed as soon as possible (usually within two weeks). A filter is provided to any customer that requests one and has a detectable level of lead. Figure 6 indicates the general criteria for prioritizing lead removals after sampling results, and providing faucet filters.

Future Plan Considerations/Alternatives for Lead and Copper Program

Currently, the City's regulatory requirements for the LCP are the Triennial Lead and Copper Tap Monitoring to determine the 90th percentiles, and Water Quality Parameter Monitoring to primarily determine the corrosive potential at the water pumping stations and within the distribution system.

Education

Since the City has not exceeded the 90th percentile for lead in all nine of its lead and copper monitoring sampling years, it is not technically required to perform public education - public education only applies to supplies that exceed the lead action level in more than 10 percent of samples taken.

However, the City recognizes that it is valuable for the community if they better understand the risks to elevated lead and copper levels so appropriate action can be made if necessary. Subsequently, staff recommends that the City continue its public education efforts associated with the lead and copper program, including using the City's main website and the www.protectyourwater.net website, maintain existing video and consider additional multi-media outlets, and disseminate information via media outlets (written articles and radio interviews).

Corrosion Control

The City's current corrosion control strategy – relying on the orthophosphate residual from the degradation from the sodium hexa-metaphosphate added to the water system – may be sufficient and therefore could be continued. However, Public Services staff is currently nearing completion with the Tetra Tech system evaluation to determine if modifications to the corrosion control strategy is advisable. The primary modifications could include the addition of/blending of orthophosphate with sodium hexa-metaphosphate, adjusted dosages of sodium hexa-metaphosphate at specific water pumping stations, and pH adjustments.

Water Lead Service Removals

Traditionally, lead services were replaced during two primary situations: when a street construction project occurred, and when maintenance or replacement was needed on a service. Based on records, approximately 75 lead services were replaced on average annually for maintenance. At this time, we do not have records for the number of services that were replaced associated with street construction but think that on average, they represented approximately one-quarter to one-third of the total. For example, in 2016, 120 total lead services were replaced with copper, with 88 (73%) being associated with road construction and 32 (27%) for maintenance. Figure 9 shows the locations of the lead services replaced in 2016 (through November 17).

All of the lead services (Figures 2 and 3) could eventually be replaced. However, with as many undefined services that exist (Figure 4), a well-planned approached will need to be implemented to maximize resources and efficiently accomplish the project with as minimal street disturbance as practical. A comparison of Figure 2 and Figure 4 helps indicate what undefined service areas are more likely/suspected to be lead. These common areas of known lead and undefined services will likely be targeted to remove as many of the lead services in specific areas as possible. Lead services will continue to be removed during routine maintenance. An effort will be made to coordinate street projects with known and suspected lead service areas.

Estimated Costs

Alternative 1: Total Lead Water Services Removal

An average cost per lead service replacement is approximately $3,500, including labor, materials, and sampling associated costs. However, this cost may vary significantly depending upon various factors, including the number of utilities and utility types within the project area.

Table 2 illustrates the Time and cost-based projections to complete all of the lead service removals. The assumptions are based on the percentage of the current undefined services that are to be determined to be lead. For discussion purposes, scenarios are shown for 25%, 50%, and 75% of the undefined services being determined to lead. Subsequently, the total number of (assumed) lead services and the associated coats to remove them are extrapolated over five, 10, 15, 20, 25, 30, 35, 40, 45, and 50 years. A 2 percent annual inflation adjustment is added after year 15.

For example, Table 2 indicates that a 10-year lead services removal plan that assumes 25% of the undefined services are lead could be accomplished if an estimated $1.689 million is made available on an annual basis to remove approximately 474 lead services a year. Consequently, the current pace of 120 in 2016 would equate to a 40-year pace. The amount of years to complete lead service removals can be planned for any of the shown scenarios on Table 2 if an increased proportional number of staff and/or a combination of contractual assistance is made to accomplish the described work.

Alternative 2: Only Remove Lead Water Services with Lead Levels ≥15 ppb

This alternative would significantly lower the overall cost of the lead water services removal by only removing those currently known and subsequently discovered to be at or above the Action Level of 15 ppb for lead. In 2016, approximately 2 percent of the 372 homes (both inside and outside of our Lead and Copper Monitoring Program) that were sampled for lead had detections ≥15 ppb.

TABLE 2
ESTIMATED LEAD SERVICES REMOVAL TIMELINES AND COSTS

Known Lead Services	**Total Undefined Services = 7308**	**Total Lead Services Total x $3,500**	**5 Years**	**10 Years**	**15 Years**	**20 Years**	**25 Years**
2914	**25% = 1827**	4741 $16.59 million	948 year $3.318 million/year	474 year $1.689 million/year	316 year $1.106 million/year 2% Inflation added → after 15 years	237 year $0.916 million/year 2% Inflation →	190 year $0.811 million/year 2% Inflation →
2914	**50% = 3654**	6568 $22.99 million	1314 year $4.598 million/year	657 year $2.299 million/year	438 year $1.533 million/year 2% Inflation added → after 15 years	328 year $1.267 million/year 2% Inflation →	263 year $1.122 million year 2% Inflation →
2914	**75% = 5481**	8395 $29.38 million	1679 year $5.876 million/year	840 year $2.938 million/year	560 year $1.959 million/year 2% Inflation added → after 15 years	420 year $1.623 million/year 2% Inflation →	336 year $1.434 million/year 2% Inflation →

Known Lead Services	**Total Undefined Services = 7308**	**Total Lead Services Total x $3,500**	**30 Years**	**35 Years**	**40 Years**	**45 Years**	**50 Years**
2914	**25% = 1827**	**4741**	158 year $0.744 million/year 2% Inflation →	135 year $0.702 million/year 2% Inflation →	119 year $0.683 million/year 2% Inflation →	105 year $0.666 million/year 2% Inflation →	95 year $0.665 million/year 2% Inflation →
2914	**50% = 3654**	**6568** **$22.99 million**	219 year $1.032 million/year 2% Inflation →	188 year $0.978 million/year 2% Inflation →	164 year $0.942 million/year 2% Inflation →	146 year $0.926 million/year 2% Inflation →	131 year $0.917 million/year 2% Inflation
2914	**75% = 5481**	**8395** **$29.38 million**	280 year $1.319 million/year 2% Inflation →	240 year $1.248 million/year 2% Inflation →	210 year $1.206 million/year 2% Inflation →	187 year $1.186 million/year 2% Inflation →	168 year $1.176 million/year 2% Inflation

NOTE: After the 15th year, cost shown per 5-year increment assumes highest cost of that period (5th year).

Alternative 3: Only Remove Lead Water Services with Lead Levels ≥5 ppb

This approach would be pro-active to the anticipated lowering of the Action Level for lead by MDEQ to 5 ppb. In 2016, approximately 9 percent of the 372 homes (both inside and outside of our Lead and Copper Monitoring Program) that were sampled for lead had detections ≥5 ppb.

Alternative 4: Only Remove Lead Water Services Associated with Street Construction and Service Maintenance Projects

Traditionally, lead services were replaced during two primary situations: when a street construction project occurred, and when maintenance or replacement was needed on a service. Based on records, approximately 75 lead services were replaced annually on average for maintenance.

Any one of these alternatives, along with continued public education and corrosion control, would currently fulfill regulatory compliance obligations and would be recommended with any of the selected alternatives. Given that approximately 91 percent of the homes sampled with lead service lines in 2016 had ≤5 ppb of lead, Alternative 3 may be a reasonable approach, considering that it would the likely meet the future 90th percentile Action Level of 5 ppb, while reducing the cost potentially by 91 percent compared to the total water lead service removal option.

Funding Sources

Currently funding for lead service removals are budgeted within the Water Capital Improvement Program (CIP). In 2015, $120,000 was budgeted and in 2016, $390,000 was budgeted for lead service removals. It is proposed that in 2017, 2018, and 2019 budgets for lead service removals be increased to $400,000, $1.7 million, and 2.717 million, respectively.

The city is considering participating in the State of Michigan Drinking Water Revolving Fund Program to assist in funding its lead water service removal program (see Attachment G). Another consideration is to solicit use of the new Foundation for Excellence funds.

Public Education and Outreach

Educational literature and letters are provided to water customers that participate in the Lead and Copper Monitoring Program (see Attachment H). In the spring of 2016, an educational video regarding lead in drinking water was prepared by City staff and released on the City's main website and its www.protectyourwater.net website. The video has also been shown at various presentations.

A section on the www.protectyourwater.net website is dedicated to the lead issue.

Lead and Copper Program updates are routinely provided on the City's main website.

In November, an e-mail newsletter was prepared and sent to the City's newsletter subscribers providing an update regarding the lead and copper program.

Several radio interviews were made with Michigan Radio, WKZO, and Kalamazoo Gazette/M-Live. Staff from Michigan Radio rode along with our sampler one morning to witness how we collected samples and interacted with the public. The next annual Water Quality Report (Consumer's Confidence Report) due the first quarter of 2017 will have additional information regarding lead and copper results.

LIST OF GENERAL REFERENCES

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ATTACHMENT A

Lead and Copper Program Project Team

Lead and Copper Program Project Team

Primary Members

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MiMi Carrillo, Public Services Supervisor

Shannan Deater, Public Services Program Manager

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JoLinda Jach, Senior Systems Programmer/Program Manager (IT)

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Bob McClenney, Public Services Field Services Manager (and All Lead Field Crews)

John Paquin, Public Services Water Resources Division Manager

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John Slack, Public Services Supervisor

Dena Wisdom-Modert, Public Services Account Coordinator/Secretary

Supporting Staff

Scott Borling, City Clerk

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Jeff Chamberlain, Deputy City Manager

Neal Conway, Communications Coordinator (City Manager's Office)

Wil Eichelberger, Public Services Engineering Lead Drafter

Sue Hoch, Senior Systems Analyst (IT)

Pat Huntley, Public Services Records Clerk

Teresa Johnson, Public Services Department Deputy Director

Peggy Rice, Public Services Administrative Support Coordinator

ATTACHMENT B

General Information Regarding Lead

Frequently Asked Questions About Lead

Q: Why is lead a problem?	**A:** Lead is known to be harmful to human health if inhaled or ingested. The degree of harm depends upon the level of exposure from all sources.
Q: Where does lead come from?	Important sources of lead exposure include: ambient air, soil and dust (both inside and outside the home), food (which can be contaminated by lead in the air or in food containers), and water (from the corrosion of plumbing). On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total lead exposure in young children. Infants who consume mostly mixed formula can receive 40 to 60 percent of their exposure to lead from drinking water. Federal controls on lead in gasoline have significantly reduced people's exposure to lead.
Q: How can lead get into my drinking water?	**A:** Lead gets into your water after the water enters your water service lines or plumbing in your home. The source of lead in your home's water can be the service pipe, which can be made of lead, or solder or fixtures in your home's own plumbing. While UTILITY water is non-corrosive, some lead can be dissolved into your water if it is left stagnant in the pipes for more than six hours.
Q: Does my service line contain lead?	**A:** We have fairly complete records. Approximately NUMBER service lines have at least one lead component, our records show. There are some unknown lines that we will assume are lead until we can establish this with certainty.
Q: Does my home's age make a difference?	**A:** Yes. Up until the early 1930s, lead pipes were sometimes used for interior plumbing. Until the early DATEs, the UTILITY often used lead piping to connect water mains to residences. Solder used to join copper plumbing before 1988 may contain lead. New brass faucets and fittings may contain up to 8% lead, and can also leach lead even though they are technically considered "lead-free." We can tell you if the service connector used in your home or area is made of lead. **Call us at PHONE.** Lead levels decrease as a building ages. This is because as time passes, mineral deposits form a coating on the inside of the pipes This coating insulates the water from the solder.
Q: How can I have my water tested for lead?	**A:** Testing can be arranged through your local health department and costs around $COST. Contact names and numbers are listed at the bottom of this document. Should you decide to utilize an independent laboratory not listed here, please be certain that the laboratory is certified by the Michigan Department of Environmental Quality (MDEQ) to test for lead in drinking water.
Q: What are the testing procedures?	**A:** Contact your local health department. In most cases, the department will provide sample containers along with instructions as to how you should draw your tap-water samples. If you collect the samples yourself, make sure you follow the health department's instructions exactly. Otherwise, the results might not be reliable. Make sure that the laboratory is following water sampling and analysis procedures certified by MDEQ. Be certain to take a "first draw" sample.

Q: What about lead in sources other than drinking water?	Important sources of lead exposure include: ambient air, soil and dust (both inside and outside the home), food (which can be contaminated by lead in the air or in food containers), and water (from the corrosion of plumbing). On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total lead exposure in young children. Federal controls on lead in gasoline have significantly reduced people's exposure to lead.
Q: What is the UTILITY doing about the problem of lead in household water?	**A:** We are taking three major actions to reduce your exposure to lead: 1. The UTILITY has undertaken corrosion control measures to minimize the amount of lead picked up by water contacting lead-bearing piping and plumbing. We continue to test treatment alternatives to further reduce the potential for lead corrosion in service lines and customer plumbing. 2. We have initiated a lead service line replacement program that will have removed all NUMBER lead service components in the areas we serve 10 years from now. 3. We are conducting a public education/awareness campaign targeted toward all of our customers by suggesting simple, effective methods to avoid lead exposure.
What measures can a customer take to reduce exposure?	**A:** The first step is to refrain from consuming water that has been in contact with your home's plumbing for more than six hours, such as overnight or during your work day. Before using water for drinking or cooking, "flush" the cold water faucet by allowing the water to run until you can feel that the water has become as cold as it will get. For instance, you might flush the toilet first thing in the morning or take a shower, then run your kitchen tap for 30 or more seconds before you draw any water for consumption. Also, you might draw water for plants or other non-consumptive use before flushing the tap. Following the intitial flush, whether toilet or shower, **you must flush the tap 30 seconds for each drinking water faucet.** This will void the service lines as well as the home plumbing. Once you have flushed a tap, you might fill one or more bottles with water and put them in the refrigerator for later use that day. The second step is to never cook with or consume water from the hot-water tap. Hot water dissolves more lead more quickly than cold water. So, do not use water taken from the hot tap for cooking or drinking, and especially not for making baby formula. (If you need hot water, draw water from the cold tap and heat it on the stove.) Use only thoroughly flushed water from the cold tap for any consumption.
Q: How much lead is too much?	**A:** Federal standards initially limited the amount of lead in water to 50 parts per billion (ppb). In light of new health and exposure data, EPA has set an action level of 15 ppb. If tests show that the level of lead in your household water is in the area of 15 ppb or higher, it is advisable - especially if there are young children in the home - to reduce the lead level in your tap water as much as possible. (EPA estimates that more than 40 million U.S. residents use water that can contain lead in excess of 15 ppb.) Note: One ppb is equal to 1.0 microgram per liter (µg/1) or 0.001 milligram per liter (mg/1).

For More Information:

County Health Department	PHONE
U.S. EPA Safe Drinking Water Hotline	(800) 426-4791
U.S. EPA Lead Web Page	http://www.epa.gov/safewater/lead/leadfacts.html

Definitions

Corrosion: A dissolving and wearing away of metal caused by a chemical reaction (in this case, between water and metal pipes, or between two different metals).

First Draw: The water that immediately comes out when a tap is first opened.

Flush: To open a cold-water tap to clear out all the water which may have been sitting for a long time in the pipes. In new homes, to flush a system means to send large volumes of water gushing through the unused pipes to remove loose particles of solder and flux. (Sometimes this is not done correctly or at all).

Flux: A substance applied during soldering to facilitate the flow of solder. Flux often contains lead and can, itself, be a source of contamination.

Naturally soft water: Any water with low mineral content, lacking the hardness minerals calcium and magnesium.

Public Water System: Any system that supplies water to 25 or more people or has 15 or more service connections (buildings or customers).

Service Connector: The pipe that carries tap water from the public water main to a building. In the past these were often made of lead.

Soft water: Any water that is not "hard." Water is considered to be hard when it contains a large amount of dissolved minerals, such as salts containing calcium or magnesium. You may be familiar with hard water that interferes with the lathering action of soap.

Solder: A metallic compound used to seal joints in plumbing. Until recently, most solder contained about 50 percent lead.

Lead (PB): Frequently Asked Questions

Lead & Water

What is lead (Pb)?
Lead is a naturally occurring element found in small amounts in the earth's crust. Lead is also a common metal found throughout the environment in lead-based paint, air, soil, household dust, food, and water. While it has some beneficial uses, it can be toxic to humans and animals causing harmful health effects.

How does lead get into my drinking water?
Lead present in drinking water is rarely the result of its dissolution from natural sources. It is mainly due to household plumbing systems containing lead pipes, solders, and fittings. Lead can enter drinking water as a result of corrosion, or wearing away of materials containing lead in the water distribution system. The highest levels of lead occur when very corrosive water stands motionless and comes in contact with lead pipe or lead solder for long periods of time.

How do I know if my drinking water is contaminated with lead?
You cannot see, taste, or smell lead in drinking water. The only way to know if your drinking water contains lead is to sample the water and have it tested. To determine your household risk, it is recommended to take a "first draw sample".

What does it mean to take a "first draw sample"?
The definition of a first draw sample is a sample that is taken first in the morning before the tap in the premise has been used for other purposes. During the stagnation period (at least 6 hours) no water should be drawn from any outlet within the property (this includes flushing of toilets).

For proper sampling, the water must sit in your pipes for at least 6 hours, can only be taken from a water faucet that is representative of your drinking water, and not be connected to a water softener or filter.

What can I do to reduce or eliminate lead in my drinking water?
If your home was built prior to 1987, you may consider replacing old pipes, service lines, and faucets to limit the lead in your drinking water. New pipes, solder, and faucets should meet EPA lead-free standards. If you have municipal water, contact your municipality's public works department to determine if the service line piping that goes into your home is lead-free.

When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using your water for drinking or cooking. Use only water from the cold-water tap for drinking, cooking, and especially for making baby formula. Hot water is likely to contain higher levels because it dissolves more lead.

You may choose to install a water filter that is NSF-certified for lead removal. If a water filter is installed, replace filters at least as often as recommended by the manufacturer. If a filter is installed and utilized, sampling is still recommended to assure water quality.

When was lead prohibited from use in plumbing and plumbing fixtures?

Section 1417 of the Safe Drinking Water Act (SDWA) prohibits the "use of any pipe, any pipe or plumbing fitting or fixture, any solder, or any flux, after June 1986, in the installation or repair of (i) any public water system; or (ii) any plumbing in a residential or non-residential facility providing water for human consumption, that is not lead free."

Additionally, the SDWA also prohibits introducing a pipe, any pipe or plumbing fitting or fixture, any solder, or any flux that is not lead free into commerce; unless the use is for manufacturing or industrial purposes.

The SDWA includes several exemptions from the lead free requirements, specifically for plumbing devices that are used exclusively for non-potable services, as well as a list of specific products: toilets, bidets, urinals, fill valves, flushometer valves, fire hydrants, tub fillers, shower valves, service saddles, or water distribution main gate valves that are 2 inches in diameter or larger.

Who do I contact for more information on lead and water testing?

If you are on municipal water, the municipality or management of the mobile home park / apartment complex should be the first place to start.

- City of Kalamazoo – 269-337-8440
  - http://www.kalamazoocity.org/departments/public-services/water
- City of Portage – 269-329-4422
  - http://www.portagemi.gov/Departments/TransportationUtilities.aspx
- City of Parchment – 269-344-6400
  - http://www.parchment.org/utilities/
- City of Galesburg – 269-665-7213
  - http://www.galesburgcity.org/index.html
- For the following jurisdictions, contact the public works / water department.
  - Charleston Township – 269-665-7805
  - Village of Augusta – 269-731-4717
  - Village of Climax – 269-746-4174
  - Village of Schoolcraft – 269-679-4304
  - Village of Vicksburg – 269-649-1919
- For the following apartment complexes / mobile home communities / other community water supplies, contact management.
  - Alamo Nursing Home – 269-343-2587
  - Andrews Estates – 269-665-9122
  - Boerman Mobile Village – Unknown Number
  - Climax Mobile Home Park – 269-746-4484
  - Evergreen Park – 269-342-5496
  - Kellogg Biological Station – 269-671-5117
  - Nazarene Camp – 269-649-2281
  - Plainwell Pines – 269-349-6649
  - Portage Terrace – 269-327-2093

    - Royal Estates – 269-349-5350
    - Sugarloaf Mobile Home Park – 269-679-5087
    - Sun Meadows Apartments – 269-649-0211
- All municipal water supplies are required to comply with the Consumer Confidence Report (CCR) Rule, which requires community water supplies to annually report to their customers on the quality of the drinking water and the sources of that water, and to characterize the risks (if any) from exposure to contaminants detected in the water. To obtain a copy of this report, contact your municipal water supplier.

If you are on a private water well, contact the Kalamazoo County Health & Community Services Department at 269-373-5336.

What can I do if I am connected to a private, residential water well?

Homes built before 1987 are more likely to have pipes, fittings, faucets, and solder that contain lead. Additionally, depending on the age of your water well, a lead packer may have been installed. Contact Environmental Health at 269-373-5336 to discuss sample recommendations and costs.

Where do I go for more information?

The United States Environmental Protection Agency provides information about drinking water and ground water programs authorized under the Safe Drinking Water Act. You can contact the Safe Drinking Water Hotline at 1-800-426-4791 or go to http://www.epa.gov/your-drinking-water/safe-drinking-water-hotline to ask an online question.

LEAD (Pb): Talking Points

Lead is a heavy metal and can be toxic to humans, especially young children, affecting brain development, behaviors, sleep patterns and many other functions of the body.

- Lead is a heavy metal and can be toxic to humans, especially young children, affecting brain development, behaviors, sleep patterns and many other functions of the body.
- No safe blood lead level in children has been determined.
- There are often no symptoms of lead exposure to alert parents, so blood testing is the best method to detect exposure.
- Historically children in many counties in Michigan, and across the nation, have been seen with elevated levels of lead in their blood. Extensive work to eliminate lead from many environmental sources, such as leaded gasoline and lead-based paints, have resulted in dramatic declines in the number of children affected and the amount of lead in their blood.
- Between April and December 2015 in Kalamazoo County, just over 2000 young children were tested for lead in their blood. 32 of these children were found to have elevated (greater than 5 mcg/dl) blood lead levels; the majority of which (81%) were found to have blood lead levels of between 5 and 9 mcg/dl.
- Elevated blood lead levels were seen in children from 9 different zip codes.
- The US Centers for Disease Control and Prevention has set 5 mcg/dl as the blood lead level at which parents need to be informed and along with their pediatrician, public health officials and others can take action to reduce the child's further exposure to lead.
- Medical treatment is not usually recommended unless the blood lead level is above 44 mcg/dl.
- Lead may be found in a number of items and places around the home, including:
    - Water that comes through lead pipes or pipes with lead solder

KALAMAZOO COUNTY HEALTH & COMMUNITY SERVICES

Promoting Health For All

http://www.kalcounty.com/hcs/

- Paint in homes built before 1978
- Toys and jewelry made in countries without high lead control standards
- Pots and cooking utensils that are brought into the US
- Dust inhaled or contaminating clothes of people using firing ranges where leaded bullets are used
- Bare soil around the home

- Kalamazoo County discontinued its lead case management program in 2012 and home environmental lead assessments in 2014 for a number of reasons, including a lack of funding at the time, the number of children with elevated blood lead levels had dropped substantially, more private businesses offered lead abatement programs for housing stock and the state of Michigan expanded their program for environmental follow up of people identified with elevated blood lead levels.

- The few counties that operate a lead program have received specific funding for community-based, lead exposure prevention from the State.

- The situation in Flint, MI began after the source for drinking water for residents of the City of Flint was switched to the Flint River and as a result of treatment of this water to kill any pathogens. The high concentrations of chemicals used proved to be corrosive to water pipes. This led to substantial leaching of lead from old pipes which contained lead into the drinking water system. Controls should have been put into place to counter the corrosive effects to prevent leaching of lead, but were not.

- Drinking water in Kalamazoo is subject to corrosion control to prevent this type of problem.

- Municipality water supplies (such as City of Portage and City of Kalamazoo) regularly test their water for the presence of a large number of chemicals, including heavy metals such as lead. Any elevation of any of these potentially harmful chemicals would require a report to the Environmental Health program at the Kalamazoo County Health & Community Services Department by the municipal water authority.

- Kalamazoo County Health and Community Services Department tests well water for those people who do not have access to a municipal supply, although because of the lack of lead in the soils of the area and the use of non-lead containing well components, lead is not routinely tested in Kalamazoo

ATTACHMENT C

90th Percentile Explanation

What is the 90th percentile and how is it calculated?

(Source: Abdul Rahim, MCA Professional. "Software Testing & Tricks")

The 90th percentile is the value for which 90% of the data points are smaller

The 90th percentile is a measure of statistical distribution, not unlike the median. The median is the middle value. The median is the value for which 50% of the values were bigger, and 50% smaller. The 90th percentile tells you the value for which 90% of the data points are smaller and 10% are bigger.

Statistically, to calculate the 90th percentile value:
1. Sort the transaction instances by their value.
2. Remove the top 10% instances.
3. The highest value left is the 90th percentile.

Example:
There are ten instances of transaction "t1" with the values 1,3,2,4,5,20,7,8,9,6 (in sec).
1. Sort by value — 1,2,3,4,5,6,7,8,9,20.
2. Remove top 10 % — remove the value "20."
3. The highest value left is the 90th percentile — 9 is the 90th percentile value.

The 90th percentile value answers the question, "What percentage of my transactions have a response time less than or equal to the 90th percentile value?" Given the above information, here is how LoadRunner calculates the 90th percentile.

In Analysis 6.5:
The values for the transaction are ordered in a list.
The 90% is taken from the ordered list of values. The place from which it is taken is

Rounding to the small value the number: 0.9 * (Number of Values – 1) + 1

In Analysis 7 and above:
Each value is counted in a range of values. For example, 5 can be counted in a range of 4.95 to 5.05, 7.2 in a range of 7.15 to 7.25. The 90% is taken from the range of values that the number of transaction in it and before it is >= (0.9 * Number of Values).

This difference in the methods can lead to different 90% values. Again, both methods lead to correct values as defined by the 90th percentile. However, the algorithm to calculate these figures has changed in LoadRunner 7 and above.

ATTACHMENT D

EPA Lead and Copper Rule –

A Quick Reference Guide

United States Environmental Protection Agency

Lead and Copper Rule: A Quick Reference Guide

Overview of the Rule

Title[1]	Lead and Copper Rule (LCR)[2], 56 FR 26460 - 26564, June 7, 1991
Purpose	Protect public health by minimizing lead (Pb) and copper (Cu) levels in drinking water, primarily by reducing water corrosivity. Pb and Cu enter drinking water mainly from corrosion of Pb and Cu containing plumbing materials.
General Description	Establishes action level (AL) of 0.015 mg/L for Pb and 1.3 mg/L for Cu based on 90th percentile level of tap water samples. An AL exceedance is not a violation but can trigger other requirements that include water quality parameter (WQP) monitoring, corrosion control treatment (CCT), source water monitoring/treatment, public education, and lead service line replacement (LSLR).
Utilities Covered	All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are subject to the LCR requirements.

Public Health Benefits

Implementation of the LCR has resulted in	► Reduction in risk of exposure to Pb that can cause damage to brain, red blood cells, and kidneys, especially for young children and pregnant women. ► Reduction in risk of exposure to Cu that can cause stomach and intestinal distress, liver or kidney damage, and complications of Wilson's disease in genetically predisposed people.

Major Monitoring Provisions

Lead and Copper Tap

Applicability	► All CWSs and NTNCWSs.
Standard	► CWSs and NTNCWSs must collect first-draw samples at taps in homes/buildings that are at high risk of Pb/Cu contamination as identified in 40 CFR 141.86(a). ► Number of samples is based on system size (see Table 1). ► Systems must conduct monitoring every 6 months unless they qualify for reduced monitoring.
Reduced	► See Table 1 for sample number and Table 2 for criteria.

Water Quality Parameter (WQP)

Applicability	► Systems serving > 50,000 people. ► Systems serving ≤ 50,000 during monitoring periods in which either AL is exceeded.
Standard	► WQP samples at taps are collected every 6 months. ► WQPs at entry points to distribution system (EPTDS) are collected every 6 months prior to CCT installation, then every 2 weeks.
Reduced	► See Table 1 for sample number and page 2 for criteria. Does not apply to EPTDS WQP monitoring.

Table 1: Lead and Copper Tap and WQP Tap Monitoring

Size Category	System Size	Number of Pb/Cu Tap Sample Sites[3]		Number of WQP Tap Sample Sites[4]	
		Standard	Reduced	Standard	Reduced
Large	> 100K	100	50	25	10
	50,001 - 100K	60	30	10	7
Medium	10,001 - 50K	60	30	10	7
	3,301 - 10K	40	20	3	3
Small	501 - 3,300	20	10	2	2
	101 - 500	10	5	1	1
	≤ 100	5	5	1	1

[3] With written State approval, PWSs can collect < 5 samples if all taps used for human consumption are sampled.
[4] Two WQP tap samples are collected at each sampling site.

Table 2: Criteria for Reduced Pb/Cu Tap Monitoring

Annual	1. PWS serves ≤ 50,000 people and is ≤ both ALs for 2 consecutive 6-month monitoring periods; or 2. Any PWS that meets optimal WQPs (OWQPs) and is ≤ Pb AL for 2 consecutive 6-month monitoring periods.
Triennial	1. PWS serves ≤ 50,000 people and is ≤ both ALs for 3 consecutive years of monitoring; or 2. Any PWS that meets OWQP specifications and is ≤ Pb AL for 3 consecutive years of monitoring; or 3. Any PWS with 90th percentile Pb and Cu levels ≤ 0.005 mg/L and ≤ 0.65 mg/L, respectively, for 2 consecutive 6-month monitoring periods (i.e., accelerated reduced Pb/Cu tap monitoring).
Every 9 years	PWS serves ≤ 3,300 people and meets monitoring waiver criteria found at 40 CFR 141.86(g).

Lead Consumer Notice

Within 30 days of learning the results, all systems must provide individual Pb tap results to people who receive water from sites that were sampled, *regardless of whether the results exceed the Pb AL*, as required by 40 CFR 141.85(d).

Consumer Confidence Report (CCR)

All CWSs, irrespective of their lead levels, must provide an educational statement about lead in drinking water in their CCRs as required by 40 CFR 141.154. Must be in 2008 CCR (due July 1, 2009) if EPA is Primacy Agency, State adopts the rule by reference automatically, or adopts during 2008. Otherwise, this statement is required in the 2009 CCR (due July 1, 2010).

[1] This document provides a summary of federal drinking water requirements; to ensure full compliance, please consult the federal regulations at 40 CFR 141 and any approved state requirements.

[2] The June 1991 LCR was revised with the following Technical Amendments: 56 FR 32112, July 15, 1991; 57 FR 28785, June 29, 1992; 59 FR 33860, June 30, 1994.

It was subsequently revised by: the LCR Minor Revisions, 65 FR 1950, January 12, 2000; and the LCR Short-Term Revisions, 72 FR 57782, October 10, 2007.

Treatment Technique and Sampling Requirements if the AL is Exceeded[5]

[5] Based on 90th percentile level. Multiply number of valid samples by 0.9 (e.g., 10 samples x 0.9 = 9; thus, use 9th highest Pb and Cu test result to compare to AL). For 5 samples, average 4th and 5th highest results. For < 5 samples, use highest result.

Water Quality Parameter (WQP)	
Applicability	Refer to page 1.
Parameters	► pH, alkalinity, calcium *(initial only, unless calcium carbonate stabilization is used)*, conductivity *(initial monitoring only)*, orthophosphate *(if inhibitor is phosphate-based)*; silica *(if inhibitor is silicate-based)*, and temperature *(initial monitoring only)*.
Frequency	► Systems installing CCT, must conduct follow-up monitoring for 2 consecutive 6-month periods. ► WQP tap monitoring is conducted every 6 months, EPTDS monitoring increases to every 2 weeks. ► After follow-up monitoring, State sets OWQP specifications that define optimal C .
Reduced Tap Monitoring	► Collect reduced number of sampling sites (see Table 1) if meet OWQPs for 2 consecutive 6-month periods. ► Collect reduced number of sampling sites at reduced frequency if meet OWQPs for: - 6 consecutive 6-month monitoring periods can monitor annually; - 3 consecutive years of annual monitoring can monitor triennially.
Public Education (PE)	
Applicability	► Systems that exceed the Pb AL (*not required if only the Cu AL is exceeded*).
Purpose	► Educates consumers about lead health effects, sources, and steps to minimize exposure.
Delivery Method	► CWSs: deliver materials to bill-paying customers and post lead information on water bills, work in concert with local health agencies to reach at-risk populations (children, pregnant woman), deliver to other organizations serving "at-risk" populations, provide press releases, include new outreach activities from list in 40 CFR 141.85(a)(2)(vi), and post to Web site (CWSs serving > 100,000 only). ► NTNCWSs: posting and distribution to all consumers (can be electronic with State permission). Can apply to CWSs such as hospitals and prisons where population cannot make improvements.
Timing	► Within 60 days *after end of monitoring period* in which Pb AL was exceeded if not already delivering PE.[6] ► Repeat annually except: water bill inserts - quarterly; press releases - 2x/year, and Web posting - continuous. ► Can discontinue whenever ≤ Pb AL but must recommence if subsequently exceed Pb AL.
[6] State may allow extension in some situations. Also, State may require approval of message content prior to delivery.	
Source Water Monitoring and Source Water Treatment (SOWT)	
Applicability	► Systems that exceed Pb or Cu AL.
Purpose	► Determine contribution from source water to total tap water Pb and Cu levels and need for SOWT.
Timing	► One set of samples at each EPTDS is due within 6 months of first AL exceedance. ► System has 24 months to install any required SOWT. ► State sets maximum permissible levels (MPLs) for Pb and Cu in source water based on initial and follow-up source water monitoring.
Standard	► Ground water PWSs monitor once during 3-year compliance periods; surface water PWSs monitor annually.
Reduced	► Monitor every 9 years if MPLs are not exceeded during 3 consecutive compliance periods for ground water PWSs or 3 consecutive years for surface water PWSs.
Corrosion Control Treatment (CCT)	
Applicability	► All large systems except those meeting requirements of 40 CFR 141.81(b)(2) or (b)(3). ► Medium and small systems that exceed either AL; may stop CCT steps if ≤ both ALs for 2 consecutive 6-month periods but must recommence CCT if subsequently exceed either AL.
Study	► All large systems except as noted above. ► If State requires study for small or medium systems, it must be completed within 18 months.
Treatment	► Once State determines type of CCT to be installed, PWS has 24 months to install. ► Systems installing CCT must conduct 2 consecutive 6 months of follow-up tap and WQP monitoring.
OWQPs	► After follow-up Pb/Cu tap and WQP monitoring, State sets OWQPs. *Refer to WQP section above.*
Lead Service Line Replacement (LSLR)	
Applicability	► Systems that continue to exceed the Pb AL after installing CCT and/or SOWT. ► Can discontinue LSLR whenever ≤ Pb AL in tap samples for 2 consecutive 6-month monitoring periods; must recommence if subsequently exceed.
Monitoring	► Optional: Sample from LSL to determine if line must be replaced. If all samples are ≤ 0.015 mg/L, line is considered "replaced through testing"; must reconsider these lines if Pb AL is subsequently exceeded. ► Required: Sample from any LSLs not completely replaced to determine impact on Pb levels.
Replacement	► Must replace at least 7% of LSLs annually; State can require accelerated schedule. ► If only portion of LSL is replaced, PWS must: - Notify customers at least 45 days prior to replacement about potential for increased Pb levels. - Collect samples within 72 hours of replacement and provide results within 3 days of receipt.

For additional information on the LCR

Call the Safe Drinking Water Hotline at 1-800-426-4791; visit the EPA Web site at http://water.epa.gov/drink; or contact your State drinking water representative.

ATTACHMENT E

MDEQ Correspondence

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

May 13, 2016

«Name»
«Organization»
«Address1»
«Address2»
«City», «State» «Zip»

WSSN: «WSSN»

Attn: Water Supply Superintendent or Operator In Charge

SUBJECT: Lead and Copper Monitoring - «Supply»

This is a reminder that you are due to sample for lead and copper this year. Please collect all samples between **June 1, 2016, and September 30, 2016**. Results must be reported to this office no later than **October 10, 2016**. It is very important for you to follow the monitoring and reporting requirements in order to protect the health of those who consume your water. Please read the steps in their entirety as some instructions have recently changed.

Please complete the following steps:

1. Ensure confidence in your existing materials inventory by investigating service lines of unknown material, verifying previous assumptions about line material, and fully documenting a complete and accurate distribution system materials inventory as soon as possible. This inventory should include the location of lead "goosenecks" or "pigtails," the publically-owned portion of the service line between the water main and a either a connector line or the curb box. Compliance with this rule is based on an accurate distribution system materials inventory.

2. Review your existing sampling pool to ensure the required number of samples are collected from designated sample locations with the highest risk for contamination. Your sampling locations should be the same as previous monitoring periods unless they no longer meet the requirements of a priority site, or higher priority sites have been discovered. **Document the reason** for any changes and include this information in your report.

   Federal guidance now states that residences with lead goosenecks or pigtails are Tier 1 sites, although Tier 1 residences should be prioritized for inclusion in the designated sampling pool as follows:

   a. Residences with full lead service lines, then
   b. Residences with partial lead service lines, then
   c. Residences with lead goosenecks or other fixtures.

   As a reminder, samples must be collected from Tier 1 sites first, then Tier 2, then Tier 3. If there are not enough Tiered sites available, collect from sites where plumbing is representative of the water system. Tier designations are enclosed.

3. Instruct participating residents how to properly collect the sample according to the enclosed sampling instructions. You are encouraged to meet directly with each resident

in the sampling pool to review the sampling instructions with them. Take every precaution to ensure that sample chain-of-custody is protected.

4. Complete sample collection between June 1 and September 30 unless otherwise instructed. The DEQ recommends sampling early in the monitoring period to ensure deadlines are met.

5. If you suspect a sample was not collected properly, do not send that sample to the lab for analysis. Ask the resident to collect another sample with a new bottle and explain the importance of proper sampling.

6. If a sample was analyzed prior to determining improper collection techniques were used, you must still report these results; however, you may request sample invalidation from the DEQ by providing supporting evidence. An invalid sample meets any of the following criteria:

    a. Laboratory analysis caused erroneous results.
    b. Sample site did not meet site criteria.
    c. Container was damaged in transit; or
    d. Substantial reason to believe the sample was subject to tampering.

    Requests to exclude a sample from the 90th percentile calculation will be carefully reviewed by the DEQ and will not be approved unless strongly supported by the evidence provided. Please note that an unusually high or low result or excessive stagnation time are not valid reasons for sample exclusion.

7. Include in the 90th percentile calculation all samples that are collected and analyzed:

    a. During the designated monitoring period.
    b. At a designated sampling site or one that fits into appropriate Tiers.
    c. According to proper methods; and
    d. Not specifically invalidated by the DEQ.

    All sample results should be submitted to the DEQ regardless of whether they are collected for compliance monitoring.

8. Deliver **individual** results and consumer notice language to the residents of the sampled sites as soon as possible, but no later than 30 days after receipt of the results. The DEQ recommends that you provide additional assistance to homes exceeding an action level. Using the DEQ Consumer Notice of Lead in Drinking Water form is highly recommended since it contains all required reporting language.

9. Send the Lead and Copper Reporting Form and copies of laboratory results for each sample, to the DEQ within ten (10) days after the end of the monitoring period (October 10 unless otherwise instructed). Failure to report on time and include all required information may result in a reporting violation and potential fines.

10. Send **one** copy of a completed Consumer Notice of Lead in Drinking Water form with certification that all notices were delivered as required to the DEQ within three (3)

months after the end of the monitoring period (no later than December 29th unless otherwise instructed).

11. Report your lead and copper 90th percentiles if they are above zero in your annual Consumer Confidence Report.

Finally, we encourage you to take proactive measures to provide lead and copper educational information to all consumers and to increase your transparency and assistance to the public in all matters regarding lead and copper in drinking water.

If you have questions about lead and copper monitoring, please contact me at 989-705-3422; gohlkeh@michigan.gov; or DEQ, Office of Drinking Water and Municipal Assistance, 2100 West M-32, Gaylord, Michigan 49735. If you have other questions regarding your water system, please continue to directly contact your district engineer or analyst. Also, please continue to submit all future reporting documents to your district office.

Thank you for your continued effort to ensure the drinking water is safe for your residents. For more information, and to find forms referenced in this letter, visit http://www.michigan.gov/drinkingwater.

Sincerely,

Holly Gohlke, R.S., M.S.A.
Environmental Quality Specialist
Community Drinking Water Unit
Field Operations Section
Gaylord Field Office
Office of Drinking Water and Municipal Assistance
Fax: 989-731-6181

Enclosures

DRINKING WATER LEAD AND COPPER SAMPLING INSTRUCTIONS

Dear Resident:

Thank you for helping to monitor for lead and copper in your drinking water. This sampling is required by the federal and state Safe Drinking Water Acts, and is being accomplished with the cooperation of homeowners, residents, and water system customers.

It is important that you follow these instructions so we obtain an accurate measurement of the lead and copper in your drinking water. This sample should represent the water you would typically drink and the faucet from where you drink the water. Call your water supplier if you have questions.

1. Water must sit idle in the pipes for an extended length of time before sampling. Therefore, do not use any water in the house for at least 6 hours before sampling. The best times to sample are early morning or after returning from work.

2. Select an unfiltered/untreated faucet in the **KITCHEN** or **BATHROOM** that is commonly used for drinking. **DO NOT** sample from a laundry sink or a hose spigot as these samples cannot be used for compliance. **DO NOT** use a faucet that has a filter attached to it unless you bypass the filter. **DO NOT** use a faucet that is connected to a home water treatment device (like a water softener, iron filter, reverse osmosis) unless you bypass the home water treatment device.

3. Place the open sample bottle below the faucet and gently open the **COLD** water tap. If you have a single handle faucet, turn it fully to the **COLD** side. Fill the sample bottle to the neck with the "first draw" of **COLD** water.

4. Tightly cap the sample bottle and place in the sample kit provided. Review the sample kit label to ensure all information contained on the label is complete and correct.

5. Answer the questions on the back of this form and sign the form.

6. Attach this form to the bottle and leave it outside your front door for pick-up.

7. Thank you again for your help. We will send you your individual results within 30 days of receiving them from the laboratory. A summary of information on this year's lead and copper monitoring will be printed in the annual water quality report that will be made available by July 1 of next year. Contact your water supplier if you have questions.

If you have questions call:
Water Supplier: _____

Manager or
Water Operator: _____

Phone: _____

Or Contact:
Michigan Department of Environmental Quality

DEQ Contact: _____

Phone: _____

TO BE COMPLETED BY RESIDENT/CUSTOMER

A. Which faucet did you use to fill the bottle?

☐ Kitchen ☐ Main bathroom ☐ Other

If OTHER, please describe: _____

_____

B. When was the faucet last used before sampling?

Date _____ TIME _____ AM/PM

C. When did you fill the bottle?

DATE _____ TIME _____ AM/PM

D. Is there a faucet mount filter? ☐ YES ☐ NO

If YES, was it bypassed? ☐ YES ☐ NO

E. Is this faucet connected to a home treatment device such as a water softener, a filter, a reverse osmosis unit, an iron removal device OR any other kind of treatment?

☐ YES ☐ NO

If YES, please describe: _____

_____

F. If any plumbing repairs or replacement has been done in the home since the previous sampling event, please note this information here:

If YES, please describe: _____

_____

I have read the Drinking Water Lead and Copper Sampling Instructions and have taken a tap sample in accordance with these directions.

_____

Signature

_____

Date

Lead and Copper Rule
Sample Site Selection Criteria

Based on a distribution system materials evaluation, community water supplies must identify a pool of lead and copper sampling sites large enough to ensure a sufficient numbers of sites are available for sampling. The sampling pool must target high risk sites using the criteria below.

- Samples must be collected from **Tier 1** sites, unless
- insufficient Tier 1 sampling sites are available, then **Tier 2** sites must be used, unless
- insufficient Tier 1 and Tier 2 sampling sites are available, then **Tier 3** sites must be used.
- If no Tier 1, 2, or 3 sites are available, sampling sites must be representative of plumbing materials typically found throughout the water system.

TIER 1 SITES - Single family residence with: o Lead service lines* o Copper plumbing with lead solder installed after 1982 and before 1989 o Interior lead plumbing o Multiple family residences (MFR) may be used as Tier 1 sites when MFR comprise at least 20 percent of the total service connections.
TIER 2 SITES - Buildings or MFR with: o Lead service lines* o Copper plumbing with lead solder installed after 1982 and before 1989 o Interior lead plumbing
TIER 3 SITES - Single family residence with: o Copper plumbing with lead solder installed before 1983
OTHER SITES o Sites representative of plumbing materials commonly found throughout the water supply.

*** If a water system has lead service lines (LSL), at least 50 percent of the sampling sites must have an LSL. EPA has clarified that sites with lead goosenecks or pigtails (commonly defined as the publically-owned portion of the service line between the water main and a either a connector line or the curb box) should be considered Tier 1 sites. Priority should be placed on sites with full LSLs, followed by partial LSLs, followed by lead goosenecks.**

Also Note:

- Each round of sampling should be conducted at the same sampling sites. If an original sampling site is not available, you should collect a tap sample from another site meeting the same Tier criteria as the original site and document the reason for the change.
- For residential sites, samples must be collected from kitchen or bathroom taps typically used for consumption. For non-residential sites, samples must be collected from taps typically used for consumption. Do not sample from outside hose spigots or utility sinks.
- Samples may not be taken from taps that have point of use or point of entry treatment devices designed to remove inorganic contaminants, such as a water softener.

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

May 13, 2016

Attn: Water Supply Superintendent or Operator in Charge

SUBJECT: Impact of Construction Activity on Drinking Water Quality

This letter is to advise water supplies about the potential impact of construction activity on localized drinking water quality, particularly from ground disturbance in the area of existing lead service lines. Recent research has indicated that vibrations from construction activity can cause particulate lead to dislodge from service lines and temporarily contribute to elevated lead levels in drinking water. The Department of Environmental Quality (DEQ) is committed to assisting water supplies in lowering risks associated with lead in drinking water and protecting public health.

The following best practices are advised:

1. Ensure confidence in your existing materials inventory by investigating service lines of unknown material, verifying previous assumptions about line material, and fully documenting a complete and accurate distribution system materials inventory as soon as possible.

2. Avoid partial lead service line replacements that leave any portion of lead line in place, including lead "goosenecks." A gooseneck, or pigtail, is the publically-owned portion of the service line between the water main and either a connector line or the curb box. Partial lead service line replacements may result in elevated lead levels in drinking water.

3. Prior to undertaking any construction activity in an area with lead service lines, contact all potentially-affected residents and provide them with information that will help reduce their risk. The enclosed brochure advises potentially impacted residents to:

    a. Flush pipes after construction activity, prior to consuming drinking water.
    b. Clean faucet aerators to remove any dislodged lead particles, and,
    c. Potentially use a water filter following construction activities, particularly if pregnant, nursing or have children under the age of six.

4. After construction activities are complete and preventative measures have been taken, consider offering to test residents' drinking water for lead to ensure the risk has been abated.

The DEQ encourages water supplies to engage their customers in a solution to eliminate both customer-owned and supply-owned portions of remaining lead service lines. While this may be a significant challenge for many communities, consider the following possible methods to assist in this effort:

- Pursue ordinances or other legal authorities to access and modify customer-owned portions of the distribution system.

- Explore availability of Drinking Water Revolving Fund loans for lead service line replacements.
- Provide low interest loans or other incentives for residents to replace their portion of lead service lines.

Above all, you are urged to carry out water distribution system activities in a fully transparent manner, providing general information to the public proactively and responding to individual requests for information responsively.

If you have any questions, please contact your district engineer or analyst. Thank you for your continued effort to ensure the drinking water is safe for your residents. For more information, visit the Web site at: http://www.michigan.gov/drinkingwater.

Sincerely,

Mary Ann Dolehanty

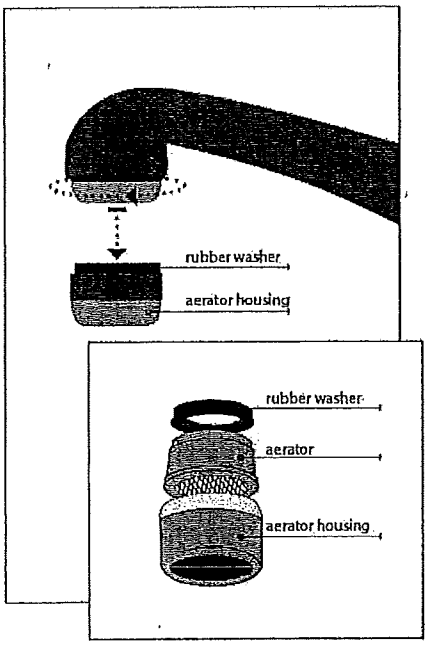
Mary Ann Dolehanty, Interim Chief
Office of Drinking Water and Municipal Assistance

Enclosure

CONSTRUCTION ACTIVITY COULD AFFECT YOUR DRINKING WATER QUALITY

State of Michigan
Environmental Assistance Center
800-662-9278 | *deq-assist@michigan.gov*

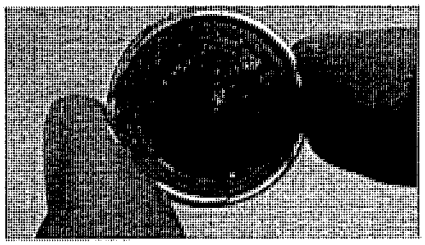
Upcoming construction activity in your neighborhood could affect your drinking water quality. We anticipate this project will proceed smoothly, with every effort made to minimize any inconvenience to you during construction.



Our records indicate that in your neighborhood, some of the pipes connecting homes to the water mains may be made of lead. Lead service lines can increase your risk of exposure to lead through drinking water, especially when the ground is disturbed close to your home. This increased risk is because the ground disturbance could cause particulates to shake free from inside the network of underground pipes. Your water may appear discolored.

During this construction and until lead service lines are replaced, you should take precautions to minimize exposure to lead in your drinking water by taking the following actions:

Clean your faucet aerator. The aerator on the end of your faucet is a screen that will catch debris. This debris could include particles of lead which have fallen off the insides of lead pipe. The aerator should be removed at least monthly to rinse out any debris. During this upcoming construction activity, check your aerator more often. Start by checking it weekly and if no debris is present, return to a monthly schedule.



Aerator with sediment

Flush your pipes before drinking. The longer water sits in your home piping, the more lead may leach from lead-containing pipes, solder or brass fixtures. Anytime a faucet used for drinking or food prep has not been used for six hours or longer, the tap should be "flushed" by turning on the cold water and letting it run until it is as cold as possible. Flushing should not take long (5-30 seconds) if there has been routine daily water use. If there has not been recent daily water use, it could take two minutes or longer for the water to become cold. Your water utility can tell you if longer flushing times are needed if you do not get cold water in a few minutes.

Do not boil water to remove lead. Boiling will not remove the lead.

Use a filter. You may also wish to use a home filter for water to be used for drinking and cooking, particularly if you are pregnant or have children under age six. This equipment is especially important if you are making baby formula. Make sure the filter is certified for lead removal. Be sure to replace a filter device as often as the manufacturer recommends. Contact NSF International at 800-NSF-8010 or visit their website at *www.nsf.org* for water filter performance standards.

Information about lead service lines, as well as important information about the harmful effects of lead and steps you can take to protect against lead exposure, is available on our website at ***www.michigan.gov/deq*** or call the Environmental Assistance Center at **800-662-9278**.

DEQ

05/2016

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
KALAMAZOO DISTRICT OFFICE

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

June 8, 2016

City of Kalamazoo
Mr. James Ritsema, City Manager
241 W. South Street
Kalamazoo, MI 49007

WSSN: 03520

Dear Mr. Ritsema:

SUBJECT: Monitoring requirements in association with the Lead and Copper Rule at the City of Kalamazoo

The Department of Environmental Quality, Office of Drinking Water and Municipal Assistance (ODWMA), has reviewed the historical lead copper file, and has determined that the city of Kalamazoo (Kalamazoo) is not currently sampling for water quality parameters in accordance with the Safe Drinking Water Act 1976 PA 399, as amended (Act 399); R325.10710b *Monitoring requirements for supplies exceeding lead and copper action levels;* of the 1979 Administrative Code. Besides requirements for systems exceeding the lead and copper action levels, this rule also includes the requirements for water quality parameter monitoring and additional requirements for large water supplies. This letter serves to inform you of changes to your water quality parameter monitoring requirements.

The Kalamazoo water system serves the city of Kalamazoo, portions of Comstock, Cooper, Oshtemo, Pavilion, Texas, Richland, and Kalamazoo Townships, and a portion of the city of Portage. For the purposes of the lead and copper rule, the entire distribution system is considered one combined water supply serving approximately 150,000 people. This qualifies Kalamazoo as a large system under R 325.10710a *Lead and copper in tap water; monitoring requirements.*

Based on the ODWMA review of the historic Kalamazoo lead and copper, and correspondence files, it appears that Kalamazoo has been sampling water quality parameters at primary pumping/well stations every two weeks, if they are in operation the day sampling occurs. It also appears that Kalamazoo has not been collecting water quality parameters in the distribution system. Due to the discovery of the existing/historic sampling not meeting the requirements of R325.10710b, any reduced or previously agreed upon water quality parameter sampling is revoked, and you must begin routine monitoring.

In accordance with R325.10710b(5)(b) "a large water supply that installs optimal corrosion control treatment shall measure the water quality parameters at each entry point (plant tap) to the distribution system, at least 1 sample at least every 2 weeks for each of the following: pH, Alkalinity, orthophosphate dosage rate and orthophosphate residual." Additionally, the ODWMA is requesting Kalamazoo also measure the chloride and sulfate, along with the other parameters, in order to determine the chloride-sulfate mass ratio.

Also, in accordance with R325.10710b(5)(a) "a large water supply that installs optimal corrosion control treatment shall measure the water quality parameters, at taps (within the distribution system) during each 6 month monitoring period, two samples for pH, alkalinity, and orthophosphate residual. Rule 325.10710b(3)(a) requires that the tap samples are measured at a minimum of 25 sites throughout the distribution system. The two samples from each of the 25

sites should be spread evenly throughout the 6 month monitoring period. Because the Kalamazoo system is divided into pressure districts, it is recommended that distribution water quality parameter samples are distributed as follows:

H-7 sites, L-6 sites, INT-6 sites, ESH-1 site, UH-1 site, SH-2 site and NWH-2 site.

In summary, please begin monitoring as indicated below, starting **July 1, 2016**:

1. Sample every entry point to the distribution system (station) every two weeks for pH, alkalinity, orthophosphate dosage, orthophosphate residual, chloride and sulfate. If the station is in operation during the two-week monitoring period, it must be sampled. If the station is down for maintenance or does not operate for some reason, please indicate the reason the station was not sampled on your report.
2. Add daily orthophosphate plant tap residual readings for each station to your monthly operating report (MOR).
3. Add orthophosphate residual readings at bacteria sampling locations in the distribution system to your MOR.
4. Sample 25 sites in the distribution system at least two times during a six-month period for pH, alkalinity, and orthophosphate residual. Samples should be distributed throughout pressure districts as follows: H-7 sites, L-6 sites, INT-6 sites, ESH-1 sites, UH-1 sites, SH-2 sites and NWH-2 sites. We recommend collecting the samples during the months when disinfection byproduct samples are collected; thus, sampling roughly every quarter (one set of 25 sample readings in August, and one set of 25 sample readings in November).
5. All data collected in a month can be submitted with that month's MOR.

will need to be added to daily & monthly

this will probably be done by Shannon

The data will be utilized to determine compliance with Act 399, determine future sampling needs, and provide assistance in determining an applicable orthophosphate residual range for each station.

Thank you for your cooperation on this important matter, and please do not hesitate to contact me at bishoph@michigan.gov, or at the number below should you have any questions.

Sincerely,

Heather Bishop

Heather Bishop, REHS
Kalamazoo District Office
Office of Drinking Water and Municipal Assistance
269-330-9153

HB:ne

cc: James Baker, Interim Director Public Services
John Paquin, Water Resources Division Manager
Tom Spitzner, Operator in Charge
Shannan Deater, Lab Manager

ATTACHMENT F

Tetra Tech Draft Report

“Desktop Corrosion Control Chemical Analysis”

MEMORANDUM

To:	Steve Skalski, P.E. Senior Civil Engineer City of Kalamazoo
From:	James Christopher, P.E. Vic Cooperwasser, P.E. Andrea Netcher, PhD, E.I.
Date:	August 31, 2016
Subject:	**City of Kalamazoo** **Desktop Corrosion Control Chemical Analysis**
Tt #:	200-19743-16001

DRAFT

BACKGROUND AND PURPOSE

The City of Kalamazoo (City) has been feeding sodium hexametaphosphate which has acted as a sequestering agent for iron, manganese and calcium as well as a corrosion control measure. The City has installed iron removal facilities at some of their supply facilities and the requirement for sequestration of iron and calcium has become a secondary concern compared to the need to continue to maintain adequate corrosion control within the system at those facilities. The City is considering changing to a liquid corrosion control chemical for ease of application and in an effort to provide a higher level of corrosion control against lead and other metallic components in the distribution system. Therefore, the City would like to have a recommendation relative to the product(s) that would be appropriate for their system.

SCOPE

The City contracted with Tetra Tech to perform a desktop analysis and review of the current corrosion control practices to provide a recommendation for a liquid phosphate corrosion inhibitor. Tetra Tech's scope of services included the following tasks:

1. Review of recent lead and copper tap sampling results to determine the level of corrosion control provided by the current practices relative to lead and copper corrosion to establish a base line of performance.
2. Review of water quality from each of the sources individually and of blends, as appropriate to simulate mixing of waters from different sources to determine the calcium carbonate saturation index and precipitation potential of the source waters and blends. Calculation of the Larson-Skold indices for each of the sources and blends as a comparison of their relative corrosion potential toward iron and steel.

Tetra Tech
710 Avis Drive, Suite 100 Ann Arbor, MI 48108
Tel 734.930.7500 tetratech.com

3. Use the water quality information provided and the flow charts contained in "Lead Control Strategies" AWWARF, 1990 and Revised Guidance Manual for Selecting Lead and Copper Control Strategies USEPA, March, 2016 to compare current practices to recommended treatment options for lead and copper corrosion control. Using the water quality of the individual sources and blends to determine the existing level of corrosion control provided by phosphate addition and the dose that would be required using orthophosphate to achieve a theoretical lead solubility of 0.015 mg/L.
4. Use the above information and information from corrosion control treatment manufacturers to develop recommendations for the type and dose of product to replace the existing sodium hexametaphosphate chemical.

EXISTING SYSTEM AND FACILITIES

The City of Kalamazoo supplies drinking water to City residents and the majority of Kalamazoo County through an interconnected distribution system. The City's system is complex consisting of nine (9) different pressure districts supplied by sixteen (16) water pumping stations. Additionally, the system contains sixteen (16) booster and bleeder stations that are capable of transferring water between the pressure districts. A summary of the City's water system is provided in **Table 1**. The City's service area map containing the pressure district zones and corresponding stations is included in **Attachment A**.

With the exception of the West Side High and West Side Low districts, water is supplied to each water pumping station from either a single or a combination of groundwater wells. At each station, the treatment scheme consists of chlorination for disinfection, fluoridation, and sodium hexametaphosphate addition for sequestering iron and providing corrosion control. Stations No. 1 and No. 11 provide additional treatment to remove iron. The same range of chemical feed doses are applied at the pumping stations; however, Station #24 applies a slightly higher dose of sodium hexametaphosphate. The chemical dose ranges for each water pumping station is provided in **Table 2**.

Table 1. City of Kalamazoo Water System

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
Low	Station #1	1-1	9.72	8.64	• 7 MG Ground Storage Tank • Cast Iron and Ductile Iron Water Mains
	Station #2	2-1	2.88	1.73	
	Station #3	3-1 3-2A 3-3 3-4 3-5 7-3 7-4 7-5	4.03	2.74	
Intermediate	Station #5	5-1A 5-2A 5-3A 5-4A	1.73	1.73	• 0.5 MG Elevated Storage Tank • Cast Iron and Ductile Iron Water Mains
	Station #14	14-1 14-2 14-3 14-4	2.30	2.30	

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
		14-5			
High	Station #4[1]	4-1 4-2 4-3 4-4 4-5 4-6 4-7 4-8 4-9 4-10	6.34	3.00	• 0.35 MG and 0.75 MG Elevated Storage Tanks • Cast Iron and Ductile Iron Water Mains
	Station #8	8-1 8-2 8-3 8-4 8-5	3.46	2.50	
	Station #9	9-1 9-2 9-3A 9-4A 9-5 9-6 9-7 9-8 9-9 9-10 9-11 9-12	4.03	2.50	
	Station #12	12-1B 12-2A 12-3B 12-4A	1.73	1.73	
	Station #17	17-1	1.01	1.01	
	Station #18	18-1 18-2	1.80	1.80	
	Station #39	39-1 39-2	3.74	2.74	
East Side High	Station #25	25-1 25-2 25-3 25-4 25-5 25-6	6.48	2.00	• 1.5 MG Elevated Storage Tank • Cast Iron and Ductile Iron Water Mains

Pressure District	Station No.	Well No.	Station Design Capacity (MGD)	Station Managed Capacity (MGD)	Storage Facilities and Distribution
		25-7 25-8 25-9			
Northwest High	Station #11[(2)]	11-1 11-2 11-3 11-4 11-5 11-6 11-7	2.59	2.59	• 1.5 MG Elevated Storage Tank • Cast Iron and Ductile Iron Water Mains
Super High	Station #22	22-1 22-2 22-4 22-5 22-6	3.17	3.17	• 1.5 MG Elevated Storage Tank • Ductile Iron Water Mains
	Station #24	24-1 24-2 24-5 24-6 24-7 24-8 24-9 24-10 24-11 24-12 24-14A 24-15 24-16 24-17A 24-18A	10.94	5.00	
Ultra High	Booster/bleeder stations supply water from Super High and Northwest High				• 1.0 MG Elevated Storage Tank • Ductile Iron Water Mains
West Side High	Booster/bleeder stations supply water from Super High				• Ductile Iron Water Mains
West Side Low	Booster/bleeder stations supply water from Super High				• Ductile Iron Water Mains

(1) Station is capable of discharging to Low.
(2) Station is capable of discharging to Northwest High.

Table 2. Treatment Chemical Dosages

Treatment Chemical	Typical Dose Range
Chlorine	0.8 to 1.3 mg/L
Fluoride	0.7 mg/L
Sodium hexametaphosphate	1.0 to 1.5 mg/L
Sodium hexametaphosphate at Station #24	2.0 to 2.5 mg/L

WATER QUALITY REVIEW

Water Quality Data

The City provided raw well water quality data from each of the water pumping stations to assist in characterizing the chemistry and corrosion potential of the groundwater sources. A summary of the average water quality data for the water supply wells is provided in **Table 3**. Blending of the waters, determining the water quality after chemical dosing, and calculating of the Langelier Saturation Index (LSI) were performed using a spreadsheet model based on the equations contained in Standard Methods 2330B. The Tetra Tech (RTW) Model for Water Process & Corrosion Chemistry was used to calculate the calcium carbonate precipitation potential.

As presented in **Table 3**, the City's groundwater sources are rich in alkalinity and hardness. Based on the data reviewed, average alkalinity ranges between about 200 and 340 mg/L as $CaCO_3$; and total hardness concentrations are greater than about 300 mg/L as $CaCO_3$. The corresponding dissolved inorganic carbon (DIC) ranges from approximately 60 to 110 mg/L C. The station water quality data shows that the pH levels vary through the system. On average, the majority of the stations have a pH range from about 6.5 to 7.2 pH units, while 5 of the 16 stations have higher pH values between 7.2 and 8.1 pH units.

The majority of the water supply wells are characterized by elevated iron and manganese levels. The secondary maximum contaminant levels (MCLs) for iron and manganese are 0.3 mg/L and 0.05 mg/L, respectively. With the exception of Stations No. 14, 22, and 25, the iron levels at the stations were greater than the secondary MCL of 0.3 mg/L. Similarly, the source water manganese concentrations were higher than the secondary MCL with the exception of Station No. 24. Iron removal treatment is provided at Stations No. 1 and 11. Polyphosphate can be applied to sequester iron and manganese and prevent possible color, particulate, taste, and staining issues in the drinking water distribution system.

On average, the lead and copper levels in the groundwater supply were less than about 0.006 mg/L and 0.045 mg/L, respectively. Based on these source water concentrations, the source water does not significantly contribute to lead and copper levels measured during regulatory tap sampling.

The City conducted a round of water quality sampling from each of the water pumping stations on June 30, 2016. The water quality parameters analyzed included chloride, fluoride, hardness, iron, nitrate, nitrite, sodium, and sulfate. Additional water quality parameters, including antimony, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, selenium, and thallium, were tested for Station 9. In addition to this sampling data, the City provided their water quality monitoring reports for the months of May and June 2016, which include the pH, ortho-phosphate, and sodium hexametaphosphate levels from the online water pumping stations. The water quality results from the June 30th sampling and monitoring reports is provided in **Attachment A**. These additional water quality data sets were used to supplement the raw well water quality summarized in **Table 3**.

In this complex inner-connected distribution system, there can be numerous iterations of source water blending scenarios. Therefore, we performed a blending analysis of adjacent station pairs. To simulate this probable mixing of the water supplies in the distribution system, the water quality from adjacent stations were blended in 25% increments. A general description of the blend ratios are summarized as follows:

- 100% Station A and 0% Station B
- 75% Station A and 25% Station B
- 50% Station A and 50% Station B
- 25% Station A and 75% Station B
- 0% Station A and 100% Station B

The composite water quality of each of these blends were calculated for 23 adjacent station pairs and is presented in **Tables A-1** through **A-23** of **Attachment A**. Interestingly for some of the combination of adjacent pairs, blended pH levels were found to be slightly higher than individual station pH levels. This pH change is likely due to a shift in carbonate species towards bicarbonate as waters are blended.

Lead and Copper Sampling

In 1991, the Environmental Protection Agency (EPA) promulgated the Lead and Copper Rule (LCR) to minimize lead (Pb) and copper (Cu) levels in drinking water. Most utilities have low levels of lead and copper in the water entering the distribution system; however, it was determined that waters that were corrosive toward lead and copper could contribute significant concentrations of these constituents at the consumer's tap where lead, copper, and brass components were present in the service lines and plumbing system. The 1991 LCR, and subsequent revisions, establishes an action level (AL) of 0.015 mg/L for lead and 1.3 mg/L for copper based on the 90th percentile level of water samples collected at the tap within the business or residential structure. It's important to note that action level exceedance is not considered a violation; however, a 90th percentile exceedance of the action level triggers additional requirements, including water quality monitoring, corrosion control treatment, source water monitoring or treatment, public education, and lead service line replacement. The results of the City's lead and copper sampling have not exceeded the action levels and the City is under reduced monitoring on a triennial basis.

The City provided their lead and copper monitoring results from 2002, 2005, 2008, 2011, and 2014. The lead and copper testing results were reviewed and compared by sampling location. The comparisons between the 2002 through 2014 lead and copper testing results are presented in **Figures 1 and 2**, respectively. Lead and copper concentrations that were less than the laboratory detection limit (<3 µg/L for lead and <20 µg/L for copper) were assigned a value equal to the detection limit so that they would show up on the graph and locations with no concentration value indicate that a sample was not collected from that location during that sampling period. A summary of the 90th percentile lead and copper concentrations, upon which the regulations are based, is provided in **Table 4**.

Table 3. Water Quality Results

Parameter	Unit	Station 1	Station 2	Station 3	Station 4	Station 5	Station 8	Station 9	Station 11	Station 12	Station 14	Station 17	Station 18	Station 22	Station 24	Station 25	Station 39
Alkalinity	mg $CaCO_3$/L	NA	311	NA	NA	338	264	225	258	262	285	251	257	233	197	261	254
Alkalinity After Chem	mg $CaCO_3$/L	NA	308	NA	NA	335	261	223	255	259	282	248	254	230	194	258	251
Ammonia Nitrogen	mg/L	NA	0.083	NA	NA	0.168	0.191	0.087	0.243	0.114	0.062	0.151	0.123	0.026	0.177	0.110	0.274
Arsenic*	µg/L	6	3	2	7	2	10	6	2	8	2	4	3	2	2	1	4
Bicarbonate, calc'd	mg/L	NA	375	NA	NA	408	318	271	311	313	344	302	310	280	237	314	306
Calcium*	µg/L	NA	110,150	98,143	82,557	106,000	87,580	67,425	85,800	72,600	99,840	86,150	80,400	68,400	55,193	80,867	88,800
Carbonate, calc'd	mg/L	NA	0.4	NA	NA	0.2	0.2	0.1	0.1	1.4	0.1	0.3	0.1	0.3	0.1	0.3	0.2
CO_2, calc'd	mg/L	NA	37	NA	NA	77	38	92	152	6	152	56	62	26	100	49	49
Chloride*	mg/L	NA	110.1	10.0	NA	66.5	65.1	52.9	64.0	27.6	79.9	19.4	33.7	17.3	16.0	15.9	24.5
Conductivity*	umhos/cm	NA	888	878	727	916	752	626	741	625	836	543	595	524	441	597	623
Copper*	µg/L	NA	45	20	21	20	20	20	20	23	20	22	20	20	20	20	28
DIC, calc'd	mg C/L	NA	84	NA	NA	101	73	78	103	63	109	75	78	62	74	75	74
Dissolved Oxygen*	mg/L	NA	2.3	1.5	1.9	4.0	3.5	1.6	1.6	2.3	5.1	1.6	3.2	3.5	1.5	4.7	1.8
Fluoride*	mg/L	0.98	0.59	NA	NA	0.13	0.13	0.09	0.13	0.17	0.06	0.17	0.09	0.11	0.09	0.08	0.15
Iron*	µg/L	NA	877	930	1,797	664	1,360	2,081	843	665	275	1,444	1,080	212	990	83	221
Lead*	µg/L	NA	2.6	3.0	3.0	3.0	5.0	3.0	3.0	3.0	3.0	2.3	3.0	3.0	5.9	3.0	3.0
Magnesium*	µg/L	NA	35,500	32,014	28,586	31,650	30,460	24,583	32,957	28,800	29,320	22,650	23,700	26,060	19,567	25,378	19,011
Manganese*	µg/L	NA	152	106	231	328	236	193	132	64	139	359	150	168	42	75	118
Nitrate Nitrogen	mg/L	0.44	0.34	NA	NA	1.00	0.10	0.10	0.10	0.10	1.18	0.09	0.10	1.06	0.10	1.34	1.40
Nitrite Nitrogen	mg/L	NA	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
Ortho Phosphorous	mg/L	NA	0.09	NA	NA	0.10	0.10	0.10	0.10	0.10	0.10	0.14	0.10	0.10	0.10	0.10	0.07
pH	pH units	NA	7.30	6.87	6.90	6.98	7.16	6.72	6.54	8.11	6.59	7.24	6.95	7.38	6.67	7.13	7.12
pH after Chem Add	pH units	NA	7.25	NA	NA	6.96	7.13	6.70	6.53	7.93	6.58	7.18	6.93	7.32	6.65	7.10	7.10
Silicate*	µg/L	NA	8,426	5,271	7,214	15,300	16,200	12	13,114	16	13,340	6,205	15,550	13,160	13,593	13,811	7,894
Sodium*	µg/L	49,000	65,250	36,343	27,614	33,625	25,500	28,433	23,943	10,525	38,280	7,460	12,550	5,940	8,400	8,511	14,955
Sulfate*	mg/L	44.5	54.3	NA	NA	53.0	44.0	20.9	35.3	35.0	33.0	26.4	21.0	32.2	15.5	35.8	32.3
Temperature	C°	NA	14.0	NA	NA	13.7	12.5	12.8	11.6	12.9	13.1	12.2	11.3	10.3	11.8	13.2	12.0
Temperature	F°	NA	57.1	NA	NA	57.2	54.6	55.1	52.8	55.2	55.6	54.0	52.3	50.6	53.3	55.7	53.6
Total Dissolved Solids	mg/L	NA	561	555	460	618	501	378	446	359	539	344	360	290	284	433	392
Total Hardness	grains/gal	NA	22	NA	NA	27	24	19	23	22	24	20	21	19	16	20	17
Total Hardness	mg/L $CaCO_3$	NA	371	NA	NA	462	417	NA	398	368	NA	347	359	328	NA	NA	294
Zinc*	µg/L	NA		24	43	20	29	NA	20	20	NA	13	20	20	NA	NA	15

*Parameters analyzed by Kar Laboratories of Kalamazoo. NA = Not Available (not analyzed for this parameter). DIC = Dissolved Inorganic Carbon. Calc'd = Calculated Value. Chem = Chemical Addition

Table 4. Lead and Copper 90th Percentile Concentrations

Year	Lead 90th Percentile Conc. (ppb)	Copper 90th Percentile Conc. (ppb)
2002	12.5	408
2005	9	745
2008	9.5	681
2011	6	732
2014	9	1,145

The lead and copper 90th percentile concentrations were below the action levels of 15 ppb and 1,300 ppb, respectively, at which the Lead and Copper Rule would require further action by the utility. As shown in **Figure 1**, the majority of the lead tap sampling results were below the lead laboratory detection limit of 3 ppb. Lead concentrations greater than the 15 ppb action level were observed during the 2002, 2005, 2008, and 2014 sampling years. Nevertheless, the 90th percentile concentration in each year remained below the 15 ppb action level.

As illustrated in **Figure 2**, the copper tap sampling results were below the copper action level of 1,300 ppb with the exception of two locational results in 2014. Even with the higher copper concentrations at these locations, the 90th percentile concentration remained below the copper action level in 2014. As compared to the lead compliance data, the copper tap sampling concentrations appear to have fluctuated more between sampling locations, particularly during the most recent 2014 sampling round. The 2014 sampling round had a higher 90th percentile copper concentration as compared to previous sampling years.

To examine the spatial variation in the lead and copper tap sample results, the data was plotted on an aerial map for each year. A composite of all years of the lead and copper sampling data is shown in **Figures 3** and **4**, respectively. The plotted lead and copper data for individual years is included in **Attachment B**. As shown in **Figures 3** and **4**, higher lead and copper levels occurred at individual tap sampling locations near Stations No. 1, 2, 3, 4, 5, 11 and 14. Generally, the higher concentrations were found in the west part of the low pressure zone, the intermediate pressure zone, the high pressure zone in the vicinity of Station 4, and the northwest high pressure zone.

Of the sampling locations with elevated lead levels, the lead concentration fell above the action level near Stations No. 1, 2, 3, 4, 11 and 14. Similarly, the measured copper concentration was greater than the action level near Stations No. 1, 2, 3 and 11. The majority of these stations had average pH levels less than 7. The higher concentrations found in these areas may be due to the water quality in these locations, but tap sampling is not performed under controlled conditions and therefore, other factors such as age of the structures, service and plumbing materials of construction, water use and age and sampling procedure may be a primary or contributing cause.

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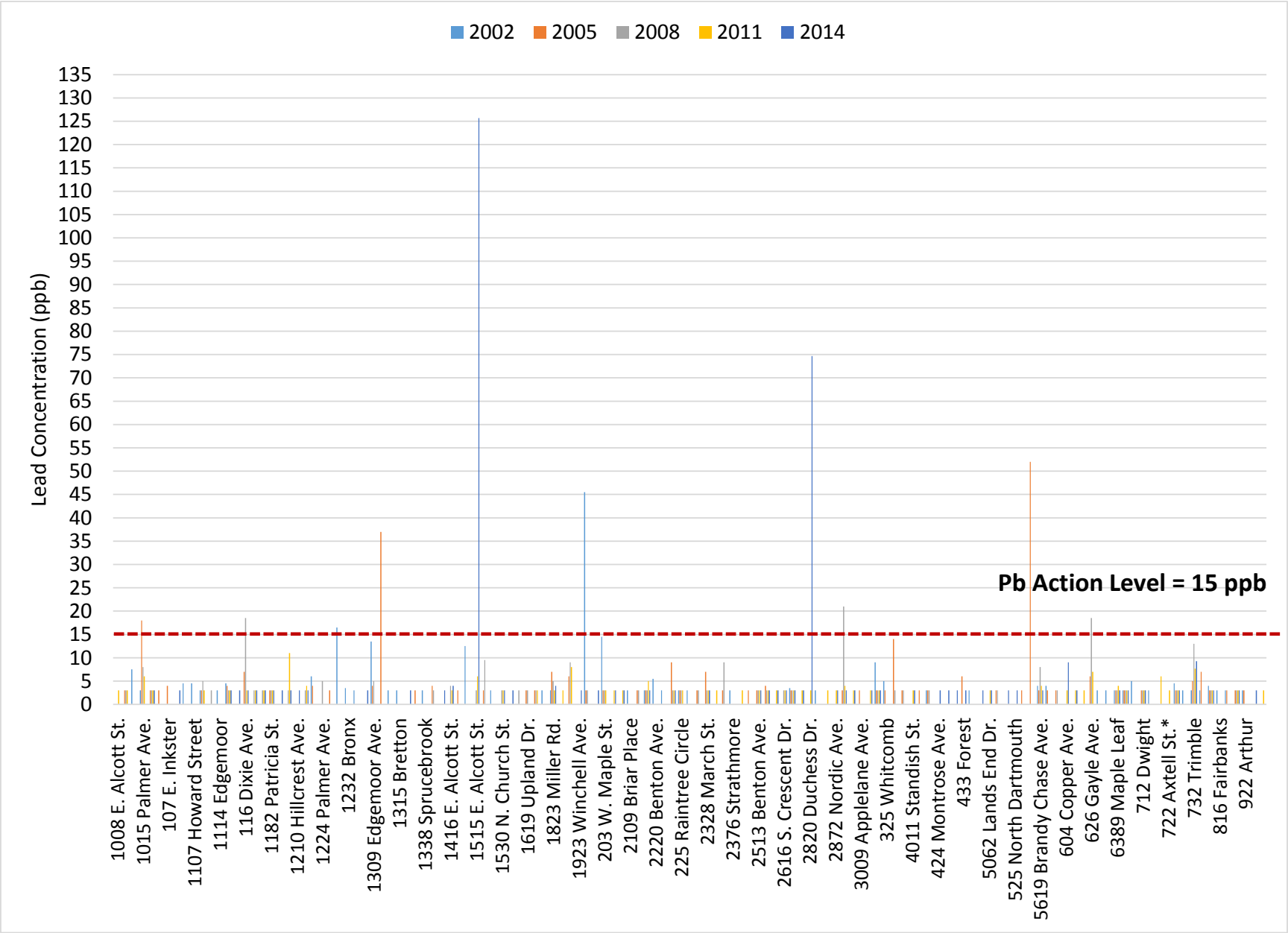

Figure 1. Kalamazoo Water Distribution System Lead Levels

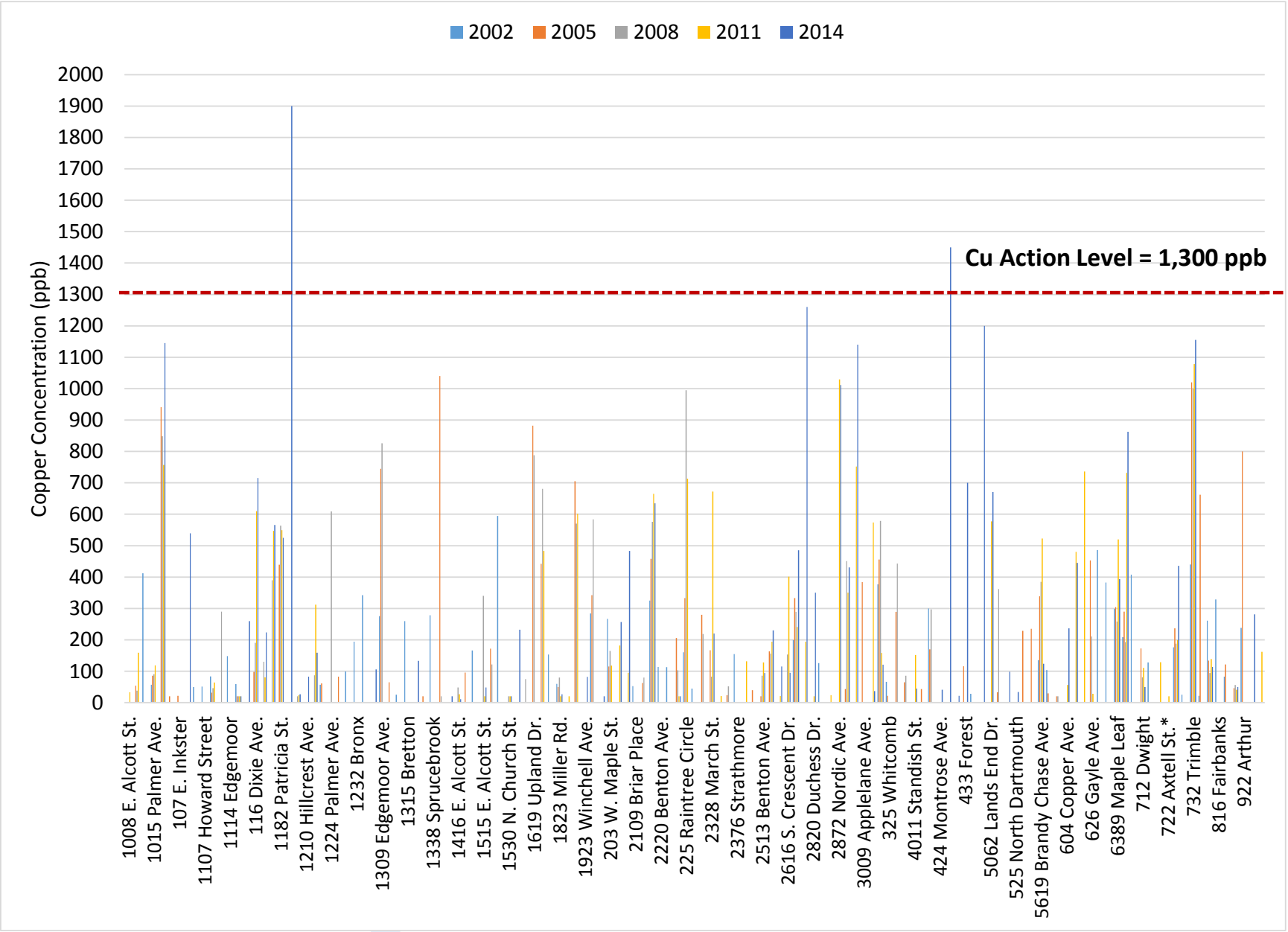

Figure 2. Kalamazoo Water Distribution System Copper Levels

Figure 3. Lead Concentration Aerial Map

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Figure 4. Copper Concentration Aerial Map

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CORROSION POTENTIAL ANALYSIS

Corrosion Indices

The values of corrosion indices for the City's current drinking water supplies were determined using the Langelier Saturation Index (LSI), the calcium carbonate precipitation potential (CCPP), and the Larson-Skold Index. The indices were calculated for the individual water plants and the identified water quality blends. A summary of the LSI, CCPP, and Larson-Skold results for the individual stations is presented in **Table 5**. The LSI, CCPP, and Larson-Skold results for the blended station pairs are included in **Tables A-1** through **A-23** of **Attachment A**. The following sections provide a brief overview of theory and discussion of results.

Table 5. Corrosion Indices

Station No.	Langelier Saturation Index			Calcium Carbonate Precipitation Potential (mg/L)			Larson-Skold Index		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Station 1	--	--	--	--	--	--	--	--	--
Station 2	0.31	0.59	-0.03	24	46	-5.6	0.697	1.01	0.210
Station 3	--	--	--	--	--	--	--	--	--
Station 4	--	--	--	--	--	--	--	--	--
Station 5	0.00	0.20	-0.19	-7.7	18	-37	0.45	0.47	0.42
Station 8	-0.01	0.09	-0.07	-4.3	5.3	-10	0.53	0.67	0.36
Station 9	-0.61	-0.47	-0.86	-79	-60	-152	0.43	0.52	0.38
Station 11	-0.65	-0.52	-0.74	-112	-77	-126	0.50	0.62	0.35
Station 12	0.88	1.1	0.68	32	39	26	0.29	0.35	0.23
Station 14	-0.49	-0.38	-0.64	-91	-64	-140	0.52	0.56	0.46
Station 17	--	--	--	-20	33	-141	0.22	0.46	0.13
Station 18	-0.26	-0.14	-0.39	-33	-20	-46	0.27	0.35	0.19
Station 22	0.05	0.23	-0.13	-2.8	7.6	-16	0.25	0.28	0.24
Station 24	-0.80	-0.58	-1.10	-98	-55	-160	0.19	0.50	0.05
Station 25	-0.05	0.48	-0.62	-17	24	-93	0.23	0.31	0.17
Station 39	--	--	--	-15	12	-93	0.25	0.41	0.00

Calcium Carbonate Stability

The LSI is a measure of the water's state of saturation with respect to calcium carbonate and is calculated using Equation 1 for pH values between 7.0 and 9.5 (Langelier, 1936).

$$\boldsymbol{LSI = pH - pH_s} \qquad \textbf{EQUATION 1}$$

The pH_s is the saturation pH at which the alkalinity and calcium hardness are in equilibrium with solid calcium carbonate and is calculated using Equation 2.

$$\boldsymbol{pH_s = pK_2' - pK_{so}' - log[Ca^{2+}] - log[Alk]} \qquad \textbf{EQUATION 2}$$

Where:

pK_2'= Second dissociation constant for carbonic acid at water temperature

pK_{so}'= Solubility product constant for $CaCO_3$ at water temperature

$log[Ca^{2+}]$= Log value of the calcium concentration

$log[Alk]$= Log value of the total alkalinity concentration

The state of calcium carbonate saturation depends on the value of the LSI, which is interpreted as follows:

- LSI < 0, the solution is undersaturated with $CaCO_3$ (will dissolve $CaCO_3$)
- LSI = 0, the solution is at equilibrium with $CaCO_3$
- LSI > 0, the solution is supersaturated with $CaCO_3$ (will precipitate $CaCO_3$)

Slight precipitation of calcium carbonate can serve as a protective scale in water distribution pipes and has been associated with reduced corrosion complaints. Although maintaining a slightly positive Langelier Index is not considered a formal corrosion control method for metals, a slightly positive LSI can help protect against leaching of concrete mortar in lined steel and ductile iron pipes. Consequently, it is common practice for water utilities to add lime or caustic soda to treated water to maintain a slightly positive LSI. A higher positive Langelier Index indicates a potential for scaling, which would require feeding a sequestrant, such as polyphosphate, reducing the pH, or softening to prevent scaling. Water from Station No. 12 has the highest scaling potential, while waters from Stations No. 9, 11, and 24 have the highest potential for leaching concrete and mortar from the system.

As opposed to the LSI, which indicates the driving force for precipitation, the CCPP is an indicator of the amount of calcium carbonate that is theoretically expected to precipitate as the solution progresses towards equilibrium. Typically, a CCPP between 4 and 10 would be considered beneficial relative to calcium carbonate. Similar to the LSI results, water from Station No. 12 could precipitate the greatest quantity of calcium carbonate. On the other hand, waters from Stations No. 11, 14, and 24 could dissolve the greatest the greatest quantity of calcium carbonate. A comparison of the calculated LSI and CCPP values for the individual stations are presented in **Figures 5** and **6**, respectively.

Based on the blending analysis, the mixing of waters from Stations No. 2 and 7, 9 and 12, and 12 and 22 could result in a shift from positive to negative LSI values or vice versa. Similarly for these station pairs, the CCPP values could shift from a higher potential for calcium carbonate precipitation to leaching of calcium carbonate or vice versa.

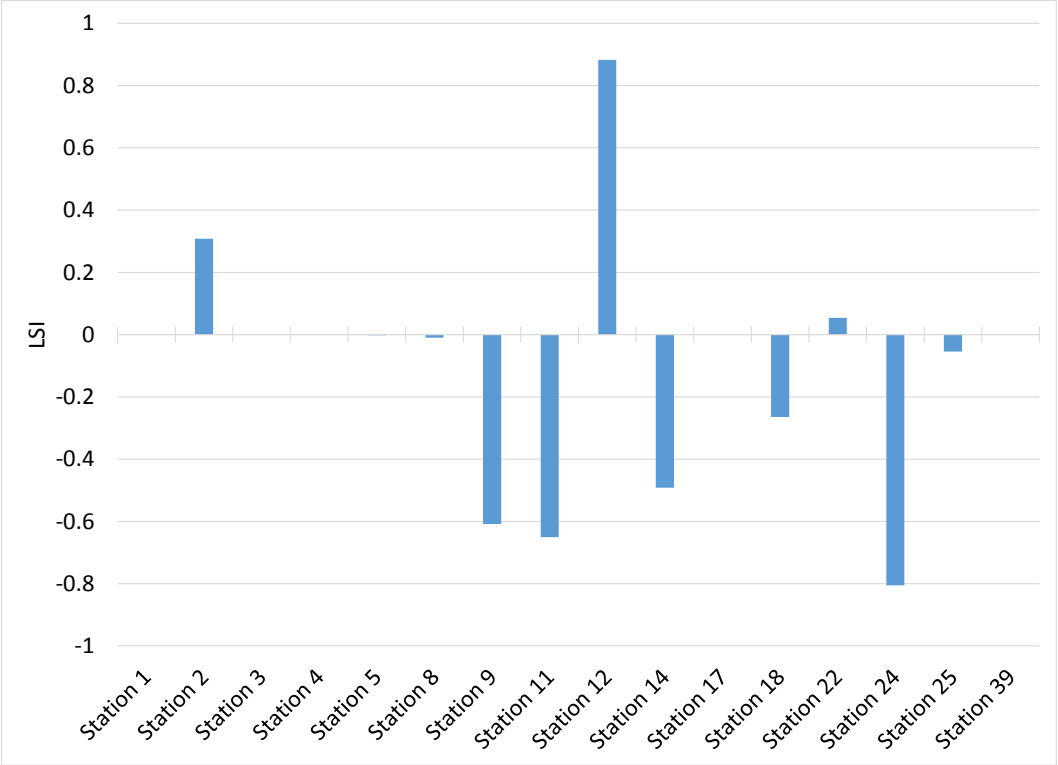


Figure 5. Comparison of LSI Values

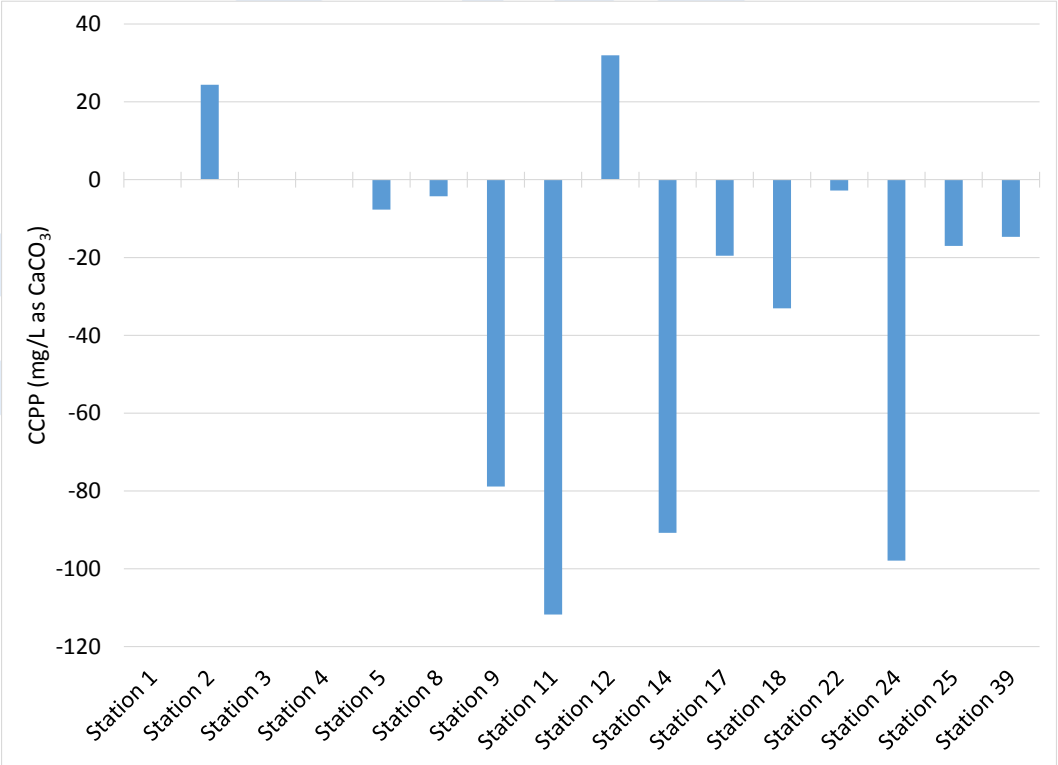


Figure 6. Comparison of CCPP Values

Larson-Skold Index

Chloride and sulfate may cause increased corrosion of iron and steel pipe by forming soluble metal compounds when combined with metal ions released by corrosion cells instead of more insoluble metal scales that provide a level of protection to the pipe surface against further corrosion. Larson and Skold (1957) studied the impact upon the ratio of chloride and sulfate ions to bicarbonate ions in solution relative to the rate of cast iron and steel corrosion. The Larson-Skold Index is calculated as the ratio of the sum of the equivalent concentrations of chloride and sulfate divided by the equivalent concentration of the bicarbonate alkalinity. Typically, Larson-Skold Index values between 0.2 and 0.3 are considered noncorrosive toward iron and steel pipe; however, values up to 1.0 have been considered acceptable. Values greater than 1.2 may indicate a tendency toward a higher rate of iron and steel corrosion and additional methods of corrosion control may be required.

A comparison of the calculated Larson-Skold indices for the individual stations are presented in **Figure 7**. The waters from Stations No. 17 through 39 have a low potential for iron and steel corrosion based on this index, while water from Station No. 2 exhibits the highest potential for iron and steel corrosion. The Larson-Skold index is a conservative parameter; therefore, blending of the individual stations would result in a similar range in the Larson-Skold indices as the individual supplies. The Larson-Skold index results for the blended stations are included in the blended water quality tables in **Attachment A**.

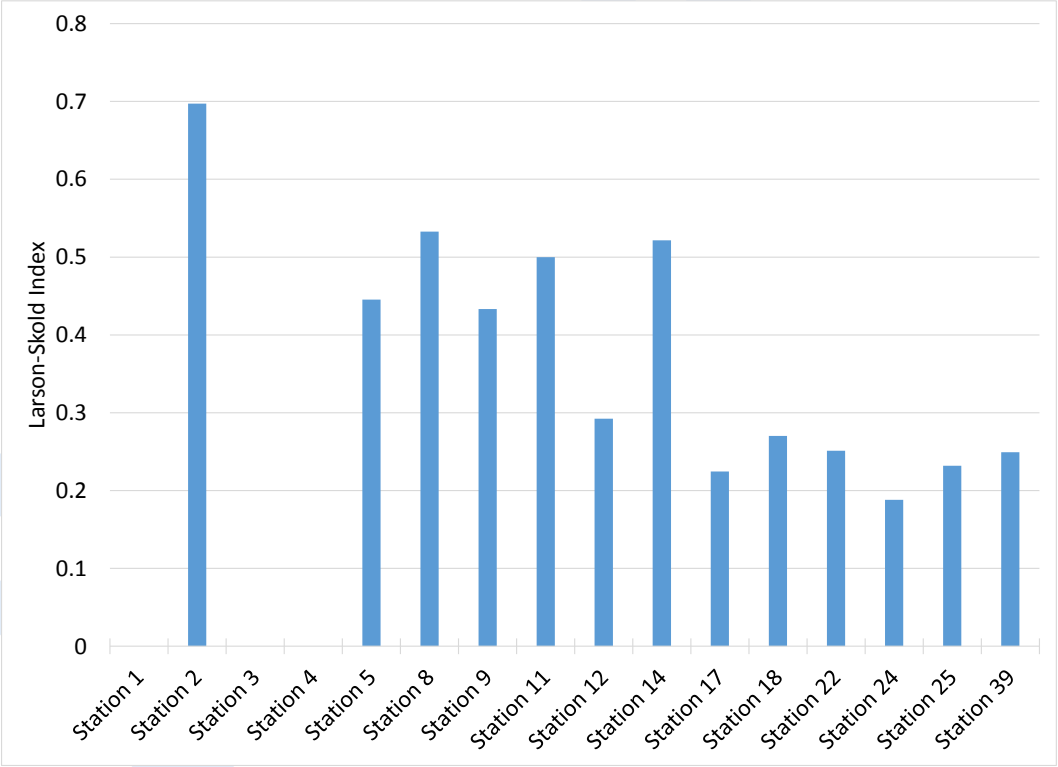


Figure 7. Comparison of Larson-Skold Indices

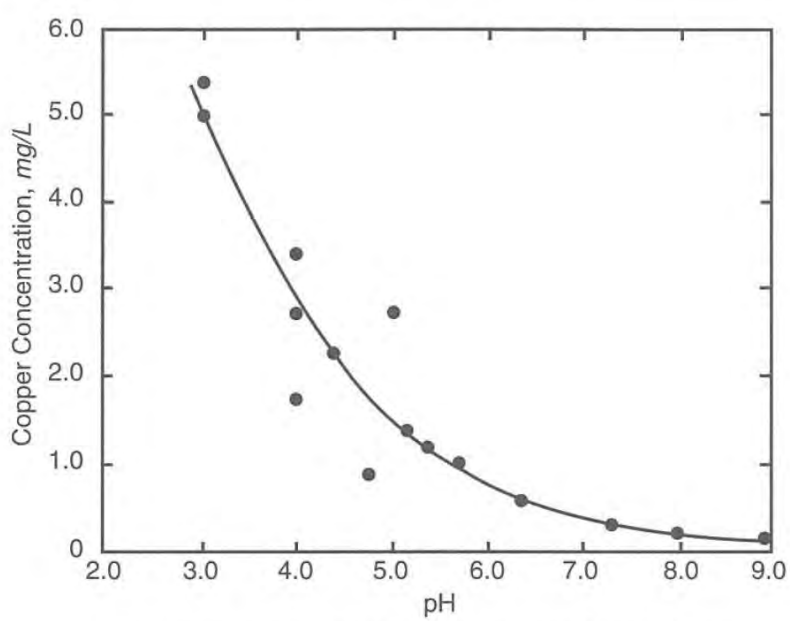
Lead and Copper Corrosion Control

Lead and copper concentrations can become elevated in the drinking water and plumbing systems when water comes in contact with materials such as certain types of pipes, lead solder and faucets containing lead, brass or bronze. The potential to reduce corrosion leading to higher lead and copper concentrations in drinking water can be improved by optimizing water quality characteristics. The water quality factors that have the greatest effect on lead and copper corrosion are pH, dissolved inorganic carbonate (DIC), orthophosphate concentration, alkalinity, and buffer intensity. Dissolved oxygen and chlorine residual are also important considerations for copper corrosion.

Copper

Corrosion of copper and release of soluble copper compounds into solution is thought to originate when the metal is oxidized, usually in the presence of dissolved oxygen and chlorine, to the +1 or +2 oxidation state. Under ideal conditions for corrosion control a uniform, tightly adherent scale of cuprite (Cu_2O) precipitates on the interior pipe surface and forms a passivation layer which prevents further corrosion and subsequent metal release. However, there are many competing reactions that can occur to form copper compounds in the form of oxides, carbonates, hydroxides, amines, chlorides, sulfates, phosphates and silicates that may govern the concentration of soluble copper under varying conditions of alkalinity, pH, DIC, ionic strength and electrical potential of the water. Therefore, very precise rules for water quality to control or limit copper corrosion and metal release into solution are difficult to develop to fit each specific water quality. However, some general tendencies have been observed. The first is that there is a general relationship between pH and the release of copper into solution. This is illustrated in **Figure 8**, which relates the release of copper from new pipe as a function of pH.

Figure 8. Effect of pH on the Release of Copper into Solution*



Conditions: Water at the desired pH was allowed to flow through 60 ft (18.5 m) of new 0.75-in. (1.9-cm) copper tubing at a rate of 0.5 gpm (2 L/min) for 1 hour and then stopped for 16 hours to simulate overnight conditions.

*Adapted from *Benjamin et al. (1996). Internal Corrosion of Water Distribution Systems. Denver, CO: Water Works Association Research Foundation*.

As the water becomes more acidic, pH < 7, the concentration of copper greatly increases and as the water becomes more alkaline, pH > 7, the release of copper into solution is at a minimum. A second general trend is that the rate of copper release tends to increase as the alkalinity of the water is increased when the pH is held constant. The alkalinity effect is less pronounced at higher pH values as compared to lower pH values for the same alkalinity concentration. The effect of various anions on the release of copper from aged pipe has been studied at pH greater than 7. The study indicated that the presence of bicarbonates and sulfates resulted in higher release of copper than chlorides. This in consistent with the finding that there is a tendency toward greater copper release as the alkalinity is increased, which in the pH range normally encountered in potable water systems also means that the concentration of bicarbonate ion is also increasing. The combination of dissolved oxygen and chlorine in the water, a high alkalinity and lower pH values in the Kalamazoo water favor the release of copper into solution.

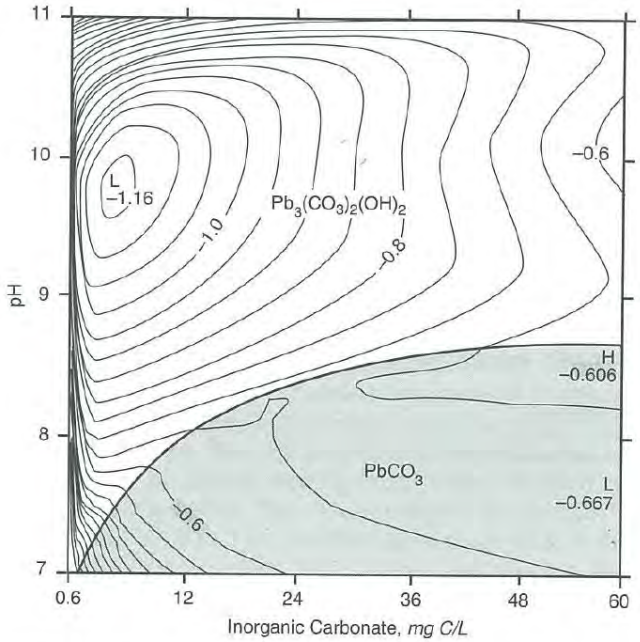
Lead

Corrosion of lead and release of soluble lead compounds into solution is thought to originate when the metal is oxidized, usually in the presence of dissolved oxygen and chlorine, to the +2 oxidation state. The degree of oxidation and release of soluble lead is dependent upon the pH, the concentration of oxidants and the complexation of the Pb^{+2} ion with various anions and ligands in the water. Under favorable conditions lead can form hydroxycarbonate, carbonate and oxides that can form an insoluble layer on the inside of the pipe surface that serves as a passivation barrier to further corrosion. Two of these compounds being hydrocerussite ($Pb_3(CO_3)_2(OH)_2$) and cerussite ($PbCO_3$). **Figure 9** shows the pH and dissolved inorganic carbonate concentrations under which these compounds would form and the equilibrium concentration of lead that would be associated with each. The formation of hydrocerussite is favored at lower concentrations of DIC and higher DIC concentrations at higher pH, >8.4. **Figure 9** also shows that the minimum lead solubility occurs at a pH of 9.8 and DIC of 4 mg/L and that as the concentration of DIC increases the equilibrium solubility of lead increases. Note that the higher DIC in the Kalamazoo raw water falls outside of the figure boundary to the right.

When orthophosphate is added to the water sparingly soluble lead hydroxyphosphate compounds can form to limit the solubility of lead in equilibrium with the passivation film. This is illustrated in **Figure 10**. This figure shows that at lower values of pH and DIC the formation of the hydroxyphosphate compound can further reduce the equilibrium lead concentration as compared to the cerussite layer produced in the absence of orthophosphate. **Figure 10** also shows that the potential effectiveness of orthophosphate addition is reduced as the DIC is increased. The DIC increases as the alkalinity of the solution is increased.

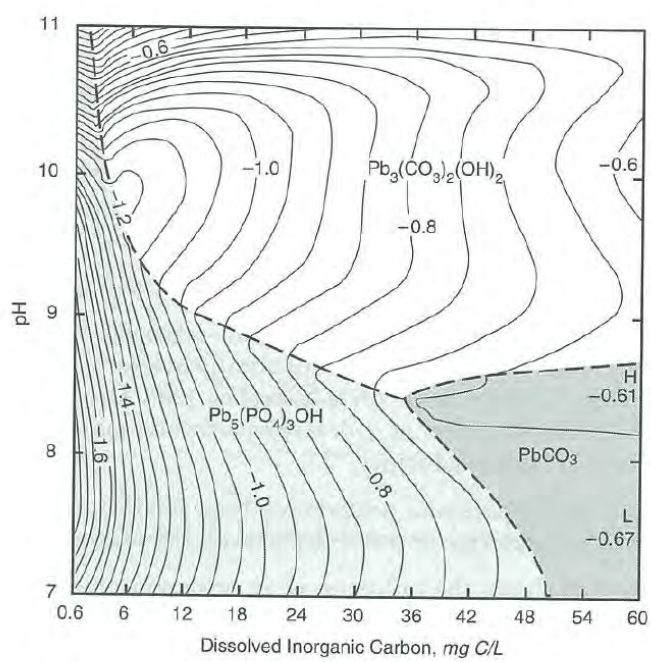
This relationship is further illustrated in **Figure 11** which shows the orthophosphate dose versus lead solubility for various values of alkalinity at pH 7.0. Since water within the distribution and plumbing systems generally do not remain in contact with the pipe surface, even during periods of nonuse, long enough to achieve complete equilibrium, a target lead solubility of 0.03 mg/L might be chosen to determine the initial orthophosphate dose. At an alkalinity of 50 mg/L an orthophosphate dose of approximately 1.8 mg/L would be required and at an alkalinity of 100 mg/L an orthophosphate dose of approximately 4.3 mg/L would be required. At an alkalinity of greater than 200 mg/L the dosing of orthophosphate would not be expected to exert a sufficient level of control to bring down the lead solubility to the target lead solubility, but would still limit the maximum lead solubility.

Figure 9. Contour Diagram of Lead Solubility vs pH and Inorganic Carbon*



NOTE: The boundary line position between the domains of the lead is approximate. Concentration units are log (mg Pb/L). Local high and low points are marked "L" and "H," respectively.

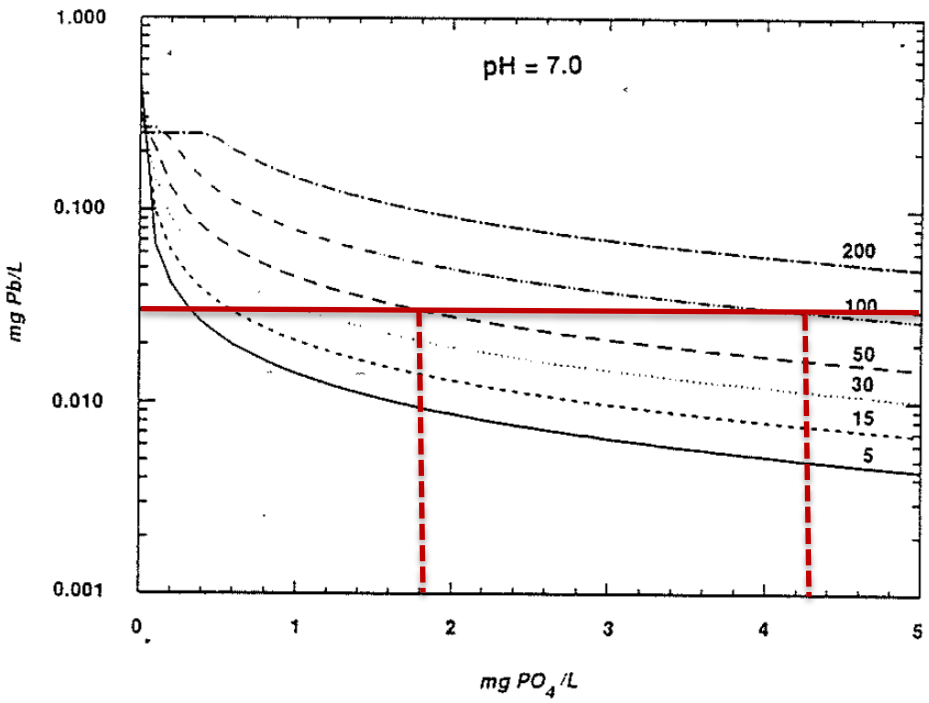
Figure 10. Contour Diagram of Lead Solubility in a System with 0.5 mg PO_4/L Orthophsphate*



NOTE: Concentration units are log (mg Pb/L). Local high and low points are indicated.

*Adapted from *Benjamin et al. (1996). Internal Corrosion of Water Distribution Systems. Denver, CO: Water Works Association Research Foundation*.

Figure 11. Lead Solubility vs Orthophosphate at Various Alkalinities*



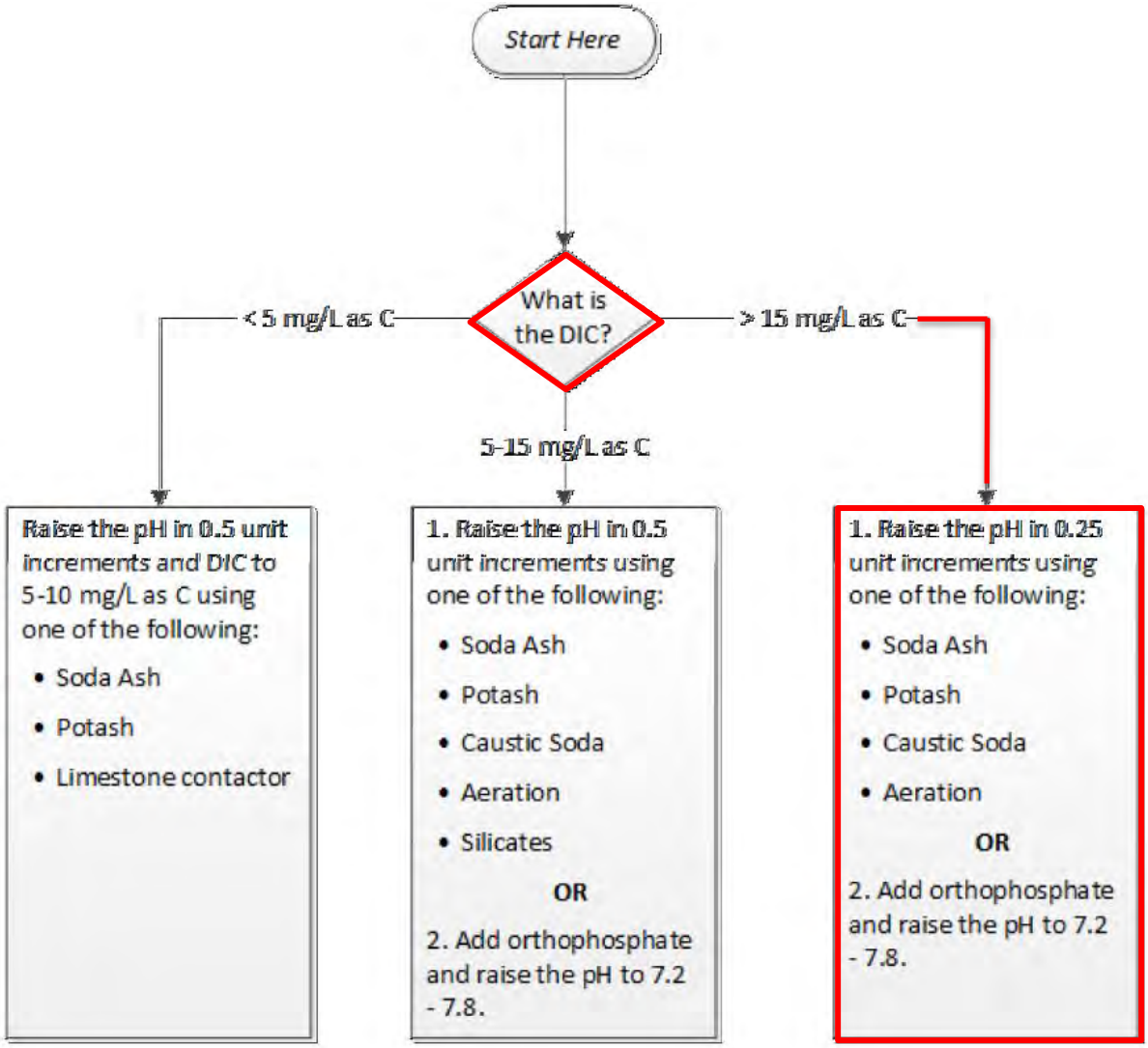
*Adapted from *American Water Works Association Research Foundation's Lead Control Strategies (1990)*.

Flow Chart Treatment Determinations

The Water Research Foundation (previously American Water Works Association Research Foundation) developed a "Lead Control Strategies" guidance manual in 1990 to provide water utilities information on how to approach lead concerns in drinking water, how to select water treatment alternatives, and how to determine the effectiveness of a lead control strategy (AWWARF 1990). This manual was later supplemented in 1997 by EPA's Guidance Manual for Selecting Lead and Copper Control Strategies, which was revised in 2003 and more recently updated in March, 2016 as Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems. Tetra Tech referred to these guidance manuals to identify treatment options for lead and copper control and to compare identified strategies to the City's current practices.

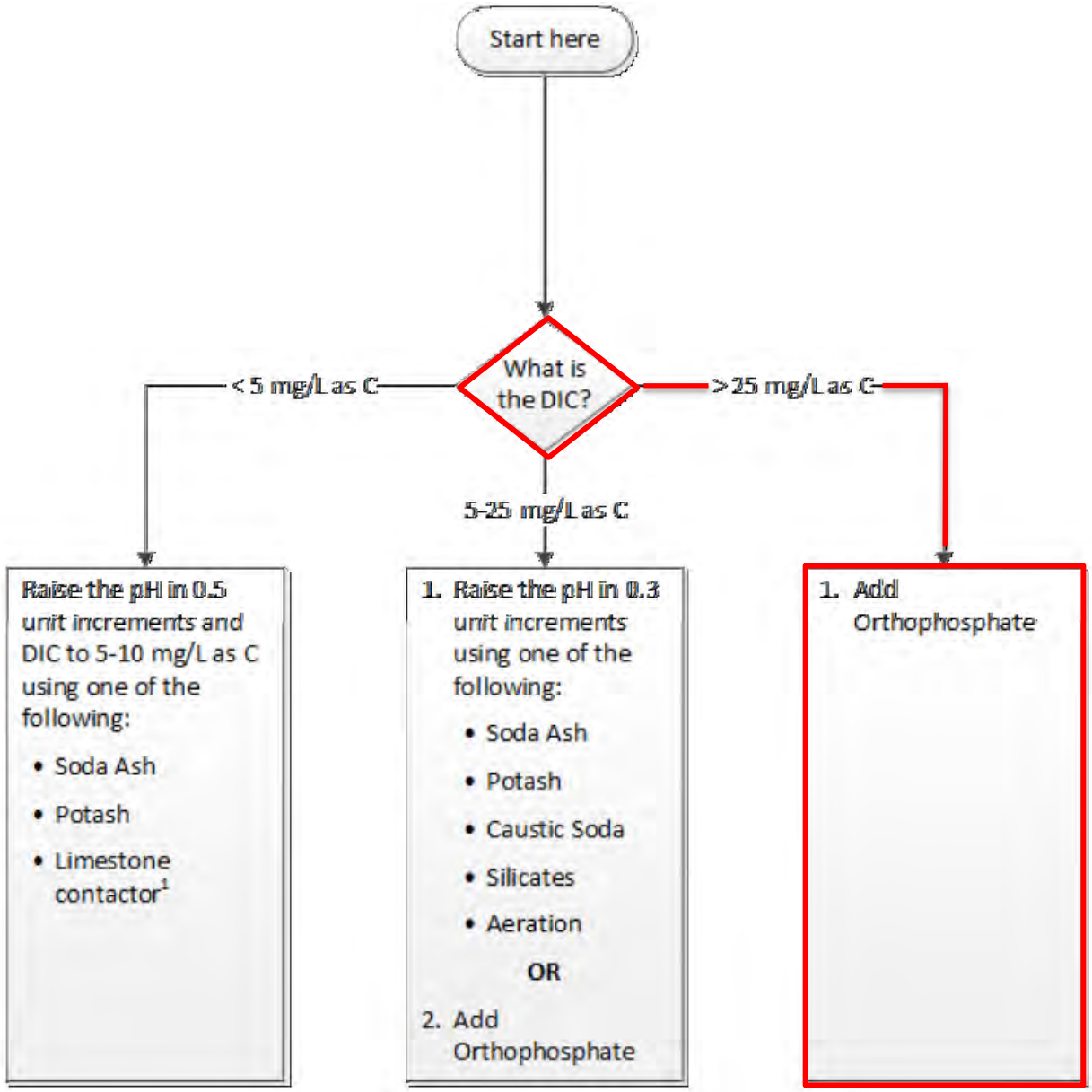
EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems includes flow charts for determining treatment approaches for mitigating lead and copper corrosion when the lead and/or copper ALs have been exceeded. Although the 90th percentile lead and copper levels throughout the City's water system are well below the lead and copper ALs, the City's desire to switch from sodium hexametaphosphate to a liquid, blended phosphate corrosion inhibitor requires consideration of optimum corrosion treatment for each station. The characteristics of the individual water supplies were used to select the flow chart in the manual that was most applicable for determining a recommended method of corrosion control. Therefore, EPA's pertinent flow charts, presented in **Figures 12** through **15**, were used to determine corrosion treatment approaches for the individual water pumping stations to aid in recommending a corrosion control management strategy.

Figure 12. Flow Chart 1a for Selecting Lead and Copper Corrosion Control Measures with pH < 7.2*



*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems.

Figure 13. Flow Chart 1b for Selecting Lead and/or Copper Corrosion Control Measures with pH from 7.2 to 7.8*

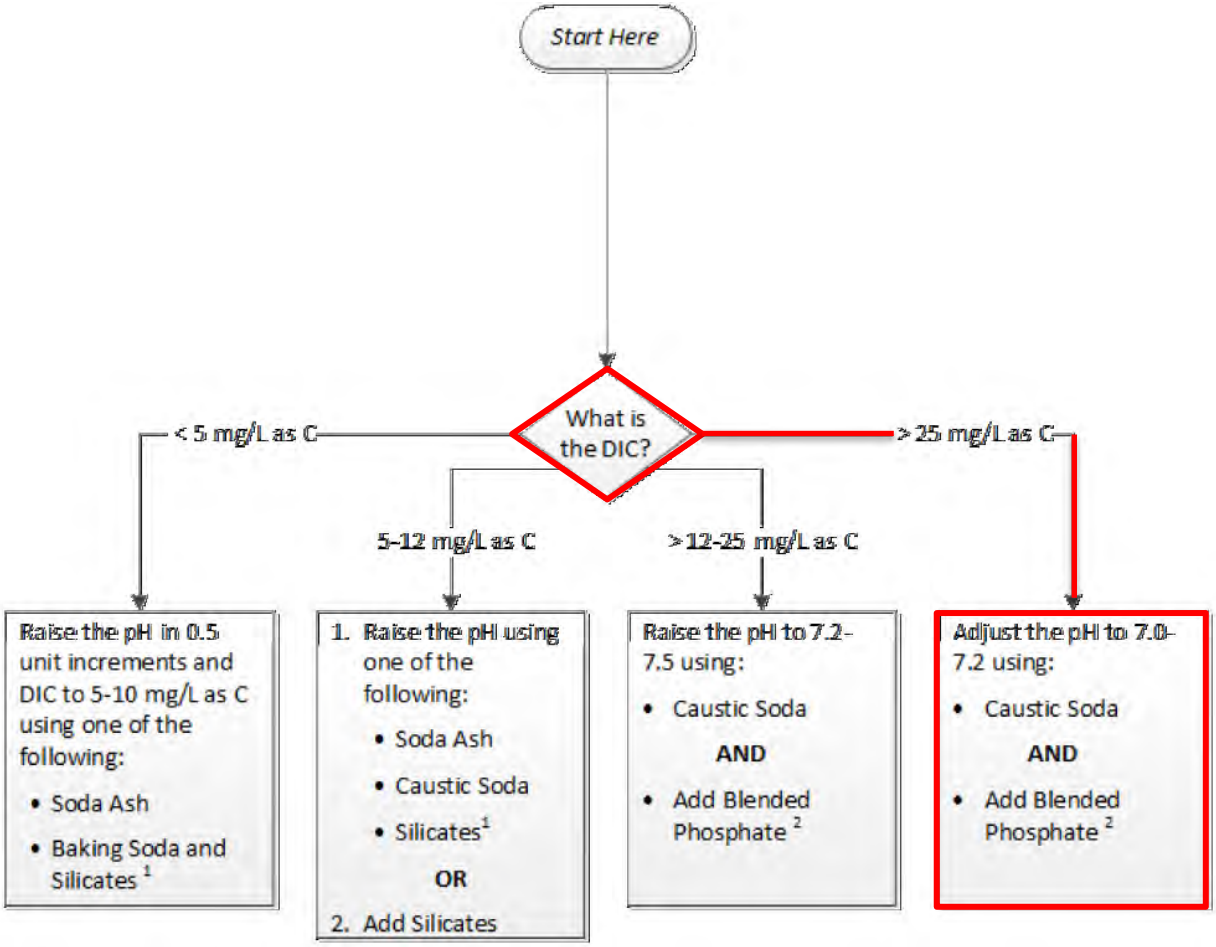


Notes:

1. Carbon dioxide feed before the limestone contactor may be necessary

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems.

Figure 14. Flow Chart 3a for Selecting Lead and/or Copper Corrosion Control Measures with Iron and Manganese in Finished Water and pH <7.2*

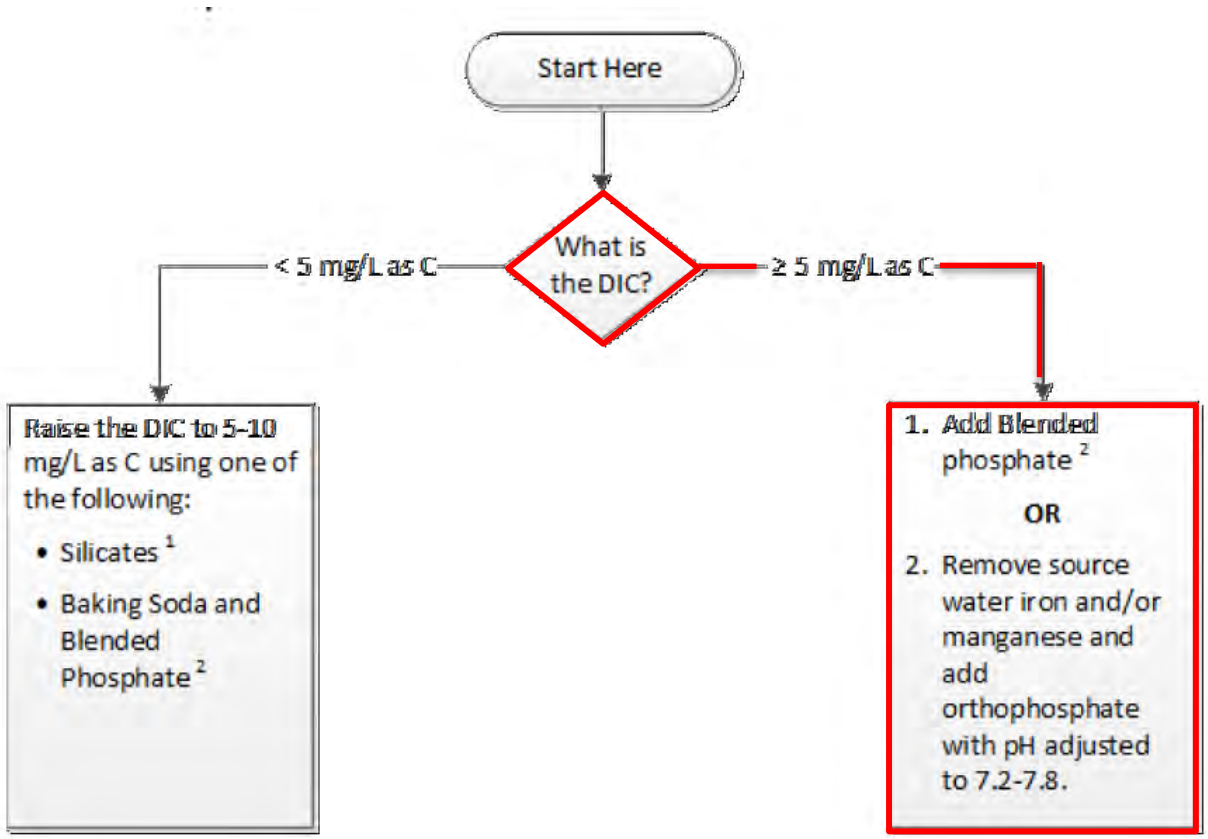


Notes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended.

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems.

Figure 15. Flow Chart 3b for Selecting Lead and Copper Corrosion Control Measures with Iron and Mangenese in Finished water and pH ≥7.2*



Notes:

1. Silicates are most effective when combined iron and manganese concentrations are less than 1.0 mg/L.
2. The effectiveness of blended phosphate varies based on the formulation. Additional evaluation and/or monitoring is recommended. Blended phosphates are less effective for controlling copper at DIC greater than 25 mg/L as C.

*Adapted from EPA's 2016 Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primary Agencies and Public Water Systems.

If additional treatment were necessary to maintain lead and copper below their respective ALs, the following treatments would be recommended according to EPA's guidance manuals:

- Station No. 11:
  - Raise the pH in 0.25 unit increments using soda ash, potash, caustic soda, or aeration. Alternatively, add orthophosphate and raise pH to between 7.2 and 7.8.
- Station No. 1:
  - Add orthophosphate.
- Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39:
  - Adjust the pH to 7.2 using caustic soda and add blended phosphate.
- Stations No. 2, 3, 4, 12, and 22:
  - Add blended phosphate. Alternatively, Remove source water iron and add orthophosphate with pH adjusted to between 7.2 and 7.8.

A comparison between these EPA recommended corrosion control treatments and currently applied treatments is included in **Table 6**.

Table 6. Comparison of EPA Recommended and Current Corrosion Control Treatments

Drinking Water Source	EPA Recommended	Currently Implemented
Station No. 11	• Raise the pH in 0.25 unit increments using soda ash, potash, caustic soda, or aeration; or • Add orthophosphate and raises pH to between 7.2 and 7.8	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L
Station No. 1	• Add orthophosphate	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L
Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39	• Adjust the pH to 7.2 using caustic soda and add blended phosphate	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L (2.0 to 2.5 mg/L is added to Station 24)
Stations No. 2, 3, 4, 12, and 22	• Add blended phosphate; or • Remove source water iron and add orthophosphate with pH adjusted to between 7.2 and 7.8.	Currently adding sodium hexametaphosphate at about 1.0 to 1.5 mg/L

REVIEW OF CORROSION INHIBITOR MANUFACTURER INFORMATION

Liquid, blended phosphate corrosion additives are primarily sold as proprietary formulations for which information must be obtained from the manufacturers and suppliers of these products. Product and dose recommendations were requested from three corrosion control chemical suppliers, including Carus Corporation, Sterling Water Technologies, and Shannon Chemical Corporation. We provided each supplier a summary of the City's water system data, including average capacity and water quality from each station. Additionally, we provided information regarding nearby stations and distribution system water mains. A summary of the recommended corrosion control strategies and products from each manufacturer are included in **Table 7**.

Table 7. Manufacturer Recommended Corrosion Control Management Strategies

Manufacturer	Recommended Corrosion Control Strategy
Carus Corporation	• At each water supply station, apply 1 to 1.5 mg/L of active CARUS™ 8100, which is a blended polyphosphate liquid product containing 70% polyphosphate and 30% orthophosphate.
Sterling Water Technologies	• At each water supply station, apply 4 equivalent parts of active polyphosphate as PO_4 for every mg/L of dissolved iron and manganese. • Recommended bended polyphosphate liquid product containing 90-85% polyphosphate and 10-15% orthophosphate. • At stations with pH < 7.2, adjust pH to between 7.2 to 7.6 pH units.
Shannon Chemical Corporation	• *Recommendation Pending*

DISCUSSION AND RECOMMENDATIONS

All of the raw water supply stations for the City of Kalamazoo have high hardness and many have elevated levels of iron and manganese, which can lead to scaling, red, brown, yellow and black water, and staining. The system has historically fed sodium hexametaphosphate at each station which can effectively sequester calcium to prevent it from causing scale build up. More importantly, hexametaphosphate serves to sequester and prevent iron and manganese in the reduced +2 oxidation states from reacting with oxygen and chlorine to oxidize to the ferric (+3) and manganic (+3,4,6) oxidation states. These oxidations states form generally insoluble compounds that will impart turbidity and color to the water. The sequestration of calcium to prevent scaling does not appear to be as important in this system because most stations have a very negative Langelier Index and calcium carbonate precipitation potential as a result of the lower pH. The sequestration of iron and manganese is a critical requirement of the phosphate inhibitor in those stations with iron greater than 300 ppb and manganese greater than 50 ppb to prevent aesthetics complaints.

An equivalent polyphosphate dose should be maintained at those stations that do not presently have treatment for iron removal. Hexametaphosphate at a neutral pH can prevent calcium carbonate from precipitating at a dose as low as 1 mg/L per 200 mg/L calcium hardness with potentially higher dosages up to 2-3 mg/L required for shorter chain polyphosphates. Pyrophosphates may be more effective at sequestering iron at dosages of 1 mg/L per mg/L of iron depending upon chain length up to dosages of 4 mg/L per mg/L of iron for metaphosphates. Therefore, it may be possible to somewhat reduce the polyphosphate doses where calcium sequestration is not essential and where only iron and manganese sequestration is required when using a product with straight chain polyphosphates.

Orthophosphate does not provide any appreciable benefits for sequestration but can build up passivation layers on the interior of pipe materials that reduce the rate of corrosion. Orthophosphate concentrations of 1 to 1.5 mg/L can be effective in creating and maintaining a corrosion barrier to reduce lead and copper corrosion. However, as described earlier in this report the effectiveness of orthophosphate is reduced as the alkalinity is increased and therefore, a higher dosage may be required to achieve significant reduction in metal release. There is a potential limit to the orthophosphate dose that can be applied to these raw water because of the high calcium concentration. Calcium phosphate is highly insoluble with a solubility product of 1×10^{-26} as compared to the calcite form of calcium carbonate which is 3.8×10^{-9}. The concentration of phosphate ion in the orthophosphate form is higher at higher pH and will tend to form turbidity and scale in the presence of high calcium concentration. Most of the stations have pH values that are neutral or slightly acidic so this should not be a problem. However,

station 12 has a pH close to 8 and a higher orthophosphate dose at this station might lead to turbidity in the potable water.

The corrosion rate of copper is reduced and the effectiveness of orthophosphate is increased at pH values that are neutral to slightly alkaline. The orthophosphate component of blended phosphate inhibitors is often made using phosphoric acid and the pH of the solution will be very acidic. The addition of these products to the raw water will tend to cause the pH to drop slightly. At those stations where the pH after chemical addition is less than 7.0 consideration should be given to raising the pH both to reduce corrosion rates and to increase the effectiveness of the orthophosphate. However, raising the pH above 8 should be avoided to prevent precipitation of calcium phosphate.

At stations 1 and 11 where iron removal is employed and if the calcium carbonate precipitation potential is low, a blended product with a high orthophosphate percentage (70-80%) would be appropriate as an initial product choice to provide an orthophosphate dose of 1 to 1.5 mg/L and lesser dose of polyphosphate to provide some control of corrosion products within the system and where blending with other sources occurs. At the remainder of the stations a product that has a higher percentage of polyphosphate (60-85%) would be appropriate as an initial product choice to provide an equivalent level of polyphosphate as the current sodium hexametaphosphate product and also providing an orthophosphate dose of 1 to 1.5 mg/L.

It is important not to significantly overdose or underdose polyphosphates. Overdosing can lead to the deflocculation of built-up corrosion byproducts, especially of iron, releasing particulate iron particles into the water system resulting in brown and red water complaints from consumers. Significantly underdosing of polyphosphates can provide inadequate sequestration and resistance to iron and manganese oxidation which can lead to brown and black water complaints as well as staining complaints from consumers as a result of the precipitation of insoluble iron and manganese oxidation products. This can also result in an additional chlorine demand upon the system which can lower chlorine residuals.

It is recommended that one or more products be tested with the raw water to determine the dosage of polyphosphate that provides for effective sequestering of iron and manganese. This testing can be performed by stain testing using a 0.45 micron filter. For the testing a sample of the raw water without chemical addition, a sample of the water after polyphosphate addition and two samples of the water after polyphosphate addition and chlorination should be collected. The first three samples will be filtered soon after chemical dosing and if the iron and manganese in the raw water are in the reduced state and the phosphate dose is sufficient these pads should be only lightly discolored. The fourth sample after chemical addition should be held for a day, measured for turbidity and then filtered. Filter pads should be retained for comparison purposes to compare different doses of a single product and to compare different products.

The corrosion control effectiveness of orthophosphate portion of the blended phosphate corrosion inhibitor is best determined using coupon racks with copper, lead, brass and steel coupons. Side by side tests can be performed to determine optimum dosage and pH for maximum corrosion rate reduction. Side by side tests can also be performed to test different products and compare their effectiveness. Coupon test rigs can often be obtained from the chemical suppliers at no cost or a relatively low rental fee.

Some testing of the water quality in the distribution system is necessary after beginning the use of a blended orthophosphate product. Polyphosphates will over time, in the presence of calcium and at higher temperature tend to revert to orthophosphates. At the water temperatures reported for the stations the reversion process is anticipated to occur very slowly. However, to ensure that the product being fed to the system maintains its effectiveness throughout the system it is recommended that samples be collected from the extremes of the system after the new product has been introduced into the system to measure the level of polyphosphates to verify that significant reversion is not occurring within the system that would compromise the effectiveness of this component. Samples should also be collected at the extremes of the system to check the orthophosphate concentration. Initially, there might be a higher orthophosphate demand in the system that would decrease the concentration as the travel time from the station increases. For the orthophosphate component to be effective for

corrosion control a minimum concentration must be present. If measurements show that the concentration is significantly reduced in portions of the system, the dosage should be increased for a period of time until the orthophosphate concentration increases and then tapered back to a maintenance dosage level.

Based upon the review and analysis of the compliance sampling results, source water quality, and manufacturer recommendations, the following recommendations are presented to maintain system water quality and corrosion control within the distribution system:

Table 8. Recommended Corrosion Control Management Strategies

Water Pumping Station	Corrosion Control Method
Station No. 11	• Add blended phosphate (>70% orthophosphate) at a dose of 1-3 mg/L and raise pH to between 7.2 and 7.8
Station No. 1	• Add blended phosphate (>70% orthophosphate) at a dose of 1-3 mg/L, adjust pH if necessary to between 7.2 and 7.8.
Stations No. 5, 8, 9, 14, 17, 18, 24, 25, and 39	• Adjust the pH to 7.2 using caustic soda and add blended phosphate (>60% polyphosphate) at a dose of 2.5-5 mg/L
Stations No. 2, 3, 4, 12, and 22	• Add blended phosphate (>60% polyphosphate) at a dose of 2.5-5 mg/L

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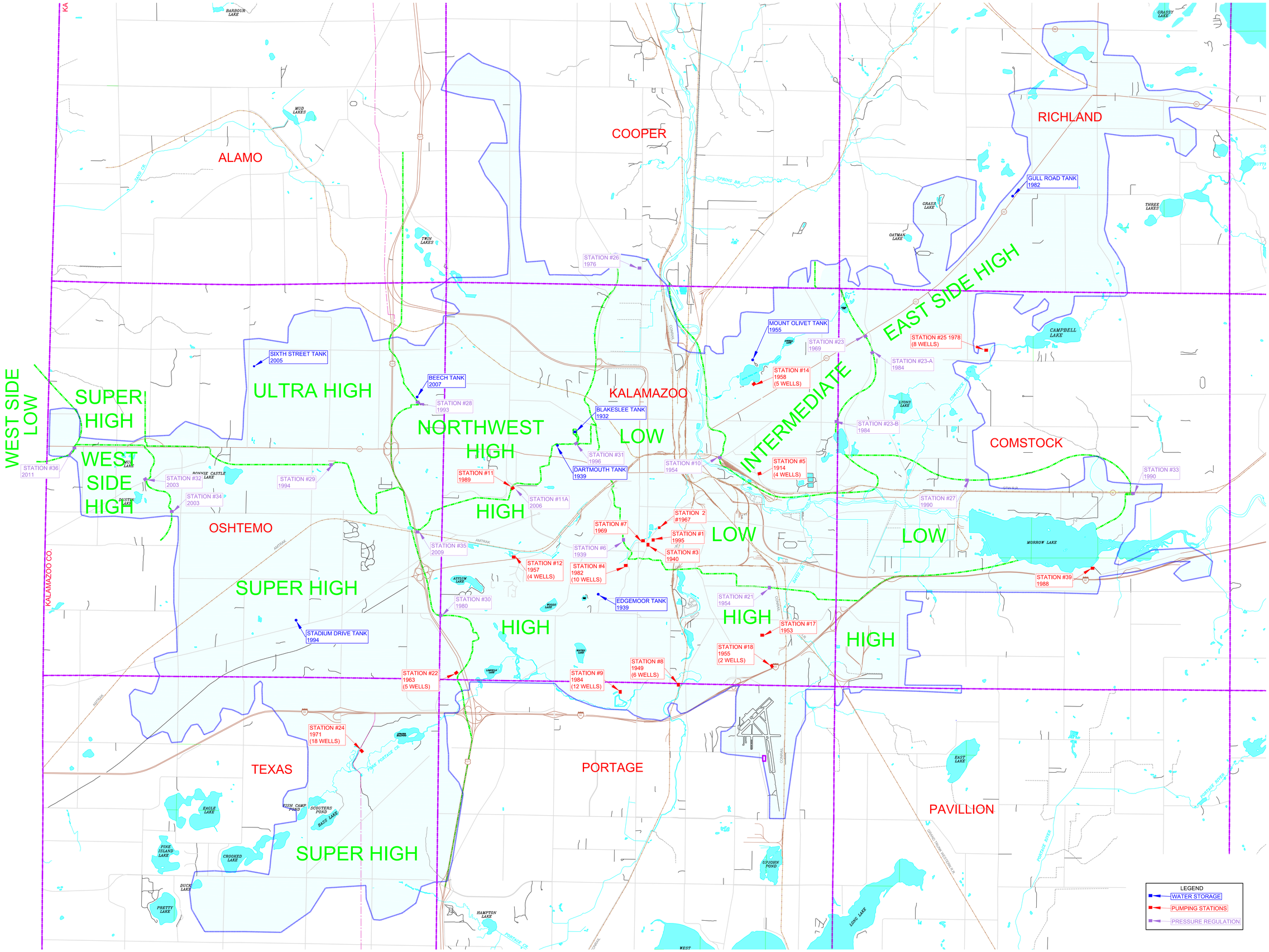
DRAFT

Attachment A

Kalamazoo Water System Data

DRAFT



DATE: 12/22/15

DRAWN BY: WEE

CITY OF KALAMAZOO WATER SERVICE AREA ~ 2015

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SHEET 1 OF 1

NO SCALE

Table A-1
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		1				2
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	311
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	308
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.08
Arsenic	ug/L	6.0	5.1	4.3	3.4	2.6
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	375
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	110,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.44
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	37
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	110.13
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	888
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	45.38
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	83.7
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	2.3
Fluoride	mg/L	0.98	0.88	0.79	0.69	0.59
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	877
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	2.64
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	35,500
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	152
Nitrate Nitrogen	mg/L	0.44	0.41	0.39	0.37	0.34
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	7.30
pH after Chem Add	pH units	ND	ND	ND	ND	7.28
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	8,426
Sodium	ug/L	49,000	53,063	57,125	61,188	65,250
Sulfate	mg/L	45	47	49	52	54
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	14.0
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	57.1
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	561
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.75
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	370.71
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.45
CCPP		ND	ND	ND	ND	-27.6
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.69

Table A-2
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		1				3
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Arsenic	ug/L	6.0	4.9	3.8	2.7	1.6
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	98,143
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	10.00
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	878
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.5
Fluoride	mg/L	0.98	#VALUE!	#VALUE!	#VALUE!	ND
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	930
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	3.00
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	32,014
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	106
Nitrate Nitrogen	mg/L	0.44	#VALUE!	#VALUE!	#VALUE!	ND
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	6.87
pH after Chem Add	pH units	ND	ND	ND	ND	ND
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	5,271
Sodium	ug/L	49,000	45,836	42,671	39,507	36,343
Sulfate	mg/L	45	#VALUE!	#VALUE!	#VALUE!	ND
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	ND
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	ND
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	555
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	ND
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	24
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
CCPP		ND	ND	ND	ND	ND
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Table A-3
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		1				17
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	251
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	248
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.15
Arsenic	ug/L	6.0	5.6	5.1	4.7	4.3
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	302
Calcium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	86,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.35
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	56
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	19.38
Conductivity	umhos/cm	ND	#VALUE!	#VALUE!	#VALUE!	543
Copper	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	22.10
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	74.8
Dissolved Oxygen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.6
Fluoride	mg/L	0.98	0.78	0.57	0.37	0.17
Iron	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	1,444
Lead	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	2.25
Magnesium	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	22,650
Manganese	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	359
Nitrate Nitrogen	mg/L	0.44	0.35	0.26	0.17	0.09
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.14
pH	pH units	ND	#VALUE!	#VALUE!	#VALUE!	7.24
pH after Chem Add	pH units	ND	ND	ND	ND	6.95
Silicate	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	6,205
Sodium	ug/L	49,000	38,615	28,230	17,845	7,460
Sulfate	mg/L	45	40	35	31	26
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.2
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.0
TDS (calculated)	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	344
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	20.25
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	346.88
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	13
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.66
CCPP		ND	ND	ND	ND	-25.30
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.22

Table A-4
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		2				7
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	311	317	324	331	338
Alkalinity After Chem	mg CaCO3/L	308	315	321	328	335
Ammonia Nitrogen	mg/L	0.08	0.10	0.13	0.15	0.17
Arsenic	ug/L	2.6	2.4	2.3	2.1	2.0
Bicarbonate, calculated	mg/L	375	383	392	400	408
Calcium	ug/L	110,150	109,113	108,075	107,038	106,000
Carbonate, calculated	mg/L	0.44	0.28	0.24	0.21	0.23
CO2, calculated	mg/L	37	46	56	67	77
Chloride	mg/L	110.13	99.23	88.33	77.43	66.53
Conductivity	umhos/cm	888	895	902	909	916
Copper	ug/L	45.38	39.03	32.69	26.34	20.00
DIC, calculated	mg C/L	83.7	88.1	92.5	96.9	101.3
Dissolved Oxygen	mg/L	2.3	2.8	3.2	3.6	4.0
Fluoride	mg/L	0.59	0.48	0.36	0.25	0.13
Iron	ug/L	877	823	770	717	664
Lead	ug/L	2.64	2.73	2.82	2.91	3.00
Magnesium	ug/L	35,500	34,538	33,575	32,613	31,650
Manganese	ug/L	152	196	240	284	328
Nitrate Nitrogen	mg/L	0.34	0.51	0.67	0.84	1.00
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.09	0.09	0.09	0.10	0.10
pH	pH units	7.30	7.22	7.14	7.06	6.98
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.91
Silicate	ug/L	8,426	10,145	11,863	13,582	15,300
Sodium	ug/L	65,250	57,344	49,438	41,531	33,625
Sulfate	mg/L	54	54	54	53	53
Temperature	C°	14.0	13.9	13.8	13.8	13.7
Temperature	F°	57.1	57.1	57.2	57.2	57.2
TDS (calculated)	mg/L	561	575	590	604	618
Total Hardness	grains/gal	21.75	23.06	24.38	25.69	27.00
Total Hardness	mg/L CaCO3	370.71	393.53	416.36	439.18	462.00
Zinc	ug/L		#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		0.15	0.06	-0.02	-0.08	-0.13
CCPP		22.88	14.39	5.14	-2.46	-9.85
Larson Index		0.69	0.62	0.56	0.50	0.45

Table A-5
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				8
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	264
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	261
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.19
Arsenic	ug/L	7.4	8.1	8.8	9.5	10.2
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	318
Calcium	ug/L	82,557	83,813	85,069	86,324	87,580
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.23
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	38
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	65.12
Conductivity	umhos/cm	727	733	740	746	752
Copper	ug/L	20.86	20.69	20.53	20.36	20.20
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	72.9
Dissolved Oxygen	mg/L	1.9	2.3	2.7	3.1	3.5
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
Iron	ug/L	1,797	1,688	1,579	1,469	1,360
Lead	ug/L	3.00	3.50	4.00	4.50	5.00
Magnesium	ug/L	28,586	29,054	29,523	29,991	30,460
Manganese	ug/L	231	232	233	235	236
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.96	7.03	7.09	7.16
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	7.12
Silicate	ug/L	7,214	9,461	11,707	13,954	16,200
Sodium	ug/L	27,614	27,086	26,557	26,029	25,500
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	44
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.5
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.6
TDS (calculated)	mg/L	460	470	480	491	501
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	24.40
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	417.20
Zinc	ug/L	43	40	36	32	29
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.10
CCPP		ND	ND	ND	ND	-4.84
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.53

Table A-6
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				9
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	225
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	223
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Arsenic	ug/L	7.4	7.0	6.6	6.2	5.8
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	271
Calcium	ug/L	82,557	78,774	74,991	71,208	67,425
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.07
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	92
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	52.95
Conductivity	umhos/cm	727	702	677	651	626
Copper	ug/L	20.86	20.73	20.60	20.46	20.33
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	78.5
Dissolved Oxygen	mg/L	1.9	1.8	1.8	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Iron	ug/L	1,797	1,868	1,939	2,010	2,081
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	27,585	26,585	25,584	24,583
Manganese	ug/L	231	221	212	202	193
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.85	6.81	6.76	6.72
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.68
Silicate	ug/L	7,214	5,414	3,613	1,812	12
Sodium	ug/L	27,614	27,819	28,024	28,229	28,433
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	21
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.8
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	55.1
TDS (calculated)	mg/L	460	439	419	398	378
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	18.92
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	43	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.69
CCPP		ND	ND	ND	ND	-81.09
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.43

Table A-7
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				11
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	258
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	255
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.24
Arsenic	ug/L	7.4	6.1	4.8	3.5	2.1
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	311
Calcium	ug/L	82,557	83,368	84,179	84,989	85,800
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.05
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	152
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	63.98
Conductivity	umhos/cm	727	731	734	738	741
Copper	ug/L	20.86	20.64	20.43	20.21	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	102.6
Dissolved Oxygen	mg/L	1.9	1.8	1.8	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
Iron	ug/L	1,797	1,559	1,320	1,081	843
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	29,679	30,771	31,864	32,957
Manganese	ug/L	231	206	181	156	132
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	6.81	6.72	6.63	6.54
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	6.52
Silicate	ug/L	7,214	8,689	10,164	11,639	13,114
Sodium	ug/L	27,614	26,696	25,779	24,861	23,943
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	35
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	11.6
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	52.8
TDS (calculated)	mg/L	460	456	453	450	446
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	23.29
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	398.00
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.72
CCPP		ND	ND	ND	ND	-113.78
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.50

Table A-8
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	262
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	259
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.11
Arsenic	ug/L	7.4	7.5	7.6	7.7	7.8
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	313
Calcium	ug/L	82,557	80,068	77,579	75,089	72,600
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	1.44
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	6
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	27.58
Conductivity	umhos/cm	727	702	676	651	625
Copper	ug/L	20.86	21.27	21.68	22.09	22.50
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	63.5
Dissolved Oxygen	mg/L	1.9	2.0	2.1	2.2	2.3
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.17
Iron	ug/L	1,797	1,514	1,231	948	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	28,639	28,693	28,746	28,800
Manganese	ug/L	231	189	147	105	64
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	7.20	7.50	7.81	8.11
pH after Chem Add	pH units	7.19	7.10	7.02	6.96	7.91
Silicate	ug/L	7,214	5,415	3,615	1,816	16
Sodium	ug/L	27,614	23,342	19,070	14,797	10,525
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	35
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.9
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	55.2
TDS (calculated)	mg/L	460	434	409	384	359
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.50
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	367.50
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.64
CCPP		ND	ND	ND	ND	31.73
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.29

Table A-9
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				17
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	251
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	248
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.15
Arsenic	ug/L	7.4	6.6	5.8	5.1	4.3
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	302
Calcium	ug/L	82,557	83,455	84,354	85,252	86,150
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.35
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	56
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	19.38
Conductivity	umhos/cm	727	681	635	589	543
Copper	ug/L	20.86	21.17	21.48	21.79	22.10
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	74.8
Dissolved Oxygen	mg/L	1.9	1.8	1.7	1.7	1.6
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.17
Iron	ug/L	1,797	1,709	1,621	1,532	1,444
Lead	ug/L	3.00	2.81	2.63	2.44	2.25
Magnesium	ug/L	28,586	27,102	25,618	24,134	22,650
Manganese	ug/L	231	263	295	327	359
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.14
pH	pH units	6.90	ND	ND	7.15	7.24
pH after Chem Add	pH units	ND	ND	ND	6.96	6.95
Silicate	ug/L	7,214	6,962	6,710	6,458	6,205
Sodium	ug/L	27,614	22,576	17,537	12,499	7,460
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	26
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	12.2
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	54.0
TDS (calculated)	mg/L	460	431	402	373	344
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	20.25
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	346.88
Zinc	ug/L	43	36	28	20	13
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.27
CCPP		ND	ND	ND	ND	-25.25
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.22

Table A-10
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		4				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	257
Alkalinity After Chem	mg CaCO3/L	ND	#VALUE!	#VALUE!	#VALUE!	254
Ammonia Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.12
Arsenic	ug/L	7.4	6.2	5.0	3.7	2.5
Bicarbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	310
Calcium	ug/L	82,557	82,018	81,479	80,939	80,400
Carbonate, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.13
CO2, calculated	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	62
Chloride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	33.75
Conductivity	umhos/cm	727	694	661	628	595
Copper	ug/L	20.86	20.64	20.43	20.21	20.00
DIC, calculated	mg C/L	ND	#VALUE!	#VALUE!	#VALUE!	77.8
Dissolved Oxygen	mg/L	1.9	2.2	2.5	2.8	3.2
Fluoride	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.09
Iron	ug/L	1,797	1,618	1,439	1,259	1,080
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,586	27,364	26,143	24,921	23,700
Manganese	ug/L	231	210	190	170	150
Nitrate Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Nitrite Nitrogen	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
Ortho Phosphorous	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	0.10
pH	pH units	6.90	ND	ND	6.94	6.95
pH after Chem Add	pH units	ND	ND	ND	6.96	6.93
Silicate	ug/L	7,214	9,298	11,382	13,466	15,550
Sodium	ug/L	27,614	23,848	20,082	16,316	12,550
Sulfate	mg/L	ND	#VALUE!	#VALUE!	#VALUE!	21
Temperature	C°	ND	#VALUE!	#VALUE!	#VALUE!	11.3
Temperature	F°	ND	#VALUE!	#VALUE!	#VALUE!	52.3
TDS (calculated)	mg/L	460	435	410	385	360
Total Hardness	grains/gal	ND	#VALUE!	#VALUE!	#VALUE!	21.00
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	359.10
Zinc	ug/L	43	37	32	26	20
Langelier Saturation Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	-0.33
CCPP		ND	ND	ND	ND	-32.50
Larson Index		#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.27

Table A-10
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		5				14
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	338	325	312	298	285
Alkalinity After Chem	mg CaCO3/L	335	322	309	296	282
Ammonia Nitrogen	mg/L	0.17	0.14	0.11	0.09	0.06
Arsenic	ug/L	2.0	1.9	1.8	1.7	1.6
Bicarbonate, calculated	mg/L	408	393	377	360	344
Calcium	ug/L	106,000	104,460	102,920	101,380	99,840
Carbonate, calculated	mg/L	0.23	0.14	0.11	0.08	0.07
CO2, calculated	mg/L	77	96	114	133	152
Chloride	mg/L	66.53	69.88	73.23	76.59	79.94
Conductivity	umhos/cm	916	896	876	856	836
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	101.3	103.3	105.3	107.3	109.3
Dissolved Oxygen	mg/L	4.0	4.3	4.5	4.8	5.1
Fluoride	mg/L	0.13	0.11	0.09	0.08	0.06
Iron	ug/L	664	567	470	372	275
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	31,650	31,068	30,485	29,903	29,320
Manganese	ug/L	328	281	234	187	139
Nitrate Nitrogen	mg/L	1.00	1.05	1.09	1.14	1.18
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.98	ND	ND	ND	6.59
pH after Chem Add	pH units	6.91	6.80	6.70	6.62	6.55
Silicate	ug/L	15,300	14,810	14,320	13,830	13,340
Sodium	ug/L	33,625	34,789	35,953	37,116	38,280
Sulfate	mg/L	53	48	43	38	33
Temperature	C°	13.7	13.6	13.4	13.3	13.1
Temperature	F°	57.2	56.8	56.4	56.0	55.6
TDS (calculated)	mg/L	618	598	579	559	539
Total Hardness	grains/gal	27.00	26.20	25.40	24.60	23.80
Total Hardness	mg/L CaCO3	462.00	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	20	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.13	-0.26	-0.38	-0.48	-0.58
CCPP		-9.85	-31.60	-54.42	-74.57	-93.96
Larson Index		0.45	0.46	0.48	0.50	0.52

Table A-12
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		8				9
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	264	254	244	235	225
Alkalinity After Chem	mg CaCO3/L	261	251	242	232	223
Ammonia Nitrogen	mg/L	0.19	0.16	0.14	0.11	0.09
Arsenic	ug/L	10.2	9.1	8.0	6.9	5.8
Bicarbonate, calculated	mg/L	318	306	295	283	271
Calcium	ug/L	87,580	82,541	77,503	72,464	67,425
Carbonate, calculated	mg/L	0.23	0.15	0.11	0.09	0.07
CO2, calculated	mg/L	38	51	65	78	92
Chloride	mg/L	65.12	62.07	59.03	55.99	52.95
Conductivity	umhos/cm	752	720	689	657	626
Copper	ug/L	20.20	20.23	20.27	20.30	20.33
DIC, calculated	mg C/L	72.9	74.3	75.7	77.1	78.5
Dissolved Oxygen	mg/L	3.5	3.0	2.5	2.1	1.6
Fluoride	mg/L	0.13	0.12	0.11	0.10	0.09
Iron	ug/L	1,360	1,540	1,720	1,901	2,081
Lead	ug/L	5.00	4.50	4.00	3.50	3.00
Magnesium	ug/L	30,460	28,991	27,522	26,053	24,583
Manganese	ug/L	236	225	214	204	193
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.16	ND	ND	ND	6.72
pH after Chem Add	pH units	7.12	6.98	6.86	6.76	6.68
Silicate	ug/L	16,200	12,153	8,106	4,059	12
Sodium	ug/L	25,500	26,233	26,967	27,700	28,433
Sulfate	mg/L	44	38	32	27	21
Temperature	C°	12.5	12.6	12.7	12.8	12.8
Temperature	F°	54.6	54.7	54.8	55.0	55.1
TDS (calculated)	mg/L	501	470	439	409	378
Total Hardness	grains/gal	24.40	23.03	21.66	20.29	18.92
Total Hardness	mg/L CaCO3	417.20	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	29	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.10	-0.28	-0.43	-0.57	-0.69
CCPP		-4.84	-24.03	-43.84	-63.11	-80.68
Larson Index		0.53	0.51	0.48	0.46	0.43

Table A-13
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		8				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	264	262	260	259	257
Alkalinity After Chem	mg CaCO3/L	261	259	257	256	254
Ammonia Nitrogen	mg/L	0.19	0.17	0.16	0.14	0.12
Arsenic	ug/L	10.2	8.3	6.4	4.4	2.5
Bicarbonate, calculated	mg/L	318	316	314	312	310
Calcium	ug/L	87,580	85,785	83,990	82,195	80,400
Carbonate, calculated	mg/L	0.23	0.19	0.17	0.09	0.13
CO2, calculated	mg/L	38	44	50	89	62
Chloride	mg/L	65.12	57.27	49.43	41.59	33.75
Conductivity	umhos/cm	752	712	673	634	595
Copper	ug/L	20.20	20.15	20.10	20.05	20.00
DIC, calculated	mg C/L	72.9	74.1	75.3	76.5	77.8
Dissolved Oxygen	mg/L	3.5	3.4	3.3	3.2	3.2
Fluoride	mg/L	0.13	0.12	0.11	0.10	0.09
Iron	ug/L	1,360	1,290	1,220	1,150	1,080
Lead	ug/L	5.00	4.50	4.00	3.50	3.00
Magnesium	ug/L	30,460	28,770	27,080	25,390	23,700
Manganese	ug/L	236	214	193	171	150
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.16	ND	ND	ND	6.95
pH after Chem Add	pH units	7.12	7.06	7.01	6.76	6.93
Silicate	ug/L	16,200	16,038	15,875	15,713	15,550
Sodium	ug/L	25,500	22,263	19,025	15,788	12,550
Sulfate	mg/L	44	38	33	27	21
Temperature	C°	12.5	12.2	11.9	11.6	11.3
Temperature	F°	54.6	54.0	53.5	52.9	52.3
TDS (calculated)	mg/L	501	466	431	395	360
Total Hardness	grains/gal	24.40	23.55	22.70	21.85	21.00
Total Hardness	mg/L CaCO3	417.20	402.68	388.15	373.63	359.10
Zinc	ug/L	29	27	24	22	20
Langelier Saturation Index		-0.10	-0.17	-0.23	-0.49	-0.33
CCPP		-4.84	-12.41	-19.53	-59.87	-32.50
Larson Index		0.53	0.47	0.40	0.34	0.27

Table A-14
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		9				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	225	234	243	252	262
Alkalinity After Chem	mg CaCO3/L	223	232	241	250	259
Ammonia Nitrogen	mg/L	0.09	0.09	0.10	0.11	0.11
Arsenic	ug/L	5.8	6.3	6.8	7.3	7.8
Bicarbonate, calculated	mg/L	271	282	293	304	313
Calcium	ug/L	67,425	68,719	70,013	71,306	72,600
Carbonate, calculated	mg/L	0.07	0.09	0.09	0.08	1.44
CO2, calculated	mg/L	92	70	75	94	6
Chloride	mg/L	52.95	46.61	40.26	33.92	27.58
Conductivity	umhos/cm	626	625	625	625	625
Copper	ug/L	20.33	20.88	21.42	21.96	22.50
DIC, calculated	mg C/L	78.5	74.7	71.0	67.2	63.5
Dissolved Oxygen	mg/L	1.6	1.8	2.0	2.1	2.3
Fluoride	mg/L	0.09	0.11	0.13	0.15	0.17
Iron	ug/L	2,081	1,727	1,373	1,019	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	24,583	25,638	26,692	27,746	28,800
Manganese	ug/L	193	161	128	96	64
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.72	ND	ND	ND	8.11
pH after Chem Add	pH units	6.68	6.81	6.80	6.72	7.91
Silicate	ug/L	12	13	14	15	16
Sodium	ug/L	28,433	23,956	19,479	15,002	10,525
Sulfate	mg/L	21	24	28	31	35
Temperature	C°	12.8	12.9	12.9	12.9	12.9
Temperature	F°	55.1	55.1	55.2	55.2	55.2
TDS (calculated)	mg/L	378	373	368	364	359
Total Hardness	grains/gal	18.92	19.56	20.21	20.85	21.50
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	367.50
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		-0.69	-0.53	-0.52	-0.58	0.64
CCPP		-80.68	-55.55	-56.23	-70.08	31.73
Larson Index		0.43	0.39	0.36	0.32	0.29

Table A-15
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		9				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	225	227	229	231	233
Alkalinity After Chem	mg CaCO3/L	223	224	226	228	230
Ammonia Nitrogen	mg/L	0.09	0.07	0.06	0.04	0.03
Arsenic	ug/L	5.8	4.8	3.8	2.8	1.8
Bicarbonate, calculated	mg/L	271	274	276	278	280
Calcium	ug/L	67,425	67,669	67,913	68,156	68,400
Carbonate, calculated	mg/L	0.07	0.08	0.08	0.06	0.28
CO2, calculated	mg/L	92	75	73	113	26
Chloride	mg/L	52.95	44.03	35.11	26.19	17.27
Conductivity	umhos/cm	626	600	575	549	524
Copper	ug/L	20.33	20.25	20.17	20.08	20.00
DIC, calculated	mg C/L	78.5	74.4	70.4	66.3	62.2
Dissolved Oxygen	mg/L	1.6	2.1	2.5	3.0	3.5
Fluoride	mg/L	0.09	0.09	0.10	0.10	0.11
Iron	ug/L	2,081	1,614	1,146	679	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	24,583	24,953	25,322	25,691	26,060
Manganese	ug/L	193	187	180	174	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.72	ND	ND	ND	7.38
pH after Chem Add	pH units	6.68	6.78	6.80	6.62	6.50
Silicate	ug/L	12	3,299	6,586	9,873	13,160
Sodium	ug/L	28,433	22,810	17,187	11,563	5,940
Sulfate	mg/L	21	24	27	29	32
Temperature	C°	12.8	12.2	11.6	11.0	10.3
Temperature	F°	55.1	54.0	52.9	51.7	50.6
TDS (calculated)	mg/L	378	356	334	312	290
Total Hardness	grains/gal	18.92	18.99	19.06	19.13	19.20
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	328.40
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	20
Langelier Saturation Index		-0.69	-0.60	-0.57	-0.74	-0.87
CCPP		-80.68	-62.71	-60.14	-97.43	-129.29
Larson Index		0.43	0.39	0.34	0.30	0.25

Table A-16
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		11				12
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	258	259	260	261	262
Alkalinity After Chem	mg CaCO3/L	255	256	257	258	259
Ammonia Nitrogen	mg/L	0.24	0.21	0.18	0.15	0.11
Arsenic	ug/L	2.1	3.5	4.9	6.3	7.8
Bicarbonate, calculated	mg/L	311	312	313	314	313
Calcium	ug/L	85,800	82,500	79,200	75,900	72,600
Carbonate, calculated	mg/L	0.05	0.07	0.17	0.09	1.44
CO2, calculated	mg/L	152	115	47	87	6
Chloride	mg/L	63.98	54.88	45.78	36.68	27.58
Conductivity	umhos/cm	741	712	683	654	625
Copper	ug/L	20.00	20.63	21.25	21.88	22.50
DIC, calculated	mg C/L	102.6	92.8	83.0	73.3	63.5
Dissolved Oxygen	mg/L	1.6	1.8	2.0	2.2	2.3
Fluoride	mg/L	0.13	0.14	0.15	0.16	0.17
Iron	ug/L	843	798	754	709	665
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	32,957	31,918	30,879	29,839	28,800
Manganese	ug/L	132	115	98	81	64
Nitrate Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.54	ND	ND	ND	8.11
pH after Chem Add	pH units	6.52	6.65	7.04	6.77	6.50
Silicate	ug/L	13,114	9,840	6,565	3,291	16
Sodium	ug/L	23,943	20,588	17,234	13,879	10,525
Sulfate	mg/L	35	35	35	35	35
Temperature	C°	11.6	11.9	12.2	12.6	12.9
Temperature	F°	52.8	53.4	54.0	54.6	55.2
TDS (calculated)	mg/L	446	424	403	381	359
Total Hardness	grains/gal	23.29	22.84	22.39	21.95	21.50
Total Hardness	mg/L CaCO3	398.00	390.38	382.75	375.13	367.50
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		-0.72	-0.60	-0.22	-0.49	-0.77
CCPP		-113.78	-82.26	-17.28	-58.60	-118.57
Larson Index		0.50	0.45	0.39	0.34	0.29

Table A-17
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		11				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	258	252	245	239	233
Alkalinity After Chem	mg CaCO3/L	255	249	243	236	230
Ammonia Nitrogen	mg/L	0.24	0.19	0.13	0.08	0.03
Arsenic	ug/L	2.1	2.1	2.0	1.9	1.8
Bicarbonate, calculated	mg/L	311	303	296	288	280
Calcium	ug/L	85,800	81,450	77,100	72,750	68,400
Carbonate, calculated	mg/L	0.05	0.06	0.12	0.06	0.28
CO2, calculated	mg/L	152	120	59	106	26
Chloride	mg/L	63.98	52.30	40.63	28.95	17.27
Conductivity	umhos/cm	741	687	633	578	524
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	102.6	92.5	82.4	72.3	62.2
Dissolved Oxygen	mg/L	1.6	2.1	2.6	3.0	3.5
Fluoride	mg/L	0.13	0.12	0.12	0.11	0.11
Iron	ug/L	843	685	527	370	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	32,957	31,233	29,509	27,784	26,060
Manganese	ug/L	132	141	150	159	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.54	ND	ND	ND	7.38
pH after Chem Add	pH units	6.52	6.62	6.93	6.67	6.42
Silicate	ug/L	13,114	13,126	13,137	13,149	13,160
Sodium	ug/L	23,943	19,442	14,941	10,441	5,940
Sulfate	mg/L	35	35	34	33	32
Temperature	C°	11.6	11.3	11.0	10.6	10.3
Temperature	F°	52.8	52.3	51.7	51.2	50.6
TDS (calculated)	mg/L	446	407	368	329	290
Total Hardness	grains/gal	23.29	22.26	21.24	20.22	19.20
Total Hardness	mg/L CaCO3	398.00	380.60	363.20	345.80	328.40
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		-0.72	-0.65	-0.38	-0.67	-0.95
CCPP		-113.78	-91.33	-35.86	-85.45	-152.08
Larson Index		0.50	0.44	0.38	0.32	0.25

Table A-18
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		12				22
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	262	254	247	240	233
Alkalinity After Chem	mg CaCO3/L	259	252	244	237	230
Ammonia Nitrogen	mg/L	0.11	0.09	0.07	0.05	0.03
Arsenic	ug/L	7.8	6.3	4.8	3.3	1.8
Bicarbonate, calculated	mg/L	313	305	298	289	280
Calcium	ug/L	72,600	71,550	70,500	69,450	68,400
Carbonate, calculated	mg/L	1.44	0.70	0.13	0.06	0.28
CO2, calculated	mg/L	6	11	57	105	26
Chloride	mg/L	27.58	25.00	22.42	19.85	17.27
Conductivity	umhos/cm	625	600	574	549	524
Copper	ug/L	22.50	21.88	21.25	20.63	20.00
DIC, calculated	mg C/L	63.5	63.2	62.9	62.6	62.2
Dissolved Oxygen	mg/L	2.3	2.6	2.9	3.2	3.5
Fluoride	mg/L	0.17	0.15	0.14	0.12	0.11
Iron	ug/L	665	552	439	325	212
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	28,800	28,115	27,430	26,745	26,060
Manganese	ug/L	64	90	116	142	168
Nitrate Nitrogen	mg/L	0.10	0.34	0.58	0.82	1.06
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	8.11	ND	ND	ND	7.38
pH after Chem Add	pH units	7.91	7.67	6.94	6.67	6.42
Silicate	ug/L	16	3,302	6,588	9,874	13,160
Sodium	ug/L	10,525	9,379	8,233	7,086	5,940
Sulfate	mg/L	35	34	34	33	32
Temperature	C°	12.9	12.3	11.6	11.0	10.3
Temperature	F°	55.2	54.1	52.9	51.8	50.6
TDS (calculated)	mg/L	359	342	324	307	290
Total Hardness	grains/gal	21.50	20.93	20.35	19.78	19.20
Total Hardness	mg/L CaCO3	367.50	357.73	347.95	338.18	328.40
Zinc	ug/L	20	20	20	20	20
Langelier Saturation Index		0.64	0.37	-0.38	-0.67	-0.95
CCPP		31.73	23.01	-35.84	-85.73	-152.08
Larson Index		0.29	0.28	0.27	0.26	0.25

Table A-19
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		14				25
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	285	279	273	267	261
Alkalinity After Chem	mg CaCO3/L	282	276	270	264	258
Ammonia Nitrogen	mg/L	0.06	0.07	0.09	0.10	0.11
Arsenic	ug/L	1.6	1.5	1.3	1.2	1.0
Bicarbonate, calculated	mg/L	344	337	329	322	314
Calcium	ug/L	99,840	95,097	90,353	85,610	80,867
Carbonate, calculated	mg/L	0.07	0.08	0.26	0.11	0.26
CO2, calculated	mg/L	152	127	35	82	49
Chloride	mg/L	79.94	63.92	47.90	31.89	15.87
Conductivity	umhos/cm	836	776	716	657	597
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	109.3	100.8	92.3	83.8	75.3
Dissolved Oxygen	mg/L	5.1	5.0	4.9	4.8	4.7
Fluoride	mg/L	0.06	0.06	0.07	0.08	0.08
Iron	ug/L	275	227	179	131	83
Lead	ug/L	3.00	3.00	3.00	3.00	3.00
Magnesium	ug/L	29,320	28,334	27,349	26,363	25,378
Manganese	ug/L	139	123	107	91	75
Nitrate Nitrogen	mg/L	1.18	1.22	1.26	1.30	1.34
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	6.59	ND	ND	ND	7.13
pH after Chem Add	pH units	6.55	6.62	7.17	6.79	6.49
Silicate	ug/L	13,340	13,458	13,576	13,693	13,811
Sodium	ug/L	38,280	30,838	23,396	15,953	8,511
Sulfate	mg/L	33	34	34	35	36
Temperature	C°	13.1	13.1	13.2	13.2	13.2
Temperature	F°	55.6	55.6	55.7	55.7	55.7
TDS (calculated)	mg/L	539	513	486	459	433
Total Hardness	grains/gal	23.80	22.93	22.07	21.20	20.33
Total Hardness	mg/L CaCO3	ND	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	ND	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.58	-0.54	-0.01	-0.42	-0.75
CCPP		-93.96	-79.20	4.00	-49.03	-118.89
Larson Index		0.52	0.45	0.38	0.31	0.23

Table A-20
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		17				18
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	251	253	254	256	257
Alkalinity After Chem	mg CaCO3/L	248	250	251	253	254
Ammonia Nitrogen	mg/L	0.15	0.14	0.14	0.13	0.12
Arsenic	ug/L	4.3	3.8	3.4	2.9	2.5
Bicarbonate, calculated	mg/L	302	305	306	308	310
Calcium	ug/L	86,150	84,713	83,275	81,838	80,400
Carbonate, calculated	mg/L	0.35	0.13	0.15	0.08	0.13
CO2, calculated	mg/L	56	57	51	92	62
Chloride	mg/L	19.38	22.97	26.56	30.15	33.75
Conductivity	umhos/cm	543	556	569	582	595
Copper	ug/L	22.10	21.58	21.05	20.53	20.00
DIC, calculated	mg C/L	74.8	75.5	76.3	77.0	77.8
Dissolved Oxygen	mg/L	1.6	2.0	2.4	2.8	3.2
Fluoride	mg/L	0.17	0.15	0.13	0.11	0.09
Iron	ug/L	1,444	1,353	1,262	1,171	1,080
Lead	ug/L	2.25	2.44	2.63	2.81	3.00
Magnesium	ug/L	22,650	22,913	23,175	23,438	23,700
Manganese	ug/L	359	307	254	202	150
Nitrate Nitrogen	mg/L	0.09	0.09	0.09	0.10	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.14	0.13	0.12	0.11	0.10
pH	pH units	7.24	ND	ND	ND	6.95
pH after Chem Add	pH units	6.95	6.95	7.00	6.75	6.50
Silicate	ug/L	6,205	8,542	10,878	13,214	15,550
Sodium	ug/L	7,460	8,733	10,005	11,278	12,550
Sulfate	mg/L	26	25	24	22	21
Temperature	C°	12.2	12.0	11.8	11.5	11.3
Temperature	F°	54.0	53.6	53.2	52.8	52.3
TDS (calculated)	mg/L	344	348	352	356	360
Total Hardness	grains/gal	20.25	20.44	20.63	20.81	21.00
Total Hardness	mg/L CaCO3	346.88	349.93	352.99	356.04	359.10
Zinc	ug/L	13	15	16	18	20
Langelier Saturation Index		-0.27	-0.28	-0.24	-0.50	-0.76
CCPP		-25.25	-26.21	-20.70	-61.64	-121.48
Larson Index		0.22	0.23	0.25	0.26	0.27

Table A-21
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		17				39
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	251	252	253	253	254
Alkalinity After Chem	mg CaCO3/L	248	249	250	251	251
Ammonia Nitrogen	mg/L	0.15	0.18	0.21	0.24	0.27
Arsenic	ug/L	4.3	4.3	4.3	4.3	4.3
Bicarbonate, calculated	mg/L	302	304	305	306	306
Calcium	ug/L	86,150	86,813	87,475	88,138	88,800
Carbonate, calculated	mg/L	0.35	0.14	0.15	0.08	0.23
CO2, calculated	mg/L	56	54	51	93	49
Chloride	mg/L	19.38	20.65	21.92	23.19	24.46
Conductivity	umhos/cm	543	563	583	603	623
Copper	ug/L	22.10	23.59	25.09	26.58	28.08
DIC, calculated	mg C/L	74.8	74.5	74.2	73.9	73.6
Dissolved Oxygen	mg/L	1.6	1.6	1.7	1.7	1.8
Fluoride	mg/L	0.17	0.16	0.16	0.15	0.15
Iron	ug/L	1,444	1,138	833	527	221
Lead	ug/L	2.25	2.43	2.60	2.78	2.95
Magnesium	ug/L	22,650	21,740	20,831	19,921	19,011
Manganese	ug/L	359	299	239	179	118
Nitrate Nitrogen	mg/L	0.09	0.42	0.74	1.07	1.40
Nitrite Nitrogen	mg/L	0.10	0.09	0.09	0.08	0.07
Ortho Phosphorous	mg/L	0.14	0.12	0.11	0.09	0.07
pH	pH units	7.24	ND	ND	ND	7.12
pH after Chem Add	pH units	6.95	6.97	7.00	6.73	6.48
Silicate	ug/L	6,205	6,628	7,050	7,472	7,894
Sodium	ug/L	7,460	9,334	11,207	13,081	14,955
Sulfate	mg/L	26	28	29	31	32
Temperature	C°	12.2	12.2	12.1	12.1	12.0
Temperature	F°	54.0	53.9	53.8	53.7	53.6
TDS (calculated)	mg/L	344	356	368	380	392
Total Hardness	grains/gal	20.25	19.46	18.67	17.88	17.09
Total Hardness	mg/L CaCO3	346.88	333.72	320.57	307.42	294.27
Zinc	ug/L	13	13	14	14	15
Langelier Saturation Index		-0.27	-0.25	-0.22	-0.49	-0.74
CCPP		-25.25	-22.37	-18.50	-61.04	-119.94
Larson Index		0.22	0.23	0.25	0.26	0.27

Table A-22
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		18				39
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	257	256	256	255	254
Alkalinity After Chem	mg CaCO3/L	254	253	253	252	251
Ammonia Nitrogen	mg/L	0.12	0.16	0.20	0.24	0.27
Arsenic	ug/L	2.5	2.9	3.4	3.8	4.3
Bicarbonate, calculated	mg/L	310	309	308	307	306
Calcium	ug/L	80,400	82,500	84,600	86,700	88,800
Carbonate, calculated	mg/L	0.13	0.13	0.16	0.08	0.23
CO2, calculated	mg/L	62	58	48	92	49
Chloride	mg/L	33.75	31.42	29.10	26.78	24.46
Conductivity	umhos/cm	595	602	609	616	623
Copper	ug/L	20.00	22.02	24.04	26.06	28.08
DIC, calculated	mg C/L	77.8	76.7	75.7	74.7	73.6
Dissolved Oxygen	mg/L	3.2	2.8	2.5	2.1	1.8
Fluoride	mg/L	0.09	0.10	0.12	0.13	0.15
Iron	ug/L	1,080	865	651	436	221
Lead	ug/L	3.00	2.99	2.98	2.96	2.95
Magnesium	ug/L	23,700	22,528	21,356	20,183	19,011
Manganese	ug/L	150	142	134	126	118
Nitrate Nitrogen	mg/L	0.10	0.43	0.75	1.08	1.40
Nitrite Nitrogen	mg/L	0.10	0.09	0.09	0.08	0.07
Ortho Phosphorous	mg/L	0.10	0.09	0.09	0.08	0.07
pH	pH units	6.95	ND	ND	ND	7.12
pH after Chem Add	pH units	6.93	6.95	7.03	6.74	6.48
Silicate	ug/L	15,550	13,636	11,722	9,808	7,894
Sodium	ug/L	12,550	13,151	13,752	14,353	14,955
Sulfate	mg/L	21	24	27	29	32
Temperature	C°	11.3	11.5	11.7	11.8	12.0
Temperature	F°	52.3	52.7	53.0	53.3	53.6
TDS (calculated)	mg/L	360	368	376	384	392
Total Hardness	grains/gal	21.00	20.02	19.05	18.07	17.09
Total Hardness	mg/L CaCO3	359.10	342.89	326.69	310.48	294.27
Zinc	ug/L	20	19	17	16	15
Langelier Saturation Index		-0.33	-0.30	-0.21	-0.49	-0.74
CCPP		-32.50	-28.38	-16.71	-60.70	-119.94
Larson Index		0.27	0.27	0.27	0.27	0.27

Table A-23
Blending of Waters from Adjacent Stations

Parameter	Unit	A				B
Station #		22				24
Station A	% in Blend	100%	75%	50%	25%	0%
Station B	% in Blend	0%	25%	50%	75%	100%
Alkalinity	mg CaCO3/L	233	224	215	206	197
Alkalinity After Chem	mg CaCO3/L	230	221	212	203	194
Ammonia Nitrogen	mg/L	0.03	0.06	0.10	0.14	0.18
Arsenic	ug/L	1.8	1.9	2.0	2.1	2.1
Bicarbonate, calculated	mg/L	280	270	259	248	237
Calcium	ug/L	68,400	65,098	61,797	58,495	55,193
Carbonate, calculated	mg/L	0.28	0.13	0.06	0.04	0.05
CO2, calculated	mg/L	26	44	84	135	100
Chloride	mg/L	17.27	16.95	16.63	16.31	15.98
Conductivity	umhos/cm	524	503	482	462	441
Copper	ug/L	20.00	20.00	20.00	20.00	20.00
DIC, calculated	mg C/L	62.2	65.2	68.1	71.0	73.9
Dissolved Oxygen	mg/L	3.5	3.0	2.5	2.0	1.5
Fluoride	mg/L	0.11	0.10	0.10	0.10	0.09
Iron	ug/L	212	407	601	796	990
Lead	ug/L	3.00	3.72	4.43	5.15	5.87
Magnesium	ug/L	26,060	24,437	22,813	21,190	19,567
Manganese	ug/L	168	136	105	73	42
Nitrate Nitrogen	mg/L	1.06	0.82	0.58	0.34	0.10
Nitrite Nitrogen	mg/L	0.10	0.10	0.10	0.10	0.10
Ortho Phosphorous	mg/L	0.10	0.10	0.10	0.10	0.10
pH	pH units	7.38	ND	ND	ND	6.67
pH after Chem Add	pH units	7.28	7.02	6.73	6.50	6.26
Silicate	ug/L	13,160	13,268	13,377	13,485	13,593
Sodium	ug/L	5,940	6,555	7,170	7,785	8,400
Sulfate	mg/L	32	28	24	20	15
Temperature	C°	10.3	10.7	11.1	11.5	11.8
Temperature	F°	50.6	51.3	52.0	52.6	53.3
TDS (calculated)	mg/L	290	288	287	286	284
Total Hardness	grains/gal	19.20	18.28	17.37	16.45	15.53
Total Hardness	mg/L CaCO3	328.40	#VALUE!	#VALUE!	#VALUE!	ND
Zinc	ug/L	20	#VALUE!	#VALUE!	#VALUE!	ND
Langelier Saturation Index		-0.09	-0.38	-0.71	-0.97	-1.24
CCPP		-3.53	-30.58	-76.35	-127.65	-197.30
Larson Index		0.25	0.24	0.23	0.21	0.20

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57140

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	3000 STADIUM DR,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP309 STATION 12	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	09:02
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

Sample Comment **LG57140** **Testing which has not been provided for test code CAS requires special containers. For residential wells contact the local county health dept. Otherwise, contact the MDEQ Drinking Water Unit: (517) 335-8184 (Lansing) or MDEQ UP District Office: (90**

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	34	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	297	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.4	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Matrix spike recovery was below the acceptance criteria due to the presence of residual chlorine in the sample. This does not affect the validity of the sample result.						
Sodium (automated)	12	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	30	07/01/2016	10		SM 4500 SO4E	14808-79-8

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
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USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57141

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	4419 SIESTA,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP313 STATION 22	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	11:27
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	13	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.53	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	274	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	0.8	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	7	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	37	07/01/2016	10		SM 4500 SO4E	14808-79-8

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3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

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Systems Mgmt. Unit Mgr: George Krisztian

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Sample Number
LG57142

Official Laboratory Report

Report To: CITY OF KALAMAZOO-SHANNAN DEAT
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	7275 EAST H STREET,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP314 STATION 25	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	13:40
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	20	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.31	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	284	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	2.1	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	10	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	33	07/01/2016	10		SM 4500 SO4E	14808-79-8

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

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TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57143

Official Laboratory Report

Report To: SHANNAN DEATER
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	331 BALCH ST,KALAMAZOO	Source:	Other	
Collected By:		Site Code:	TP303 STATION 3	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	08:00
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	79	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.54	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	348	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	2.7	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	35	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	41	07/01/2016	10		SM 4500 SO4E	14808-79-8

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

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Sample Number
LG57144

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	3531 KONKLE,KALAMAZOO	Source:	Other	
Collected By:		Site Code:	TP311 STATION 17	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	10:12
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	38	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.15	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	294	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	1.1	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	17	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	27	07/01/2016	10		SM 4500 SO4E	14808-79-8

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
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MPN : Most Probable Number
CFU : Colony Forming Unit

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Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57145

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	200 EAST KILGORE,KALAMAZOO	Source:	TYPE I	
Collected By:	MARY ALLEN	Site Code:	TP306 STATION 8	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	12:38
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Treated Public Distribution System	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	80	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	334	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.9	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	27	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	45	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57146

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	4131 PENWAY ST,KALAMAZOO	Source:	Other	
Collected By:		Site Code:	TP312 STATION 18	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	09:41
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	53	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	293	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	22	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	26	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57147

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
415 STOCKBRIDGE
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	5999 S 9TH ST,KALAMAZOO	Source:	Other	
Collected By:		Site Code:	TP315 STATION 24	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	11:06
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	12	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.34	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	202	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	8	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	11	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Systems Mgmt. Unit Mgr: George Krisztian

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Sample Number
LG57148

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520
Collection Address:	2000 W CROSSTOWN MAPLE ST,KALAMA	Source:	Other
Collected By:		Site Code:	TP304 STATION 4
Township/Well#/Section:	//	Collector:	Other
County:	Kalamazoo	Date Collected:	06/30/2016
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016 09:43
Water System:	Other	Purpose:	Other

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	63	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.31	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	314	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.6	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	30	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	35	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Nazareth, MI 49048
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MPN : Most Probable Number
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Laboratory Contacts
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Systems Mgmt. Unit Mgr: George Krisztian

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Sample Number
LG57149

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	432 KENDALL,KALAMAZOO	Source:	Other	
Collected By:		Site Code:	TP308 STATION 11	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	09:10
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	79	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	328	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.2	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	26	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	35	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Nazareth, MI 49048
269 373-5200

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AL : Action Level
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MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
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Systems Mgmt. Unit Mgr: George Krisztian

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Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57150

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	8801 MILLER ROAD,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP316 STATION 39	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	13:05
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	38	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.65	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	288	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.7	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	1.6	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	19	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	26	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Nazareth, MI 49048
269 373-5200

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Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

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P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57151

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	112 CROSSTOWN-BOUN CT,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP302 STATION 2	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	08:17
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	199	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.13	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	385	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	1.0	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	94	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	45	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Sample Number
LG57152

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	2300 HENSON AVE,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP310 STATION 14	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	14:00
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	91	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.39	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	338	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	1.2	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	41	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	32	07/01/2016	10		SM 4500 SO4E	14808-79-8

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Lansing, MI 48909
TEL: (517) 335-8184
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Sample Number
LG57153

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	215 W STOCKBRIDGE,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP201 CENTRAL/STATION 1	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	07:45
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:43
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Chloride	145	07/01/2016	4		SM 4500-Cl E	7647-14-5
Fluoride	0.52	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	371	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	Not detected	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Nitrate as N	0.6	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Sodium (automated)	63	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	39	07/01/2016	10		SM 4500 SO4E	14808-79-8

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ppm : parts per million
MPN : Most Probable Number
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Sample Number
LG57154

Official Laboratory Report

Report To: CITY OF KALAMAZOO - SHANNAN DE
1415 N HARRISON
KALAMAZOO MI 49007

System Name/Owner:	CITY OF KALAMAZOO	WSSN/Pool ID:	03520	
Collection Address:	813 WEST KILGORE,KALAMAZOO	Source:	Other	
Collected By:	MARY ALLEN	Site Code:	TP307 STATION 9	
Township/Well#/Section:	//	Collector:	Other	
County:	Kalamazoo	Date Collected:	06/30/2016	12:18
Sample Point:	STANDARD SAMPLING POINT	Date Received:	07/01/2016	09:44
Water System:	Other	Purpose:	Other	

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #
Antimony	Not detected	07/06/2016	0.0006	0.006	EPA 200.8	7440-36-0
Arsenic	0.003	07/06/2016	0.002	0.010	EPA 200.8	7440-38-2
Barium	0.09	07/06/2016	0.01	2	EPA 200.8	7440-39-3
Beryllium	Not detected	07/06/2016	0.0004	0.004	EPA 200.8	7440-41-7
Cadmium	Not detected	07/06/2016	0.0003	0.005	EPA 200.8	7440-43-9
Chloride	77	07/01/2016	4		SM 4500-Cl E	7647-14-5
Chromium	Not detected	07/06/2016	0.01	0.1	EPA 200.8	7440-47-3
Fluoride	0.48	07/01/2016	0.1	4.0	SM 4500 FC	16984-48-8
Hardness as CaCO3	261	07/01/2016	20		SM 2340 C	HARD-00-C
Iron (automated)	0.2	07/01/2016	0.1		SM 3500 FeB	7439-89-6
Lead	Not detected	07/06/2016	0.001	0.015	EPA 200.8	7439-92-1
Mercury	Not detected	07/06/2016	0.0001	0.002	EPA 200.8	7439-97-6
Nickel	Not detected	07/06/2016	0.01	0.1	EPA 200.8	7440-02-0
Nitrate as N	Not Detected	07/01/2016	0.4	10	10-107-04-2-B	14797-55-8
Nitrite as N	Not detected	07/01/2016	0.05	1	10-107-04-2-B	14797-65-0
Selenium	Not detected	07/06/2016	0.001	0.05	EPA 200.8	7782-49-2
Sodium (automated)	34	07/01/2016	5		SM 3500 NaB	7440-23-5
Sulfate	Not detected	07/01/2016	10		SM 4500 SO4E	14808-79-8
Thallium	Not detected	07/06/2016	0.0002	0.002	EPA 200.8	7440-28-0

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003
P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Sample Number
LG57154

TESTING INFORMATION			REGULATORY INFORMATION			
Analyte Name	Result (mg/L)	Date Tested	RL (mg/L)	MCL/AL (mg/L)	Method	CAS #

The analyses performed by the MDEQ Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

Your local health department has detailed information about the quality of drinking water in your area. If you have concerns about the health risks related to the test results of your sample, please contact the Environmental Health Section through the address and telephone number listed below:

Kalamazoo County Human Services Dept.
3299 Gull Rd.
Nazareth, MI 49048
269 373-5200

CAS# : Chemical Abstract Service Registry Number
MCL : Maximum Contaminant Level
AL : Action Level
RL : Reporting Limit

mg/L : milligrams / Liter (ppm)
ppm : parts per million
MPN : Most Probable Number
CFU : Colony Forming Unit

Laboratory Contacts
Drinking Water Unit Mgr: Julia Pieper
Systems Mgmt. Unit Mgr: George Krisztian

CITY OF KALAMAZOO PUBLIC SERVICES LABORATORY REPORT
WATER QUALITY MONITORING

Date	SEQ	Location	pH	Ortho-Phos	Hexameta-Phos
5/16/2016	31	STA 1	8.08	0.34	1.88
5/16/2016	39	STA 9	7.49	<0.10	1.98
5/16/2016	41	STA 11	7.83	0.24	1.65
5/16/2016	42	STA 12	7.43	<0.10	1.96
5/16/2016	44	STA 14	7.03	<0.10	2.05
5/16/2016	54	STA 24	7.28	0.11	3.94
5/16/2016	55	STA 25	7.29	<0.10	1.96
5/16/2016	69	STA 39	7.19	0.10	2.49
5/31/2016	31	STA 1	7.56	0.22	1.28
5/31/2016	41	STA 11	7.31	0.25	1.79
5/31/2016	44	STA 14	6.80	<0.10	1.96
5/31/2016	48	STA 18	6.89	<0.10	1.81
5/31/2016	52	STA 22	6.97	<0.10	2.30
5/31/2016	55	STA 25	6.86	<0.10	1.47
5/31/2016	69	STA 39	6.95	<0.10	2.04

Total Samples	pH	Ortho-Phos	Hexameta-Phos
15.00	15.00	15.00	15.00

UNITS: mg/L
Acceptable Limits for pH: 6.5 - 8.5
Acceptable Limits for Total Phos: .5 - 4.0

CITY OF KALAMAZOO PUBLIC SERVICES LABORATORY REPORT
WATER QUALITY MONITORING

Date	SEQ	Location	pH	Ortho-Phos	Hexameta-Phos
6/13/2016	31	STA 1	7.88	0.21	1.07
6/13/2016	34	STA 4	7.16	<0.10	1.60
6/13/2016	41	STA 11	7.38	0.21	1.53
6/13/2016	42	STA 12	7.22	<0.10	1.56
6/13/2016	44	STA 14	7.06	<0.10	1.61
6/13/2016	54	STA 24	7.31	<0.10	1.73
6/13/2016	55	STA 25	7.12	<0.10	2.02
6/27/2016	31	STA 1	7.83	0.15	1.10
6/27/2016	39	STA 9	7.25	<0.10	2.24
6/27/2016	41	STA 11	7.67	0.22	1.82
6/27/2016	42	STA 12	7.22	<0.10	2.00
6/27/2016	44	STA 14	7.05	<0.10	2.17
6/27/2016	54	STA 24	7.29	<0.10	1.73
6/27/2016	55	STA 25	7.16	<0.10	0.55

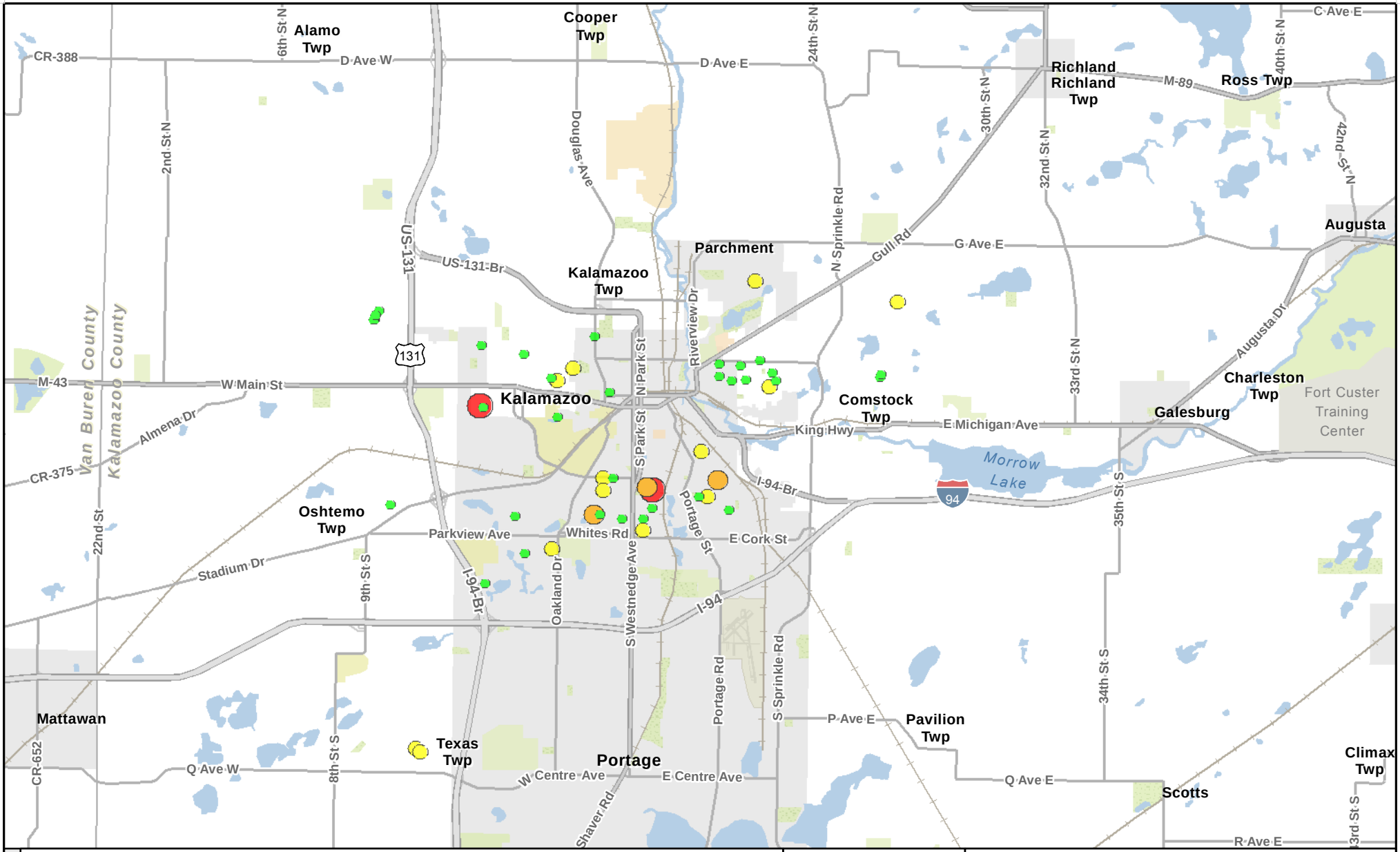
Total Samples	pH	Ortho-Phos	Hexameta-Phos
14.00	14.00	14.00	14.00

UNITS: mg/L
Acceptable Limits for pH: 6.5 - 8.5
Acceptable Limits for Total Phos: .5 - 4.0

Attachment B

Lead and Copper Aerial Maps

DRAFT



LEGEND

Lead Concentration (ppb) - 2002

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

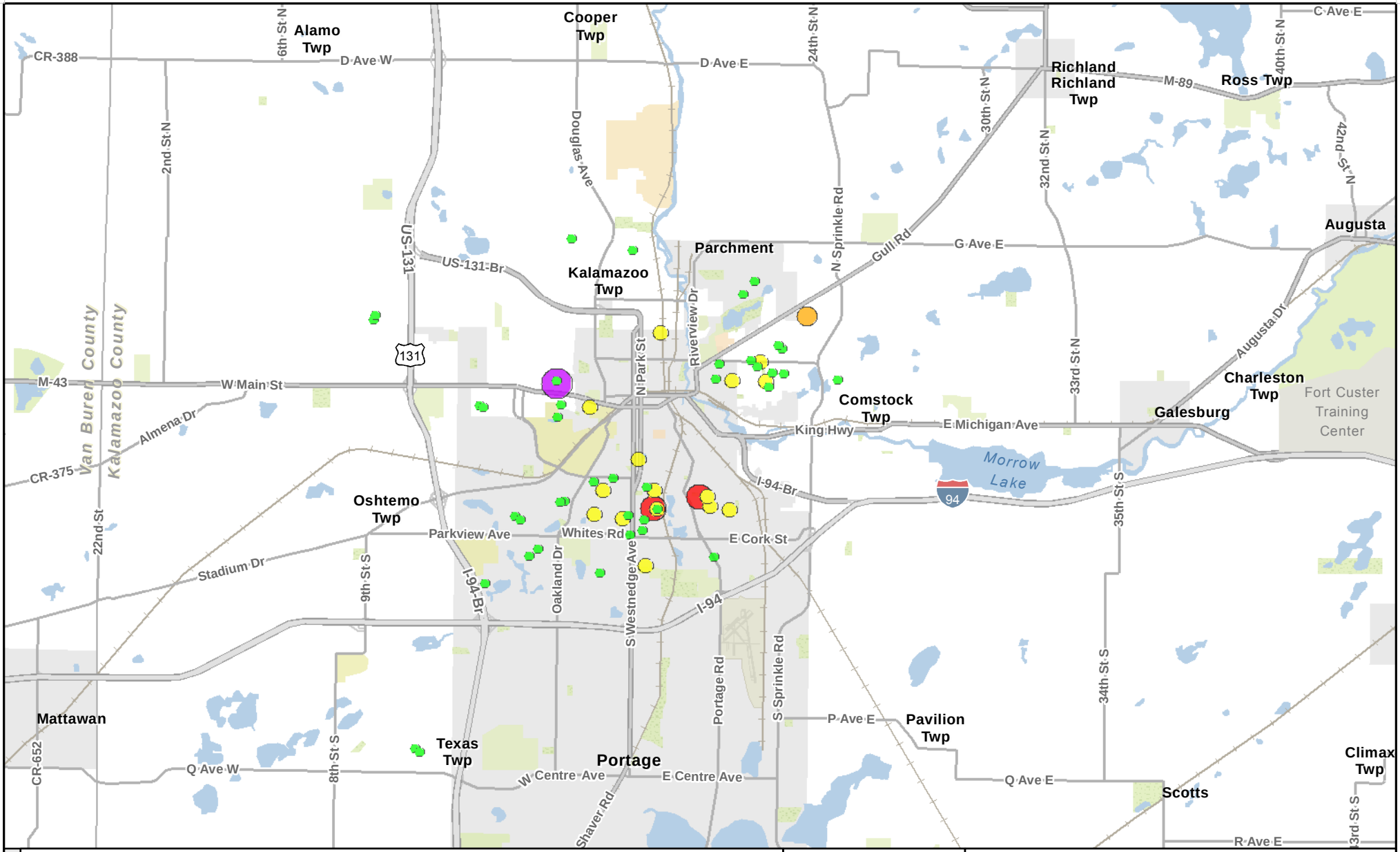
LEAD CONCENTRATION

TETRA TECH

FIGURE 1

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2002.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2005

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

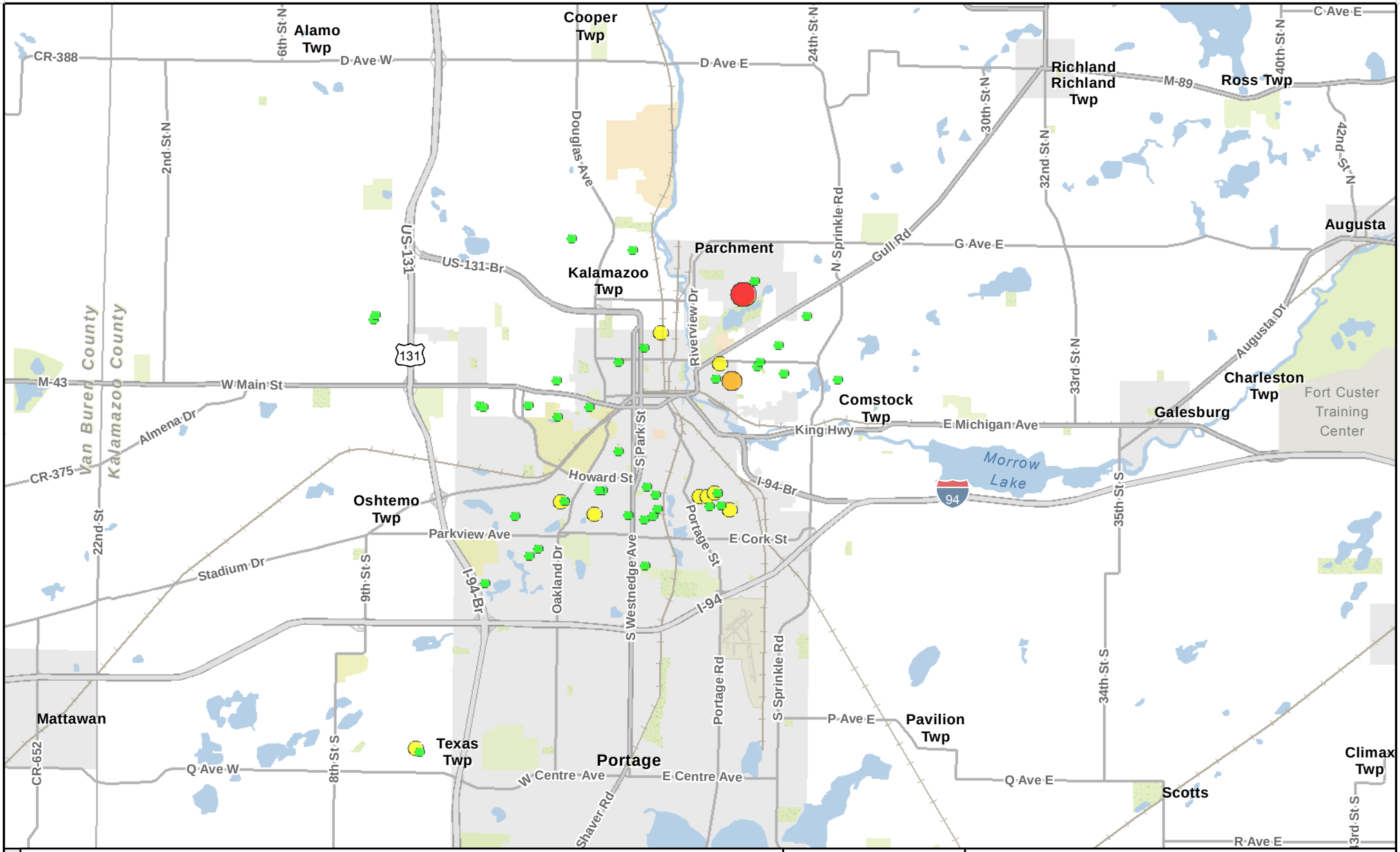
LEAD CONCENTRATION

TETRA TECH

FIGURE 2

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2005.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2008

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

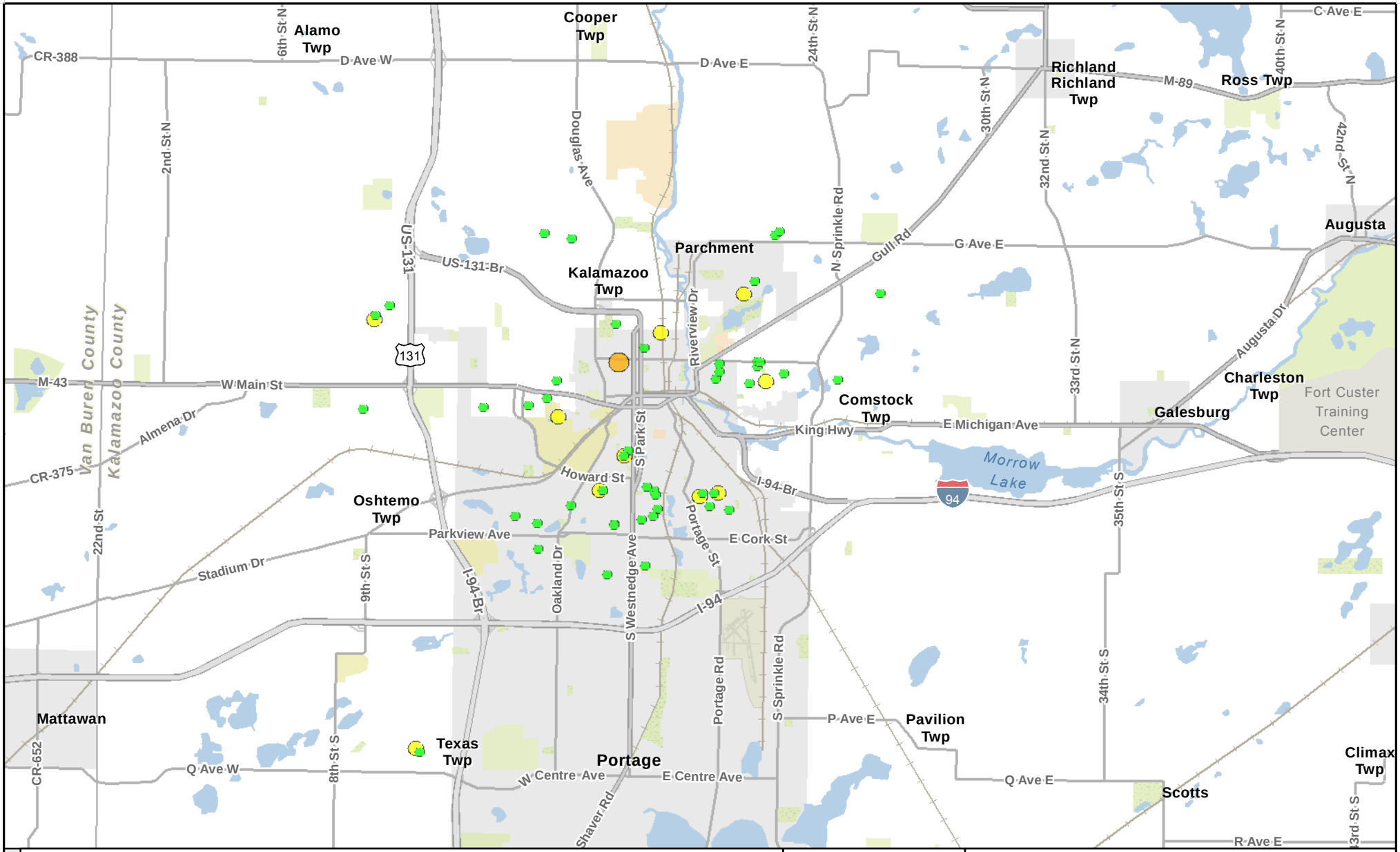
LEAD CONCENTRATION

TETRA TECH

FIGURE 3

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2008.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2011

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

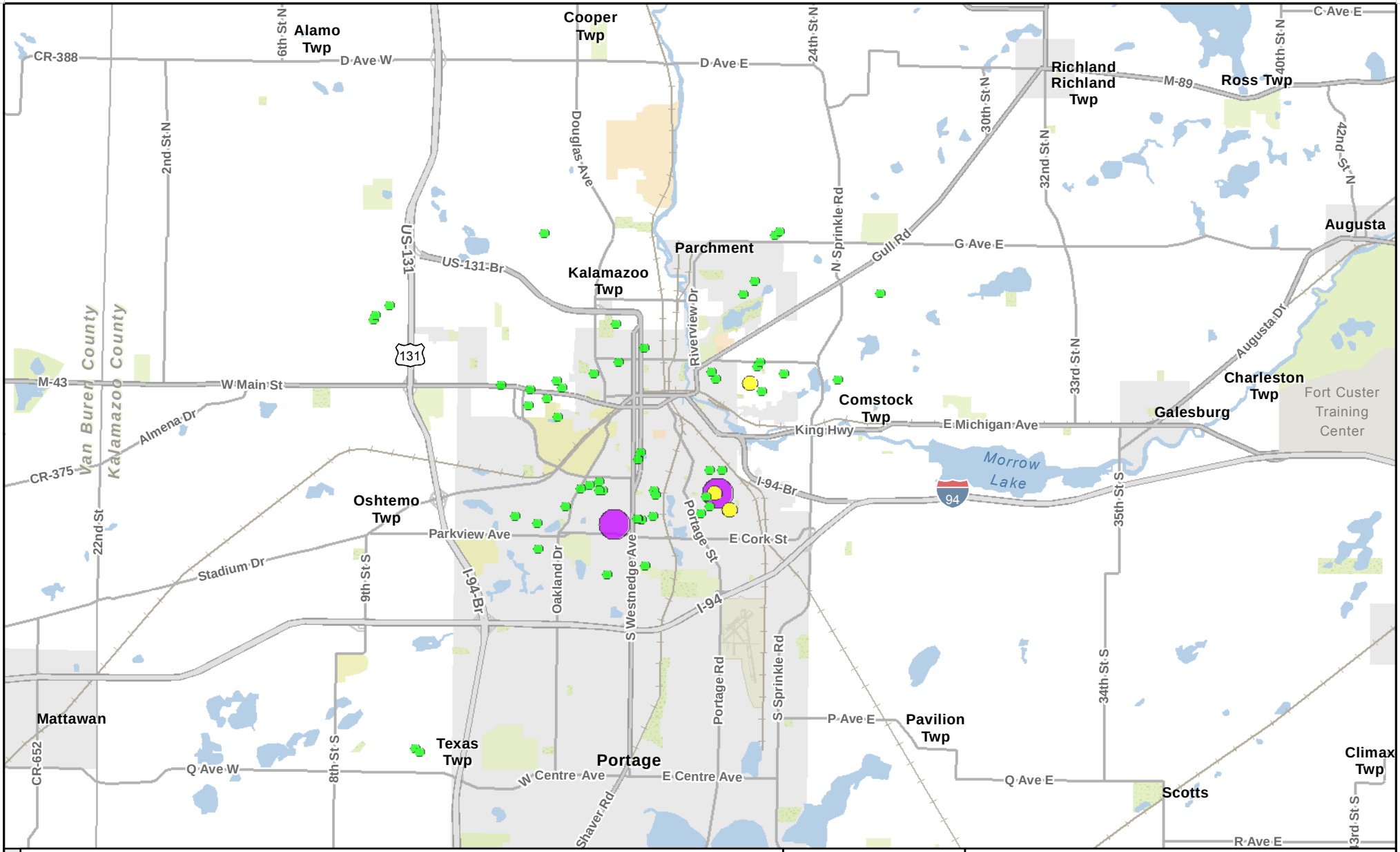
LEAD CONCENTRATION

TETRA TECH

FIGURE 4

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2011.mxd [alex.montalvo 8/25/2016]



LEGEND

Lead Concentration (ppb) - 2014

- > 0 - 3.9
- 4 - 9.9
- 10 - 14.9
- 15 - 49.9
- Greater than 50

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

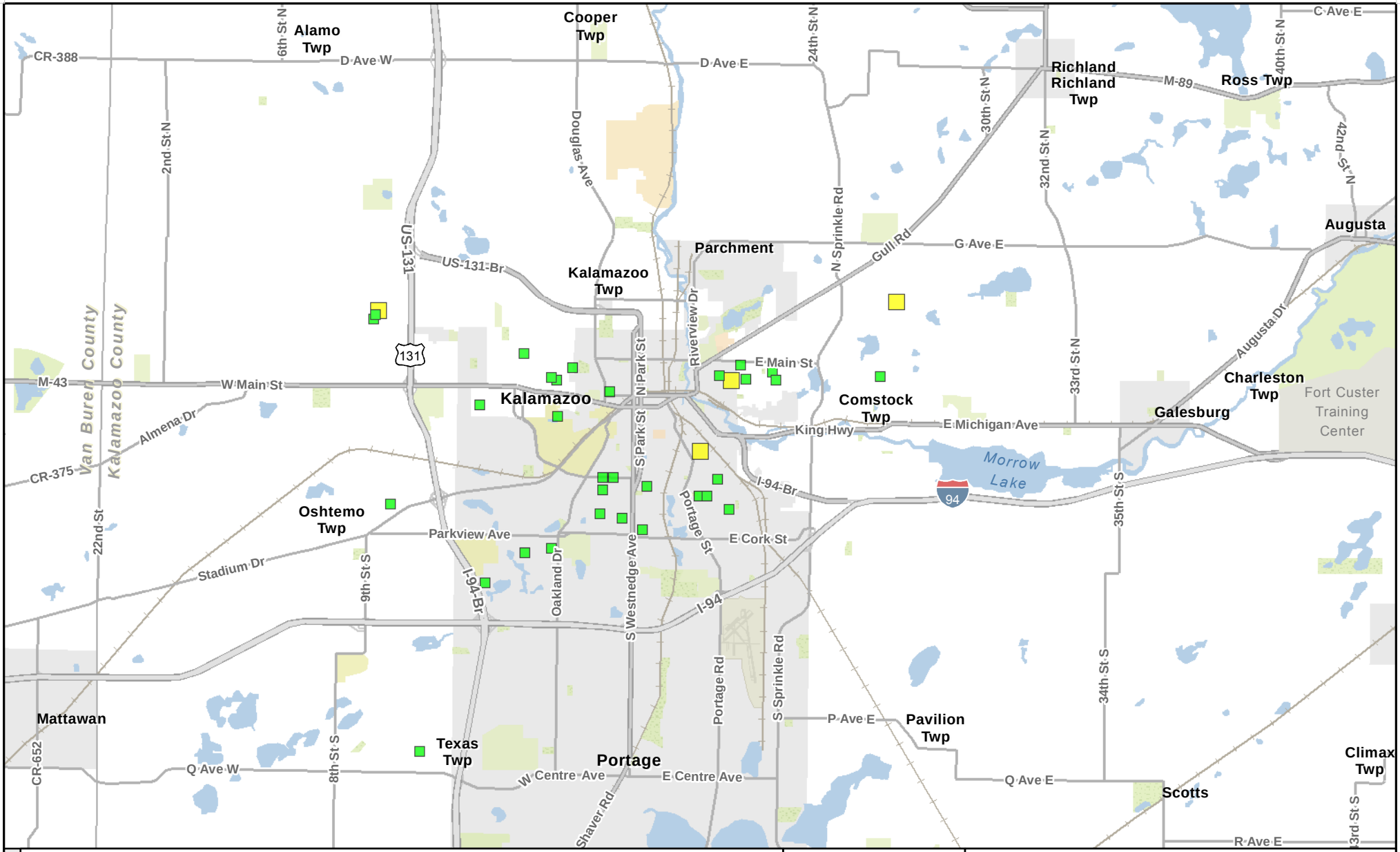
LEAD CONCENTRATION

TETRA TECH

FIGURE 5

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Pb_2014.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2002

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

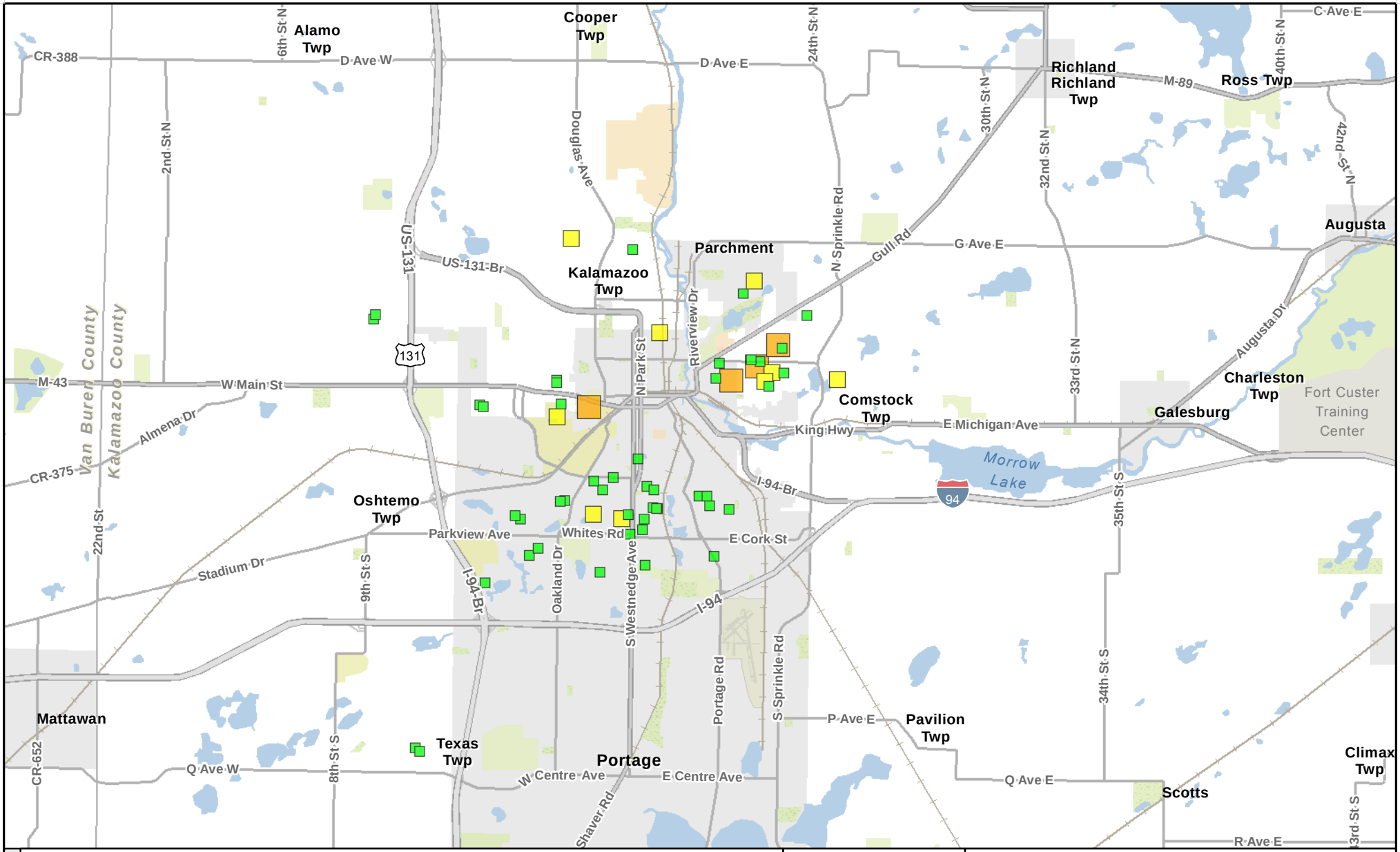
COPPER CONCENTRATION

TETRA TECH

FIGURE 6

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2002.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2005

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

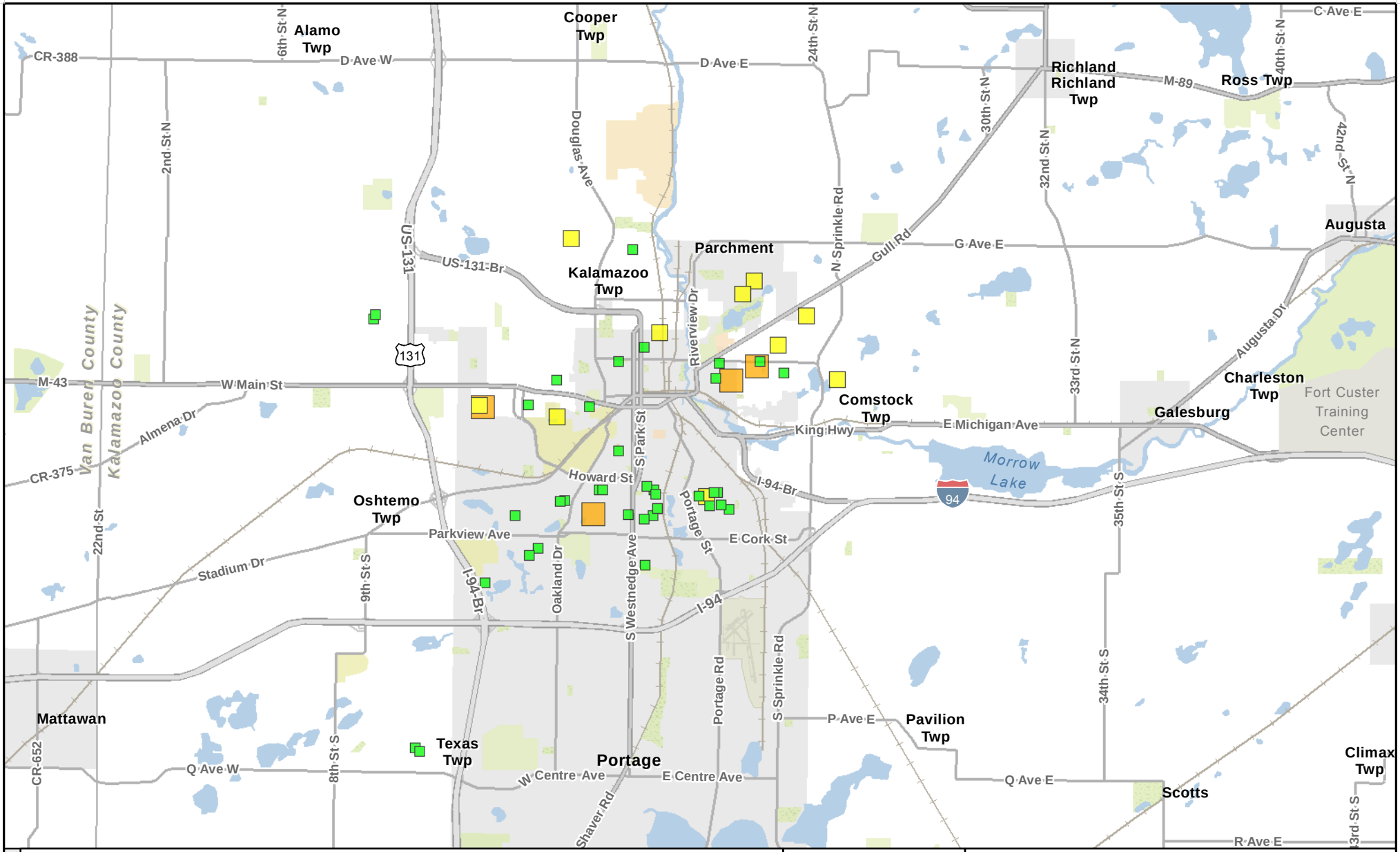
COPPER CONCENTRATION

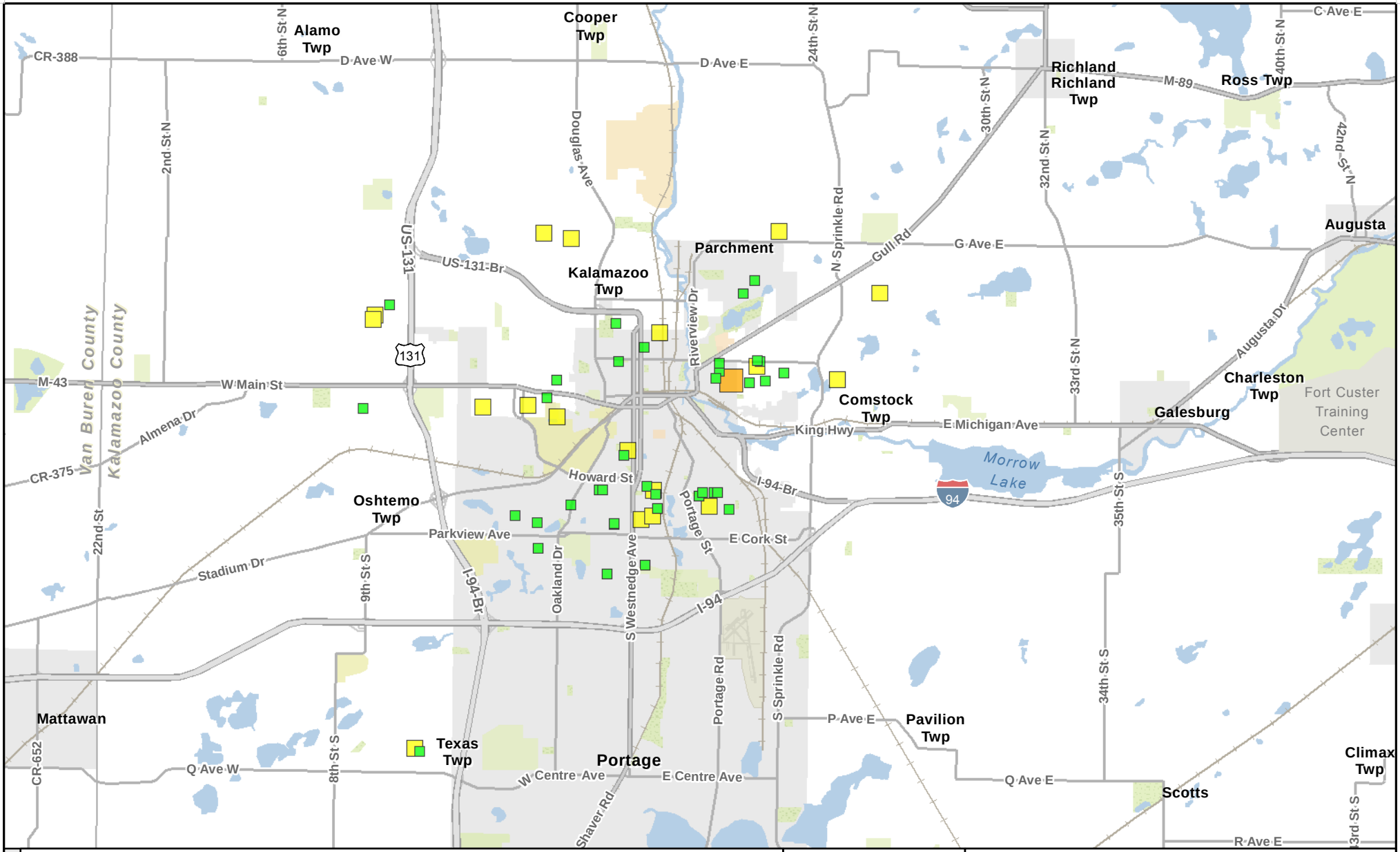
TETRA TECH

FIGURE 7

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2005.mxd [alex.montalvo 8/25/2016]


Alamo Twp
Cooper Twp
Richland Richland Twp
Ross Twp
Augusta
Parchment
Kalamazoo Twp
Comstock Twp
Charleston Twp
Galesburg
Fort Custer Training Center
Morrow Lake
Oshtemo Twp
Mattawan
Texas Twp
Portage
Pavilion Twp
Scotts
Climax Twp
Van Buren County
Kalamazoo County
CR-388
D Ave W
D Ave E
C Ave E
M-89
G Ave E
M-43
W Main St
E Michigan Ave
King Hwy
Almena Dr
CR-375
Howard St
Parkview Ave
E Cork St
Stadium Dr
I-94-Br
I-94
US-131
US-131-Br
Q Ave W
Q Ave E
P Ave E
R Ave E
W Centre Ave
E Centre Ave
Gull Rd
Douglas Ave
Riverview Dr
S Park St
S Westnedge Ave
Portage St
Portage Rd
S Sprinkle Rd
N Sprinkle Rd
Oakland Dr
Shaver Rd
Augusta Dr
CR-652
22nd St
2nd St N
6th St N
9th St S
8th St S
24th St N
30th St N
32nd St N
33rd St N
34th St S
35th St S
40th St N
42nd St N
3rd St S
131
94
LEGEND
Copper Concentration (ppb) - 2008
> 0 - 399
400 - 799
800 - 1299
Greater than 1300
N
0
2.25
Miles
CITY OF KALAMAZOO
WATER QUALITY TESTING
COPPER CONCENTRATION
TETRA TECH
FIGURE 8
Source: City of Kalamazoo
T:\AMontalvo\Kalamazoo\Maps\Cu_2008.mxd [alex.montalvo 8/25/2016]



LEGEND

Copper Concentration (ppb) - 2011

- > 0 - 399
- 400 - 799
- 800 - 1299
- Greater than 1300

N

0 2.25 Miles

CITY OF KALAMAZOO
WATER QUALITY TESTING

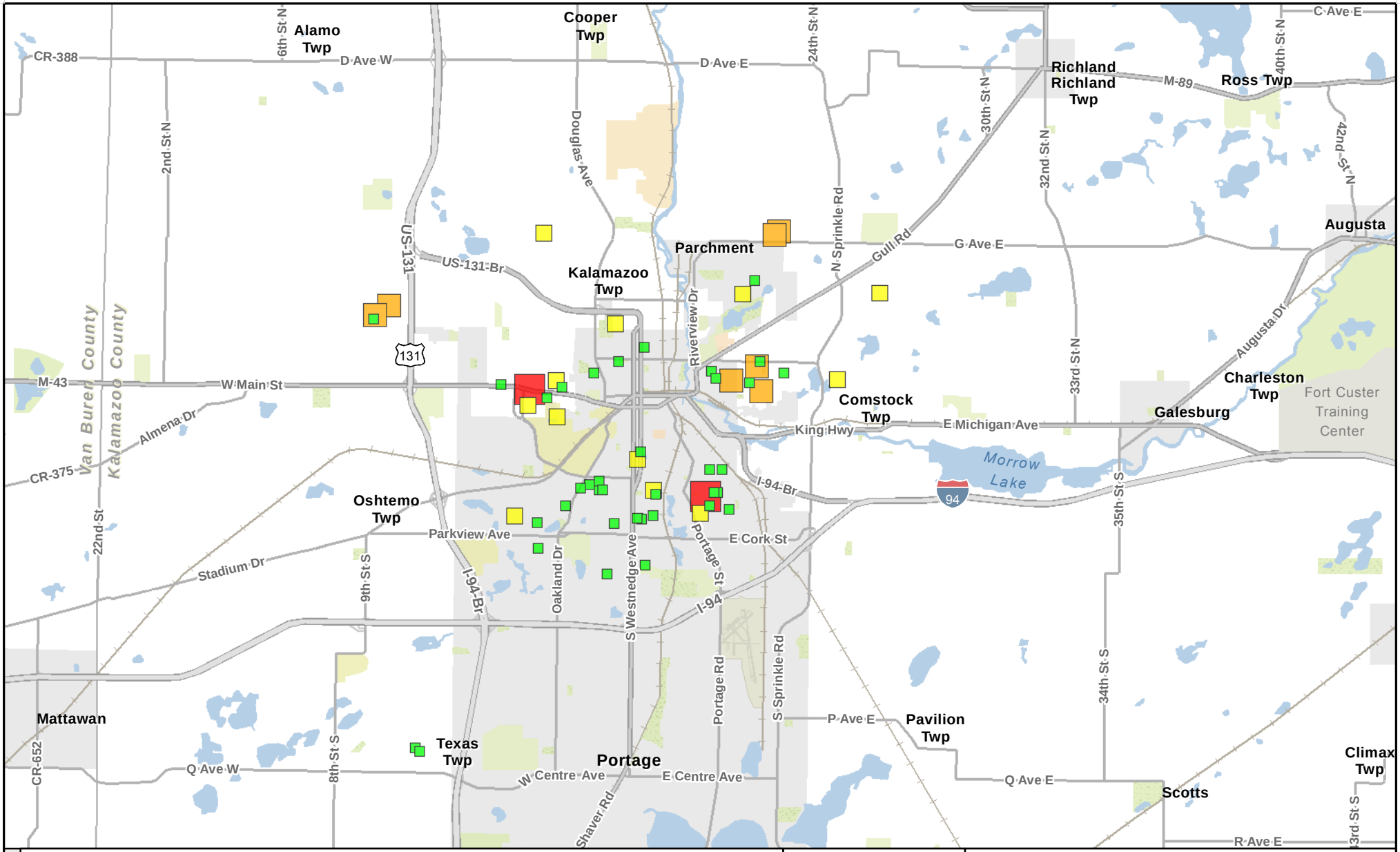
COPPER CONCENTRATION

TETRA TECH

FIGURE 9

Source: City of Kalamazoo

T:\AMontalvo\Kalamazoo\Maps\Cu_2011.mxd [alex.montalvo 8/25/2016]


Alamo Twp
Cooper Twp
Richland Richland Twp
Ross Twp
Augusta
Parchment
Kalamazoo Twp
Comstock Twp
Charleston Twp
Galesburg
Fort Custer Training Center
Morrow Lake
Oshtemo Twp
Mattawan
Texas Twp
Portage
Pavilion Twp
Scotts
Climax Twp
Van Buren County
Kalamazoo County
CR-388
D Ave W
D Ave E
C Ave E
M-89
G Ave E
M-43
W Main St
Almena Dr
CR-375
US-131
US-131-Br
131
Douglas Ave
Riverview Dr
N Sprinkle Rd
Gull Rd
King Hwy
E Michigan Ave
Augusta Dr
I-94-Br
I-94
94
Parkview Ave
E Cork St
Stadium Dr
Oakland Dr
S Westnedge Ave
Portage St
Portage Rd
S Sprinkle Rd
P Ave E
Q Ave W
Q Ave E
W Centre Ave
E Centre Ave
Shaver Rd
R Ave E
2nd St N
6th St N
24th St N
30th St N
32nd St N
33rd St N
40th St N
42nd St N
22nd St
9th St S
8th St S
35th St S
34th St S
3rd St S
CR-652
LEGEND
Copper Concentration (ppb) - 2014
> 0 - 399
400 - 799
800 - 1299
Greater than 1300
N
0
2.25
Miles
CITY OF KALAMAZOO
WATER QUALITY TESTING
COPPER CONCENTRATION
TETRA TECH
FIGURE 10
Source: City of Kalamazoo
T:\AMontalvo\Kalamazoo\Maps\Cu_2014.mxd [alex.montalvo 8/25/2016]

ATTACHMENT G

“Securing Financial Assistance through the Drinking Water Revolving Fund A Guidance Document for Water Suppliers and Consultants”

Michigan Department of Environmental Quality, 2013

Securing Financial Assistance Through the Drinking Water Revolving Fund

A Guidance Document for Water Suppliers and Consultants

Office of Drinking Water and Municipal Assistance
Revolving Loan Section
PO Box 30241
Lansing, MI 48909-7741
517-284-5433
www.michigan.gov/drinkingwaterrevolvingfund

Michigan Department of Environmental Quality

Rev. 4/2013

INTRODUCTION

The Michigan Department of Environmental Quality (DEQ) has designed this guide to assist potential Drinking Water Revolving Fund (DWRF) applicants and their consultants. There are three main purposes of this guide:

- *To help water suppliers and their consultants understand DWRF planning requirements*

- *To help potential applicants understand the steps necessary to receive DWRF loan assistance*

- *To explain the financia transactions that are necessary to close a loan and receive loan payments*

This guide can serve as a valuable resource to help qualified water suppliers secure financial assistance through the DWR , but it cannot replace a close working relationship with DEQ staff. It will, however, lead you through the program and identify the sequence of events that must take place. A staff person from the Revolving Loan Section of the DEQ's Office of Drinking ater and Municipal Assistance will be assigned as your project manager. Your DEQ project manager will assist you in taking the steps necessary for inclusion on the next Project Priority List (PPL).

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What is the Drinking Water Revolving Fund? 1
Who Benefits from the DWRF? 2
Developing A Project Plan 3
The Project Priority List 8
Project Eligibility 10
Application Submittal and Review 17
The Order of Approval 20
The Loan Closing 21
Constructing the Project 23
Submitting and Receiving Loan Disbursements 25
Administrative Completion and Loan Repayments 26
How to Contact Us 27
Other Available Resources 28

WHAT IS
THE DRINKING WATER REVOLVING FUND?

The DWRF program is designed to assist Michigan water suppliers in satisfying the requirements of the Safe Drinking Water Act (SDWA). On August 2, 1996, Congress reauthorized the federal SDWA and included provisions to establish the DWRF program for states. On June 17, 1997, Governor John Engler signed legislation establishing the Michigan DWRF (Part 54 of PA 451, 1994). The DWRF program helps to protect Michigan's drinking water resources by offering low-interest loans to eligible water suppliers. DWRF loan moneys have been used to upgrade existing water distribution systems to meet drinking water standards, enhance source supplies, provide storage to satisfy peak demand needs, replace old or inadequate systems, construct regional distribution systems, and provide safe drinking water to communities previously served by individual wells.

The DWRF is a public health and an environmental protection program that provides low-interest financing to assist qualifying water suppliers that have documented their needs. The revolving nature of the fund will enable Michigan to finance drinking water projects for years to come. The DEQ and the Michigan Finance Authority (MFA) jointly administer the DWRF. Each agency lends its particular expertise for efficient operation of the program

Each fiscal yea , Congress authorizes an amount to be appropriated for the DWRF, which is then allocated among the states. To receive its share of federal funds, Michigan must contribute one dollar in matching funds for each five dollars given by the federal government

WHO BENEFITS FROM THE DWRF?

In a sense, we all benefit. Completed DWRF projects have helpe ensure Michigan residents have an adequate supply of safe drinking water while ensuring reliability for emergency situations of high water demand. The DWRF program has helped to ensure that drinking water standards are met. Large metropolitan areas, as well as many smaller water suppliers, have already solved their water supply, storage, or distribution problems by financing projects throu h the DWRF.

Several communities have drilled new wells, added or replaced storage tanks, established new connections to existing sources of drinking water, and built treatment facilities. DWRF money can be used to create a new community water system when necessary to address an actual public health problem with serious risks. The proposed system must be limited in scope to the specific geographic area affected by contamination and sized to accommodate only a reasonable amount of growth over the life of the facility. The new water system must comply with requirements of the federal SDWA.

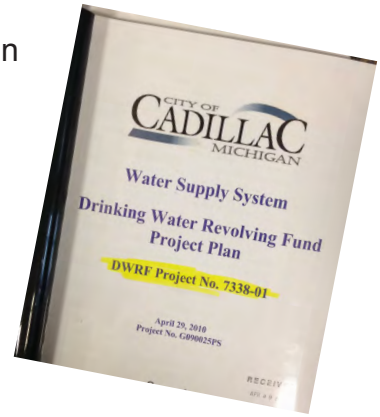
The citizens who reside in communities that have constructed drinking water projects financed by the DWRF obviously receive the most direct benefit from those p ojects. However, having safe and reliable drinking water results in a healthier environment for all of us. Groundwater protection helps foster a healthy population, leading to prosperity and service reliability for generations to come. The DWRF program has helped, and will continue to help, make this possible.

Public or private water suppliers (community water systems and non-community water systems that operate as non-profit entities) are eligible to borrow fro the DWRF. All DWRF projects are designed to serve residential, commercial, or industrial customers provided the projects are not determined to be primarily for growth or fire protectio . Examples include water main replacement, looping to eliminate dead-ends in a distribution system, replacement of inadequate storage facilities, construction of new storage facilities, well field improvements, extensions for consolidation with other existing systems, and upgrades to water treatment facilities. If you think you may have a qualifying project, the first step is to contact DWRF program staff in the Revolving Loan Section at 517-284-5433 and consider preparing a project plan.

DEVELOPING A PROJECT PLAN

You must submit two project plans to the DEQ to be considered for funding in the DWRF program. One copy will be forwarded to the Office of Drinking ater and Municipal Assistance (ODWMA) district engineer for review. The information provided in the project plan must document the need for your project and evaluate potential alternatives for correcting the drinking water problems in your community. You must submit the plan in its final form by no later than May 1 of any year to be considered for funding in the next fiscal yea , beginning October 1. A draft plan should be submitted for DEQ review at least two to three months prior to the May 1 deadline. This will allow the DEQ time to comment on your draft so that the final project plan covers all the necessary federal and state requirements.

There are seven distinct elements that must be included in a project plan:



1. Project Background
2. Need for the Project
3. Analysis of Alternatives
4. The Selected Alternative
5. Evaluation of Environmental Impacts
6. Mitigation of Environmental Impacts
7. Public Participation

You must address each of these topics in your planning efforts. Your DEQ project manager and ODWMA district engineer will review the project plan to ensure that a cost-effective, eligible alternative has been selected that meets state and federal requirements. If so, your project manager will propose that your project be ranked for funding on the state's Project Priority List (PPL). If significant deficiencies exist in the plan, you will have to correct them before the projec can be ranked on the PPL. The following discussion will help to clarify the information necessary to complete each section of the plan.

1. Project Background

This part of the project plan serves as the foundation from which the water supplier and the DEQ assess needs, evaluate alternatives, and identify key environmental issues. (The project plan must explain the needs for the entire system over a 20-year planning period.)

The project background includes the following items:

- A delineation of the study area and identification of its characteristics (for example, land use, surface waters, location of key landscape features, etc.)
- A discussion of present and future economic growth in the service area
- A description of the existing water system and deficiencies if applicable, as established by a recent reliability study and sanitary survey
- Population to be served by the project (including 10 and 20-year projections)
- Environmental conditions in the area (both natural and cultural)

2. Need for the Project

In this section of the plan, you will describe the drinking water problem(s) that your community is experiencing. This will provide the supporting documentation necessary to justify the conclusion that the problems need to be corrected. The project plan shall include documentation that demonstrates that the project is needed to assure maintenance of, or progress toward, compliance with the Michigan SDWA (1976 Public Act 399). Discussion should include the status of compliance with environmental regulations, the existence of legal orders (if any), the water quality data that demonstrate impairment or a health concern, and the source, distribution, and storage capacity needs of the study area for 20 years. If your water supply has deficiencies or inadequacies and/or is proposing an extension of its distribution system, you must document drinking water problems by using resources such as local health department records, well water testing analyses, DEQ district staff recommendations, etc. You must provide schematic drawings identifying system deficiencies and limiting site characteristics on a map that also shows existing habitation.

3. Analysis of Alternatives

Your project plan must include a thorough analysis of the principal alternatives considered for correcting your community's drinking water problem. You must do a systematic evaluation of all potential alternatives to justify the decision to proceed with the selected alternative, and you must review the reasons why all other alternatives were dropped from consideration. In addition to considering conventional distribution, source and storage needs, each DWRF applicant must evaluate the "no action" alternative, regional alternatives, and optimal performance of existing facilities. You must evaluate and document alternate routings of distribution systems, storage facilities, etc., and alternate sites for major facilities, to avoid impacting sensitive environments.

Your analysis and selection of principal alternatives should be based on:

- The goals of the project(s)
- Drinking water needs (20-year design life or planning horizon)
- Technical issues, feasibility, and constraints
- A 20-year net present worth cost-effectiveness analysis (including capital costs, operation, maintenance, and replacement costs, and salvage value)
- Potential environmental impacts
- Social acceptance
- Revenue system rate structures and ordinances
- Inter-agency coordination and/or agreements between all municipalities, or entities involved with the proposed project

4. The Selected Alternative

Your project plan must explain the selected alternative in detail. It must include information on the technical, administrative, financial, environmental, and social aspects of the project. Creative use of maps, tables, graphs, schematic drawings, overlays, etc., will assist citizens' understanding of how the proposed facility will improve the water system.

The following items need to be included in this section of the plan:

- Description of the selected alternative
- Cost estimates
- Basis of design
- Authority to implement the alternative
- Input from the local regional planning agency
- Proposed user charges (including operation, maintenance, and replacement, debt service, and any other costs that will be incurred to construct and operate the selected alternative and an explanation of the financing mechanism [s]) that will be used to support the DWRF loan
- A proposed project schedule
- Environmental impacts and mitigative measures (see discussion below)

5. Evaluation of Environmental Impacts

You must describe the direct, indirect, and cumulative environmental impacts of the selected alternative in detail. Direct impacts are caused by the construction and operation of the project. Indirect impacts are secondarily linked to, or induced by, the completion and use of the constructed facilities. Cumulative impacts are those that increase over time or result from individually minor, but collectively significant, actions taking place over time. All impacts (direct, indirect, and cumulative) need to be assessed for beneficial and adverse effects, short and long-term effects, and ability to reverse the impact (whether it is irretrievable or irreversible).

A. Direct Impacts

Direct impacts to be considered include:

- Effects on historical/archeological/cultural resources
- Effects on existing water quality (surface and groundwater)
- Effects on air quality
- Socioeconomic changes
- Effects on natural habitat (includes wetlands and sensitive ecosystems) or endangered species
- Aesthetic concerns
- Fostering of community growth

B. Indirect Impacts

Indirect impacts that should be considered are:

- Development (new construction) changes in the study area
- Land use changes
- Changes in air or water quality due to development
- Changes to natural habitats, sensitive ecosystems, wildlife, and/or endangered species due to secondary development
- Impacts on cultural/historical or socioeconomic resources
- Aesthetic concerns
- Resource consumption over the project's useful life

C. Cumulative Impacts

Examples of cumulative impacts that bear consideration are:

- Increased population growth
- Development impacts from new distribution systems, storage or treatment facilities

6. Mitigation of Environmental Impacts

Your project plan must detail the structural and non-structural measures that will be undertaken to ensure that the environmental impacts from implementation of the selected alternative are not, or will not be, significantly adverse. Structural mitigation measures relate to the design and construction of a facility or transmission lines that may be part of the project. Non-structural measures relate to institutional, governmental or private plans, policies or regulations, or the phasing of the facility construction over the planning period. For example, structural mitigation could involve erecting silt fences or installing riprap to avoid erosion into a stream. Non-structural measures could involve enacting a local ordinance to protect environmentally sensitive features in the study area.

7. Public Participation

Public participation during project plan development is vital to the successful completion of a public works project. The law requires opportunities for public input and documentation of that input in the plan. Informal methods of public involvement may include newspaper articles, notices in billing statements, and mass mailings to affected citizens. The law also requires other methods of participation during the final project planning stages. A formal public hearing must take place prior to plan adoption. Many communities also hold one or more public meetings during planning to solicit input and inform the citizenry and inter-agency groups of progress to date.

A. The Public Meeting

Your community is encouraged to conduct a public meeting before selecting the final alternative. Adequate notice of the meeting should be published in a local newspaper. Appropriate state and local agencies should also receive notification. Attendance should be encouraged by holding the meeting at a convenient time and place.

B. The Public Hearing

A public hearing must be held before adopting the proposed project plan. Publication of the hearing notice must appear in local media of general circulation at least 30 days prior to the hearing (at least 45 days for controversial or complex projects). Consider running the notice more than once or using additional means of communication to increase attendance. Try scheduling it during a time most convenient for the citizens, such as evenings or weekends.

C. Content of Public Notice

When published, the notice should contain:

- A description of the drinking water problem(s)
- A description of the alternatives considered to meet/maintain SDWA compliance
- Cost of the proposed project(s)
- Estimated user charges and method of assessing charges
- Where the project plan can be viewed by the public
- Time and place of meeting

Note: The project plan should be ready and available to the public for the duration of the entire public notice period (minimum 30 days).

D. Public Participation Components in the Project Plan

Once the public hearing record is closed, the project plan should be bound with the following information:

- An official public hearing transcript (as recorded by a stenographe , court reporter, or transcribed from an audio recording), or an audio tape of the entire hearing, which can serve as the transcript.
- A copy of the public notice and an affidavit of publicatio
- A legible list of hearing attendees and their addresses
- A copy of written comments received during the public notice period
- A copy of the water supplier's responses to testimony and comments
- A copy of the applicant's resolution to adopt the plan and its selected alternative, or a private supplier's statement of intent to implement the project plan, whichever is applicable

NOTE: Your DEQ project manager will provide you with the DWRF Project Plan Preparation Guidance once you have decided to proceed with a project plan. It will cover each of the above items in greater detail than can be presented here.

THE PROJECT PRIORITY LIST

To be eligible for DWRF loan assistance, a project must appear on Michigan's Project Priority List. The PPL is a list of drinking water projects ranked in descending order of total points assigned by the state's project priority system set forth in Part 54 law. DEQ staff evaluate whether a plan is sufficiently complete to be included on the PP that will take effect at the start of the next fiscal year. DEQ staff rank projects under Part 54, section 5405, for each upcoming fiscal year based on the information provided in project plans.

Project ranking is based on the following criteria established by the DEQ to assess the relative severity of problems being addressed by each drinking water project:

1. A maximum of 450 points may be awarded to a project that addresses drinking water quality as outlined in Act 399;

2. A maximum of 350 points may be awarded to a project that addresses infrastructure improvements/upgrades;

3. A maximum of 50 points may be awarded to a project based on the population served by the system;

4. 50 points shall be awarded to a project that benefits a disadvantaged community

5. Up to 100 points shall be awarded to a project that results in the consolidation of one or more public water system(s);

6. 100 points shall be awarded for a water supply with a DEQ-approved wellhead protection plan or a source water protection plan.

Each fiscal yea , the DEQ prepares a draft of the PPL and a draft Intended Use Plan (IUP), which establishes how the DWRF will be administered for the fiscal yea . A public hearing notice is published in the DEQ calendar and selected newspapers throughout the state to invite public input. In the late summer, the DEQ conducts a public hearing on the draft PPL and IUP. Hearing comments are received and recorded and, when appropriate, changes are made. On or about October 1, the DEQ completes the final PP and IUP. Upon notification of the federal appropriation, the DEQ sends a letter to affected water suppliers and their representatives for the purpose of announcing the proposed "fundable range," establishing requirements for assistance, setting quarterly milestone schedule deadlines, and confirming the loan interest rate.

Projects listed in the "fundable range" are those that could be funded with available DWRF moneys during the fiscal yea . Projects not in the fundable range are given contingency status. Actual funding of projects depends on a number of factors, including a water supplier's willingness and ability to proceed with the application process for its project in a timely manner. A water supplier that cannot proceed with its project, does not wish to do so, and/or fails to meet program requirements (including adherence to a milestone schedule), will be subject to bypass. Moneys previously targeted for a project that is bypassed will be released to lower priority projects according to rank order on the PPL. Many contingency projects ultimately get funded in this way.

Please note that particularly large, expensive and/or complex projects may be divided into segments to facilitate efficient project management and/or allow a more balanced allocation of loan funds. Part 54 DWRF law allows the DEQ to limit monetary assistance to a maximum of 30 percent of available fiscal year funds to any one project each yea .

The following photos show examples of one DWRF project that addressed infrastructure improvements.

Northerly 12 MGD (150 HP) and 4 MGD (40 HP) Pumps in the new Low Service Pump Station.
All of the pumps are controlled by Variable Frequency Drives (VFDs) which are located in a different area of the building. The purpose of the Low Service Pump Station is to pump water into the plant from Lake Michigan for treatment and distribution to the customers. Lake Michigan provides the head to convey the water to the wet well and the suction side of the pumps.

Southerly two pumps (again with 12 MGD and 4 MGD capacities) can be seen at the rear of the shot. The tee riser in foreground leads to the 48” diameter intake pipe. The black HDPE pipes are the raw water sampling and chlorine feed lines that extend out to the intake drums.

PROJECT ELIGIBILITY

The DWRF program may provide 100 percent of the financing needed for a project s eligible costs. Eligibility criteria are summarized below. New eligibility issues may arise occasionally. You can obtain additional information about specific eligibility items from your DEQ project manage .

1. General Eligibility Criteria

To receive DWRF assistance, you must demonstrate (1) that the project is needed to assure maintenance of, or progress towards, compliance with the federal Safe Drinking Water Act (Section 5405(3)); (2) that the project is not planned primarily to foster growth or development (residential, commercial, or industrial); (3) that the project is not planned primarily for fire protection; and (4) that feasible alternatives to the project were evaluated, taking into consideration the demographic, topographic, hydrologic, and institutional characteristics of the area. A water supplier is required to submit a project plan that examines 20-year projected water supply needs for the system's service area.

The selected alternative proposed for construction must (1) be cost-effective and implementable; (2) be included in a project plan that meets the requirements of Section 5405, Part 54 of 1994 PA 451, the Natural Resources and Environmental Protection Act, and its rules and procedures; and (3) show satisfactory compliance with capacity development requirements (Section 5404(9)).

Terms:

"Primarily to foster growth or development" means that the waterworks system and component parts as planned have as a primary purpose the construction or expansion of a waterworks system to accommodate future development. The project will not be considered primarily for growth or future development if it follows the recommendations of a previously prepared Reliability Study/Master Plan or Engineer's Report to supply existing needs within the boundaries of a water supply's existing service area. However, water main extensions into an undeveloped area, regardless of the existence of a Reliability Study/Master plan, will be considered primarily to accommodate future development and are not eligible for funding under the DWRF program (unless it is necessary to traverse an undeveloped area to benefit existing customers, or to resolve water supply problems by replacing or consolidating existing on-site water supplies).

"Primarily for fire prevention" means project expenses relating to fire protection when that is the primary reason for the project. Examples: 1) Eligible DWRF expense - Source or storage capacity upgrades to resolve specific water system deficiencies; o when source or storage capacity increases are necessary to meet other water system peak demands and are designed to meet current fire flow standards; 2) Not an eligibl expense - Replacement or installation of fire hydrants and associated appurtenances capable of supplying water to a fire engine pumper when this work is apart from transmission or distribution water main replacement projects.

"Capacity development requirements" are a demonstration that the applicant has the technical, financial, and managerial capability to comply with the state and federal Saf Drinking Water Acts, both now and into the future.

2. Specific Eligibility Criteri

A. DWRF Ineligible Items

The following items are ineligible for inclusion in a DWRF loan:

Fire Protection

Costs associated with projects deemed “primarily for fire protection” will not be eligible for DWRF assistance.

Litigation

Costs associated with project-related personal injury or property damage claims, either as defendant or plaintiff, are not eligible. However, some costs such as those to replace damaged contractor equipment that is not covered by insurance, and legal fees associated with claims, may be eligible. Consult with your DEQ project manager for further guidance.

Operation, Maintenance, and Replacement Costs

Work considered to be part of normal operation, maintenance, and replacement of a waterworks system, such as routine transmission main flushing, is not eligible. Rehabilitation of transmission lines for structural integrity alone may not be eligible unless the water supplier demonstrates in the project plan that the existing condition of the water distribution system has deteriorated to a point where major rehabilitation and/or replacement of the system is necessary. Expendable supplies associated with operation and maintenance are not eligible. Maintenance contracts, service contracts, and extended warranties are also not eligible.

Project Refinancing

Project refinancing of a debt obligation of eligible water suppliers is not allowable in the DWRF loan program as it does not provide an environmental benefit

Vehicles

General-purpose vehicles, such as pickup trucks, cars, etc., to transport personnel are not eligible.

Waterworks System Expansion

DWRF assistance is not available for water system projects or component parts when the purpose of the project is primarily to accommodate growth or development. Costs for extending transmission mains into undeveloped areas solely to create developable tracts are not eligible. Likewise, over-sized mains or waterworks facilities to accommodate future development or growth beyond 20-year needs are also ineligible.

B. DWRF Eligible Items

Bid Advertisement Costs

The cost of bid advertisements in newspapers or trade journals is eligible.

Bond Counsel Fees and Bond Insurance

The expenses of hiring bond counsel to issue a qualified opinion, and the costs of a financial advis 's assistance in structuring the loan or preparing a revenue system, are eligible. Administrative costs incurred by a larger unit of government (i.e., county) serving as the applicant for a smaller municipality that is unable to acquire the necessary investment grade rating for its bonds are eligible for DWRF assistance if such costs are adequately documented in the application.

Construction Costs

Eligibility of construction contracts is limited to the amount of the low responsive, responsible bidder.

Construction of Test Wells

Although the costs of constructing test wells that become tangible property are not eligible for DWRF assistance as a planning cost, they are DWRF eligible expenses. Other test well costs include performing the pump test, conducting an aquifer analysis, delineating the capture zone, and analyzing water samples for all required parameters. Environmental clearances must be obtained prior to the drilling of test wells to protect natural/cultural resources. Check with your DEQ project manager for specific details

Delay Costs

To the extent that they satisfy other eligibility criteria, costs associated with delays in project completion, regardless of the cause, may be eligible for DWRF assistance using available project funds within the loan amount specified as “contingencies” in the Order of Approval.

Demolition and Restoration

Demolition and/or decommissioning of an existing waterworks system or component is eligible if necessary to accomplish eligible construction, and if the decommissioned facilities were operating at the time the final project plan was submitted. Restoration of work sites disrupted by project construction is eligible provided the restoration is strictly limited to those areas directly affected, and is necessary to restore the disrupted area to a pre-construction condition. (Example: If a gravel roadway is disrupted to install project-related water main, the roadway may be restored to its original pre-construction condition. If paving the roadway is included as part of the project, this portion of the work is ineligible.)

Furnishings

Furnishings for the waterworks facility are eligible if new construction, expansion or remodeling has occurred and if documented in the project plan. Examples of eligible items include desks, tables, chairs, storage cabinets, refrigerators, microwaves, stoves, floor treatments, window treatments, computer hardware and software needed to control the waterworks system, etc. Contact your DEQ project manager for more information.

Legal Fees

Standard legal services necessary to implement the project, such as preparation and review of contracts, resolution of bid protests, enforcement of contracts, and litigation associated with eligible land acquisition, are eligible.

Mitigation of Adverse Environmental Impacts

Mitigation of adverse construction or operational impacts is eligible if included in the project plan and Finding of No Significant Impact, and required by the DEQ

Operation and Maintenance (O&M) Manuals

Preparation of O&M Manuals for newly-constructed, eligible facilities are DWRF eligible.

Planning and Associated Costs

To be eligible, project planning costs must be directly related to the proposed waterworks project. Eligible project planning costs include:

- Archaeological surveys
- Biological surveys
- Environmental audits of project sites (Phase I - baseline assessments)
- Hydrogeological studies
- Project plan preparation
- Public participation activities
- Public hearing transcripts
- Reliability studies

For a water system project or supplier serving more than 10,000 people, or for a water supplier that is not a municipality, incurred planning costs can be drawn after the loan is closed.

For a water system project or supplier serving less than 10,000 people, incurred planning costs may become eligible for early reimbursement upon submittal of a project plan. Such reimbursement would be a short-term planning loan, which would be rolled into the eventual DWRF loan amount at closing. Talk to your project manager for more information about early reimbursement.

Professional Services

The costs of engineering, legal, and financial services related to planning, designing and building the project may be eligible for DWRF assistance. Examples of eligible expenses include design and construction engineering, bonding and financing opinions, financial and accounting advice, preparation of bidding documents, costs for acquisition of land and/or structural components integral to the project, and reasonable expenses for administration and supervision of project activities. Eligible engineering services may also include facility start-up assistance during the first yea of operation.

Project Administration (Force Account)

Force account costs incurred by a water supplier to administer a DWRF project are eligible for DWRF assistance if they are adequately documented during the application process.

Includes costs incurred by a water supplier to administer the DWRF loan.

Excludes project planning activities, salaries, fringe benefits, or travel expenses of elected officials.

See your DEQ project manager for additional guidelines.

Residuals Handling Equipment

The cost of facilities or equipment designed to handle drinking water treatment residuals is eligible for DWRF assistance.

C. Items That May Be Eligible If Special Conditions Are Met

Bid Allowances

Some types of bid allowances may be eligible if properly documented. Consult with your DEQ project manager for further guidance.

Computer Hardware and Software

These items are eligible only if necessary as a direct interface or process control component of a waterworks system. For all other uses, this equipment is ineligible.

Construction Site Restoration

Restoration of work sites disrupted by construction is eligible only within the limits of the construction zone and only when restored to a quality equal to, but not exceeding, the present conditions.

Contaminated Site Materials – Removal and Disposal

DWRF assistance may be provided for cleanup activities necessary in areas directly affected by project construction, except in cases where a responsible party can be positively identified. Site remediation in excess of that necessary to construct the project is not an eligible cost under the DWRF program. Consult your DEQ project manager for further guidance.

Force Account Construction

Force account labor may be approved by the DEQ for DWRF assistance if municipal employees can effectively perform the construction, it is cost-effective, and the total cost of the force account work is less than $50,000.

Land Acquisition/Easements/Relocation Costs, Etc.

The purchase cost of land is eligible on the condition that:

- *The purchase of land or easement is necessary for siting the eligible waterworks system; and*
- *The purchase is from a willing seller at fair market value; and*
- *The parcel is not larger than what is needed to construct the project; and*
- *The land or easement must be purchased after the water supplier adopted the project plan demonstrating the need for its acquisition.*

Other land-related costs may be eligible, e.g., costs of surveys, appraisals, title searches, litigation, or relocation of displaced persons. Under no circumstances will the DWRF provide assistance to cover the cost of land acquired through condemnation or eminent domain. Federal regulations must be followed during the acquisition process. Consult your DEQ project manager for further details.

Water Main Replacement

Costs for the replacement of water mains or distribution system components may be eligible for DWRF assistance if required for SDWA compliance. A substantial increase in breaks may be an indication that sections of the distribution system have reached the limits of their useful life. The applicant must demonstrate in the project plan that the existing condition of the water distribution system has deteriorated to a point where major rehabilitation and/or replacement of portions of the system is necessary.

Purchase of Public Water Supply Capacity

In some cases, costs incurred to purchase public water supply capacity from another supplier is eligible if it is determined to be the most cost-effective alternative for meeting the needs identified in the project plan. The contractual basis for a capacity buy-in must be demonstrated to the DEQ's satisfaction.

Water Services and Meters

Only the portions of water services (house leads) within the public right-of-way are eligible (the connecting transmission line must be eligible as well). Water meters installed for new service will be eligible if the water supplier owns them.

D. Eligibility of Multi-Purpose Projects

Some projects may have overlapping eligible and ineligible components with joint cost items that serve both eligible and ineligible functions. A good example is a water main replacement project with street resurfacing that improves the street above and beyond pre-construction conditions. These types of projects are subject to an Alternative Justifiable Expenditure (AJE) analysis to identify the total amount of eligible cost attributable to the water supply component of the multi-purpose project.

Typically, the design engineer prepares the AJE during design of plans and specifications. It is then reviewed by the DEQ for approval. An AJE guidance document is available from the DEQ upon request.

3. When Is Eligibility Determined?

Your DEQ project manager can assist you with a preliminary eligibility determination during project planning to enable accurate project cost disclosure. A second eligibility review is made when bidding documents are submitted to the DEQ. Information included with your DWRF application forms is also reviewed for eligibility. After the DWRF loan is approved, eligibility reviews of construction change orders and final costs are made before the project is administratively completed.

Any questions concerning DWRF eligibility should be directed to your DEQ project manager. If a project manager has not been designated to work with you, please call the Revolving Loan Section at 517-284-5433.

APPLICATION SUBMITTAL AND REVIEW

After a complete project plan has been submitted to the DEQ and your project has been included on the PPL, you will need to submit an application in accordance with a milestone schedule negotiated with your DEQ project manager.

1. Investment Grade Credit Rating

   The Michigan Finance Authority requires that each DWRF loan be rated, at a minimum, as an investment grade issue. If the water supplier's credit rating is below investment grade, or is not rated at all, additional steps will be necessary to prepare the application. These additional steps may include:

   - obtaining a favorable rating, if one does not already exist
   - purchasing credit enhancements to guard against disruption of repayments
   - financing through another governmental entit , such as a county, to gain the strength of its rating
   - state revenue sharing or general obligation pledge
   - debt service reserve

   Early involvement of your bond counsel in planning the project could help avoid critical delays later in the process and/or prevent failure to obtain a loan.

2. DWRF Application Form

   The DWRF Application for Financial Assistance consists of three parts. Part I provides detailed information regarding the financial capability of the pplicant, as well as a list of the various advisors who will assist the applicant. The MFA is responsible for reviewing and evaluating Part I of your application. You may be asked to provide additional information to support your application. The MFA notifies the DEQ when Part I is approved. Part II addresses DWRF program requirements, including the covenants, assurances, and certifications that the applicant must attest to in order to comply with federal and state statutes and regulations. Part III requires the applicant to provide bid information and an estimated loan disbursement schedule. Both Part II and Part III contain project cost information and supporting documentation. Your DEQ project manager will review Parts II and III of the application. You will need to correct any deficiencies or omissions as quickly as possible.

   Your project manager will provide you with a blank application form after a milestone schedule has been signed. Be sure to read the application instructions carefully before filling it out. Contact your DEQ project manager if you have q estions about Parts II and III. Call the MFA with Part I questions.

3. Review and Approval of Plans and Specification

   A water supplier applying for DWRF loan assistance is required to prepare and submit "a set of plans and specifications suitable for bidding." The bidding documents must be

consistent with the contents of the state-approved project plan and meet all of the applicable federal and state requirements. Bidding documents must be prepared by a professional engineer registered in Michigan. The design engineer may either be a qualified employee of a water supplier that is applying for DWRF loan assistance, or a consulting engineer hired by the water supplier on a contractual basis. The design engineer must follow DWRF program requirements and the design standards guidance, which is published by the Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers.

In order to maintain a competitive bidding process and result in reasonable costs for Michigan communities, the following projects are no longer eligible for DWRF funding: Design-Build projects effective October 1, 2012, and those utilizing Construction Management effective July 2, 2013.

Final plans and specifications must include the applicable Davis-Bacon wage rates for all contracts over $2,000. Any wage rate modification that occurs within 10 days prior to bid opening will need to be added by addendum. In addition, the loan recipient must complete and submit a DEQ Davis-Bacon Act Compliance Certification form with each request for loan reimbursement when reimbursement is being requested for construction costs.

The Disadvantaged Business Enterprise (DBE) program was created by the EPA to increase the participation of small, minority, and women owned firms in the procurement process for goods and services as required by rule, 40 CRF Part 33. Prime Contractors bidding on a project must follow, document, and maintain records of their Good Faith Efforts to ensure that certified DBEs have the opportunity to participate.

Draft bidding documents should be mailed to the DEQ project manager and appropriate district office engineer for revie . You will need to revise the draft documents to address all the DEQ comments. You will then submit 100 percent final bidding documents to the district engineer and the project manager, in accordance with the milestone schedule.

A construction permit issued by the DEQ pursuant to Act 399, P.A. 1976, as amended, is required for DWRF projects. After all technical deficiencies found in the plans and specifications have been rectified, the DEQ District Office will issue the construction permit and you will receive a stamped, approved set of plans along with an approval letter.

4. Addenda to the Approved Bidding Documents

After the issuance of the construction permit and publication of the bid advertisement, modifications of the approved final bidding documents may become necessa . In such cases, an addendum to the approved final bidding documents will be issued to all prospective bidders.

You must submit each addendum to your DEQ project manager for review and approval. When the addendum is approved, an approval letter will be mailed to the project's authorized representative. If the addendum cannot be approved, either a revised addendum or a change order will need to be issued to correct the problem.

5. The Revenue System

Sound financial management is important to the success of any d inking water project. The water supplier must show that it will collect sufficient revenue to operate and maintain the system, as well as retire the debt. A water supplier applying for assistance must:

- Demonstrate that it has the legal, institutional, and managerial capability to guarantee adequate construction, operation, and maintenance of the system
- Demonstrate financial capability by adopting a user-based revenue sys em sufficient to fund the operation, maintenance, and replacement costs of the system
- If applicable, execute intermunicipal service agreements or supply contracts

The revenue system must be drafted and submitted to staff of the Revolving Loan Section in accordance with the project milestone schedule. DEQ staff will review and comment on the draft revenue system. The draft must be revised incorporating DEQ comments, then a final version submitted for approval.

Once you have successfully completed the application form and received project plan approval, revenue system approval, and a construction permit, the DEQ may issue an Order of Approval to the MFA.

THE ORDER OF APPROVAL

The Director of the DEQ may exercise the authority vested in 1994 PA 451, Part 54 (Safe Drinking Water Assistance) and issue an "Order of Approval" after you have completed all the application requirements for receiving assistance from the DWRF. This Order serves as legal notification to the MFA that it may proceed with the final steps of purchasing the bonds by using funds from the DWRF account.

The Order of Approval specifically references the dollar amount (rounded to the nearest $5,000), term, and interest rate for the loan. It also specifies the date by which principal repayments must start. The following attachments are completed as part of the order:

- A cost summary identifying eligible amounts for each line item (e.g., design engineering, construction, bid advertisement, etc.), including a 6-percent loan contingency
- A description of the project, referencing the required construction permit(s)
- If applicable, special conditions placed upon the applicant

The DEQ's Order of Approval represents a binding commitment of loan funds to the water supplier. **The Order is not a loan nor does it guarantee receipt of a loan**. Final loan approval will depend on completion of typical finance requirements and activities under the purview of your bond counsel and the MFA. You will receive a copy of the Order at or before loan closing.

Drinking Water Revolving Fund
ORDER OF APPROVAL

Applicant/Issuer: , County

Project No.

Assistance Amount: $ (Dollars)

Rate: (Percent)

Term: Not to exceed twenty ( ) years, with annual principal payments commencing no later than (date).

Pursuant to: Part 54, Safe Drinking Water Assistance, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

****

The Director of the Department of Environmental Quality of the state of Michigan, acting upon the application submitted by the applicant/issuer for assistance in financing the project pursuant to the referenced Act,

ORDERS that the application is approved based upon the requirements, provisions, and information included in the application and other documents submitted to the Department of Environmental Quality, and which are incorporated herein and made part hereof by this reference.

Special conditions of this Order are identified in the attached Exhibits A - C.

This approval is based on the application and other documents currently filed with the Director of the Department of Environmental Quality and no material change may be made to the application or this approval without the prior written approval of the Department of Environmental Quality.

The Department of Environmental Quality certifies to the Michigan Finance Authority that the applicant/issuer is eligible to receive assistance as provided by this Order.

_____
Liane J. Shekter Smith, P.E., Chief
Office of Drinking Water and Municipal Assistance
Department of Environmental Quality

Dated:
Lansing, Michigan

THE LOAN CLOSING

After the DEQ issues the Order of Approval, the MFA will contact you to close the loan and purchase the debt. This part of the DWRF process may seem almost anti-climactic to the applicant. Nevertheless, the loan closing is extremely important and demands your careful attention.

Various legal documents are necessary to purchase the debt instrument of the water supplier. In exchange for the bonds, the MFA establishes an account from which funds can be drawn as the project proceeds. You must deliver, in acceptable form, the following documents to the MFA to close on the loan:

- A supplemental agreement
- A bond resolution or authorizing ordinance
- A purchase contract
- An issuer's certificat
- A favorable opinion from your bond counsel addressed to the MFA
- The bond
- Approval or exception from prior approval from the Department of Treasury's Local Audit and Finance Division with respect to the issuance of the bond

Note: From the applicant's perspective, this is a municipal bond activity, subject to all applicable municipal debt, legal and financial requirements

Under normal circumstances, the financing schedule permits a reasonable length of time to execute all of the loan closing documents. Up to two weeks is often available to allow adequate time for pre-closing conferences and telephone calls. Final closing requires submission of the signed documents and delivery of the bond.

1. The Supplemental Agreement

   The supplemental agreement contains all representations, covenants, and agreements between the water supplier, the MFA, and the DEQ. It includes assurances of compliance with all federal and state laws and contains exhibits to reflect project costs, and any additional special conditions imposed upon the water supplier (bond issuer).

2. The Bond Resolution or Ordinance

   Adoption of the bond resolution or ordinance constitutes the official legal action taken by a water supplier that authorizes the issuance of the bonds to finance the project

3. The Purchase Contract

   The purchase contract is executed between the MFA and the water supplier to set forth the terms and conditions of the bond purchase. The MFA offers to purchase the bond contingent upon the terms, conditions, representations, warranties, and agreements made.

The purchase is subject to the MFA's ability to disburse funds from the DWRF. The issuer (water supplier) must agree that it has the full legal right, power, and authority to enter into the purchase contract and to sell and deliver the bonds.

The purchase contract sets forth the time and location for the delivery of the bond and the accompanying documents.

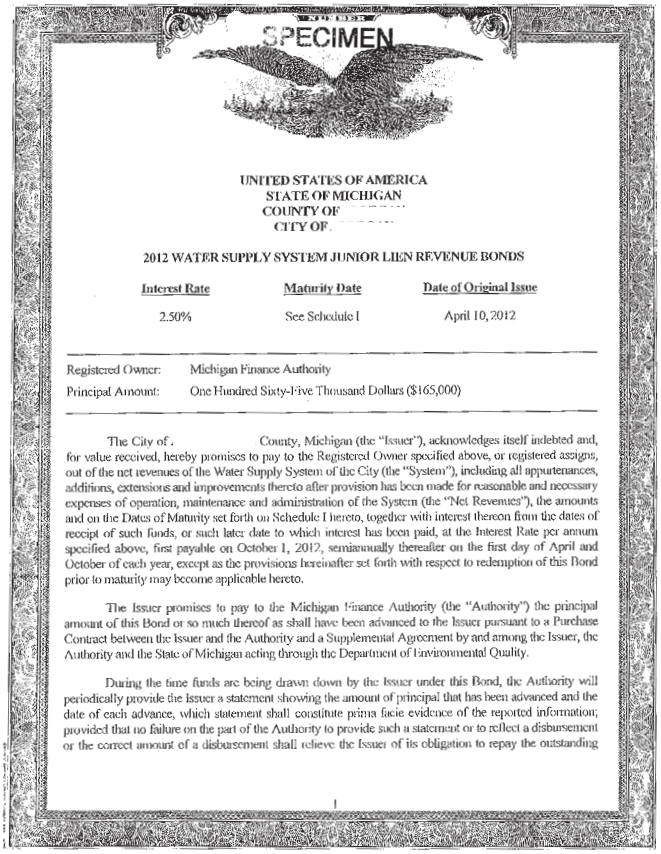
4. The Bond Counsel's Opinion

Before the MFA can purchase the bond, your bond counsel must deliver an opinion that states, in summary, that the bond has been duly authorized, executed, and delivered in accordance with applicable laws, and constitutes the valid and binding obligation of the water supplier.

5. The Bond

The bond certificate is the legal instrument of debt and is printed in a form acceptable to the MFA. Further explanations and the specific timeframe for delivery of all documents may be addressed by the MFA in preparation for closing the loan.

Once again, the loan closing is critical. **You are advised to carefully select knowledgeable bond counsel and work closely with him/her from early in the planning process through the preparation and delivery of the loan documents.**



SPECIMEN

UNITED STATES OF AMERICA
STATE OF MICHIGAN
COUNTY OF
CITY OF

2012 WATER SUPPLY SYSTEM JUNIOR LIEN REVENUE BONDS

Interest Rate	Maturity Date	Date of Original Issue
2.50%	See Schedule I	April 10, 2012

Registered Owner: Michigan Finance Authority
Principal Amount: One Hundred Sixty-Five Thousand Dollars ($165,000)

The City of County, Michigan (the "Issuer"), acknowledges itself indebted and, for value received, hereby promises to pay to the Registered Owner specified above, or registered assigns, out of the net revenues of the Water Supply System of the City (the "System"), including all appurtenances, additions, extensions and improvements thereto after provision has been made for reasonable and necessary expenses of operation, maintenance and administration of the System (the "Net Revenues"), the amounts and on the Dates of Maturity set forth on Schedule I hereto, together with interest thereon from the dates of receipt of such funds, or such later date to which interest has been paid, at the Interest Rate per annum specified above, first payable on October 1, 2012, semiannually thereafter on the first day of April and October of each year, except as the provisions hereinafter set forth with respect to redemption of this Bond prior to maturity may become applicable hereto.

The Issuer promises to pay to the Michigan Finance Authority (the "Authority") the principal amount of this Bond or so much thereof as shall have been advanced to the Issuer pursuant to a Purchase Contract between the Issuer and the Authority and a Supplemental Agreement by and among the Issuer, the Authority and the State of Michigan acting through the Department of Environmental Quality.

During the time funds are being drawn down by the Issuer under this Bond, the Authority will periodically provide the Issuer a statement showing the amount of principal that has been advanced and the date of each advance, which statement shall constitute prima facie evidence of the reported information; provided that no failure on the part of the Authority to provide such a statement or to reflect a disbursement or the correct amount of a disbursement shall relieve the Issuer of its obligation to repay the outstanding

CONSTRUCTING THE PROJECT

Several activities occur before and during construction of DWRF-assisted projects. Some of these activities are described below.

1. Contract Award and Signing

   The MFA cannot issue loan disbursements for construction costs until all contracts necessary to proceed with construction of the project have been signed and submitted to the DEQ. Signed construction contract documents must include the following:

   - Agreement
   - Addenda (if applicable)
   - Payment Bond
   - Performance Bond
   - Notice of Award
   - Notice to Proceed

   Your DEQ project manager will review the signed contract documents to ensure they are complete before giving approval to process the first loan disbursement request containing construction costs.

2. Pre-construction Conference

   All parties directly involved with the project should attend a pre-construction meeting. This meeting is normally arranged and scheduled by the consulting engineer. It provides an excellent opportunity to discuss details of the project, the proposed schedule, and all procedural considerations. Effective communication among the state and local officials and the hired consultants and contractors will help reduce delays caused by oversights.

3. Project Inspections

   The DEQ may perform inspections of the project during construction. The initial visit may take place shortly after start of construction. Thereafter, additional inspections may occur at any time, or at the request of an affected party. The DEQ may conduct a final inspection before start-up of the facility. Any information collected at the inspections may be shared among DEQ staff as appropriate.

4. Change Orders

All change orders must be submitted to the DEQ for review and approval. Each change order should identify the change(s) made and provide an explanation of necessity for the change(s). The DEQ will review the change orders for DWRF eligibility and consistency with the project plan. In addition, a DEQ district engineer will review technical changes for permit requirements.

Contract time extensions can only be approved by change order. They are acceptable provided there is a legitimate reason for the extension. Approval of a time extension change order does not relieve the water supplier from complying with any enforcement schedule.

All unit price contracts should have final balancing change orders completed. This will ` result in a tally of the final as-built quantities for contract cost adjustment.

5. Minimal Cost Items

Services or equipment that cost less than $50,000 and are procured without a formal competitive bidding process are defined as “minimal cost items.” These items may be listed in the original loan if the information is available at the time of loan application. You may purchase minimal cost items that were not in the original loan using the 6-percent contingency allocation. Each request must be accompanied by an explanation of the purchase and the reasons for including it in the scope of the project. While it is not necessary to contact more than one source for procurement, it is advisable. The cost of the item must not be divided up to avoid the bidding process.

6. Initiation of Operation

The loan recipient’s authorized representative must provide a written notice of the initiation of operation date for the constructed facility to the DEQ project manager within 30 days of its occurrence.

The process of administrative completion may begin any time after the project initiates operation and final costs are established

SUBMITTING AND RECEIVING LOAN DISBURSEMENTS

As construction of the project moves forward, draws on the DWRF will be needed to reimburse costs for contracted services. You may request your first disbursement immediately after loan closing to cover expenses incurred in the pre-construction phase.

The DEQ will process subsequent requests for disbursement on a monthly cycle. A given disbursement request may be submitted any time during the month; except for Requests #1 and #2, only one request per month will be processed. You are advised to work closely with all contractors to ensure that their monthly invoices are delivered to you in time for inclusion in your next request for disbursement.

Generally, loan funds will be wire-transferred to your bank by the MFA within ten working days of the DEQ's approval of a disbursement request. This means faster payment of contractor invoices and should ensure a steady flow of funds throughout the project construction period.

The DEQ will accept disbursement request forms submitted by fax or e-mail (with the exception of the first and last requests), provided they are completed and signed by the project s authorized representative. Supporting documentation must be included with each disbursement request.

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF DRINKING WATER AND MUNICIPAL ASSISTANCE - REVOLVING LOAN SECTION

DRINKING WATER REVOLVING FUND (DWRF) AND CLEAN WATER STATE REVOLVING FUNDS (SRF/SWQIF)
REQUEST FOR DISBURSEMENT OF FUNDS
THIS INFORMATION IS REQUIRED UNDER AUTHORITY OF PARTS 52, 53, AND 54, 1994 PA 451.

PLEASE SEE OTHER SIDE FOR INSTRUCTIONS TO COMPLETE REQUEST

A. Project #	B. Request #	C. Period Covered by Request _____ (M/D/Y) to _____ (M/D/Y)	D. Request Type ☐ partial ☐ final	E. Recipient's EIN	F. Loan Amount

G. Recipient's Name:		Phone #
Address:		
H. Recipient's Bank Name:		Phone #
Address:		
Account Name:	ABA #	Account #
Special Instructions:		

I. Budget Items (round amounts to the nearest dollar)	Approved Amount Incurred this Period	Approved Amount Incurred to Date
1. PLANNING COSTS		
2. USER CHARGE SYSTEM DEVELOPMENT COSTS		
3. DESIGN ENGINEERING COSTS		
4. LEGAL/FINANCIAL SERVICE FEES		
5. ADMINISTRATIVE COSTS		
6. BOND COUNSEL FEES		
7. BOND ADVERTISEMENT COSTS		
8. BID ADVERTISEMENT COSTS		
9. CAPITALIZED INTEREST		
10. LAND ACQUISITION/RELOCATION COSTS		
11. LAND PURCHASE COSTS		
12. CONSTRUCTION ENGINEERING COSTS		
13. CONSTRUCTION COSTS (bid contracts)		
14. CONSTRUCTION COSTS (force account)		
15. EQUIPMENT COSTS		
16. OTHER PROJECT COSTS		
17. ADJUSTMENTS DUE TO OTHER FUNDING		
18. TOTAL AMOUNT INCURRED THIS PERIOD		
19. TOTAL CUMULATIVE AMOUNT INCURRED TO DATE		
20. AMOUNT PREVIOUSLY DISBURSED		
21. AMOUNT REQUESTED FOR DISBURSEMENT		

I certify that I am an authorized representative of the recipient and am authorized to make the following certifications on behalf of the recipient: (i) there is no pending litigation or event which will materially and adversely affect the project, the prospects for its completion, or the recipient's ability to make timely repayments on the obligation issued in connection with this project; (ii) the representations, warranties and covenants contained in the supplemental agreement for the obligations pursuant to which this request for disbursement is submitted continue to be true and accurate in all material respects as of the date hereof; (iii) to the best of my knowledge and belief, the costs above were incurred in accordance with the terms of the supplemental agreement and the application for assistance for this project; and (iv) the amount requested for disbursement represents the loan amount due, which has not previously been requested.

Authorized Representative Name (Print or Type): _____ **Title:** _____

Authorized Representative Signature (Original): _____ **Date:** _____

PLEASE RETURN THIS COMPLETED REQUEST TO THE ADDRESS SHOWN ON THE REVERSE SIDE

(EQP 3522 REV. 1/13)

ADMINISTRATIVE COMPLETION AND LOAN REPAYMENTS

Your DEQ project manager will review the final project cost documentation to determine the final loan amount and ensure program compliance. Approval of final costs will prompt fina disbursement of loan funds, or repayment of any overdrawn funds. A final letter of notificatio indicating that the project has reached administrative completion will be sent to you. This will trigger a downward adjustment of the loan repayment schedule by the MFA, if applicable.

1. Records Retention

   Loan recipients must retain pertinent project files and/or records for a period of three years from the date of administrative completion. The required period lengthens if an audit or review is undertaken during the initial three years. A community may opt to keep records longer.

2. Loan Repayments

   The MFA will send you a statement in advance of the due date for each semi-annual interest payment and annual principal payment, as outlined in the closing documents. This statement will include any instructions necessary for properly crediting the amount to your account. Loan repayments are due semi-annually on April 1 and October 1. Annual principal payments (due April 1 or October 1) begin within one year of project operation, while interest payments (due each April 1 and October 1) begin after the first loan draw and are determined by the MFA based on the amount of funds drawn.

   Failure to make timely repayment to the DWRF constitutes default. The MFA will address remedies with you and your bond counsel. The MFA does have the legal authority to intercept other state aid payments to satisfy obligations of the water supplier. Questions regarding loan repayment should be directed to the MFA at 517-335-0994.

HOW TO CONTACT US

Michigan Department of Environmental Quality

Ms. Sonya T. Butler, Chief
Revolving Loan Section
Office of Drinking ater and Municipal Assistance
Department of Environmental Quality
525 W. Allegan
Constitution Hall
Lansing, MI 48933
(This address is for deliveries only.)
(For regular mail the following post office box address is to be used.
P.O. Box 30241
Lansing, MI 48909-7741

Phone/Voice Mail: 517-284-5433
FAX: 517-373-4797
E-mail: butlers2@michigan.gov

****

Mr. Richard Benzie, Chief
Community Drinking Water Unit
Field Operations Section
Office of Drinking ater and Municipal Assistance
Department of Environmental Quality
P.O. Box 30241
Lansing, MI 48909-7741

Phone/Voice Mail: 517-284-6512
FAX: 517-241-1328
E-mail: benzier@michigan.gov

Michigan Finance Authority

Mr. Joe Fielek, Executive Director
Michigan Finance Authority
Treasury Building
430 W. Allegan
Lansing, MI 48922

Phone/Voice Mail: 517-335-0994
FAX: 517-335-2160

Most documents and forms in this booklet are available electronically on the DEQ website, **www.michigan.gov/drinkingwaterrevolvingfund.**

OTHER AVAILABLE RESOURCES

DWRF Brochure

DWRF Project Planning Guidance

DWRF Eligibility Guidance

Davis-Bacon FAQs

DWRF Disadvantaged Community Guidance

Applicant Actions Related to Revolving Funds (SRF/SWQIF/DWRF) Project Planning

DWRF Guidance Regarding Bidding Documents

Guidance to Applicants and Consultants Regarding Alternative Justifiable Expenditures (AJE

DWRF Construction Phase Guidance

The Loan Arranger – a Revolving Loan Section newsletter

State Revolving Fund (SRF) resources are also available for wastewater projects

PLEASE NOTE: The above materials are available upon request from the DEQ's Office of Drinking Water and Municipal Assistance, Revolving Loan Section, or on the DEQ website. Small orders are free; however, the state of Michigan may charge for photocopying if you are requesting a large order.

State of Michigan
Michigan Department of Environmental Quality
www.michigan.gov/deq

ATTACHMENT H

Customer Correspondence

Associated with Lead and Copper Sampling

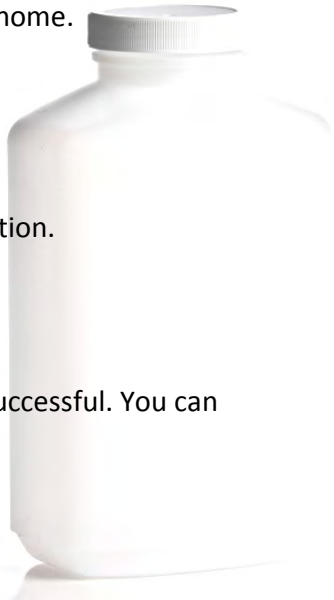
PUBLIC SERVICES DEPARTMENT
Wastewater Division/Lead-Copper
1415 N. Harrison Street
Kalamazoo, MI 49007
Ph.269.337.8550

June 23, 2016

Dear City of Kalamazoo Water Supply Customer:

In 1991, U.S. Environmental Protection Agency (EPA) published a regulation to control lead and copper in drinking water. The Lead and Copper Rule (LCR) is federal regulation which limits the concentration of lead and copper allowed in public drinking water at the consumer's tap, as well limiting the permissible amount of pipe corrosion occurring due to the water itself.

The City has had an active lead and copper program and in 2016, is attempting to identify homes that had copper piping installed after 1982 and before 1989 for our lead and copper monitoring sampling program. We are requesting that you participate in this program by allowing the City to determine if your household plumbing meets the requirements and if so, collect a sample of your water in your home.



What can you expect if your internal piping meets the requirements?

- We will contact you to schedule the sample collection.
  - Samples are collected in the morning.
  - Samples will be taken from the kitchen or bathroom.
  - There must be NO water use for 6 – 8 hours prior to the sample collection.
  - A City of Kalamazoo staff member will collect the sample.
  - The sample is sent to an independent lab.
  - Within 30 days of the sample, you will be notified of the results.
- Please consider participating in this sampling program to make this effort successful. You can contact us to participate either by taking a short survey:
  - SurveyMonkey: https://www.surveymonkey.com/r/kzoosampling

  OR

  - Return the SASE with the completed information.

The first 100 qualified respondents will be scheduled as soon as possible. We will process all other requests as time permits.

Participation helps us maintain a healthy water system, provide quality water and keeps our water supply customers informed. Thanks for your consideration and we look forward to hearing from you soon.

The City of Kalamazoo Public Water Supply System is the second largest groundwater-based drinking water system in Michigan and is ranked one of the lowest for water rates out of the twelve largest systems within the state.2015 Water Quality Report – City of Kalamazoo

Sincerely,

Shannan Deater

Shannan Deater
Public Services Programs Manager
deaters@kalamazoocity.org

REDUCING POTENTIAL LEAD EXPOSURE FROM DRINKING WATER

State of Michigan
Environmental Assistance Center
800-662-9278 | *deq-assist@michigan.gov*

Flush your pipes before drinking. The longer water sits in your home's pipes, the more lead the water may contain. Anytime a faucet used for drinking or food prep has not been used for six hours or longer, you should run the water through ("flush") the tap. To do this flushing, turn on the cold water and let it run until it is as cold as possible. This should not take long (5-30 seconds) if there has been routine daily water use. If there has not been recent daily water use, it could take two minutes or longer. Your water utility can tell you if longer flushing times are needed.

Do not boil water to remove lead. Boiling will not remove the lead.

Clean your faucet aerator. The aerator on the end of your faucet is a screen that will catch debris. This debris could include particles of lead. The aerator should be removed at least monthly to rinse out any debris.

Use a filter. Make sure the filter is certified for lead removal. Be sure to replace a filter device as often as the manufacturer recommends. Contact NSF International at 800-NSF-8010 or visit their website at *www.nsf.org* for water filter performance standards.

Consider replacing your kitchen and bathroom sink faucets. Most existing homes have leaded brass faucets unless they have been replaced since 2013. Any new connecting plumbing and fittings should also meet the 2014 lead-free definition. If you replace your faucet, buy a new one with pieces that meet the 2014 lead-free definition. These should be certified as lead-free by an independent testing agency. Learn more from the Environmental Protection Agency's Publication Center at 800-490-9198 and ask for the document entitled *How to Identify Lead-Free Certification Marks for Drinking Water System & Plumbing Materials* (number 600F13153).

Deep flush your cold water pipes after long periods of non-use. If you are moving into a new home or apartment, or moving back to a place of residence that has been unoccupied for some time, you should run all faucets an extended period of five minutes or more before using any water for drinking or cooking.

Learn about your drinking water supply. Read your community's Consumer Confidence Report that is mailed to you each year or can be found at your local water utility's website. If you wish to get your drinking water tested, use a certified lab. To find a certified lab, go to the Michigan Department of Environmental Quality's home page, *www.michigan.gov/deq* and search "certified lab list."

For further assistance, contact the State of Michigan Environmental Assistance Center at **800-662-9278** or ***deq-assist@michigan.gov.*** Hours of operation are 8 a.m. – 4:30 p.m. Monday through Friday.

Rev. 06/2016

THE CITY OF Kalamazoo

Department of Public Services
Environmental Services Division
Harrison Street Facility
1415 N. Harrison Street
Kalamazoo, MI 49007-2565
Ph.269.337.8701
Fx.269.337.8535

Date

LCS-
Homeowner Name
Address
Kalamazoo, Michigan

Please find the results of the sampling performed at **Address** on **Date**. The State & Federal action level is defined as the concentration of lead or copper in the first draw tap sample that determines the treatment requirements a water system must meet. Your test results do not exceed those values and are listed in the following table:

Key to Table	Contaminant	AL	MCLG	Your First Draw Result	Your Second Draw Result
Action Level (AL): The concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow. **Maximum Contaminant Level Goal (MCLG)**: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety. **ppb**: parts per billion or micrograms per liter.	Lead (ppb)	15	0	<1	<1
	Copper (ppb)	1300	1300	70	<20

Although your sample results are below the lead and copper action levels, it is still a good idea to allow your faucet to run a while prior to using the water for cooking or drinking. This is especially true when returning from an extended period away from home. Following these suggestions ensures that your exposure to the effects of lead, copper and other problems associated with stagnant water are minimized.

The following information on the sources and effects of lead is provided by the U.S. EPA to educate consumers: *Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and it can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones, and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.*

To reduce exposure to lead in drinking water:

- *Run your water to flush out lead.* Run the water until it becomes cold.
- *Use cold water for cooking and preparing baby formula.* Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water.
- *Do not boil water to remove lead.* Boiling water will not reduce lead levels.
- *Look for alternative sources or treatment of water.* If your lead result is above 15 ppb, you may want to consider purchasing bottled water or a water filter. Read the package to be sure the filter is approved to reduce lead or contact NSF International at 800-NSF-8010, or www.nsf.org for information on performance standards for water filters.
- *Identify if your plumbing fixtures contain lead.* New faucets, fittings, and valves, may contain up to 8 percent lead including those advertised or labeled as "lead-free" and may contribute lead to drinking water. Consumers should be aware of this when choosing fixtures and take appropriate precautions.

Although the primary sources of lead exposure for most children are deteriorating lead-based paint, lead-contaminated dust, and lead-contaminated soil, the U.S. EPA estimates that 10 to 20 percent of human exposure to lead may come from drinking water. For more information on reducing lead exposure around your home and the health effects of lead, visit the U.S. EPA's Web site at www.epa.gov/lead, call the National Lead Information Center at 800-424-LEAD, or contact your health care provider.

Please contact me at 269-337-8667 if you have any further questions.

Sincerely,

Shannan Deater
City of Kalamazoo
ESD Programs Manager