CITY OF BIG RAPIDS
MECOSTA COUNTY, MI

WATER SYSTEM RELIABILITY STUDY

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

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I. EXECUTIVE SUMMARY

This report is an evaluation of the City of Big Rapids's water system facilities, capacities and needs through the year 2036. In addition, it provides a master plan for water system improvements to be implemented as feasible.

The system was evaluated in three categories: water supply, water distribution and water storage. In general, the system was found to meet the current daily demands but has some distribution deficiencies.

A. WATER SUPPLY & TREATMENT

Water supply is currently met with four wells that have capacities sufficient to meet 20-year projected demands. The water is treated at the Water Treatment Plant (WTP) located along the Muskegon River at Waterloo Street and Osceola Avenue. The WTP removes iron and manganese by means of chlorine oxidizidation, then two upflow clarifiers followed by gravity filtration through three filters. Orthophosphate (a corrosion inhibitor), fluoride (dental health) and a calcium hypochlorite tablet feed (disinfection) is added to the water after the filters. The treated water meets the state drinking water requirements.

B. WATER STORAGE

The City has two ground storage tanks (0.5 MG and 1.0 MG reservoirs) located at the WTP. The reservoirs were last inspected by Dixon Engineering, the 1.0 MG in 2011 and the 0.5 MG in 2012. The 0.5 MG reservoir wet interior was recoated in 2012. The 1.0 MG reservoir received exterior and wet interior recoating, along with miscellaneous repairs/improvements, in 2012.

The City also has four elevated storage tanks. Two, the 0.25 MG Bjornson and 0.3 MG State Street towers, are within the low-pressure district. The other two towers, 0.2 MG Perry Street and 0.5 MG Ferris, are within the high-pressure district. All towers were inspected by Dixon Engineering between 2013 and 2016. The Bjornson tower had the exterior, wet interior, and pit piping recoated, along with miscellaneous repairs/improvements in 2013. The Perry Street tower exterior and wet interior surfaces were recoated, along with miscellaneous repairs/improvements in 2015. No further work is suggested for these two towers at this time.

C. WATER DISTRIBUTION

The water distribution system is comprised of watermain ranging in size from 4-inch to 20-inch with cast iron and ductile iron pipes.

D. RECOMMENDED IMPROVEMENTS

Miscellaneous touch-up paint recoating at the WTP clarifiers within the next 5 years and possibly re-coating the clarifiers within the next 20 years is recommended as well.

Recoating of the 1.0 MG reservoir exterior and adding cathodic protection is estimated to cost $90,000.

High service pump No. 3 should be replaced with an adequately sized pump for approximately $225,000.

Recommendations for the State Street water tower include recoating the exterior and miscellaneous repairs/improvements for approximately $350,000. The Ferris water tower needs recoating the exterior, wet interior, and pit piping along with partial recoating the dry interior and minor miscellaneous repairs/improvements for approximately $200,000.

Provide a new pump and motor for the State Street booster station at approximately $80,000.

The City should begin budgeting for a redundant raw water feed from the well field to the treatment plant estimated at $2,000,000.

Short term water distribution improvements are recommended with an estimated cost of $2,100,000. Long term water distribution improvements are recommended for an approximate cost of $8,852,000. Implementation of these projects should coincide with the City's street improvements plan or master plan.

Each recommended improvement has an estimated cost associated with it. These costs are rough estimates to be used for budgeting purposes.

II. BACKGROUND AND PURPOSE

The City of Big Rapids lies along the Muskegon River east of US-131 in Mecosta County, Michigan. Big Rapids has a type 1 (public) water supply and distribution system with four production wells, an iron removal water treatment plant (WTP), two booster pump stations separating the system into two main pressure districts and one subdivision pressure district, and four elevated storage tanks.

The purpose of this report is to provide the City with a comprehensive analysis of their water system for compliance with MDEQ and Act 399. The report evaluates the existing water supply, treatment, storage and distribution, and provides recommendations for improvements to serve the existing and future needs of the City. This report is intended to be the master plan for guiding the community on the overall future water system capital improvement needs to meet future daily water and fire flow demands.

The study and service area consists of the City of Big Rapids, including Ferris State University, and portions of Big Rapids Charter Township. The City of Big Rapids water system was originally constructed in 1903, and the last water reliability study for the system was completed in 2011.

III. EXISTING WATER SYSTEM

A. WATER SUPPLY

1. Wells

The City of Big Rapids's water supply system currently consists of four wells in a single well field. The City originally treated surface water of the Muskegon River for public use but changed to groundwater supply in 2001. The wells, located northwest of the City, are designated as Wells No. 1, No. 2, No. 3, and No. 4, and are shown on Figure 1.

The capacity and total dynamic head (TDH) information was obtained from the Peerless Midwest Inc. 2016 Annual Maintenance Testing Report. A summary of the wells and their capacities are given in Table 1. The current firm well capacity (largest well out of service) is 2,500 gpm (3.6 MGD).

TABLE 1
WELL SUMMARY

Well No.	Year Drilled	Diameter	Depth	Current Capacity	TDH
1	2001	12 inch	210 feet	500 gpm	167 feet
2	2001	16 inch	155 feet	1,200 gpm	96 feet
3	2001	16 inch	168 feet	1,200 gpm	80 feet
4	2001	16 inch	213 feet	800 gpm	118 feet

Well No. 2 was chemically cleaned last year to restore lost capacity and the pump for Well No. 4 was overhauled at the same time. Additionally, well field protection project was completed to provide secured isolation distances and to abandon unused well field monitoring wells to prevent contamination.

Table 2 shows the amount of water that was pumped from each supply source in fiscal year 2015-2016.

TABLE 2
2015-2016 WELL PRODUCTION LEVELS

Month	Well No. 1 (gallons)	Well No. 2 (gallons)	Well No. 3 (gallons)	Well No. 4 (gallons)	Total (gallons)
July	15,405,000	18,075,000	1,161,000	7,678,000	42,319,000
August	573,000	9,159,000	19,147,000	16,394,000	45,273,000
September	10,430,000	13,879,000	127,000	15,155,000	39,591,000
October	8,749,000	13,834,000	10,745,000	2,263,000	35,591,000
November	14,434,000	2,508,000	6,201,000	6,200,000	29,343,000
December	5,487,000	0	957,000	20,139,000	26,583,000
January	40,000	12,686,000	16,685,000	43,000	29,454,000
February	18,000	17,983,000	13,511,000	329,000	31,841,000
March	754,000	16,090,000	14,971,000	11,000	31,826,000
April	5,709,000	13,976,000	8,852,000	5,255,000	33,792,000
May	126,000	8,512,000	13,112,000	10,174,000	31,924,000
June	535,000	19,026,000	16,960,000	0	36,521,000
Totals	**62,260,000**	**145,728,000**	**122,429,000**	**83,641,000**	**414,058,000**

The well water is pumped into a 20-inch raw water gravity transmission main to the 5.4 MGD WTP (3.6 MGD firm capacity) located along the Muskegon River at Waterloo Street and Osceola Avenue. The City may want to begin budgeting for placement of a redundant raw water supply line to provide uninterrupted flow in case of damage to the existing raw water supply line. The cost of a second line is estimated at $2,000,000 and the City may want to explore other alternatives such as an emergency connection from the well field to the treated distribution system as a more cost effective alternative.

The treated water is pumped with two low service pumps to two ground storage tanks (0.5 MG and 1.0 MG in series) at the WTP. The low service pumps are flow paced to maintain a constant level in the ground storage tanks and have a total pumping capacity of 7,500 gpm and a firm capacity of 3,750 gpm.

Four high service pumps, controlled by the elevated storage tank levels, pump the water from the ground storage tanks and into the distribution system. These pumps have a total capacity of 10,350 gpm and a firm capacity of 6,600 gpm (9.5 MGD).

TABLE 3
HIGH SERVICE PUMP SUMMARY

Pump Number	Year Installed	Horsepower	Pumping Capacity
1	1983	250	3,750 gpm
2	1983	150	2,500 gpm
3	Unknown	75	1,600 gpm
4	1983	150	2,500 gpm

The DEQ WSSS states that Pump 3 is not sized to run as currently piped causing low capacity output when run alone and no output when run with another pump. Replacement of this pump with an adequately sized pump is recommended at a cost of approximately $225,000.

The water system is divided into two main pressure districts and one small subdivision pressure district. The low pressure district is maintained by the high service pumps and the levels in the State Street and Bjornson elevated storage tanks. The high pressure district is maintained by the State Street booster station at the State Street water tower and the levels in the Ferris State and Perry Street elevated storage tanks. The Hills of Mitchell Creek subdivision's pressure is maintained by a small booster station located west of Sheridan on Rolling Hills Lane. The low and high pressure districts are separated by ten closed valves listed below in Table 4.

TABLE 4
PRESSURE DISTRICT SEPARATION VALVES (CLOSED)

Valve Number	Location
256	Willow and Cypress
388	Winter and Chestnut
206	Chestnut, E of Ives in alley
162	Ives and Oak
195	Chestnut and Warren
184	Chestnut, alley E of S. State
109	S. State and Spring

107	S. State and Woodward
318	Woodward and Division
121	Woodward and Hutchinson

Table 5 summarizes the two booster pump station capacities that serve the high pressure district and Mitchell Creek subdivision.

TABLE 5
BOOSTER STATION CAPACITY

Pump	**Capacity**	
	gpm	mgd
State Street Booster Station		
Pump 1	970	1.4
Pump 2	970	1.4
Pump 3	1,940	2.8
Hills of Mitchell Creek Booster Station		
Pump 1	260	0.37
Pump 2	260	0.37

The State Street booster station is set up for future installation of a 2,000 gpm pump. The booster station's meter is read daily from the WTP. The Hills of Mitchell Creek booster station doesn't have any elevated storage which may be necessary when the subdivision reaches its full capacity. The addition of a hydropneumatic tank at the Mitchell Creek booster station would allow the pumps to run longer and less often, extending pump service life.

The firm capacities of the wells, WTP, and high service pumps are 3.6 MGD, 3.6 MGD and 9.5 MGD respectively. The firm capacity for the low pressure district and the WTP is 3.6 MGD. The firm capacity for the high pressure district booster station is 2.8 MGD and the Mitchell Creek pressure district booster station is 0.37 MGD.

2. Well House

   The wells have a common wellhouse which is secure and in good condition with no noted problems.

3. Water Treatment & Quality

   Groundwater is the source water for the Big Rapids Water System. The raw water contains concentrations of iron and manganese that occasionally exceed secondary drinking water standards. Secondary water standards are non-enforceable guidelines regulating constituents that may cause cosmetic (staining) or aesthetic (taste, odor, or color) effects in drinking water. The secondary standard is 0.3 mg/L for iron and 0.05 mg/L for manganese.

   Big Rapids regularly tests the water quality of its wells and throughout the system per MDEQ requirements. Testing is performed monthly for bacteria, yearly for partial chemical and every 3 years for metals analysis. The most recent testing conducted reports that the contaminant levels were well below the state requirements. The metals and radiological testing performed in 2015 indicate that the water met the State drinking water standards.

   The City tests for lead and copper on a triennial basis. Lead/copper levels were much lower than the MDEQ action levels in the most recent testing. The City is in compliance and the next round of testing is due in 2017.

Treatment Process Overview

The water from all four wells is directed to an iron removal system before it enters the distribution system. The dissolved iron and manganese oxidizes by means of chlorination, then two upflow clarifiers followed by gravity filtration through three filters. Orthophosphate (a corrosion inhibitor), fluoride (dental health) and a calcium hypochlorite tablet feed (disinfection) is added to the water after the filters. Aeration for additional iron removal is available but not needed at this time so water simply flows through the aerator.

Oxidation

Calcium hypochlorite in tablet form is currently fed to the raw water prior to the detention tanks. The hypochlorite reacts with the iron and manganese in the raw water to form precipitates, which can then be removed through filtration. The treatment process was originally designed to use potassium permanganate as the oxidizer; however that chemical never achieved good results and calcium hypochlorite feed was enacted shortly after commissioning the groundwater treatment operations.

The WTP utilizes a gravity tablet feed system to feed CaClO to both the raw water and the filter effluent. The feed system includes one chlorinator rated for 650 pounds per day and two chlorinators rated for up to 50 pounds per day each.

The WTP is also equipped with an aerator which was intended to add oxygen to the water to assist with the oxidation step. The aerator blower is not currently used because it had caused oversaturation of the dissolved oxygen and concerns with corrosion of copper piping and plumbing equipment.

Recommended Standards for Water Works published by the Great Lakes-Upper Mississippi River Board Water Supply Committee, more commonly referred to as *Ten States Standards*, requires redundancy for chemical feed systems considered essential to treatment, including chlorination and oxidation.

The chlorine tab system has installed redundant feeders and is sufficient to meet the 20-year projected demand.

No issues have been identified with the oxidation/chlorination system.

Detention

Two modified clarifier tanks are used as detention tanks to ensure the iron and manganese oxidation reactions are as complete as possible prior to filtration. The tanks were originally designed to settle sediment when the Muskegon River intake provided the source water. One tank is a clarifier by Walker Process, the other tank is a clarifier by General Filter. The tanks are typically operated in parallel.

Because the detention tanks are actually large clarifiers, settling of sludge/residuals occurs. The settled iron/manganese sludge is pump out periodically and dewatered in a filter press then disposed.

Ten States Standards recommends a 30 minute detention time for iron and manganese removal using aeration; however chemical oxidation processes are typically complete within a few minutes. The clarifier tanks were part of the original surface water plant and are much larger than required to meet the 30 minute detention time.

Existing Clarifier/Detention Tank Capacities

Unit	Approx. Volume (gallons)	Detention Time at 20-yearAvg. Demand (1.41 MGD)	Detention Time at 20-year Max. Demand (2.11 MGD)
Walker Process	405,500	414 minutes	277 minutes
General Filter	283,552	290 minutes	194 minutes
TOTAL	689,052	704 minutes	470 minutes

The Walker and General Filter Clarifiers were inspected by Dixon Engineering, Inc. in 2016.

Dixon states the overall condition of the Walker Clarifier has not changed significantly since last inspected in 2012, however, the walkway deck, it's supporting steel, the circular trough stitch welds, and the bottom seal on the base of the drum have continued deteriorating since 2012. The coating failure on the main roof girder bottom flange remains present and in poor condition. Dixon recommends recoating the bottom flange of the support girder over the Walker Clarifier, otherwise measurable steel loss could occur. The General Filter Clarifier structure is in good condition and the deterioration is only slightly worse than in 2012. Touch-ups on the weir troughs of the General Filter Clarifier could be completed at the same time as recoating the support girder flange in the Walker Clarifier. Budgeting for repainting both clarifiers should be considered for completion within the next 20 years.

The MDEQ recommends the railings around the clarifiers be repainted and the clarifiers cleaned regularly for preventative maintenance.

Filtration

Filtration is used to remove the iron and manganese precipitates from the water. There are three gravity rapid sand filters at the existing WTP. Each filter has a surface area of 425 square feet (ft^2), for a total surface area of 1,275 ft^2. The filters are equipped with 24-inches of sand on top of 12-inches of gravel and a 2-inch anthracite cap. The filters are also equipped with Leopold underdrains and fiberglass wash water troughs.

The filters are periodically backwashed to remove the iron and manganese residues from the media. Backwash is routed to the backwash recycle basin.

The approved filtration rate for the filters is 3 gallons per minute (gpm) per ft^2. *Ten States Standards* recommends filtration rates of 2-4 gpm/ft^2. The capacity of all three filters in service is approximately 5.5 MGD, at the approved filtration rate of 3 gpm/ft^2. The firm capacity of the filter process, with one filter out of service, is approximately 3.6 MGD. The current filters have sufficient firm capacity to meet the 20-year projected maximum daily demand of 2.11 MGD.

A water-only backwash is performed every 200 hours of operation and is done as a scheduled procedure, not due to breakthrough of iron or manganese or headloss. One backwash pump is provided for this purpose. The pump is a vertical turbine pump rated at 8,000 gpm at 27 feet of total dynamic head (TDH). The filters can also be backwashed from either of the ground storage tanks, providing redundancy for the backwash process in case the backwash pump is out of service.

The anthracite/sand media was installed in 1983 and was tested in 2010. Test results indicated that the media is in good condition.

There are no issues currently identified with the filter system. The current oxidation-filtration system has been providing the City with consistent, good-quality water and the City should continue its current practice of inspecting the filter tank and media on a regular basis to determine when media replacement is necessary. Continued routine inspections and maintenance are necessary to keep treatment equipment in working order.

Finished Water Chemical Feed Systems

Fluoride is added to the treated water for its dental benefits. Hydrofluosilicic acid is fed to the clearwell effluent by a flow-paced chemical metering pump. The fluoride dose is automatically adjusted based on the incoming raw water flow. The average dose is approximately 0.7 mg/L.

Polyphosphate is added to the filtered water to reduce corrosion in the distribution system. The polyphosphate solution is fed after filtration by a flow-paced chemical metering pump and the dosage is automatically adjusted based on the incoming raw water flow.

Both finished water chemical feed systems are sufficient for the 20-year projected demand and have adequate redundant systems. Both the fluoride and polyphosphate systems have back-up shelf spares that can easily be put into service when needed.

Backwash Water and Residuals Disposal

Iron and manganese precipitate is removed from the filter media through a water backwash process. The filter backwash water is routed to a 250,000-gallon backwash recycle basin. Two turbine transfer pumps, each rated at 1,400 gpm, route the backwash water back through the treatment process. The iron/manganese precipitate (sludge) settles out in the clarifier tanks. The sludge is removed from the tank and discharged to the sanitary sewer.

4. Wellhead Protection

The City's wellhead protection plan was last revised in July 2013.

5. Auxiliary Power

An auxiliary 250 kW natural gas fixed generator is present to operate the wells and a 500 kW diesel fixed generator is present for the WTP. Both generators are able to sustain full use of the equipment. A 6.8 kW natural gas fixed generator is located at the Ferris Tank to operate tank telemetry. The State Street booster station has a 150 kW natural gas fixed generator with a 1,250 gpm capacity. Although the firm capacity of the booster station is 1,940 gpm, a 2003 P&N Study indicates Pumps 1 and 2 only produce 625 gpm when run simultaneously. The Hills of Mitchell Creek booster station has a 60 kW natural gas fixed generator with capacity to run both pumps. The generators are load tested weekly to insure proper operation. All fixed generators have automatic transfer switches and receive annual maintenance. The Perry and Bjornson tanks have receptacles for portable generators if needed. As the Bjornson tank is the hub for the radio communication system, a permanent power supply would be beneficial and would cost approximately $35,000.

6. Emergency Response Plan

The City Emergency Response Plan was updated in March of 2016.

B. DISTRIBUTION SYSTEM

1. Pipe Condition

The existing water distribution system was originally constructed in 1903, however, approximately 73% of the system has been updated from 1960-2010 as shown on Figure 1. The water system resides within the City limits, Ferris State College, and portions of Big Rapids Charter Township. Watermain ranges from 4 to 20 inches in diameter for primary distribution mains. The majority of the City's distribution system is made up 6, 8, and 12-inch watermain and made primarily of ductile iron.

An inventory of the distribution system showing watermain sizes and the approximate lengths of each size are shown in Table 6.

TABLE 6
WATERMAIN INVENTORY

Watermain Size (inches)	Length (feet)	Percentage of Total (%)
4	26,777	9.0%
6	83,516	28.0%
8	67,984	22.8%
10	6,704	2.2%
12	89,556	30.0%
16	16,349	5.5%
20	7,824	2.6%
Total	**298,710**	**100.0%**

The 20-inch ductile iron transmission line from the wells to the WTP were installed in 1999.

2. Low Flow Areas

No recent areas of low flow have been noted.

3. Watermain Breaks

Multiple breaks have occurred on the following streets:

- Ridgeview/Bailey
- Escott
- Clark
- Ives/South
- Winter

C. WATER STORAGE

The City has two ground storage tanks (reservoirs) located near the WTP which are supplied by the WTP low service pumps. One tank has a capacity of 500,000 gallons and is connected in series to the 1,000,000 gallon tank. These tanks are on the suction side of the high service pumps.

The City also has four elevated storage tanks. Two, the Bjornson and State Street towers, are within the low pressure district. The 250,000 gallon Bjornson tank is located on Bjornson Street between Milton Avenue and E. Madison Street. The 300,000 gallon State Street tank is located on State

Street at Fuller Avenue. The other two towers, Perry and Ferris, are within the high pressure district. The 200,000 gallon Perry tank is on Perry Avenue west of Water Tower Road while the 500,000 gallon Ferris tank is also on State Street but near the southern City limit. Table 7 summarizes the water storage tanks in Big Rapids.

TABLE 7
WATER STORAGE

Tank/Tower	Capacity (MG)	Year Built	Pressure District
WTP Reservoir	0.5	1983	Low
WTP Reservoir	1.0	1959	Low
Bjornson Water Tower	0.25	1968	Low
State Street Water Tower	0.3	1952	Low
Perry Water Tower	0.2	1968	High
Ferris Water Tower	0.5	1996	High

The following paragraphs address the specifications and maintenance for each tower.

1. 500,000 Gallon (0.5 MG) Reservoir
   a) Specifications

      This tank is a ground storage tank with an overflow elevation of approximately 943 feet (USGS). The total head range is 48 feet with a normal operating range of 35 to 45 feet.

   b) Tank Maintenance

      The tank was built in 1983 by Prairie Tank Company and last inspected by Dixon Engineering, Inc. in 2010. Dixon states the exterior coating is in good condition while the wet interior is in fair condition. The exterior and wet interior were last painted in 1999, both by MK Painting. The wet interior roof was repainted in June of 2012 by MC Sandblasting and Painting. The remaining improvements are recommended to be completed as soon as possible.

2. 1,000,000 Gallon (1.0 MG) Reservoir

   a) Specifications

      This tank has the same height as the 500,000 gallon reservoir, however, the diameter of the tank is larger.

   b) Tank Maintenance

      The tank was built in 1959 by Hammond Tanks and last inspected by Dixon Engineering, Inc. in 2011. Dixon states the exterior coating is in good condition, the wet interior is in fair condition, however, the roof coating is deteriorated with severe coating loss and steel loss on the roof beams. The exterior was last painted in 1999 by MK Painting, the wet interior in 1984 by Craftsmen, and floor spot repairs in 1990 by Richard Brothers. Dixon recommended the following improvements:

      - Recoat the exterior
      - Recoat the wet interior

- Repair areas of missing grout between the tank's base-plate and the foundation
- Install a 30-inch manway in the sidewall
- Installation of cathodic clips and pressure fitting for future installation of a submerged cathodic protection system
- Cleaning and coating the foundations would be incidental to exterior painting

The recommended repairs were completed in September of 2012 by MC Sandblasting and Painting.

3. Bjornson Tower

a) Specifications

The tower is a 250,000 gallon (0.25 MG) toroellipse elevated tank with an overflow elevation of approximately 1,063 feet (USGS). The total head range is 25 feet with a normal operating range of 10 feet.

b) Tank Maintenance

The tank was built in 1968 by Universal Tank and last inspected by Dixon Engineering, Inc. in 2014. The exterior, wet interior, and pit piping was re-coated in 2013 along with various miscellaneous installation/replacement of the following: riser manway, manway gasket, wet interior roof hatch, overflow flap gate, replace ladder rung, wet interior ladder, sidewall ladder with platform, frost free roof vent, roof safety couplings, and bowl safety clips. No further work is recommended at this time.

4. State Street Tower

a) Specifications

The tower is a 300,000 gallon (0.3 MG) double ellipse elevated tank with an overflow elevation of approximately 1,063 feet (USGS). The total head range is 20 feet with a normal operating range of 8 feet.

b) Tank Maintenance

The tank was built in 1952 by Pitt-Des Moines and last inspected by Dixon Engineering, Inc. in 2013. Dixon states the exterior coating is in fair to poor condition, however the wet interior coating is in good condition overall. The exterior was last painted in 1992 by G&M Painting, the wet interior sidewalls, bowl, and riser in 1982 by Neumann Painting, and the interior roof in 2008 by Dave Cole Decorators. Dixon recommends budgeting for the following improvements:

- recoat the exterior at ~$180,000 plus a containment system at ~$60,000
- create an air gap in the overflow pipe and install a flap gate (~$2,000) or replace the overflow pipe with an 8-inch line (~$10,000)
- install a 30-inch diameter manway in the bottom of the riser at ~$8,000
- replace the wet interior roof hatch with a 30-inch diameter hatch at ~$3,000
- replace the roof vent with a new frost-free pressure vacuum vent at ~$5,000
- install a wet interior ladder with a fall prevention device for ~$10,000
- replace the sidewall/roof ladder with a vertical ladder and a step-off platform for ~$9,000

Cleaning and coating the foundation along with installing rigging couplings under the bowl, halfway between each leg and the riser, would be incidental to repainting costs. The exterior painting is primarily for aesthetics and can be delayed, and the safety improvements can also be delayed until the exterior is repainted. The screen in the vent should be replaced and secured within the next year or so for ~$500.

5. Perry Tower

   a) Specifications

   The tower is a 200,000 gallon (0.2 MG) toroellipse elevated tank with an overflow elevation of approximately 1,154 feet (USGS). The total head range is 30 feet with a normal operating range of 10 feet.

   b) Tank Maintenance

   The tank was built in 1968 by Universal Tank and last inspected by Dixon Engineering, Inc. in 2016. The exterior and wet interior was re-coated in 2015 along with various miscellaneous installation/replacement of the following: riser manway, wet interior roof hatch, riser grate, overflow flap gate, wet interior ladder, sidewall ladder with platform, roof couplings, bowl safety couplings, and transition cone rungs. No further work is recommended at this time.

6. Ferris Tower

   a) Specifications

   The tower is a 500,000 gallon (0.5 MG) spheroid elevated tank with an overflow elevation of approximately 1,154 feet (USGS). The total head range is 40 feet with a normal operating range of 11 feet.

   b) Tank Maintenance

   The tank was built in 1996 by Chicago Bridge and Iron and last inspected by Dixon Engineering, Inc. in 2015. The tank is generally in good condition. The exterior and dry interior was last recoated in 2010 by MC Sandblasting and Painting. The wet interior has not been recoated since the tower's construction. Dixon recommends budgeting for recoatings in approximately ten years for the exterior at ~$80,000 and the wet interior at ~$100,000. They also recommend partial recoating of the dry interior at the same time for approximately $15,000. Recoating the pit piping is recommended at the same time for about $4,000. Other recommendations to be completed when recoating is done with the price incidental to the recoating includes installation of rigging couplings on the roof at the existing painter's rigging rail and a handhold at the roof openings for entering and exiting the openings. Requesting the antenna owner to return for correction of deficiencies in cable sealing and routing and in-house installation of a neoprene cover over the access tube air gap is also recommended.

The tanks should be inspected every five years.

D. CONTROLS

1. Telemetry

   The City uses scada radio control system based at the Bjornson water tank for telemetry at the towers and wells. High and low alarms at the towers are received by the WTP operators.

E. SYSTEM OPERATIONS

1. Operators

The City of Big Rapids's water distribution classification is S-2 and the water treatment classification is D-2. The City has nine operators with licenses totaling three D2 classifications, one D3, three S2, two S3, one S4, one F1, one F2, and one F3 classification. This meets the MDEQ recommendation that public water systems have a minimum of two certified people on staff to operate the system.

2. Meters

The meter reading takes place monthly by the City employees. There are approximately 2,305 service connections in the system with most of them metered. The meters in the system are Ivensys/Badger with touchpad readers. The City replaces meters when they are determined to be an odd brand, non-touch, or defective.

3. Maintenance

The City operates the system valves somewhat, however, the valve turning program needs improvement with a regular and consistent application to ensure the valves function during an emergency. The hydrants are flushed annually in the spring and approximately 100 hydrants are annually tested.

4. Parts

The City maintains spare parts for the system including two spare mains for each size, as well tees, crosses, elbows, valves, and services (corp & curb stops, clamps and lines). Hydrants are purchased on an as needed basis.

IV. WATER USE AND FIRE PROTECTION

A. WATER USE

1. Customers

The City of Big Rapids water system currently serves 2,305 customers, consisting of roughly 28% commercial/institutional and 72% residential. Past water usage data is presented in Table 8 below. Peak hour demands are estimated based on a peaking factor of 3.0 times the average day demand.

TABLE 8
WATER USAGE

Fiscal Year	Total Water Pumped* (gal)	Average Day Demand (gpd)	Maximum Day Demand** (gpd)	Average Day Demand (gpm)	Maximum Day Demand* (gpm)	Maximum Day Peaking Factor	Peak Hour Demand (gpm)
2011-12	448,677,000	1,229,252	1,776,000	854	1,233	1.4	2,562
2012-13	456,391,000	1,250,386	1,871,000	868	1,299	1.5	2,604
2013-14	506,503,000	1,387,679	2,173,000	964	1,509	1.6	2,892
2014-15	426,078,000	1,167,337	1,803,000	811	1,252	1.5	2,433
2015-16	407,729,000	1,117,066	1,720,000	776	1,194	1.5	2,328

*WTP effluent

** Maximum days include days with main breaks, hydrant flushing, etc.

2. Historical Water Loss

Water losses were between 18% and 25% from 2014 to 2016 as calculated by dividing the unbilled water by annual pumpage. These losses exceed the 10-15% target level that is typical of similar systems. The target range of 10% to 15% accounts for acceptable system leakage and routine hydrant flushing. Checking the system for leaks, unauthorized consumption, and testing meters within the system is recommended to find the sources of the water losses.

TABLE 9
WATER LOSS CALCULATIONS*

Billing Year (Jul – Jun)	Total Water Pumped** (gal)	Total Water Billed (gal)	Total Unbilled Water (gal)	Unbilled Percentage
2014-15	426,078,000	320,874,000	105,204,000	25%
2015-16	407,729,000	332,789,000	74,940,000	18%

* Information based on monthly operating reports and City billing records

**WTP effluent

3. Large Water Users

Table 10 shows the average monthly use for the system’s largest metered water users. These water users represent approximately 31% of the City’s daily water use, mostly due to the University usage.

TABLE 10
LARGEST WATER USERS

Customer	Average Monthly Use (gal)	Average Daily Use (gal)	Average Demand (gpm)
Ferris State University	6,977,583	229,400	159.3
Haworth	1,380,500	45,386	31.5
Spectrum Health Big Rapids	862,083	28,342	19.7
Hillcrest/Oakwood Apartments	682,583	22,441	15.6
Big Rapids Housing Commission	549,750	18,074	12.6

As Table 10 shows, the City has a small number of locations that have higher water demands than residential use. Therefore, the system demand for water can be related to population served. The customer type distribution and water usage data is listed below in Table 11 for planning purposes.

TABLE 11
CUSTOMER PLANNING DATA

Customer Type	Number of Connections	Approximate REUs	March 2014 – February 2015 Water Usage (Gallons)
Institutional	225	2,598	114,373,000
Industrial	17	587	25,829,000
Commercial	392	2,754	121,262,000
Residential	1,620	1,620	71,325,000
Totals	**2,254**	**7,559**	**332,789,000**

B. POPULATION PROJECTIONS

The projected 20-year water demand for the City was estimated with consideration to the past and current population numbers obtained from the U.S. Census Bureau. The population of Big Rapids decreased at an average rate of 0.23% annually between 2000 and 2010. As population growth in the long term may increase rather than decrease, a conservative estimate of 0.5% annual population growth was used for population projections. Table 12 shows the past and projected populations for the City.

No proposed developments adding major water users are planned in the near future.

TABLE 12
POPULATION PROJECTIONS

Year	Population
1960	8,686
1970	11,995
1980	14,361
1990	12,603
2000	10,849
2010	10,601
2016	10,649 Est
2021	10,915 Est
2026	11,188 Est
2036	11,747 Est

C. PROJECTED WATER DEMANDS

The projected water demands for the 20-year study period were calculated using projected population and the current average usage per capita. Table 13 shows the current per capita water usage. Estimated populations are from the U.S. Census Bureau and report projections.

TABLE 13
PER CAPITA WATER USAGE

Year	Average Day Demand (gpd)	Estimated Population	Average Day Demand (gpcd)
2011-12	1,229,252	10,655	115
2012-13	1,250,386	10,657	117
2013-14	1,387,679	10,529	132
2014-15	1,167,337	10,543	111
2015-16	1,117,066	10,596	105

The amount of water used on a per capita basis has been fairly consistent over the last few years with an average of 116 gpcd, so a conservative value of 120 gpcd will be used for analysis. Since 2010, the maximum peaking factor (maximum day demand divided by average day demand) has averaged 1.5 including flushing days and other high demand days. Based on this, a maximum day peaking factor of 1.5 is used in this report to estimate future maximum day demands. Table 14 shows the projected water demands.

TABLE 14
PROJECTED WATER DEMANDS

	2021 (Estimate)	2026 (Estimate)	2036 (Estimate)
Population	10,915	11,188	11,747
Average Usage (gpcd)	120	120	120
Average Day Demand (gallons)	1,309,800	1,342,560	1,409,640
Average Day Demands (gpm)	910	932	979
Peaking Factor	1.5	1.5	1.5
Maximum Day Demand (gallons)	1,964.700	2,013,840	2,114,460
Maximum Day Demand (gpm)	1,364	1,399	1,468
Peak Hour Peaking Factor	3.0	3.0	3.0
Peak Hour Demand (gpm)	2,979	2,797	2,937

D. FIRE PROTECTION

1. ISO Rating System

The Insurance Services Office (ISO) establishes suggested fire flow protection standards based on various factors including building construction type, area, height, type of development and density. These factors and others such as fire fighting capabilities, when combined, result in an ISO rating of between 1 and 10, 1 being the best and 10 being the worst. This rating is used by insurance companies to determine appropriate insurance rates for its customers that live within the water supply system. The City of Big Rapids currently has an ISO rating of 4. The current rating is based on an evaluation from July 2015, and this is a typical rating for a community of this size.

2. Recommended Fire Flows

The ISO establishes suggested fire flows at various locations throughout a community during a survey. It is not always cost-effective for a community to build a water system that meets all of the suggested ISO fire flows. In such a situation, the community can choose to adopt target fire flow values. Table 15 below presents the suggested ISO fire flows and recommended target fire flow values. These recommended target fire flows were obtained from tabular values presented in the *“Fire Protection Handbook’*, and the AWWA’s Manual of Water Supply Practices – *“Distribution System Requirements for Fire Protection”*. It will be necessary for the City to decide as to whether these recommended target fire flows provide the desired level of protection.

TABLE 15
ISO SUGGESTED AND RECOMMENDED TARGET FIRE FLOW VALUES AND DURATIONS

Classification	ISO Suggested Fire Flows at 20 psi	Recommended Target Fire Flows at 20 psi	Duration (hrs)
Residential	1,000-1,500	1,000	2
Commercial	2,000-2,500	2,000	2
Industrial	3,000	3,000	3
Institutional	3,500	3,500	3

3. Hydrant Flow Tests

Fleis & VandenBrink Engineering and City staff performed fire hydrant flow tests at select locations throughout the system (see Figure 2) on December 22, 2015 to obtain information used in calibration of the WaterCAD hydraulic computer model. Table 16 provides the results of the fire hydrant tests. The available fire flow amount at the minimum residual pressure of 20 psi was calculated using the following formula:

$$\text{AVAILABLE FIRE FLOW at 20 psi} = \frac{\text{Hydrant Flow} * (\text{Static Pressure} - 20)^{0.54}}{(\text{Static Pressure} - \text{Residual Pressure})^{0.54}}$$

TABLE 16
AVAILABLE FIRE FLOW at 20 PSI FOR SELECT LOCATIONS

Test #	Location	Hydrant Flow (gpm)	Static Pressure Reading (psi)	Residual Pressure Reading (psi)	Calculated Flow at 20 psi (gpm)
1	Mason Industrial Drive, dead end	1,866	52	40	3,169
2	S Bronson Avenue, N of Taft Road	2,224	60	52	5,304
3	Ives Avenue/Elm Street	1,717	50	30	2,137
4	Novak Lane, dead end	1,173	67	52	2,173
5	Clark Street/Perry Avenue	1,161	77	66	2,823
6	Ice Arena Circle, W of Northland Drive	1,717	52	44	3,630
7	14 Mile Road at Hillcrest/Oakwood	1,173	55	48	2,797
8	215 Avenue, S of Menards	1,984	55	45	3,902
9	Waldron Way, at Meijers	2,874	54	42	5,043
10	Woodward Avenue, at W City limit	2,429	70	38	3,091
11	Marion Avenue/Bellevue Street	604	58	37	832
12	West Avenue, W of Sheridan Street	1,020	55	46	2,124

The results of the fire hydrant flow tests indicate that the City's system provides adequate static pressures. The available fire flow is within the recommended range for all except one location in Table 16, however, the pumps were not running during the hydrant testing. See Table 18 for fire flows with the pumps running at firm capacity. Figure 3 shows the static pressures for the City's water system.

V. EVALUATION OF SYSTEM CAPACITY

A. HYDRAULIC MODEL ANALYSIS

1. Model Description

In order to evaluate the water distribution system, a computer model was developed to simulate the existing system. The software used was WaterCAD version 8.0 developed by Bentley. The watermain sizes, configuration, friction factors, well pump curves, topographic information, flow demands and storage tank data were input into the model to simulate the existing and proposed water distribution systems. Watermain friction factors were estimated based on values required to achieve model calibration to within ±10% of the calculated available fire flow at 20 psi residual for the test locations. Table 167presents the comparison of the calculated available fire flow at 20 psi to the values obtained in the calibrated WaterCAD model for the test locations listed.

TABLE 17
COMPARISON OF CALCULATED FIRE FLOWS FROM FIELD MEASUREMENTS TO WATERCAD FIRE FLOWS

Test #	Location	Available Fire Flow at 20 psi (field test) (gpm)	Available Fire Flow at 20 psi (WaterCAD) (gpm)	Difference Between Calculated & WaterCAD (%)
1	Mason Industrial Drive, dead end	3,169	3,024	4.6%
2	S Bronson Avenue, N of Taft Road	5,304	4,875	8.1%
3	Ives Avenue/Elm Street	2,137	2,112	1.2%
4	Novak Lane, dead end	2,173	2,104	3.2%
5	Clark Street/Perry Avenue	2,823	2,759	2.3%
6	Ice Arena Circle, W of Northland Drive	3,630	3,309	8.8%
7	14 Mile Road at Hillcrest/Oakwood	2,797	2,873	-2.7%
8	215 Avenue, S of Menards	3,902	4,116	-5.5%
9	Waldron Way, at Meijers	5,043	4,759	5.6%
10	Woodward Avenue, at W City limit	3,091	3,232	-4.6%
11	Marion Avenue/Bellevue Street	832	908	-9.1%
12	West Avenue, W of Sheridan Street	2,124	2,289	-7.8%

2. Test Results

As the results of Table 17 show, the difference between the calculated available fire flow at 20 psi from hydrant testing and that predicted by the calibrated WaterCAD model is within a +/-10% tolerance. Therefore, the model is an accurate approximation of the system.

3. Fire Flow Results

Fire flows were simulated throughout the existing system. The simulations were completed under existing firm capacity conditions. The elevated tank water levels were set at average operating depth. MDEQ recommends a minimum of 20 psi residual pressure in the system at all times. This is to ensure positive water pressure remains in the distribution system for customer use and to ensure safe water quality. All available fire flows reported are with a 20 psi residual pressure. Table 18 below presents available fire flow at 20 psi under max day conditions for the existing water distribution system. These values were obtained by running the WaterCAD model under firm capacity conditions and target fire flow demands.

Figure 4 shows residual pressures and Figure 5 shows the existing available fire flow, expressed as contours, throughout the City for the 2015 maximum day demand. Figures 5.1 and 5.2 show the existing system under the future 2021 and 2036 demands.

TABLE 18
COMPARISON OF TARGET FIRE FLOWS TO WATERCAD FIRE FLOWS

Test #	Location	Recommended Target Fire Flow at 20 psi (gpm)	Available Fire Flow at 20 psi (WaterCAD) (gpm)	Difference between Target & Available (%)
1	Mason Industrial Drive, dead end	3,000	3,091	3%
2	S Bronson Avenue, N of Taft Road	3,000	4,985	66%
3	Ives Avenue/Elm Street	2,000	2,187	9%
4	Novak Lane, dead end	1,000	2,134	113%
5	Clark Street/Perry Avenue	2,000	3,147	57%
6	Ice Arena Circle, W of Northland Drive	3,000	3,603	20%
7	14 Mile Road at Hillcrest/Oakwood	2,000	2,869	43%
8	215 Avenue, S of Menards	2,000	4,161	108%
9	Waldron Way, at Meijers	2,000	4,794	140%
10	Woodward Avenue, at W City limit	1,000	3,400	240%
11	Marion Avenue/Bellevue Street	1,000	1,048	5%
12	West Avenue, W of Sheridan Street	2,000	2,638	32%

The available fire flows shown in Table 18 vary from the values shown in Table 17 for multiple reasons. In Table 17, all pumps were turned off for calibration, and in Table 18, the pumps were operating to model firm capacity conditions. Also, Table 18 shows the flows during the maximum day demands, while the calibration model portrays minimal flow conditions.

In all test locations, the recommended target fire flow can be met at 20 psi residual pressure.

B. WATER SUPPLY

The MDEQ recommends that the firm capacity of a community's water supply be greater than its maximum day demand. Currently, the firm capacity of the City's water supply is 2,500 gpm and the 2016 maximum day demand was 1,194 gpm. Therefore, the existing firm capacity is sufficient for the current demands of the system. The MDEQ recommends that communities plan to increase supply when maximum day demand reaches 80% of firm capacity. The projected maximum day demand of 1,468 gpm for 2036 is approximately 59% of firm capacity. If population growth remains low, the City's water system would not require any additional supply source in the next twenty years to cover daily water demands.

C. WATER STORAGE

The recommended target fire flow for commercial areas is 2,000 gpm for two hours. To provide the required volume of water to combat a fire of this duration, 240,000 gallons of water would be used (2,000 gpm times 120 minutes). Table 19 compares the volume of available water using current firm well capacity and the existing storage volume for each of the classifications of recommended target fire flows and fire flow durations for the existing maximum day demand.

TABLE 19
REQUIRED STORAGE CAPACITY FOR FIRE FIGHTING
(EXISTING MAXIMUM DAY DEMAND)

Classification	Desired Fire Flow at 20 psi (gpm)	Duration (hr)	Existing Maximum Day Demand (gpm)	Total Flow Required (system outflow) (gpm)	Firm Well Flow (system inflow) (gpm)	Net (system outflow) (gpm)	Total Storage Required (gal)	Existing Storage (gal)	Addt'l Storage Required (gal)
Residential	1,000	2	1,194	2,194	2,500	0	0	1,250,000	0
Commercial	2,000	2	1,194	3,194	2,500	694	83,280	1,250,000	0
Industrial	3,000	3	1,194	4,194	2,500	1,694	304,920	1,250,000	0
Institutional	3,500	3	1,194	4,694	2,500	2,194	394,920	1,250,000	0

As the data in Table 18 shows, the City has sufficient storage to meet the target fire flow requirements for fires classified at all levels.

Table 20 shows the estimated storage needed for the future maximum day demand. The estimated change in storage needed over the next twenty years is minimal.

TABLE 20
REQUIRED STORAGE CAPACITY FOR FIRE FIGHTING
(2036 PROJECTED MAXIMUM DAY DEMAND)

Classification	Desired Fire Flow at 20 psi (gpm)	Duration (hr)	Maximum Day Demand (gpm)	Total Flow Required (system outflow) (gpm)	Firm Well Flow (system inflow) (gpm)	Net (system outflow) (gpm)	Total Storage Required (gal)	Existing Storage (gal)	Addt'l Storage Required (gal)
Residential	1,000	2	1,468	2,468	2,500	0	0	1,250,000	0
Commercial	2,000	2	1,468	3,468	2,500	968	116,160	1,250,000	0
Industrial	3,000	3	1,468	4,468	2,500	1,968	354,240	1,250,000	0
Institutional	3,500	3	1,468	4,968	2,500.	2,468	444,240	1,250,000	0

VI. RECOMMENDED IMPROVEMENTS

Figure 6 shows the recommended improvements. Figure 7 shows the residual pressure contours under the future 2021 maximum day demand after completion of the recommended improvements, and Figure 8 shows available future 2021 fire flows as contour lines. Figures 7.1 and 8.1 show the residual pressures and fire flows under the 2036 maximum day demand with the recommended improvements.

Table 20 provides a comparison of the future available 2036 fire flows to the recommended target fire flows after completion of the recommended improvements.

TABLE 21
COMPARISON OF AVAILABLE FIRE FLOW TO TARGET FIRE FLOWS
AFTER COMPLETION OF RECOMMENDED IMPROVEMENTS

Test #	Location	Recommended Target Fire Flow at 20 psi (gpm)	2036 Available Fire Flow at 20 psi (WaterCAD) (gpm)	Difference between Target & Available (%)
1	Mason Industrial Drive, dead end	3,000	3,202	7%
2	S Bronson Avenue, N of Taft Road	3,000	5,165	72%
3	Ives Avenue/Elm Street	2,000	2,303	15%
4	Novak Lane, dead end	1,000	2,122	112%
5	Clark Street/Perry Avenue	2,000	3,350	66%
6	Ice Arena Circle, W of Northland Drive	3,000	3,652	22%
7	14 Mile Road at Hillcrest/Oakwood	2,000	4,997	150%
8	215 Avenue, S of Menards	2,000	4,731	137%
9	Waldron Way, at Meijers	2,000	6,544	227%
10	Woodward Avenue, at W City limit	1,000	8,005	701%
11	Marion Avenue/Bellevue Street	1,000	1,039	4%
12	West Avenue, W of Sheridan Street	2,000	3,043	52%

As seen in Table 20, the recommended improvements increase the available fire flow at each location and exceed the target flows.

<u>Recommended Improvements – Estimated Cost</u>

Distribution system improvements are recommended to improve available fire flows and overall system reliability. These improvements should be considered and implemented by City officials as deemed necessary and as funding allows. Distribution improvements are shown in Figure 6. The City should plan on replacing 4-inch or smaller watermains as road improvements are conducted in the City. These small lines should be replaced with minimum 8-inch lines.

Estimated costs are included with the recommended improvements. They are meant to be rough estimates for budgeting purposes only. They include appurtenances such as valves, hydrants, fittings, water services, restoration, engineering and contingencies. A unit price of $120 ($160) per foot was used for the 8-inch watermain and $130 ($180) per foot for the 12-inch watermain. It is assumed that the watermains could be placed outside of the paved roadway. The costs are estimated to increase by anywhere from $50 per foot to $100 per foot if watermain must be constructed within the paved roadway, depending on the amount and type of road construction.

Recommended Improvements

General Improvements:

1.	Miscellaneous Water Treatment Plant improvements.	
2.	Replace HS pump No. 3 with adequately sized pump.	$225,000
3.	Repaint and Install a cathodic protection system on 1.0 million gallon reservoir. (1-5 yrs)	$90,000
4.	Recoat the exterior of the State Street water tower along with other miscellaneous improvements (1-5 yrs).	$350,000
5.	Recoat the exterior, wet interior, and part of the dry interior of the Ferris water tower along with other miscellaneous improvements (1-5 yrs).	$199,000
6.	New pump and motor at State Street booster station (7-10 yrs)	$80,000
7.	Clarifier Painting (3-5 yrs)	$110,000
8.	Redundant raw watermain from wellfield to treatment plant (7-10 yrs)	$2,000,000
	General Improvements Total Cost:	**$3,054,000**

Short Term Distribution Improvements:

The short-term distribution improvements include the improvements already planned to be completed within the next five years.

1.	Replace 5,100 feet of 10-inch watermain with 12-inch watermain on Ives Avenue and South Street from Oak Street to S. State Street.	$1,500,000
2.	Replace 1,900 feet of 4-inch and 6-inch watermain with 8-inch watermain on Clark Street from Woodward Avenue to Morrison Avenue.	$228,000
3.	Replace 1,000 feet of 4-inch watermain with 8-inch watermain on Darwin Avenue from Catherine Street to Bjornson Street.	$120,000
4.	Replace 900 feet of 4-inch watermain with 8-inch watermain on Olaf Street from Darwin Avenue to 12-inch watermain north of Speer Avenue.	$108,000
5.	Replace 700 feet of 4-inch watermain with 8-inch watermain on Bjornson Street from Milton Avenue to Speer Avenue.	$96,000
6.	Loop 400 feet of 8-inch watermain on Magnolia Street from Ives Avenue to Winter Street.	$48,000

Short Term Improvements Total Cost:	**$2,100,000**

Long Term Distribution Improvements:

Most of the long-term distribution improvements address existing pipes with excessive breakage and future expansion of the system.

7. Install 6,000 feet of 12-inch watermain on 205th Avenue from 15 Mile Road south to west of Gilbert Road, then east to existing 12-inch watermain.	$780,000
8. Replace 1,400 feet of 6-inch watermain with 12-inch watermain on Northland Drive from Waterloo Street to Williams Street, then west to Marion Avenue.	$182,000
9. Replace 500 feet of 8-inch watermain with 12-inch watermain on Marion Avenue from Williams Street to Fremont Street.	$65,000
10. Replace 600 feet of 4-inch watermain with 12-inch watermain, then continue with 900 feet of 12-inch watermain on West Avenue from Northland Drive to Sheridan Street.	$195,000
11. Replace 1,500 feet of 6-inch watermain with 8-inch watermain on Winter Avenue from Chestnut Street to Cypress Street, then east 90 feet.	$180,000
12. Replace 500 feet of 4-inch watermain with 8-inch watermain on Marion Avenue from Pine Street to Spruce Street.	$60,000
13. Replace 2,100 feet of 4-inch watermain with 8-inch watermain on Colburn Aveune from Bronson Avenue to Third Avenue.	$252,000
14. Replace 600 feet of 6-inch watermain with 8-inch watermain on Dexter Avenue from Baily Drive to cul-de-sac.	$72,000
15. Replace 1,300 feet of 6-inch watermain with 8-inch watermain on Baily Drive from Woodward Avenue to Fuller Avenue.	$156,000
16. Replace 900 feet of 6-inch watermain with 8-inch watermain on Ridgeview Drive from Dexter Avenue to Fuller Avenue.	$108,000
17. Replace 1,200 feet of 4-inch watermain with 8-inch watermain on Stewart Avenue from Elm Street to Spruce Street, then west on Spruce to the alley.	$144,000
18. Replace 1,000 feet of 6-inch watermain with 12-inch watermain on Dekraft Avenue from Milton Avenue N, then install another 1,700 feet to Harding Drive.	$351,000
19. Loop 1,300 feet of 8-inch watermain on Harding Drive from Bjornson Street to 190th Avenue.	$156,000
20. Replace 500 feet of 6-inch watermain with 8-inch watermain on Escott	

Street from Rust Avenue to Sanborn Avenue.	$60,000
21. Replace 400 feet of 6-inch watermain with 8-inch watermain on Finley Avenue from Bellevue Street to Madison Street.	$48,000
22. Install 5,300 feet of 12-inch watermain on Woodward Avenue from the existing 12-inch watermain west of Bailey Dr to Waldron Way.	$689,000
23. Install 2,300 feet of 12-inch watermain on Waldron Way from Woodward Avenue south to the existing 16-inch watermain west of Meijers.	$299,000
24. Install 700 feet of 12-inch watermain on Northland Drive from Gilbert Road to 14 Mile Road.	$91,000
25. Install 1,300 feet of 12-inch watermain on 14 Mile Road from Northland Drive to the University Park Suites, then continue with 6,100 feet of 8-inch watermain to near the Muskegon River.	$901,000
26. Install 2,400 feet of 8-inch watermain on Woodward Avenue from Waldron Way to 220th Avenue.	$288,000
27. Loop 7,100 feet of 8-inch watermain on 220th Avenue from Woodward Avenue south, then east 2,700 feet to 215th Avenue and north 1,400 feet to connect to the existing 12-inch watermain.	$1,344,000
28. Replace 1,800 feet of 6-inch and 8-inch watermain with 12-inch watermain, then continue with 11,600 feet of 12-inch watermain on Northland Drive from Fremont Street to 19 Mile Road.	$1,742,000
29. Install 5,300 feet of 12-inch watermain on 19 Mile Road from Northland Drive to Sheridan Street.	$689,000
Long Term Improvements Total Cost:	**$8,852,000**
TOTAL COST OF ALL RECOMMENDED IMPROVEMENTS:	**$14,006,000**

VII. FUNDING SOURCES

Six possible sources of funding have been identified for the City of Big Rapids to complete the recommended improvement projects if desired. A brief description of each follows:

Drinking Water Revolving Fund

This is a preferred alternative. It is a low interest loan program sponsored by the Michigan Department of Environmental Quality. The current interest rate is 2.5 percent, and some communities may be eligible for principle forgiveness under the Green Project Reserve funding if the project reduces system energy use or provides water conservation.

The program is competitive and projects are scored on a point system that ranks them on a priority list. Not all projects submitted are funded so it is important to maximize points on the application. Requirements include a fairly extensive project plan, but most expenses, including the project plan, are eligible activities that can be rolled into the loan. In order for a community to be competitive, they should have a completed wellhead protection program. Applications are submitted by May 1st of every year.

USDA - Rural Utilities Service Grants or Loans (formerly FHA)

Rural Utility Service offers grants and loans for water improvements to communities with a low to moderate average household income. There are two types of loans available from RUS: direct loans and guaranteed loans.

Direct loans are only issued if the City is unable to obtain funding from other sources at reasonable rates. The current interest rate is approximately 2.75 percent.

Guaranteed loans are made and serviced by lenders such as banks and savings and loan associations. Guarantees will not exceed 80 percent on any loss of interest and principal on the loan.

Special Assessment Bonds

Special assessments levied under PA 188 of 1954 are one of the most common ways to finance infrastructure improvements. The City may levy special assessments against properties that receive special benefits from a public improvement. Property owners have petition rights that must be satisfied before the special assessment can go forward. The current bond rate is approximately 5.0 percent.

Special assessments typically can be repaid in installments with interest. The bonds may not exceed the amount of the special assessment roll, and may be secured secondarily by a pledge of the City's full faith and credit.

Revenue Bonds

Revenue bonds are authorized by PA 94 of 1933. They authorize the City to borrow money and issue bonds. They are paid from user fees generated by the operation of the improvements.

Revenue bonds are subject to the right of referendum. Petitions for a public vote can be filed by registered City voters during a 45-day referendum period. Voter approval is not required if the referendum period expires without petitions being filed. The current bond rate is approximately 5.0 percent.

Contract Bonds

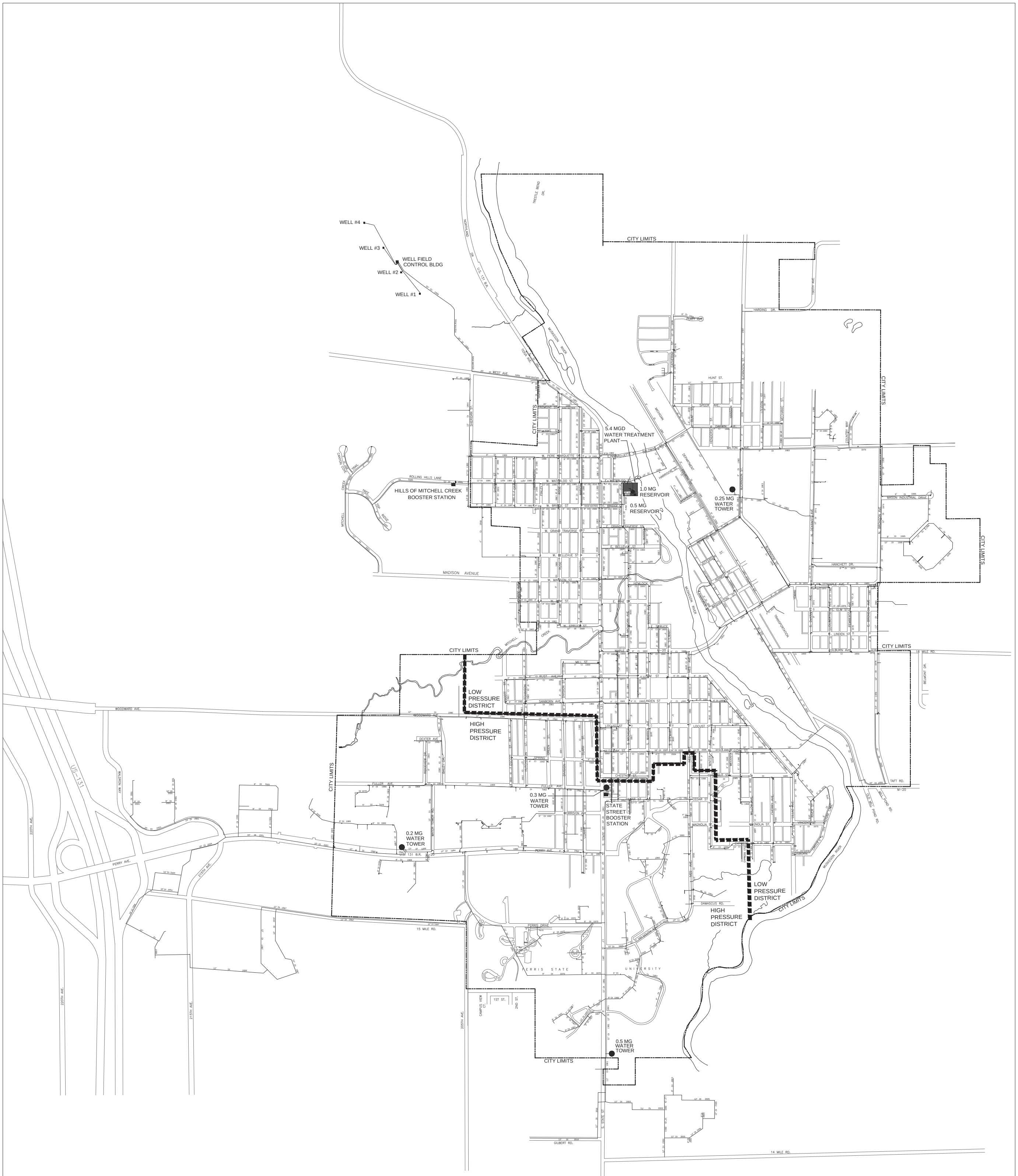
Contract bonds are authorized by several state laws. They authorize the City to enter into an agreement with the County or a public authority in order to have the County or authority issue bonds on behalf of the City.

The City may want to consider a contract bond as the County may be able to borrow at a more favorable rate than the City if they are willing to pledge its taxing power as secondary security for repayment of the bonds. Also contract bonds may be paid back by a number of sources including: specials assessments, connection fees, and user fees. The current bond rate is approximately 5.0 percent.

Economic Development Administration (EDA) and Michigan Economic Development Commission (MEDC)

EDA and MEDC fund infrastructure improvements when a business or industry is interested in locating in a community that will need to provide infrastructure improvements to support the incoming industry.

As an example, if an industry wanted to locate in the City where there is not currently watermain, or the watermain is undersized to serve the business, these organizations could assist in funding the improvements. Also, water supply and/or storage improvements could be funded with grant dollars if the improvements are necessary to support the new business.



EXISTING WATER SYSTEM

LEGEND

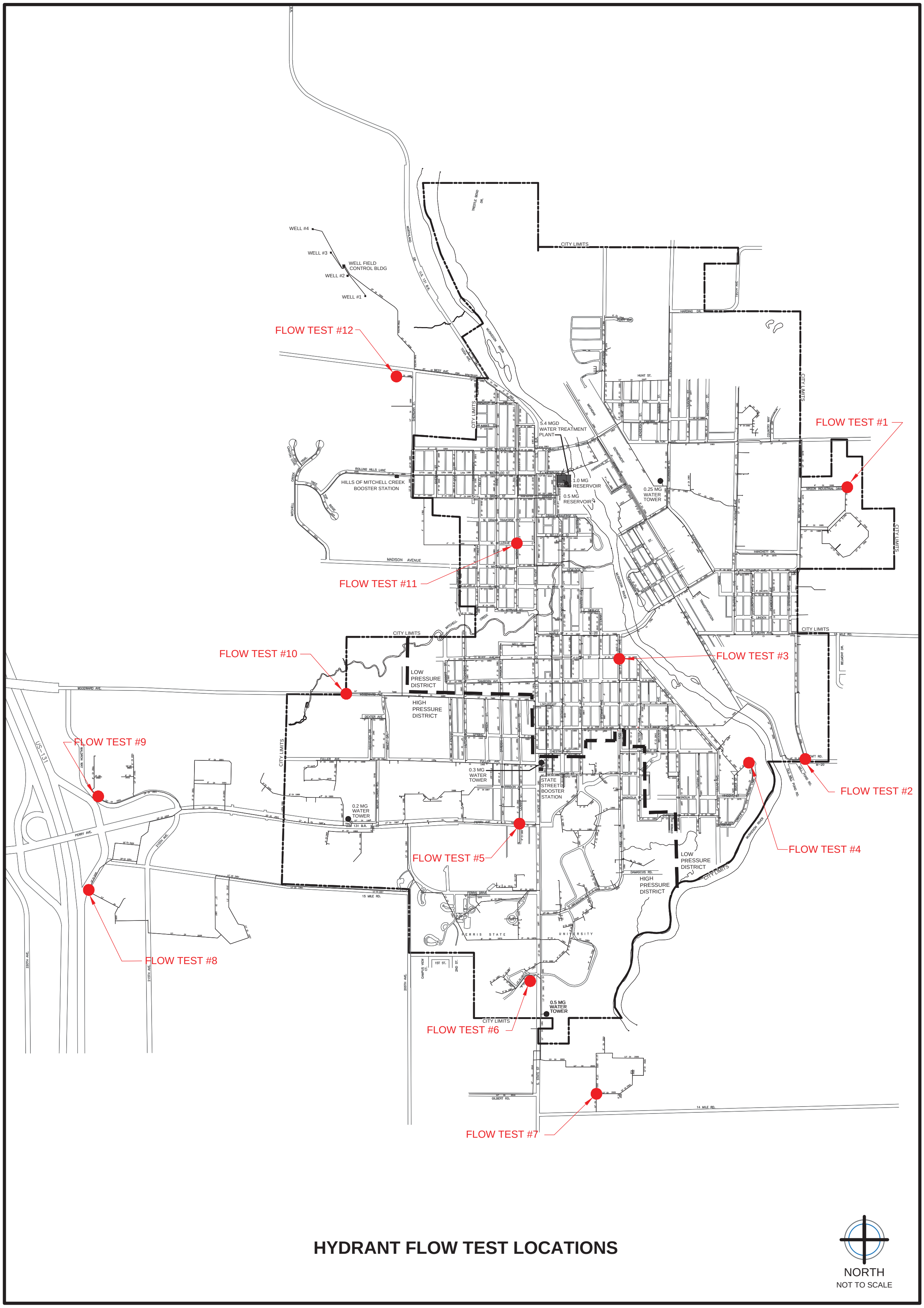
- WATERMAIN WITH SIZE
- FIRE HYDRANT
- VALVES
- PRESSURE DISTRICT BORDER

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 1

F&V PROJECT NO. 825280

F&V



HYDRANT FLOW TEST LOCATIONS

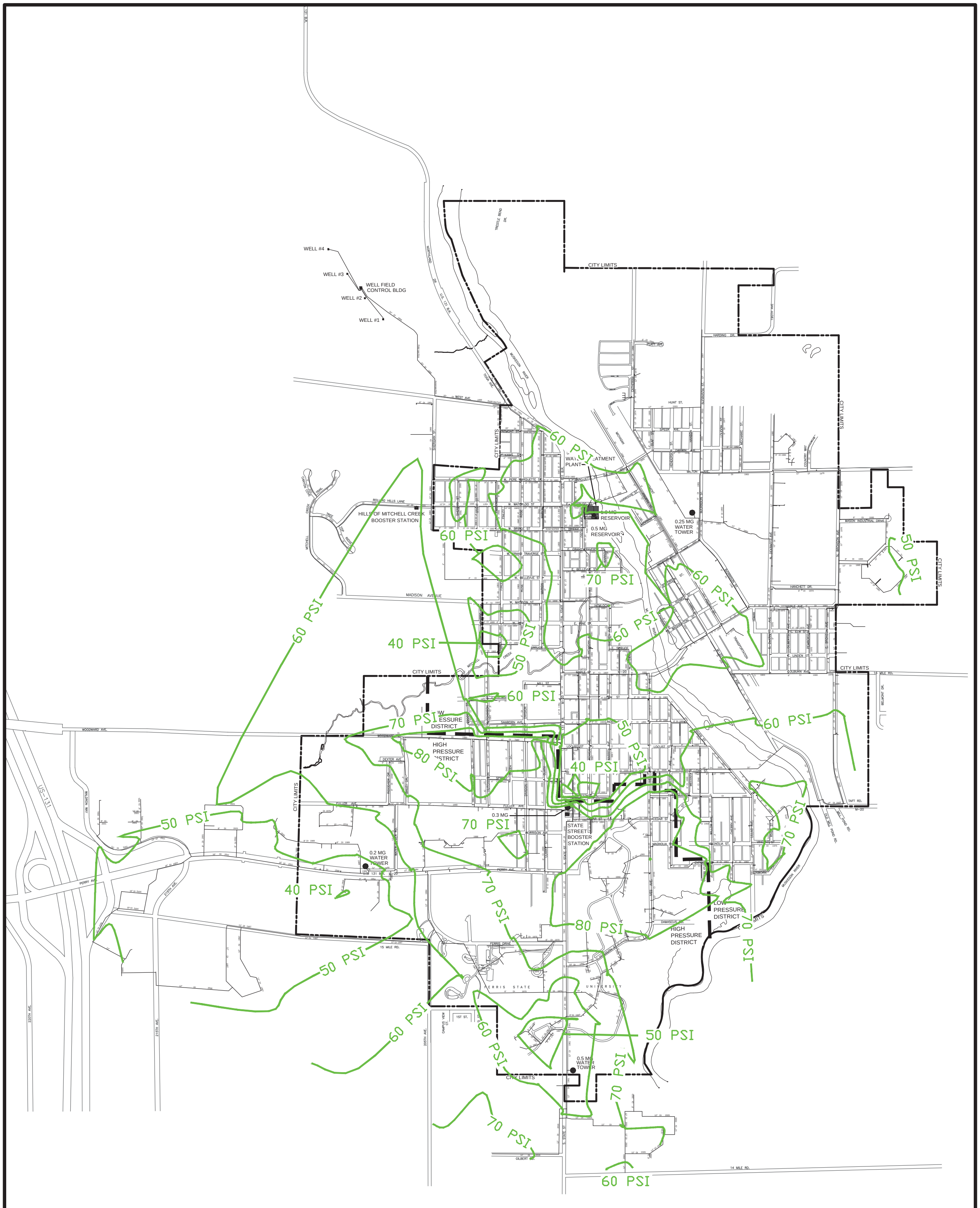
LEGEND

- WATERMAIN WITH SIZE
- FIRE HYDRANT
- VALVES
- PRESSURE DISTRICT BORDER

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 2

F&V PROJECT NO. 825280



EXISTING STATIC PRESSURES

NORTH
NOT TO SCALE

LEGEND

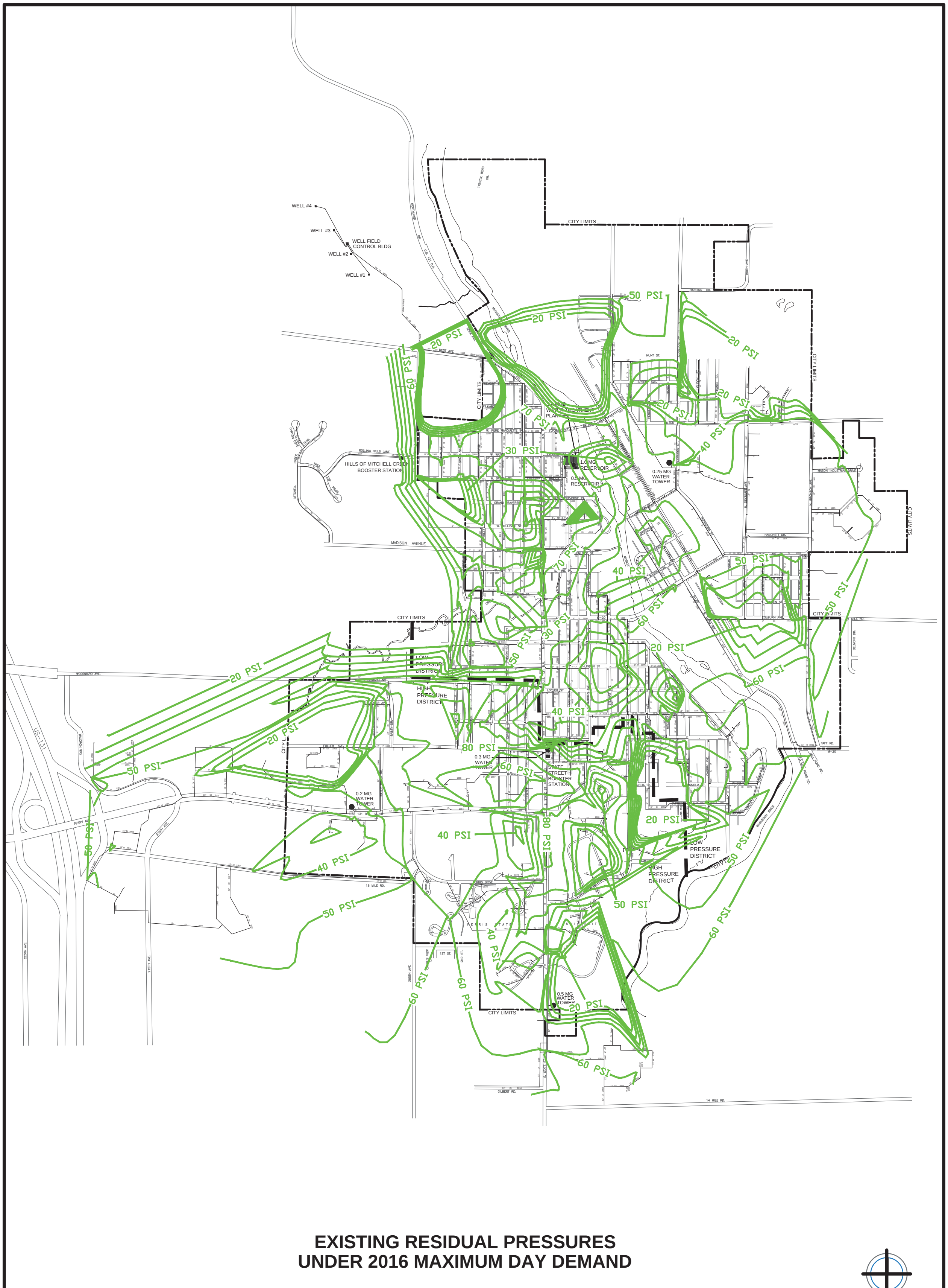
XX PSI — EXISTING STATIC PRESSURE CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 3

F&V PROJECT NO. 825260

F&V



EXISTING RESIDUAL PRESSURES
UNDER 2016 MAXIMUM DAY DEMAND

LEGEND

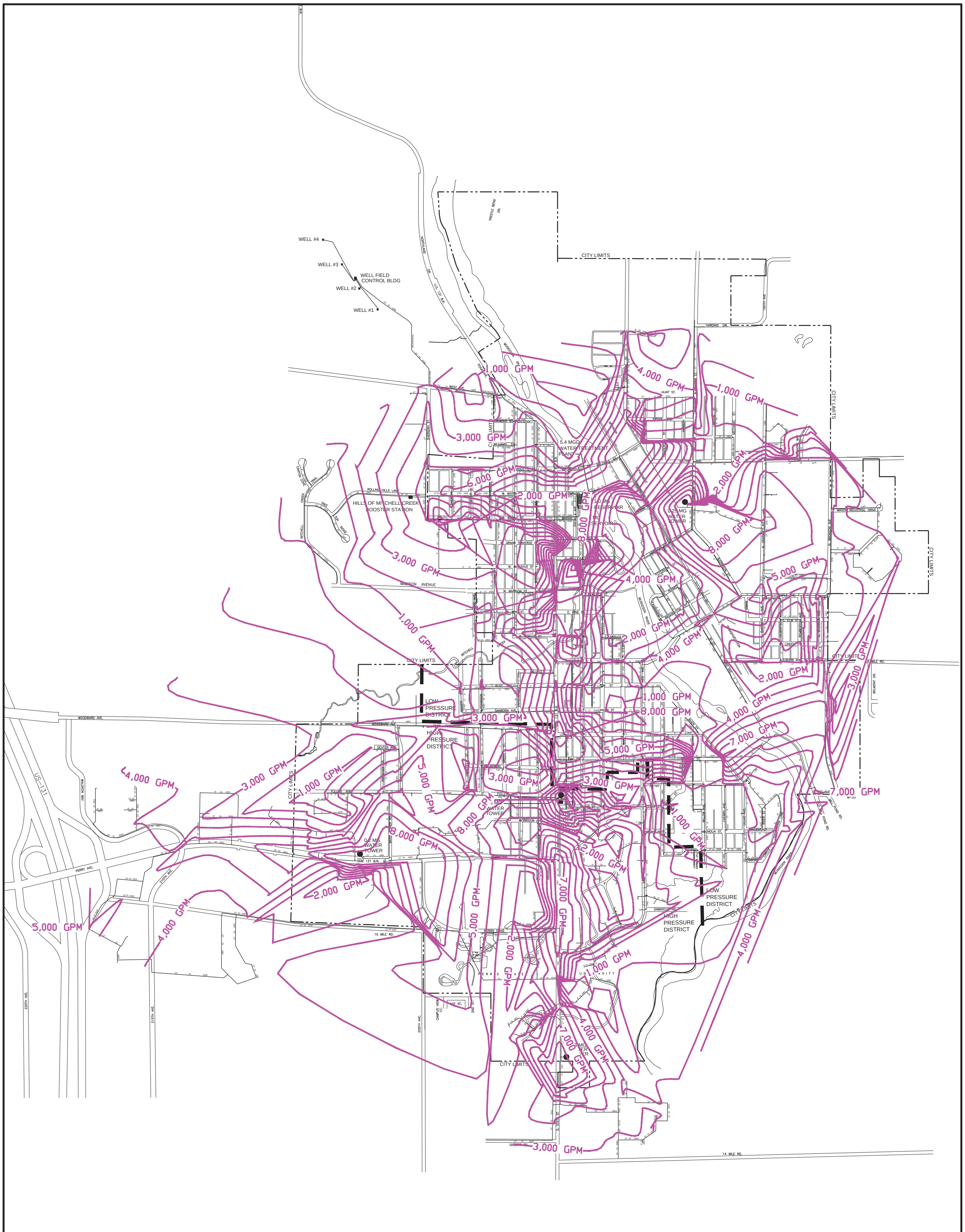
XX PSI — EXISTING RESIDUAL PRESSURE CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 4

F&V PROJECT NO. 825280

F&V



AVAILABLE FIRE FLOWS @ 20 PSI
UNDER 2016 MAXIMUM DAY DEMAND

LEGEND

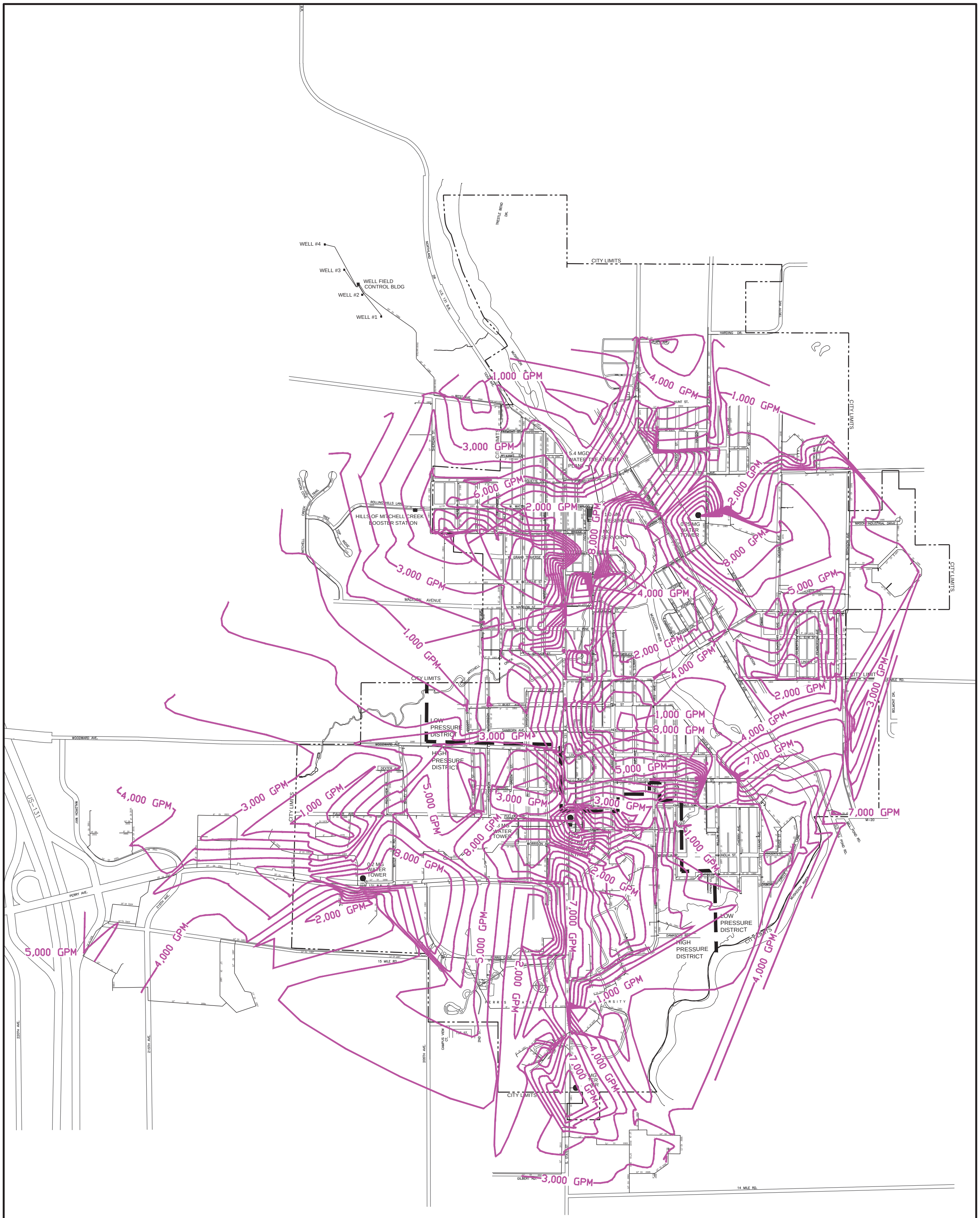
XX PSI — AVAILABLE FIRE FLOW CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 5

F&V PROJECT NO. 825280

F&V



AVAILABLE FIRE FLOWS @ 20 PSI

UNDER 2021 MAXIMUM DAY DEMAND

NORTH
NOT TO SCALE

LEGEND

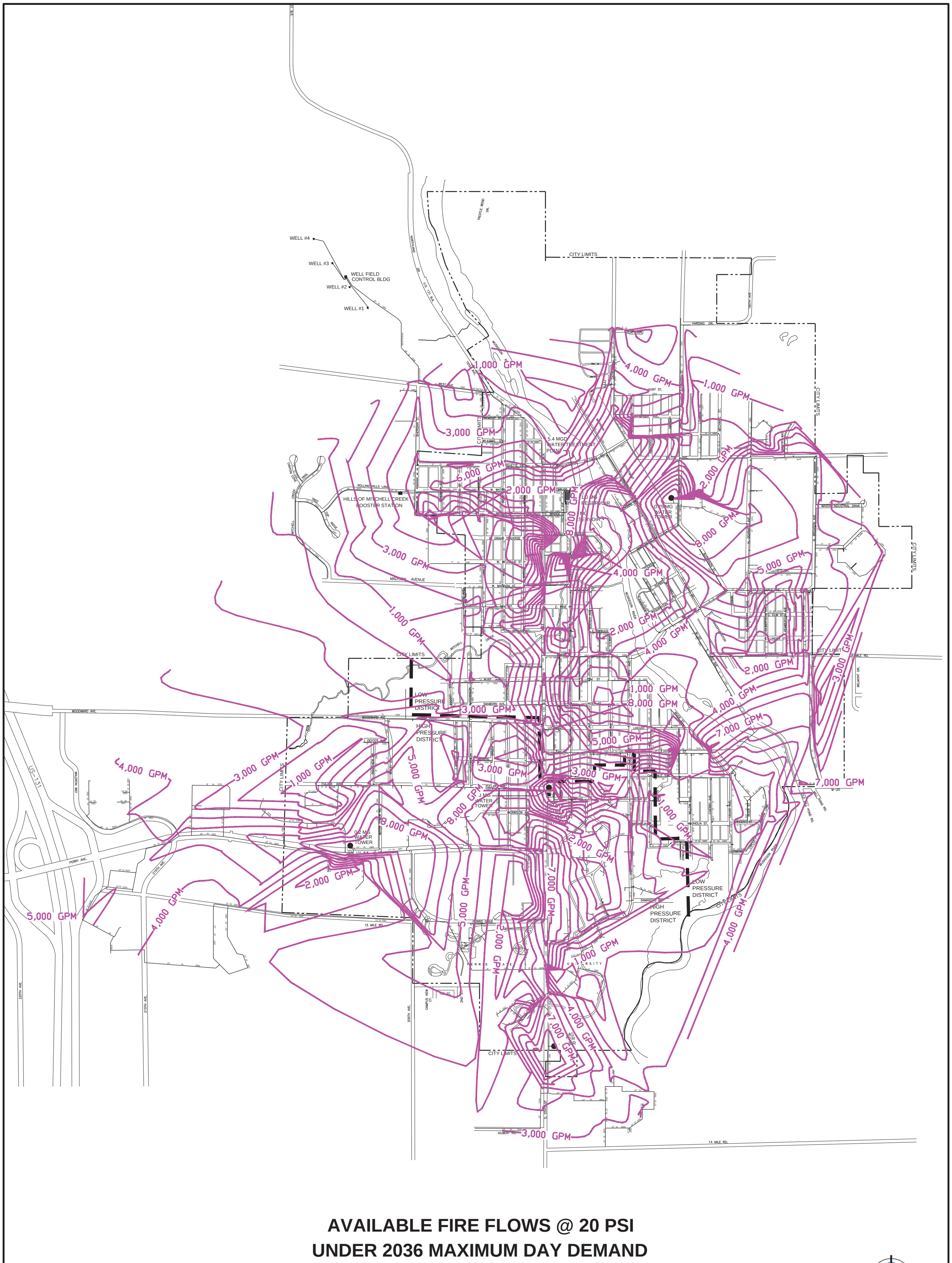
XX PSI — AVAILABLE FIRE FLOW CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 5.1

F&V PROJECT NO. 825280

F&V



AVAILABLE FIRE FLOWS @ 20 PSI
UNDER 2036 MAXIMUM DAY DEMAND

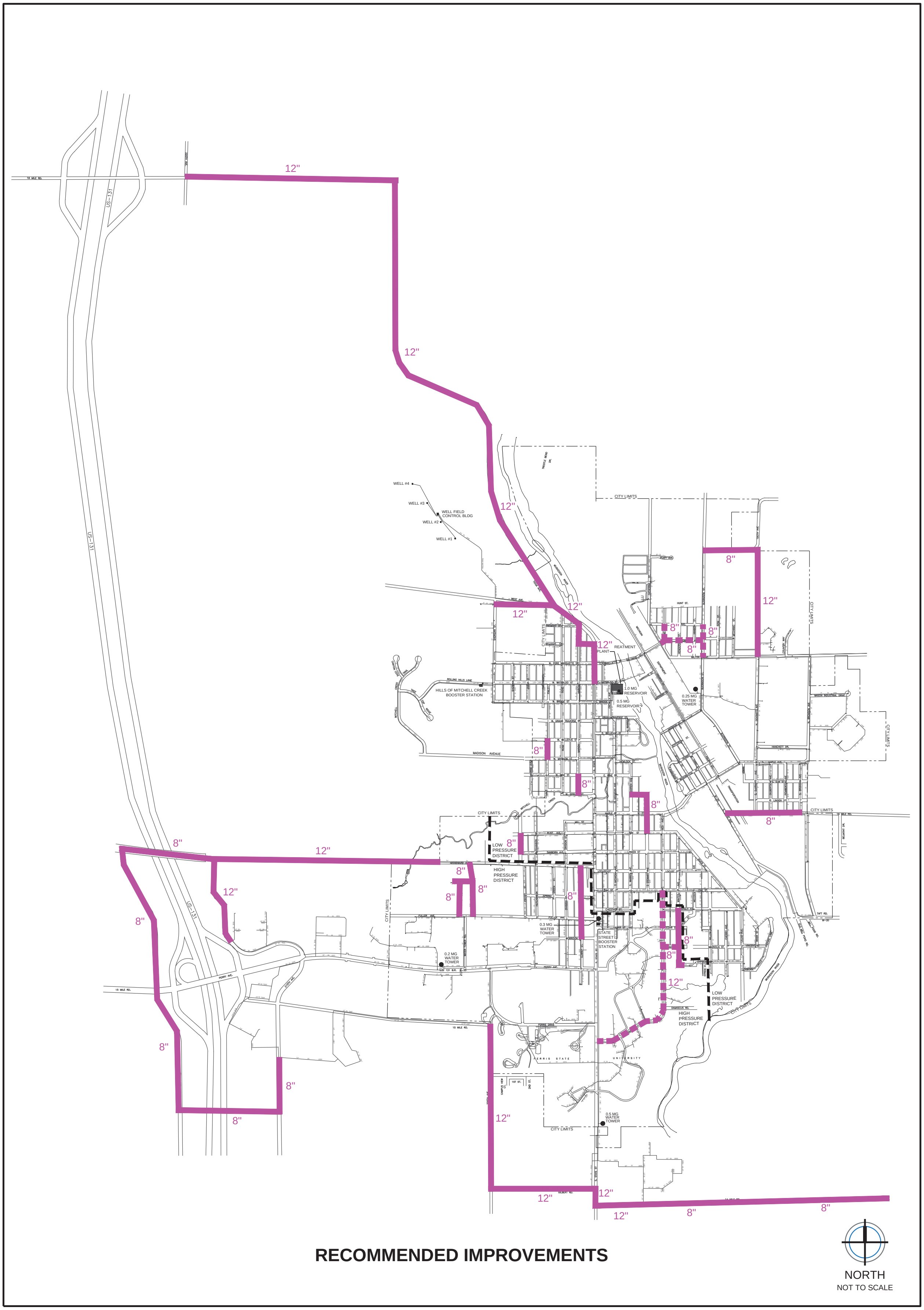
LEGEND

XX PSI — AVAILABLE FIRE FLOW CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 5.2

F&V PROJECT NO. 825280



RECOMMENDED IMPROVEMENTS

LEGEND

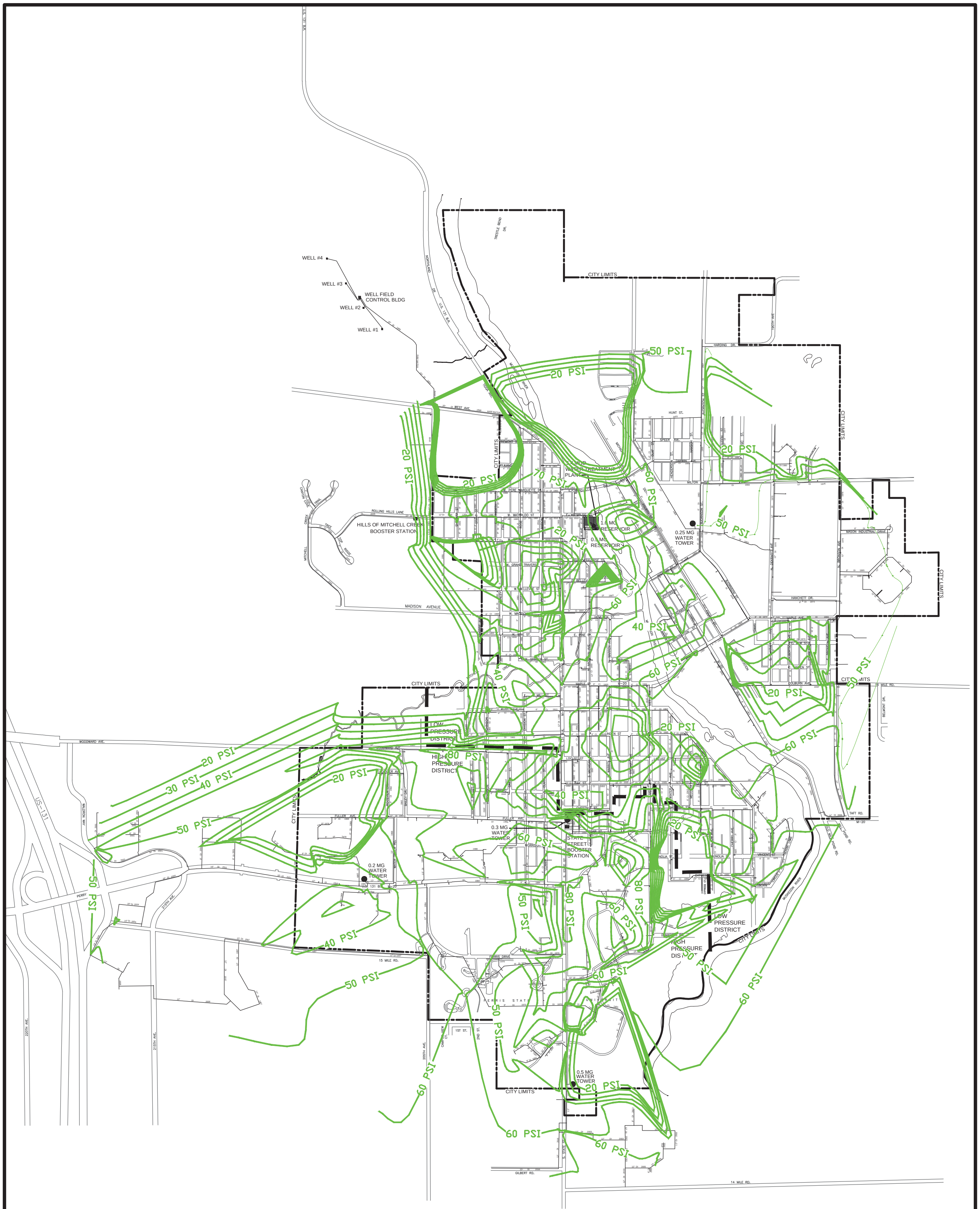
X" (thin line)	EXISTING WATERMAIN WITH SIZE
X" (dashed line)	PROPOSED SHORT TERM WATERMAIN WITH SIZE
X" (solid line)	PROPOSED LONG TERM WATERMAIN WITH SIZE

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 6

F&V PROJECT NO. 825280

F&V



RESIDUAL PRESSURES
UNDER 2021 MAXIMUM DAY DEMAND
WITH RECOMMENDED IMPROVEMENTS

NORTH
NOT TO SCALE

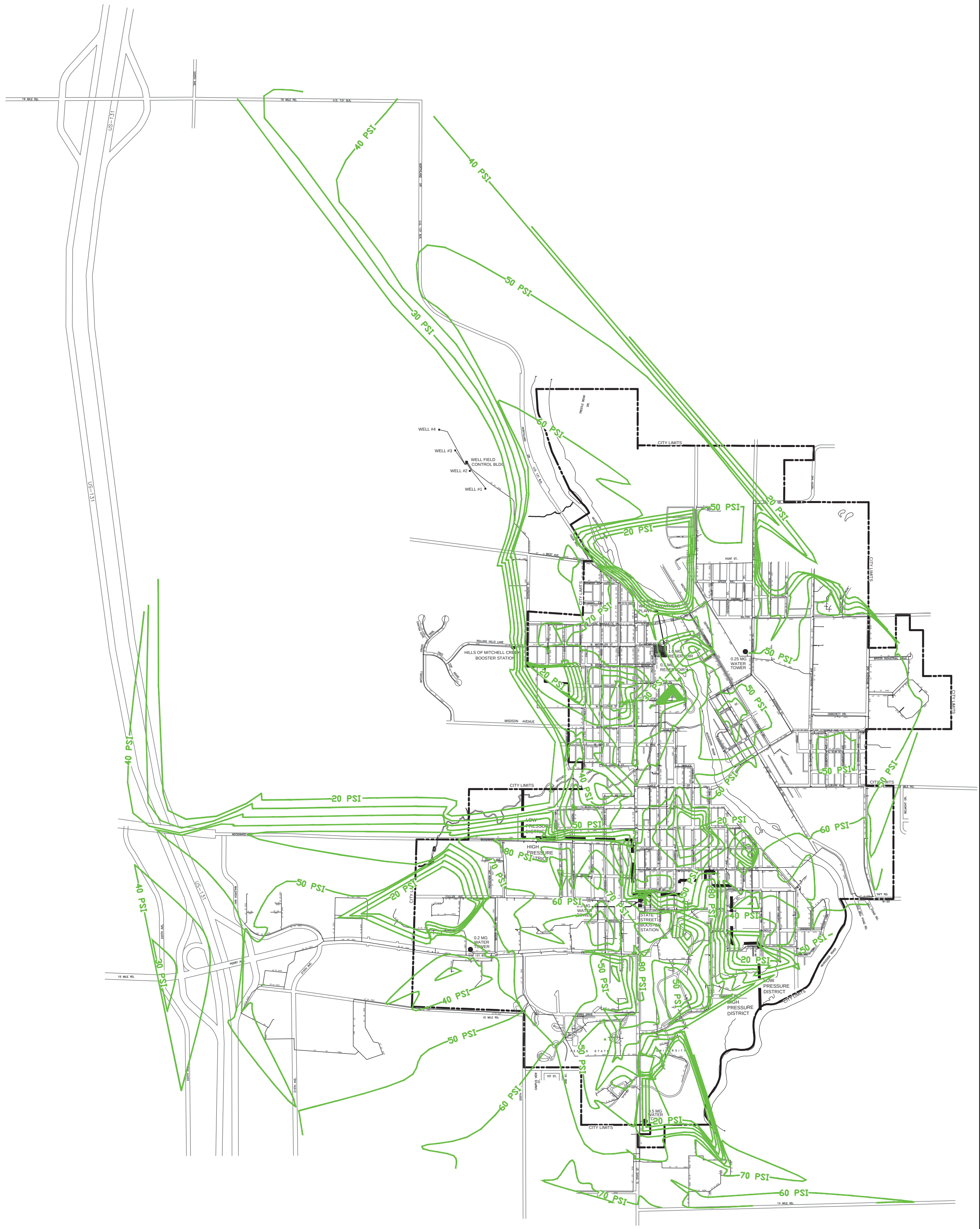
LEGEND

XX PSI — EXISTING RESIDUAL PRESSURE CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 7

F&V PROJECT NO. 825280



RESIDUAL PRESSURES
UNDER 2036 MAXIMUM DAY DEMAND
WITH RECOMMENDED IMPROVEMENTS

NORTH
NOT TO SCALE

LEGEND

XX PSI — EXISTING RESIDUAL PRESSURE CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 7.1

F&V PROJECT NO. 825280

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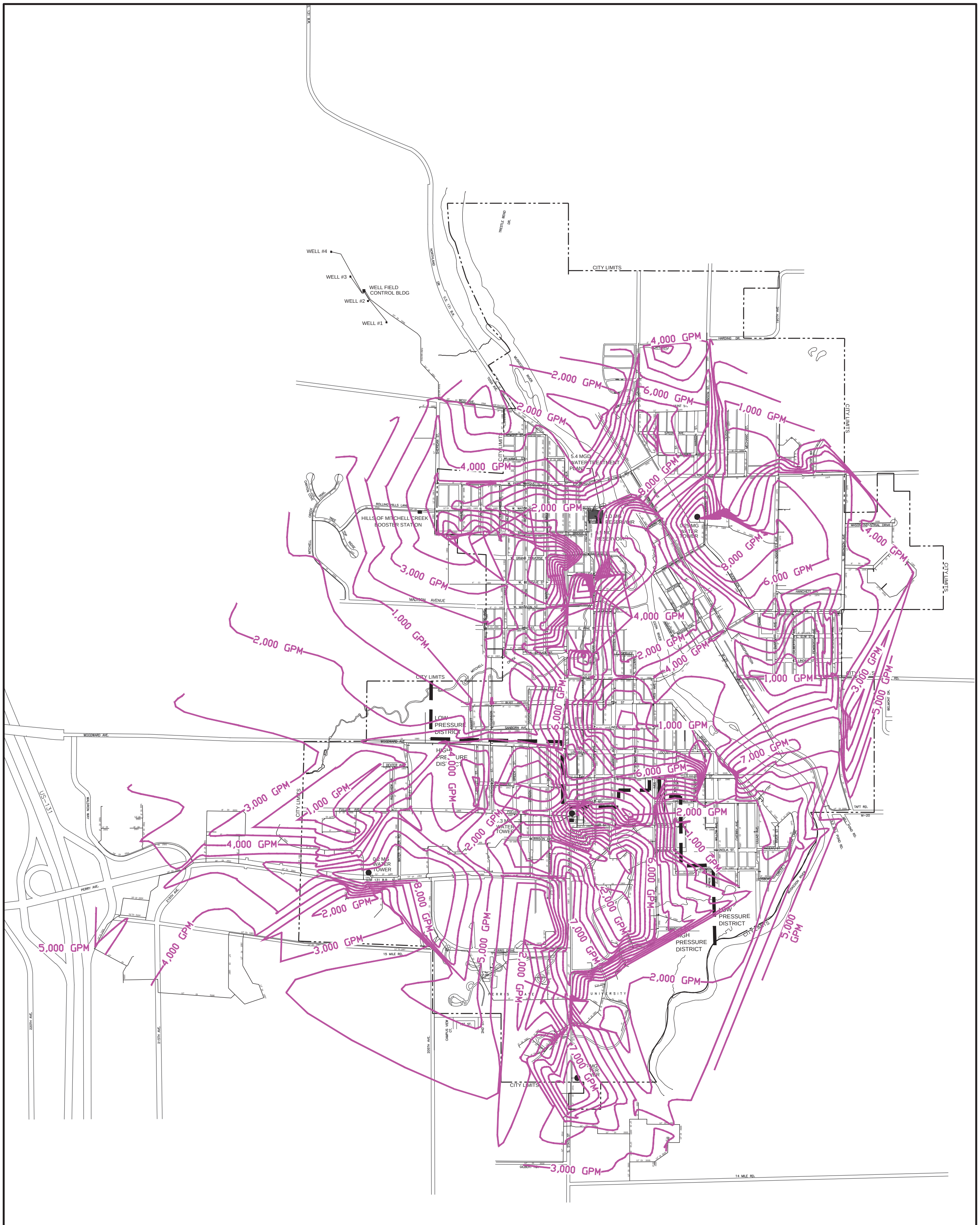


AVAILABLE FIRE FLOWS @ 20 PSI
UNDER 2021 MAXIMUM DAY DEMAND
WITH RECOMMENDED IMPROVEMENTS

LEGEND

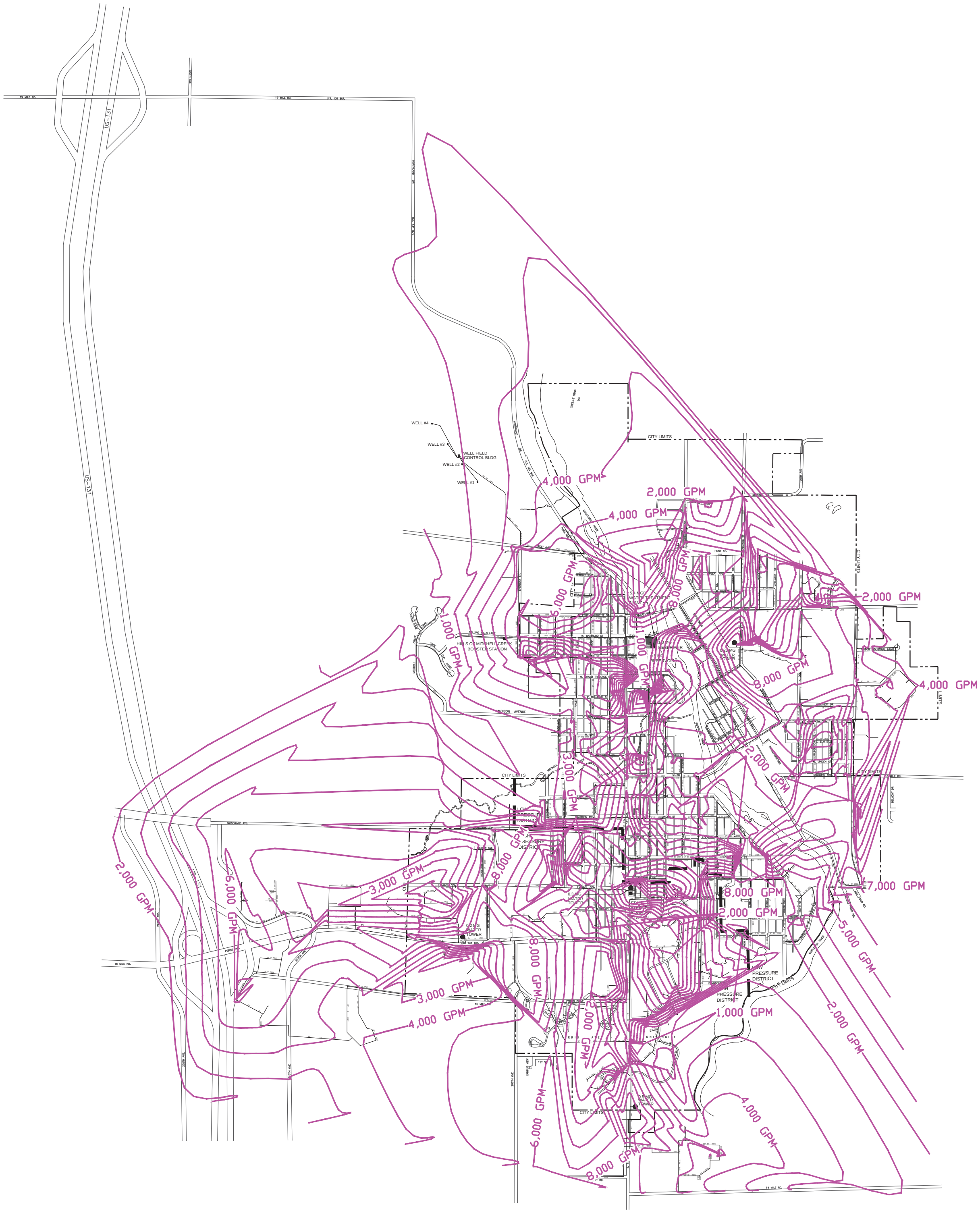
XX PSI — AVAILABLE FIRE FLOW CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 8

F&V PROJECT NO. 825280

F&V



AVAILABLE FIRE FLOWS @ 20 PSI
UNDER 2036 MAXIMUM DAY DEMAND
WITH RECOMMENDED IMPROVEMENTS

NORTH
NOT TO SCALE

LEGEND

XX PSI — AVAILABLE FIRE FLOW CONTOURS

CITY OF BIG RAPIDS
MECOSTA COUNTY, MICHIGAN

WATER RELIABILITY STUDY
FIGURE 8.1

F&V PROJECT NO. 825280

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