Lansing Board of Water & Light
Softened Water Supply

City of Grand Ledge

Project No. 200549
September 28, 2020

Review Draft

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Prepared For:
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Eaton County, Michigan

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List of Acronyms

ADD	average daily demand
ccf	hundred cubic feet
DWRF	Drinking Water Revolving Fund
EGLE	Michigan Department of Environment, Great Lakes, and Energy
gpm	gallons per minute
hp	horsepower
LBWL	Lansing Board of Water & Light
MDD	maximum daily demand
MG	million gallon
mgd	million gallons per day
mg/L	milligrams per liter
O&M	operation and maintenance
psi	pounds per square inch
RD	Rural Development
SCADA	supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SESC	Soil Erosion and Sedimentation Control
sf	square foot
USDA	United States Department of Agriculture
USEPA	U.S. Environmental Protection Agency
VFD	variable frequency drive
WTP	water treatment plant
WWTP	wastewater treatment plant
10-States	Recommended Standards for Water Works

1.0 Executive Summary

The City of Grand Ledge (City) retained Fishbeck to evaluate options for the replacement of the City's existing iron removal treatment system. Fishbeck is evaluating three options as part of this process: the installation of a new iron removal treatment system, the installation of a new softening treatment system, and receiving water from the adjacent Lansing Board of Water & Light (LBWL) system. This report evaluates the third option, connection to the LBWL system. Three potential alternatives to connect to the LBWL water system were evaluated, and a present worth analysis for all three options was conducted to compare the three options to replace the existing iron removal treatment system.

A basis of design for each LBWL supply alternative was developed to determine the required capacity of new pumping, storage, treatment, and transmission facilities. A 2040 projected average daily demand (ADD) of 0.91 million gallons per day (mgd) and a 2040 projected maximum day demand (MDD) of 1.74 mgd were estimated. For the purposes of this study, a supply capacity of 2.0 mgd was selected by the City for analysis of supply route connections. This was the practical limit that could be supplied by LBWL through the northern route evaluated in this study.

Three LBWL alternatives for system connections and wholesale supply to the City were evaluated. The first alternative consists of a primary connection at the end of the existing LBWL system in Watertown Township near the intersection of Grand River Highway and Forest Hill Road. From this point, a 20-inch single transmission feed would be constructed along Grand River Highway from Forest Hill Road to Highway M-100, then running south along M-100 from Grand River Highway to the existing City distribution system and connecting at Burt Avenue and Winstanley Boulevard. At the Forest Hill Road connection point, a booster station would be constructed to distribute water to the City's existing distribution system. A 0.5 million-gallon (MG) ground storage tank would be constructed on the site of the Forest Hill Road booster station. This alternative includes a redundant 16-inch transmission main connection to the LBWL system through Delta Township running along the south side of Saginaw Highway from Upton Road to Charlevoix Drive. This system connection would require an inline booster station to distribute water to the City system. Both booster stations would include provisions for disinfection to maintain a chloramine residual throughout the City's distribution system.

The second alternative consists of a parallel connection to the LBWL system at the end of the existing LBWL system in Watertown Township near the intersection of Grand River Highway and Forest Hill Road. From this point, parallel 16-inch transmission feeds would be constructed along Grand River Highway from Forest Hill Road to Highway M-100, then run south along M-100 from Grand River Highway to the existing City distribution system and connect at Burt Avenue and Winstanley Boulevard. An additional segment of transmission main would be required through Watertown Township back to Airport Road to maintain redundancy along the entire length of the water system supply connection. At the Forest Hill Road connection point, a booster station would be required to pump water to the City's distribution system. A 0.5 MG ground storage tank would be constructed on the site of the Forest Hill Road booster station. Similar to Alternative 1, the booster station would include provisions for disinfection to maintain a chloramine residual throughout the City's distribution system.

The third alternative consists of a parallel 16-inch mains along Saginaw Highway connecting to the LBWL system through Delta Township. One main would run on the south side of the road from the end of the Delta Township distribution system at Upton Road to the extent of the City's existing distribution system at Charlevoix Drive. The redundant main would be routed along the north side of Saginaw Highway from Broadbent Road to Charlevoix Drive. The redundant main would be slightly longer to connect to a better supplied area of the Delta Township water system. At the Charlevoix Drive connection point, a booster station would be constructed to pump water to the City's existing distribution system. A 0.5 MG ground storage tank would be constructed on the site of the booster station. Because of the extended length of a single transmission main, there is a high risk of interruption of water supply to the City. As a result, this alternative does not consider a single transmission main connection to the Delta Township distribution system. The booster station would include provisions for disinfection to maintain a chloramine residual throughout the City distribution system.

Capital and annual operation and maintenance (O&M) costs were estimated for each alternative. Costs for the LBWL supply are summarized in Table 1. The capital cost opinions include the cost of new water mains, pumping and storage facilities, site work, and associated work at the existing wells and WTP. Estimated costs for engineering and a corrosion control study are included in the capital costs. The annual O&M costs include the electrical, chemical, and labor costs. Water commodity costs that would be charged by LBWL (and Delta Township) were included as annual O&M costs.

Table 1 – LBWL Supply Alternative Cost Comparison

Supply Alternative	Total Project Capital Costs	Annual O&M Costs
Alternative 1 - Single Grand River Highway Feed	$40,959,000	$1,369,500
Alternative 2 - Parallel Grand River Highway Feed	$36,636,000	$1,367,500
Alternative 3 - Parallel Saginaw Highway Feed	$21,614,000	$2,633,100

The previous Iron Removal Treatment Plant Study and Water Softening Treatment Plant Study evaluated options for replacing the City's existing iron removal plant with City owned and operated treatment. The feasibility of each treatment process alternative was evaluated, and cost estimates were developed.

A 20-year net present worth analysis was performed on all the options evaluated as potential replacements of the existing iron removal process. This analysis included the capital costs, equipment replacement costs, annual O&M costs, and salvage value of assets at the end of the 20-year planning period. Present worth for each component was determined assuming a 3% discount rate. Table 2 includes the summary of the costs for each of the alternatives considered. Costs for improvements to the City distribution system as needed for each respective option are shown separately from the Alternative capital costs.

Table 2 – Water Supply Replacement Cost Summary

Option	Water Supply Alternative	Alternative Capital Costs	City Distribution Improvements Capital Costs	Annual O&M Costs	Salvage Value	20-Year Net Present Worth
Iron Removal	HPF in New Plant	$13,395,000	$667,000	$104,900	($3,408,000)	**$12,215,000**
Softening	Reverse Osmosis	$32,440,000	$667,000	$509,000	($6,882,000)	**$33,798,000**
Softening	Ion Exchange	$22,142,000	$667,000	$508,000	($5,279,000)	**$25,088,000**
Softening	Lime Softening	$29,449,000	$667,000	$637,000	($6,562,000)	**$33,031,000**
LBWL Supply	Alternative 1	$39,516,000	$1,443,000	$1,369,500	($12,195,000)	**$49,139,000**
LBWL Supply	Alternative 2	$35,193,000	$1,443,000	$1,367,500	($15,647 ,000)	**$41,334,000**
LBWL Supply	Alternative 3	$20,947,000	$667,000	$2,633,000	($4,069,000)	**$56,717,000**

The treatment alternatives were based on a plant design capacity of 4.0 million gallons per day (mgd) compared to the limit of 2.0 mgd for the LBWL supply. Therefore, capital costs of the treatment alternatives are not directly comparable on a capital cost basis. However, these were the capacities that met the City's needs for the respective analyses. In order to achieve 4.0 mgd treatment capacity additional groundwater supply would be required. Costs for additional wells were not included in the present worth analysis. Future increases in capacity above 2.0 mgd for the LBWL supply alternatives would require significant additional capital costs for reinforcement in the LBWL system that were not considered in this study, similar to the development of additional water supply capacity in the treatment alternatives.

Iron removal has the lowest 20-year present worth, which is expected as the cost to soften water is considerably more than the cost for iron removal. The lowest cost softening alternative is for ion exchange softening. It should be noted that this alternative would need further consideration to resolve uncertainties with disposal of brine wastewater to the City's WWTP. Ion exchange would also result in higher sodium concentrations in the finished water, which may be undesirable.

The parallel LBWL supply through a northern connection passing through Watertown Township was the lowest present worth of the LBWL softened water supply alternatives evaluated. Though this alternative would result in the highest water age, provisions for maintaining a disinfectant residual through the City distribution system are included with the alternative. Parallel water mains are included along the entire route to maintain redundancy.

There are a few issues that would need to be further evaluated if the City decided to pursue connection to LBWL through a Delta Township connection. Delta Township is currently supplied by a single feed from LBWL. The Township relies on their existing wells for redundancy. LBWL staff indicated that a second feed to Delta Township is in the planning stages, but the timing of this connection is uncertain. If the City were to connect prior to the installation of a second feed, the existing well supply used by the Township would need to be verified to be suitable to provide redundancy to the Grand Ledge feed, or else the City would need to maintain their wells for redundancy until the second feed to Delta Township was established. Delta Township system reinforcement costs were estimated assuming improvements to transmission, booster pumping, and storage would be required by the Township to supply water to Grand Ledge and would need to be verified as part of the development of a water supply agreement between the parties. Cost estimates presented are based on September 2020 cost indices and the project components as presented herein. Actual project costs may differ based on the final scope of the project design components, the bidding climate at the time the project is bid, material pricing fluctuations, and other factors.

This evaluation was conceptual in nature for the purpose of comparing the alternatives. Further refinement of the assumptions used in the development of the alternatives for the required treatment processes, sizing of components, and cost estimates would be completed for the selected alternative as part of the preliminary design process to further refine cost estimates and develop preliminary project scheduling.

2.0 Introduction and Background

The City's water supply includes four groundwater supply wells and an iron removal treatment plant. The existing iron removal plant utilizes an AERALATER® Type II-Q Packaged Iron and Manganese Removal System by General Filter (Aeralater) for iron removal. The Aeralater is at the end of its useful life and has significant signs of deterioration. The repair of the Aeralater system was investigated as part of a prior study completed by Fishbeck, which determined that repair of the Aeralater would be costly and would give a low return on investment. The City opted to move forward assuming the Aeralater unit would need to be replaced, rather than attempt to repair it.

The City's existing raw water has a significant amount of hardness, about 460 milligrams per liter (mg/L) as calcium carbonate. A target hardness value after softening would be about 120 mg/L as calcium carbonate. Many Grand Ledge water customers have home softeners to reduce the high level of hardness in the City's water. A softer water would reduce the amount of soap needed when washing clothes and dishes. Soft water can also reduce lime scale buildup in pipes and appliances in homes. The LBWL system softens water at its two conditioning plants for distribution to customers.

The City retained Fishbeck to evaluate replacing the existing water supply with a connection to a softened water supply from the LBWL water system. Fishbeck coordinated with LBWL to provide engineering support to identify the quantity of water to be supplied, the point of connection to the City system, the hydraulic grade line at the point of the connection, and life cycle costs. LBWL completed an evaluation of improvements to their transmission and system reinforcement requirements for the LBWL system to serve the City and provided estimated costs for those improvements.

Fishbeck conducted modeling of the existing City system to ensure water could be conveyed from the point of connection with LBWL to the City's existing elevated storage and throughout the City's distribution system to meet future demands. This modeling was used to identify distribution system improvements needed within the City system to receive water from the LBWL system and to provide redundancy within the water system.

The LBWL provided a proposal to the City dated February 3, 2017 for supplying the City with softened water through Delta Township. As part of this proposal, LBWL indicated that water age could be a concern for the City if they were supplied by the LBWL. They indicated that the City should include provisions to boost disinfection residual concentrations. Modeling was conducted as part of this current study to estimate water age throughout the system. The water age information was used to determine areas of the City system that would see the largest changes in water age resulting from a change in source water.

The 2017 proposal by LBWL looked at three different routes for delivery of water to Grand Ledge, including two that would connect through Delta Township and one from Forest Hill Road at West Grand River Highway to Eaton Highway, then west on Eaton Highway to the City's ground storage tank in the Industrial Park. For this latest evaluation, the City requested further evaluation of routes from the end of the existing LBWL system in Watertown Township near Forest Hill Road and Grand River Highway.

Three connection/route alternatives were considered for the current study. Alternative 1 consists of a primary connection along Grand River Highway and M-100 from Forest Hill Road to a connection to the existing City's system at Burt Avenue on the north side of the City and a secondary emergency connection through Delta Township along Saginaw Highway. Alternative 2 follows the same route as the primary connection from Alternative 1, but would include parallel mains between the two systems for redundancy. Alternative 3 would connect the two systems through parallel mains along Saginaw Highway from Delta Township to the eastern edge of the City. These route alternatives are shown in Figures 4, 5, and 6 following this report.

Regardless of the route, the transmission main delivering water to Grand Ledge would pass through other municipal jurisdictions before connecting to the City's system. For the purposes of this study, it was assumed that the City would own the transmission main from the point of connection to the LBWL supply, including piping installed in those areas not under the City's control.

It was assumed that the City would become a wholesale customer of the LBWL water system, and that the City would not maintain their wells for redundancy; thus, the study includes redundant feeds from LBWL with each alternative.

3.0 Baseline Conditions for Study

3.1 Existing City System

In the current system configuration, three groundwater supply wells feed raw water to the WTP for iron removal and disinfection. After treatment, water is pumped to the distribution system, which includes two elevated tanks: the 0.5 MG tank on West Saginaw Highway and the 0.1 MG tank on West Front Street. Both elevated tanks have an overflow elevation of 995 feet above sea level. Additionally, there is a ground storage tank and pumping station at the Willis Industrial Park on the north side of the City. This tank has a capacity of 0.75 MG, but only 0.39 MG of this storage are available to the City, as the remainder is reserved for the Michigan National Guard facility for fire protection and other emergency use.

3.2 LBWL Supply

The LBWL provides softened groundwater to its customers from two treatment plants. The Dye Water Plant supplies a maximum of 40 mgd and is in downtown Lansing along Cedar Street, and the Wise Road Water Plant supplies a maximum of 10 mgd to the customers around the southern portion of the system.

Connection to the LBWL system at Forest Hill Road and Grand River Highway in Watertown Township is considered in this study. Based on conversations with LBWL engineers, the potential connection point is supplied by a single 16-inch main. This single feed through Watertown Township runs southeasterly from the potential connection point for approximately 4.25 miles back towards Lansing, where it is supplied from other looped water mains near the Capital Region International Airport. This extended length of single transmission main represents a single point of failure if used as the sole system connection for the City.

Connection to the LBWL via the Delta Township water system is also considered in this study. Delta Township is a wholesale customer of the LBWL. Their municipal system is supplied by a direct feed from LBWL. The Delta system includes five standby wells, three ground storage tanks with pump stations, and two elevated storage tanks. The wells are maintained for emergency use only. According to LBWL, there is enough remaining capacity through this supply to supply the City of Grand Ledge and still provide capacity for each of the municipalities to develop and grow over the planning period.

LBWL uses chloramination for disinfection. The City uses gas chlorine for disinfection. Chloramination is not considered as potent of a disinfectant as the use of chlorination, but it is beneficial in large systems because compared to a chlorine residual, the residual disinfectant stays active longer. Chloramines are also beneficial in that they do not generate as many disinfection byproducts in waters with significant organic content. The City would need to convert to chloramine disinfection if they were to be supplied as a customer of LBWL water. This item was considered when comparing options and the lifecycle costs of each alternative.

3.3 Demand Projections

Demand projections were developed for use in all three of the studies for the City. Historical water demand data from the City for the last fifteen years was evaluated to develop the baseline usage for the City. Figure 1 shows the average day demand (ADD) and maximum day demand (MDD) recorded over the prior ten years. As shown in the figure, the ADD has trended downward slightly, but the MDD has remained relatively consistent.

Figure 1: Historical Demands, 2010-2019

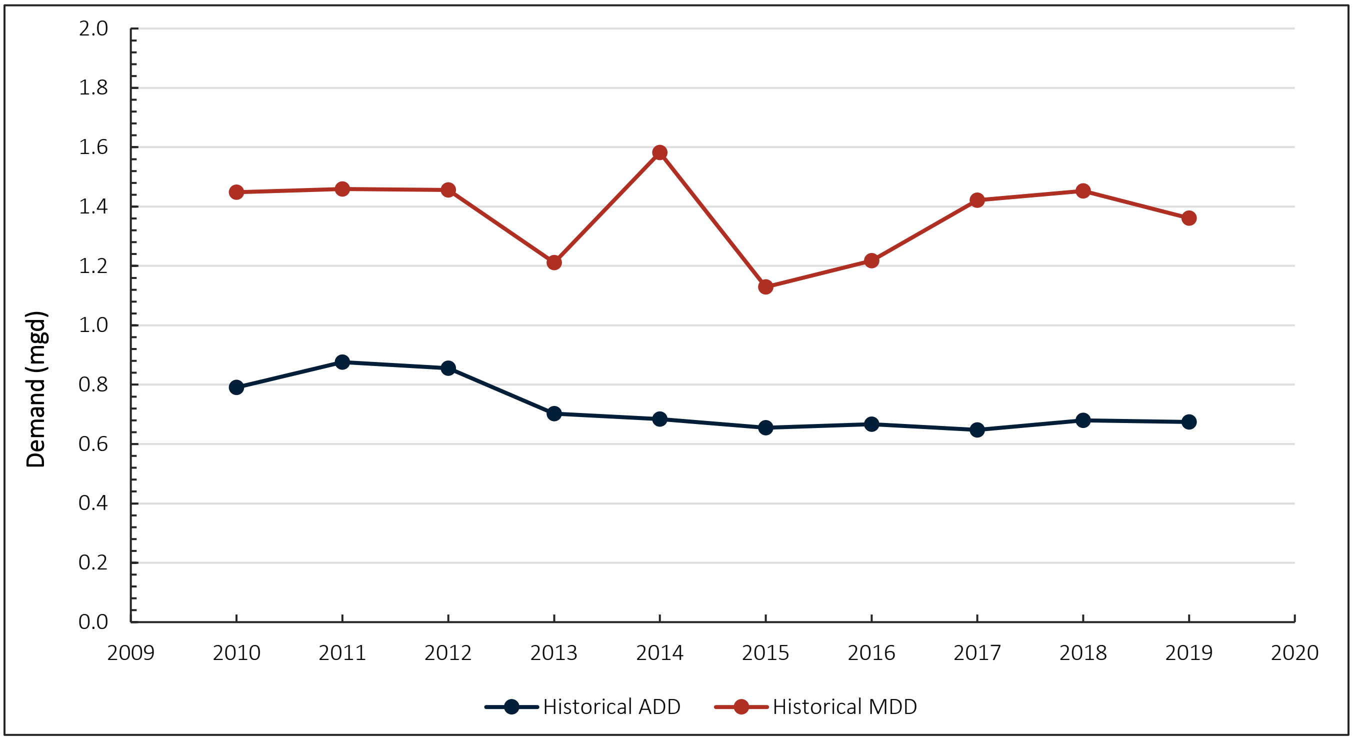
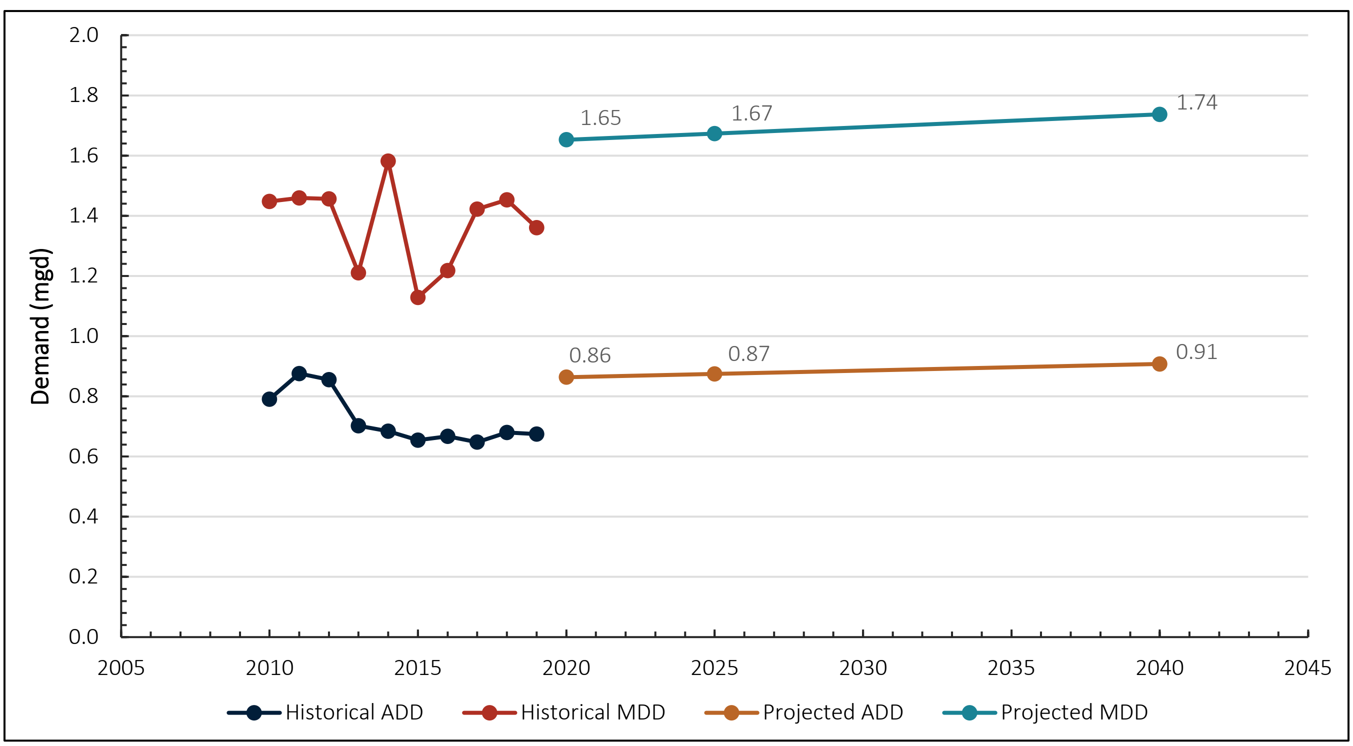


Figure 2 shows the projected demands through 2040 alongside historical usage. Moderate growth is projected over the next twenty-year planning period. The 2040 ADD is estimated at 0.91 mgd and the 2040 MDD is estimated to be 1.74 mgd.

Figure 2: Projected Water Demands, 2020-2040



There are several factors that were not considered in the demand projections. There is potential for customers to be added along the route from the LBWL connection to north connection of the City. Customers in Watertown and Eagle Townships along the transmission main route may desire to purchase LBWL water from the City to replace or supplement their existing water supplies. In addition, with the softened water supplied by LBWL, a potential reduction in demand could be realized because customers with in-home softening systems would not need to operate their own treatment systems, eliminating the water demand to backwash from these individual softeners. While exact quantities are unknown, this could account for as much as 10% of current demands based on estimates in the prior proposal from the LBWL. This has not been factored into the demand projections.

4.0 Distribution System Modeling

The City's existing water distribution system hydraulic model was updated to reflect piping improvements completed since the completion of the Water System Reliability Study in December 2016. The hydraulic model was calibrated at that time and is believed to still accurately reflect the current conditions of the system. The model was used to determine the hydraulic grade required at the extents of the City's system to fill the existing elevated tank on West Saginaw Highway under the various connection and supply alternatives.

With the existing system configuration, water is supplied with very little friction loss to the Saginaw Highway elevated tank, due to the close proximity to the WTP. If LBWL supplies softened water to the City, water would be supplied to the system from a different part of the distribution system, located a much greater distance from the elevated tank. This results in more headloss through the system to fill the elevated tank from the supply connection. The overflow of the City's elevated tanks is at an elevation of 995 feet above sea level. Based on the current City demand projections and hydraulic model, the City would require an estimated hydraulic grade line (HGL) of 1,016 feet at the proposed connection point to the LBWL system at Forest Hill Road and Grand River Highway for the northern route alternatives to fill the Saginaw Highway elevated tank. This represents an HGL of 1,002 feet at the proposed connection of the new transmission supply main to the existing City distribution system along M-100 at Burt Avenue and Winstanley Boulevard. For the system connection through Delta Township along Saginaw Highway, an estimated HGL of 998 feet is required at the edge of the existing City distribution system to fill the elevated tanks in the City. The estimated HGL required only considers the distribution system as it currently exists, but distribution system improvements could reduce this requirement.

Changing the origin of the City's water supply, whether from the north or from the east, would change the direction of flow through the water mains and could increase velocities significantly through some mains. This is of more concern with a feed from the north. Based on the location of water services and demands, over 67 percent of the system demands occur on the south side of the Grand River. The distribution system was designed and mains were sized for distribution of water supply from the south. As a result, some of the water mains in the northern part of the system would be required to convey nearly double existing flow rates when water is supplied from the north.

A good indication of the amount of stress put on a water main during system operations is the velocity in the main and the resulting headlosses. Higher velocities lead to increased headloss through water mains, increased wear on the water mains, and increased pumping and supply pressure requirements. Pipe velocities were evaluated for both the existing system and with water supplied from LBWL from the two connection points. Hydraulic modeling was performed at peak hour demands to evaluate the new systems at worst-case scenarios. Water mains in and around sections near the system connections experience significant changes with a new water supply. These areas were targeted for replacement to improve hydraulic conditions and remove constrictions through the City water system to accommodate the supply from LBWL. Different infrastructure improvements are recommended for the water supply connection alternatives.

Available fire flow is another metric that can give a good indicator of system performance. It is used to assess ability of the water system to provide flows above maximum daily usage for emergency use (like firefighting) before pressures drop below the minimum requirement of 20 pounds per square inch (psi) anywhere in the system. Areas with a significant change in available fire flow resulting from the water supply change were targeted for distribution system improvements within the City to facilitate the connection to the LBWL system.

In the following sections discussing the alternatives, City improvement projects that would have the most impact to the distribution system following a connection to LBWL were included for each alternative. Improvements were prioritized in order of most to least impact to distribution system performance. These improvements do not replace the need to continue completing projects previously identified in the Reliability Study and Asset

Management Plan, though the prioritization of improvements should be reevaluated in future studies if the LBWL supply is selected as the new source alternative for the City.

Table 3 shows unit costs assumed in this study for water main installation with surface restoration. As shown by the table, these costs are heavily dependent on the location of the water main and the restoration work that must be performed after the main is installed. The unit costs generally assume installation of water main only, and do not account for replacement of other utilities, gutters, or roadways beyond what would be disturbed by installation of the main. These unit costs include a 20% factor in addition to the construction costs and contingency to account for the cost of engineering.

Table 3 – Water Main Unit Costs

Accessibility Rating	Description	Nominal Pipe Diameter				
		8-inch	12-inch	16-inch	20-inch	24-inch
1	In a field.	$174	$212	$251	$352	$421
2	In the right of way.	$201	$238	$277	$378	$447
3	Under a minor road.	$286	$324	$363	$465	$534
4	Under a major road.	$304	$340	$381	$482	$551
5	Directionally drilled main under river, train tracks, etc.	$496	$530	$573	$674	$743

5.0 Storage Analysis

Storage capacity for the City distribution system was evaluated to determine if additional storage should be included in the various supply alternatives for the 20-year projected demands. Two different storage calculation methods were used in accordance with two differing methods of storage analysis. The larger value calculated from the two equations is used.

The first calculation used was as follows:

(Equalization Storage) + (Higher of Fire Storage or Emergency Storage) = Recommended Storage

The second calculation used was as follows:

(Fire Storage) + (Emergency Storage) = Recommended Storage

For equalization storage, which is intended to provide operational flexibility to meet varying demands, a value of 25% of the MDD is generally accepted. The maximum fire flow requirement for a major industrial user in the system is 3,500 gallons per minute (gpm) for 4 hours. Emergency storage, which considers major power outages, main breaks, or similar scenarios, considers the need to supply ADD from storage for an extended duration. A 12-hour emergency was considered in this evaluation.

The projected 2040 MDD for the existing City customers is approximately 1.74 mgd. The projected 2040 MDD for the build-out along the transmission route is 2.00 mgd. Therefore, for equalization storage, 25% of 2.00 mgd equals 0.50 MG. For fire flow, 3,500 gpm for 4 hours is equivalent to a volume of 0.84 MG. For emergency storage, a 12-hour emergency with ADD equals 0.50 MG. Since the fire storage requirement exceeds the emergency storage requirement, the fire storage requirement was used in the first calculation:

0.50 MG + 0.84 MG = 1.34 MG of storage recommended

For the second calculation:

0.84 MG + 0.50 MG = 1.34 MG of storage recommended

The value of the calculations is the same, for a recommended storage of 1.34 MG in the City distribution system.

The existing City distribution system has two elevated storage tanks and a ground storage tank at the Industrial Park Pump Station. The elevated storage tanks have volumes of 0.5 MG and 0.1 MG, respectively. The ground storage tank at the Industrial Park Pump Station has a usable volume of 0.39 MG; the remainder of the volume for the ground storage tank is reserved for the National Guard Armory. The usable storage totals 0.99 MG of existing usable storage. There is a 0.35 MG shortfall between the recommended storage volume of 1.34 MG and the usable storage of 0.99 MG.

It should be noted that the 0.1 MG elevated tank is over 100 years old and should be taken out of service within the next 20 years. This results in a storage shortfall of 0.45 MG. Constructing a ground storage tank at the new booster station connection with a capacity of 0.50 MG would allow the City to make up this storage shortfall. Constructing additional storage at the system connection to the LBWL would help to provide equalization volume for the pumps and allow the LBWL to supply the City at a levelized flow rate. A ground storage tank at the booster station would also improve the operational efficiency of the booster pumps and maintain net positive suction head. All connection alternatives were evaluated with a 0.50 MG gallon ground storage tank at the system connection.

Depending on the system connection configuration, it may be recommended that the City plan to construct a new elevated storage tank at the same time the 0.1 MG tank is taken out of service. The City should maintain adequate storage on each side of the Grand River to provide more redundancy and emergency capacity throughout the system. At that time, an updated analysis of the storage needs of the system should be completed to ensure the new tank is sized properly.

6.0 LBWL Connection Requirements and Redundancy Considerations

Several LBWL supply connection route alternatives were evaluated for comparison. Each alternative provides a fully redundant system connecting the existing City distribution system to the LBWL system, capable of providing 2.0 mgd with the largest unit (pump or transmission main) out of service. In order to account for potential future growth in the City, additional customers along the transmission routes, or new service area, space for additional pumps in the proposed booster stations was assumed in the cost evaluations. The operations of the existing system with the elevated tank and ground storage tank/booster station at the National Guard Armory would not be changed, with water supply through a connection to the LBWL system. This requires the system connections to be able to fill the 0.5 MG elevated tank up to the overflow elevation.

LBWL determined that significant hydraulic losses would occur in their system when supplying the connection point at Forest Hill Road and Grand River Highway through the single 16-inch main at 2.0 mgd. Reinforcement of the LBWL infrastructure would be necessary to provide the City's required hydraulic grade along the northern connection route while supplying the required MDDs in their existing service area. LBWL provided project costs for the necessary reinforcement, which would include additional booster pumping.

The 2017 LBWL proposal evaluating connections through Delta Township assumed water would be routed to the City's existing WTP for repumping to the system. In order to achieve the required hydraulic grade in the City directly from the LBWL system, construction of additional pumping facilities would be required. The alternative considering supply from the Delta Township system included booster pumping since the existing WTP would not be used.

Water systems must be able to provide consistent, dependable service to its customers for regular and emergency usage. Equipment maintenance and failure are a part of operating these infrastructure systems. Water treatment and distribution processes and systems must be able to meet average demands with the largest unit out of service. For transmission mains, there should be no single point of failure that would interrupt continuous service of the supply.

For the evaluation of a LBWL connection to the City water system, two primary redundancy options were considered. The first was for the City to maintain their existing groundwater wells in the event of failure from a single feed from LBWL. The second was installation of two separate and independent feeds from the point of connection to LBWL.

The City well supply is high in iron and has radium levels close to the drinking water standard. In addition to raw water quality and concerns with blending unsoftened water into the distribution system when used, the City would have to continue to maintain the wells for the long term. Currently, the City uses gaseous chlorine at the WTP as a disinfectant and also has provisions for sodium hypochlorite feed at Well No. 2, which is a standby well used in case of emergency. The City would need to outfit the existing wells for chloramine feed if they were going to rely on them as the redundant supply. Due to the complications associated with this transition and the ongoing maintenance required to keep the wells available as a standby water supply, the City does not wish to maintain its existing groundwater wells as a standby water supply alternative.

For each alternative, redundant mains would be necessary. Regardless of the size of the transmission main, it represents a single point of failure and a significant risk to the City and its ability to provide its customers with a consistent, dependable supply of safe drinking water. As a part of each alternative, redundancy is provided through parallel transmission mains, secondary connections, and redundant pumps within each booster station. The improvements are described in Section 7.

7.0 Alternative 1 – Single Feed along Grand River Highway

The first alternative evaluates a primary supply connection to LBWL from the north at Grand River Highway and Forest Hill Road, with a secondary, redundant connection along Saginaw Highway through Delta Township. The primary connection would include the construction of a 20-inch transmission main along Grand River Highway and M-100 routed to the connections to the City's distribution system at Burt Avenue and Winstanley Boulevard, and a ground storage tank and booster station at the Forest Hill connection point. The secondary connection through Delta Township would include a 16-inch transmission main along Saginaw Highway from Upton Road to Charlevoix Drive. The City owns a parcel of property near the eastern city limits along Saginaw Highway that could be used to construct a backup booster station along the emergency connection route to fill the City's elevated tanks. Alternative 1 is shown on Figure 4.

7.1 LBWL Reinforcements

LBWL reinforcements are projects that must be completed within the LBWL system that would allow the City's water demands to be conveyed to the connection point. The City demand cannot be supplied through the primary connection point as the LBWL distribution system currently exists. Table 4 outlines the improvements and expected costs associated with the necessary improvements. Required lengths of LBWL water main reinforcements were provided by LBWL engineering staff, but the unit costs from Section 4 of this study will be used to determine the total cost of these reinforcements. Figure 4 highlights the location of these improvements as well.

Table 4 – Alternative 1 - LBWL Reinforcement Main Cost Estimates Estimate

Location	Length (feet)	Accessibility (1-5)	Pipe Diameter (inch)	Unit Cost ($/lf)	Total Cost ($)
Bon Air Road, West Saginaw Street, North Waverly Road from Michigan Avenue to North Grand River Avenue/Airport Service Drive	16,900	2	16	277	$4,682,000
West Grand River Avenue from Franette Road to Airport Road	1,605	4	24	551	$885,000
				LBWL Water Main Cost	$5,567,000

For the alternatives that include a connection to the LBWL system at Forest Hill Road and Grand River Highway, additional booster pumping must be performed within the LBWL system to maintain service to existing customers. Under ADD conditions, additional boosting is not required to fill the above ground storage tank at the primary booster station. However, under MDD and emergency conditions, an additional booster station in the LBWL system is required to maintain pressures above 20 psi through Watertown Township and provide fire flows in excess of 2,000 gpm. This station would require 10 horsepower (hp) pumps for regular use as well as 100 hp fire pumps. Three of the regular use pumps would be installed in the booster station to provide pressures required for demands at and above the projected ADDs; two of these pumps would always be available. Two fire pumps would be installed in this booster station to maintain enough firm capacity to maintain fire protection for existing customers in Watertown Township while providing MDD flows to the City.

The location of the booster station was not determined for this study, but there was previously a booster station at the intersection of Airport Road and Grand River Avenue that is no longer in service that could be rebuilt to maintain service to existing customers along Grand River through Watertown Township. This study evaluated constructing a new booster station because the condition of the prior LBWL booster station and associated equipment was unknown. Costs to construct a new booster station are estimated to be approximately $2.6 million. Table 5 highlights the costs associated with each category of the construction of this facility. Chemical feed provisions were not included with this booster station estimate. If this alternative proves to be a cost-effective option, the other potential locations and costs for this booster station should be evaluated in further detail with the LBWL.

Table 5 – Alternative 1 - Airport Road Booster Station

Component	Estimated Cost
Building Construction	$539,000
Process Equipment	$117,000
Process Piping and Valves	$240,000
Mechanical Equipment (HVAC)	$75,000
Electrical, Instrumentation, Controls	$450,000
General Sitework	$65,000
Site Utilities, Piping, Valves	$145,000
Subtotal	$1,631,000
General Conditions, OHP (15%)	$245,000
Construction Subtotal	$1,876,000
Conceptual Design Contingency (20%)	$376,000
Construction Cost Opinion	$2,252,000
Design and Construction Engineering (15%)	$338,000
Project Cost Opinion	$2,590,000

Table 6 summarizes the total costs associated with all the LBWL reinforcement required to connect the two systems as outlined in Alternative 1.

Table 6 – Alternative 1 - LBWL Reinforcement Cost Summary

Component	Estimated Cost
LBWL Water Main Reinforcement	$5,567,000
Booster Station	$2,590,000
LBWL Reinforcement Cost	$8,157,000

7.2 Delta Township Reinforcements

Supplying the City demands through Delta Township, even if only in emergency scenarios, will require improvements to the Delta Township water system and infrastructure. Reinforcement costs were assumed for improvements to existing transmission main from the LBWL Dye Conditioning Plant, booster pumping, and storage to support supply to the Grand Ledge system. The exact costs for reinforcement would need to be developed in further detail based on evaluation of the Delta Township system and negotiation of a water service agreement. An estimate of $10 million is used for this study.

7.3 Transmission Infrastructure

Two possible routes for water transmission from the Forest Hill Road connection point were evaluated, one following the Forest Hill Road/Eaton Highway route included in the prior evaluation by LBWL and another route along West Grand River Highway from Forest Hill Road to M-100, then continuing south on M-100 to the point of connection to the existing City distribution system, which is assumed to be at Burt Avenue and Winstanley Boulevard. The length of these two routes only differs by about 1,500 feet in length of water main and behave similarly hydraulically. The Grand River Highway route has additional benefits in that it could serve additional customers along the route. Only the Grand River Highway route was considered for the northern system connection alternatives. Depending on other considerations, the route could be modified to follow Eaton Highway with minimal changes to the results in this report.

A second transmission main would be required for the redundant connection between Delta Township's water system and the City water system along Saginaw Highway. This transmission main requires a shorter length to connect these two systems than the transmission main along the northern connection route.

Table 7 includes the approximate length, size, and cost associated with the transmission mains construction.

Table 7 – Alternative 1 Transmission Main Cost Estimate

Location	Length (ft.)	Accessibility (1-5)	Pipe Diameter (in.)	Unit Cost ($/lf)	Total Cost ($)
Grand River Highway from Forest Hill Rd to M-100; M-100 from Grand River Highway to Burt Avenue	28,780	2	20	378	$10,879,000
West Saginaw Highway from Upton Road to Charlevoix Drive	9,610	2	16	277	$2,662,000
Transmission Main Cost					$13,541,000

Though the water main leading up to the connection point at Forest Hill Road and Grand River Highway is 16-inch, this segment of water main would be upsized to 20-inch. Hydraulic modeling indicated this was necessary to accommodate industrial fire flows on top of MDDs without inducing excessive headloss. This would also allow for some room for growth in City demands. The second segment listed would serve the same purpose for the redundant emergency connection. Because it has a shorter length, less headloss occurs under fire flow conditions in the backup transmission main, so this main can be constructed with a smaller diameter.

7.4 Forest Hill/Grand River Connection

The primary booster station at Forest Hill and Grand River would be designed to provide the projected MDDs of 2.0 mgd to the City distribution system with the largest pump out of service to meet firm capacity requirements.

The estimated head requirement of the pumps is 149 feet, based on hydraulic modeling of the system at design flows. Three 50 hp pumps were assumed in the estimate for the initial build. Variable frequency drives (VFDs) would be installed to provide better efficiency and a wider range of operating points to manage various demand conditions. In addition to the primary design point provided above, the secondary design point for the pumps would allow the station to provide an additional 3,500 gpm for fire protection as the pressures and tank levels are drawn down in the City. On a maximum demand day, the primary booster station can provide the City's demands as well as flows for an industrial fire for the recommended 4 hours. Table 8 provides a conceptual basis of design for the booster station.

Table 8 – Alternative 1 Primary Booster Station Basis of Design

Category	Design Condition
Firm Capacity	1,400 gpm
Total Capacity	2,100 gpm
No. of Pumps	Three – original construction. Four – future build-out and expansion.
Primary Pump Design Point (MDD, two pumps operating)	700 gpm @ 149’ TDH
Emergency Pump Design Point (MDD + Fire, two pumps operating)	990 gpm @ 140’ TDH
Motor Size	50 hp

A 120 kVA backup generator was assumed in the conceptual design to operate the booster station at firm capacity and operate the chemical feed systems in case of an emergency. The generator was assumed to be built in a soundproof enclosure attached to the building. Enclosure requirements and soundproofing would be determined after a specific piece of property is selected with this alternative.

The primary booster station would pump out of the adjacent ground storage tank, though capabilities would be included to pump in-line from the transmission main. The storage tank would provide a flooded suction for the pumps to operate without cavitation. Operation of the booster pumps would be controlled using discharge pressures or level in the existing elevated storage tanks.

The transmission main and booster station would be sized based on a normal capacity of 2.0 mgd, but be able to provide a fire demand to the City of 2.84 mgd to provide industrial fire flows under MDD conditions. These demands are a more accurate representation of the City’s water and fire protection demands in this planning period. If demands increase beyond the projections in following decades, a combination of the primary and backup connections may be utilized to meet larger demand increases.

In this alternative, the primary booster station would have space for a fourth pump to increase station capacity in the future. The conceptual footprint of the booster station is estimated at approximately 2,250 sf, including the attached rooms for chloramine storage and feed.

In order to maintain consistent operation and supply to the City water system, a 500,000-gallon ground storage tank and booster station would be constructed at the LBWL connection point. Under typical operation, LBWL water system would supply water to the ground storage tank. The booster station would pump out of the ground storage tank to the City water system, though capabilities would be included to pump in-line from the transmission main if the tank is out of service for maintenance, cleaning, or repairs.

The ground storage tank would act as a buffer against fluctuations in water supply from the LBWL water system and water demand from the City water system. The water demands for the City would vary throughout the day, but with the ground storage tank there to equalize flow, the LBWL system would not need to supply peak demands, but could instead rely on the ground storage tank to “shave” those peak demands. This lessens the strain on and need for additional capacity for the LBWL water system and provides redundancy for the City water system.

This storage would also provide a buffer between the two systems in an emergency. The LBWL indicated they would have challenges to supply flows above 2.0 mgd to the City in addition to continuing service to existing Watertown Township, even in an emergency scenario. In order to supply an industrial fire flow of 3,500 gpm for 4 hours in addition to a maximum day demand, the booster station can draw down extra volume from the ground storage tank to meet the brief need for a higher flow rate, before slowly filling the ground storage tank back up over subsequent days as demands decrease from the peak.

To maintain water quality and prevent thermal stratification in the tank, an active mixing system would be installed in the tank to ensure a more uniform composition of the water. If chemical feed must be utilized to maintain a disinfectant residual throughout the City system, the mixing in the tank can jump start chloramine formation or reformation and encourage the chemical reactions to take place. Without sufficient mixing in the tank, temperature stratification can occur which would impact the equilibrium relationship of the chloramine formation and potentially lead to nitrification or di- and tri-chloramine formation instead of the desired monochloramines.

Additionally, the storage analysis section of this report indicated there may be a future shortfall in water storage throughout the City system of 0.45 MG with the projected demands and anticipated fire flow requirements. The construction of this tank at the booster station would increase the available storage for emergency and equalization in the City water system, as well as improving the performance of the booster station.

Provisions for chloramine feed were included in the conceptual cost estimates for the booster station. Chloramines are formed from a combination of chlorine and ammonia. Provisions were included for each of these components. A chemical feed point for each component was assumed before the ground storage tank and a second backup feed point located downstream of the booster pumps. This will allow operators to control chemical dosing depending on the system demands and influent chloramine concentrations.

In determining the chemical feed requirements, it was conservatively assumed that there would be no disinfectant residual remaining at the system connection point. Historical City MORs indicate that a free chlorine residual of 0.5 mg/L is required leaving the WTP to maintain a disinfectant residual throughout the distribution system. Chloramine residuals must be maintained at approximately four times the concentration required for free chlorine disinfection; therefore, approximately 2.0 mg/L as monochloramine should be applied at the booster station. The 10-States Standards for Water Works (10-States) guidance for chloramine addition state that typical initial concentration is 2 mg/L or higher at each system entry point. Additionally, the 10-State standards state a residual of at least 1.0 mg/L should be maintained in the distribution system, so additional chloramine may need to be added at the connection point to maintain this residual through the City's distribution system and avoid nitrification based on sampling results. Chlorine and ammonia should be applied at a 4.5:1 ratio to optimize chloramine formation, so 2.0 mg/L of chlorine should be applied, and 0.44 mg/L of ammonia applied at the booster station. At average day demands, this results in chlorine demand of 15.2 lbs/day and ammonia requirements of 3.4 lbs/day.

Chlorine can be added in the form of pure, gaseous chlorine or a liquid sodium hypochlorite solution. When added to water, both options behave similarly. This selection would be completed during the preliminary design process after conversations with the City and Michigan Department of Environment, Great Lakes, and Energy (EGLE).

The City currently uses gaseous chlorine at its iron removal plant for oxidation and disinfection and is familiar with typical operations. Using gaseous chlorine at the booster stations would require a slightly larger footprint and equipment costs during the construction of a new facility. Regulations require spare chlorine gas canisters be stored in a separate room from the chlorine feed room. Additionally, a chlorine gas scrubber may be required by EGLE to safely contain a release of chlorine gas since there are residences near the proposed location for the booster station. These requirements would be evaluated if a LBWL connection is feasible. Typically, three to four 150-pound gas canisters would be used in an average month, so six gas canisters would likely need to be kept on site at a time. Costs assumed gaseous chlorine feed.

Alternatively, sodium hypochlorite is a concentrated bleach solution, typically between 10 to 15%. It is typically delivered by a chemical truck through exterior fill connections to a bulk tank, which is used to fill a day tank, out of which hypochlorite is metered to the process. With the estimated chemical demands required to maintain a residual for the City system, sodium hypochlorite could be delivered in 275-gallon totes. Three totes of hypochlorite should be kept onsite, because a spare tote or two should always be kept on hand in addition to covering typical monthly usage.

Ammonia is the other chemical that must be fed to the water to form monochloramines for disinfection. At the treatment plant, ammonia is typically fed after the chlorine to form chloramines. In a chloramine boosting scenario, only one chemical or the other may be required to reach the necessary disinfectant residual.

There are several different methods to deliver ammonia to the water. Ammonia can be fed to treatment processes as anhydrous ammonia that is vaporized and fed as a gas or liquid ammonium hydroxide, also known as aqua ammonia, that is fed from an aqueous solution. Like chlorine gas, gaseous ammonia is fed from 50- or 150-lb gas canisters. The liquid solution is typically delivered by either 275-gallon totes or 55-gallon drums, depending on chemical needs. A spare storage unit should always be kept on hand, at a minimum covering 30-days of usage plus a typical delivery quantity. Assuming gaseous feed from 50-lb canisters, four canisters should be stored onsite at a time. Costs were developed assuming gaseous ammonia feed.

Table 9 summarizes each of the categories and the estimated cost for each component. These are preliminary estimates and may change slightly without a specific site or property selected. Costs are reflective of current construction and bidding climate, but may change based on the timeframe for this project.

Table 9 – Alternative 1 Primary Booster Station and Tank Cost

Component	Estimated Cost
Building Construction	$563,000
Process Equipment	$195,000
Process Piping and Valves	$260,000
Chemical Storage and Feed Equipment	$165,000
Mechanical Equipment & HVAC	$80,000
Electrical, Instrumentation, Controls	$450,000
Pump Station Subtotal	$1,713,000
Ground Storage Tank/Standpipe	$750,000
Appurtenance Allowance	$75,000
Mixing System	$50,000
Ground Storage Tank Subtotal	$875,000
General Sitework	$65,000
Site Utilities, Piping, Valves	$145,000
Property Purchase	$50,000
Subtotal	$2,848,000
General Conditions, OHP (15%)	$428,000
Construction Subtotal	$3,276,000
Conceptual Design Contingency (20%)	$656,000
Construction Cost Opinion	$3,932,000
Design and Construction Engineering (15%)	$590,000
Project Cost Opinion	$4,522,000

7.5 Saginaw Highway System Connection

A secondary booster station and transmission main would be constructed between Delta Township and the City on Saginaw Highway to provide redundancy. This emergency booster station would be designed to be fully redundant to the primary booster station in the event of an emergency. If City demands increase above the 20-

year projections or LBWL experiences a capacity reduction through the northern system, the Delta Township connection and booster station could potentially transition away from being exclusively an emergency connection to supply the remaining demand of the City that cannot be met by the Grand River Highway connection alone.

The emergency booster station would be designed to provide the projected MDDs of 2.0 mgd at firm capacity. The conceptual footprint of the emergency booster station was estimated at 1,700 square feet. Note that this station would be smaller than the primary booster station, as there was no space assumed for an additional pump in the future.

Because of the shorter transmission distance, booster station located at the City limits, and a connection on the southern side of the river to the City system, the head requirements of the pumps are lower than the requirements of the pumps for the northern booster station. The estimated head requirements of the pump are 125 feet based on hydraulic modeling of the system, allowing the pumps to be slightly smaller and driven by a 40 hp motor. VFDs would provide more operational flexibility and improve efficiency, and would be included with this station even though the booster station would not operate regularly. Table 10 includes the booster station basis of design points for the pumping requirements.

Table 10 – Alternative 1 Emergency Booster Station Basis of Design

Category	Design Condition
Firm Capacity	1,400 gpm
Total Capacity	2,100 gpm
No. of Pumps	3 – original construction & ultimate build-out
Pump Design Point	700 gpm @ 125’ TDH
Motor Size	40 hp

The backup booster station would be designed to pump in-line from the transmission main. Since this station would only operate periodically, it was assumed that no ground storage tank would be needed. A 100 kVA backup generator would be provided that can operate two duty pumps, building loads, and chemical feed facilities. It was assumed that this generator would be built in an enclosure outside the building. Enclosure requirements and soundproofing would be determined after a specific piece of property is selected with this alternative.

The backup booster station along Saginaw Highway would have identical chemical feed facilities, pumps, and connections to the primary booster station on Grand River Highway. Only a single chemical feed point is required for each chemical. Chemical equipment costs were included to fully outfit the booster station with the necessary feed equipment, chemical feed lines, monitoring equipment, and gas scrubber. The water composition at each of the connection points should be evaluated and compared if this alternative moves on further into design.

Cost estimates for the backup booster station and associated equipment, building, and construction are included in Table 11.

Table 11 – Alternative 1 Emergency Booster Station Cost

Component	Estimated Cost
Building Construction	$425,000
Process Equipment	$169,000
Process Piping and Valves	$260,000
Chemical Storage and Feed Equipment	$143,000
Mechanical Equipment (HVAC)	$75,000
Electrical, Instrumentation, Controls	$450,000
General Sitework	$65,000
Site Utilities, Piping, Valves	$145,000
Property Purchase	$50,000
Subtotal	$1,782,000
General Conditions, OHP (15%)	$268,000
Construction Subtotal	$2,050,000
Conceptual Design Contingency (20%)	$410,000
Construction Cost Opinion	$2,460,000
Design and Construction Engineering (15%)	$369,000
Project Cost Opinion	$2,829,000

7.6 City Distribution Improvements

Improvements to the City's water system would be needed to convey water from the LBWL connection to the City's system.

One of the primary improvements recommended within the City's distribution system is an additional crossing of the Grand River. The Grand River separates the northern and southern sections of the City with only two water mains connecting the sections across the river. There is a river crossing near Jaycee Park and the boat launch; this section of 12-inch ductile iron water main was installed in 1987. The other river crossing is near the 100,000-gallon elevated tank, to the northwest of Bridge Street; this crossing was installed 1908 and is composed of 8-inch cast iron main. AWWA studies of water main service life around the nation estimate cast iron pipe to have an expected service life of 100 years in the Midwestern US. The 8-inch crossing is beyond its expected service life and would likely need to be abandoned soon; this would eliminate the redundant water system connection across the river. In the calibrated hydraulic model, Hazen Williams C-factors provide an estimate of the pipe interior condition. This segment has a C-factor of 35 in the hydraulic model; for reference, a new ductile iron pipe has a C-factor of 130.

With the existing distribution system supplied from by LBWL from the north, 85 percent of the demand on the south side of the river would flow through the 12-inch river crossing with the remainder flowing through the crossing at the Front Street, 100,000-gallon elevated tank. An additional crossing of the Grand River would improve redundancy and reliability for the water system. The location highlighted for this crossing in the previous reliability study was near the City's wastewater treatment plant, between Hawks Ridge Drive and Fitzgerald Park Drive. Additionally, a segment of main on the north side of the proposed river crossing would also need to be upsized to mitigate the flow demands on the existing crossing.

Another improvement that is critical to the success of the LBWL supply option along Grand River Highway is along North Clinton Street. The North Clinton Street improvement would replace and upsize the main at the northern connection point to the City's existing distribution system; along Highway M-100/North Clinton Street, an 8-inch water main currently runs from Burt Avenue to North Bridge Street. This section acts as a significant constriction that limits the pressure and flow to the remainder of the system. This stretch of main should be replaced by a 16-inch main to better convey flow from the transmission main(s) into and through the City's distribution system.

The water main along Hawks Ridge Drive should be upsized to support the change in water supply and additional Grand River crossing. The Hawks Ridge improvement is recommended in conjunction with the additional river crossing to fully utilize the capacity of this improvement. On the south side of the proposed river crossing, the City recently upsized the size of the water main through Fitzgerald Park to a 12-inch main.

Together, these improvements reduce the hydraulic losses through the system and reduce the hydraulic grade requirements at the northern extent of the City's distribution system by several feet. Table 12 outlines the expected project costs for the water main improvements required within the City's water system.

Table 12 – Alternative 1 City Distribution System Improvement Cost Estimate

Location	Length (ft.)	Accessibility (1-5)	Pipe Diameter (in.)	Unit Cost ($/lf)	Total Cost ($)
North Clinton Street from Burt Avenue to North Bridge Street	2,035	4	16	381	$776,000
New Grand River Crossing	800	5	12	530	$424,000
Hawks Ridge Drive	750	3	12	324	$243,000
				Total City Main Cost	$1,443,000

7.7 Decommissioning and Demolition of Existing City Facilities

Each of the alternatives would require decommissioning and some degree of demolition of the City's existing groundwater wells and iron removal plant. The costs shown in Table 13 are the same for each of the three alternatives in this study. These costs are dependent on the assumption that the treatment building would stay in place and be repurposed without the treatment equipment. General sitework would include disconnecting pipe from the system and restoration.

Table 13 – Alternative 1 Decommissioning & Demolition Cost

Component	Estimated Cost
Iron Removal Plant Decommissioning	$80,000
Groundwater Wells	$60,000
General Sitework	$40,000
Subtotal	$180,000
General Conditions, OHP (15%)	$27,000
Construction Subtotal	$207,000
Conceptual Design Contingency (20%)	$42,000
Construction Cost Opinion	$249,000
Design and Construction Engineering (15%)	$38,000
Project Cost Opinion	$287,000

7.8 Alternative 1 Project Cost Summary

Table 14 summarizes the construction cost opinions from each of the subcategories. Total capital costs for this supply route alternative are approximately $31.5 million.

Table 14 – Alternative 1 Capital Cost Summary

Cost Category	Estimated Cost
LBWL Reinforcement	$8,157,000
Delta Township Reinforcement	$10,000,000
Transmission Infrastructure	$13,541,000
North Booster Station & Ground Storage Tank	$4,522,000
South Emergency Booster Station	$2,829,000
City Distribution Improvements	$1,443,000
Decommissioning & Demolition	$287,000
Corrosion Control Study	$180,000
Total Project Cost Opinion	$40,959,000

7.9 Alternative 1 Operation and Maintenance Costs

The City's water system would have O&M costs to operate each LBWL supply alternative. The O&M costs for each treatment alternative include electrical costs to run equipment in the booster stations, natural gas costs and chemical costs for disinfection. The O&M costs are based on water use at ADD. The cost of electrical power was assumed to be $0.10/Kilowatt-hour.

Chemical costs are based on the assumptions that a monochloramine residual of 2.0 mg/L is required for disinfection in the City's distribution system and that there is no available disinfectant residual remaining when the water reaches the system connection point at the ground storage reservoir. The chemical requirements and other assumptions are outlined in greater detail in Section 7.3 of this report.

It was assumed that all the existing labor utilized at the existing iron removal plant would be reallocated to the booster stations, so this cost would remain the same as the City's current costs. A commodity charge would be assessed by LBWL to supply the City with the specified volume of water. These costs are included as O&M costs. It is noted that Delta Township would likely add a surcharge to water served through the emergency connection. However, it was assumed that the amount of water from the Delta Township would be limited to the minimum needed for maintenance of the pipeline, and no Delta Township surcharge was assumed for the O&M costs. Further description of the commodity rates and Delta Township surcharge assumptions is included in Section 14. Table 15 outlines the costs associated with O&M.

Table 15 –Alternative 1 O&M Cost Summary

Cost Category	Estimated Cost
Labor	$32,500
Chemical Usage	$49,000
Electrical Usage	$20,000
Natural Gas Usage	$2,500
LBWL Water Commodity Charges*	$1,265,500
Annual O&M Costs	$1,369,500

*subject to annual increases

8.0 Alternative 2 – Parallel Transmission along Grand River Hwy

Alternative 2 would consist of parallel 16-inch transmission mains along Grand River Highway and M-100 for the entire length from LBWL system near Airport Road to the City distribution system at Burt Avenue. Each main would need to be able to meet the 2.0 mgd demand in case the other transmission main needs to be taken out of service for maintenance or emergency repairs. Alternative 2 would also include a booster station at Forest Hill Road and Grand River Highway with a 500,000-gallon ground storage tank and chloramine feed system. Firm capacity requirements are established when one of the transmission mains is out of service. If one main is out of service during a peak water usage period, the City may need to operate under an emergency water order to continue providing industrial fire flows or have reduced available fire flows across the City.

An additional booster station would need to be constructed in the LBWL system to maintain fire service for the existing service area into Watertown Township. Additionally, water main reinforcement and construction would be required within the existing LBWL distribution system to maintain service to the existing service area while supplying the City's demands. Figure 5 shows the location of the transmission routes and pumping facilities required to construct this alternative.

8.1 LBWL Reinforcements

The same reinforcements of the LBWL system would be required for Alternative 2 as included in Alternative 1 with an additional reinforcement to install a parallel main along Grand River Highway through Watertown Township to the connection point at Forest Hill Road. These reinforcement costs are included in Table 16. Because of the LBWL's long single feed through Watertown Township up to the connection point, there would also need to be additional main installed by LBWL from Airport Road to Forest Hill Road to remedy the City's reliability concerns. This would require an additional 4.2 miles, or 21,960 feet, of water main to be installed through Watertown Township to develop a fully redundant, parallel system connection.

Table 16 – Alternative 2 LBWL Reinforcement Main Cost Estimates Estimate

Location	Length (feet)	Accessibility (1-5)	Pipe Diameter (inch)	Unit Cost ($/lf)	Total Cost ($)
Bon Air Road, West Saginaw Street, North Waverly Road from Michigan Avenue to North Grand River Avenue/Airport Service Drive	16,900	2	16	277	$4,682,000
West Grand River Avenue from Franette Road to Airport Road	1,605	4	24	551	$885,000
Parallel main on Grand River Highway from Airport Road to Forest Hill Road	21,960	2	16	277	$6,083,000
LBWL Water Main Cost					$11,650,000

Similar booster pumping requirements are needed for these alternatives since the hydraulic modeling was performed with one of the parallel transmission mains out of service. Table 17 includes the cost summary for the LBWL reinforcements required for Alternative 2.

Table 17 – Alternative 2 LBWL Reinforcement Cost Summary

Component	Estimated Cost
LBWL Water Main Reinforcement	$11,650,000
Airport Road Booster Station	$2,590,000
LBWL Reinforcement Cost	$14,240,000

8.2 Transmission Infrastructure

Alternative 2 follows the same primary feed route as Alternative 1, but utilizes a parallel 16-inch feed instead of a single feed to the City.

The same system connection point at Forest Hill Road and Grand River Highway would be utilized, and the transmission mains would connect to the City system at M-100 and Burt Avenue. Table 18 includes the costs for each of the water main projects required to develop this system connection alternative.

Table 18 – Alternative 2 Transmission Main Cost Estimate

Location	Length (ft.)	Accessibility (1-5)	Pipe Diameter (in.)	Unit Cost ($/lf)	Total Cost ($)
Grand River Hwy from Forest Hill Road to M-100; M-100 from Grand River Highway to Burt Avenue	28,780	2	16	277	$7,973,000
Parallel main on Grand River Hwy and M-100 from Forest Hill to Burt Avenue	28,780	2	16	277	$7,973,000
				Transmission Main Cost	$15,946,000

8.3 Forest Hill/Grand River Connection

Table 19 shows the basis of design for the booster station in Alternative 2. The design basis for the booster pumps for this alternative is slightly different than in Alternative 1 because of the decreased transmission main diameter. This smaller diameter transmission main increases friction losses and increases the head requirements of the pumps at the same flow rates.

To determine the limiting conditions that establish the supply's firm capacity, only one emergency was considered at a single time with one transmission main or one pump out of service. The firm capacity of the system is limited by having one of the transmission mains out of service rather than just the largest pump out of service. As a result, under MDD or emergency conditions, all three pumps in the booster station would be required to operate. The secondary design point has much higher head requirements as friction losses increase more rapidly than Alternative 1 due to the smaller pipeline diameter. These design points allow the City to maintain peak service in a situation with one of the transmission mains out of service, but these level of service goals may change; only the ADD must be met with at under the supply's firm capacity. Table 18 shows the basis of design for the booster station in Alternative 2.

Table 19 – Alternative 2 Booster Station Basis of Design

Category	Design Condition
Firm Capacity	1,400 gpm
Total Capacity	2,100 gpm
No. of Pumps	Three – original construction Four – future build-out and expansion
Primary Pump Design Point (ADD, single pump, one transmission main out of service)	700 gpm @ 134 feet TDH
Emergency Pump Design Point (MDD + Fire, three pumps, one transmission main out of service)	660 gpm @ 225 feet TDH
Motor Size	60 hp

The remainder of the booster pumping station, chemical storage and feed facilities, and above ground storage tank design requirements are identical to those described for Alternative 1. It would have the same capacities with slightly different pumping design points as shown in Table 19 compared to the first alternative outlined in this report. Table 20 outlines the costs associated with the creation of a booster station at Grand River Highway and Forest Hill Road to supply the City's requirements.

Table 20 – Alternative 2 Booster Station and Tank Cost

Component	Estimated Cost
Building Construction	$563,000
Process Equipment	$207,000
Process Piping and Valves	$260,000
Chemical Storage and Feed Equipment	$165,000
Mechanical Equipment & HVAC	$80,000
Electrical, Instrumentation, Controls	$450,000
Pump Station Subtotal	$1,725,000
Ground Storage Tank	$750,000
Appurtenance Allowance	$75,000
Mixing System	$50,000
Ground Storage Tank Subtotal	$875,000
General Sitework	$65,000
Site Utilities, Piping, Valves	$145,000
Property Purchase	$50,000
Subtotal	$2,860,000
General Conditions, OHP (15%)	$429,000
Construction Subtotal	$3,289,000
Conceptual Design Contingency (20%)	$658,000
Construction Cost Opinion	$3,947,000
Design and Construction Engineering (15%)	$593,000
Project Cost Opinion	$4,540,000

8.4 City Distribution Improvements

City distribution improvement costs would be identical to those laid out in Alternative 1 because the same quantity of water is being delivered to the same northern connection point. The same system connection point at Forest Hill Road and Grand River Highway would be utilized, and the transmission mains would connect to the City's system at M-100 and Burt Avenue. As such, the City's system still presents the same hydraulic restrictions as outlined by the distribution system modeling and included in Alternative 1 City distribution improvements water main costs. Table 21 shows the costs associated with this alternative.

Table 21 – Alternative 2 City Distribution System Improvement Cost Estimate

Location	Length (feet)	Accessibility (1-5)	Pipe Diameter (inch)	Unit Cost ($/lf)	Total Cost ($)
North Clinton Street from Burt Avenue to North Bridge Street	2,035	4	16	381	$776,000
New Grand River Crossing	800	5	12	530	$424,000
Hawks Ridge Drive	750	3	12	324	$243,000
				Total City Main Cost	$1,443,000

8.5 Decommissioning and Demolition of Existing City Facilities

Decommissioning costs and process would be identical to those laid out in Alternative 1. Table 22 shows the costs associated with this alternative.

Table 22 – Alternative 2 Decommissioning & Demolition Cost

Component	Estimated Cost
Iron Removal Plant Decommissioning	$80,000
Groundwater Wells	$60,000
General Sitework	$40,000
Subtotal	$180,000
General Conditions, OHP (15%)	$27,000
Construction Subtotal	$207,000
Conceptual Design Contingency (20%)	$42,000
Construction Cost Opinion	$249,000
Design and Construction Engineering (15%)	$38,000
Project Cost Opinion	$287,000

8.6 Alternative 2 Capital Cost Summary

Table 23 summarizes the construction cost opinions from each of the subcategories. Total capital costs for this supply route alternative are estimated to be approximately $37.2 million.

Table 23 – Alternative 2 Capital Cost Summary

Cost Category	Estimated Cost
LBWL Reinforcement	$14,240,000
Delta Township Reinforcement	$0
Transmission Infrastructure	$15,946,000
North Booster Station & Ground Storage Tank	$4,540,000
City Distribution Improvements	$1,443,000
Decommissioning & Demolition	$287,000
Corrosion Control Study	$180,000
Total Project Cost Opinion	$36,636,000

8.7 Alternative 2 Operation and Maintenance Costs

The City water system would have O&M costs to operate each LBWL supply alternative. The basis for the O&M costs for Alternative 2 is similar to that described for Alternative 1. The primary differences being slight differences in utility usage based on the differences in booster pump facilities. A commodity charge would be assessed by LBWL to supply the City with the specified volume of water. These costs are included as O&M costs. Further description of the commodity rates is included in Section 14. Table 24 outlines the costs associated with each category.

Table 24 – O&M Costs for Alternative 2

Cost Category	Estimated Cost
Labor	$32,500
Chemical Usage	$49,000
Electrical Usage	$19,000
Natural Gas Usage	$1,500
LBWL Water Commodity Charges*	$1,265,500
Annual O&M Costs	$1,367,500

*subject to annual increases

9.0 Alternative 3 – Parallel Transmission along Saginaw Highway

Alternative 3 was included as a supply alternative in the 2017 proposal for supply from LBWL and is being reevaluated as a part of this study. This alternative would install parallel 16-inch mains to the LBWL system through Delta Township. The parallel mains would run down each side of Saginaw Highway and connect to the existing Delta Township distribution system at Upton Road and Broadbent Road, respectively. At the connection to the City's distribution system near Charlevoix Drive, a new pump station and ground storage tank would be constructed to deliver the water from Delta Township to the City's distribution system. In the prior LBWL proposal, a direct water main would run from the system connection point directly to the existing WTP clearwell where it would be repumped by the high service pump, but this option was not considered due to the condition of the high service pumps. Additionally, the existing clearwell has a relatively small volume to act as a buffer between the two systems. Thus, in this study, a booster station was assumed along Saginaw Highway to pump out of a 500,000-gallon ground storage tank directly to the City's distribution system rather than using the aging clearwell. Figure 6 shows the location of the transmission routes and pumping facilities required for this alternative.

9.1 LBWL Reinforcements

No water main or booster pumping reinforcements are known to be required in the LBWL system to supply the City's identified hydraulic requirements for this alternative. Discussions should continue with Delta Township to identify additional hydraulic constrictions if the City decides to move forward with this alternative.

9.2 Delta Township Reinforcements

Supplying the City demands through Delta Township will require improvements to the Delta Township water system and infrastructure. Currently, Delta Township is supplied by a single direct transmission main from the LBWL, so an additional transmission main would be needed so that the City would not need to rely on its own groundwater wells or Delta Township's emergency wells as a backup water supply. Reinforcement costs were assumed for improvements to existing transmission main from the LBWL Dye Conditioning Plant, booster pumping, and storage to support supply to the Grand Ledge system. The exact costs for reinforcement would need to be developed in further detail based on evaluation of the Delta Township system and negotiation of a water service agreement. An estimate of $10 million is used for this study.

9.3 Transmission Infrastructure

Connecting through Delta Township results in the shortest distance required for the transmission mains of all the alternatives to connect the two systems. Even with the construction of parallel transmission mains, this alternative has the lowest transmission main length and associated cost. Table 25 provides the estimated costs associated with the water main construction.

Table 25 – Alternative 3 Transmission Main Cost Estimate

Location	Length (ft.)	Accessibility (1-5)	Pipe Diameter (in.)	Unit Cost ($/lf)	Total Cost ($)
W Saginaw Hwy from Upton Rd to Charlevoix Dr	9,610	2	16	277	$2,662,000
Parallel main on W Saginaw Hwy from Broadbent Rd to Charlevoix Dr	12,280	2	16	277	$3,402,000
Transmission Main Cost					$6,064,000

9.4 Saginaw Highway System Connection

The booster station, chemical storage and feed facilities, and adjacent above ground storage tank design requirements are as described for the first two alternatives. The booster station would have the same pumping capacities, but slightly different design points as the first alternatives. Due to the reduced transmission distance, pumping head required is reduced. Table 26 outlines the basis of design for the booster station for this alternative.

Table 26 – Alternative 3 Booster Station Basis of Design

Category	Design Condition
Firm Capacity	1,400 gpm
Total Capacity	2,100 gpm
Number of Pumps	Three – original construction Four – future build-out & expansion
Primary Pump Design Point (ADD, single pump, one transmission main out of service)	700 gpm @ 125 feet TDH
Emergency Pump Design Point (MDD, two pumps operating)	990 gpm @ 109 feet TDH
Motor Size	40 hp

There is a parcel owned by the City near the edge of the City limits that could be used to construct a booster station and storage tank. Table 27 outlines the costs associated with the creation of a booster station along Saginaw Highway. Property purchase costs have been excluded from this alternative assuming the City owned parcel would be used to construct the booster station and ground storage tank.

Table 27 – Alternative 3 Booster Station and Tank Cost

Component	Estimated Cost
Building Construction	$563,000
Process Equipment	$179,000
Process Piping and Valves	$260,000
Chemical Storage and Feed Equipment	$165,000
Mechanical Equipment & HVAC	$80,000
Electrical, Instrumentation, Controls	$450,000
Pump Station Subtotal	$1,697,000
Ground Storage Tank	$750,000
Appurtenance Allowance	$75,000
Mixing System	$50,000
Ground Storage Tank Subtotal	$875,000
General Sitework	$65,000
Site Utilities, Piping, Valves	$145,000
Subtotal	$2,782,000
General Conditions, OHP (15%)	$418,000
Construction Subtotal	$3,200,000
Conceptual Design Contingency (20%)	$640,000
Construction Cost Opinion	$3,840,000
Design and Construction Engineering (15%)	$576,000
Project Cost Opinion	$4,416,000

9.5 City Distribution Improvements

Alternative 3 would have the connection from LBWL to the City system on the southern side of the Grand River where most of the system demand is located. Because the supply connection ties into the City system near the existing iron removal plant, fewer improvements are needed in the City to allow the water to move through the distribution system.

The primary improvement recommended within the City distribution system is an additional crossing of the Grand River to improve redundancy and reliability for the water system. The location highlighted for this crossing in the previous reliability study was near the City's wastewater treatment plant.

The water main along Hawks Ridge Drive should be upsized to support the change in water supply and additional Grand River crossing. The Hawks Ridge improvement is recommended in conjunction with the additional river crossing to fully utilize the capacity of this improvement. On the south side of the proposed river crossing, the City recently upsized the size of the water main through Fitzgerald Park to a 12-inch main.

Together these improvements reduce the hydraulic losses through the system and reduce the hydraulic grade requirements at the northern extent of the City's distribution system by several feet. Table 28 outlines the expected project costs for the water main improvements required within the City's water system.

Table 28 – Alternative 3 City Distribution System Improvement Cost Estimate

Location	Length (ft.)	Accessibility (1-5)	Pipe Diameter (in.)	Unit Cost ($/lf)	Total Cost ($)
New Grand River Crossing	800	5	12	530	$424,000
Hawks Ridge Drive	750	3	12	324	$243,000
				Total City Main Cost	$667,000

9.6 Decommissioning and Demolition of Existing City Facilities

Decommissioning costs are identical to those laid out in Alternative 1. Table 29 shows the costs associated with this alternative.

Table 29 – Alternative 3 Decommissioning & Demolition Cost

Component	Estimated Cost
Iron Removal Plant Decommissioning	$80,000
Groundwater Wells	$60,000
General Sitework	$40,000
Subtotal	$180,000
General Conditions, OHP (15%)	$27,000
Construction Subtotal	$207,000
Conceptual Design Contingency (20%)	$42,000
Construction Cost Opinion	$249,000
Design and Construction Engineering (15%)	$38,000
Project Cost Opinion	$287,000

9.7 Alternative 3 Capital Cost Summary

Table 30 summarizes the project cost opinions from each of the subcategories. Total capital costs for this supply route alternative are approximately $12.2 million.

Table 30 – Alternative 3 Capital Cost Summary

Cost Category	Estimated Cost
LBWL Reinforcement	$0
Delta Township Reinforcement	$10,000,000
Transmission Infrastructure	$6,064,000
Saginaw Highway Booster Station & Ground Storage Tank	$4,416,000
City Distribution Improvements	$667,000
Decommissioning & Demolition	$287,000
Corrosion Control Study	$180,000
Total Project Cost Opinion	$21,614,000

9.8 Alternative 3 Operation and Maintenance Costs

The City water system would have O&M costs to operate each LBWL supply alternative. The O&M costs for Alternative 3 would be similar to the costs of the other alternatives, with the primary difference being that the entire volume of water supplied to Grand Ledge would be subject to a surcharge from Delta Township in addition to the LBWL commodity rate. The commodity and surcharge costs are included as O&M costs. Further description of the commodity rates is included in Section 14. Table 31 outlines the O&M costs for this alternative.

Table 31 – O&M Costs for Alternative 3

Cost Category	Estimated Cost
Labor	$32,500
Chemical Usage	$49,000
Electrical Usage	$19,000
Natural Gas Usage	$1,500
LBWL Water Commodity Charges*	$1,265,500
Delta Twp. Water Commodity Charges*	$1,265,500
Annual O&M Costs	$2,633,000

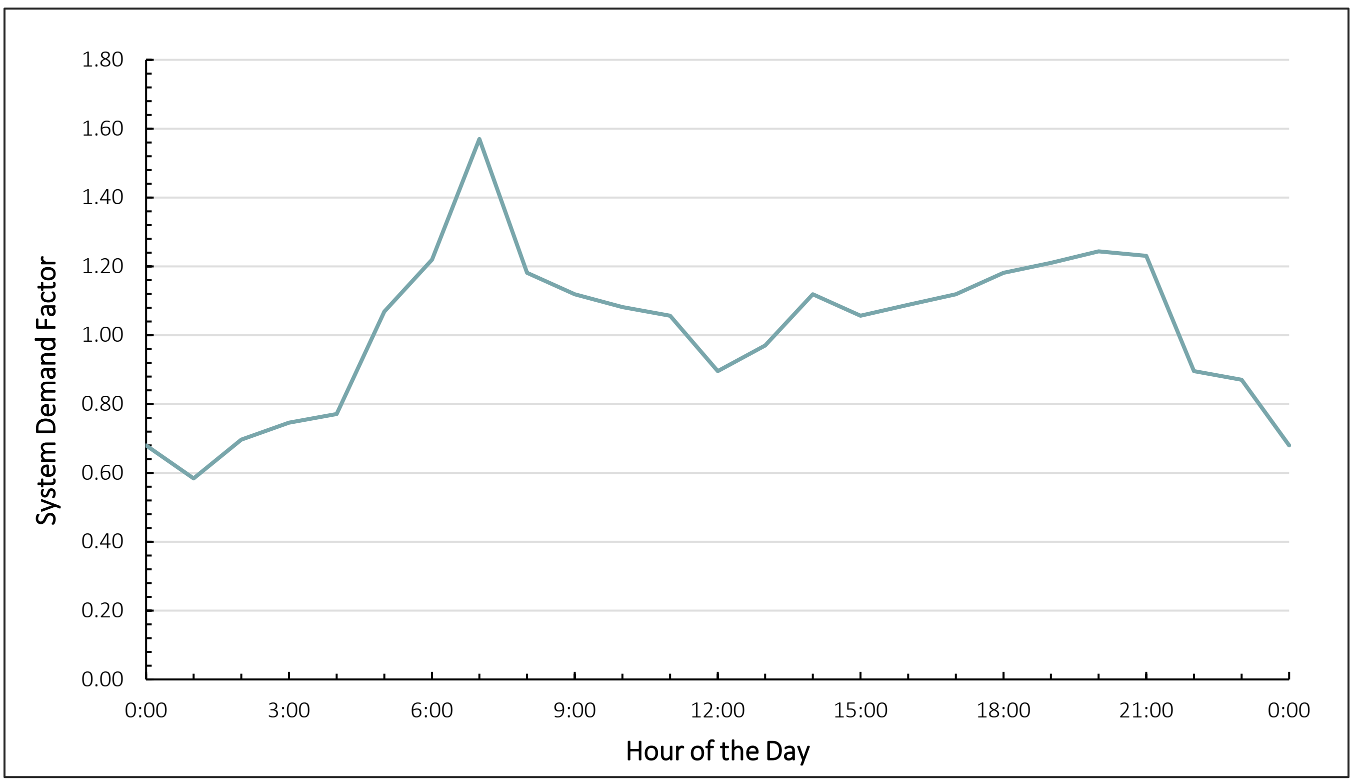
*subject to annual increases

10.0 Water Age

The hydraulic model of the City's water system was used to estimate water age throughout the system. Water age can help indicate areas of the distribution system that may have issues maintaining a disinfectant residual or could have elevated concentrations of disinfectant by-products. Water age is a consideration for all of the alternatives due to the long distance to the City's system from the LBWL treatment plants and the proposed ground storage tanks present in all the alternatives, which would add to the water age before water reaches City taps. The water storage tanks add the equivalent of a half day to the water age under average demands. As a result of the anticipated issues with water age, chemical feed provisions to boost disinfectant residuals were included at all new booster station facilities as part of each alternative. The chemical feed systems would allow the City to maintain proper residuals across the City's system. Though the additional disinfectant feed may not always be required, the booster stations should be outfitted with chemical feed provisions and maintained in ready condition.

Additional scenarios were created in the hydraulic model to run an extended period simulation to determine the average water age across the distribution system. Pumping data and tank level were analyzed to determine the hourly variations in system demands to develop a diurnal demand curve which was applied to all demand junctions, rather than a fixed demand. Controls and setpoints were added to the model to simulate the typical operation of the City's water system. Figure 3 includes the scale factors applied to the baseline demand of the model to develop an approximate diurnal demand pattern for the City.

Figure 3: Daily Diurnal Demand Curve



Three extended period simulations were performed evaluating the water age: one with the existing system as it is currently fed, one with a system connection at Grand River Highway and Forest Hill Road, and another with the connection on Saginaw Highway and Charlevoix Road through Delta Township. These simulations were run with ADDs for 10 days, or 240 hours, to allow the hydraulic model to stabilize.

10.1 Existing System Water Age Modeling

In the existing water distribution system, the water age throughout most of the City was estimated to range from about 10 to 30 hours. The highest water ages predicted ranged from 75 to 90 hours, or 3 to 3.75 days, around the northern extents of the existing distribution system.

Figure 7 provides water age contours across the City under these conditions.

10.2 Grand River Highway Connection Modeling

A water age analysis for the City's system with a northern connection to the LBWL system (Alternatives 1 and 2) was completed. LBWL provided the water age through their distribution system to the point of connection at Grand River Highway and Forest Hill Road. Under ADDs, the water age was usually around 190 hours, or 3.25 days, up to the presumed connection point at Forest Hill and Grand River Highway. After factoring in the aging of the water in the ground storage reservoir for 12 hours, the water would exit the connection point with an approximate age of 90 hours, or 3.75 days.

By the time the water travels to the City's existing distribution system from the Forest Hill Road connection point, the age at Burt Avenue is 101 hours. The areas of the City's distribution system with the highest water age with a northern LBWL connection were found throughout the southwestern section of the City, primarily at the end of dead-end mains or neighborhoods with lower demands. Model junctions in this area reported water ages peaking between 170 to 190 hours, or 7 to 8 days. These locations show the most extreme water ages as the mains in these areas are less looped than the remainder of the City. For the rest of the City between the Grand River and Saginaw Highway, water age ranges from 110 to 125 hours. The portion of the City system to the north of the Grand River experiences slightly lower water age, ranging from 95 to 110 hours.

After connecting along Grand River Highway, all the water in the City would be as old or older than the existing water system. The most extreme transition would occur in the southwestern section of the City; this area is near the existing iron removal plant and currently has very low water age, but would be the farthest from the new supply connection point.

Figure 8 provides water age contours across the City under these conditions.

10.3 Saginaw Highway Connection Modeling

A water age analysis evaluating age in the City system with a southern connection to the LBWL system (Alternative 3) was completed. Under ADDs, the water age was usually around 50 hours, or 2.1 days, near the eastern edge of the City limits and border with Delta Township at the presumed connection point to the existing City system.

This connection alternative behaves similarly to the existing system since the system connection point would be only 1.5 miles from the existing WTP and utilize the same primary distribution arteries. The areas of the City's distribution system with the highest water age were found throughout the northwestern section of the City, primarily at the end of dead-end mains or neighborhoods with lower demands. Model junctions in this area reported water ages peaking between from 115 to 130 hours. These locations show the highest water ages, as the mains in these areas are less looped than the remainder of the City and have lower demands. For the rest of the City between the Grand River and Saginaw Highway, water age ranges from 50 to 60 hours; on the north side of the river, typical water age is between 60 to 80 hours.

Figure 9 provides water age contours across the City under these conditions.

10.4 Water Age Summary

Table 32 summarizes the water age analyses. The water age modeling approximations can be used to compare the estimated water age between the alternatives and highlight potential concern areas.

Table 32 – Water Age Summary

Scenario	Initial Age at Connection (hrs.)	Average Water Age (hrs.)
Existing System	0.0	34.1
Alternative 1 – Single Grand River Highway Connection	90.0	141.8
Alternative 2 – Parallel Grand River Highway Connection	92.3	147.1
Alternative 2 – Parallel Grand River Highway Connection	50.4	91.3

City water operators and plant staff could use the water age modeling results and contours to initially select new sites for distribution system sampling and monitoring. These distribution sample and disinfectant residual results taken throughout the system would determine how much chemical is required to be fed at the connection booster station.

One advantage to transitioning to chloramines rather than chlorine gas upon a switch to a LBWL supply is that chloramine residuals decay at a slower rate than chlorine. This would make it easier to maintain a consistent residual in the City's system, even though the chemical application points are distant and water age may become elevated at times of low demand in the City.

Additional modeling may be required if the City selects an LBWL supply alternative to optimize pumping and storage operations. The City may need to adjust tank and pump operations to prevent water from stagnating in the existing finished water storage tanks or draw levels down enough each day to turn over the stored volume. Proper mixer design in the ground storage reservoir would also serve to create a more homogeneous feed into the City's distribution system and allow the water age modeling to have a stronger relationship to chemical residual.

11.0 Corrosion Control Study

Each supply alternative would introduce new water chemistry and chemicals to the City's water system. It is likely that EGLE would require an updated corrosion control study to ensure that the finished water in the City's distribution system remains stable with the changes in treatment, source water, and water chemistry. This study is estimated to cost $180,000. This cost would be the same for all three alternatives evaluated in this report and would be an additional capital cost associated with all the alternatives.

There are several approaches to completing a corrosion control study. It is our understanding that EGLE prefers a style of study that uses a combination of multiple corrosion control study techniques.

The solubility of the scaling on the inside of lead pipes could be tested by exhuming some lead pipe samples and analyzing the layers of the scale on the inside of the pipe. A model of the solubility of the interior of the pipe would be created based from this information. Different lead compounds have differing solubility (some are more stable than others) and knowing which compound is dominant can be informative for corrosion control treatment decisions. The solubility model created from this analysis can then be used to predict the most effective means of corrosion control treatment to prevent the leaching of lead and copper into the water.

Finished water samples with and without phosphate addition could be obtained. These samples would be put in jars with lead coupons for about two months to determine how much of the lead would leach from the coupon into the water. It is also likely that some samples from households throughout the City system would be gathered to assess the lead present at customer taps.

12.0 Permitting Requirements

A preliminary review of the permits needed for the evaluated alternatives was performed. An Act 399 Permit for the construction of the booster station or stations, the ground storage tank, and water mains would need to be submitted to EGLE.

A soil erosion and sedimentation control (SESC) permit would need to be obtained by the contractor from the local enforcement agency. Similarly, the contractor would need to acquire a building permit from the authority having jurisdiction.

At this stage of design, there are no other permits identified. If additional permits are needed, they would be identified and completed during preliminary design.

13.0 Funding Sources

There are several funding sources available to finance the project. These sources are generally described in this section. It should be noted that some of the funding sources have limited funds or specific requirements that may impact availability and/or timing of the funding.

13.1 Drinking Water Revolving Fund

The Drinking Water Revolving Fund (DWRF) provides reduced interest rate loan financing to qualified water suppliers to finance construction of public water systems. In addition to the loan provided by EGLE, suppliers also have the option to pay for part of their project with cash and other resources. Funding is provided at the federal level and administered by EGLE.

The rates on the loans for Fiscal Year 2021 are 1.875% for a 20-year loan and 2.125% for a 30-year loan. Communities that qualify as disadvantaged are eligible for a 40-year loan at 1.875%. Some project components may be eligible for principal forgiveness. The amount of loan dollars and principal forgiveness available each year is subject to the federal allocation.

The loan is handled as a municipal bond issued by the applicant community. The bond must have an investment-grade rating and is subject to all applicable state and federal requirements associated with municipal finance/debt activity. A bond attorney must be involved; communities typically retain a financial adviser to assist them through the financing process.

Eligible projects may include new wells, new water treatment plants, storage facilities, upgrades or expansions to existing facilities, transmission lines, pumping facilities, and other related waterworks system improvements. Part 54 of Act 451 permits suppliers serving less than 10,000 persons to receive reimbursement of project planning costs upon delivery of an approvable project plan to EGLE. Legislation has been passed to provide a funding mechanism for this reimbursement. Projects must comply with Davis-Bacon wage rate requirements and American Iron and Steel provisions.

All projects are reviewed and scored based upon a priority point system. All scoring factors point to the need for the project to comply with federal drinking water requirements. The scoring system is designed to address the most serious risks to human health and ensure compliance with the requirements of the federal Safe Drinking Water Act (SDWA). Affordability is addressed by the award of additional points. Eligible projects are prioritized in the order of highest score with their costs; all projects that fall within the federal allocation for loans can proceed with the loan.

The following is the timeline for the program:

- Intent to Apply Form Due: April 1.
- Project Plan Submittal: July 1 (extended from May 1 due to COVID-19).
- Projects are reviewed and placed on the priority list: October 1.

13.2 Water & Waste Disposal Loan & Grant Program – Rural Development

The United States Department of Agriculture (USDA) Rural Development (RD) program provides funding for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and stormwater drainage to households and business in eligible rural areas.

Funds are generally distributed as long-term, low-interest loans. If funds are available, a grant may be combined with a loan for eligible activities. The program provides low-interest loans, usually, over a 40-year period to assist communities of 10,000 people or less to finance drinking water treatment projects.

Fixed interest rates are assigned based on the need for the project and the median household income of the area to be served. These needs are updated quarterly and include poverty line, intermediate, and market rates. The rate is only locked in once the full application is completed and reviewed and the letter of conditions are issued.

Projects are not required to comply to Davis Bacon wage rate requirements (unless leveraging sources require it). American Iron and Steel provisions are required. Projects are required to openly bid all materials and equipment. For example, piping specifications must include plastic pipe and ferrous pipe, or two different types of plastic pipe. Sole sourcing preferred suppliers for equipment may be allowed with written request for less than normal competition if the owner can demonstrate that they have standardized on a supplier to facilitate spare parts inventory and/or maintenance activities.

The loan amount applied for is the amount given for the loan. If the project comes in lower than expected, the excess funds can be used to fund additional activities, if they are identified in the original Preliminary Engineering Report and Environmental Report. Extra funds cannot be used to pay off debt or to pay salaries. There are no penalties for early repayment of the loan.

Applications for funding are accepted year-round.

13.3 Issuance of a Bond

The issuing of a bond to pay for the selected alternative is a common method of funding a water project. The market rates for a bond are likely to be higher than the loan rates obtained through a DWRF or RD loan. However, the City would not have any of the funding program restrictions in terms of product or material selections.

14.0 Present Worth Analysis of Water Supply Alternatives

Water supply replacement options investigated for the City included a new iron removal treatment system, a new softened water treatment system, and a water supply connection to the LBWL water system.

A present worth analysis was performed to compare the system costs for the options and the alternatives for each option. Present worth is the sum which, if invested now at a given interest, or discount, rate, would provide exactly the funds required to pay all present and future costs. The option with the lowest present worth represents the most economical solution based on the costs factored in. Sunk costs are not included in the analysis. Sunk costs include any investments or financial commitments made before or during the project planning. The present worth analysis for all alternatives was performed at a discount rate of 3% over 20 years.

The salvage value of the equipment was also considered in the present worth analysis. Many of the components that would be installed as a part of each alternative have an expected service life beyond the 20-year period analyzed. As a result, the depreciation of these longer-lifespan items is spread out over a larger time period. The salvage value captures the value of each of the assets that exists at the end of the 20-year period, The present worth of the future salvage value at the end of the 20-year period is subtracted from the other costs to determine the net present worth of each project alternative.

Cost estimates presented are based on September 2020 cost indices and the project components as presented herein. Actual project costs may differ based on the final scope of the project design components, the bidding climate at the time the project is bid, material pricing fluctuations, and other factors.

14.1 Iron Removal

Iron removal was evaluated in the Iron Removal Treatment Plant Study. Iron removal would only remove the targeted contaminants of iron, manganese, and radium; this alternative would not soften the water for the City's distribution system. This alternative would produce a finished water product comparable to the existing WTP with the additional benefit of radium removal.

A few alternatives were investigated including the installation of a new Aeralater system in place of the existing, the installation of high-pressure filters (HPF) in the existing treatment building, and the construction of a new treatment building utilizing HPFs for iron removal. Ultimately, with input from City staff, the construction of a new treatment building with HPFs was identified as the best alternative for replacement of the Aeralater system with a new iron removal process. Costs were not developed for the other alternatives as they were eliminated from the evaluation early in the process.

The conceptual design, layout, and sitework for the new treatment plant building were completed with input from City staff. Capital and O&M cost estimates were created based on the conceptual design of the treatment plant. A 20-year present worth analysis was completed for the cost of the new treatment plant including associated work at the wells and elevated tanks, the cost of operating the treatment plant, the engineering design fee, and associated studies to aid in the efficient and effective design of a new plant.

Table 33 outlines the present worth analysis for the iron removal alternative. Improvements to the City's existing distribution system were added to each treatment alternative for comparison in the present worth analysis. These costs are shown in a separate column for clarity. Like the City distribution improvements in Alternative 3 for a LBWL supply connection, an additional river crossing would improve the system reliability and ability to distribute 4.0 mgd from the WTP throughout the distribution system.

Table 33 – Iron Removal Present Worth Analysis

Water Supply Alternative	Capital Costs	City Distribution Improvements Capital Costs	Annual O&M Costs	Salvage Value	Net Present Worth
Iron Removal and City Distribution Improvements	$13,395,000	$667,000	$104,900	($3, 408,000)	**$12,215,000**

It should be noted that the design of the treatment plant was based on a capacity of 4.0 mgd, which would allow for significant growth and provide a significant safety factor for the City. Additional source water development would be required to supply this quantity of water to the treatment plant. Costs for additional raw water supply were not included in the present worth analysis.

14.2 Softening

Water softening was evaluated for the City's water supply in the Water Softening Treatment Plant Study. The softening alternatives would provide softened water to the City. These treatment options would also meet the same iron, manganese, and radium removal targets as the iron removal alternative.

Three softening alternatives were evaluated including reverse osmosis softening, ion exchange softening, and lime softening. As a note, there is uncertainty as to the viability for both the RO and IX softening options for the handling of the treatment residuals.

A lift station and force main from the plant to the Grand River for discharge of the RO concentrate was assumed to be part of the project. A National Pollutant Discharge Elimination System (NPDES) permit would have to be obtained from EGLE to allow the discharge to the Grand River. The brine waste stream from an IX softening plant was assumed to be discharged to the sanitary sewer. The City WWTP could require expansion or improvements to handle the brine waste stream. If the City wishes to move forward with either the RO or IX softening option, further investigation into the handling of these treatment residuals would be needed.

The conceptual design, layout, and sitework for each of the softening treatment alternatives were evaluated. Capital and O&M cost estimates were created for each alternative. The cost of a new treatment plant including associated work at the wells and elevated tanks, the cost of operating the treatment plant, the engineering design fee, and associated studies to aid in the efficient and effective design of a new plant were included in the cost estimates of each alternative.

Table 34 outlines the present worth analysis for the softening plant alternatives. Improvements to the existing City distribution system were added to each treatment alternative for comparison in the present worth analysis. These costs are shown in a separate column for clarity. Like the City distribution improvements in Alternative 3 for an LBWL supply connection, an additional river crossing would improve the system reliability and ability to distribute 4.0 mgd from the WTP throughout the distribution system.

Table 34 – Water Softening Present Worth Analysis

Water Supply Alternative	Capital Costs	City Distribution Improvements Capital Costs	Annual O&M Costs	Salvage Value	Net Present Worth
Reverse Osmosis and City Distribution Improvements	$32,440,000	$667,000	$509,000	($6,882,000)	**$33,798,000**
Ion Exchange and City Distribution Improvements	$22,142,000	$667,000	$508,000	($5,279,000)	**$25,088,000**
Lime Softening and City Distribution Improvements	$29,449,000	$667,000	$637,000	($6,562,000)	**$33,031,000**

The ion exchange softening option has the lowest present worth of the three options, but may pose significant issues related to discharge of residuals and would increase the sodium concentrations in the water delivered to customers. Further evaluation of water quality goals and residuals handling is recommended prior to selecting a softening alternative.

As with the iron removal study, the design of the treatment plant was based on a capacity of 4.0 mgd, which would allow for significant growth and provide a significant safety factor for the City. Additional source water development would be required to supply this quantity of water to the treatment plant. It should be noted that the RO softening option would require 5.6 mgd of source water capacity to achieve a production flow of 4.0 mgd due to its significant concentrate flow. Costs for additional raw water supply were not included in the present worth analysis.

14.3 LBWL Softened Water Supply

Three connection and supply alternatives to LBWL water system are evaluated in this report. Table 35 outlines the present worth analysis for the LBWL supplied softened water alternatives.

Table 35 – LBWL Softened Water Present Worth Analysis

Water Supply Alternative	Capital Costs	City Distribution Improvements Capital Costs	Annual O&M Costs	Salvage Value	Net Present Worth
Alternative 1 - Single Grand River Highway Feed	$39,516,000	$1,443,000	$1,369,500	$(12,195,000)	**$49,139,000**
Alternative 2 - Parallel Grand River Highway Feed	$35,193,000	$1,443,000	$1,367,500	$(15,647,000)	**$41,334,000**
Alternative 3 - Parallel Saginaw Highway Feed	$20,947,000	$667,000	$2,633,000	$(4,069,000)	**$56,717,000**

Improvements to the City's existing distribution system were included for each supply alternative for comparison in the present worth analysis. These costs were separated out from the other capital costs for comparison between the other water supply studies. The annual costs for the LBWL supply alternatives were calculated assuming an annual average day demand of 0.91 mgd. This average demand is slightly higher than the 0.91 mgd used in the calculation for the other annual costs for all treatment alternatives. Commodity costs for water supplied from LBWL are reflected as annual costs in the present worth analysis for the LBWL supply alternatives. The commodity rate used for the study was $2.85/100 cubic feet (ccf) assuming average usage of 0.91 mgd. A range of commodity rate values were provided by LBWL staff between $2.30/ccf and $2.60/ccf. Additionally, the LBWL assesses a power and chemical adjustment factor, typically between $0.18/ccf and $0.25/ccf. Annual O&M costs were determined assuming a commodity rate of $2.65/ccf plus a $0.25/ccf adjustment for power and chemical costs as a conservative evaluation. These values would need to be verified as a part to the negotiation of a water service agreement. The LBWL rate structure is tiered such that water usage over a baseline value would be charged at a higher rate. The commodity charges in this analysis were based on average daily use at the lower rate tier. It is noted therefore that actual commodity charges would be higher on days when the usage exceeds the lower tier threshold. The LBWL water commodity charges would be subject to annual increases as the LBWL cost to provide service will rise over time.

It is understood from discussions with the City that Delta Township would assess a surcharge to the LBWL commodity rate for connection through the Delta Township system. The surcharge value was not available, but it is expected to range from a factor of 1.5 to 2 times the standard commodity rate charged by LBWL. A factor of 2.0 was used in this study. This factor is assumed and would need to be verified by the parties in negotiation of a water service agreement. The Delta Township water commodity surcharges would also be subject to annual increases.

As previously noted, the LBWL supply connection alternatives were analyzed at a lower design capacity of 2.0 mgd compared to the 4.0 mgd evaluated in the other studies. Discussions with LBWL indicated it would not be possible to supply a 4.0 mgd demand while maintaining service to existing customers without drastic reinforcement to their system. To match the design point of the treatment studies, significant additional capital investment would be required to expand the supply capacity beyond 2.0 mgd. This supply capacity exceeds the projected 20-year maximum day demands of the City but should be kept in mind when comparing the alternatives.

15.0 Summary

Three alternatives were investigated for the replacement of the existing system by connection to the LBWL system. The alternatives include two route options, one assuming a connection to the LBWL system at Grand River Highway and Forest Hill Road, and another connecting through the Delta Township water system along Saginaw Highway. Each option was evaluated to provide fully redundant supply connections, which would allow the City to take their existing treatment plant and groundwater wells out of service.

The northern connection alternatives (Alternatives 1 and 2) require a longer length of transmission main and additional improvements to the existing City distribution system compared to the connection through Delta Township. Additionally, there are significant reinforcements that must be completed within the LBWL system to allow them to serve the City and maintain pressures to existing customers. The northern connection alternatives also require the construction of a multiple booster stations to meet the targeted service goals. The northern alternatives would allow the City to potentially expand its water service area to serve customers along the transmission connection routes.

The connection through Delta Township would have a lower capital cost than the northern routes due to the shorter length of transmission main, lower hydraulic requirements, and fewer changes to the City's existing distribution system, even with the inclusion of reinforcements to Delta Township's water system. It was assumed that transmission, pumping, and storage improvements must be completed within the LBWL and Delta systems. The length of water main required to connect the two systems is about half of what is required by the northern connection alternatives Additionally, water age is lower when connected through Delta Township, which would reduce potential water quality concerns after transitioning the source of the City's water supply. However, there are questions as to the impact on the commodity charges to utilize the Delta Township route. It is understood that the commodity charge would be assessed a surcharge by Delta Township. A factor of 2.0 times the LBWL rate was assumed; this factor would need to be verified by the parties in negotiation of a water service agreement. This significantly increases the annual O&M costs associated with this alternative; as a result, this alternative has the highest net present value of all water supply alternatives. Lastly, it is understood that the Delta Township system maintains their well supply for emergency use.

If the City decides to pursue a connection to LBWL, discussions between the City and LBWL are recommended to solidify an understanding of contractual requirements and commodity rates. Similarly, it is recommended that the City reach out to the respective municipalities with jurisdiction in the area of the proposed improvements to verify land use requirements and limitations, if any. In the case of the Delta Township connection, the surcharge that would be added to the LBWL commodity rate and any costs associated with reinforcement of the Delta Township system would need to be further understood. Costs for reinforcement of the Delta Township system were considered in this study but should be verified if this alternative will be pursued.

The conceptual design of the LBWL supply alternatives was based on a capacity of 2.0 mgd, rather than the 4.0 mgd design capacity used for two treatment studies. This lower design capacity was used due to limitations of the LBWL water system to supply higher quantities to the City, particularly through the northern route, without major additional improvements throughout the LBWL system that would be prohibitively expensive. It should be noted that the 2.0 mgd design capacity is still above the 20-year projected MDDs, which would allow for some growth in the City and along the supply routes. However, future increases in capacity would require significant additional capital costs for reinforcement in the LBWL system but are not considered in this study. The effect is that the capital costs and present worth costs for the treatment alternatives are comparatively higher than for the LBWL supply alternatives. However, to achieve 4.0 mgd treatment capacity, additional water supply would be required. Costs for additional wells were not included in the present worth analysis.

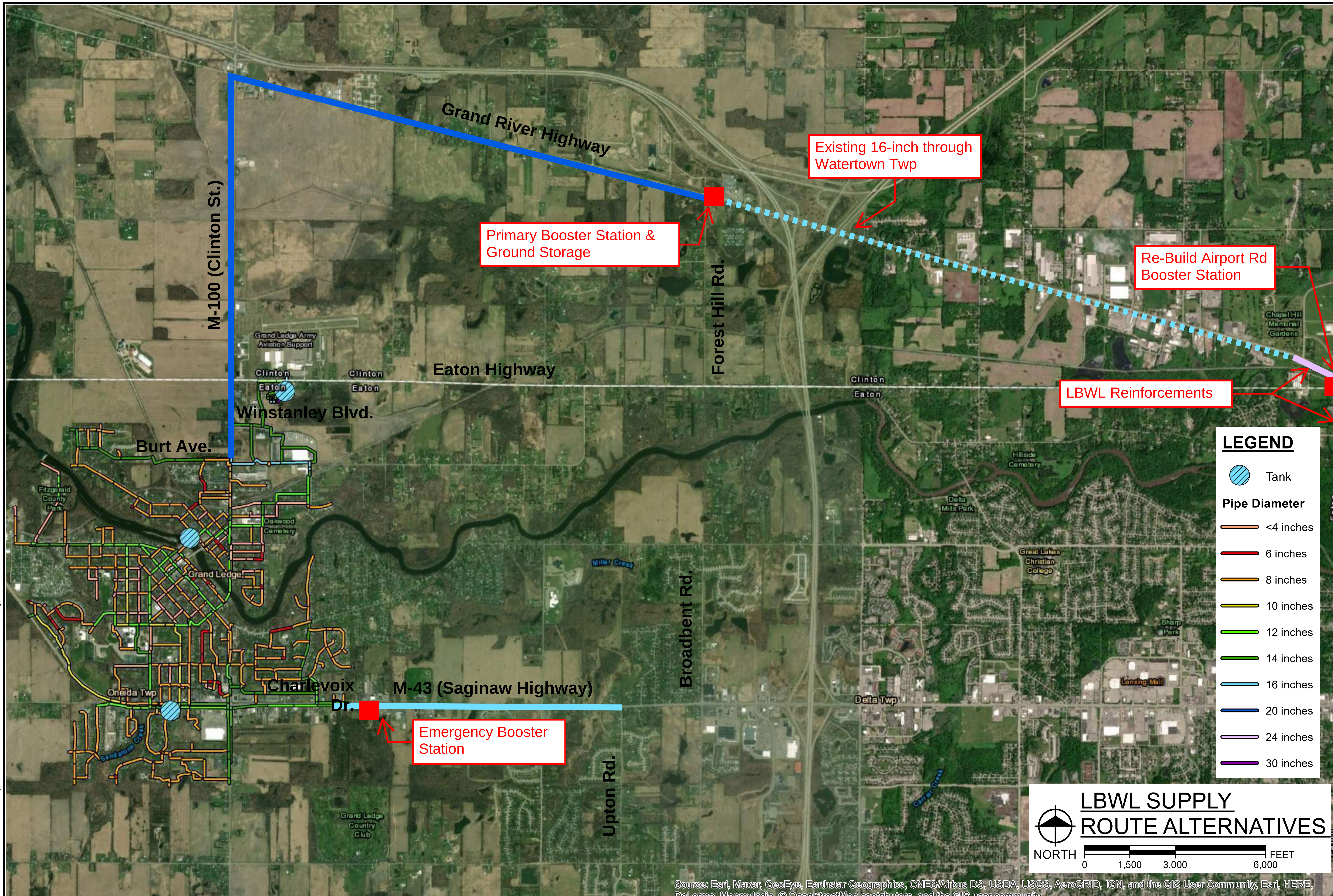
Iron removal has the lowest 20-year present worth, and the lowest capital cost of all water supply alternatives. The lowest cost softening alternative is for ion exchange softening. It should be noted that this alternative would need further consideration to resolve uncertainties with disposal of brine wastewater to the City's existing WWTP. Ion exchange would also increase sodium concentrations in the finished water, which may be undesirable.

The parallel LBWL supply through a northern connection passing through Watertown Township was the lowest present worth of the LBWL softened water supply alternatives evaluated. Though this alternative would result in the highest water age, provisions for maintaining a disinfectant residual through the City distribution system are included with the alternative. Parallel water mains are included along the entire route to provide redundancy.

There are a few issues that would need to be further evaluated if the City decided to pursue connection to LBWL through a Delta Township connection. Delta Township is currently supplied from LBWL by a single feed. The Township relies on their existing wells for redundancy. LBWL staff indicated that a second feed to Delta Township is in the planning stages, but the timing of this connection is uncertain. If the City were to connect prior to the installation of a second feed, the existing well supply used by the Township would need to be verified to be suitable to provide redundancy to the Grand Ledge feed, or else the City would need to maintain their wells for redundancy until the second feed to Delta Township was established. Also, it is not known the magnitude of reinforcements required for the Delta Township system to supply the City.

The costs to users related to in-home water treatment systems were not considered in this study. If the City were to provide a softened water supply to customers, users with in-home treatment systems could discontinue their use, thereby reducing their costs, i.e., for salt in the case of softeners, or filters in the case of RO membrane point of use systems. To more fully consider these costs, the number and types of systems would need to be quantified. Considering the magnitude in the difference in costs between the options and alternatives, this cost is not considered to be significant.

Figures



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City of Grand Ledge
Eaton County, Michigan

LBWL Supply Evaluation

PROJECT NO.
200549

FIGURE NO.
4

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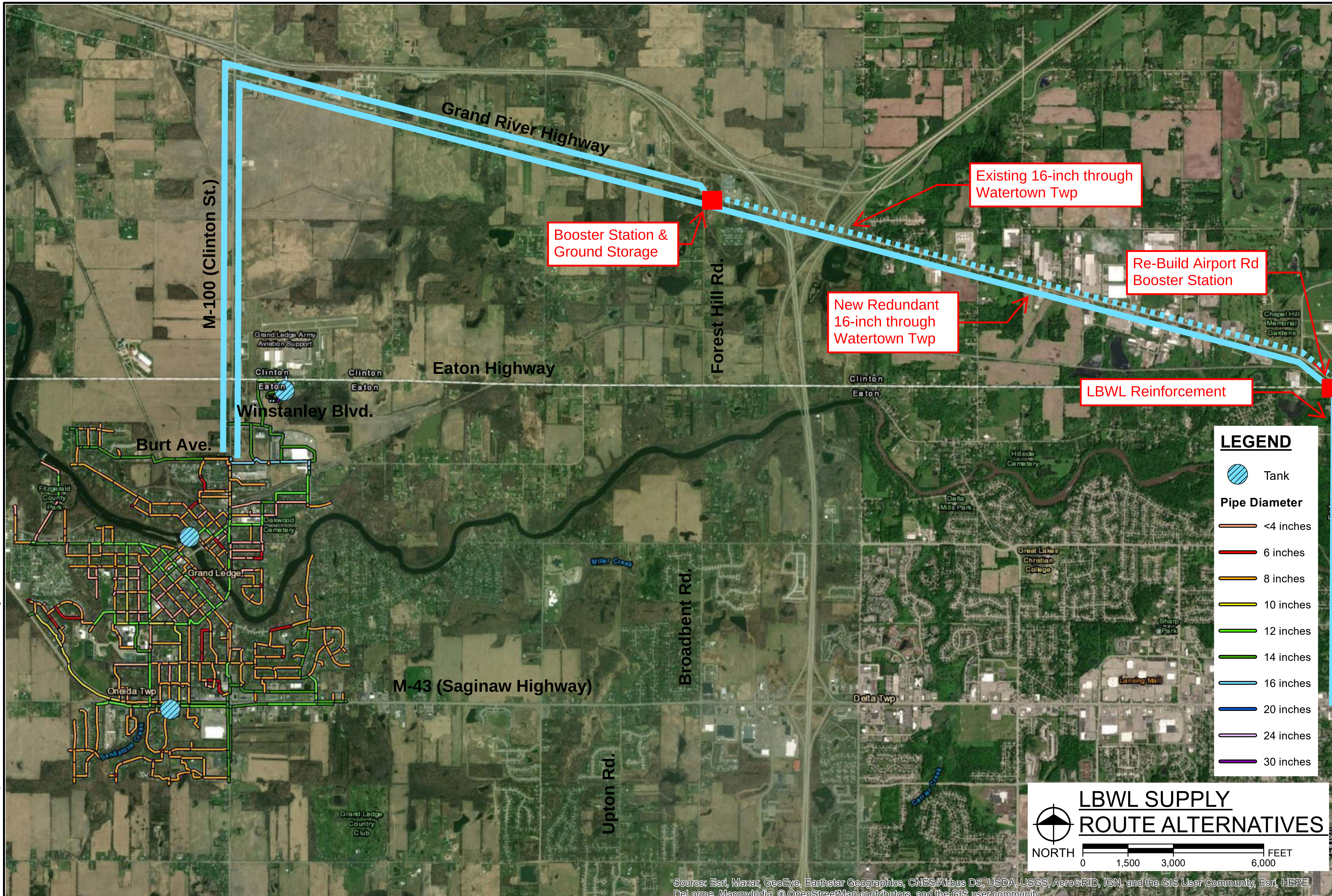

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LBWL Supply Evaluation

PROJECT NO.
200549

FIGURE NO.
5

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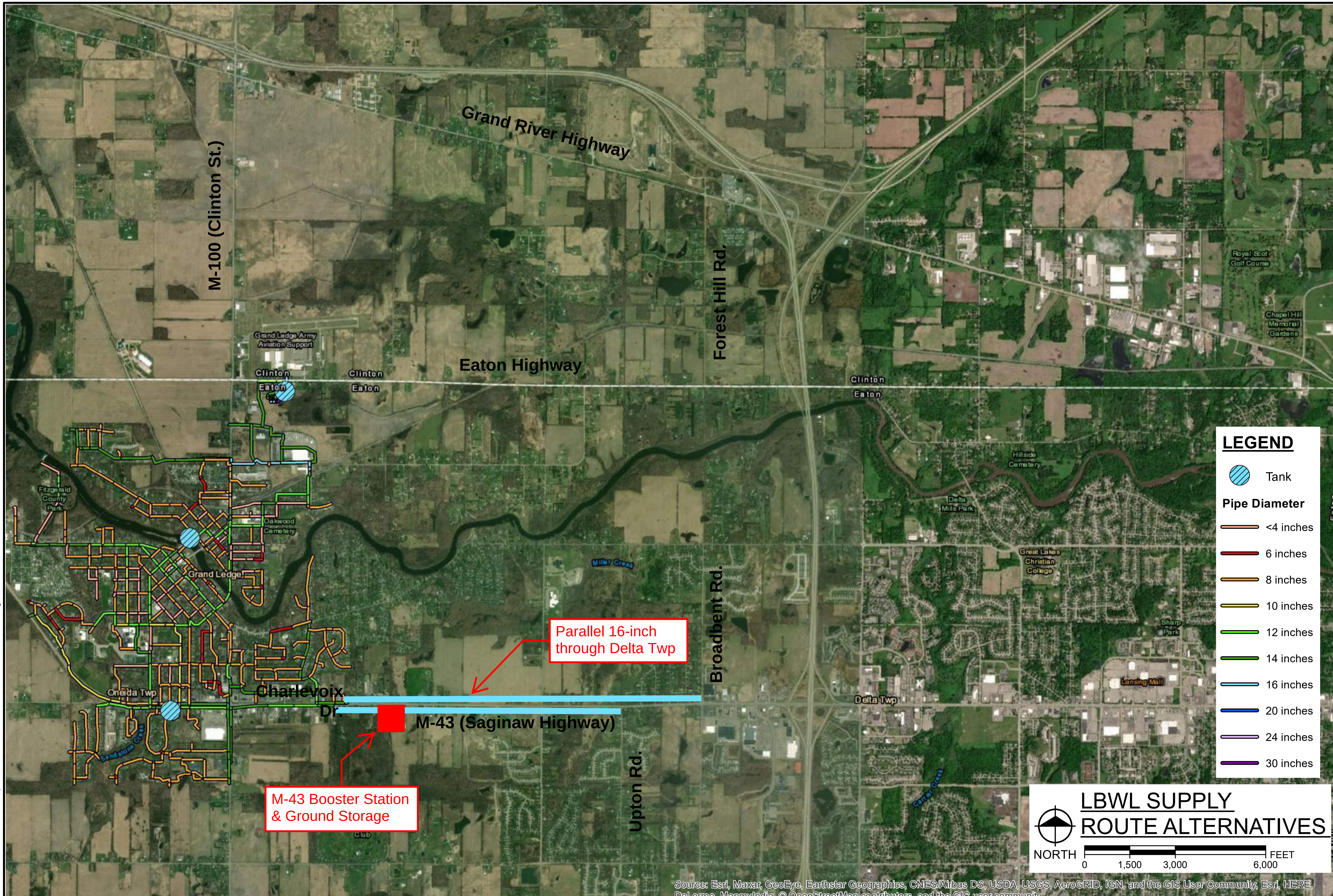

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LBWL Supply Evaluation

PROJECT NO.
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FIGURE NO.
6

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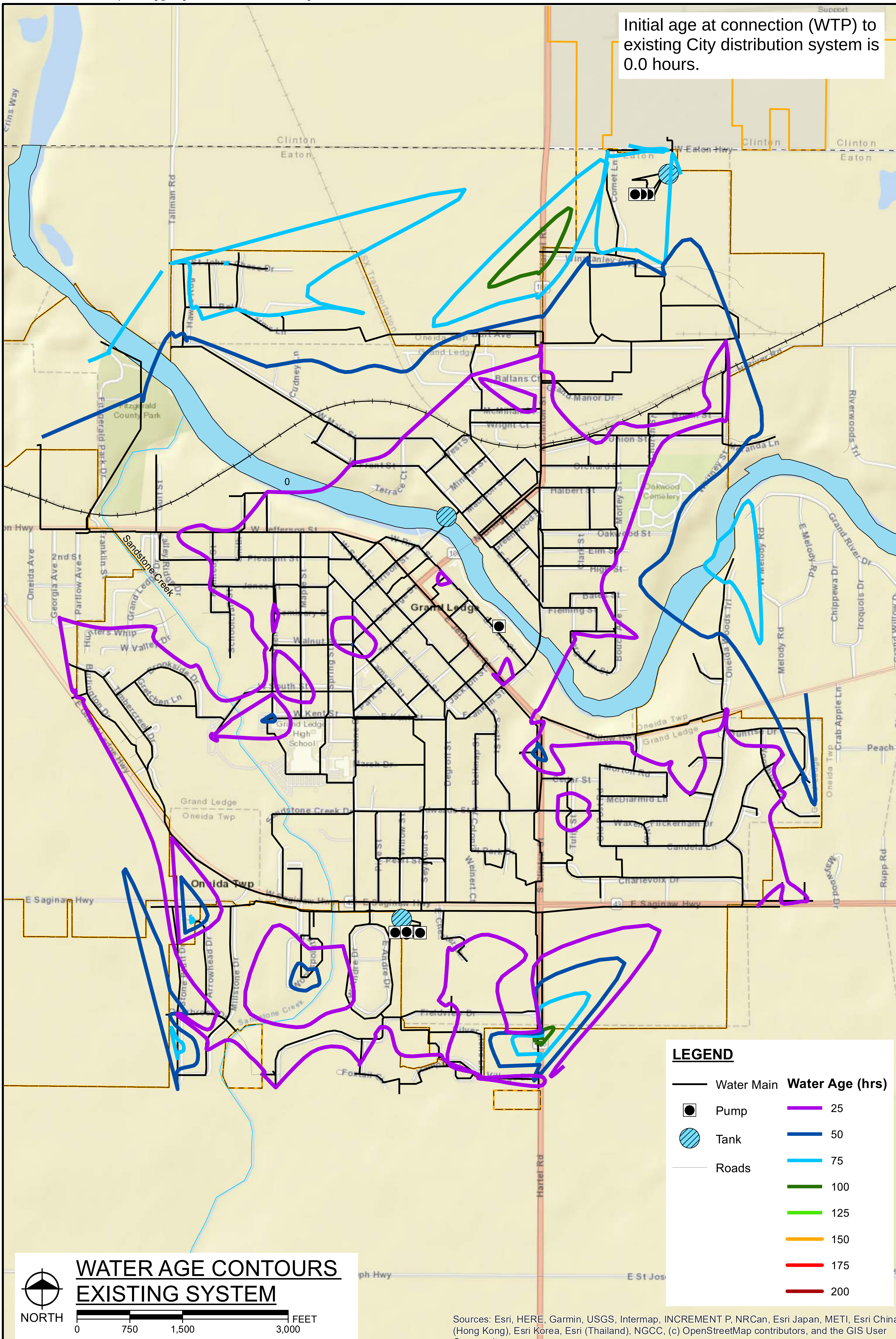

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LBWL Supply Evaluation

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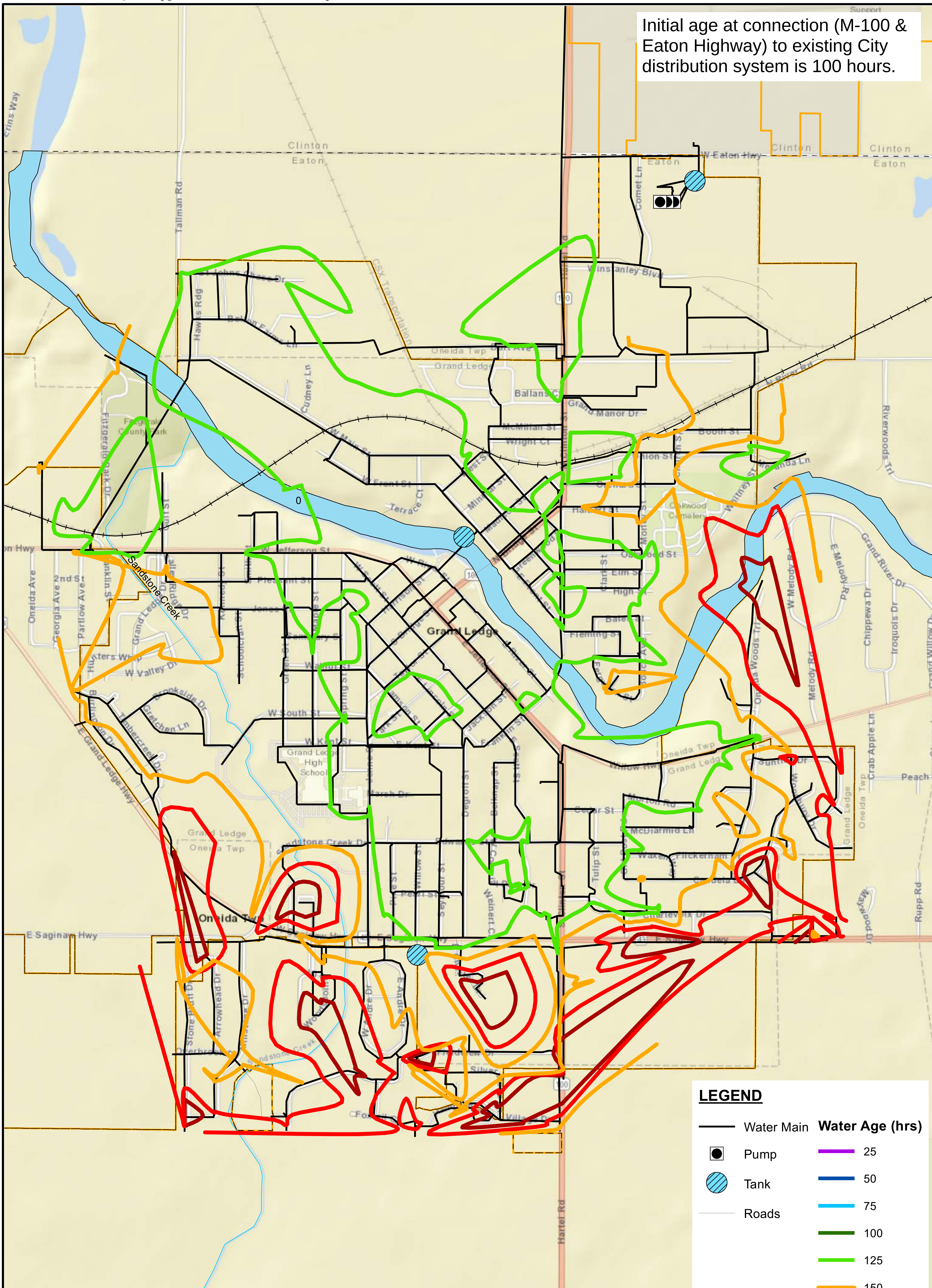
FIGURE NO.
7



WATER AGE CONTOURS NORTHERN LBWL CONNECTION

NORTH

0 750 1,500 3,000 FEET

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

FIGURE NO. 8

PROJECT NO. 200549

City of Grand Ledge
Eaton County, Michigan

LBWL Supply Evaluation

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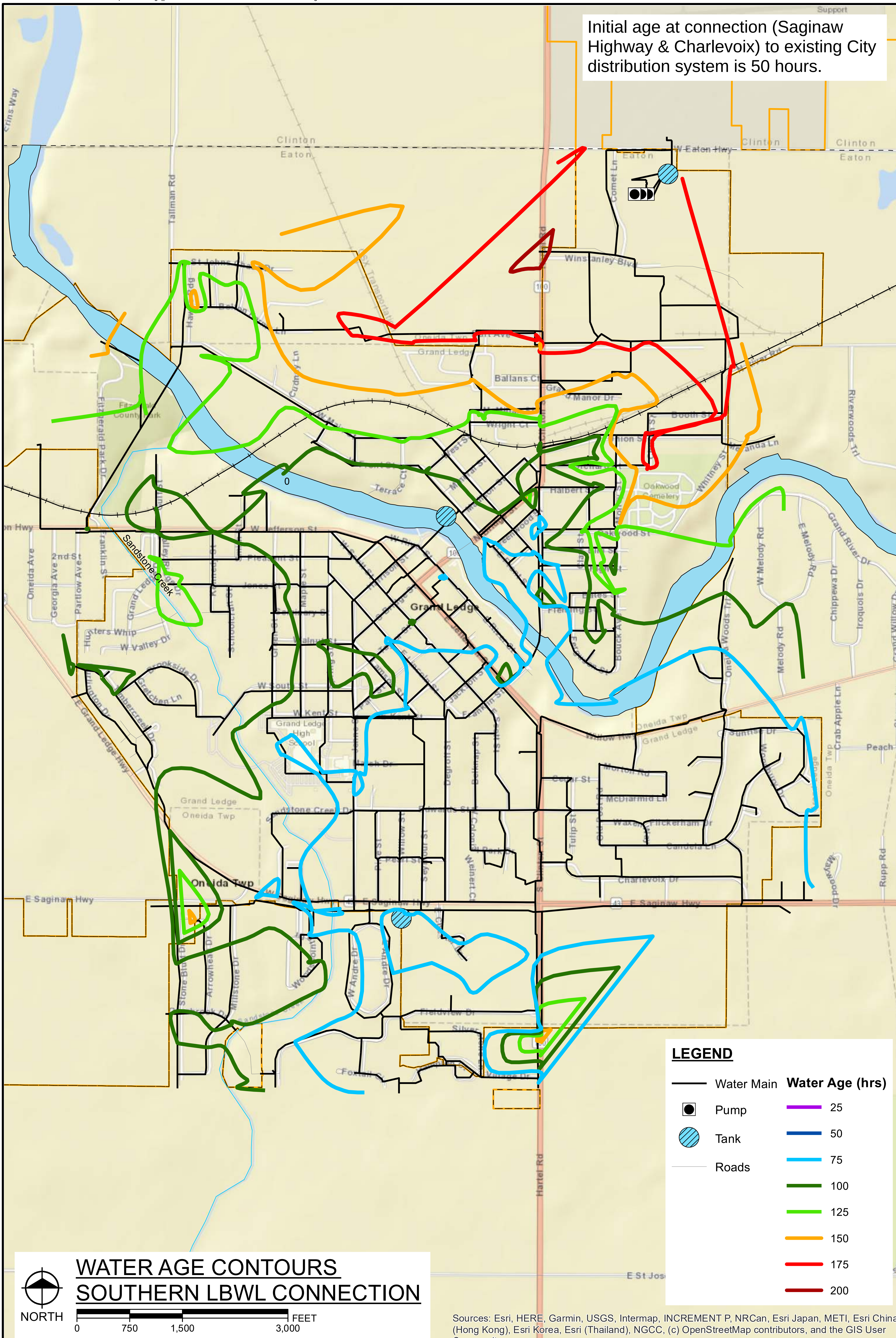

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LBWL Supply Evaluation

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FIGURE NO.
9