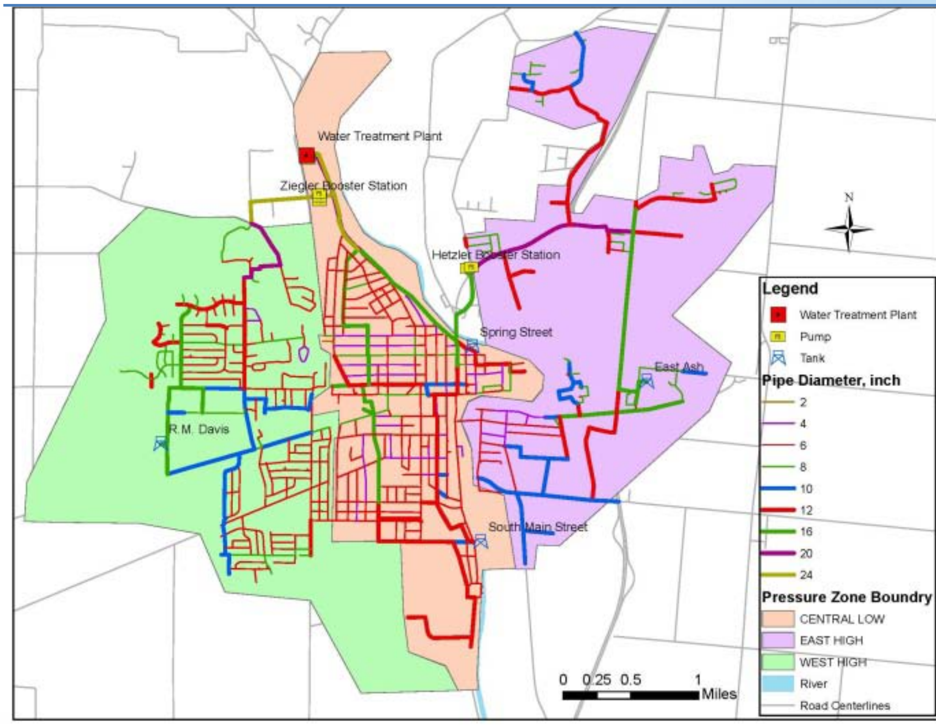
FINAL REPORT



Water Distribution System Master Plan

Prepared for

The City of Piqua

July 2012

City of PIQUA Ohio

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Table of Contents

Appendices

Tables

Figures

Executive Summary

Introduction

The City initiated this Water Distribution System Master Plan to accomplish two primary goals:

- Identify capital improvements required to meet the City's current and future customer demand over a 20-year planning period. Create a dependable and calibrated hydraulic computer model to analyze the City's water distribution system and identify the needed improvements.
- Evaluate the impacts of supplying finished water from the City of Troy, and identify required capital improvements to distribute water from the new supply source to the City's current and future customers over a 20-year planning period.

System Overview

The City of Piqua owns and operates a surface Water Treatment Plant (WTP), which is designed to produce up to 7.0 million gallons per day (MGD) of drinking water. Once the water is treated by the WTP, four high service pumps deliver finished water to the distribution system.

The City maintains a water distribution system that includes a high service pump station at the plant, 2 booster stations, and 4 elevated tanks, approximately 110 miles of water distribution mains up to 24-inches in diameter, as well as numerous valves and fire hydrants throughout the system. The system is divided into three Pressure Zones, known as, Central Low, West High, and East High Pressure Zones.

It was understood that during normal operational conditions, only high service pump No. 4 at the WTP is running constantly. The high service pump No. 4 is equipped with a Variable Frequency Drive (VFD) which is used to control the discharge pressure at approximately 68 psi. The Ziegler Road and Hetzler Road Booster Stations are manually controlled based on water levels in the storage facilities, which means that the operators manually turn on and off the pumps according to the operation guidelines. In modeling the pump station controls, manual operation guidelines were used to set the facility controls where appropriate.

Model Development

The City had an existing model developed by Black & Veatch (B&V) which was used as the base for the new model development. The updated model was developed in the latest version of WaterGEMS, Version 8i (SELECT Series 1), and included junctions, water mains, pumps and storage facilities. Separate pressure zones were delineated by closing of boundary valves. However, to be consistent with the City's operational practice during the model development and calibration, there are two locations where the valves between West High and Central Low, and East High and Central Low are open.

The City provided total finished water pumping data from the WTP for the past four years, as well as historic water billing data (September 2009 to August 2011) for all residential, commercial, and industrial accounts. Analysis of these pumping data indicated the average day plant pumping rate decreased in 2009 and 2010, compared to the 2007 and 2008 years, from 3.1 to 2.7 mgd.

The maximum daily demand factors (ratio of maximum day demand to average day demand) ranged from 1.32 to 1.55 for the past four years. To be conservative, a maximum daily demand factor of 1.55 is used in the analysis.

CDM Smith also collected City's historical water billing records. Each water account was geo-coded in the GIS to represent the physical location of the account. The demands were then allocated to the appropriate modeled junctions by using the GIS applications.

Field Tests

Field data collection was performed to collect distribution system information that was used in the development and calibration of the hydraulic model. Field tests performed in the City's water distribution system included pump testing, hydrant pressure recording, and hydrant flow tests.

Pump testing was conducted at all nine pumps that the City currently operates, including the four High Service Pumps at the Water Treatment Plant, three pumps at the Ziegler Road Booster Station, and two pumps at the Hetzler Road Booster Station.

To provide data for the Extended Period Simulation (EPS) model calibration, hydrant pressure recoding was conducted at six hydrants, two in each pressure zone, West High, Central Low, and East High, during the period of September 7 to 23, 2011.

To sufficiently stress the system and calibrate C factors, a total of twelve hydrant flow tests were conducted throughout the system, including six locations in the Central Low Pressure Zone, four locations in the West High Pressure Zone, and two locations in the East High Pressure Zone.

Model Calibration

The model was calibrated both steady-state and EPS conditions.

The model achieved a high level of steady-state calibration with the model results within 5 psi of the measured field test data at all locations.

The EPS calibration results indicated a high level of correlation of modeled vs. field tested results on both pressure recorder readings and tank levels.

Demand Projections

The approach in developing future flows is consistent with that used in the Piqua Water Treatment Plant – Preliminary Engineering Report (PER).

The future land use is categorized as three usage types, commercial, industrial, and residential. In addition to the growth from zoning maps, the projection also accounted for redevelopment areas, which is 20 areas totaling 647 acres of currently vacant or un-serviced industrial and commercial sites.

Once the areas of future development were identified, a unit water demand factor was used to calculate future water demands. To develop the unit factor, historical water billing data was referenced.

For the future build-out scenario, average day water demand for the City is estimated at 8.03 MGD, including a 15% UFW factor.

To develop water demand for year 2030, it was assumed that the commercial and industrial areas will be fully developed. Residential demand for year 2030 is based on Traffic Analysis Zone (TAZ) data from the Miami Valley Regional Planning Commission (MVRPC). For the 2030 scenario, average day water demand for the City is estimated at 5.98 MGD, including a 15% UFW factor.

System Evaluation and Alternative Analysis

The model used for the analysis was the calibrated extended period simulation (EPS) model for the existing system and 2030 time horizon. Alternative water sources analyzed included a new Water Treatment Plant or a finished water supply from the City of Troy. Therefore, the four scenarios analyzed are:

- Existing demand with water supplied from the City's existing WTP
- Existing demand with water supplied from Troy
- 2030 demand with water supplied from the City's new WTP
- 2030 demand with water supplied from Troy

Storage analysis demonstrates that Central Low pressure zone has insufficient storage for both current and 2030 conditions. The East High pressure zone will have insufficient storage for the 2030 condition. The overall system storage requirement is met as the combined system storage of 3.6 MG exceeds the current average day demand of 2.91 mgd. However, additional storage is required as the average day demand increases to 5.98 mgd in year 2030.

Model runs were conducted under maximum day demand to verify that the minimum pressure throughout the system is above 40 psi for both current and 2030 conditions. Two alternatives were analyzed, one is with existing or proposed new Water Treatment Plant, and the other is with water supplied from Troy.

With the WTP scenario, under the current maximum day demand condition, all system pressure is above 40 psi. Minimum pressure for most areas falls between 60-100 psi. Higher pressure of 100-120 psi is observed in the Shawnee area in the East High pressure zone due to lower elevation, which is acceptable. Lower but acceptable pressure of 40-60 psi is observed in the west side of the Central Low pressure zone due to higher elevation.

With the WTP scenario, under the 2030 maximum day demand condition, low pressure mainly occurs in the East High pressure zone due to greatly increased water demand. At the same time, the East Ash Street elevated tank serving this pressure zone cannot be filled. During this model run, the two pumps at the Hetzler pump station are both turned on but cannot meet the high demand in the East High pressure zone in 2030, which indicates that there is inadequate capacity at the Hetzler Road pump station to supply the East High pressure zone in 2030.

With the Troy scenario, under the current maximum day demand condition, slightly lower system pressure is observed with the Troy supply alternative; however, no pressure lower than 40 psi is observed. The lowest pressure is located in the west border of Central Low pressure zone due to higher elevation. Minimum pressure for most areas falls between 60-100 psi. Higher pressure of 100-

120 psi is observed in the Shawnee area in the East High pressure due to lower elevation, which is acceptable.

With the Troy scenario, under the 2030 maximum day demand condition, minimum pressure of lower than 40 psi is observed throughout the system, indicating the water mains proposed are not capable of supplying the maximum day demand for the City of Piqua in 2030.

Fire flow analysis was conducted to verify that the system has sufficient fire flow capacity. Several large industrial users were identified and the locations were dispersed throughout all pressure zones. The analysis indicated insufficient fire flow capability at Hartzell Industries, located on 1025 S. Roosevelt Ave., as the area is supplied mainly by 6 inch pipes.

Recommended Improvements

After identifying deficiencies in system performance for both current and 2030 scenarios and both WTP and Troy supply scenarios, solutions were identified that will meet the performance criteria. The decision point for a pipe improvement is minimum pressure of less than 40 psi under maximum day demand (unless certain exceptions were taken). When a pipe improvement is recommended, the improved pipes (parallel or upsize) are sized to meet the demand requirements of the ultimate build-out scenario because the life-span of water mains far exceeds the 20 year planning horizon. Larger transmission mains were evaluated for redundancy so that each of any parallel transmission main would be able to supply the maximum day water demand by itself if the other transmission line would be out of service due to a main break.

The recommended improvements include pipe, storage, and pump station improvements. Two water-supply scenarios were analyzed. The first scenario assumes that the finished water supply is from the City of Piqua's Water Treatment Plant (current or new). The second scenario assumes the finished water supply is from the City of Troy.

Once the recommended projects are identified, they are prioritized into two phases.

Phase I:

The first priority of implementation is to complete the projects which resolve existing deficiencies and problems. Deficiencies include lack of effective storage capacity in the Central Low pressure zone. This is the highest priority improvement. Phase I also includes either the new WTP or new transmission mains to facilitate a new supply from Troy. There are other known system issues that the City has identified regarding looping, replacement of small distribution lines, and replacing lines that experience frequent main breaks.

Phase II:

The infrastructure components necessary for serving additional demands of 2030 were identified by analyzing the system for deficiencies. The timing of the growing demands is difficult to predict, therefore, some projects may need to be initiated when planned development occurs, which may occur sometime up to 2030.

The total projected capital cost for the distribution system improvement plan is approximately $12.2 million for the WTP scenario (not including costs of WTP and interconnecting transmission mains), and $20.8 million for the Troy supply scenario (not including costs of facilities from the Troy WTP to booster station at County Road 25A and Farrington Rd., the new booster pump station, and any necessary improvements to the Troy WTP).

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Section 1

Introduction

The City of Piqua is a community of approximately 20,000 people in west central Ohio along the banks of Great Miami River. The City is located at the intersection of I-75 and State Route 36 in Miami County. The City owns and operates a water distribution system to meet the demands of its residents, businesses, and industries in the water service area, as well as to provide fire protection.

The City initiated this Water Distribution System Master Plan to accomplish two primary goals:

- Identify capital improvements required to meet the City's current and future customer demand over a 20-year planning period. Create a dependable and calibrated hydraulic computer model to analyze the City's water distribution system and identify the needed improvements.
- Evaluate the impacts of supplying finished water from the City of Troy, and identify required capital improvements to distribute water from the new supply source to the City's current and future customers over a 20-year planning period.

This report is a summary of the work completed on the project and a discussion of the phasing and timing of proposed capital projects that were determined to be beneficial to the system. Each task of the project is summarized in this report, including the following sections:

Section 2 – System Overview

Section 3 –Model Development

Section 4 – Field Tests

Section 5 – Model Calibration

Section 6 – Demand Projections

Section 7 – System Evaluation and Alternative Analysis

Section 8 – Recommended Improvements

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Section 2
System Overview

This section provides an overview of City of Piqua's water distribution system and a summary of the system operational parameters. To understand the operation of the City's distribution system, CDM Smith obtained information for the following water distribution facilities:

- Water Treatment Plant (WTP) – High Service Pumps (4)
- Ziegler Road Booster Station - Pumps (3)
- Hetzler Road Booster Station - Pumps (2)
- R.M. Davis Elevated Storage Tank (1.5 MG)
- Spring Street Elevated Storage Tank (0.25 MG)
- South Main Street Elevated Storage Tank (0.25 MG)
- East Ash Street Elevated Storage Tank (1.0 MG)

The information and data used in this report was mainly obtained from the following sources:

- City's previous water model
- Discussions and communications with the City staff
- City's GIS to-date
- Record drawings for the WTP, storage tanks, and newly constructed water mains

A description of these system components and operational parameters are provided below.

2.1 System Overview

The City of Piqua owns and operates a surface Water Treatment Plant (WTP) on State Route 66 north of the City. The plant is designed to produce up to 7.0 million gallons per day (MGD) of drinking water. The WTP has undergone the many improvements and additions in the years since the original construction in 1925. The current plant provides conventional treatment through clarification, lime-soda softening, stabilization, filtration, fluoridation, and disinfection. Once the water is treated by the WTP, four high service pumps deliver finished water to the distribution system.

The City maintains a water distribution system that includes a high service pump station at the plant, 2 booster stations, and 4 elevated tanks, approximately 110 miles of water distribution mains up to 24-inches in diameter, as well as numerous valves and fire hydrants throughout the system. The system is divided into three Pressure Zones, known as, Central Low, West High, and East High Pressure Zones.

To develop a hydraulic model of the distribution system, it is critical to understand the inter-relationships among the facilities and Pressure Zones. **Table 2-1** through **Table 2-3** presents a summary of the City's distribution system major facilities. The WTP, booster stations and tanks are listed for each Pressure Zone. All the information presented in the tables was input into the model to accurately simulate the operating behavior of the distribution system. A system schematic is provided in **Figure 2-1**. **Figure 2-2** shows the locations of the WTP, booster stations, pressure zone boundaries and location of elevated tanks.

Table 2-1 Water Treatment Plant Pump Name Plate Data

Facility	Location (Pressure Zone)	Pump	Design Capacity, gpm	Design Head, ft	Horsepower, Hp
High Service Pumps	Central Low	HS_1	2,260	200	NA
		HS_2	NA	NA	200
		HS_3	3,500	200	250
		HS_4	NA	NA	250

NA – name plate data not readable.

Table 2-2 Booster Stations Pump Name Plate Data

Facility	Location (Pressure Zone)	Pump	Design Capacity, gpm	Design Head, ft	Horsepower, Hp
Ziegler Road Booster Station	West High	Z_1	2,000	100	75
		Z_2	2,000	100	75
		Z_3	2,000	100	75
Hetzler Road Booster Station	East High	H_1	1,500	100	60
		H_2	1,500	100	60

Table 2-3 Storage Facilities Data

Facility Type	Facility	Location (Pressure Zone)	Size, MG	Bottom Capacity Elevation, ft	Maximum Water Level, ft	Overflow Elevation, ft
Elevated Tank	R.M. Davis	West High	1.5	1,100	40	1,140
	Spring Street	Central Low	0.25	987.5	30.9	1,018.4
	South Main Street	Central Low	0.25	958	31	989
	East Ash Street	East High	1.0	1,076.5	40.5	1,117
Below Ground Storage	Clearwells at WTP	Central Low	0.55	865	13	878

Figure 2-1 Existing Water Distribution System Schematic

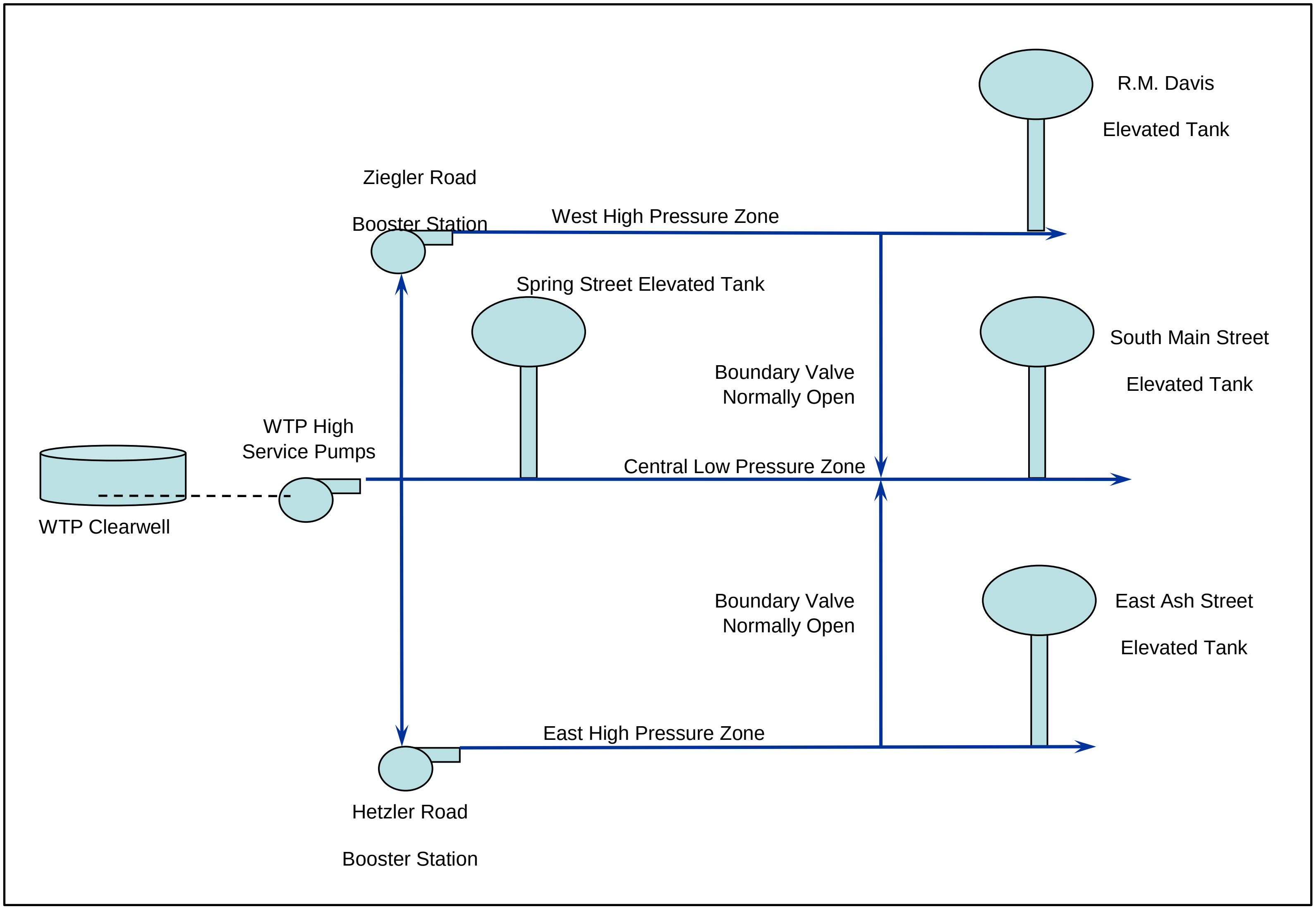
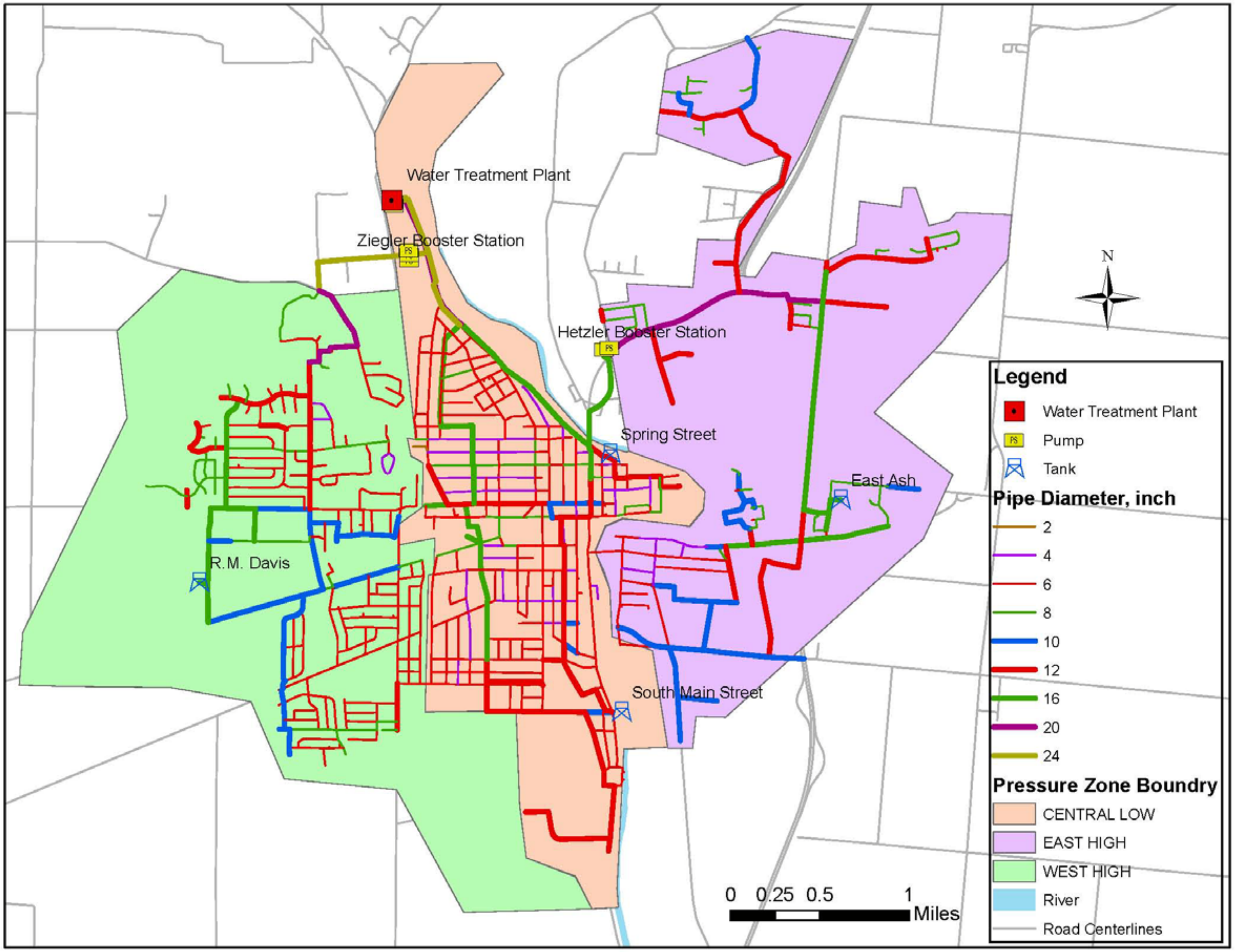


Figure 2-2 Existing Water Distribution System Overview Map



2.2 Review of System Operations

It was understood that during normal operational conditions, only high service pump No. 4 is running constantly. The high service pump No. 4 is equipped with a Variable Frequency Drive (VFD) which is used to control the discharge pressure at approximately 68 psi. The Ziegler Road and Hetzler Road Booster Stations are manually controlled based on water levels in the storage facilities, which means that the operators manually turn on and off the pumps according to the operation guidelines. In modeling the pump station controls, manual operation guidelines were used to set the facility controls where appropriate.

2.2.1 WTP High Service Pump Station

The WTP pump station includes a total of 4 High Service pumps, which takes suction from the WTP Clearwell. Typically only pump No. 4 is operated and three other pumps remain off. The pump No. 4 is equipped with VFD and is used to control the discharge pressure from the WTP at approximately 68 psi. Pump No. 1 at the WTP is equipped with diesel engine.

2.2.2 Central Low Pressure Zone

The Central Low Pressure Zone is served by the high service pumps from the WTP. This zone also contains two elevated storage tanks (0.25 MG each) that remain full most of the time.

The City currently keeps two boundary valves open, one is between the West High and Central Low pressure zones on Linden and Manier, and the other is between the East High and Central Low pressure zones on Main and Miami. Due to low Hydraulic Grade Lines (HGL), the two elevated storage tanks in the Central Low pressure zone (Spring Street tank and South Main tank) stay full and are only used during emergency situations.

2.2.3 West High Pressure Zone

This zone is located west of Forest Avenue, Washington Avenue and Linden Avenue and is supplied by the Ziegler Road booster station. This station is an in-line booster station that takes suction from the Central Low Pressure Zone through a 24-in water main. The booster station has three pumps that supply water to the R.M. Davis Elevated Tank and the surrounding area. Typically only one pump is operated which is manually controlled based on the water level from the R.M. Davis Elevated Tank. The City desires to maintain the water level in the R.M Davis tank between 162 and 167 feet.

2.2.4 East High Pressure Zone

This pressure zone is located east of Great Miami River. The Hetzler Road booster station serving this zone is an in-line station that takes suction from the Central Low Pressure Zone through a 16-in water main. The pump station has two pumps that supply water to the East Ash Elevated Tank and the surrounding area. Typically only one pump is operated which is manually controlled based on the water level from the East Ash Elevated Tank. The City desires to maintain the water level in the East Ash tank between 151 and 157 feet.

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Section 3

Model Development

This section provides a review of the steps involved in the development of the updated hydraulic model and demand development/allocation.

3.1 Model Network Development

The City had an existing model developed by Black & Veatch (B&V) which was used as the base for the new model development. This previous model was a steady state model created in WaterGEMS software Version 8.11. Since this model was more than five years old, it was concluded that the water demand allocation was outdated and water demands needed to be reallocated using the most up to date water billing data. Furthermore, the model was a steady-state model. To provide a better evaluation of the City's distribution system, an extended-period-simulation (EPS) model is required.

Therefore, the previous model was updated for this project based on 2010 water billing data and any new water main improvements. The updated model was developed in the latest version of WaterGEMS, Version 8i (SELECT Series 1).

3.1.1 GIS Development

A GIS database of the City's existing water distribution system was developed based on the previous model. Early in the project, it was observed that the water mains in the model did not contain the appropriate coordinates and therefore did not match up with the County's GIS background layers. In order to develop a model that accurately described the system, locations of the water mains were adjusted in the GIS environment by overlaying the County's GIS background files, such as streets, and aerial photos. The GIS database was also re-projected to the NAD 83 Ohio State Plane Coordinates – Ohio South, which is consistent with what is being used in the GIS background files.

As a result, the GIS database contains system water mains, tanks, and pump stations. All the GIS layers contain the same coordinate system and line up with the GIS background files.

3.1.2 Water Mains and Junctions

All water mains and junctions were imported into the updated WaterGEMS model. No model skeletonization was performed. In summary, the updated model contains approximately 900 pipe segments and 600 junctions. Attributes like pipe diameter and material data were obtained from the old model. Water main age (installation year) was obtained from City map describing the general age of the distribution system areas. This map was used to estimate the age of the water mains, assuming water mains were constructed during the same time period as the area was developed. Pipe length is scaled length in the GIS model environment. Junction elevations were calculated from 2-foot elevation contour files in GIS.

The updated model also contains up to date water main improvements, such as the 16-in on Gordon that connects Water and High on Downs Street, and new water mains on County Road 25A.

The network connectivity was examined and verified before finalizing the layout of the model. The disconnections, such as disconnected junctions and duplicate junctions, were corrected.

3.1.3 Pump Stations

There are several alternative methods for simulating pump stations, such as design point, and multiple point curves. For this project, multiple point curves from field pump testing are used to describe the pumps' operating range. Results of the pump testing are summarized in Section 4.

3.1.4 Storage Facilities

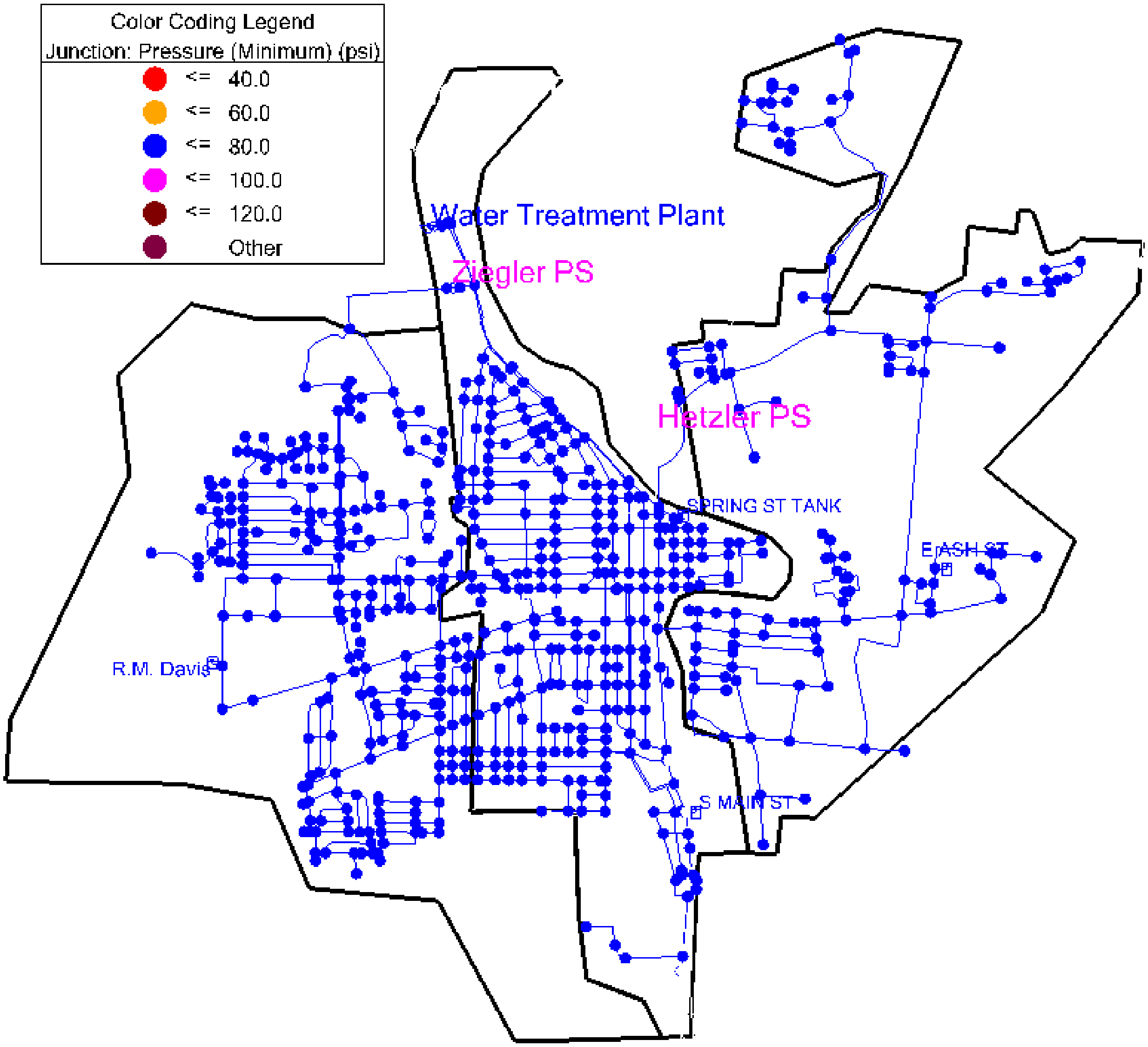
There are two types of storage facilities in the City's system, reservoirs and elevated tanks. The clearwell at the WTP provides water to the distribution system and is modeled as an unlimited water source at a set hydraulic grade line elevation. All four elevated tanks, including R.M. Davis, Spring Street, South Main Street and East Ash, are modeled as cylindrical tanks represented by tank diameter and height.

3.1.5 Pressure Zones

There are three pressure zones in the City's distribution system, West High, Central Low, and East High pressure zones. These zones are separated by valves, however there are two locations where the valves between West High and Central Low, and East High and Central Low are open.

The updated hydraulic model network is shown in **Figure 3-1**.

Figure 3-1 – Updated WaterGEMS Model



3.2 Demand Development and Allocation

Accurately estimating water demands on the distribution system is key in developing a hydraulic model that can be used to identify system deficiencies. Water demands for existing conditions were developed to simulate operations and to identify deficiencies experienced under existing demands.

3.2.1 Demand Development

The City provided total finished water pumping data from the WTP for the past four years, as well as historic water billing data (September 2009 to August 2011) for all residential, commercial, and industrial accounts. The accounts were geo-coded to street addresses so that each metered account could be associated with a billing address.

3.2.1.1 Average Day Demand

The City provided total finished water pumping data from the WTP for year 2006, 2007, 2008, 2009 and 2010. The data is summarized in Table 3-1. The average day plant pumping rate decreased in the last 2 years compared to the 2007 and 2008 years, from 3.1 to 2.7 mgd.

Table 3-1 Total Finished Water Pumping Data

Month	2006, mgd		2007, mgd		2008, mgd		2009, mgd		2010, mgd	
	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day	Average Day	Maximum Day	Average Day
Jan	3.07	2.51	3.3	3.05	3.4	3.08	3.65	2.97	2.72	2.58
Feb	2.92	2.68	3.5	2.89	3.4	3.26	4.25	3.19	2.87	2.7
Mar	3.57	2.93	3.44	3.15	3.42	2.95	2.98	2.63	2.82	2.6
Apr	3.01	2.79	3.24	2.76	3.48	3.12	2.86	2.5	2.88	2.65
May	3.4	3.02	4.73	3.57	3.28	2.97	3.04	2.6	3	2.71
Jun	3.5	3.08	3.95	3.44	3.6	3.24	3.6	2.85	3.01	2.68
Jul	4.2	3.39	3.9	3.3	3.65	3.28	3.81	2.94	3.45	2.9
Aug	3.5	3.08	4.11	3.24	3.69	3.25	3.23	2.87	3.35	2.89
Sep	3.45	3.16	3.96	3.09	4.0	3.26	3.32	2.79	3.61	3.04
Oct	3.1	2.91	3.89	2.96	3.35	2.94	2.82	2.56	3.12	2.7
Nov	3.3	3	3.37	2.86	2.95	2.46	2.75	2.52	3.06	2.64
Dec	3.1	2.85	3.21	2.97	3.1	2.57	2.7	2.5	3.14	2.78
Maximum Day	**4.2**	-	**4.73**	-	**4.0**	-	**4.25**	-	**3.61**	-
Average Day	-	**2.95**	-	**3.11**	-	**3.03**	-	**2.74**	-	**2.74**
Max Day/ Average Day Ratio	**1.42**		**1.52**		**1.32**		**1.55**		**1.32**	

3.2.1.2 Maximum Day Demand

Maximum daily demand is the maximum anticipated demand during a 24-hour period within any given year. The ratio of maximum daily demand to average annual demand is referred to as the "maximum daily demand factor." This factor usually varies from 1.2 to 3.0.

The plant pumping data in **Table 3-1** indicated this ratio ranged consistently from year 2006 through 2010. The maximum daily demand factors ranged from 1.32 to 1.55 for the past four years. To be conservative, a maximum daily demand factor of 1.55 is used in the analysis.

3.2.1.3 Unaccounted-for-Water

Unaccounted-for-water (UFW) is the difference between water produced and water billed. It is calculated by subtracting the amount of water billed from the amount of water produced. UFW can be caused by:

- Physical losses due to leakage in the system
- Administrative losses due to illegal connections and under-registration of water meters
- Activities such as hydrant flushing, fire training, etc.

Historical UFW data are summarized in **Table 3-2**. The City staff has observed inaccurate meter readings at the WTP, therefore, the UFW values in the table were calculated based on a reduction factor of 20% on the plant meter readings.

Table 3-2 Summary of UFW

Year	Water Produced, mgd	Water Billed, mgd	UFW	
			mgd	Percent of Water Produced
2007	2.49	1.78	0.71	28
2008	2.43	1.68	0.75	31
2009	2.19	1.63	0.56	26
2010	2.19	1.59	0.60	27

Note: Total Plant Production data was reduced by 20% based on information provided by plant staff to correct for inaccurate meter readings at the plant

Many water utilities in southwest Ohio operate in the 15% - 25% UFW range, with those water utilities operating with older infrastructure generally exhibiting higher UFW percentages. In 1996, the American Water Works Association (AWWA) Leak Detection and Accountability Committee recommended a 10% UFW benchmark, but this recommendation has no regulatory driver. The City's UFW performance is generally higher than its peer communities and industry benchmarks. Historically a 15% UFW has been an acceptable range and may be an appropriate future target.

In the past, the City has undergone a leak detection program and has eliminated known large leaks, which included one estimated to be 300,000 gpd. The high UFW could also be contributed partially to unmetered water from hydrants and some customers. The City also operates blow-offs at dead ends and/or bleed tanks to maintain the chlorine residual which would add to the amount of UFW.

The City should undertake focused efforts to reduce this UFW percentage to reduce its operating costs and reduce finished water pumped from the plant. To do so, the City could replace or rebuild customer water meters more frequently, recalibrate or replace the plant's two finished water meters, and implement a rigorous leak detection and repair program for leaky pipes. The City could also re-evaluate its tank flushing program for disinfection by products (DBP) control by incorporating physical mixing instead of flushing.

3.2.1.4 Demand Pattern

Common water user types include residential, commercial, and industrial. Different user types may have different water usage patterns throughout the day. For example, residential users follow a diurnal usage pattern with peaks in the morning and evening hours, while an industrial user with three shifts may have very uniform water usage throughout the day.

The large user analysis in **Table 3-3** concluded that no single large user contributes to a significant portion of the system demand. The largest water user only consumed approximately 1% of the total system demand. Therefore, specific demand patterns are not warranted and a system-wide demand pattern is used during modeling.

Table 3-3 Top 20 Large Water Users – September 2009 to August 2011

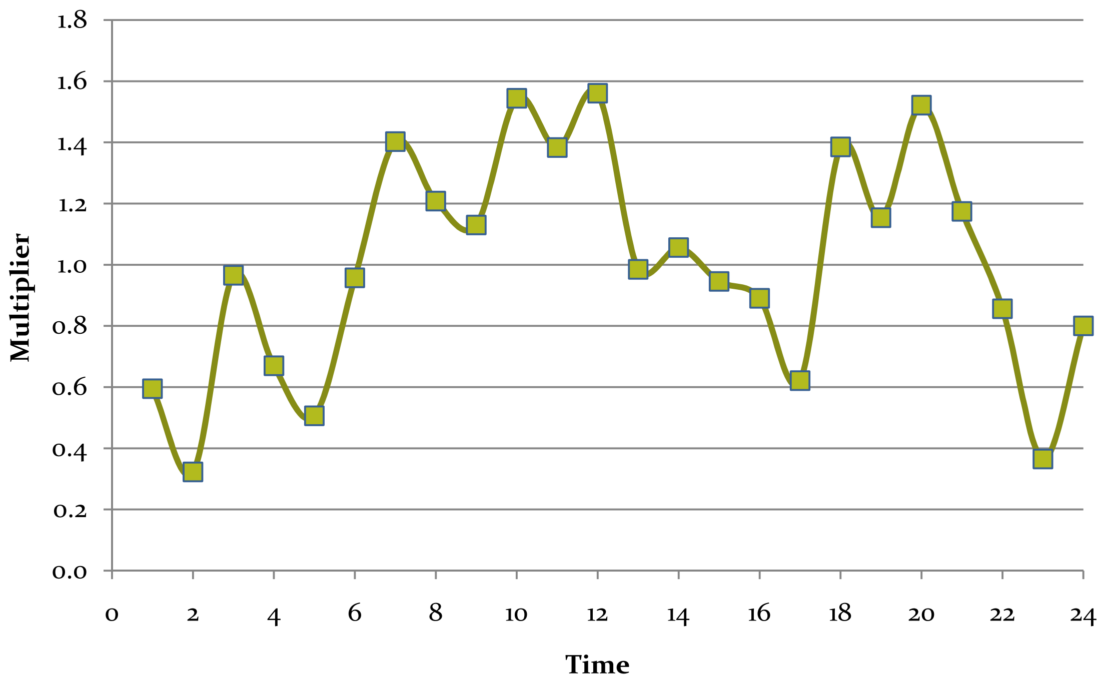
Rank	Account Number	Customer	Service Address	Consumption (gallon/month)	% of Total
1	3-022-121-00-002	Northrop Grumman Corp	350 Washington Ave	761,500	1.1%
2	2-023-048-04-000	Miami Co. Sanitary Engr	Country Club Rd	720,708	1.1%
3	3-022-128-00-000	Hartzell Propeller	1 Propeller Pl Rr	633,125	0.9%
4	3-022-038-01-000	Hartzell Industries	1025 S Roosevelt Ave	572,917	0.8%
5	2-034-085-15-001	Polysource Inc	555 E Statler Rd	475,042	0.7%
6	3-037-085-01-000	Board Of Education	1 Indian Trail	324,875	0.5%
7	2-028-034-00-002	Comfort Inn	987 E Ash St	315,333	0.5%
8	3-022-125-04-000	Crayex Corp	1747 Commerce Dr	311,652	0.5%
9	3-037-138-01-002	Tolson Enterprises	1206 E Ash St W/S	303,583	0.4%
10	3-037-060-00-000	Piqua Manor	1840 W High St	300,875	0.4%
11	3-022-107-03-000	Jackson Tube	8210 Industry Prk Dr	281,125	0.4%
12	2-034-095-00-000	Joint Hospital Services	103 Hemm Rd	258,708	0.4%
13	2-023-154-02-000	Edison State College	1973 Edison Dr	223,750	0.3%
14	2-028-045-01-000	Odot District 7	1020 W Statler Rd Rr	223,650	0.3%
15	3-021-133-01-002	Cleaners Sunset	111 S Downing St	223,500	0.3%
16	3-037-197-00-000	Heartland of Piqua	275 Kienle Dr	202,250	0.3%
17	2-024-264-01-002	Terrance Creek	90 Maryville Ln Cm	175,792	0.3%
18	3-022-115-01-000	French Oil Mill	1035 W Greene St	171,208	0.3%
19	3-037-001-00-003	Bay N Wash	1330 Covington Ave	170,833	0.3%
20	2-023-154-00-000	Upper Valley Jvs	8811 Career Dr	170,208	0.2%
Total				6,820,634	**10.0%**

Note: Seasonal water users, such as golf courses and swimming pools, are not included in the table.

To develop the water demand pattern, CDM Smith collected the City's SCADA records from September 2 to October 18, 2011, which coincides with the period of field testing. SCADA data quality in general was good except a WTP flow meter was not functioning most of the time due to equipment failure. It was suspected that a flow meter was damaged by lightening. After carefully reviewing the available SCADA records, data from September 2nd was used to conduct a system-wide mass balance analysis as SCADA data on this day seemed reasonable with no missing data. The system demand was calculated by subtracting the flow rates into the elevated storage tanks from water delivered by the High Service pumps at the WTP.

After a demand pattern was established, a clear correlation between demand magnitude and the time of day was noted, demonstrating the maximum and minimum demand periods throughout a typical day. **Figure 3-2** shows the demand pattern developed from SCADA data. The Y-axis is the pattern multiplier, defined as instantaneous demand divided by average day demand.

Figure 3-2 System Wide Water Demand Pattern



3.2.2 Demand Allocation

3.2.2.1 Metered Accounts Allocation

After daily demands were calculated to represent existing conditions in the distribution system, a water account GIS shapefile was created by using the addresses of the accounts in an Excel spreadsheet. Each water account was geo-coded in the GIS to represent the physical location of the account. The demands were then allocated to the appropriate modeled junctions by using the GIS applications.

Approximately 99 percent of the water billing records were successfully allocated through the above-mentioned method, which is considered very high by industry standards. The remaining <1 percent of water usage that could not be allocated was treated as UFW. Those accounts could not be allocated because they had addresses in the water billing database that did not exist, or street numbers that could not be located in the street centerline GIS data.

3.2.2.2 UFW Allocation

The UFW was allocated equally to each model node in the system to represent random and periodic water losses that may occur in all parts of the system. Because detailed information is unknown on when and where UFW occurs, an average value was applied.

Section 4

Field Tests

This section summarizes the results of the field tests. Field data collection was performed to collect distribution system information that was used in the development and calibration of the hydraulic model. Field tests performed in the City's water distribution system included pump testing, hydrant pressure recording, and hydrant flow tests. The CDM Smith contracted with ADS Environmental Services to conduct the field tests. During the field tests, CDM Smith staff was present to ensure the data collected are suitable for model calibration.

Detailed field test results are presented in the report, Water Distribution System Testing, by ADS Environmental Services, dated October 2011, attached as **Appendix A**.

4.1 Pump Testing

Pump testing was performed to develop actual pump performance curves (total dynamic head vs. flow rate) to be used in the model. During pump testing, Pitot gages were inserted in the pump discharge piping to measure pump flows. Pump head was read from pressure gages (one on the suction side of the pump, and the other on discharge side).

Pump testing was conducted at all nine pumps that the City currently operates, including the four High Service Pumps at the Water Treatment Plant, three pumps at the Ziegler Road Booster Station, and two pumps at the Hetzler Road Booster Station.

4.1.1 High Service Pumps at the Water Treatment Plant

Pump testing of the four high service pumps at the WTP was conducted on October 7, 2011. The name plate data of the pumps are presented in **Table 4-1**.

4.1.1.1 Pump Curves

Pump testing results are presented in **Figure 4-1** though **Figure 4-4**. The results indicated the pumps experienced some wear as the tested pump curves fall below the manufacturer curves on the Head and Flow graphs.

Table 4-1 Name Plate Data - High Service Pumps

Pump Nameplate	Pump 1	Pump 2	Pump 3	Pump 4
Manufacturer	Aurora Pump	Worthington	Crane Deming	Allis-Chalmers
Style	Horizontal Split Case	Horizontal Split Case	Horizontal Split Case	Vertical Turbine
No.	75-10844	735856	DC-525347	69198T
Type	411BF	6 CLBS	5064 81752011	18 VTO
Size	6 x 18	Not Shown	10 x 8	Not Shown
Flow	2260 gpm	Not Shown	3500 gpm	Not Shown
Head	200 feet	Not Shown	200 feet	Not Shown
RPM	1760	Not Shown	1750	Not Shown
Impeller Dia	Not Shown	Not Shown	16-5/8	Not Shown
Motor Nameplate	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 4**
Manufacturer	Diesel Engine	Elliott	US Motor	Allis-Chalmers
Serial No.		CY-21964-1	E08 00080921-100R-01	7-5160-31215-1-1
Horsepower		200	250	250
Model No.		Not Shown	D250P2C	Not Shown
Frame		BA-505-S	447T	26C8
Type		Not Shown	J532	HSO
RPM		1775	1785	1770
Volts		440	460	440
Amps		240	286	296
SF Amps		Not Shown	328	Not Shown
Hz		60	60	60
Code		F	G	Not Shown
Des		B	B	Not Shown
SF		1.15	1.15	1.15
Phase		3	3	3
Max Amb		40 C	40 C	40
Duty		Continuous	Continuous	24 (Continuous)
Shaft End Bearing		312	6220-J	7326 - oil lube
Opp. End Bearing		312	6313-J	6319 - grease
Ins. Class		Not Shown	F	Not Shown
Nema Eff.		Not Shown	96.2	Not Shown
PF		Not Shown	85.1	Not Shown
Guaranteed Eff.		Not Shown	95.4	Not Shown
Max KVAR		Not Shown	55.9	Not Shown
Wt.		Not Shown	1700	Not Shown
KVA Code		Not Shown	Not Shown	F

Figure 4-1 Pump Testing Result - Pump 1 at WTP

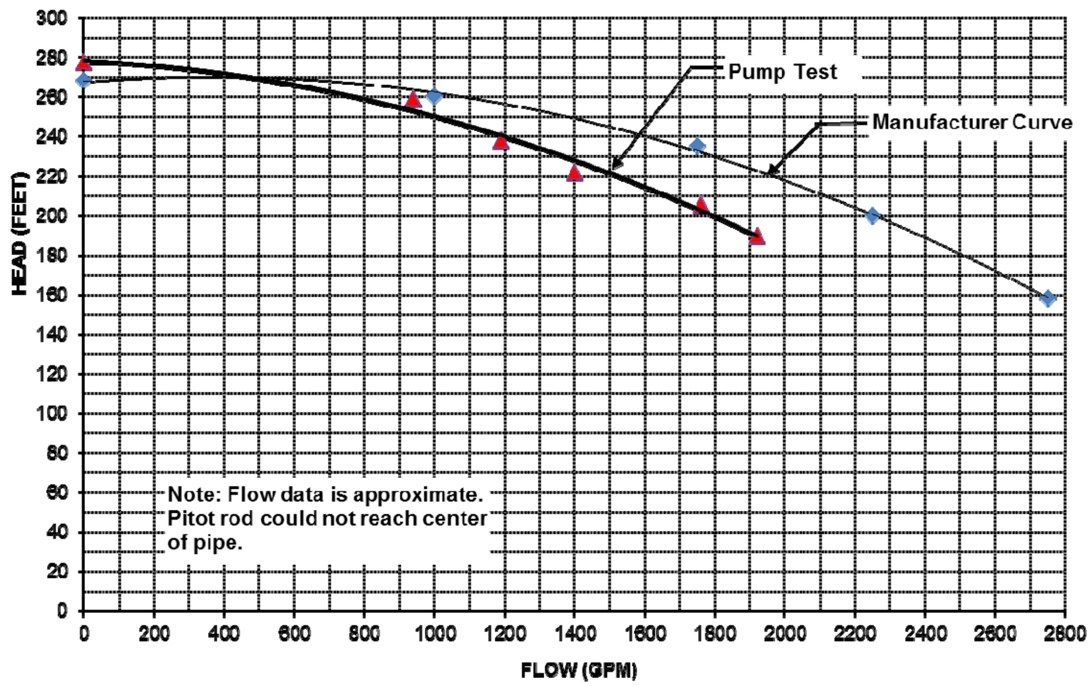


Figure 4-2 Pump Testing Result - Pump 2 at WTP

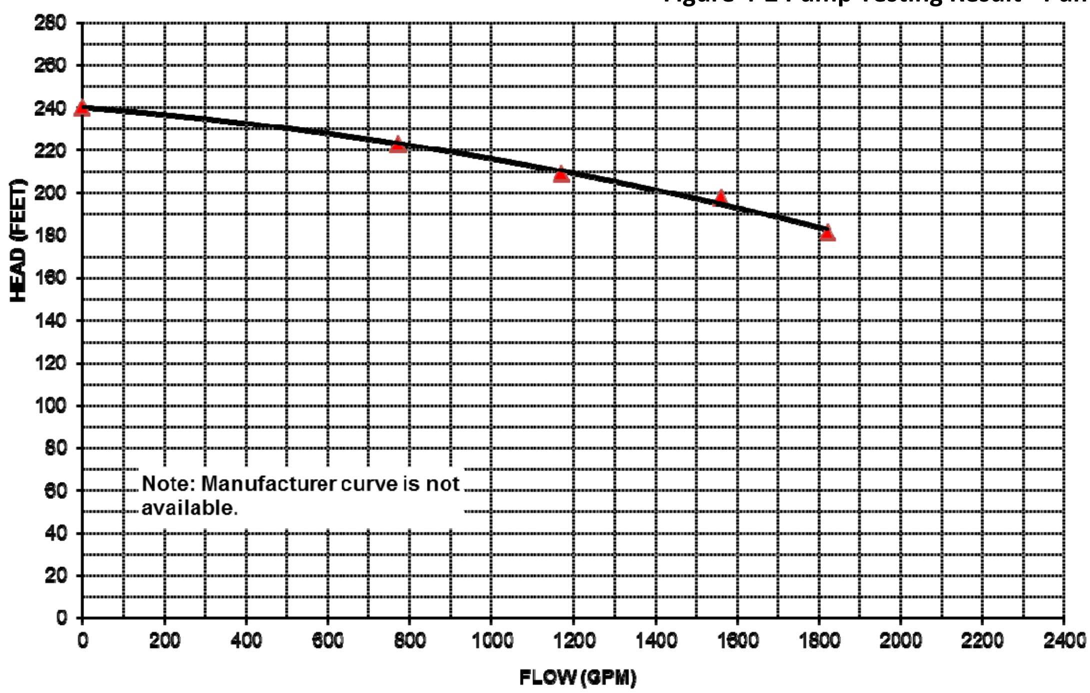


Figure 4-3 Pump Testing Result - Pump 3 at WTP

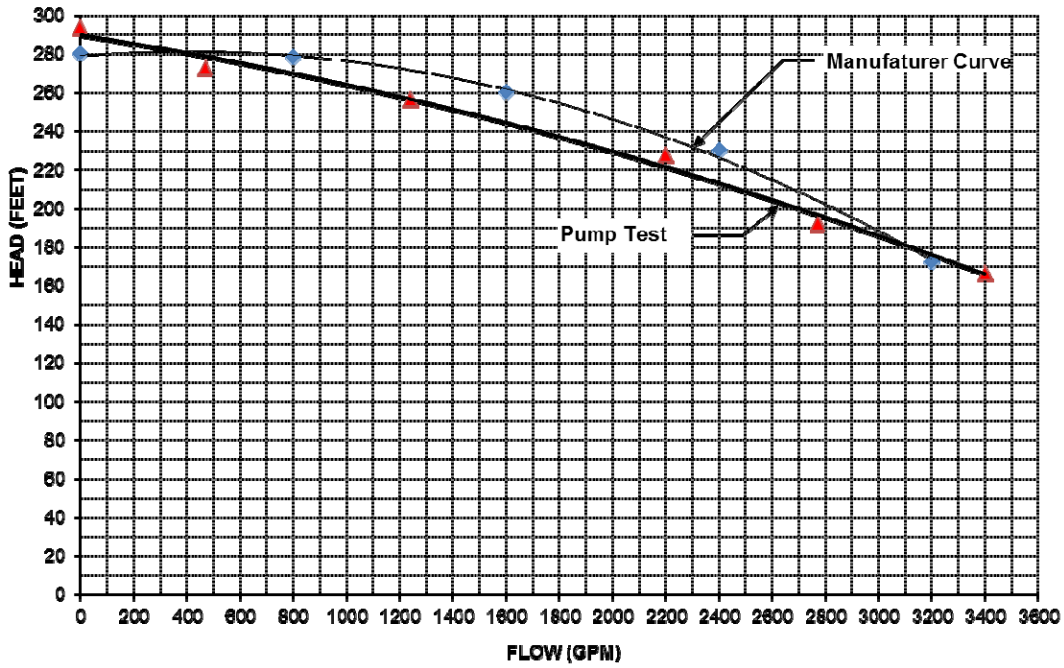
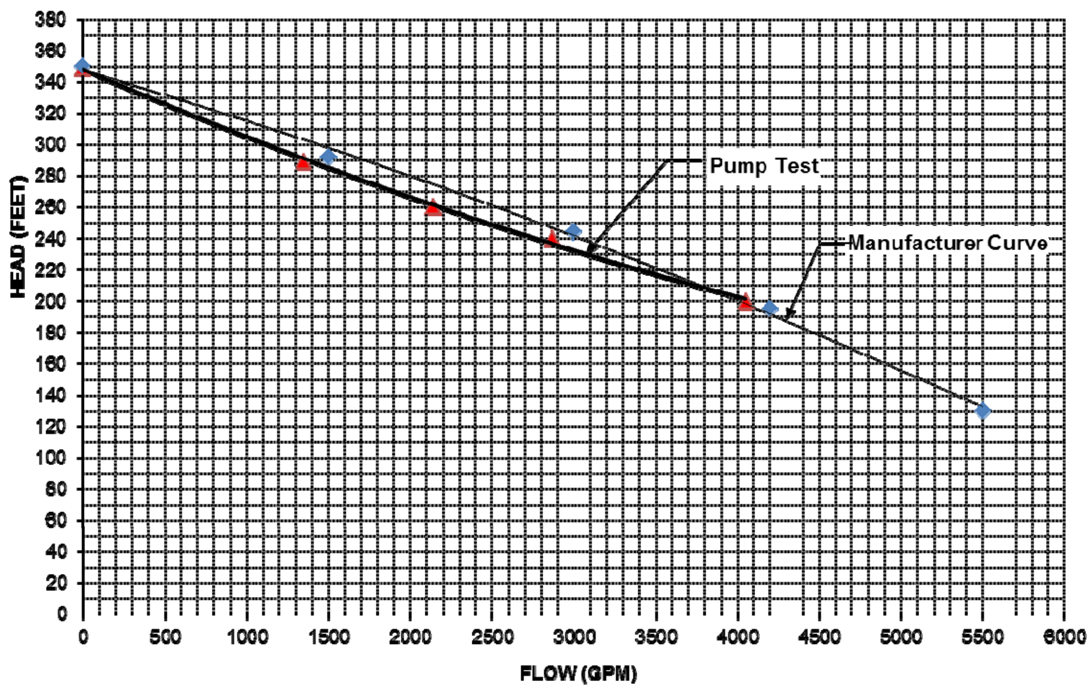


Figure 4-4 Pump Testing Result - Pump 4 at WTP



4.1.1.2 Meter Accuracy

There are two flow meters at the WTP, the front meter and the back meter. The City staff expressed concerns that these meters are not well calibrated. CDM Smith intended to check the flow meter accuracy during the pump testing by comparing flow meter readings with the Pitot gage reading. However, this could not be achieved due to the following reasons:

- Front Meter: Unable to estimate meter accuracy due to front meter not operational during pump tests (lightning damage).
- Back Meter: not enough clearance to insert a proper size Pitot rod. A small Pitot rod was used and data was less reliable.

4.1.2 Hetzler Road Booster Station

Pump testing of the two Hetzler Road Booster Station pumps was conducted on October 6, 2011. The name plate data of the pumps are presented in **Table 4-2**.

Table 4-2 Name Plate Data - Hetzler Road Booster Station Pumps

Pump Nameplate	Pump 1	Pump 2
Manufacturer	Weinman	Weinman
Model	Illegible	8-L-2
No.	Illegible	700790-2
Flow	Illegible	1500 gpm
Head	Illegible	100 feet
RPM	Illegible	1750
Date	Illegible	12/6/1974
Working Pressure	Illegible	150 psi
Spec. No.	Illegible	8L2-414-4SG10
Motor Nameplate	**Pump 1**	**Pump 2**
Manufacturer	Lincoln	Lincoln
Frame	364T	364T
RPM	1775	1775
Serial No.	1348299	1197129
HP	60	60
Phase	3	3
Ins	B	B
Volts	230/460	230/460
Hz	60	60
Amps	154/77	154/77
Max Amb	40 C	40 C
SF	1.15	1.15
Time Rating	Continuous	Continuous
Lincoln Code	TV-2656-A1	TV-2656-A1
Nema Code	F	F
Nema Design	B	B

4.1.2.1 Pump Curves

Pump Testing results are presented in **Figure 4-5** and **Figure 4-6**. The results indicated the pumps experienced very little wear as the tested pump curves fall close to the manufacturer curves on the Head and Flow graphs.

Figure 4-5 Pump Testing Result - Pump 1 at Hetzler Road Booster Station

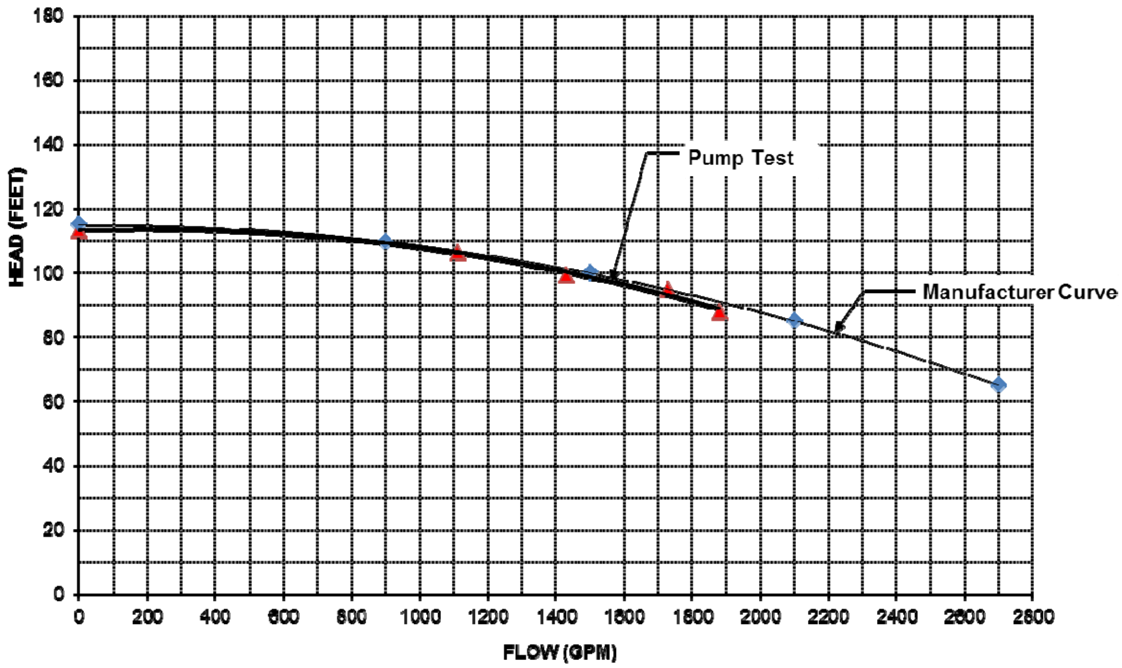
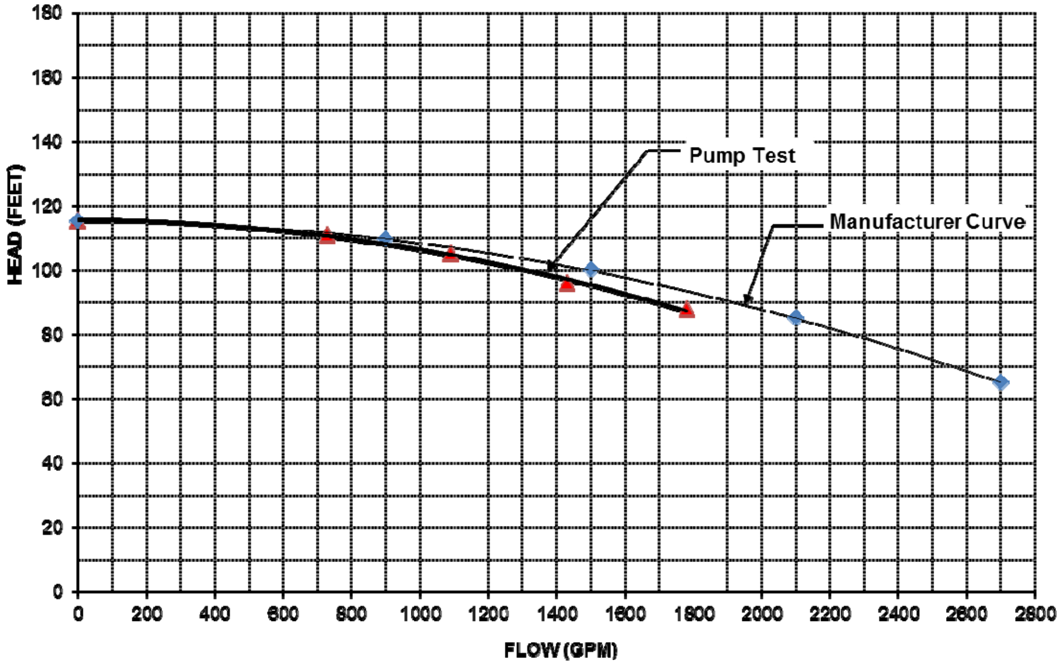


Figure 4-6 Pump Testing Result - Pump 2 at Hetzler Road Booster Station



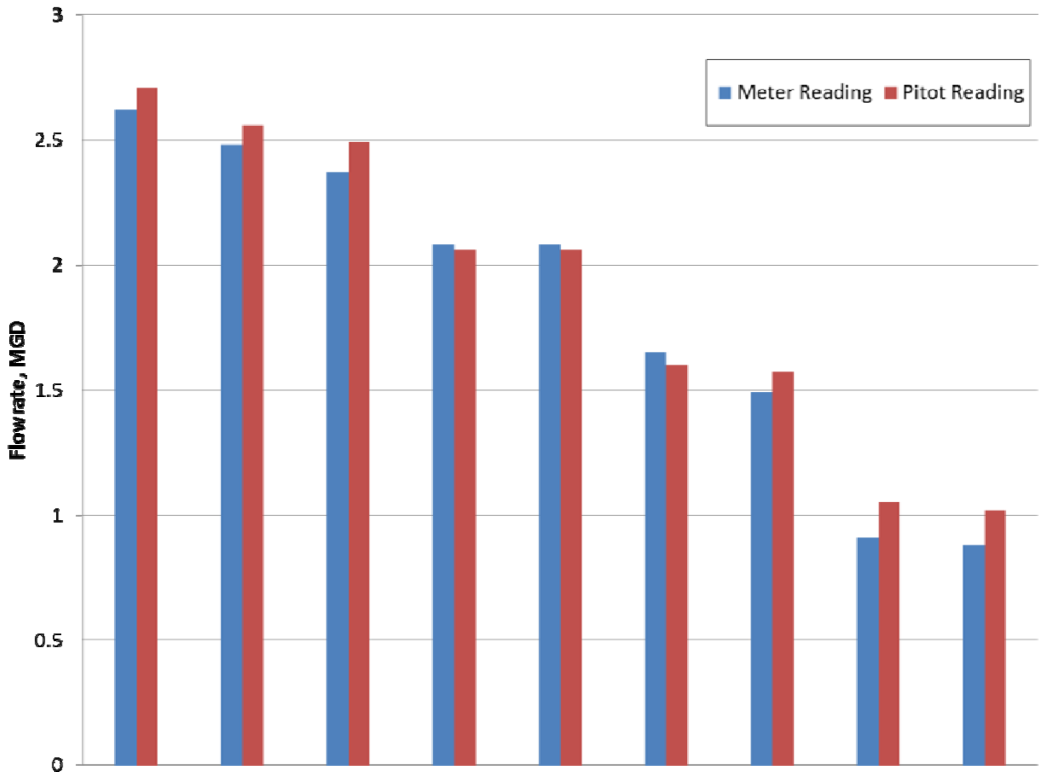
4.1.2.2 Meter Accuracy

CDM Smith was able to check the meter accuracy by comparing the booster station meter reading with the Pitot reading during the pump tests. It was concluded the meter at Hetzler Road Booster Station slightly under registered, especially at lower flow rates, as presented in **Table 4-3**. A bar chart comparing the results is presented in **Figure 4-7**.

Table 4-3 Meter Accuracy Analysis – Hetzler Road Booster Station

Meter Reading, MGD	Pitot Reading, MGD
2.62	2.71
2.37	2.49
2.08	2.06
1.65	1.60
0.88	1.02
2.48	2.56
2.08	2.06
1.49	1.57
0.91	1.05

Figure 4-7 Bar Chart of Meter vs. Pitot Reading - Hetzler Road Booster Station



4.1.3 Ziegler Road Booster Station

Pump testing of the three Ziegler pumps was conducted on October 6, 2011. The name plate data of the pumps are presented in **Table 4-4**.

Table 4-4 Name Plate Data - Ziegler Road Booster Station Pumps

Pump Nameplate	Pump 1	Pump 2	Pump 3
Manufacturer	Aurora Pump	Aurora Pump	Aurora Pump
No.	76-3852-1	76-3852-1	76-3852-1
Type	411 BF	411 BF	411 BF
Size	8x11B	8x11B	8x11B
Flow	2000 gpm	2000 gpm	2000 gpm
Head	100 feet	100 feet	100 feet
RPM	1750	1750	1750

Motor Nameplate	Pump 1	Pump 2	Pump 3
Manufacturer	Marathon Electric	Marathon Electric	Marathon Electric
Serial No.	EE-96600-5/21-5	EE-96600-5/21-1	EE-96600-5/21-2
Horsepower	75	75	75
Model No.	365TSTDS7026EC W F1	365TSTDS7026EC W F1	365TSTDS7026EC W F1
Frame	365TS	365TS	365TS
Type	TDS-BE	TDS-BE	TDS-BE
RPM	1770	1770	1770
Volts	460	460	460
Hz	60	60	60
Code	F	F	F
Des	B	B	B
SF	1.15	1.15	1.15
Phase	3	3	3
Max Amb	40 C	40 C	40 C
Duty	Continuous	Continuous	Continuous
Shaft End Bearing	3210	3210	3210
Opp. End Bearing	3210	3210	3210

4.1.3.1 Pump Curves

Pump Testing results are presented in **Figure 4-8** though **Figure 4-10**. The results indicated the pumps experienced very little wear as the tested pump curves fall close to the manufacturer curves on the Head and Flow graphs.

Figure 4-8 Pump Testing Result - Pump 1 at Ziegler Road Booster Station

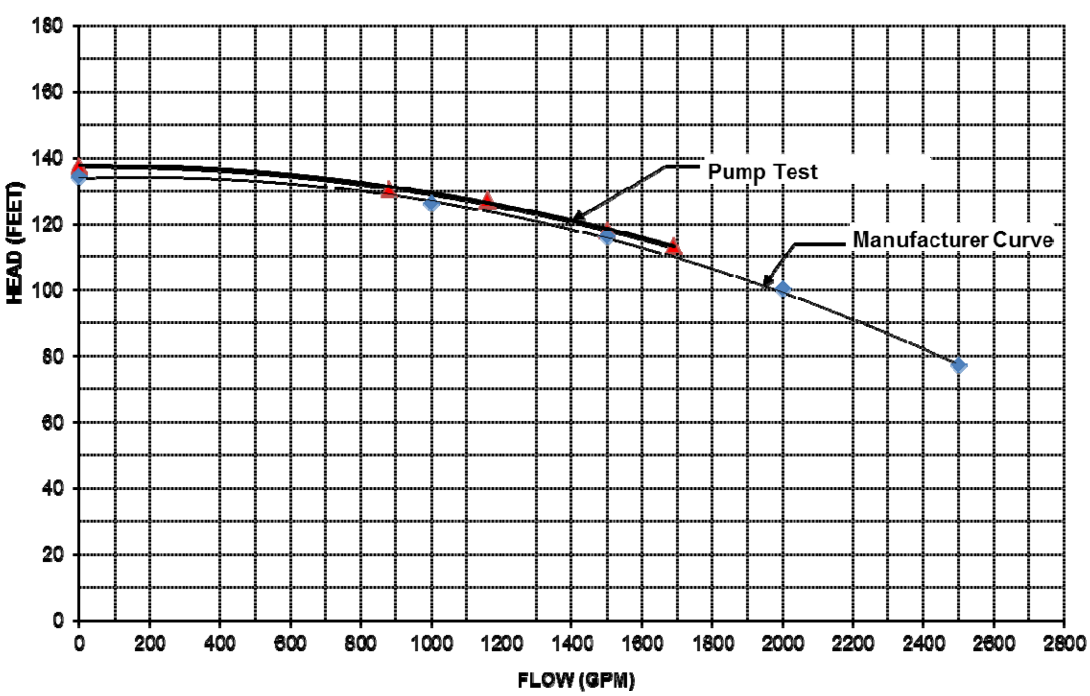


Figure 4-9 Pump Testing Result - Pump 2 at Ziegler Road Booster Station

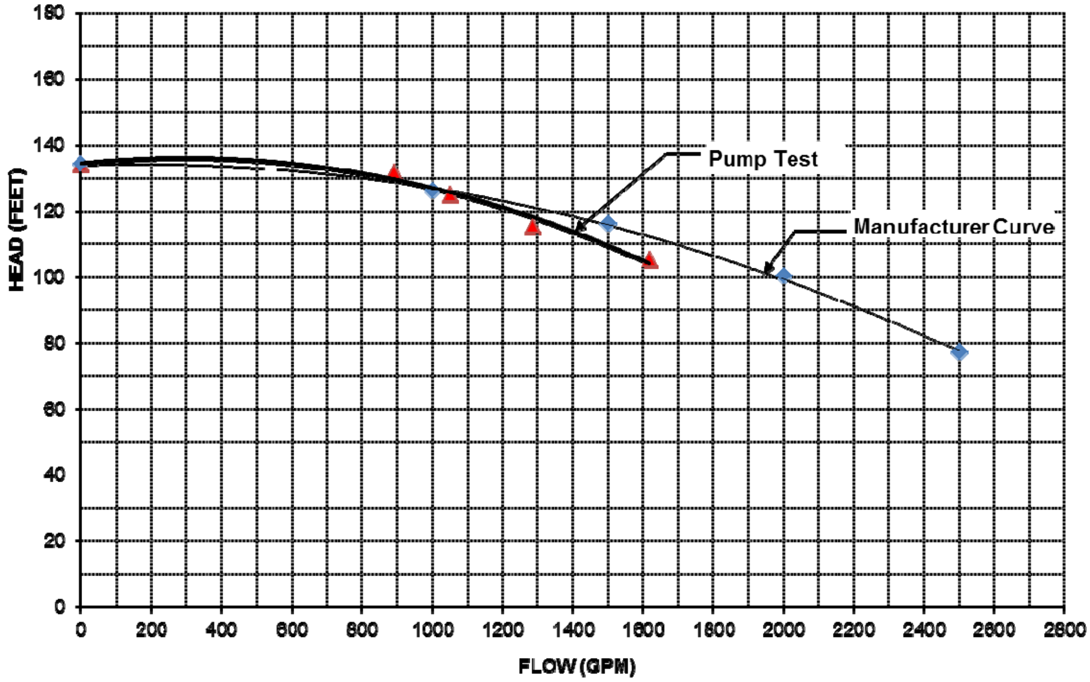
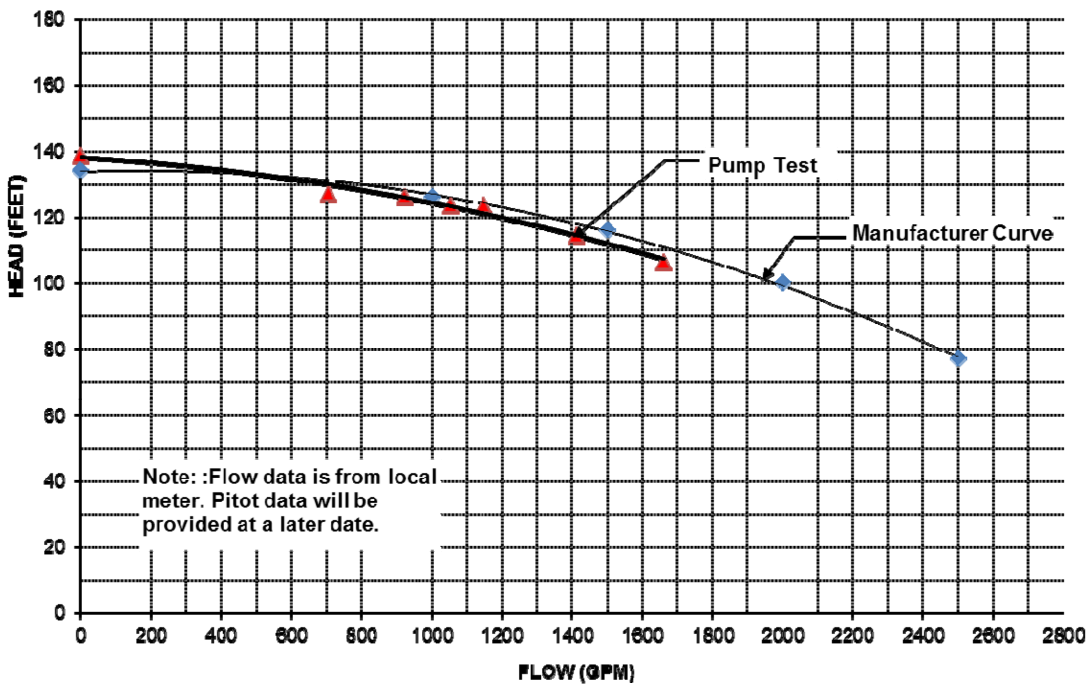


Figure 4-10 Pump Testing Result - Pump 3 at Ziegler Road Booster Station



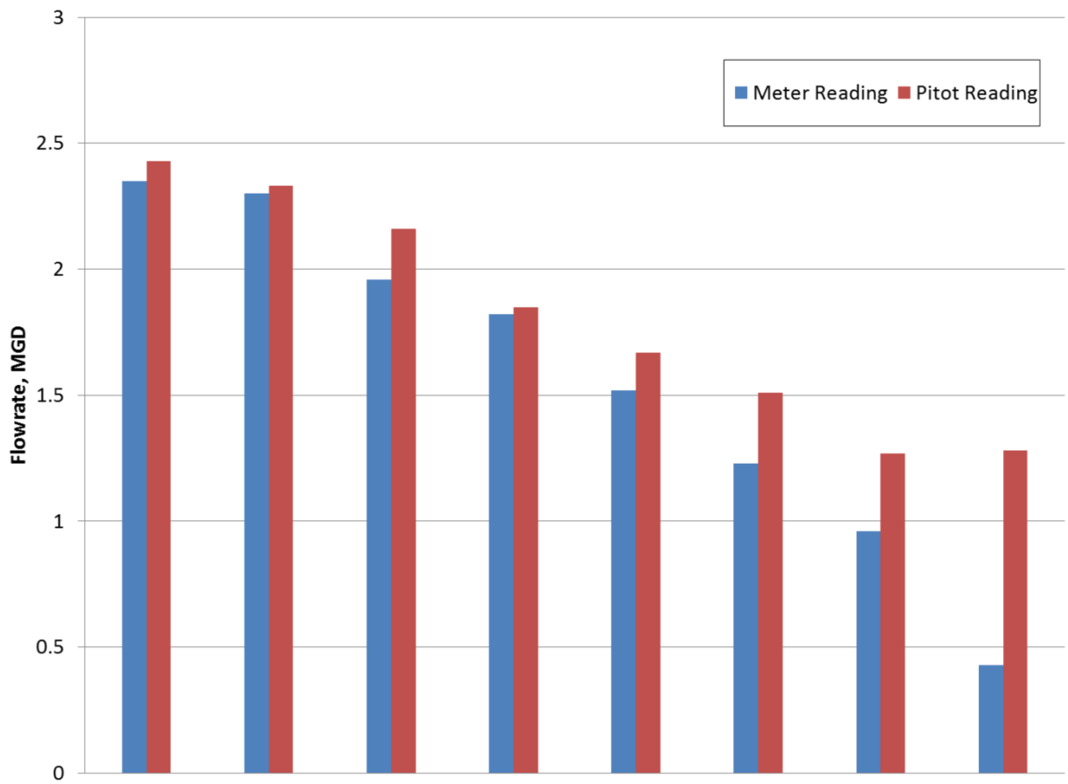
4.1.3.2 Meter Accuracy

CDM Smith was able to check the meter accuracy by comparing meter reading with the Pitot reading during the pump tests. It was concluded the meter at Ziegler Road Booster Station slightly under registered, especially at lower flow rates, as presented in **Table 4-5**. A bar chart comparing the results is presented in **Figure 4-11**.

Table 4-5 Meter Accuracy Analysis – Ziegler Road Booster Station

Meter Reading, MGD	Pilot Reading, MGD
2.35	2.43
1.96	2.16
1.52	1.67
0.96	1.27
2.30	2.33
1.82	1.85
1.23	1.51
0.43	1.28

Figure 4-11 Bar Chart of Meter vs. Pitot Reading - Ziegler Road Booster Station



4.2 Hydrant Pressure Recording

Hydrant pressure recording was used to monitor pressure variations over an extended time at different locations in the system, generally at the high and low elevations of each pressure zones. The goal of this test was to provide data for the Extended Period Simulation (EPS) model calibration.

For this project, six hydrants, two in each pressure zone, West High, Central Low, and East High, had pressure recorders installed during the period of September 7 to 23, 2011. The number and locations of the proposed test hydrants were selected based on the following:

- To record pressure at high and low elevation locations in the pressure zone.
- To provide a system-wide coverage.
- To minimize the likelihood that the recording devices will be disturbed or vandalized.

Locations of the hydrant pressure recording are presented in **Figure 4-12** and **Table 4-6**. Results of the hydrant pressure recording tests are also summarized in **Figure 4-13** and **Table 4-6**.

Figure 4-12 Locations of Hydrant Pressure Recoding Tests

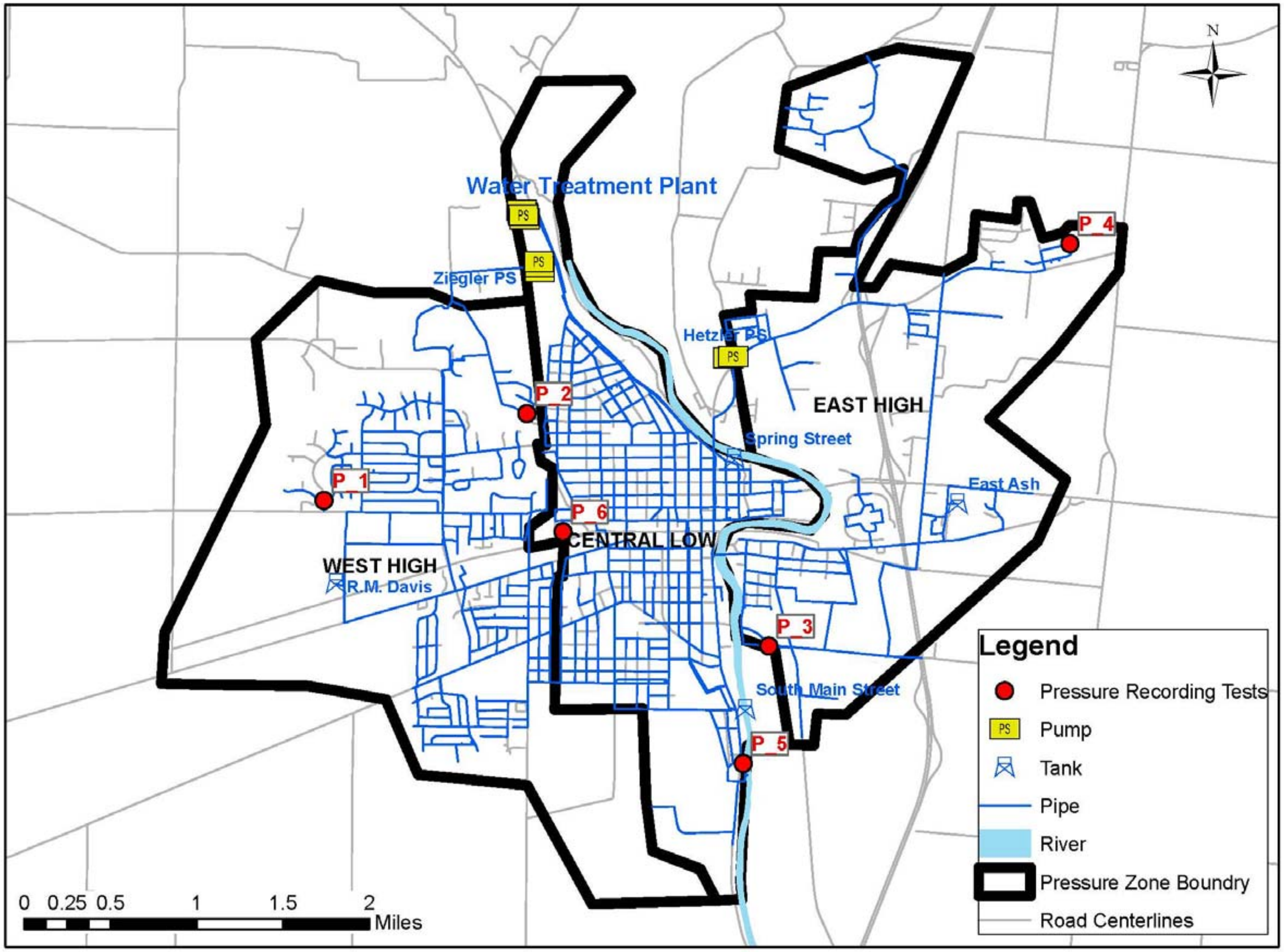
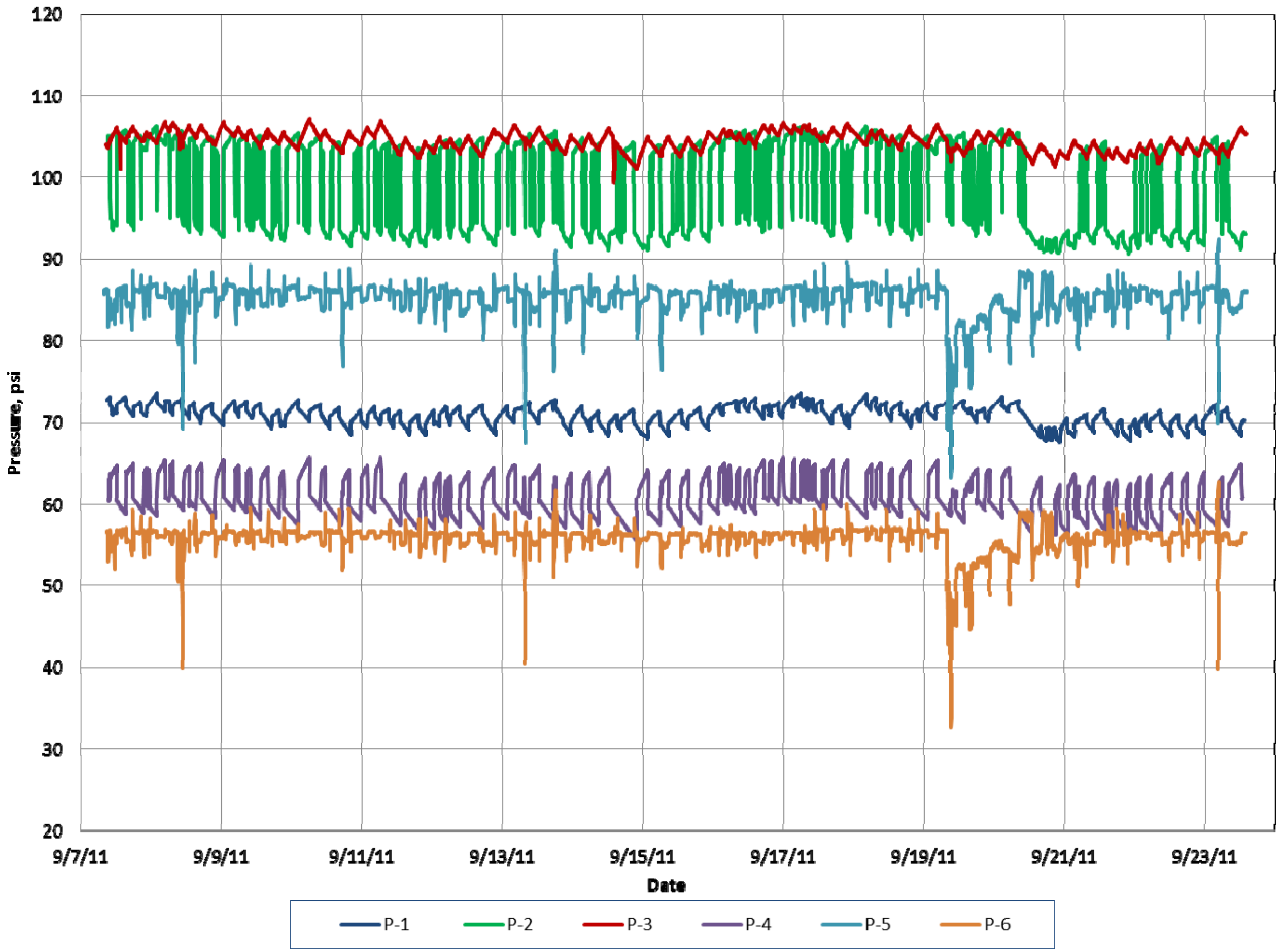


Table 4-6 Hydrant Pressure Recording Locations and Summary of Results

Test ID	Service Area	Street Location	Pipe Diameter, inches	Ground Elevation*, feet	Average Pressure, psi		
					Min	Max	Average
P-1	West High	Lambert Dr. at Wilshire Dr.	8	966.9	67.6	73.7	70.9
P-2	West High	Echo Lake Dr. at Fountain Blvd.	6	904.9	90.6	106.5	99.4
P-3	East High	Garnsey St. east of S. Main St.	6	862	90.5	107.4	104.5
P-4	East High	Sioux Dr. south of Cherokee Dr.	8	969.9	55.6	65.8	60.7
P-5	Central Low	S. Main St. at Statler Ave.	6	852	63.3	92.6	85.3
P-6	Central Low	Cassell St. south of W. Water St.	6	924	32.7	62.8	56

* Elevation estimated based on “NAD_1983_StatePlane_Ohio_South_FIPS_3402_Feet” vertical datum

Figure 4-13 Results of Hydrant Pressure Recording Tests – Average Pressure



4.3 Hydrant Flow Tests

Hydrant flow tests are among the most common methods of collecting hydraulic model calibration data. During hydrant flow tests, the system was stressed during known hydraulic baseline conditions. Two close-by hydrants (flow hydrant and residual hydrant) were located, preferably on a straight run of pipe preferably without any tees or interconnections in between. Before opening the flow hydrant, static pressure was measured at both the flow and residual hydrants. The pressure readings were used to ensure that the model is accurately simulating conditions before stressing the system. The flow hydrant was then opened and discharge flow was measured. Residual pressure was also recorded at the non-flowing hydrant. The testing equipment typically included one Pitot gage to measure hydrant discharge flow rates and two pressure gages. The equipment used was Hose Monster with built-in pitot by Hydro Flow Products, Inc.

To stress the system adequately, it was preferred to have a pressure drop at the test hydrant (non-flowing) of at least 10 psi during the flow test. Tests generally were conducted away from any supply points, such as water plants, storage tanks, and pump stations, which typically exhibit very little change in pressure during the flow test. Supply sources are also typically locations of high pressures because water has just been pumped. Excessively high pressures were avoided as they could exceed the acceptable range of the testing equipment available. To achieve sufficient pressure drop, the tests were conducted on fire hydrants connecting to smaller water lines (6-, 8- or 10-inch lines), as smaller diameter pipes are more sensitive to system stresses than larger pipes.

The procedure for hydrant flow tests is as follows:

1. Synchronize the clock that will be used in the field tests with the SCADA system clock.
2. Confirm which facilities are in operation and which are inactive.
3. At each location, designate the flow hydrant and the test hydrant.
4. Slowly open each of the fire hydrants to be used in the test and flush hydrant laterals. Allow the hydrant to discharge until water is clear. Slowly close the fire hydrant. Both flow and test hydrants should be flushed. This is to clear the hydrant of debris so it doesn't get caught in the pressure recording equipment.
5. Measure and record the static pressure at both the flow and test hydrants using pressure gages.
6. Close the flow hydrant, and remove the pressure gage. The pressure gage at the test hydrant should remain on the cap.
7. Attach the Pitot gage to the flow hydrant.
8. Slowly open the flow hydrant fully, and let the stream adjust to a clear and steady flow. Release air in the Pitot gage. Record the time and the residual pressure at the test hydrant. Record the Pitot pressure at the flowing hydrant. Ideally, the residual pressure in the test hydrant should have dropped 10 psi.
9. Shut off both hydrants slowly so as not to cause water hammer in the main.

10. Allow the pressure to stabilize at both the test and flow hydrants, and once again record the static pressure after the test is complete. This may be helpful to indicate if there was a change to the baseline conditions, such as a pump being turned on or off during the test.

11. Monitor and record SCADA information during the tests. Data is required from every facility in operation at the time of the tests in the pressure zone being tested. It is preferred that the same facilities be operating for all the tests.

One critical factor for conducting successful hydrant flow tests was obtaining accurate boundary conditions during the tests. This information was easily available and downloaded from the City's SCADA system. This information included the following:

- WTP production rates
- Tank levels
- Pump station status and flow rates

The following criteria were used in selecting hydrant flow test locations:

- Locations provided a thorough, system-wide coverage.
- Small pipe diameters (6 or 8 inches) in areas where tests were conducted.
- Points of supply (storage tanks, pump stations, water plants, and interconnections) were avoided as much as possible.

For this project, a total of twelve hydrant flow tests were conducted throughout the system, as presented in **Figure 4-14 and Table 4-7**, including six locations in the Central Low Pressure Zone, four locations in the West High Pressure Zone, and two locations in the East High Pressure Zone. All the tests were conducted on September 7, 2011.

CDM Smith developed a data collection sheet for the hydrant flow tests. A sample sheet is presented in **Figure 4-15**.

Figure 4-14 Locations of Hydrant Flow Tests

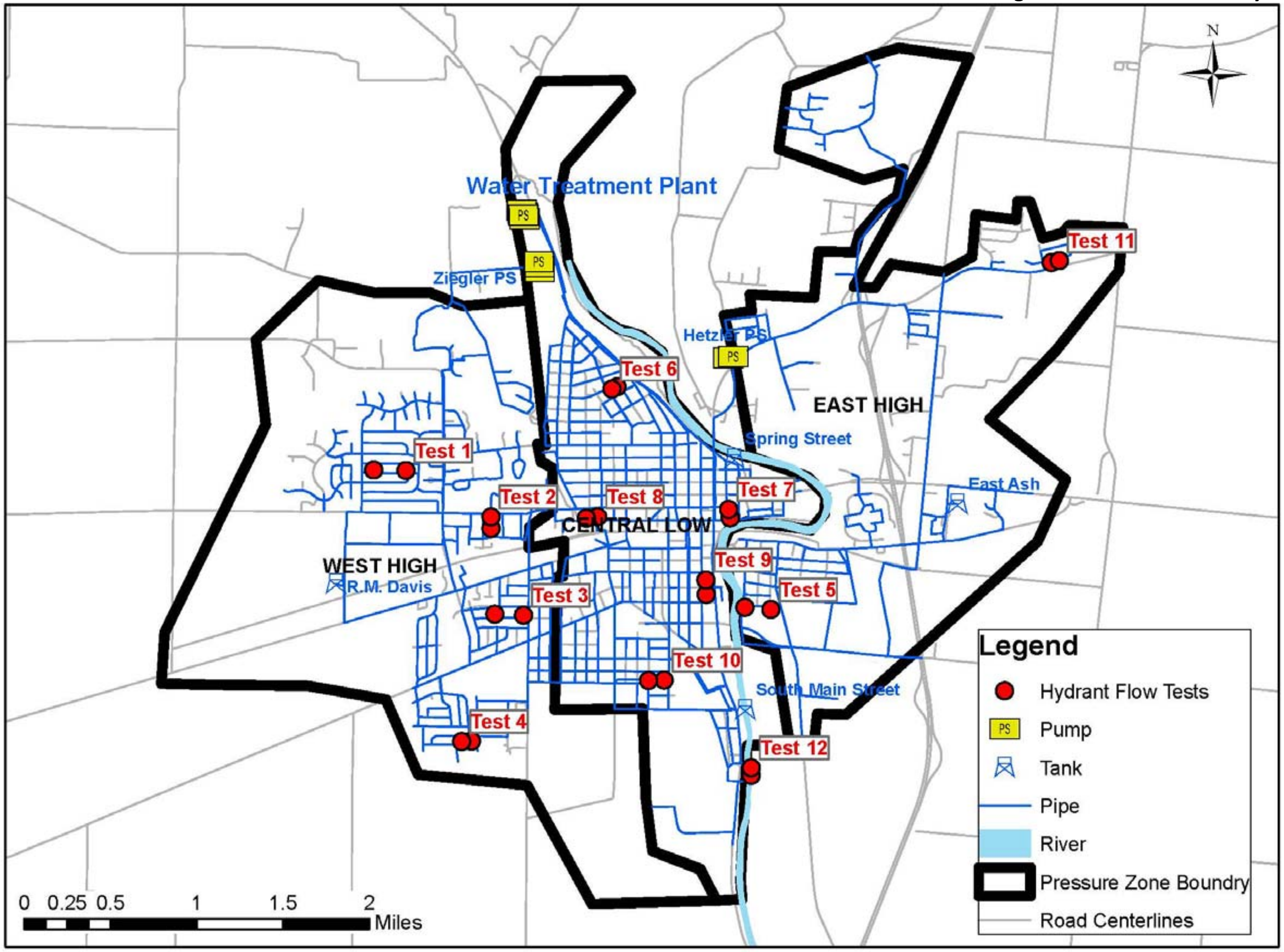


Table 4-7 Hydrant Flow Test Locations and Summary of Results

Test ID	Pressure Zone	Street Location	Pipe Diameter, inches	Pressure, psi		Flow during Test, gpm	Estimated Flow Available at 20 psi, gpm
				Static	Residual		
Test 1	West High	Britton near Wilshire	6	77	56	1,960	3,400
Test 2	West High	Lyndhurst near High	6	82	42	1,840	2,300
Test 3	West High	Garfield west of McKinley	6	79	38	1,260	1,500
Test 4	West High	Dover at Rutland	6	78	34	1,540	1,800
Test 5	East High	4th Street and Hilliard	6	107	83	750	1,500
Test 6	Central Low	Robinson at Nicklin	6	76	60	1,960	3,900
Test 7	Central Low	Spring and High Street	6	80	64	1,300	2,700
Test 8	Central Low	Water Street at Downs	16	78	63	2,330	4,800
Test 9	Central Low	Wayne and Johnson	6	82	44	1,460	1,900
Test 10	Central Low	Manier at Roosevelt	6	75	66	1,210	3,200
Test 11	East High	Sioux Dr. S. of Cherokee Dr.	8	67	50	1,930	3,300
Test 12	Central Low	S. Main St. near Statler	6	88	43	1,840	2,300

Figure 4-15 Hydrant Flow Tests Data Collection Sheet

City of Piqua
Water Distribution Model and Master Plan
Hydrant Flow Test Field Data Collection Sheet

Hydrant Flow Test ID	________
Date	________
Time	________
Staff	________
Size of Hydrant	________
Hydrant Coefficient	________
Sides of Hydrant Open	

Before test

Flow Hydrant Pressure, psi	________
Residual Hydrant Pressure, psi	________

During test

Flowing Hydrant Reading, psi	________
gpm	________
Residual Hydrant Pressure, psi	________

After test

Flow Hydrant Pressure, psi	________
Residual Hydrant Pressure, psi	________

Reservoir/Tank Levels

Clearwell, ft	________		
R.M. Davis Tank, ft	________	Inlet Pressure, psi	________
Spring St. Tank, ft	________	Inlet Pressure, psi	________
South Main St. Tank, ft	________	Inlet Pressure, psi	________
Ash Tank, ft	________		

WTP PS

	On/Off		
Pump 1	________	Flow 1, MGD	________
Pump 2	________	Flow 2, MGD	________
Pump 3	________	Pressure, psi	________
Pump 4	________	Pump 4 Speed, Hz	________

Ziegler PS

	On/Off		
Pump 1	________	Flow, MGD	________
Pump 2	________	Inlet Pressure, psi	________
Pump 3	________	Outlet Pressure, psi	________

Hetzler PS

	On/Off		
Pump 1	________	Flow, MGD	________
Pump 2	________	Inlet Pressure, psi	________
		Outlet Pressure, psi	________

Section 5

Model Calibration

5.1 Steady-State Model Calibration

The field data used for the steady-state hydraulic calibration were collected during 12 hydrant flow tests (shown in **Figure 5-1**) performed on September 7, 2011. The test locations were distributed throughout the distribution system to ensure system-wide coverage.

During model calibration, model results were compared to field data. The comparisons included pressures at the flow and residual hydrants for each field test during both static and flow conditions. Fire hydrants were modeled as nodes at the appropriate locations. Hydrant nozzles were assumed to be 2.5 feet higher than the ground elevation.

The initial model run was conducted without a hydrant flowing to compare the static pressures. Then the hydrant flow rate data from field testing was input into the model as a demand at the flowing hydrant, and model-predicted pressure was compared with the field-tested residual pressure. Hydrant flow rates were calculated from the field-measured pressure. Because a Pitot gage converts virtually all of the velocity head associated with the flow stream to pressure head, the Pitot gage pressure reading can be converted to a hydrant discharge rate using the orifice relationship:

where Q = hydrant discharge (gallons per minute [gpm])

Cf = unit conversion factor (29.8)

Cd = discharge coefficient

D = outlet diameter (inch)

P = pressure reading from the gage (pounds per square inch [psi])

Therefore, for City of Piqua, where a typical 2.5-inch hydrant outlet was used, and a discharge coefficient of 0.9, the equation can be reduced to:

$$Q = 168\sqrt{P}$$

Figure 5-1 Fire Flow Test

The hydraulic model steady state calibration approach is as follows:

- Examine the pipe attributes and group the pipes based on pipe material and installation date information for estimating the Hazen-Williams C-value.

The Hazen-Williams C-value is a relative measure of the hydraulic capacity of a water main. At a constant flow rate, the lower the C-value, the greater the drop in water pressure along a given length of main. Therefore, the initial C-value assumptions were adjusted during calibration based on static model conditions and hydrant flow results.

The original model provided by the City included pipe material and majority of the distribution system contained Cast Iron as pipe material. CDM Smith collected the age of the system based on the map provided by the City. CDM Smith studied the map and established 4 pipe age groups, which were before 1950, 1950-1980, 1980-1995, and 1995 to present. These groups were further broken down by pipe diameter. Pipes within the same group would have the same material, pipe age and similar diameter, therefore assumed to have similar C-values.

Initial C-values are presented in **Table 5-1**, based on data from Advanced Water Distribution Modeling and Management.

Table 5-1 Initial C-Values

Material	Installation Period	Pipe Size, inches	Initial C-value*
Unlined Cast Iron	100 years old	3	61
	60 years old		69
	30 years old		83
	100 years old	6	70
	60 years old		79
	30 years old		90
	New		133
	100 years old	12	78
	60 years old		85
	30 years old		97
	New		138
	100 years old	24	83
	60 years old		92
	30 years old		102
	New		140

*Source: Haestad Methods, Advanced Water Distribution Modeling and Management, First Edition, Page 36 - Table 2.3, Type 2, moderate attack.

- Set up scenarios and boundary conditions.

For static calibration purposes, 12 scenarios were set up in the model, one for each flow test. Boundary conditions during each test, such as pump status and water levels in tanks, were collected from the City's SCADA records and entered into the corresponding model scenario.

- Calibrate the Model for 12 Scenarios.

The Darwin Calibrator module of the WaterGEMS was then run and the C-values were calibrated, one scenario at a time. During calibration, the Darwin Calibrator ran hundreds or thousands of iterations until the error was within the preset limit. During the running process, the Darwin Calibrator automatically calculated the C-values that best fit the measured vs. modeled data. After each calibration run, calibrated C-values were exported into the model. Calibrated C-values are presented in **Table 5-2**.

Table 5-2 Pipe Groups and Calibrated C-Values

Material	Installation Period	Pipe Size	Calibrated C-value
Unlined Cast Iron	Before 1950	4" and 6"	68
	1950 - 1980		70
	1980 - 1995		73
	1995 - Present		104
	Before 1950	8" and 10"	71
	1950 - 1980		76
	1980 - 1995		90
	1995 - Present		120
	Before 1950	12"	80
	1950 – 1980		88
	1980 - 1995		98
	1995 - Present		124
	Before 1950	16"	85
	1980 - 1995		106
	1995 - Present		130
	1950 – 1980	20" or 24"	110
	1980 - 1995		111
	1995 - Present		130
Concrete or Ductile Iron	Any Year	All Sizes	130

Table 5-3 presents a comparison of field data and model results for the flow and residual hydrants. The model achieved a high level of steady-state calibration with the model results within 5 psi of the measured field test data at all locations.

Originally, test location 7 and 11 did not calibrated well. After discussion, City staff pointed out a closed valve on Water Street and water main on Looney Road should be 16-in instead of 12-in. After these updates were incorporated into the model, the calibration results were greatly improved to an acceptable range.

Tacble 5-3 Hydrant Data Comparison

Test ID	Flow Conditions	Hydrant	Measured Pressure, psi	Flowrate, gpm	Modeled Pressure, psi	Modeled – Measured, psi
Test 1	Static	Residual	77		74.7	-2.3
		Flow	79		76.8	-2.2
	Flow	Residual	56		56.6	0.6
		Flow	34	1960	32.5	-1.5
Test 2	Static	Residual	82		82.6	0.6
		Flow	84		83.4	-0.6
	Flow	Residual	42		44.3	2.3
		Flow	30	1840	28.4	-1.6
Test 3	Static	Residual	79		81.2	2.2
		Flow	79		81.2	2.2
	Flow	Residual	38		39.5	1.5
		Flow	14	1260	14.9	0.9
Test 4	Static	Residual	78		78.7	0.7

Test ID	Flow Conditions	Hydrant	Measured Pressure, psi	Flowrate, gpm	Modeled Pressure, psi	Modeled – Measured, psi
		Flow	78		78.7	0.7
	Flow	Residual	34		35.2	1.2
		Flow	21	1540	18.3	-2.7
Test 5	Static	Residual	107		106.4	-0.6
		Flow	103		103.8	0.8
	Flow	Residual	83		85.4	2.4
		Flow	5	750	4.8	-0.2
Test 6	Static	Residual	76		75.1	-0.9
		Flow	76		74.7	-1.3
	Flow	Residual	60		55.6	-4.4
		Flow	34	1960	34.1	0.1
Test 7	Static	Residual	80		77.5	-2.5
		Flow	79		77.5	-1.5
	Flow	Residual	64		67.0	3.0
		Flow	15	1300	16.1	1.1
Test 8	Static	Residual	78		74.6	-3.4
		Flow	79		75.4	-3.6
	Flow	Residual	63		64.9	1.9
		Flow	48	2330	47.6	-0.4
Test 9	Static	Residual	82		79.1	-2.9
		Flow	83		79.5	-3.5
	Flow	Residual	44		44.3	0.3
		Flow	19	1460	18.8	-0.2
Test 10	Static	Residual	75		71.5	-3.5
		Flow	77		73.8	-3.2
	Flow	Residual	66		61.1	-4.9
		Flow	13	1210	11.6	-1.4
Test 11	Static	Residual	67		66.8	-0.2
		Flow	68		67.3	-0.7
	Flow	Residual	50		46.2	-3.8
		Flow	33	1930	34.5	1.5
Test 12	Static	Residual	88		85.4	-2.6
		Flow	89		85.4	-3.6
	Flow	Residual	43		44.0	1.0
		Flow	30	1840	28.8	-1.2

5.2 Extended Period Simulation Model Calibration

After the model was calibrated for steady-state conditions, the next step was to calibrate the model for extended period simulation (EPS). Unlike steady-state calibration, which matches field data taken from a snapshot in time, EPS calibration verifies that the model accurately replicates the performance of the distribution system over some period, 24 hours for example.

The field data used for EPS calibration were pump station and tank level trends on September 2, 2011. This day was chosen because SCADA data quality on this day was good and it was within the general time frame of the other field tests. Boundary conditions, such as pump station and tank data were obtained from the City's SCADA system. The pump station ON/OFF status was entered into the model using time-controlled rules to match the actual operations during the calibration day. Tank levels at 12 a.m. were entered into the model as initial levels.

Accurate EPS calibration of the City's distribution system was demonstrated by three factors: pressure variation at the pressure recorders, tank level variation, and tank fill and draft behavior. In all cases, the model corresponded well with the field data provided. **Figures 5-2** through **Figure 5-8** present the results of the EPS calibration, including recorded vs. modeled pressures at the six hydrant pressure test locations and the tank levels at R.M. Davis and East Ash Street tank. Please note a water level of 2.3 feet is equivalent to 1 psi.

CDM Smith

Figure 5-2 EPS Calibration Results – Hydrant Pressure Test Location 1

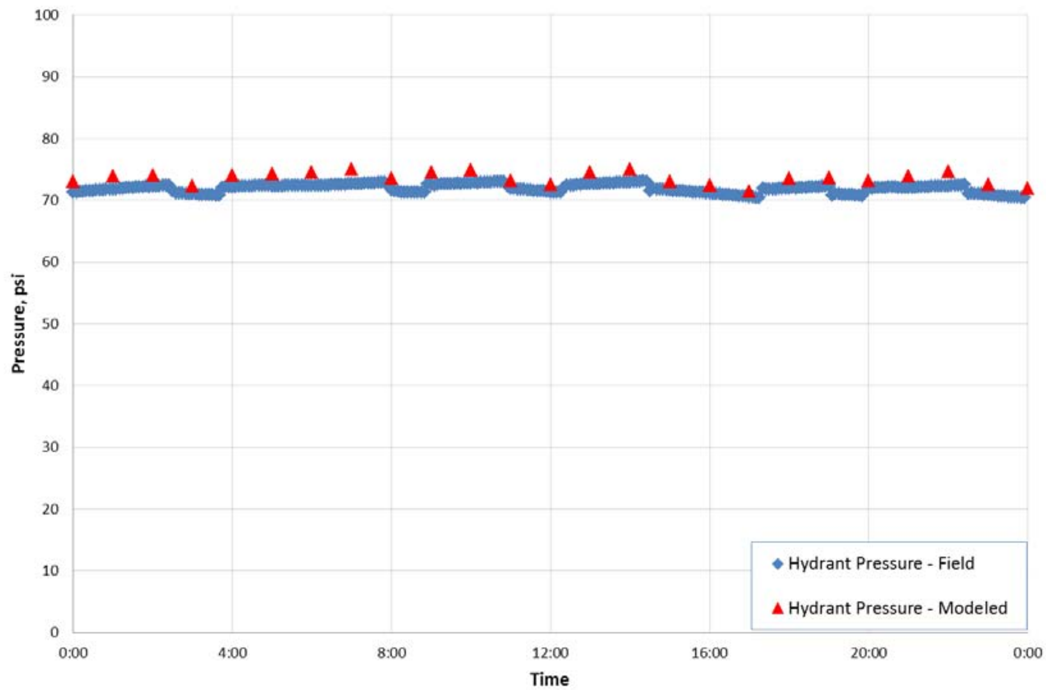


Figure 5-3 EPS Calibration Results – Hydrant Pressure Test Location 2

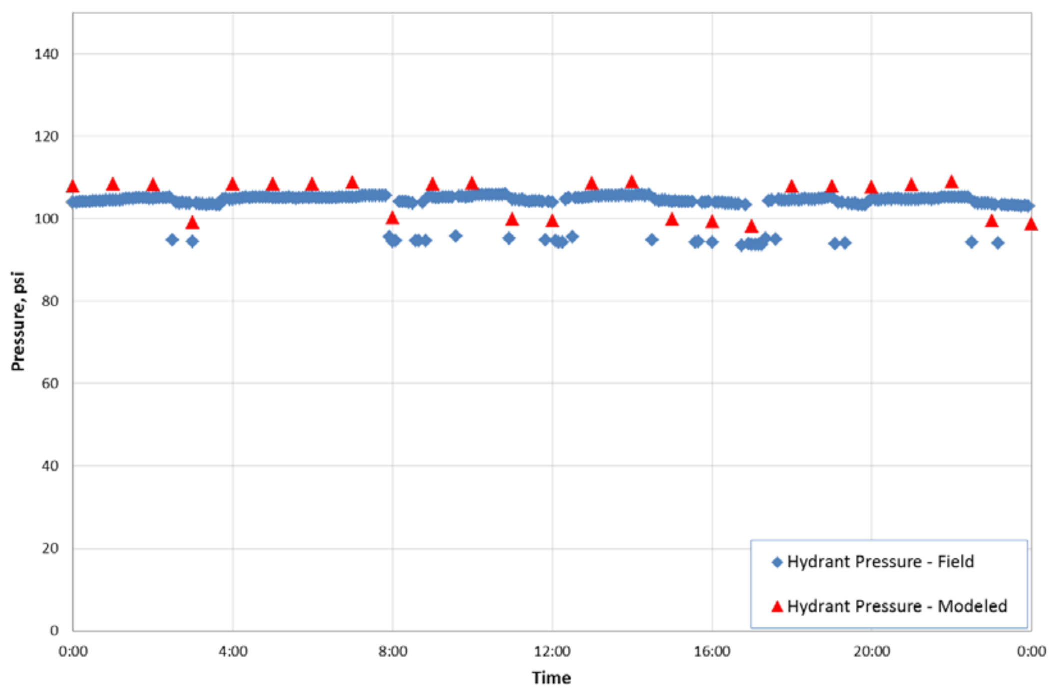


Figure 5-4 EPS Calibration Results – Hydrant Pressure Test Location 3

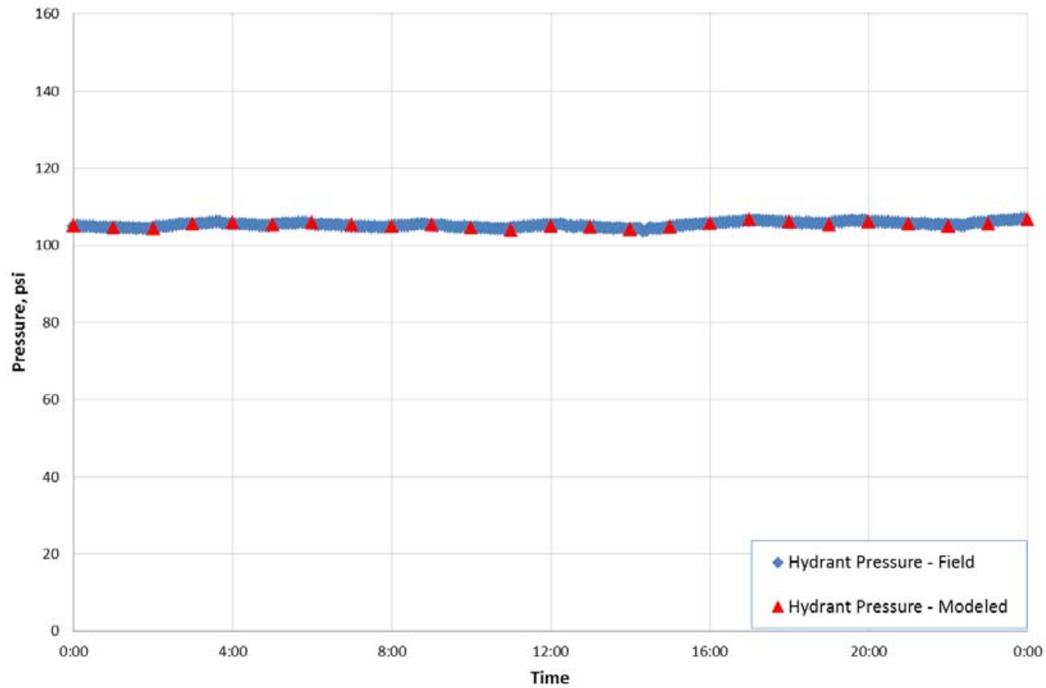


Figure 5-5 EPS Calibration Results – Hydrant Pressure Test Location 4

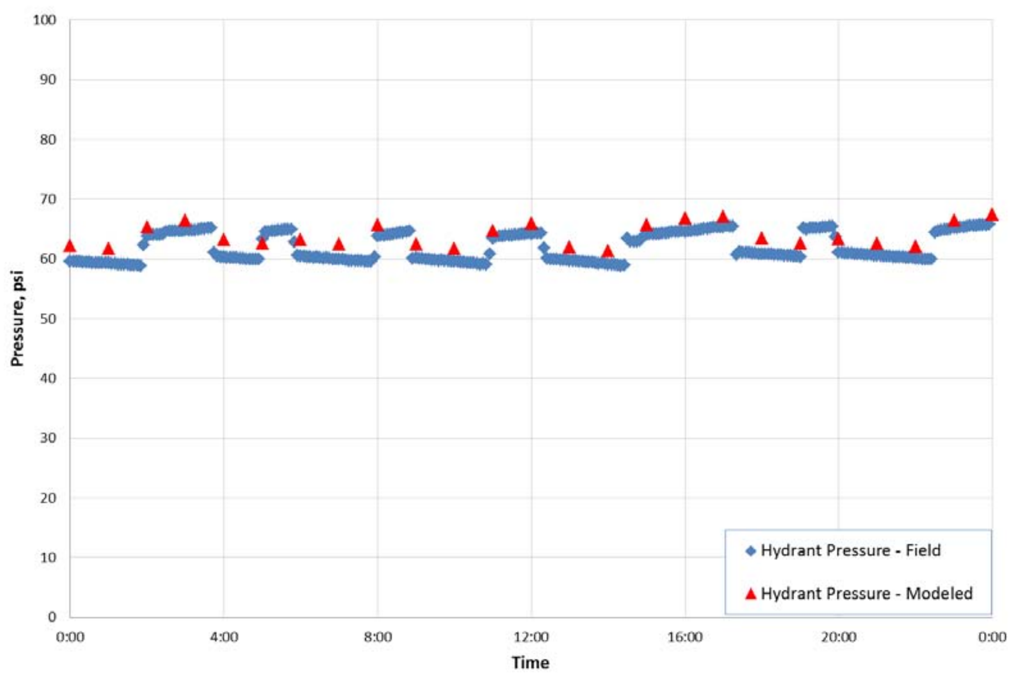


Figure 5-6 EPS Calibration Results – Hydrant Pressure Test Location 5

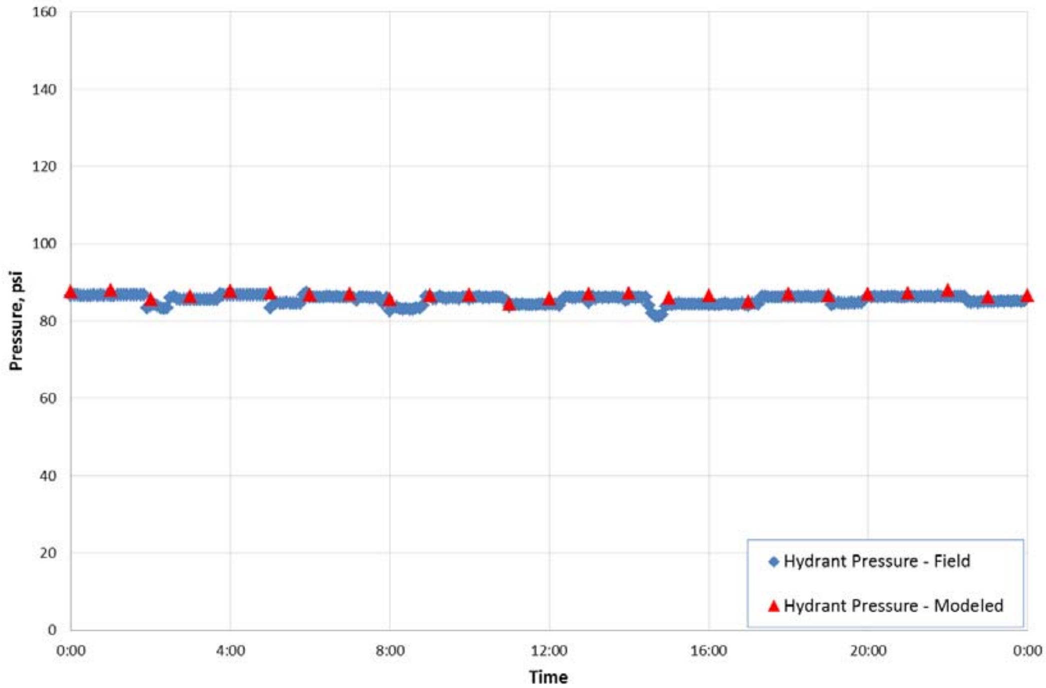


Figure 5-7 EPS Calibration Results – Hydrant Pressure Test Location 6

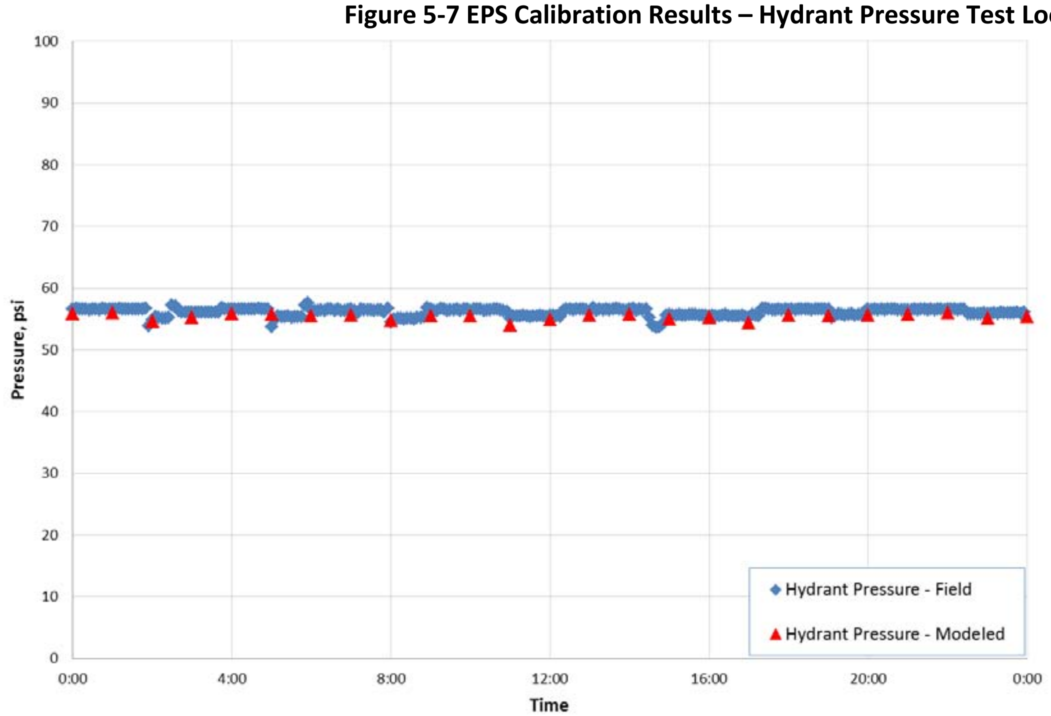


Figure 5-8 EPS Calibration Results – R.M. Davis Tank Levels

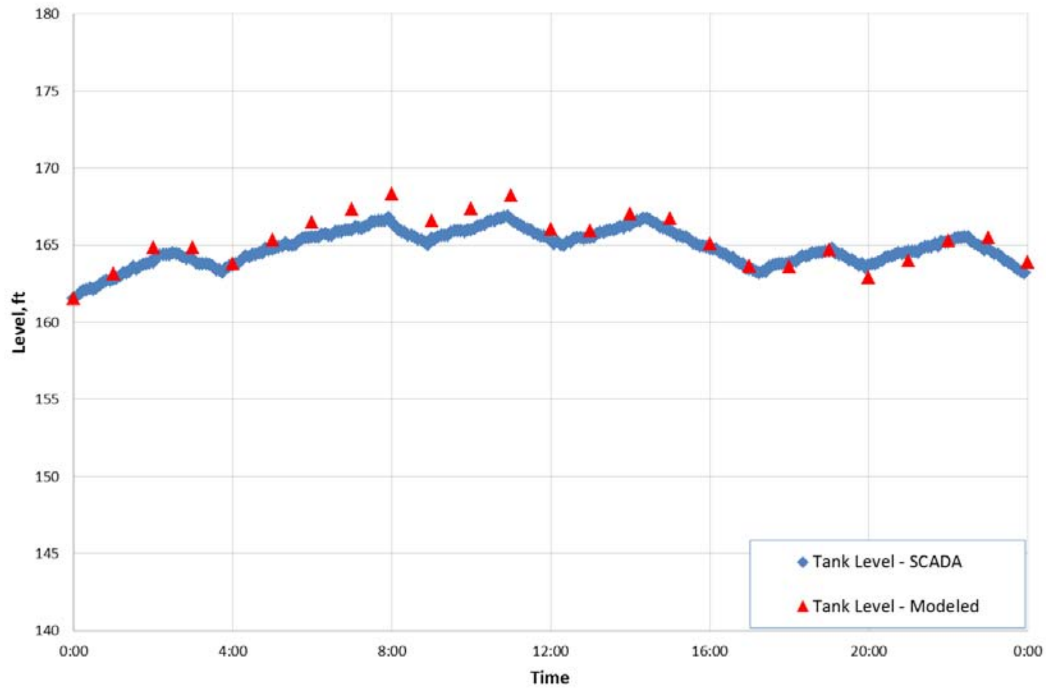
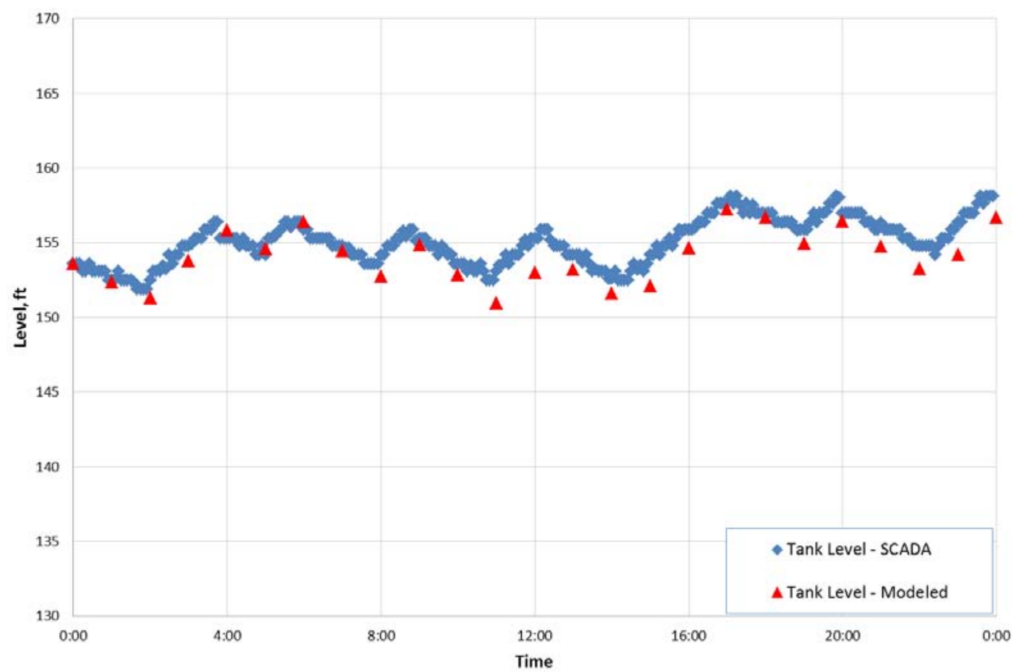


Figure 5-9 EPS Calibration Results – East Ash Tank Levels



Section 6
Demand Projections

This section describes the methodology and results in developing the City's future service area, land use categories, and estimate future flows of the City's water distribution system for year 2030.

6.1 Data Source

The approach in developing future flows is consistent with that used in the Piqua Water Treatment Plant – Preliminary Engineering Report (PER), Draft, dated November 2011. The following data sources and documents were referenced in developing the future flows.

- Piqua Water Treatment Plant – Preliminary Engineering Report (PER), Draft, November 2011
- City of Piqua – historical WWTP flow data from Operator 10 system, 2008-2011
- City of Piqua – water billing records from 2006-2010
- City of Piqua – water treatment plant production data from 2006-2010
- Geographic Information Systems (GIS) data from Miami Valley Regional Planning Commission (MVRPC)
- Plan It Piqua – Redevelopment Analysis Report, April 2010

6.2 Approach

6.2.1 Future Build-out Demand Projection

As described in the PER, the future land use is categorized as three usage types, commercial, industrial, and residential. **Figure 6-1** and **Figure 6-2** present the existing and future land use for the City. **Table 6-1** presents the comparison of current and future land use categories. **Figure 6-3** presents the future land use distribution percentage for each usage type.

In addition to the growth (from **Figure 6-1** and **Figure 6-2**), the result of **Table 6-1** also accounts for redevelopment areas (**Figure 6-4**), which is 20 areas totaling 647 acres of currently vacant or un-serviced industrial and commercial sites. These areas are defined in the Redevelopment Analysis Report, dated April 2010.

Figure 6-1 Current Land Use

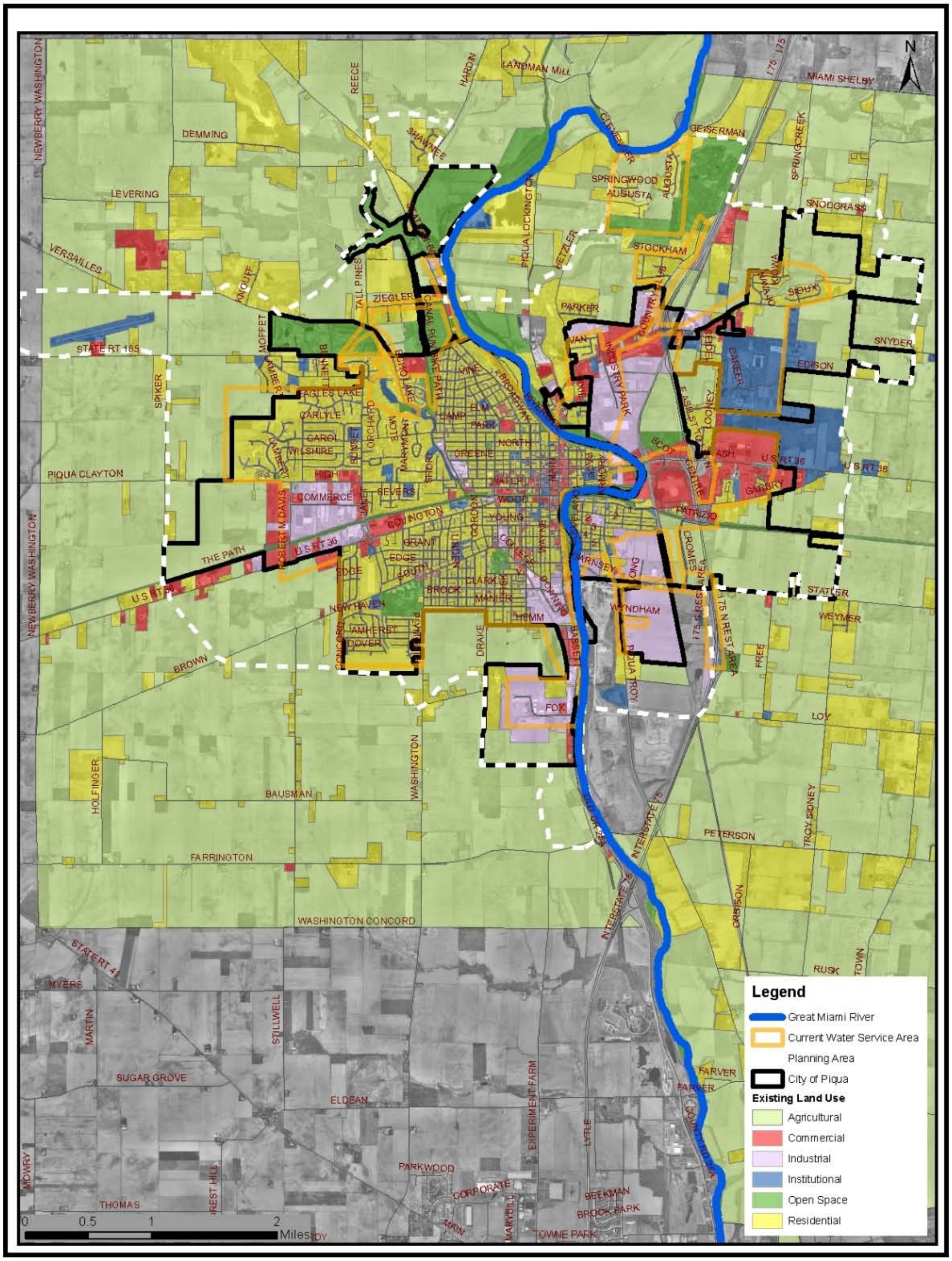


Figure 6-2 Future Land Use

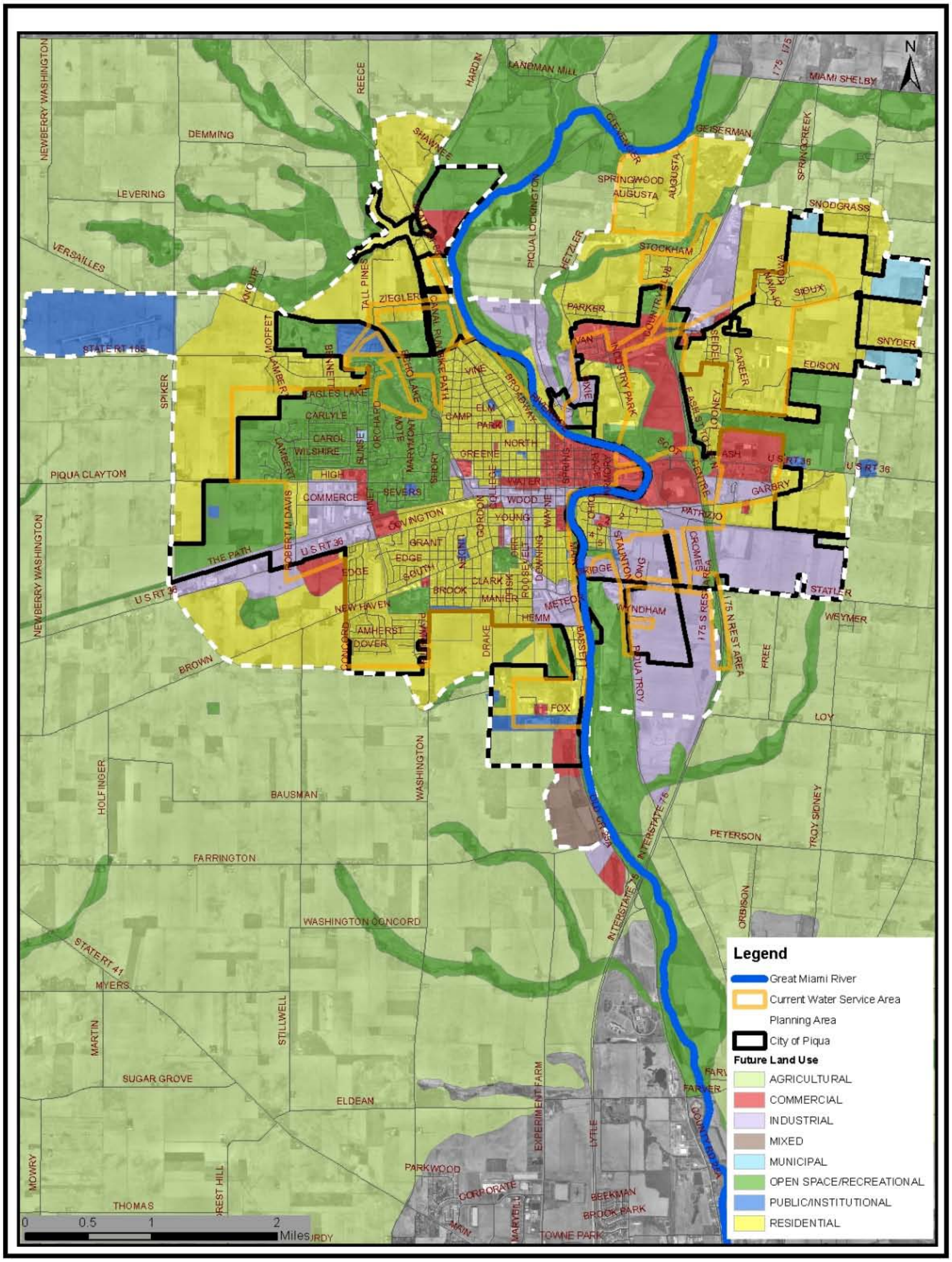
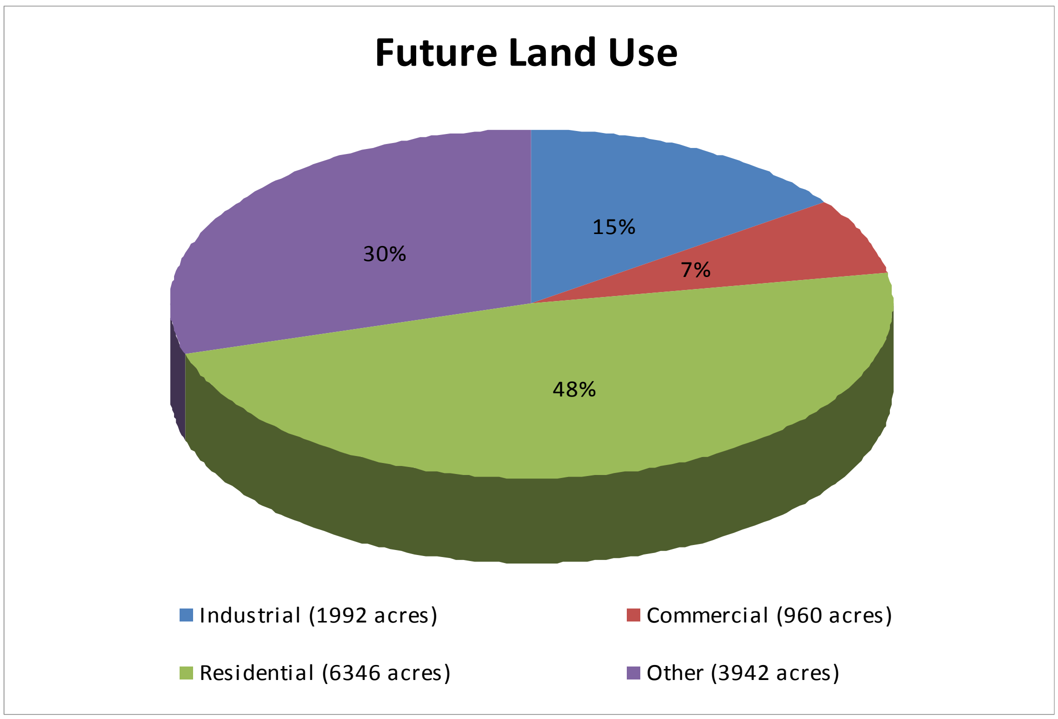


Table 6-1 Comparison of Current and Future Land Use Categories

Land Use Category	Current Water Service Area, acres	Future Water Service Area, acres	Redevelopment Area, acres
Industrial	538	1,992	409
Commercial	584	960	155
Residential	2,198	6,346	46
Others	1,872	3,942	37
TOTAL	**5,192**	**13,240**	**647**

Figure 6-3 Future Land Use Distribution



Note: Categories identified as "Other" include Institutional, Agricultural, Mixed, Municipal, and Open Space

Figure 6-4 Redevelopment Areas (Twenty Areas of Interest)

Once the areas of future development were identified, a unit water demand factor was used to calculate future water demands. To develop the unit factor, historical water billing data was referenced. Unit factors are summarized in **Table 6-2**.

Table 6-2 Unit Water Demand Factors

Land Use	Unit Water Demand Factors, gpd/acre
Commercial	950
Industrial	1,000
Residential	527

Total projected future water demand for the City is summarized in **Table 6-3**. For the future build-out scenario, average day water demand for the City is estimated at 8.03 MGD, including a 15% UFW factor.

Table 6-3 Future Average Day Water Demand

Land Use	Flow, MGD
Commercial	0.91
Industrial	1.99
Residential	3.34
Redevelopment Area	0.58
Total Future Average Day Water Demand	**6.83**
Total Future Average Day Water Demand with UFW	**8.03**

6.2.2 Year 2030 Demand Projection

To develop water demand for year 2030, it was assumed that the commercial and industrial areas will be fully developed. Since there is no specific timeline associated with the build-out scenario, this approach is conservative.

Residential demand for year 2030 is based on Traffic Analysis Zone (TAZ) data from MVRPC. In the TAZ data, population values are provided for each TAZ area. Water Demand for each TAZ area is calculated by multiplying population by a per capita water use factor. Although there is a nominal decrease in per capita residential demand over the past 5 years from 58 gpcd to 54 gpcd, the projected demand for average per capita residential consumption has been conservatively assumed to be 60 gpcd for planning purpose.

Total projected 2030 water demand for the City is summarized in **Table 6-4**. For the 2030 scenario, average day water demand for the City is estimated at 5.98 MGD, including a 15% UFW factor.

Table 6-4 2030 Average Day Water Demand

Land Use	Flow, MGD
Commercial	0.91
Industrial	1.99
Residential	1.60
Redevelopment Area	0.58
Total 2030 Average Day Water Demand	**5.09**
Total 2030 Average Day Water Demand with UFW	**5.98**

Once the additional flows for each area are calculated, they are assigned to a nearby model junction using the LoadBuilder tool in the WaterGEMS software. Diurnal patterns are also applied to account for daily flow variations at each location. UFW factor of 15% is distributed evenly throughout the system to each model junction.

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Section 7

System Evaluation and Alternative Analysis

This section identifies existing and potential future deficiencies in the City's water distribution system with the use of the computer model. Once an understanding of the deficiencies throughout the distribution system under different operating scenarios and demand conditions are identified and causes understood, the basis for the development of a Capital Improvement Plan (CIP) will be established.

The model used for the analysis was the calibrated extended period simulation (EPS) model for the existing system and 2030 time horizon. Alternative water sources analyzed included a new Water Treatment Plant or a finished water supply from the City of Troy. Therefore, the four scenarios analyzed are:

- Existing demand with water supplied from the City's existing WTP
- Existing demand with water supplied from Troy
- 2030 demand with water supplied from the City's new WTP
- 2030 demand with water supplied from Troy

The findings of the analysis include a review of system performance with respect to low pressure, high headloss, as well as evaluations of the storage and pumping capacities.

7.1 Water System Performance Metrics

System performance metrics were established to evaluate the distribution system for the safety and satisfaction of all water system customers. The metrics were used to determine whether facility or distribution system piping is designed and operating sufficiently well to meet the demands imposed by normal customer demand, fire flow need, or redundancy. These metrics, or "levels of service," can be monitored by using parameters that are easily identified in the water distribution model, including variables used to determine sizing of the water system network components, and cover aspects of water production, system pressures, water velocities, pipeline headloss, storage volumes, and fire-flow availability.

Table 7-1 summarizes the system performance metrics used for the City's system, including the parameter, means of measurement or evaluation, suggested service levels, and comments.

Table 7-1 Summary of Performance Metrics

Parameter	Measurement	Suggested Level	Comments
Pressure	Max. pressure – avg. day flow	120 psi	Normally measured at high and low elevations in each pressure zone of the distribution system.
	Min. pressure – peak hour flow	40 psi	
Fire Flow Pressure	Min. pressure – fire flow	20 psi	This is a standard pressure set point for fire flow evaluations. The model uses this setting to calculate available fire flow.
Fire Flow and Duration	Residential	1,000 gpm @ 2 hr	Fire flow demand set by node in the model. Sufficient storage volume is needed to provide fire flow over the specified duration.
	Commercial	3,000 gpm @ 3 hr	
	Industrial	3,500 gpm @ 3 hr	
Velocity	Normal operations – peak hour flow	7 ft/sec	May be higher for fire flow
Storage	Emergency reserve, peak shaving, fire fighting	Equal to average day demand	Evaluate combination of storage and pumping
Pumping	Normal operations – max. day flow	Varies	Supply maximum day flow with largest pump out of service.

7.2 Boundary Conditions

To analyze the distribution system, it is important to define the boundary conditions of each model run as they have direct impact on the model results.

7.2.1 Pump Station Controls

Currently, the WTP Pump #4 is equipped with VFD and the discharge pressure at the WTP is maintained at 68 psi. The two booster stations, Hetzler Road and Ziegler Road, are manually controlled; however, the operators follow a control guideline in operating the pumps. The City desires to maintain the water level in the R.M Davis tank between 162 and 167 feet (turn Ziegler pump(s) off when water level in R.M. Davis reaches 167 feet, and turn on when water level drops to 162 feet), and the water level in the East Ash Street tank between 151 and 157 feet (turn Hetzler pump(s) off when water level in East Ash tank reaches 157 feet, and turn on when water level drops to 151 feet). These control schemes are input into the model to represent typical pump operation.

7.2.2 Pressure Zones

There are three pressure zones in the City's distribution system: West High, East High, and Central Low. The City currently operates the system with 2 boundary valves open, one valve is located at Linden and Manier to connect the West High and Central Low pressure zones, and the other valve is located at Main and Miami to connect the East High and Central Low.

In the evaluations, these boundary valves are closed to maintain three separate pressure zones.

CDM Smith

7.3 Storage Analysis

Sufficient elevated storage must be maintained throughout the distribution system for both existing and 2030 scenarios. The storage facilities will provide diurnal balancing of water use and allowance for fire-fighting or other emergencies. There are many acceptable industry standard ways for determining adequate storage in the system. One common way of determining adequate storage in the system is that it is equal to the average daily demand over 24 hours for each pressure zone.

The City maintains three pressure zones, the East High, West High, and Central Low. There are two types of storage facilities in the City's system, underground storage (WTP Clearwells) and elevated storage (tanks). The WTP contains two below-ground clearwells each with a capacity of approximately 550,000 gallons to provide storage of the finished water. There are four elevated storage tanks in the system, with one in East High, one in West High and two in Central Low. Due to relatively low overflow elevations, the two elevated tanks in the Central Low are not effectively used as they stay full most times and are only used during emergency situations.

The City has discussed the possibility of raising these two tanks to a higher overflow elevation so that the storage volume can be effectively utilized. But this option is not desirable due to the age and deteriorated conditions of the two tanks. Therefore, these two tanks in the Central Low zone are not considered during the storage analysis.

The existing average day demand for the City of Piqua is 2.91 mgd. This value was derived from averaging daily finished water pumping rates at the WTP from 2006 to 2010 (**Table 3-1**). The 2030 average day demand is estimated at 5.98 mgd (**Table 6-4**).

Using the GIS data (overlaying the model junction layer with the pressure zone boundaries), the current average day demand in the East High, West High, and Central Low pressure zones is estimated at 0.56 mgd, 0.95 mgd, and 1.39 mgd, respectively. The 2030 average day demand, including UFW, in the East High, West High, and Central Low pressure zones is estimated at 2.82 mgd, 1.34 mgd and 1.82 mgd, respectively. These values suggest the majority of the future development will occur in the East High pressure zone.

Table 7-2 presents the results of the storage analysis. This analysis demonstrates that Central Low pressure zone has insufficient storage for both current and 2030 conditions. The East High pressure zone will have insufficient storage for the 2030 condition. The overall system storage requirement is met as the combined system storage of 3.6 MG exceeds the current average day demand of 2.91 mgd. However, additional storage is required as the average day demand increases to 5.98 mgd in year 2030.

The clearwells at the WTP are assumed to be available to supply the average day demand during a power outage since the existing plant has a diesel powered high service pump and a back-up generator, and the new plant will have a backup electric generator to power new high service pumps to be able meet the future average day demand. However, in the Central Low service pressure zone, elevated storage is needed to meet the fire flow demand assumed to be 3,500 gpm for a duration of 3 hours, which equates to 5.04 MGD and 630,000 gallons of required storage.

Table 7-2 Storage Analysis

Pressure Zones	Storage Facilities	Storage Capacity, MF	Existing Average Day Demand, mgd	Storage Analysis - Existing	2030 Average Day Demand, mgd	Storage Analysis - 2030
East High	E. Ash Elevated Tank	1.0	0.56	Sufficient Storage	2.82	**Insufficient Storage**
West High	R.M Davis Elevated Tank	1.5	0.95	Sufficient Storage	1.34	Sufficient Storage
Central Low	Clearwells at existing WTP	1.1	1.39	**Insufficient Storage**	-	-
	Clearwells at new WTP -	3.0	-	Sufficient Storage	1.82	**Insufficient Storage to meet fire flow**
	Supply from Troy	0	1.39	**Insufficient Storage**	1.82	**Insufficient Storage**

7.4 Minimum System Pressure

Model runs were conducted under maximum day demand to verify that the minimum pressure throughout the system is above 40 psi for both current and 2030 conditions. Two alternatives were analyzed, one is with existing or proposed new Water Treatment Plant, and the other is with water supplied from Troy. Under both alternatives, a new elevated storage tank of 1.0 MG is connected to the 16 inch water main at the intersection of Gordon and Covington in the Central Low pressure zone, as the above storage analysis indicated insufficient storage in this zone.

7.4.1 Scenario 1 – Finished Water Supply from Water Treatment Plant

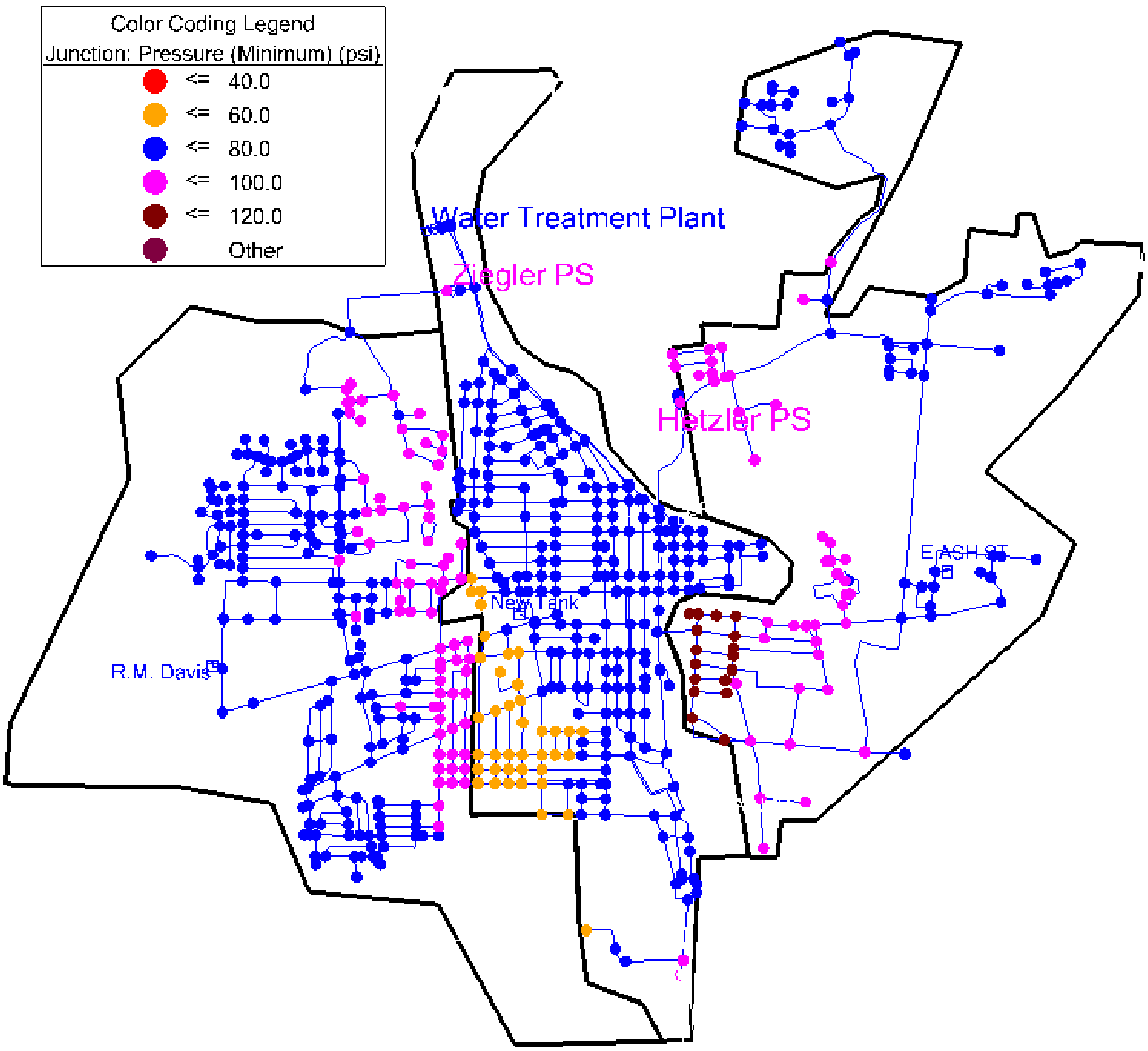
Under this scenario, water is supplied to the distribution system from the City's WTP. For the 2030 condition, the water is supplied from the City's new WTP located at State Route 66 and Hardin Road.

Under both current and 2030 demand scenarios, the discharge pressure at the WTP is maintained at 68 psi. The results of the minimum pressure are presented in **Figure 7-1** and **Figure 7-2**.

Under the current maximum day demand condition, all system pressure is above 40 psi. Minimum pressure for most areas falls between 60–100 psi. Higher pressure of 100-120 psi is observed in the Shawnee area in the East High pressure zone due to lower elevation, which is acceptable. Lower but acceptable pressure of 40-60 psi is observed in the west side of the Central Low pressure zone due to higher elevation.

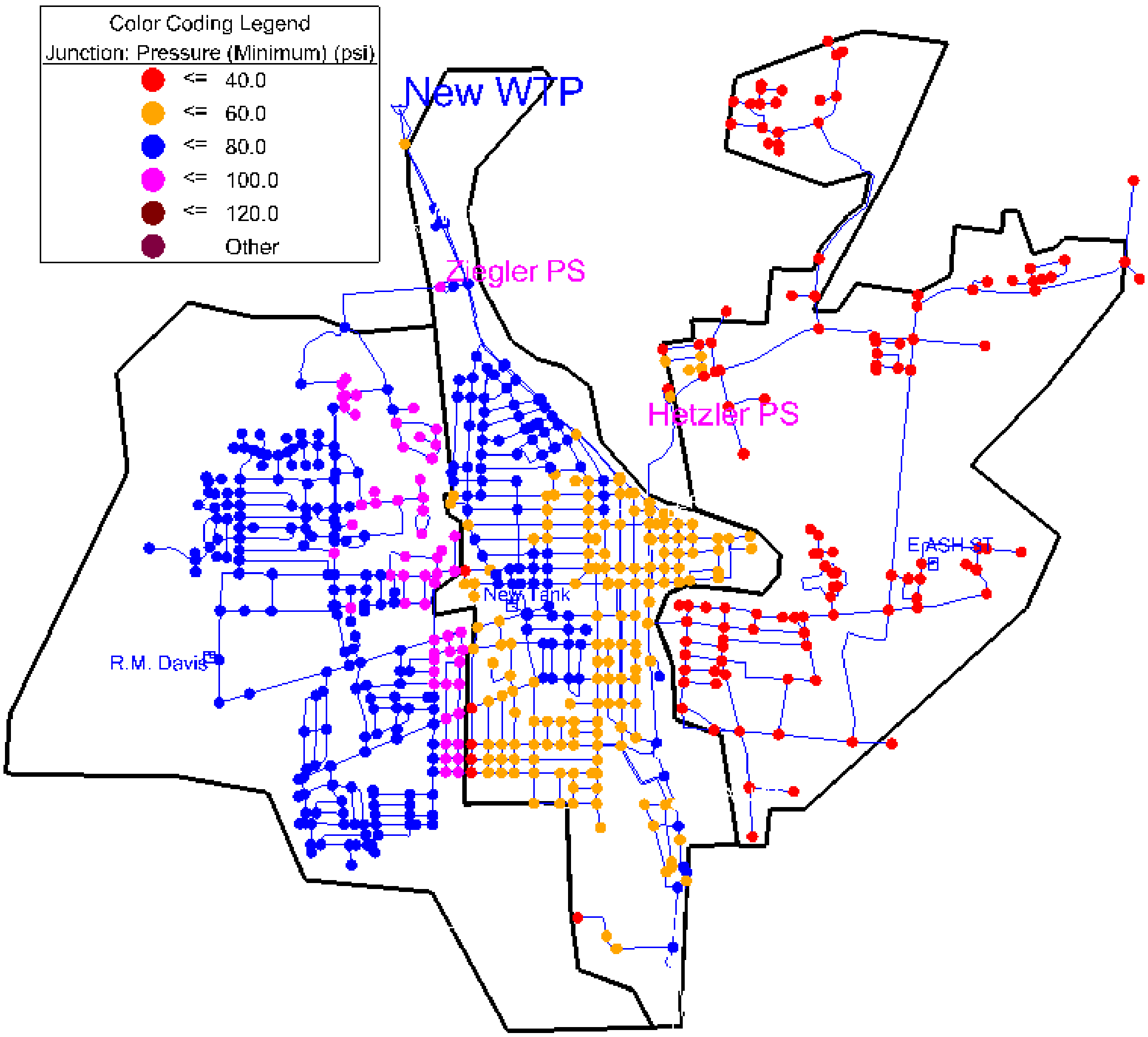
CDM Smith

Figure 7-1 System Minimum Pressure during Current Max Day Demand – WTP



Under the 2030 maximum day demand condition, low pressure mainly occurs in the East High pressure zone due to greatly increased water demand. At the same time, the East Ash Street elevated tank serving this pressure zone cannot be filled. During this model run, the two pumps at the Hetzler pump station are both turned on but cannot meet the high demand in the East High pressure zone in 2030, which indicates that there is inadequate capacity at the Hetzler Road pump station to supply the East High pressure zone in 2030.

Figure 7-2 System Minimum Pressure during 2030 Max Day Demand – WTP



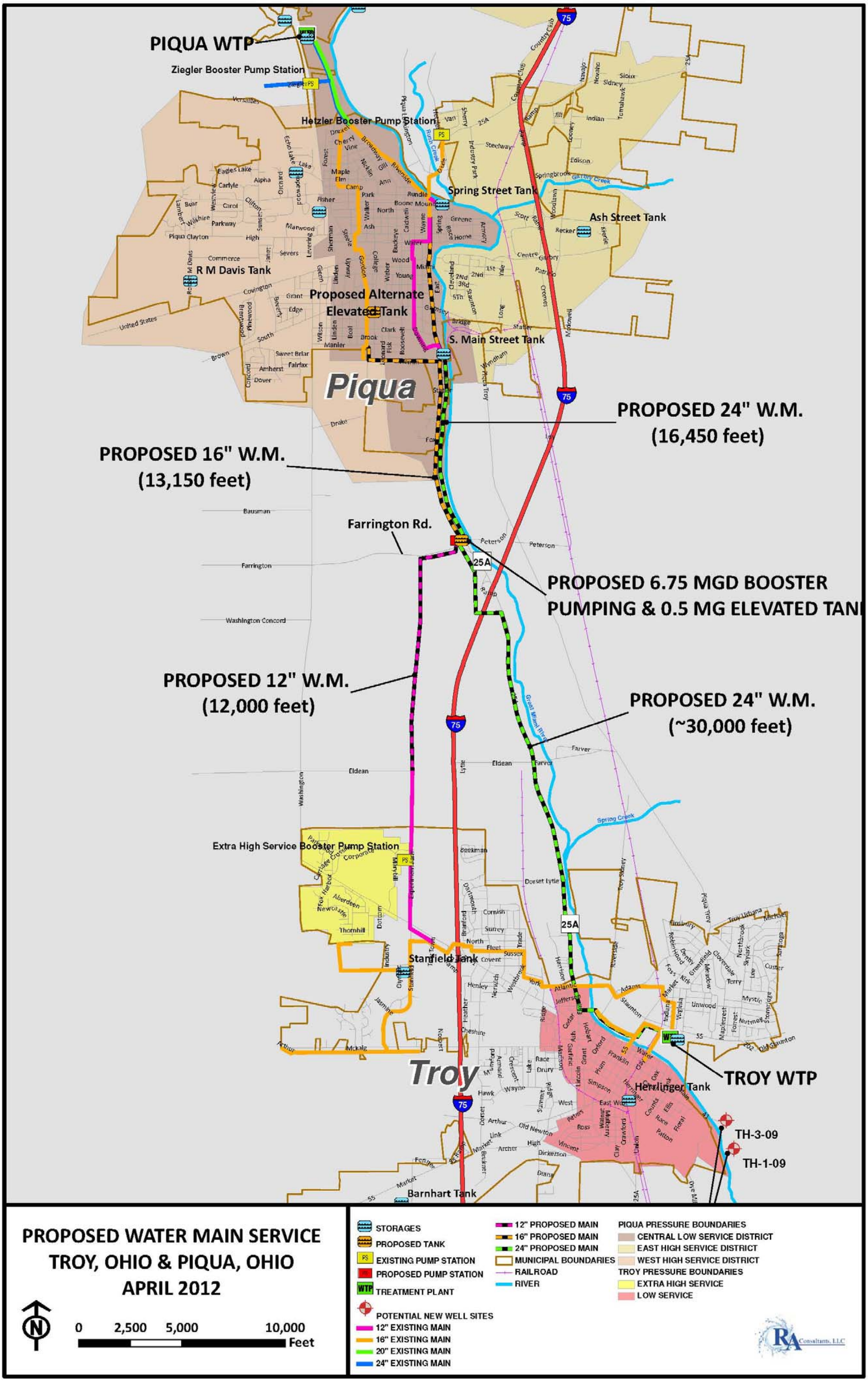
7.4.2 Scenario 2 –Finished Water Supply from Troy

Under this scenario, the City's distribution system is supplied from the City of Troy. In February, 2011, RA Consultants prepared a draft study "City of Piqua City of Troy Water System Study" to investigate the financial feasibility of creating a joint water treatment and supply utility operation that could treat and supply drinking water to the communities of Piqua and Troy, Ohio verses the current independent operations within the two communities. The study proposed the following water transmission main improvements, as presented in **Figure 7-3** (from City of Piqua City of Troy Water System Study, Draft Final Report, February 10, 2012, Appendix C Map of Proposed Water Main Service Improvements for Troy and Piqua, Ohio).

In the Troy supply alternative model runs, water supply from Troy is modeled as a fixed head reservoir, providing sufficient source of water to meet Piqua's water demands, both current and future. This reservoir is located at the intersection of Farrington Road and County Road 25A, where a proposed booster station is located in **Figure 7-3**. The HGL of this location is set at 1,060 feet in order to match the existing pressure at the intersection of Greene and Main Street where the proposed 16 inch water main from Troy ties in to Piqua's existing 16 inch water main.

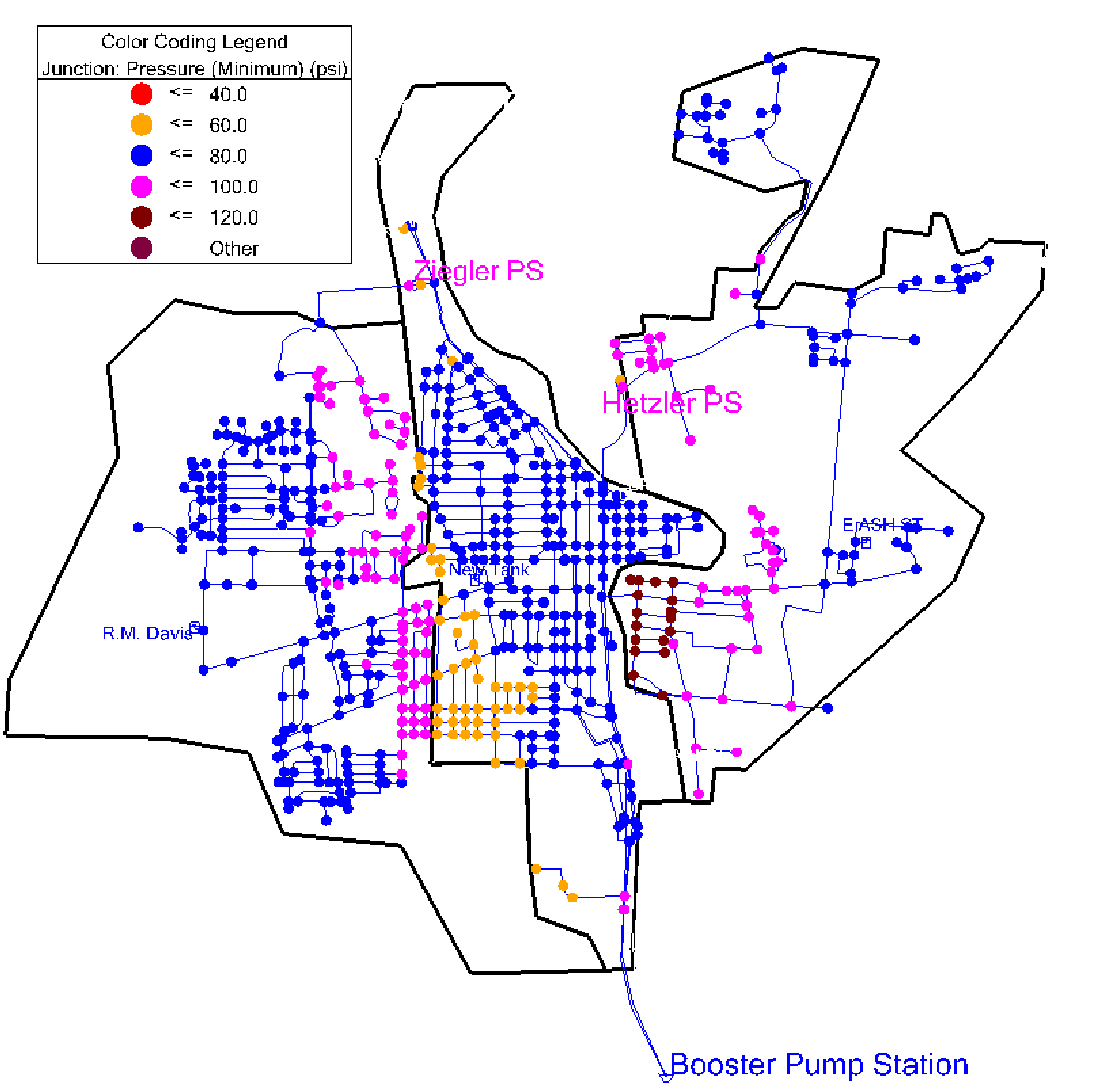
For the water supply from the City of Troy, the results of the minimum pressure under both current and 2030 maximum day demand conditions are presented in **Figure 7-4** and **Figure 7-5**.

Figure 7-3 Map of Proposed Water Transmission Main Improvements for Troy and Piqua, Ohio



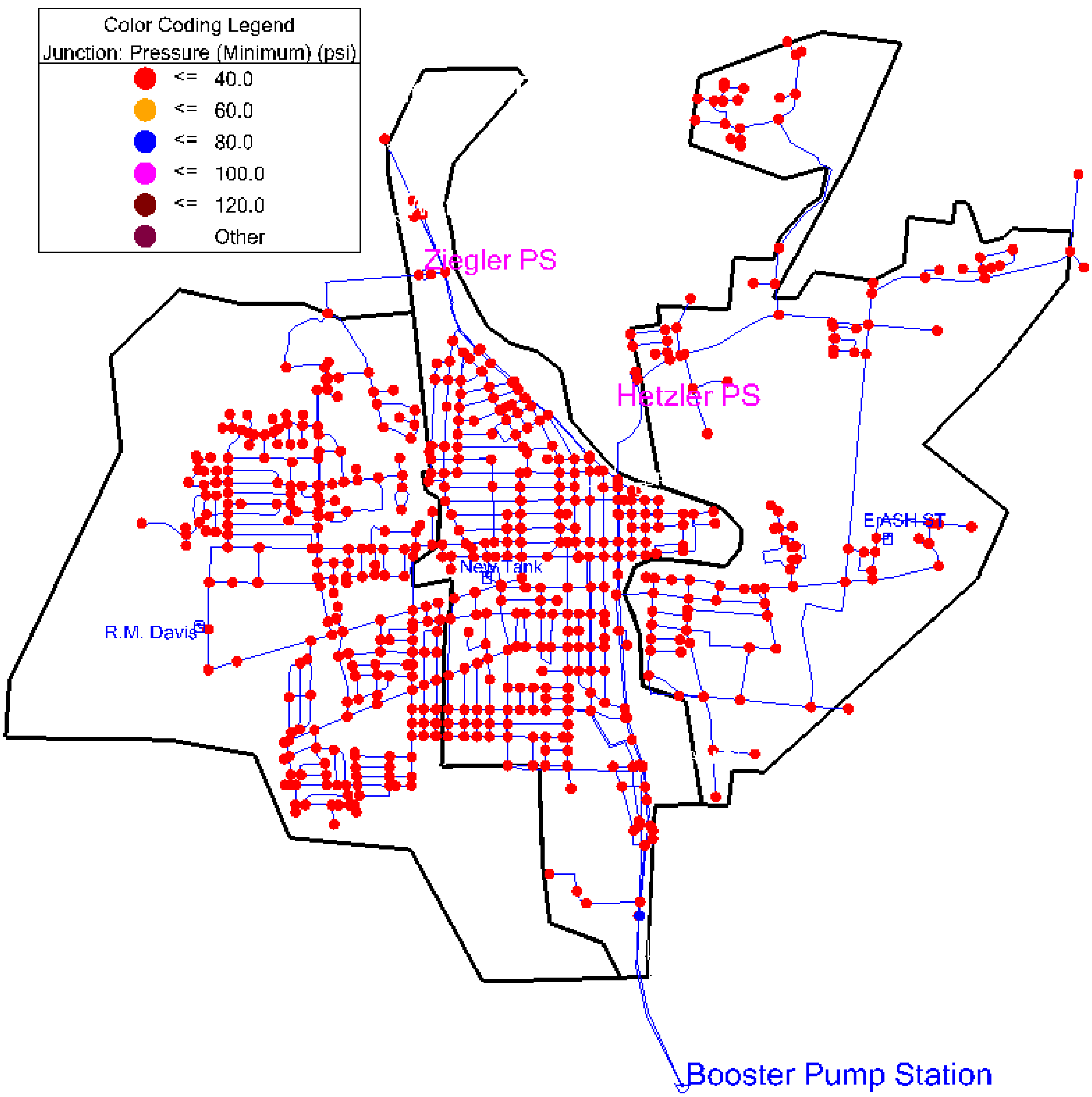
Comparing the City of Piqua's WTP and the Troy supply alternatives, under the current maximum day demand condition, slightly lower system pressure is observed with the Troy supply alternative; however, no pressure lower than 40 psi is observed. The lowest pressure is located in the west border of Central Low pressure zone due to higher elevation. Minimum pressure for most areas falls between 60–100 psi. Higher pressure of 100–120 psi is observed in the Shawnee area in the East High pressure due to lower elevation, which is acceptable.

Figure 7-4 System Minimum Pressure during Current Max Day Demand – Troy



Under the 2030 maximum day demand condition, minimum pressure of lower than 40 psi is observed throughout the system, indicating the two 16 inch water mains proposed are not capable of supplying the maximum day demand for the City of Piqua in 2030.

Figure 7-5 System Minimum Pressure during 2030 Max Day Demand – Troy



CDM Smith

7.5 Fire Flow Analysis

Fire flow analysis was conducted to verify that the system has sufficient fire flow capacity. Several large industrial users were identified and the locations were dispersed throughout all pressure zones, as presented in **Figure 7-6**. Industrial users were selected because they require the largest amount of flow and longest duration, which is 3,500 gpm for 3 hours. The performance criterion for fire flow simulation is to maintain a residual pressure of 20 psi throughout the distribution system during the fire flow event. Results of the fire flow analysis are summarized in **Table 7-3**.

Figure 7-6 Locations of Fire Flow Simulations

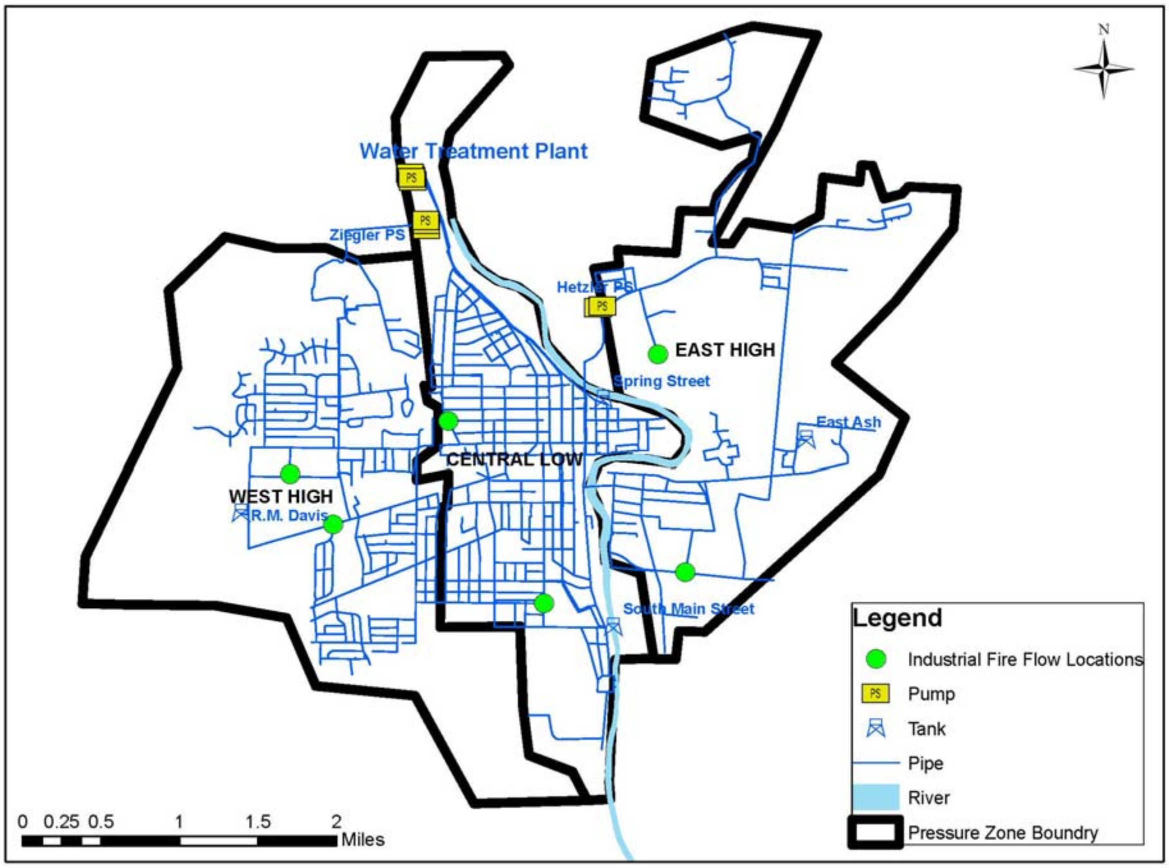


Table 7-3 Fire Flow Analysis of Industrial Users

Industrial Users	Locations	Pressure Zone	Results
Hartzell Industries	1025 S. Roosevelt Ave.	Central Low	**Insufficient fire flow capacity as the area is supplied mainly by 6" pipes.**
Northrop Grumman Corp.	350 Washington Ave.	Central Low	Sufficient fire flow capacity
Hartzell Propeller	1 Propeller Pl.	West High	Sufficient fire flow capacity
Crayex	1747 Commerce Drive	West High	Sufficient fire flow capacity
Jackson Tube Services	8210 Industry Park Drive	East High	Sufficient fire flow capacity
Industry Products	500 Statler Rd.	East High	Sufficient fire flow capacity

Section 8

Capital Improvement Plan

After identifying deficiencies in section 7 with system performance for both current and 2030 scenarios and both WTP and Troy supply scenarios, solutions were identified that will meet the performance criteria previously established utilizing the computer model. This section presents the proposed recommendations and how to phase the implementation of the improvements to address existing system deficiencies and to meet projected demands in 2030.

8.1 Methodology

The desired performance matrix of the distribution system is presented in **Table 7-1** of this report, which was used to evaluate the distribution system for the safety and satisfaction of all water system customers. However, the matrix was not given equal weight in considering necessary improvements. For example, when flow velocity is high and exceeds 7 fps, it creates an undesirable situation as higher velocity is associated with higher headloss; therefore less efficiency of the system. However, high velocity alone does not necessarily warrant an improvement to the existing pipes, unless low pressure occurs. Therefore, the velocity criterion, as compared with low pressure criterion, is secondary. This approach also takes into consideration the project affordability and avoids developing a CIP that is unaffordable and potentially unfeasible.

Therefore, the decision point for a pipe improvement is minimum pressure of less than 40 psi under maximum day demand (unless certain exceptions were taken).

When a pipe improvement is recommended, the improved pipes (parallel or upsize) are sized to meet the demand requirements of the ultimate build-out scenario. This was done because the life-span of water mains far exceeds the 20 year planning horizon. Therefore, once an improvement is warranted, the pipes are designed to meet not only 2030 demand, but also demand of the ultimate build-out scenario.

Larger transmission mains were evaluated for redundancy so that each of any parallel transmission main would be able to supply the maximum day water demand by itself if the other transmission line would be out of service due to a main break.

Once improvements are developed to meet the pressure, storage, and pumping criteria, additional model analyses were conducted to verify if the improved system met fire flow requirements.

The recommended improvements include pipe, storage, and pump station improvements. Two water-supply scenarios were analyzed. The first scenario assumes that the finished water supply is from the City of Piqua's Water Treatment Plant (current or new). The second scenario assumes the finished water supply is from the City of Troy. The recommended pipe and storage improvements are different for each scenario, but the pump station improvements for serving the high pressure zones are the same for both scenarios.

8.2 Pipe Improvements

Pipe improvements recommended in this reports include improvements to meet both existing and future demands. There are some current known deficiencies in the system that needs to be addressed, such as main breaks and water quality issues (Section 8.2.1). Other pipe improvements are needed to address the projected increased demands of 2030 (Section 8.2.2 through 8.2.4).

8.2.1 Known Deficiencies of Current System

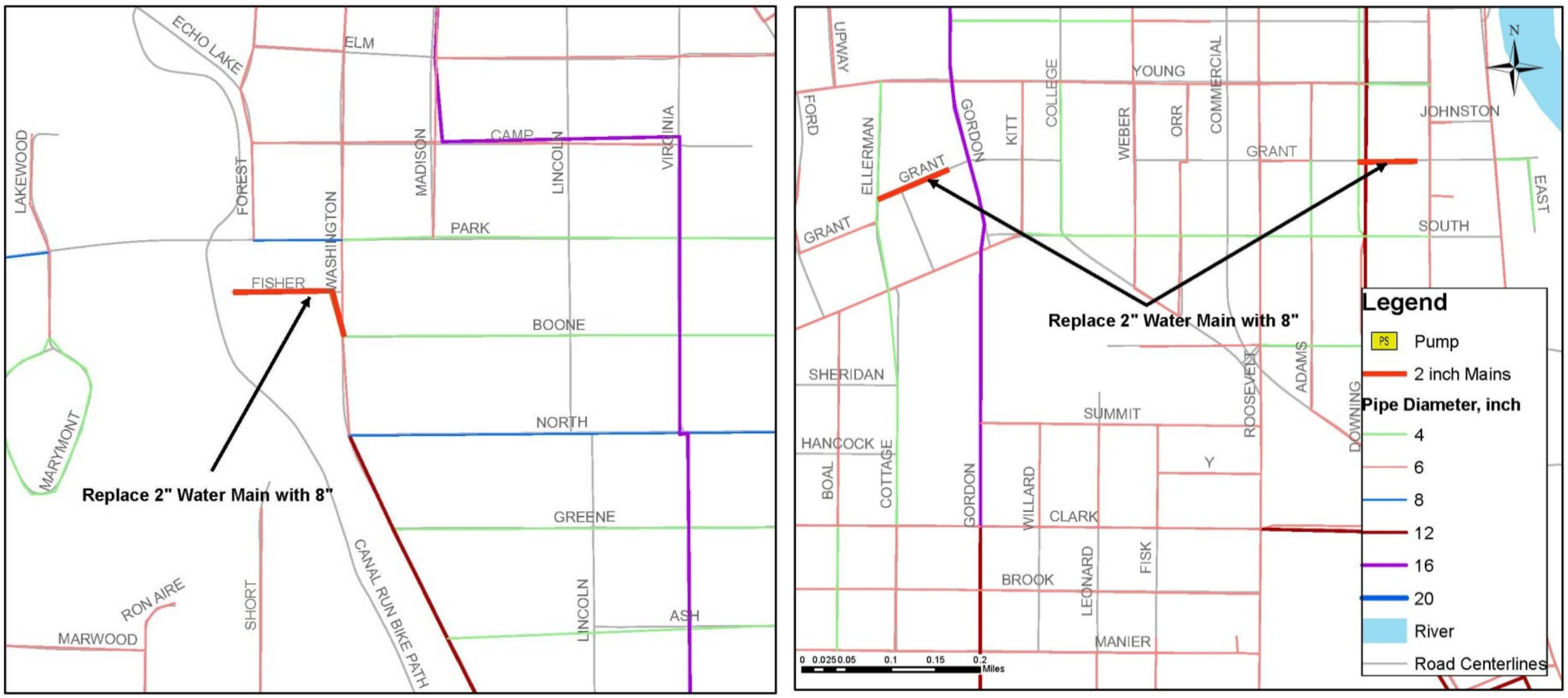
The following improvements are recommended to correct existing known system deficiencies, such as replacement of 2 inch water mains, known water quality issues, and frequent main breaks.

8.2.1.1 Replacement of 2 inch Water Mains

Three areas that have 2 inch water mains are identified, as presented in **Figure 8-1**, and are recommended to be replaced by 8 inch water mains. These 2 inch mains are located at:

- Fisher
- Grant and Ellerman
- Grant and Downing

Figure 8-1 Replacement of 2 inch Water Mains



8.2.1.2 Looping of Water Mains

Looping of water mains is recommended at several locations to improve water quality and chlorine residual. It is recommended to loop the 6 inch on Ron Aire to the 6 inch on Short (**Figure 8-2**) to avoid water quality issues, as this area currently suffers from low chlorine residuals. Another recommended location is at Fox Drive (**Figure 8-3**).

Figure 8-2 Looping of Water Main on Ron Aire

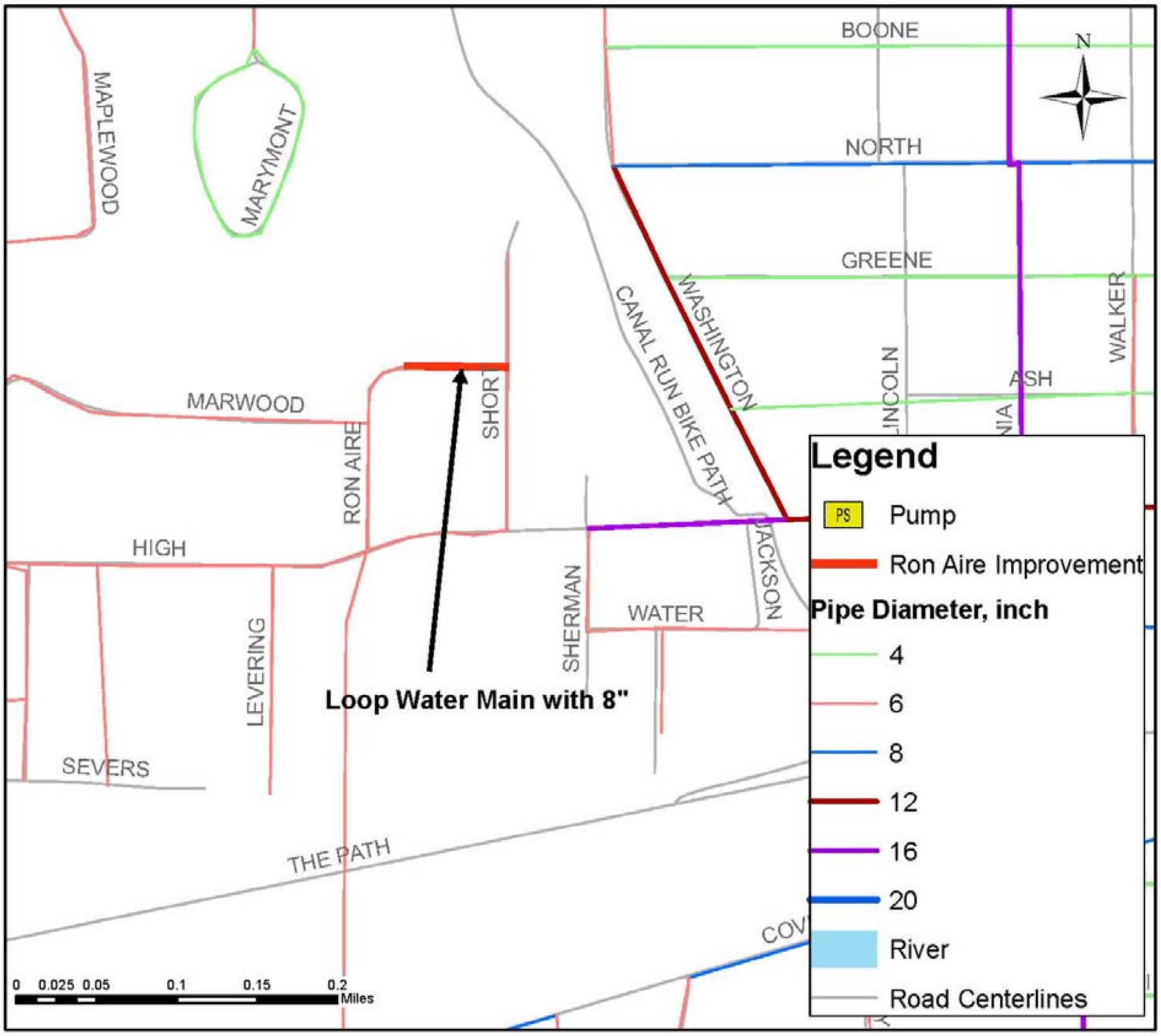
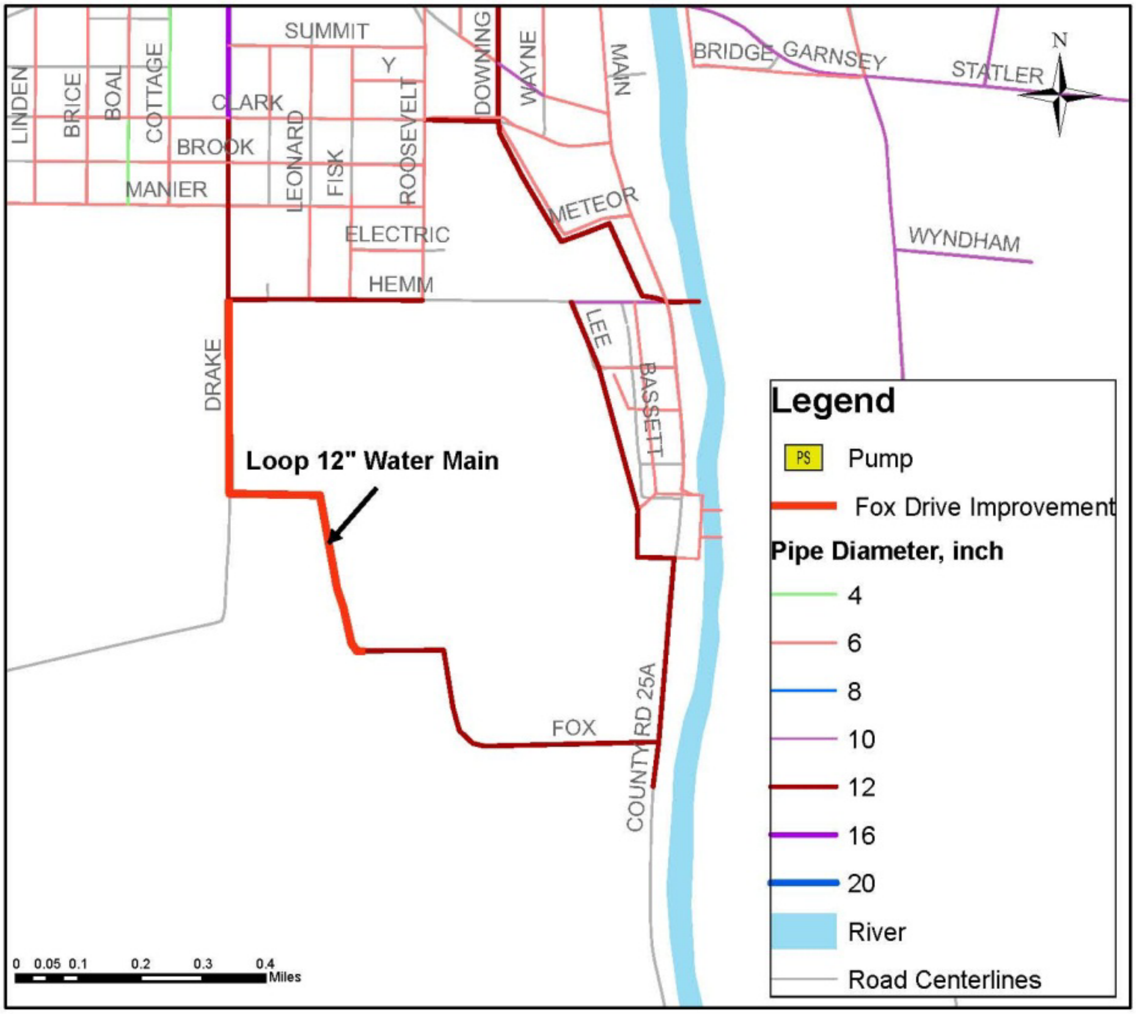


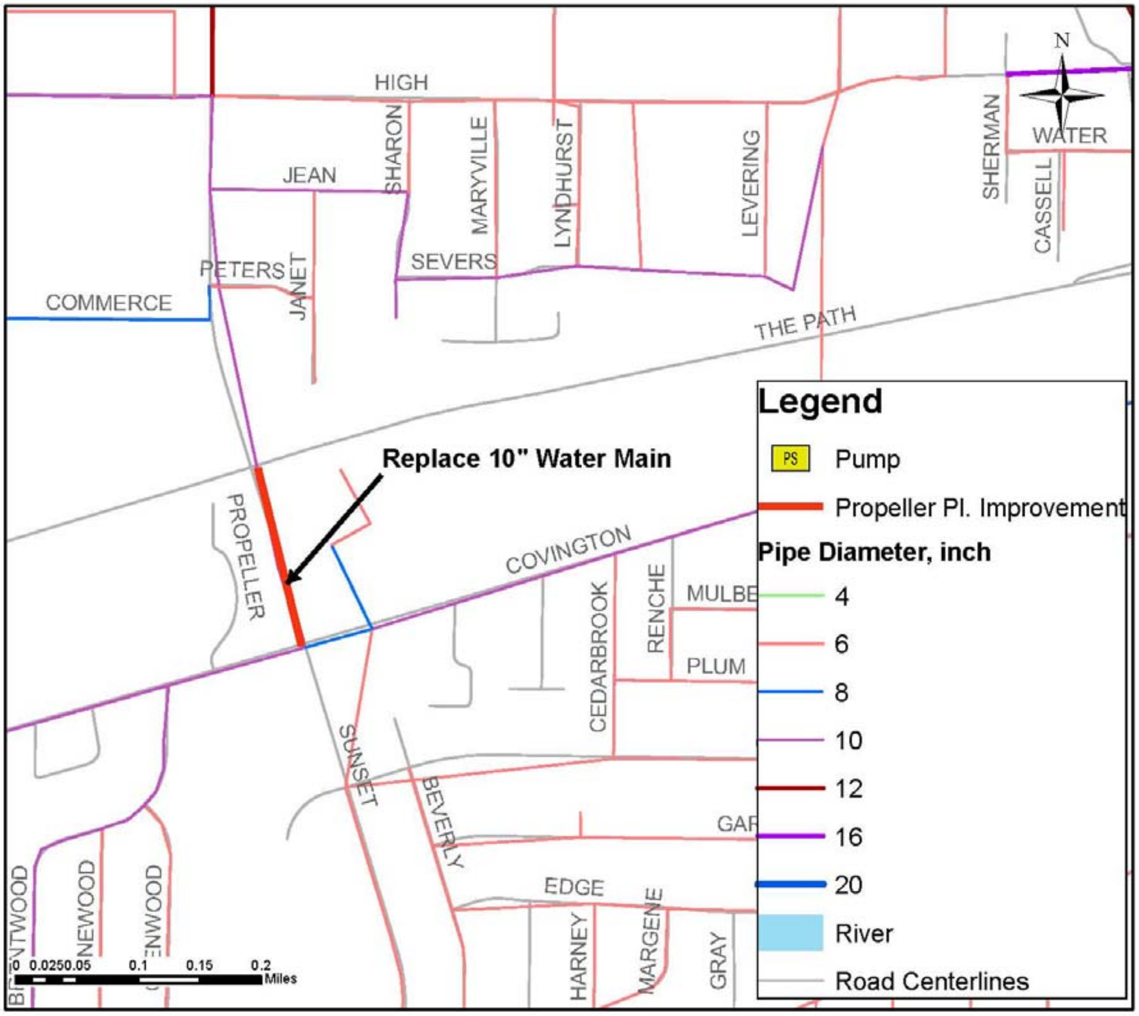
Figure 8-3 Looping of Water Main on Fox Drive



8.2.1.3 Replacement of 10 inch Water Main on Propeller

It is recommended to replace the existing 10 inch Cast Iron water main on Propeller Pl. between the Bike Path and Covington Ave., as main breaks are common on this line. See **Figure 8-4**.

Figure 8-4 Replacement of 10 inch Water Main on Propeller Pl.



8.2.2 Water Mains to Connect Proposed Development

By 2030, new areas will be developed that are outside of the current service area of the City's distribution system. In this situation, a new water main is proposed that connects between the existing system to the proposed new development, as shown in **Figure 8-5**. When a new water main is proposed, the proposed diameter is 8 inches or larger. The need for these water mains applies to both scenarios.

Figure 8-5 New Water Mains to Connect the Proposed Development

8.2.3 Scenario 1 – Finished Water Supply from Water Treatment Plant

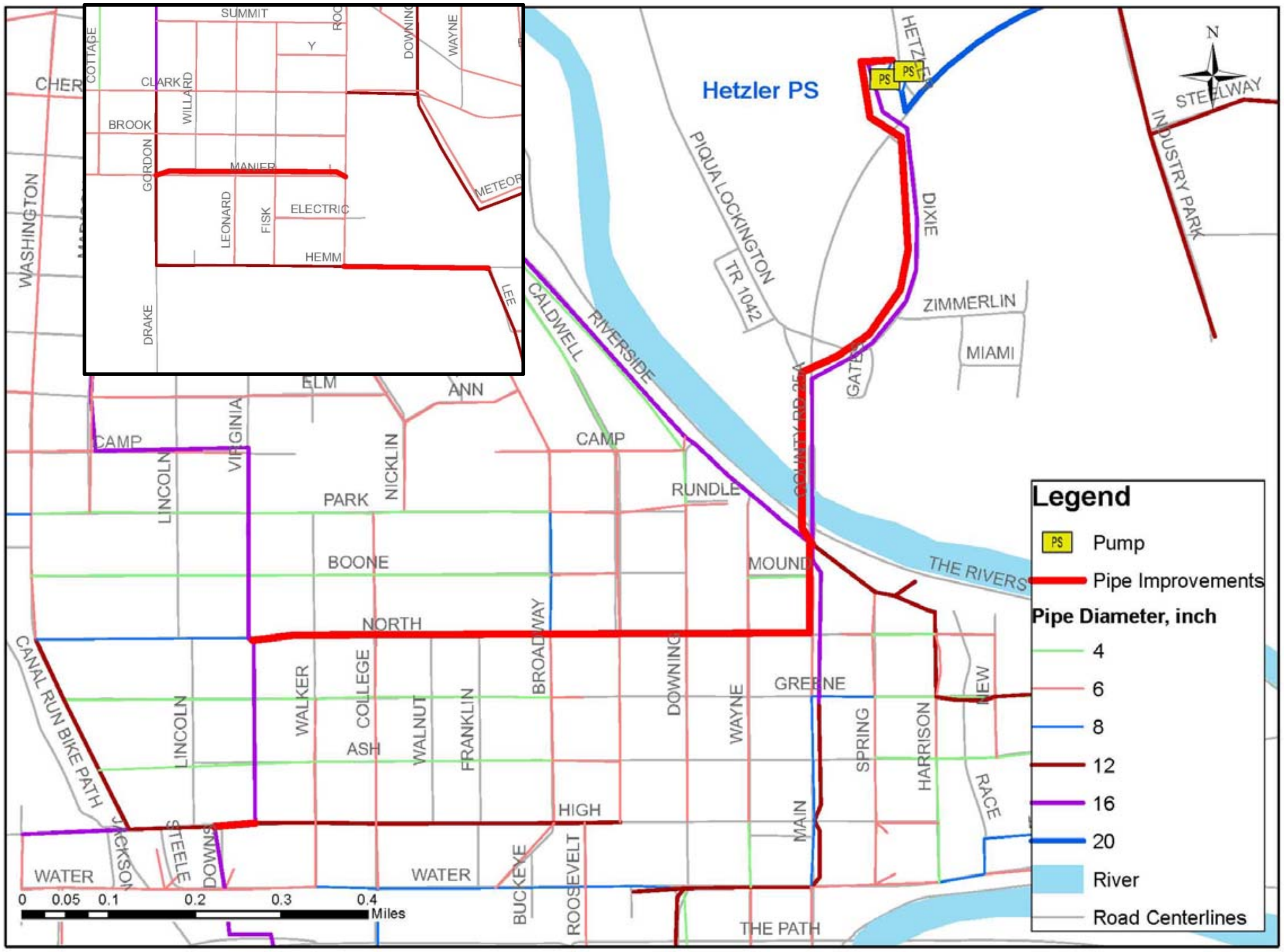
This sub-section describes pipe improvements associated with a new WTP. The cost of the new WTP is not included in this report. Also, the transmission mains between the proposed new WTP and the existing WTP are not included in the analysis of this report and are included in the study of the new WTP.

By 2030, the majority of the pipe deficiency exists due to the dramatically increased demand in the East High pressure zone and the existing transmission mains are not capable of supplying the higher demand to the Hetzler Road booster station. The recommended improvements include:

- parallel 24 inch pipe along the existing 16 inch along County Road 25A and Dixie Drive,
- a new 16 inch pipe on North Street and Main Street that connects the existing 16 inch on Virginia Street and the 16 inch on Main Street and Riverside Drive,
- upsize existing 12 inch on High Street between Downs and Virginia to 16 inch, and
- connect Roosevelt and Lee on Hemm Road with 12 inch and parallel 12 inch along Gordon and Roosevelt on Manier. This is to provide sufficient fire flow at nearby industries (Hartzell Industries).

A more detailed map of this area is presented in **Figure 8-6**.

Figure 8-6 Pipe Improvements –WTP



8.2.4 Scenario 2 –Finished Water Supply from Troy

To supply water to the City of Piqua through tie-in from the south, the report "City of Piqua City of Troy Water System Study" recommended that a 24 inch and 16 inch transmission main, as presented in **Figure 7-3**, be installed from the booster pump station, north, into the City. To meet the demand with sufficient redundancy, both of these water mains are recommended to be 24 inch in diameter.

CDM Smith suggested both mains follow the same route, which is north along County Road 25A until it reaches Hemm Road. At Hemm Road, one 24 inch main continues north following Main Street, and the other travels west on Hemm and connects to the existing 12 inch on Drake. A detailed map is presented in **Figure 8-7**.

Other recommended pipe improvements also includes the parallel pipe along the existing 16 inch along County Road 25A and Dixie, upsize existing 12 inch on Market Street between Downs and Virginia to 16 inch and parallel 12 inch along Gordon and Roosevelt on Mariner to provide fire flow capacity.

Figure 8-7 Pipe Improvements - Troy

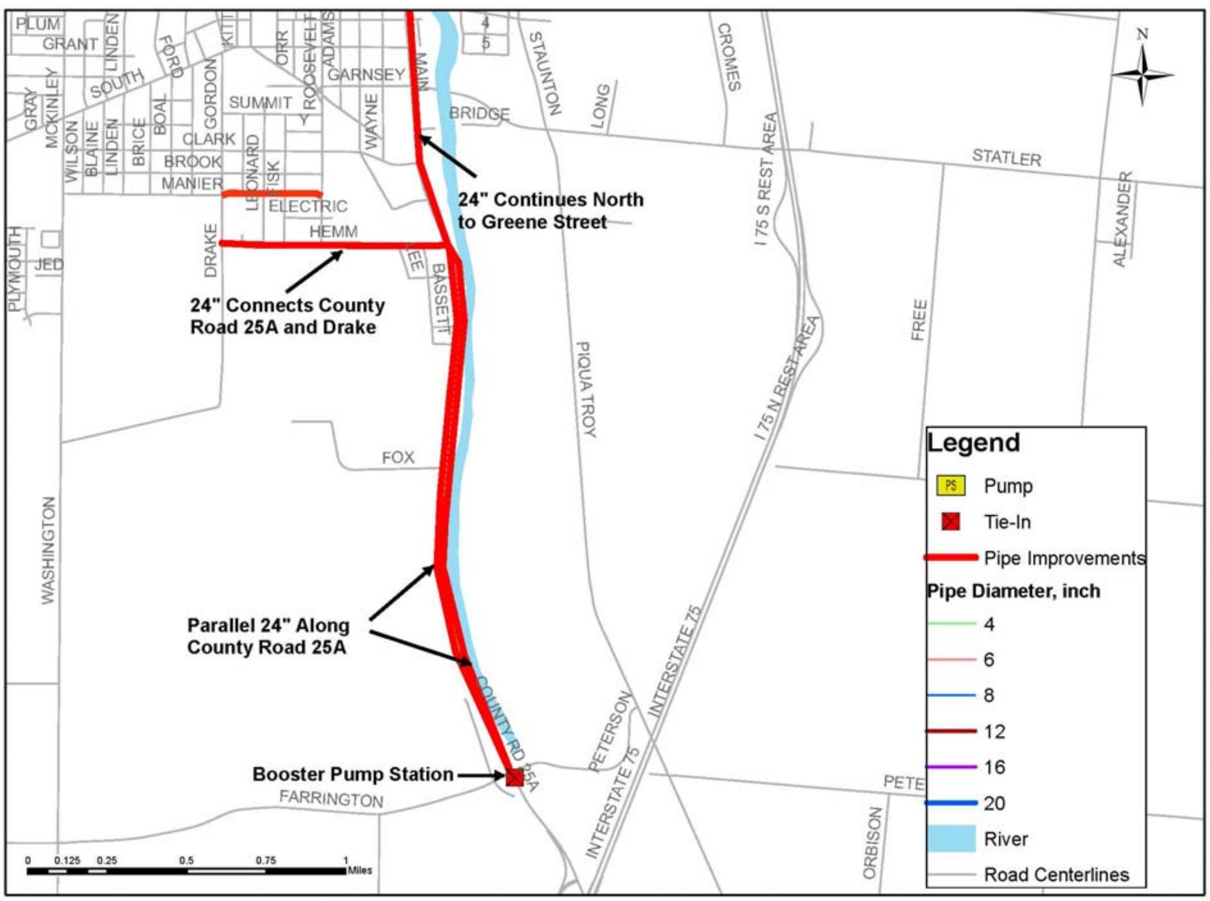


Table 8-1 summarizes the breakdown by length including all proposed pipe improvements described for Scenarios 1 and 2.

Table 8-1 Pipe Improvements

Diameter, inches	Pipe Length, ft		
	Scenario 1 – Finished Water Supply from WTP	Scenario 2 –Finished Water Supply from Troy	Known Deficiencies
8	6,770	10,820	1,740
10	-	-	790
12	3,030	1,760	3,850
16	4,230	690	-
24	3,590	32,690	-
Total	17,620	45,960	6,380

8.3 Storage Improvements

As presented in Section 7, the storage capacity is currently deficient in the Central Low pressure zone, and the situation deteriorates in 2030 with increased water demand. In 2030, the East High pressure zone will also have insufficient storage.

A new 1-MG elevated storage tank is recommended in the Central Low pressure zone that will meet both current and 2030 demand requirements under scenario 1, water supply from the new WTP. For scenario 2, finished water supplied from Troy, a larger elevated storage tank of 2 MG is recommended in the Central Low pressure zone. This scenario does not include clearwell storage should an emergency situation arise, such as fire.

The two existing tanks in the Central Low pressure zone are inadequate in height and are currently offline (emergency service only). Once the new elevated tank is constructed, it is recommended that the two 0.25 MG tanks be demolished.

The East High pressure zone contains sufficient storage (1.0 MG E. Ash Street Tank) for the current demand condition. An additional 2-MG elevated tank is recommended to meet the additional future needs for 2030. **Table 8-2** summarizes the recommended storage improvements.

Table 8-2 Storage Improvements

Pressure Zones	Storage Improvements - Current		Storage Improvements - 2030
	Scenario 1 – Finished Water Supply from WTP	Scenario 2 –Finished Water Supply from Troy	Both Scenarios
East High	-	-	2 MG
West High	-	-	-
Central Low	1 MG	2 MG	-

8.4 Pump Station Improvements

There are currently 2 booster pump stations in the distribution system. The Hetzler Road booster pump station serves the East High pressure zone and the Ziegler Road booster pump station serves the West High pressure zone. The Hetzler Road station is equipped with 2 pumps, each rated at 1,500 gpm at 100 feet of head. The Ziegler Road station is equipped with 3 pumps, each rated at 2,000 gpm at 100 feet of head.

The pump stations should be able to supply maximum day flow with the largest pump out of service. Therefore, Ziegler Road station has sufficient capacity to meet the 2030 demand; however, the Hetzler Road station will be insufficient by 2030. As presented in Section 7, **Table 7-2**, the projected 2030 average day demand for the East High pressure zone is 2.82 MGD, or 1,960 gpm. With a maximum day demand to average day demand factor of 1.55, the maximum day demand for the East High pressure zone is approximately 3,000 gpm. This exceeds the firm capacity of the current Hetzler Road station, which is 1,500 gpm with one pump running and the other pump out of service.

The Hetzler Road pump station currently houses two pumps with room for one additional pump. It is recommended that one of the existing pumps be replaced and a new, third pump, be installed to meet the projected 2030 demand.

Table 8-3 summarizes the recommended pump station improvements.

Table 8-3 Pump Station Improvements

Pressure Zone	Pump Stations	Pump Improvements – Current	Pump Improvements - 2030
East High	Hetzler BPS: 2 pumps at 1,500 gpm/100’	Sufficient Capacity	**Insufficient Capacity, replace 1 & install 1 new pump each at 2,000 gpm**
West High	Ziegler BPS: 3 pumps at 2,000 gpm/100’	Sufficient Capacity	Sufficient Capacity
Central Low	Existing WTP High Service: 4 pumps with 1 VFD	Sufficient Capacity	-
	New WTP High Service: 4 pumps each rated at 3 MGD	-	Sufficient Capacity

Note: The above table does not consider the Troy booster pump station requirements for Scenario 2. See the “City of Piqua City of Troy Water System Study”.

8.5 Project Prioritization

The CIP solutions discussed above provided a list of separate infrastructure improvements that need to be implemented to assure that the system is operated efficiently during the planning period. The improvements consist primarily of parallel and/or replacement pipes, new elevated storage tanks, and an upgraded booster pump station. These improvements are recommended to correct pressure deficiencies, accommodate 2030 development needs, and improve water system reliability, water quality and redundancy.

The recommended projects are prioritized into two phases.

Phase I:

The first priority of implementation is to complete the projects which resolve existing deficiencies and problems. Deficiencies include lack of effective storage capacity in the Central Low pressure zone. This is the highest priority improvement. Phase I also includes either the new WTP or new transmission mains to facilitate a new supply from Troy. There are other known system issues discussed earlier that the City has identified regarding looping, replacement of small distribution lines, and replacing lines that experience frequent main breaks.

Phase II:

The infrastructure components necessary for serving additional demands of 2030 were identified by analyzing the system for deficiencies. The timing of the growing demands is difficult to predict, therefore, some projects may need to be initiated when planned development occurs, which may occur sometime up to 2030.

In addition, Piqua's water distribution system includes many old 4 and 6 inch pipes, some of which date back to the early 1900s. While replacing all of these pipes with 8 inch pipes will greatly improve system capacity, the costs associated with the replacing all these pipes at once are prohibitively high. It is recommended to develop a continuous replacement and rehabilitation program to gradually replace the older 4 and 6 inch pipes in the system. This will allow the City flexibility in capital spending over the planning period as spending for replacement of these smaller, older water mains may be increased or decreased as necessary.

Figure 8-8 and **Figure 8-9** present the layout of recommended improvements for the 2030 distribution system broken down by phases.

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Figure 8-8 Recommended Projects by Phase- WTP

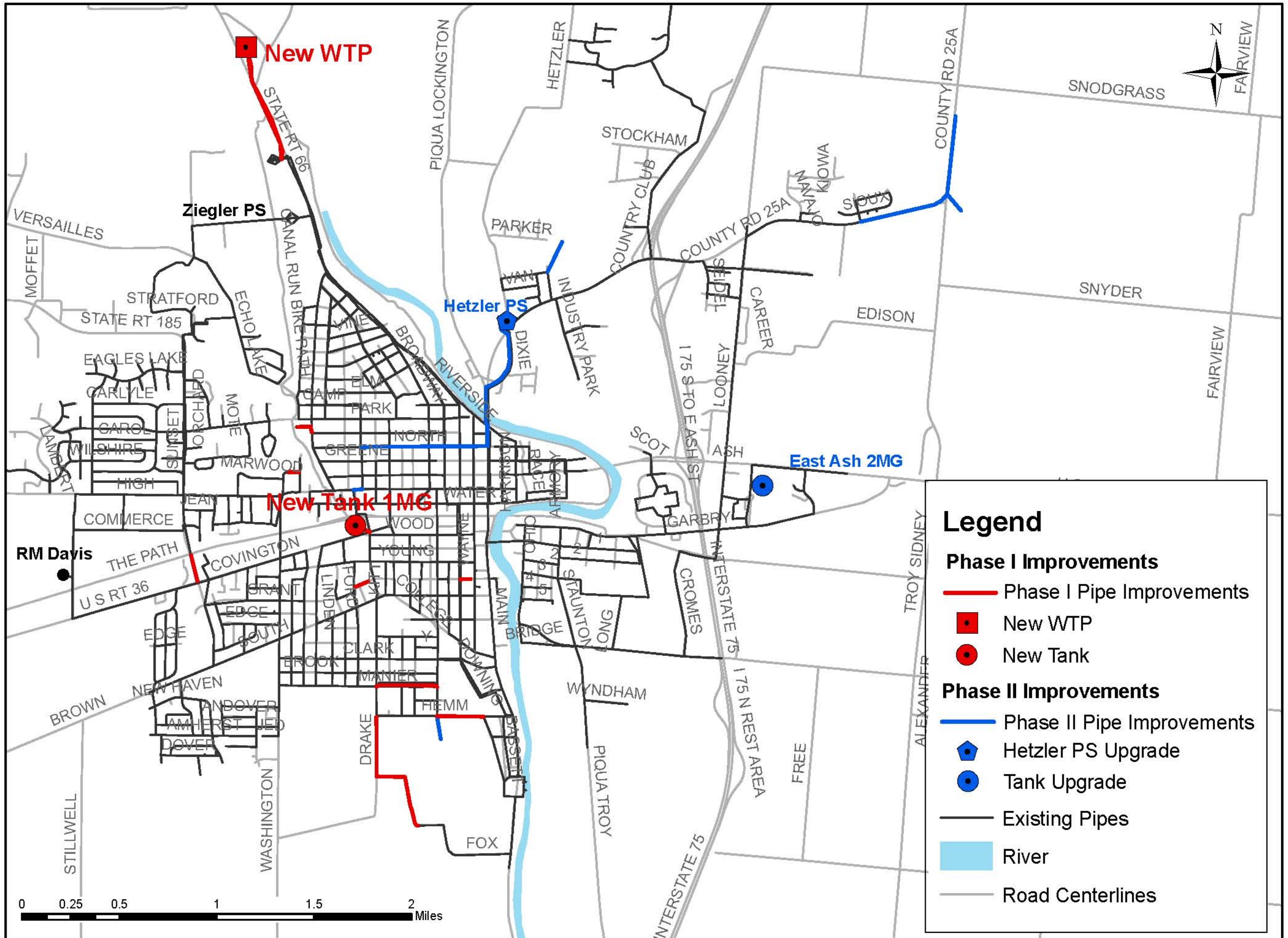
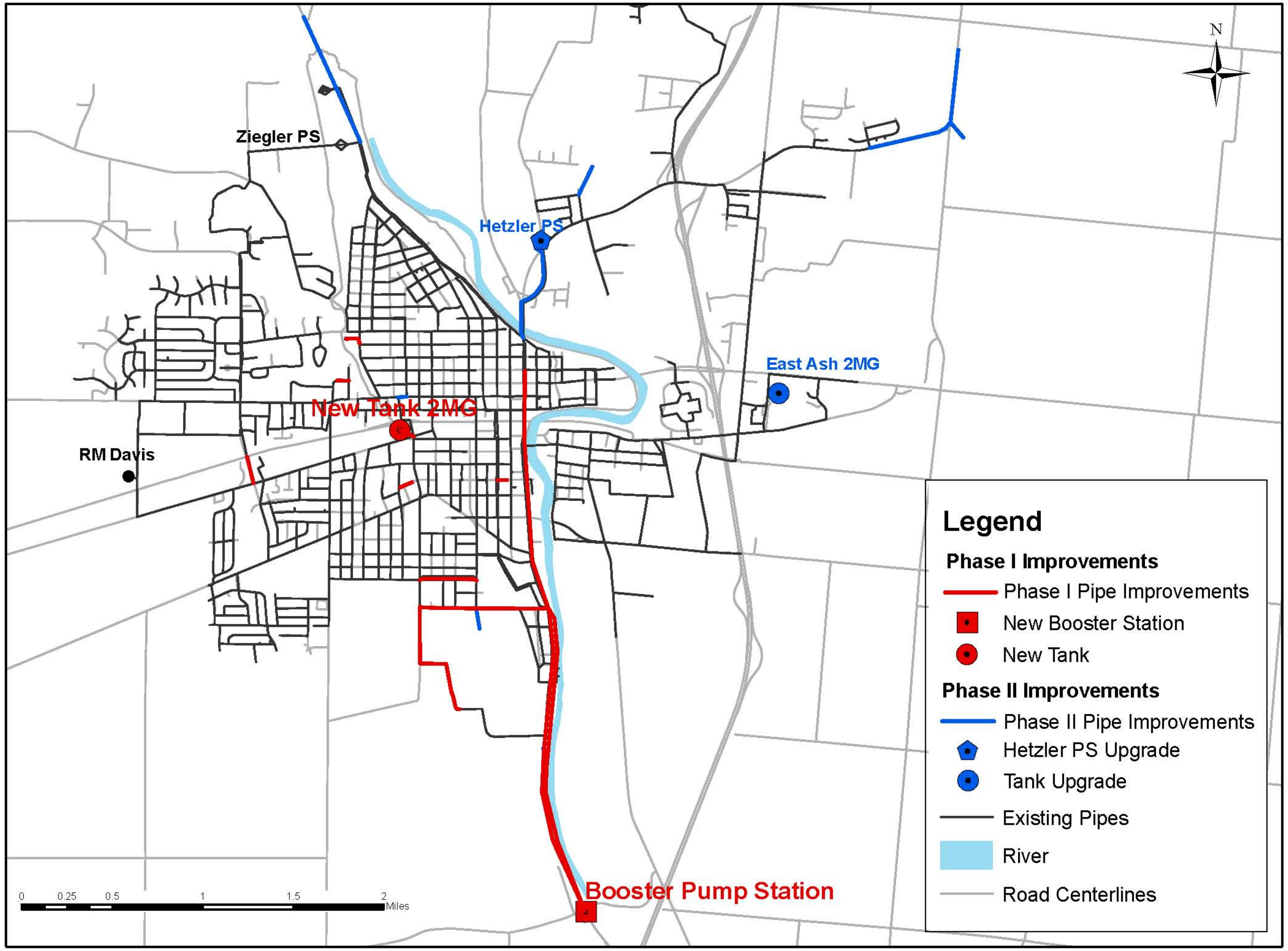


Figure 8-9 Recommended Projects by Phase- Troy



8.6 CIP Implementation Cost

The total planning and implementation horizon utilized for this plan is 20 years, with implementation beginning in 2012 and ending in 2030 and assuming projected growth is achieved by 2030.

8.6.1 Unit Costs

8.6.1.1 Pipes

Unit costs for pipes are developed for both rural and urban areas, as presented in **Table 8-4**. The cost is based on similar project costs from other ductile iron water main projects in southwest Ohio. Costs are based on 2012 dollars. For this report, water mains on and to the south of Hemm Road are considered in rural areas, and all other pipes are assumed to be in urban areas. An additional 10% construction cost is included for the Troy-Piqua section of transmission mains (from Troy booster station to Hemm Road along County Road 25A) to account for rock excavation.

The unit costs are project costs that include construction, 20% for contingency, and 15% for engineering.

Table 8-4 Pipe Unit Costs per Foot

Diameter (in)	Rural	Urban
8	$110	$154
10	$124	$172
12	$138	$180
16	$159	$232
20	$171	$275
24	$207	$292

8.6.1.2 Tanks

Costs for elevated storage tanks were derived from manufactures quotes, adding site improvement costs, property acquisition, a contingency, and engineering. It is assumed that a hydropillar-style tank 140 feet tall from the top of the foundation to the maximum water level would be constructed.

The costs are project costs that include construction, 15% for contingency, and 10% for engineering. The cost for elevated storage is presented in **Table 8-5**.

Table 8-5 Elevated Storage Tank Costs

Size (MG)	Cost
1	$ 2,910,000
2	$ 4,660,000

8.6.1.3 Pump Stations

Pump suppliers were contacted to provide cost information on pumps. Assuming new pumps will be horizontal centrifugal pumps installed in the existing Hetzler Road booster pump station, the costs is estimated at $136,000. The cost is project cost that includes construction, 20% for contingency, and 15% for engineering.

8.6.2 CIP Costs

The total projected capital cost for the distribution system improvement plan is approximately $12.2 million for the WTP scenario (not including costs of WTP and interconnecting transmission mains), and $20.8 million for the Troy supply scenario (not including costs of facilities from the Troy WTP to booster station at County Road 25A and Farrington Rd., the new booster pump station, and any necessary improvements to the Troy WTP).

Pipe improvements costs by each project is summarized in **Table 8-6**.

Tabel 8-6 Pipe Improvement Project Costs

Pipe Projects	Diameter, inches	Length, ft	Scenario 1: WTP		Scenario 2: Troy	
			Phase I	Phase II	Phase I	Phase II
Replacement of 2" water mains	8	1,390	$213,000	-	$213,000	-
Looping of water main on Ron Aire	8	350	$53,000	-	$53,000	-
Looping of water main on Fox Drive	12	3,850	$531,000	-	$531,000	-
Replacement of 10" water main on Propeller Pl.	10	790	$136,000	-	$136,000	-
New main to connec the new tank	16	440	$102,000		$102,000	
New main to connect the proposed development	8	6,770	-	$1,016,000	-	$1,016,000
New main to connect the proposed development near WTP	8	4,020	-	-	-	$618,000
Parallel main to the existing 16" along CR 25A and Dixie Drive	24	3,590	-	$1,048,000	-	$1,048,000
Parallel main on North Street and Main Street	16	3,540	-	$820,000	-	-
Upsize existing 12" on High St. between Downs and Virginia	16	250	-	$58,000	-	$58,000
Parallel 12" main on Manier between Gordon and Roosevelt	12	1,760	$318,000	-	$318,000	-
New main to Connect Roosevelt and Lee on Hemm Road	12	1,260	$174,000	-	-	-
New dual 24" mains from proposed booster pump station to Hemm Rd along CR 25A	24	18,300	-	-	$4,099,000	-
New main on Hemm Rd between CR 25A and Drake	24	3,790	-	-	$1,000,000	-
New main along Main St. from Hemm Rd to Greene St.	24	7,010	-	-	$2,047,000	-
Total			**$1,530,000**	**$2,940,000**	**$8,500,000**	**$2,740,000**

Cost breakdown for each planning phase is presented in **Table 8-7**.

Table 8-7 Project Prioritization and Cost Breakdown by Planning Phase

Distribution System Improvements	Scenario 1: WTP		Scenario 2: Troy	
	Phase I	Phase II	Phase I	Phase II
New Tank in Central Low Pressure Zone – 1 or 2 MG	$2,910,000	-	$4,660,000	-
Demolition of Existing 0.25 MG Tanks	$50,000		$50,000	
Pipe Improvements	$1,530,000	$2,940,000	$8,500,000	$2,740,000
New Tank in East High Pressure Zone – 2 MG	-	$4,660,000	-	$4,660,000
Hetzler Rd. Pump Station Improvements	-	$140,000	-	$140,000
Total Estimated Capital Cost	**$4,490,000**	**$7,740,000**	**$13,210,000**	**$7,540,000**
Total, Each Scenario	**$12,230,000**		**$20,750,000**	

CDM Smith

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ADS Environmental Services
1445 Jamike Drive, Suite One
Erlanger, KY 41018

Tel: 859.283.0130

October, 2011

City of Piqua c/o CDM
8805 Governor's Hill Drive
Suite 260
Cincinnati, Ohio 45249

RE: ADS Environmental Services
Professional Services – Water Distribution System Testing
For the City of Piqua, Ohio

In accordance with our agreement, we have completed the Water Distribution System Testing in the City of Piqua, Ohio, and herewith submit this Report.

The Testing included:

- Pump Performance Testing at the Water Treatment Plant, Ziegler Road Booster Station and Hetzler Road Booster Station
- Hydraulic Pressure Recording
- Hydrant Flow Testing

This Report presents the methods and results of the testing, including summary tables and graphs.

We wish to express our appreciation for the courtesy and cooperation extended to us during the course of this survey and will be available to discuss the report with you as desired.

Respectfully submitted,
ADS Environmental Services

Timothy Calder, PE
Senior Project Manager

Hydrant Flow Test - Summary Table

Test ID #	Service District	Street Location	Pressure		Flow during Test (gpm)	Flow Available at 20 psi (gpm)
			Static	Residual		
1	West High Service	Britton near Wilshire	77	56	1,960	3,400
2	West High Service	Lyndhurst near High Street	82	42	1,840	2,300
3	West High Service	Garfield west of McKinley	79	38	1,260	1,500
4	West High Service	Dover at Rutland	78	34	1,540	1,800
5	East High Service	4th Street and Hilliard	107	83	750	1,500
6	Central Low District	Robinson at Nicklin	76	60	1,960	3,900
7	Central Low District	Spring and High Street	80	64	1,300	2,700
8	Central Low District	Water Street at Downs	78	63	2,330	4,800
9	Central Low District	Wayne and Johnson	82	44	1,460	1,900
10	Central Low District	Manier at Roosevelt	75	66	1,210	3,200
11	East High Service	Sioux Drive	67	50	1,930	3,300
12	Central Low District	South Main Street near Statler	88	43	1,840	2,300

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	1
Service	West High Service		
Location	Britton near Wilshire		
Date	7-Sep-11	**Time**	10:55

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	34
Actual Pitot Press. - psi	34
Quantity - gpm	**1,960**

Static Pressure psi	77
Correction +/-	0.0
Corrected Static Pressure - psi	**77.0**

Residual Pressure psi	56.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**56.0**

Available at 20 psi - gpm	**3,400**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	2
Service	West High Service		
Location	Lyndhurst near High Street		
Date	7-Sep-11	**Time**	11:10

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	30
Actual Pitot Press. - psi	30
Quantity - gpm	**1,840**

Static Pressure psi	82
Correction +/-	0.0
Corrected Static Pressure - psi	**82**

Residual Pressure psi	42
Correction +/-	0.0
Corrected Residual Pressure - psi	**42**

Available at 20 psi - gpm	**2,300**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	3
Service	West High Service		
Location	Garfield west of McKinley		
Date	7-Sep-11	**Time**	14:35

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	14
Actual Pitot Press. - psi	14
Quantity - gpm	**1,260**

Static Pressure psi	79
Correction +/-	0.0
Corrected Static Pressure - psi	**79.0**

Residual Pressure psi	38.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**38.0**

Available at 20 psi - gpm	**1,500**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	4
Service	West High Service		
Location	Dover at Rutland		
Date	7-Sep-11	**Time**	15:00

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	21
Actual Pitot Press. - psi	21
Quantity - gpm	**1,540**

Static Pressure psi	78
Correction +/-	0.0
Corrected Static Pressure - psi	**78**

Residual Pressure psi	34
Correction +/-	0.0
Corrected Residual Pressure - psi	**34**

Available at 20 psi - gpm	**1,800**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	5
Service	East High Service		
Location	4th Street and Hilliard		
Date	7-Sep-11	**Time**	13:35

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	5
Actual Pitot Press. - psi	5
Quantity - gpm	**750**

Static Pressure psi	107
Correction +/-	0.0
Corrected Static Pressure - psi	**107.0**

Residual Pressure psi	83.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**83.0**

Available at 20 psi - gpm	**1,500**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	6
Service	Central Low District		
Location	Robinson at Nicklin		
Date	7-Sep-11	**Time**	10:30

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	34
Actual Pitot Press. - psi	34
Quantity - gpm	**1,960**

Static Pressure psi	76
Correction +/-	0.0
Corrected Static Pressure - psi	**76**

Residual Pressure psi	60
Correction +/-	0.0
Corrected Residual Pressure - psi	**60**

Available at 20 psi - gpm	**3,900**

Hydrant Flow Test

City Piqua, Ohio **Test #** 7

Service Central Low District

Location Spring and High Street

Date 7-Sep-11 **Time** 12:15

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	15
Actual Pitot Press. - psi	15
Quantity - gpm	**1,300**

Static Pressure psi	80
Correction +/-	0.0
Corrected Static Pressure - psi	**80.0**

Residual Pressure psi	64.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**64.0**

Available at 20 psi - gpm	**2,700**

Hydrant Flow Test

City Piqua, Ohio **Test #** 8

Service Central Low District

Location Water Street at Downs

Date 7-Sep-11 **Time** 11:40

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	48
Actual Pitot Press. - psi	48
Quantity - gpm	**2,330**

Static Pressure psi	78
Correction +/-	0.0
Corrected Static Pressure - psi	**78**

Residual Pressure psi	63
Correction +/-	0.0
Corrected Residual Pressure - psi	**63**

Available at 20 psi - gpm	**4,800**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	9
Service	Central Low District		
Location	Wayne and Johnson		
Date	7-Sep-11	**Time**	13:15

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	19
Actual Pitot Press. - psi	19
Quantity - gpm	**1,460**

Static Pressure psi	82
Correction +/-	0.0
Corrected Static Pressure - psi	**82.0**

Residual Pressure psi	44.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**44.0**

Available at 20 psi - gpm	**1,900**

Hydrant Flow Test

City	Piqua, Ohio	**Test #**	10
Service	Central Low District		
Location	Manier at Roosevelt		
Date	7-Sep-11	**Time**	14:15

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	13
Actual Pitot Press. - psi	13
Quantity - gpm	**1,210**

Static Pressure psi	75
Correction +/-	0.0
Corrected Static Pressure - psi	**75**

Residual Pressure psi	66
Correction +/-	0.0
Corrected Residual Pressure - psi	**66**

Available at 20 psi - gpm	**3,200**

Hydrant Flow Test

City Piqua, Ohio **Test #** 11

Service East High Service

Location Sioux Drive

Date 7-Sep-11 **Time** 9:45

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	33
Actual Pitot Press. - psi	33
Quantity - gpm	**1,930**

Static Pressure psi	67
Correction +/-	0.0
Corrected Static Pressure - psi	**67.0**

Residual Pressure psi	50.0
Correction +/-	0.0
Corrected Residual Pressure - psi	**50.0**

Available at 20 psi - gpm	**3,300**

Hydrant Flow Test

City Piqua, Ohio **Test #** 12

Service Central Low District

Location South Main Street near Statler

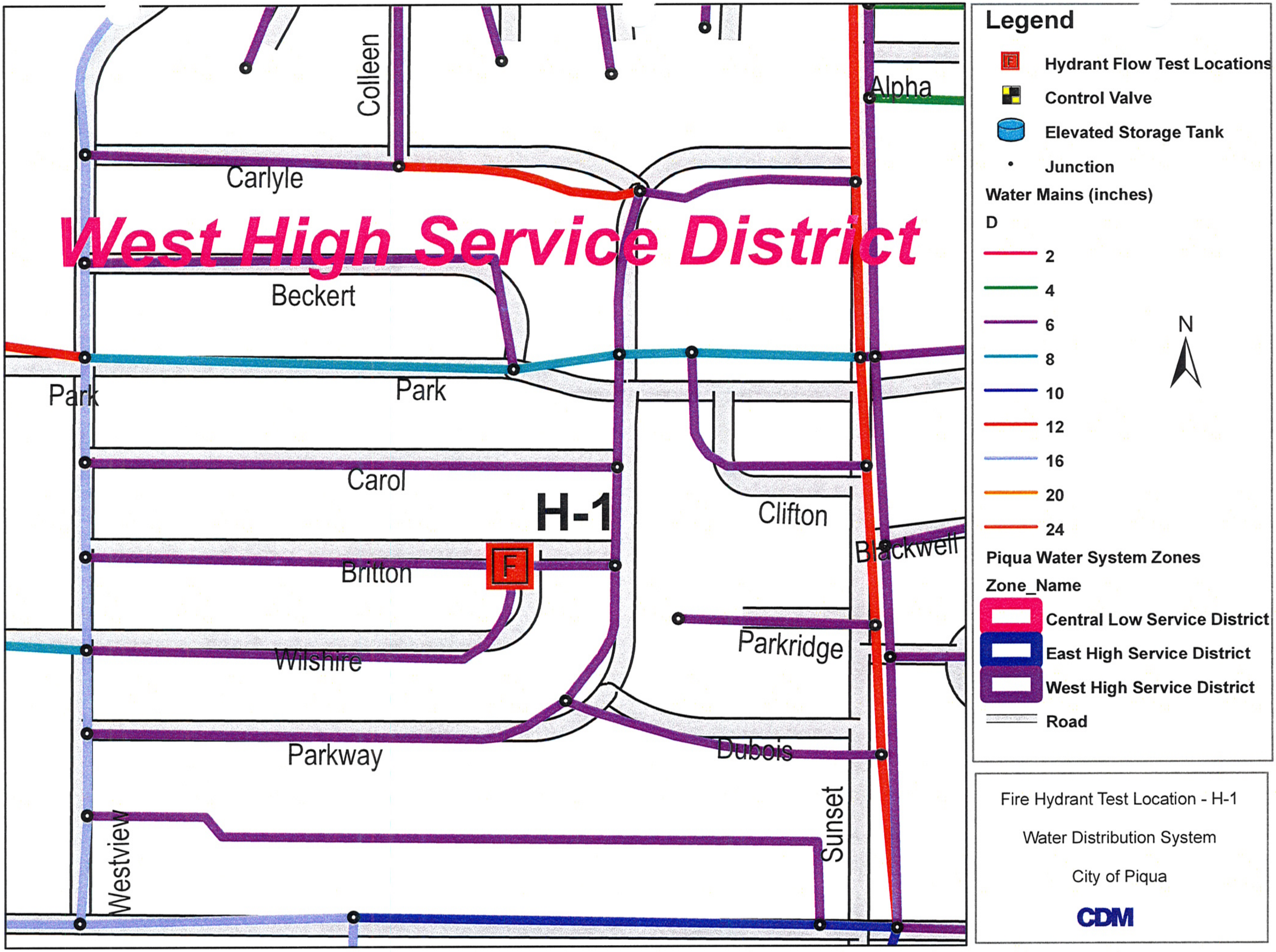
Date 7-Sep-11 **Time** 14:00

Flow Hydrant Data	
Port Size - inch	2.5
No. of Ports	2
Coefficient	0.9
Gauge Correction +/-	0.0
Measured Pitot Press - psi	30
Actual Pitot Press. - psi	30
Quantity - gpm	**1,840**

Static Pressure psi	88
Correction +/-	0.0
Corrected Static Pressure - psi	**88**

Residual Pressure psi	43
Correction +/-	0.0
Corrected Residual Pressure - psi	**43**

Available at 20 psi - gpm	**2,300**

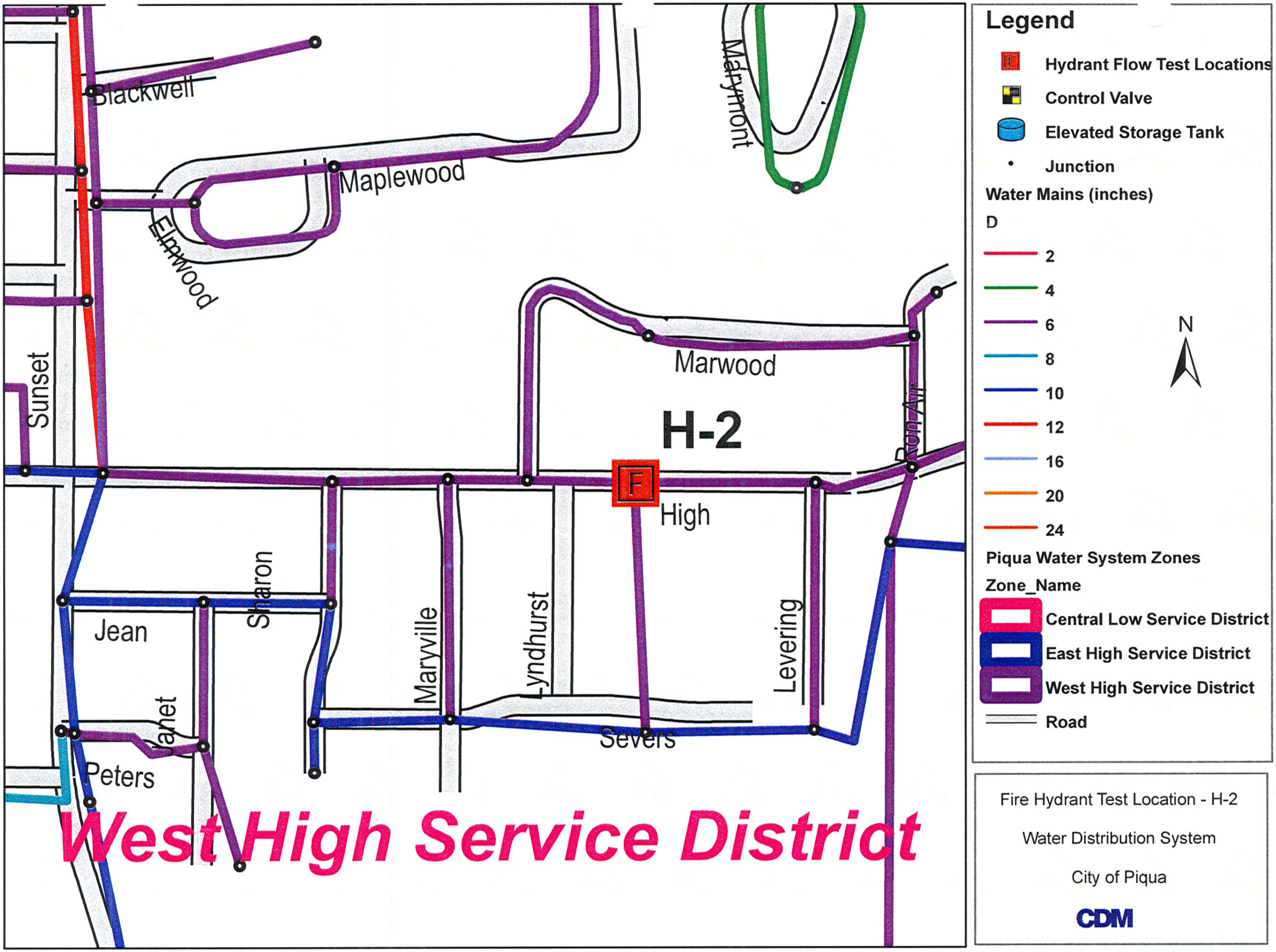


Fire Hydrant Test Location - H-1

Water Distribution System

City of Piqua

CDM

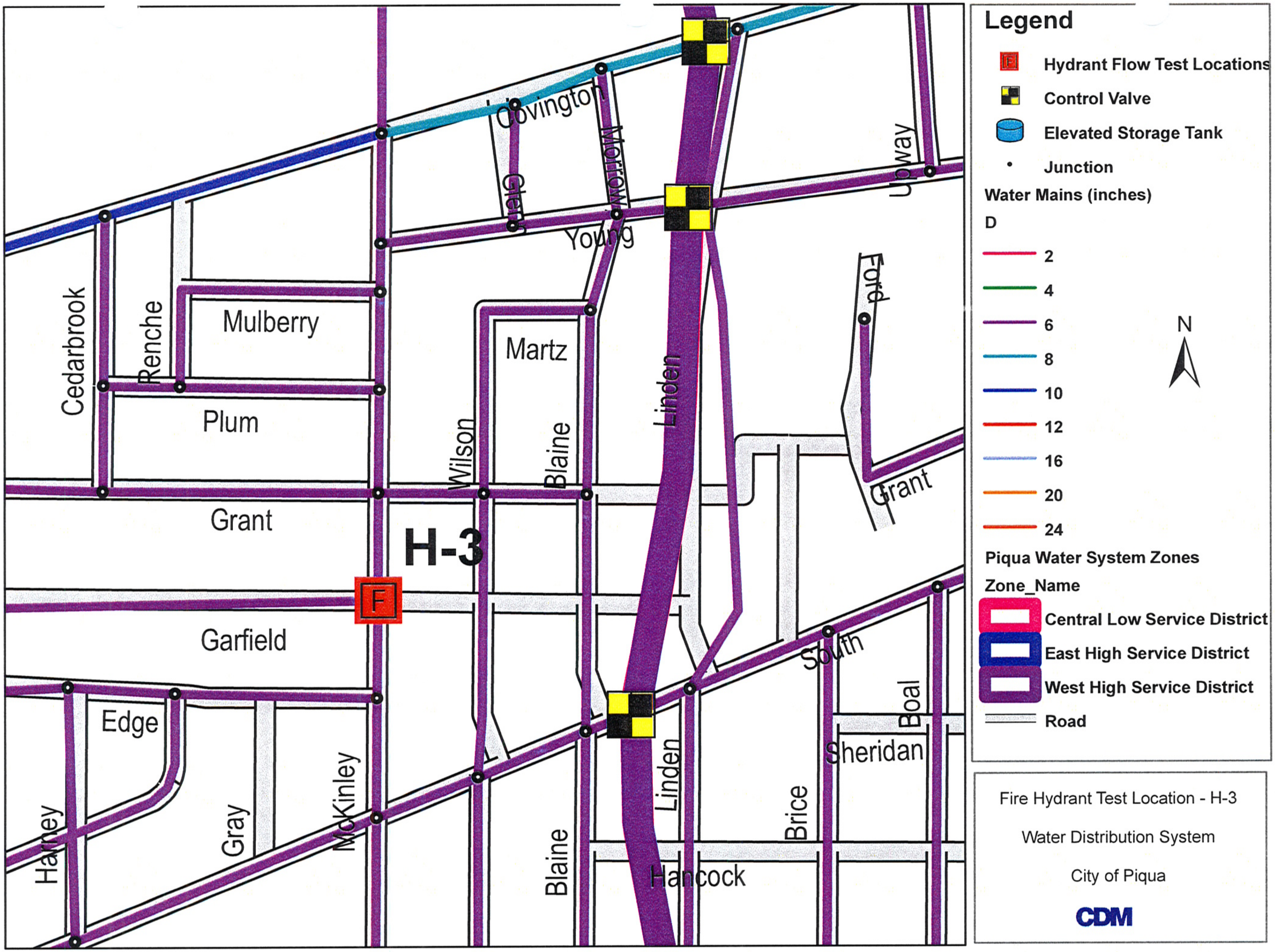


Fire Hydrant Test Location - H-2

Water Distribution System

City of Piqua

CDM

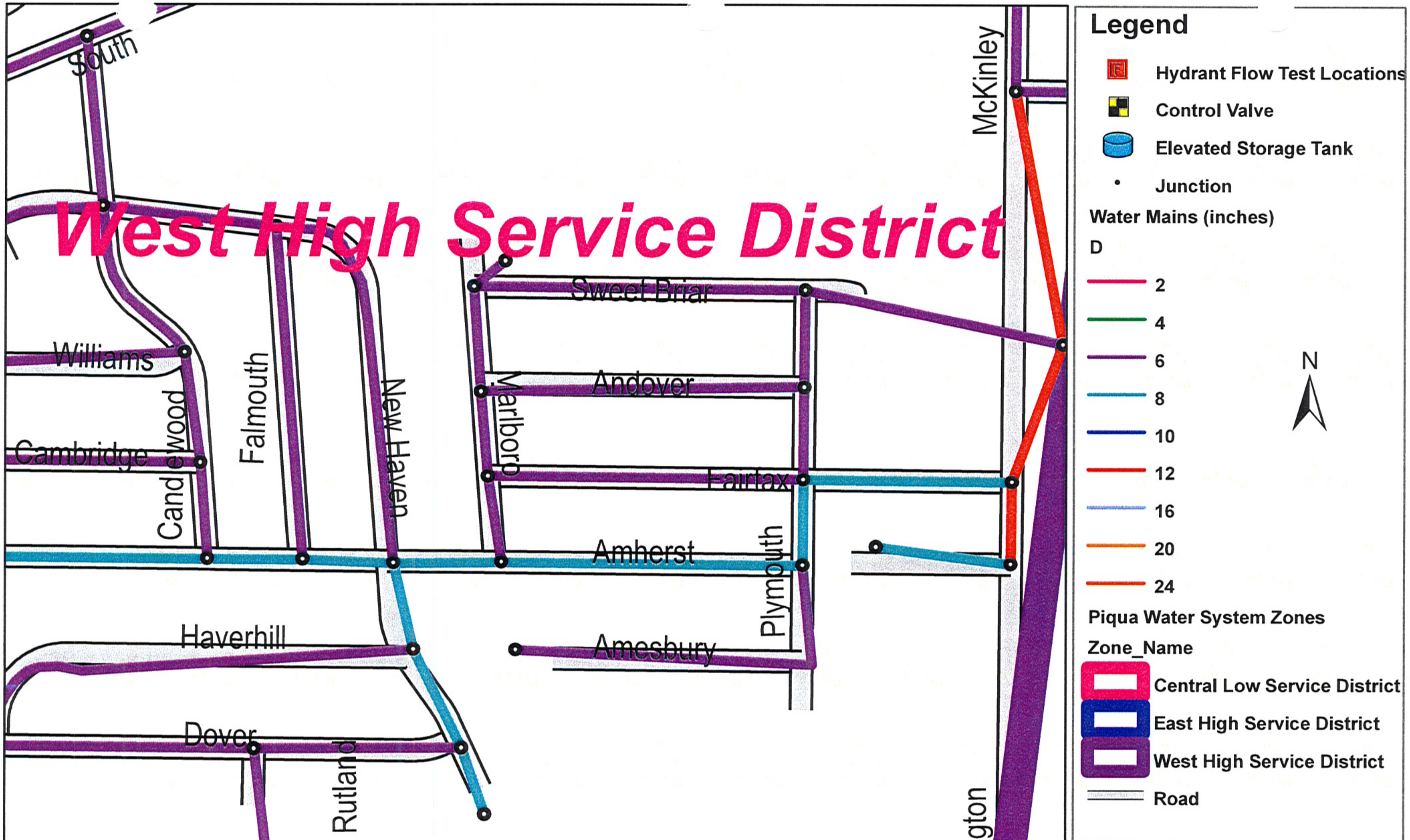


Fire Hydrant Test Location - H-3

Water Distribution System

City of Piqua

CDM

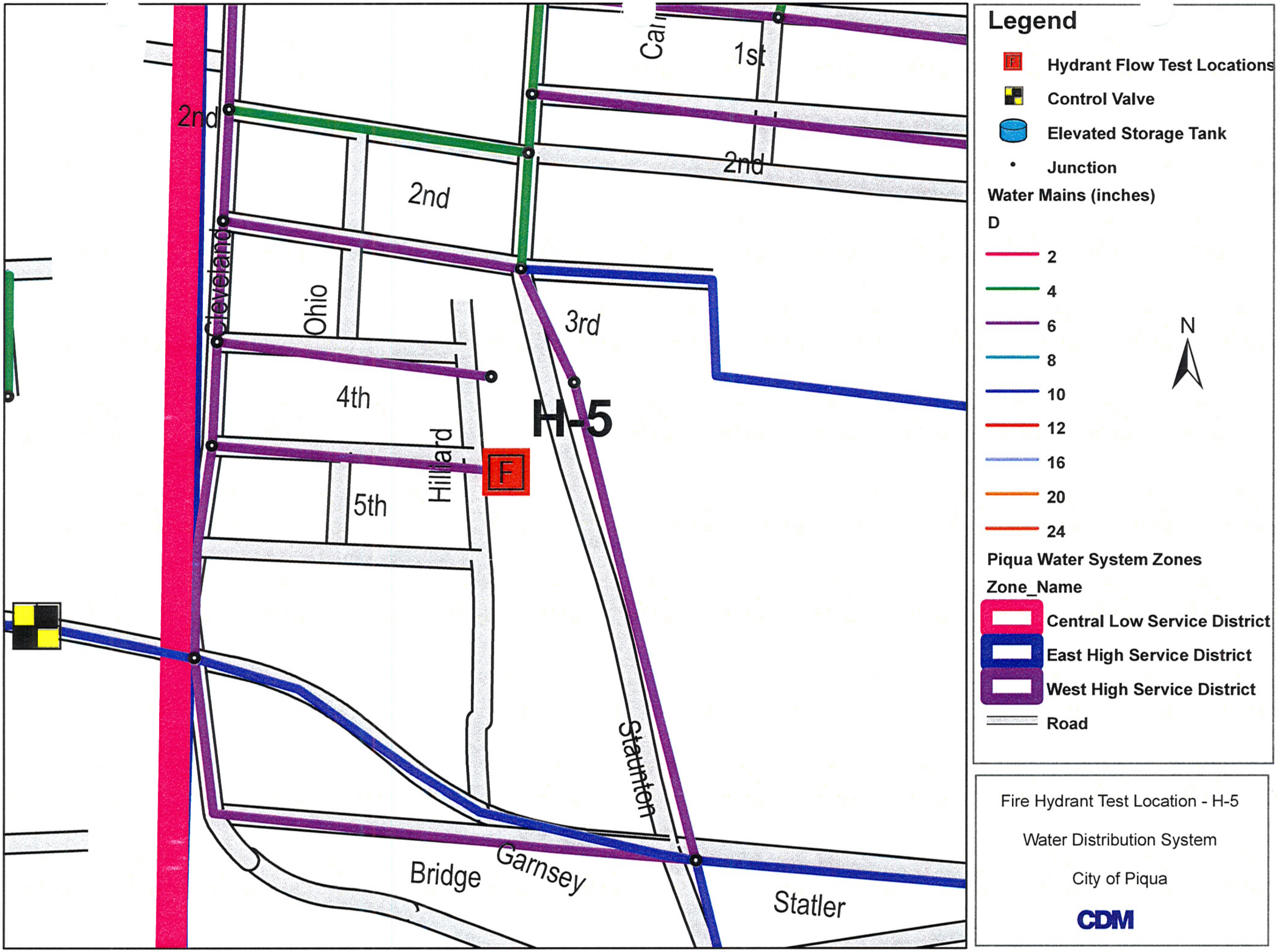


Fire Hydrant Test Location - H-4

Water Distribution System

City of Piqua

CDM

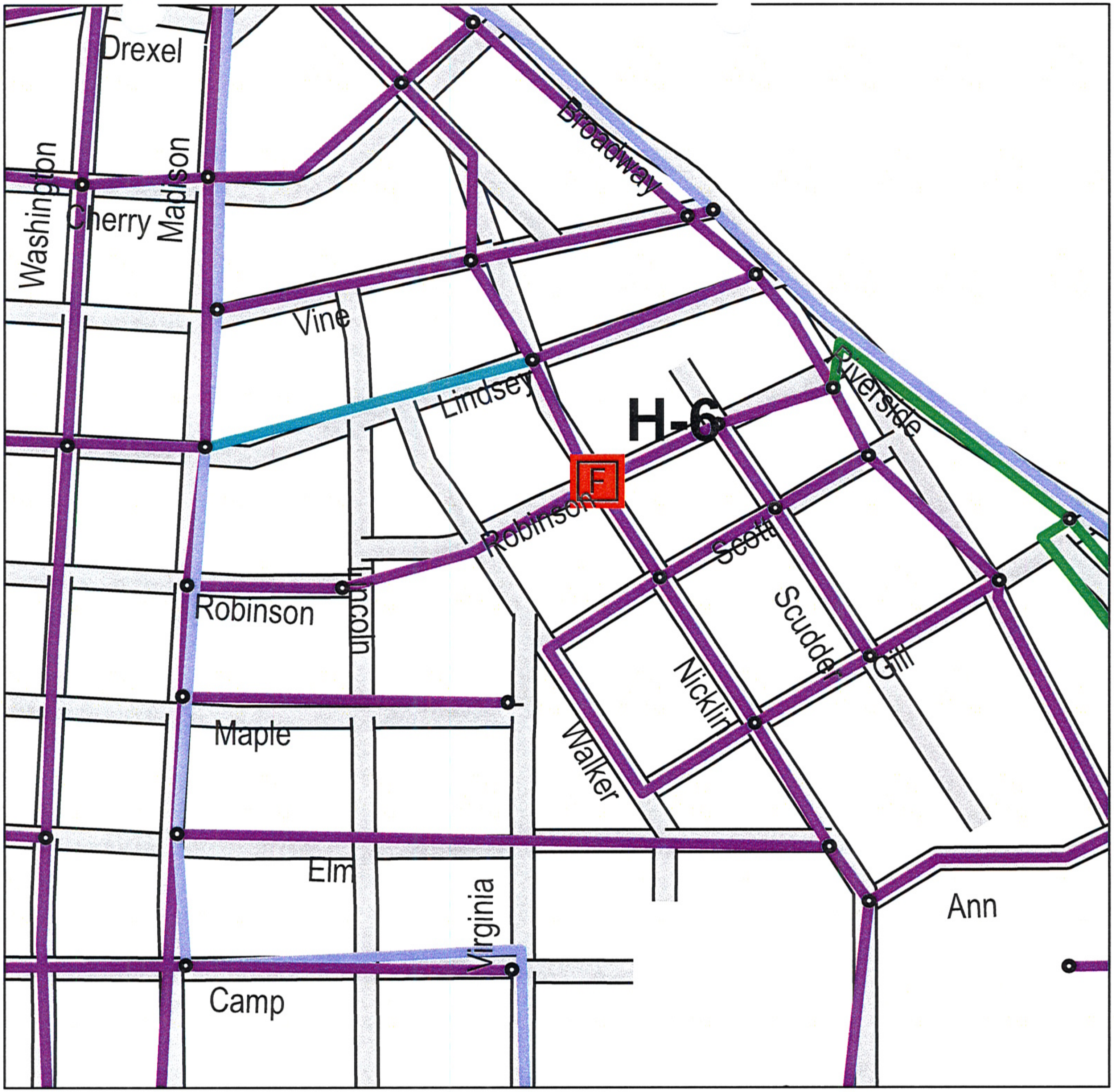


Fire Hydrant Test Location - H-5

Water Distribution System

City of Piqua

CDM



Legend

- Hydrant Flow Test Locations
- Control Valve
- Elevated Storage Tank
- Junction

Water Mains (inches)

D

- 2
- 4
- 6
- 8
- 10
- 12
- 16
- 20
- 24

Piqua Water System Zones

Zone_Name

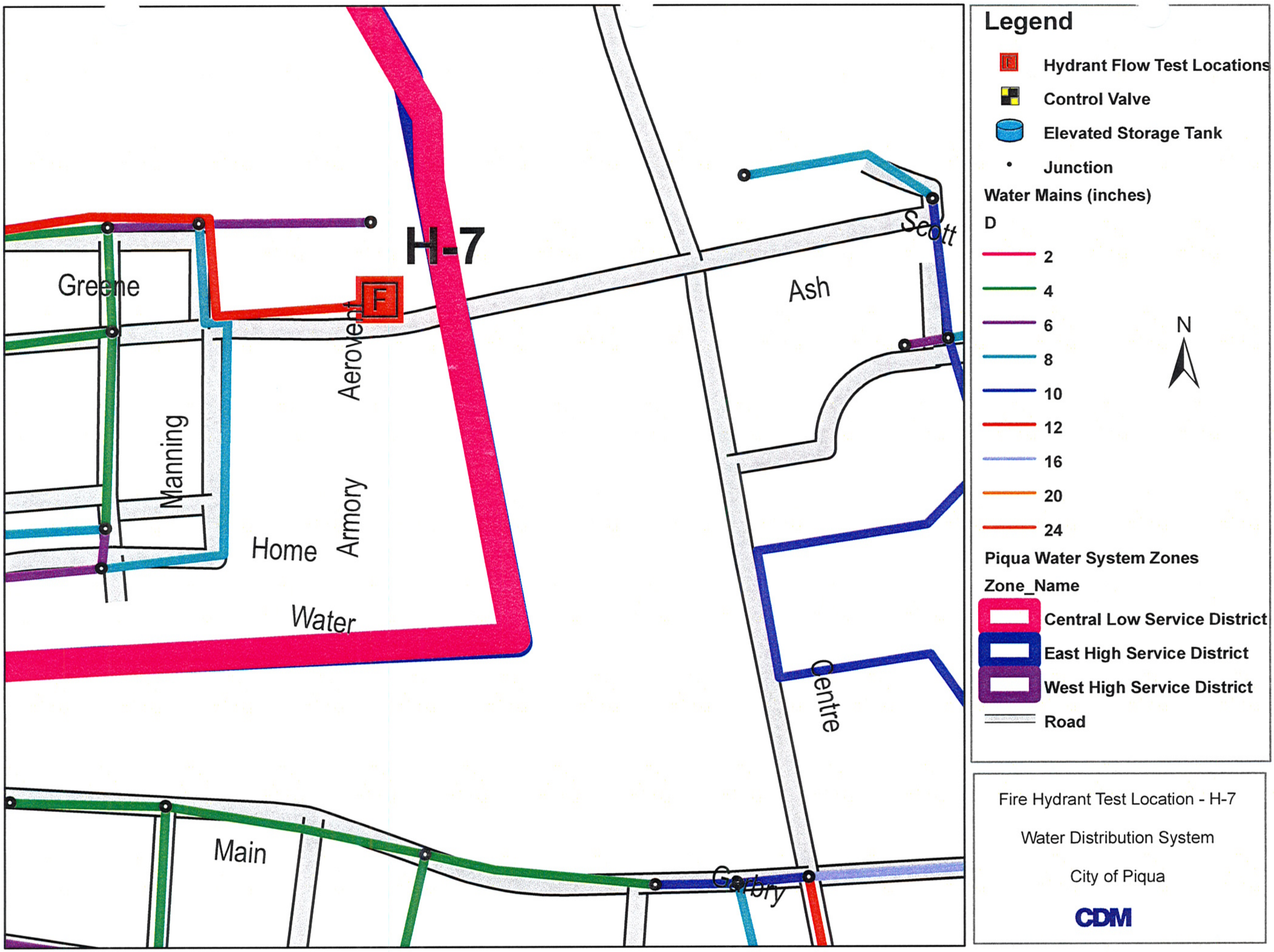
- Central Low Service District
- East High Service District
- West High Service District
- Road

Fire Hydrant Test Location - H-6

Water Distribution System

City of Piqua

CDM

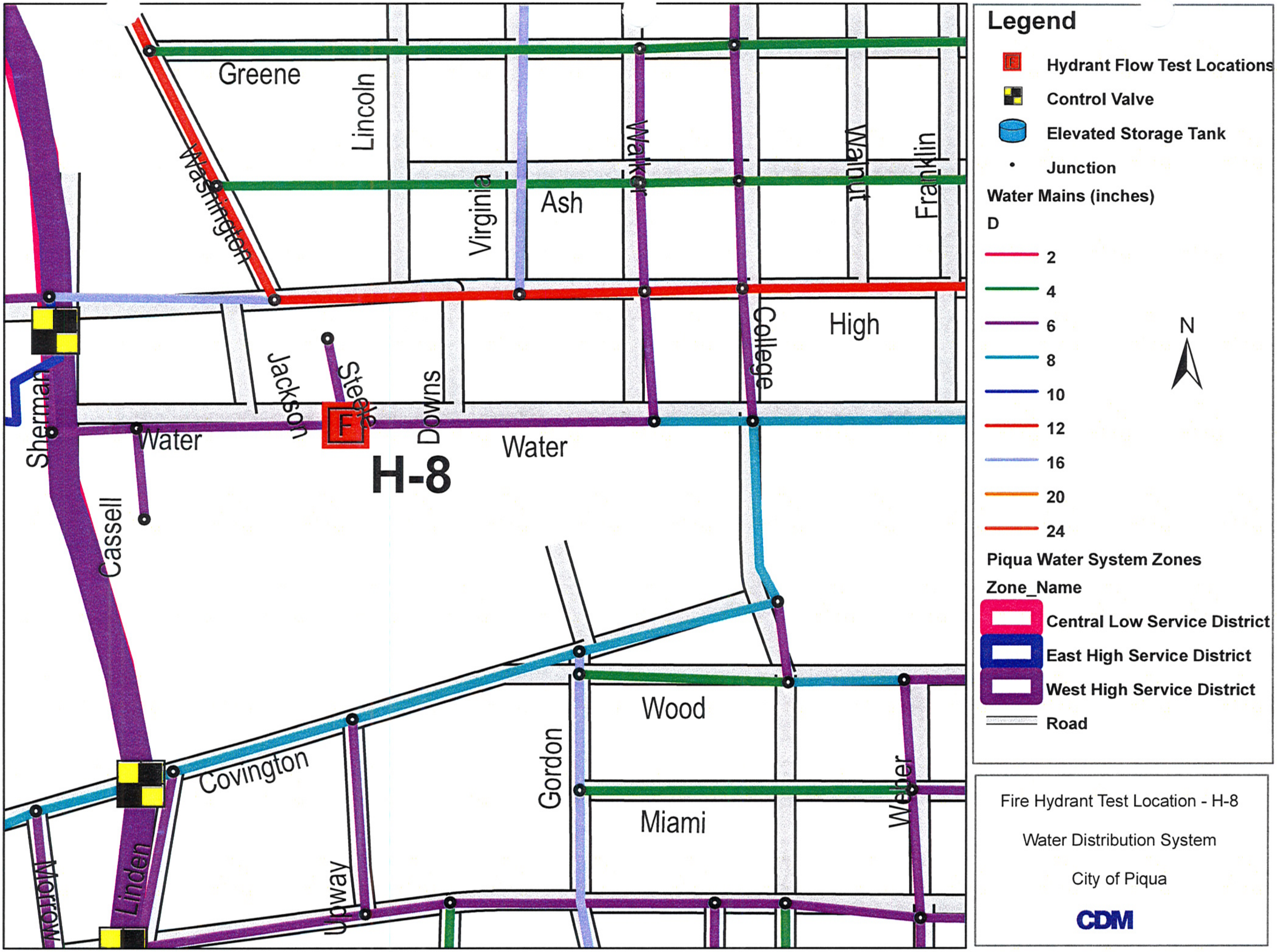


Fire Hydrant Test Location - H-7

Water Distribution System

City of Piqua

CDM

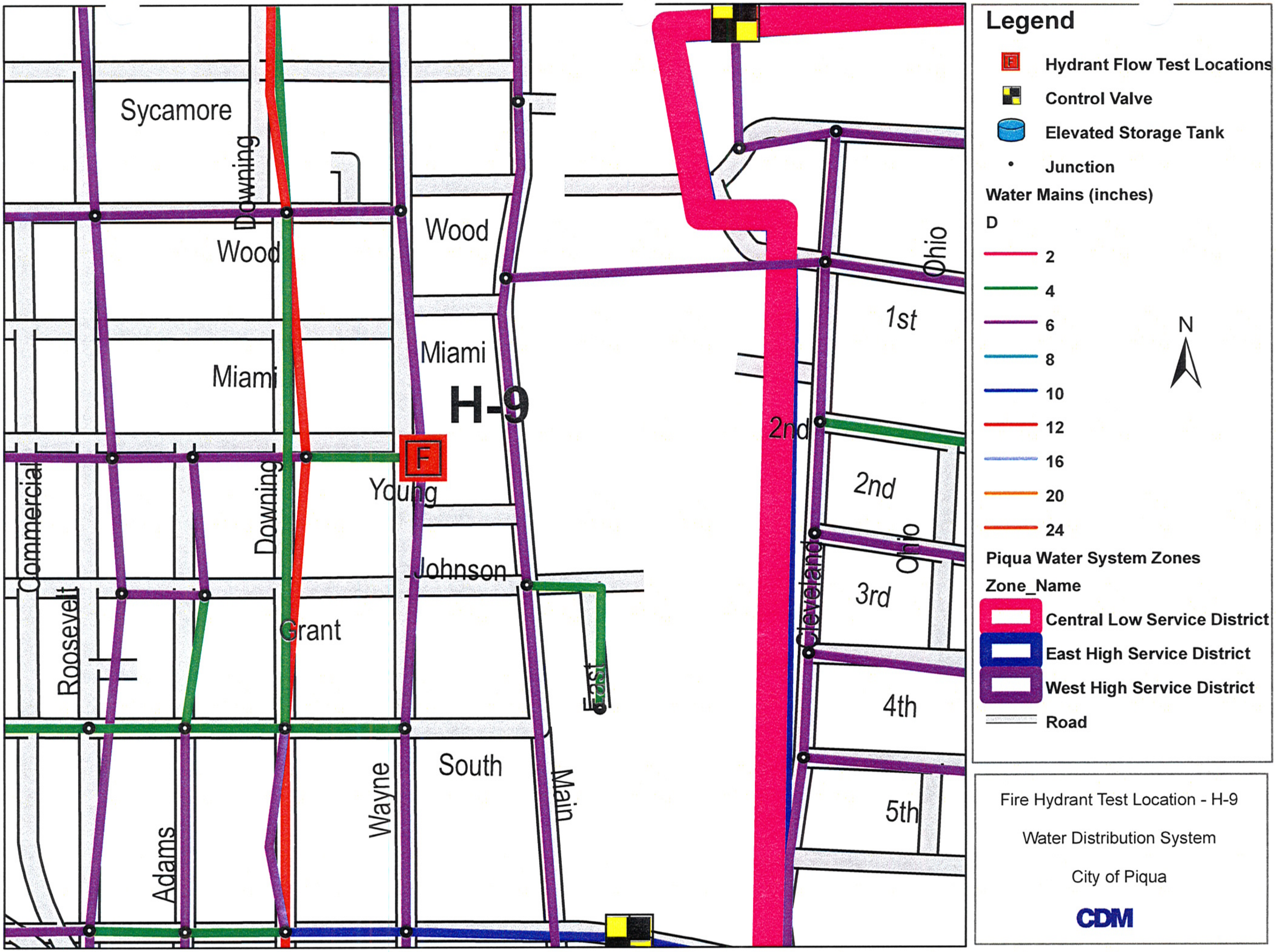


Fire Hydrant Test Location - H-8

Water Distribution System

City of Piqua

CDM

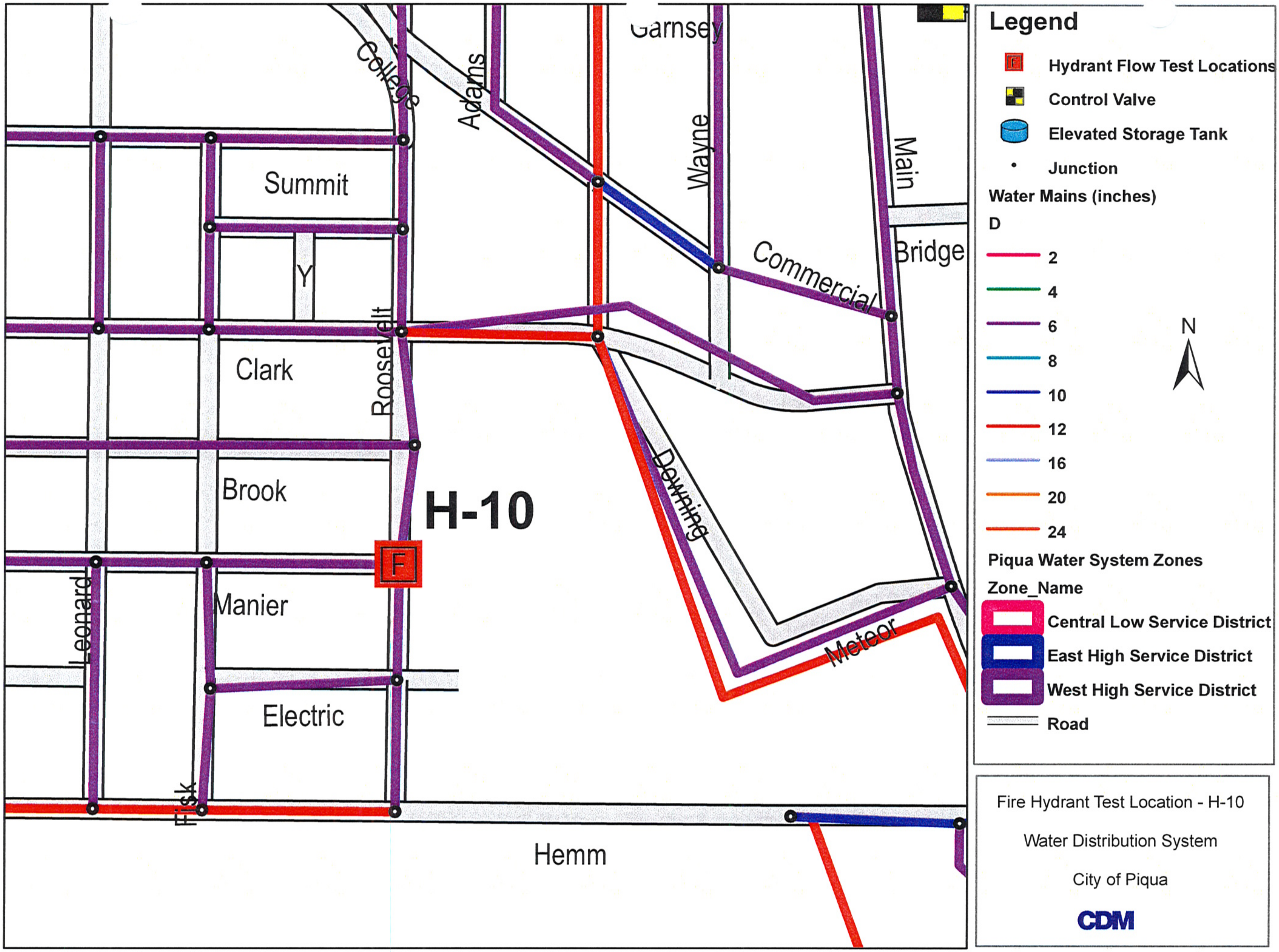


Fire Hydrant Test Location - H-9

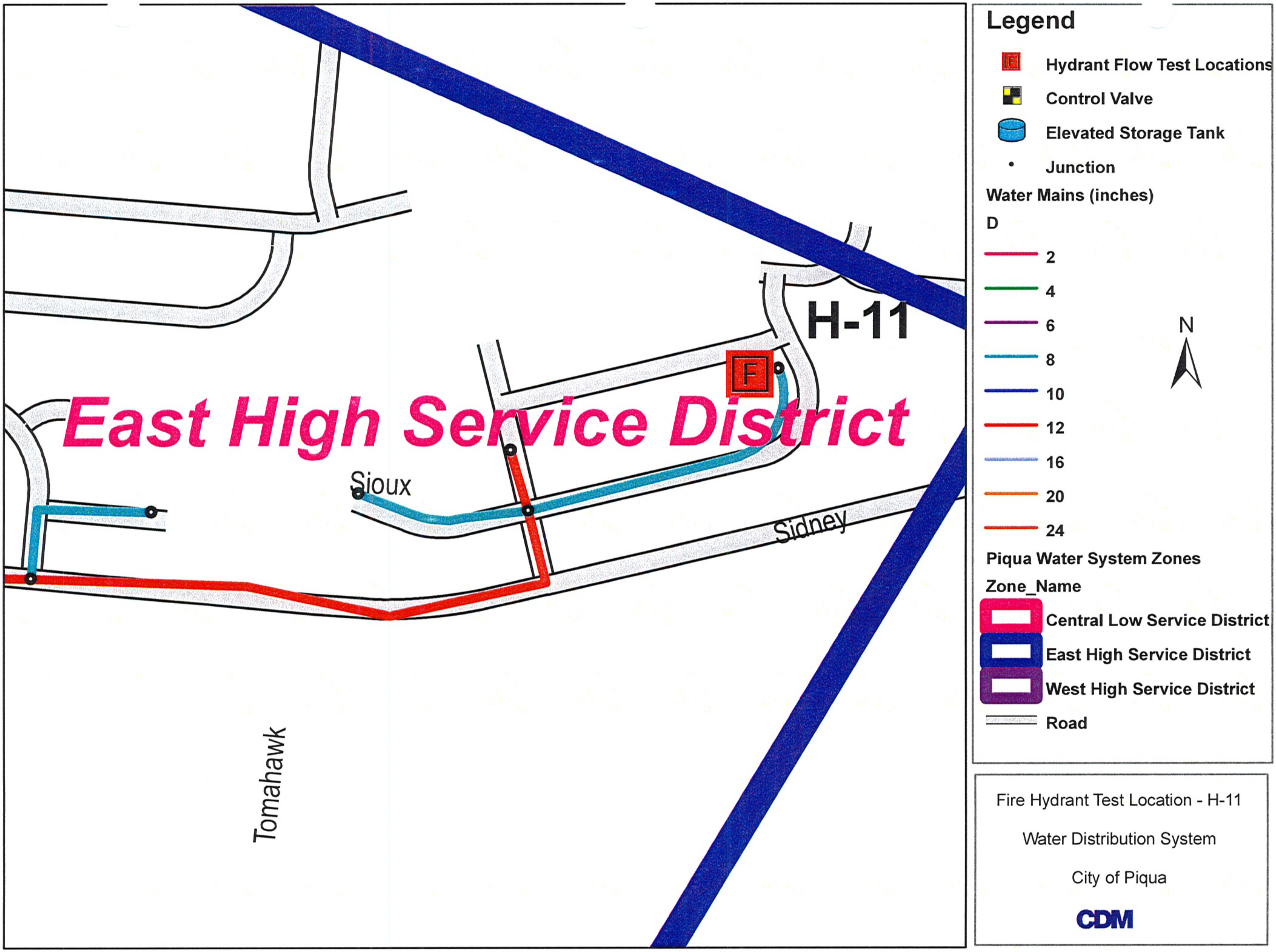
Water Distribution System

City of Piqua

CDM



Garnsey
College
Adams
Wayne
Main
Bridge
Commercial
Summit
Y
Clark
Roosevelt
Brook
H-10
F
Downing
Manier
Leonard
Meteor
Electric
Fisk
Hemm
Legend
Hydrant Flow Test Locations
Control Valve
Elevated Storage Tank
Junction
Water Mains (inches)
D
2
4
6
8
10
12
16
20
24
N
Piqua Water System Zones
Zone_Name
Central Low Service District
East High Service District
West High Service District
Road
Fire Hydrant Test Location - H-10
Water Distribution System
City of Piqua
CDM

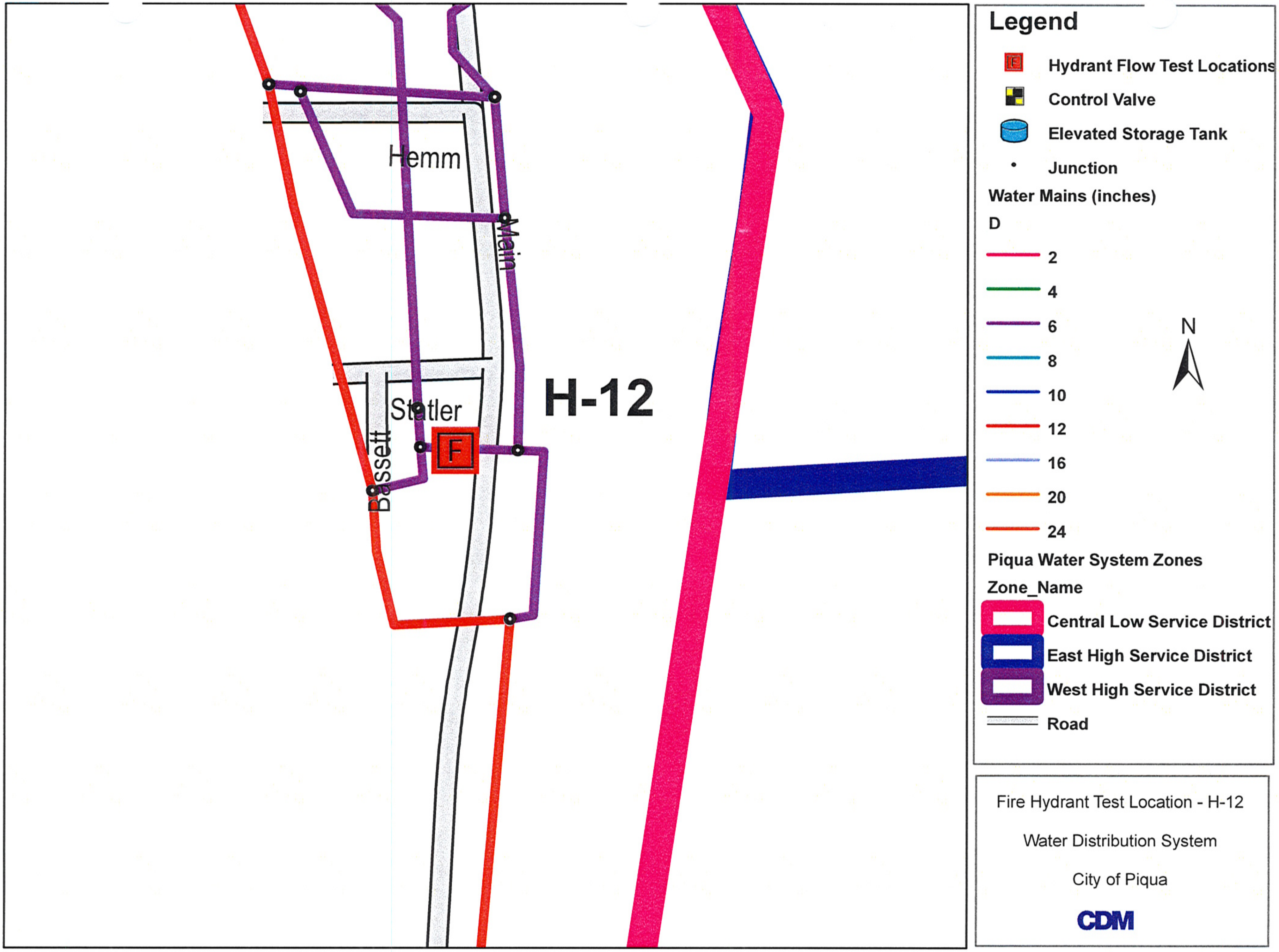


Fire Hydrant Test Location - H-11

Water Distribution System

City of Piqua

CDM



Fire Hydrant Test Location - H-12

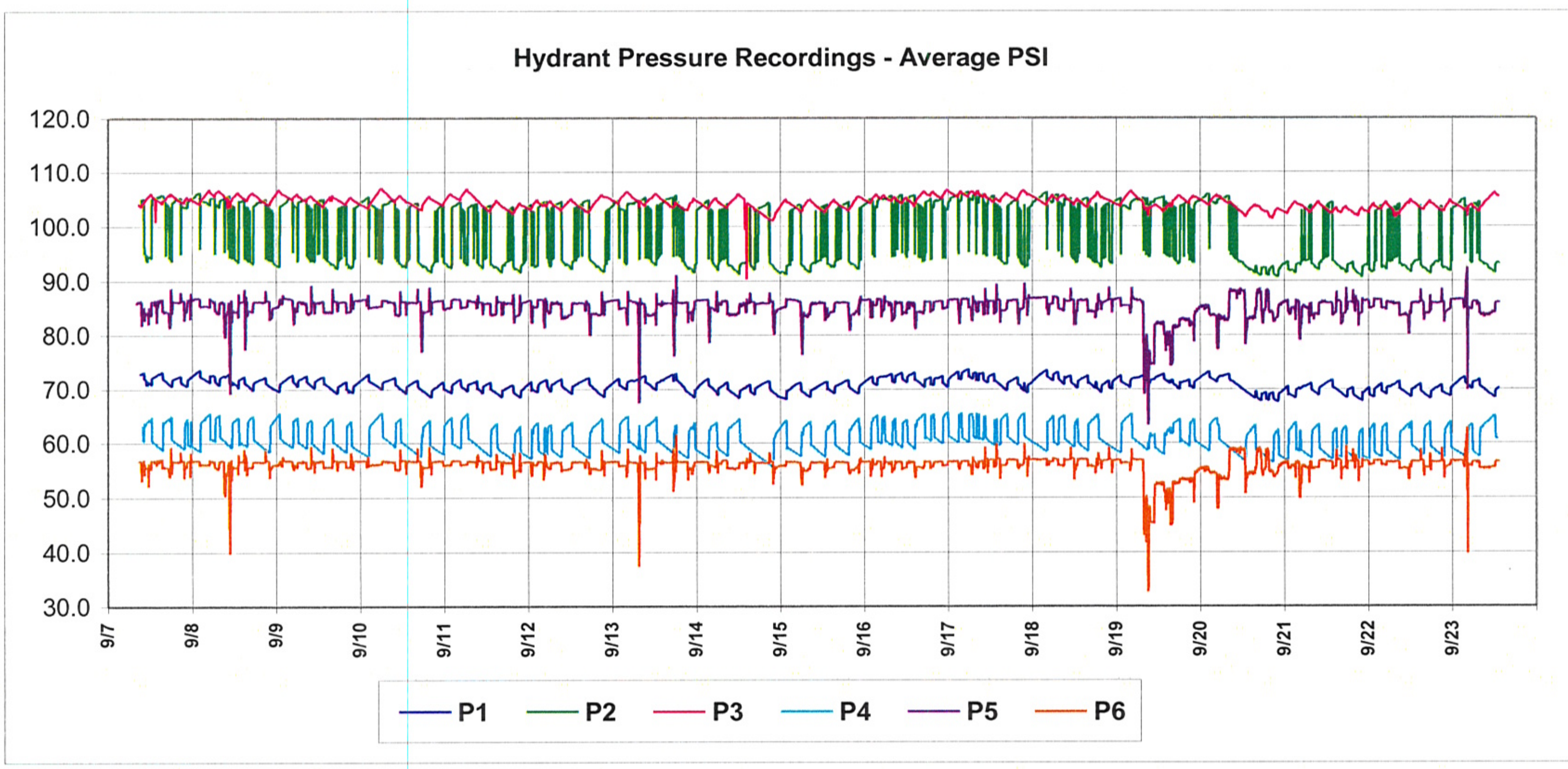
Water Distribution System

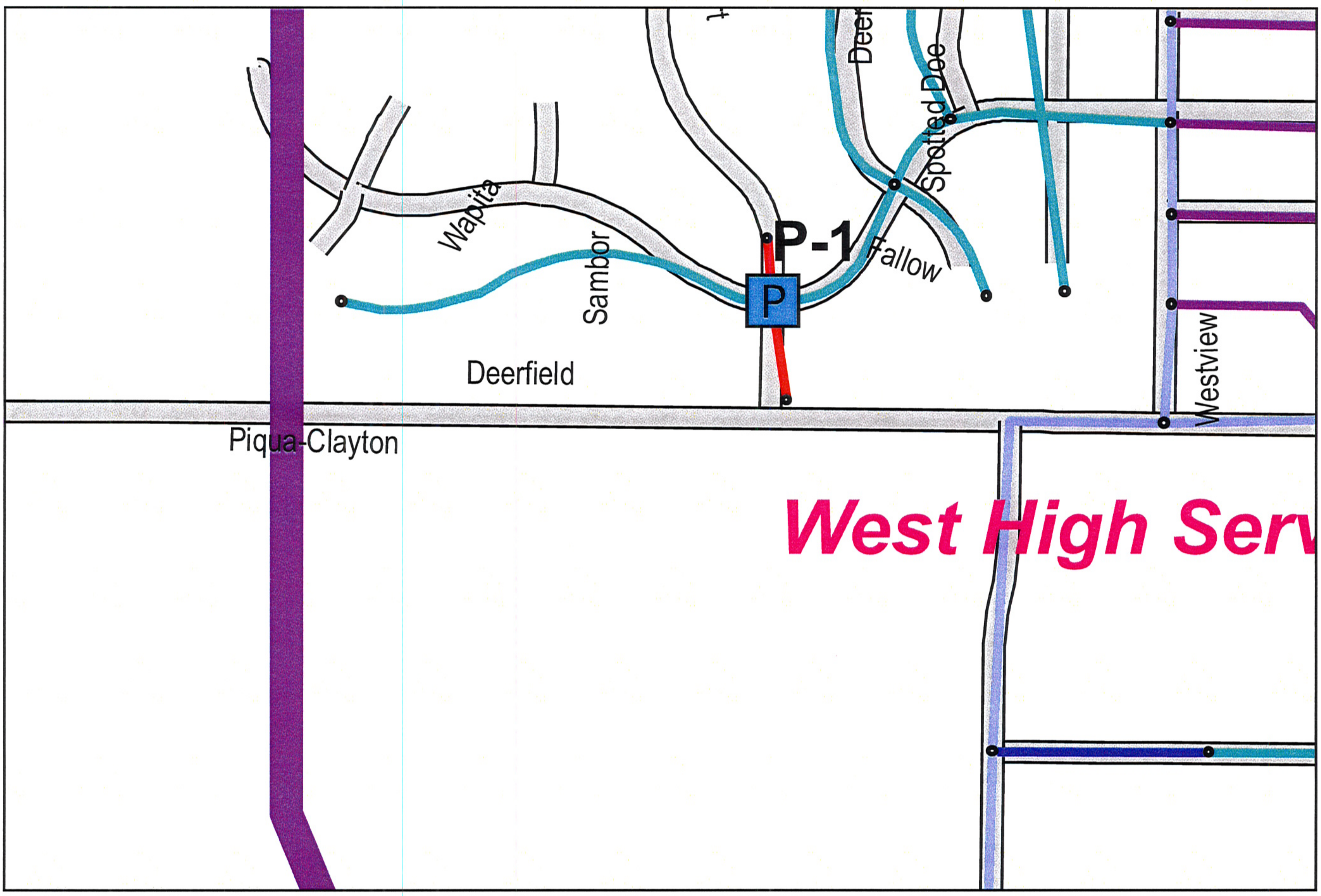
City of Piqua

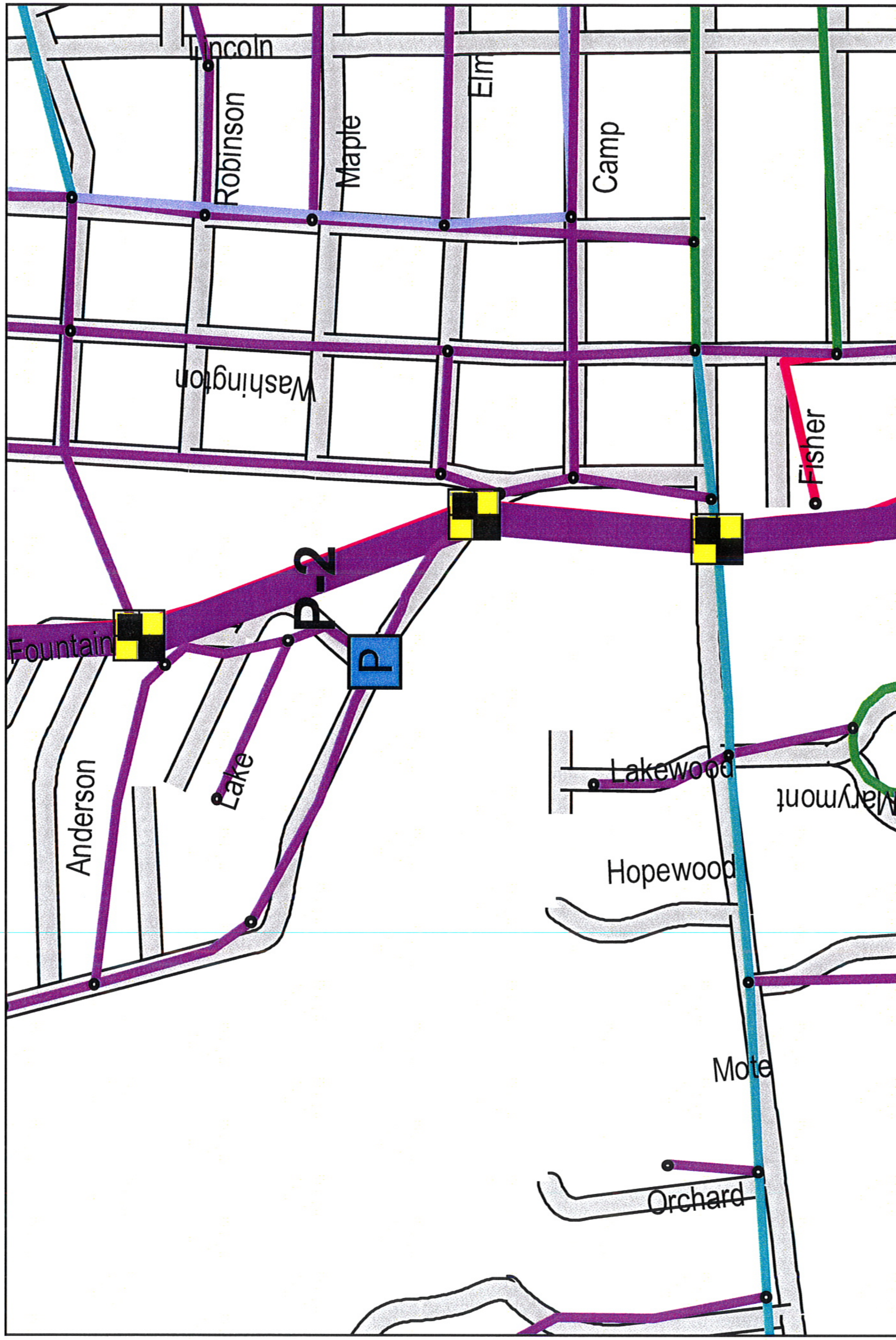
CDM

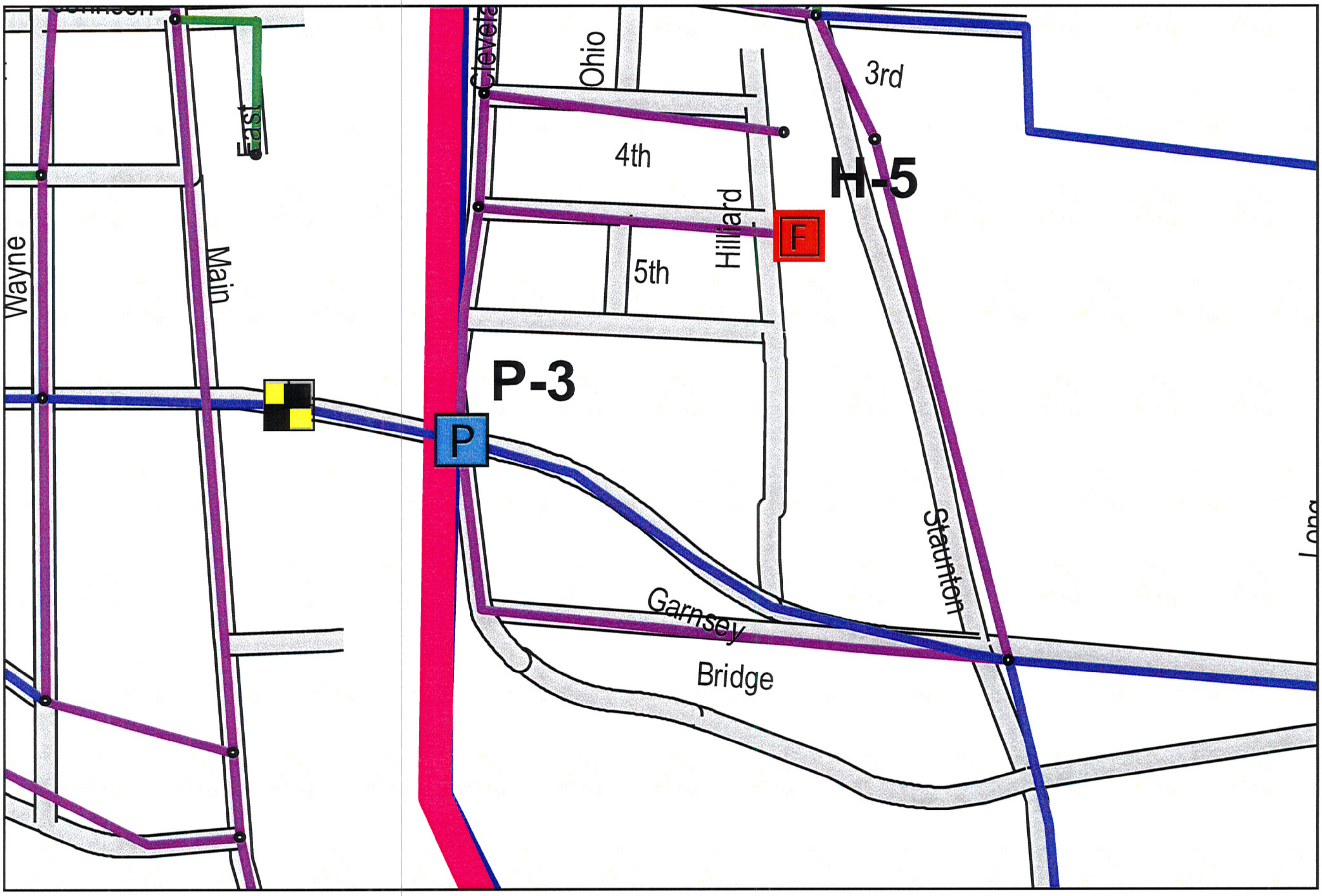
Hydrant Pressure Recording - Summary Table

Test ID #	Service Area	Street Location	Date Installed	Date Removed	Average Pressures (psi)		
					Min	Max	Average
P1	West High Service	Lambert Drive at Wilshire Drive	7-Sep	23-Sep	67.6	73.7	70.9
P2	West High Service	Echo Lake Dr at Fountain Blvd	7-Sep	23-Sep	90.6	106.5	99.4
P3	East High Service	Garnsey St east of S. Main St	7-Sep	23-Sep	90.5	107.4	104.6
P4	East High Service	Sioux Dr south of cherokee Dr	7-Sep	23-Sep	55.6	65.8	60.7
P5	Central Low Service	S Main St at Statler Ave	7-Sep	23-Sep	63.3	92.6	85.3
P6	Central Low Service	Cassell St south of W Water St	7-Sep	23-Sep	32.7	62.8	56.0

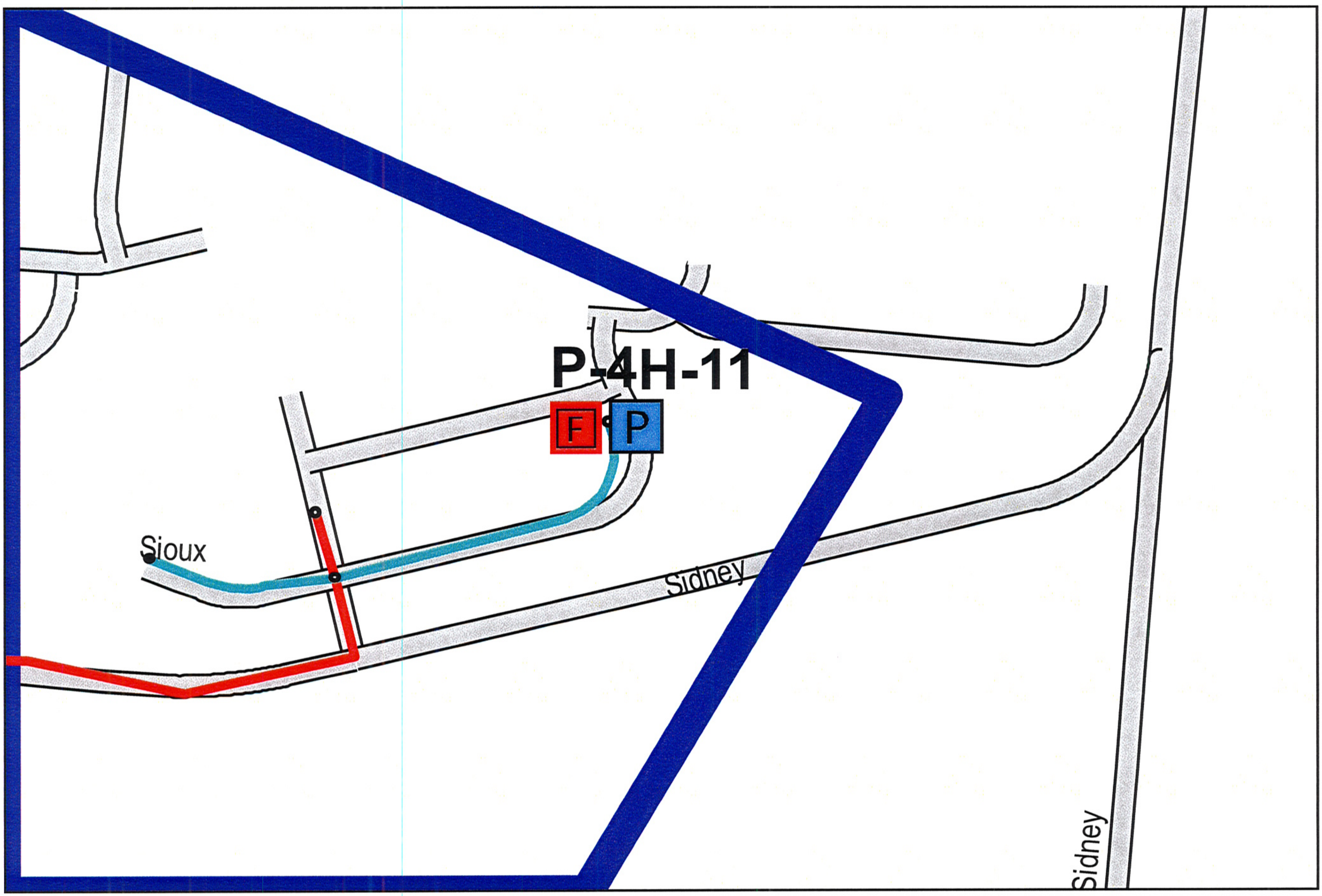


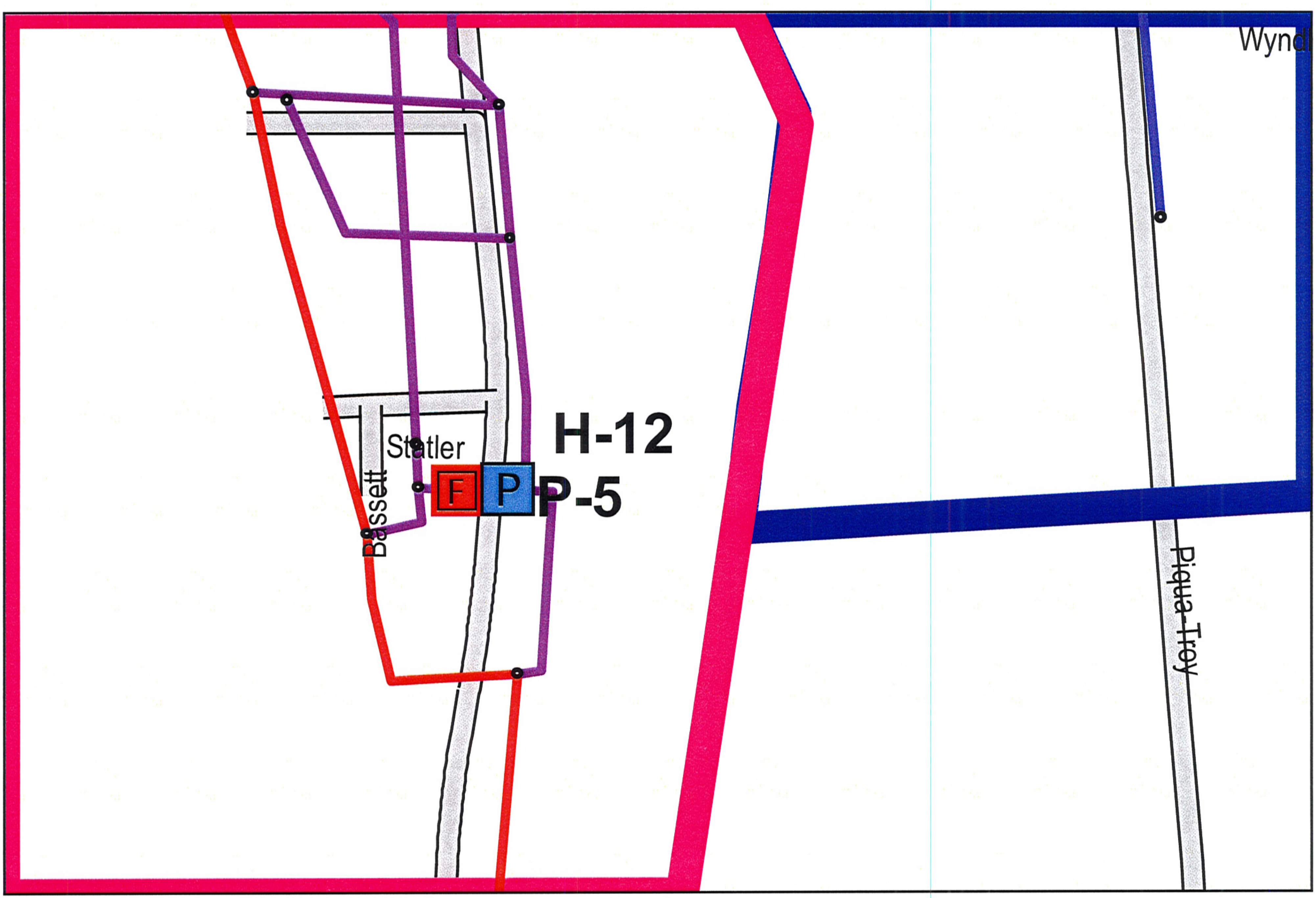

Wapita
Sambor
P-1
P
Fallow
Spotted Doe
Westview
Deerfield
Piqua-Clayton
West High Serv

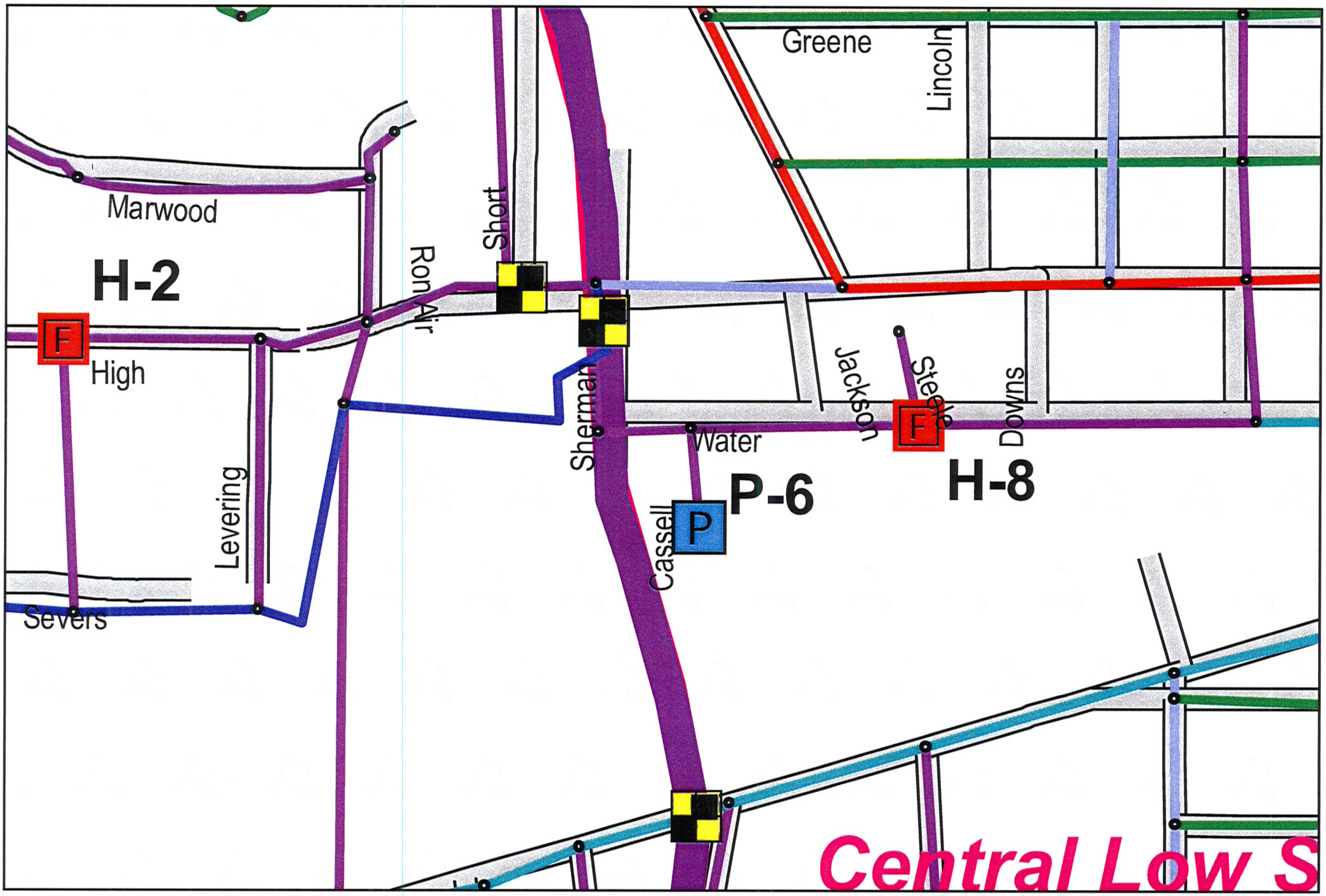

Lincoln
Robinson
Maple
Elm
Camp
Washington
Fisher
P-2
P
Fountain
Anderson
Lake
Lakewood
Marymont
Hopewood
Mote
Orchard



Ohio
3rd
4th
H-5
Hilliard
F
5th
Wayne
Main
East
P-3
P
Garnsey
Staunton
Bridge


P-4H-11
F
P
Sioux
Sidney
Sidney


H-12
P-5
F
P
Statler
Bassett
Piqua-Troy
Wynd


Central Low S
Greene
Lincoln
Marwood
H-2
F
High
Ron Air
Short
Sherman
Jackson
Steele
Downs
F
H-8
Water
P-6
P
Cassell
Levering
Severs

Piqua, Ohio
Ziegler Road Booster Station
Pump No. 1

Name Plate Data

Make	-	Aurora	
Head	-	100	feet
Speed	-	1,750	rpm.
Discharge	-	2,000	gpm.
Serial #	-	76-3852-1	

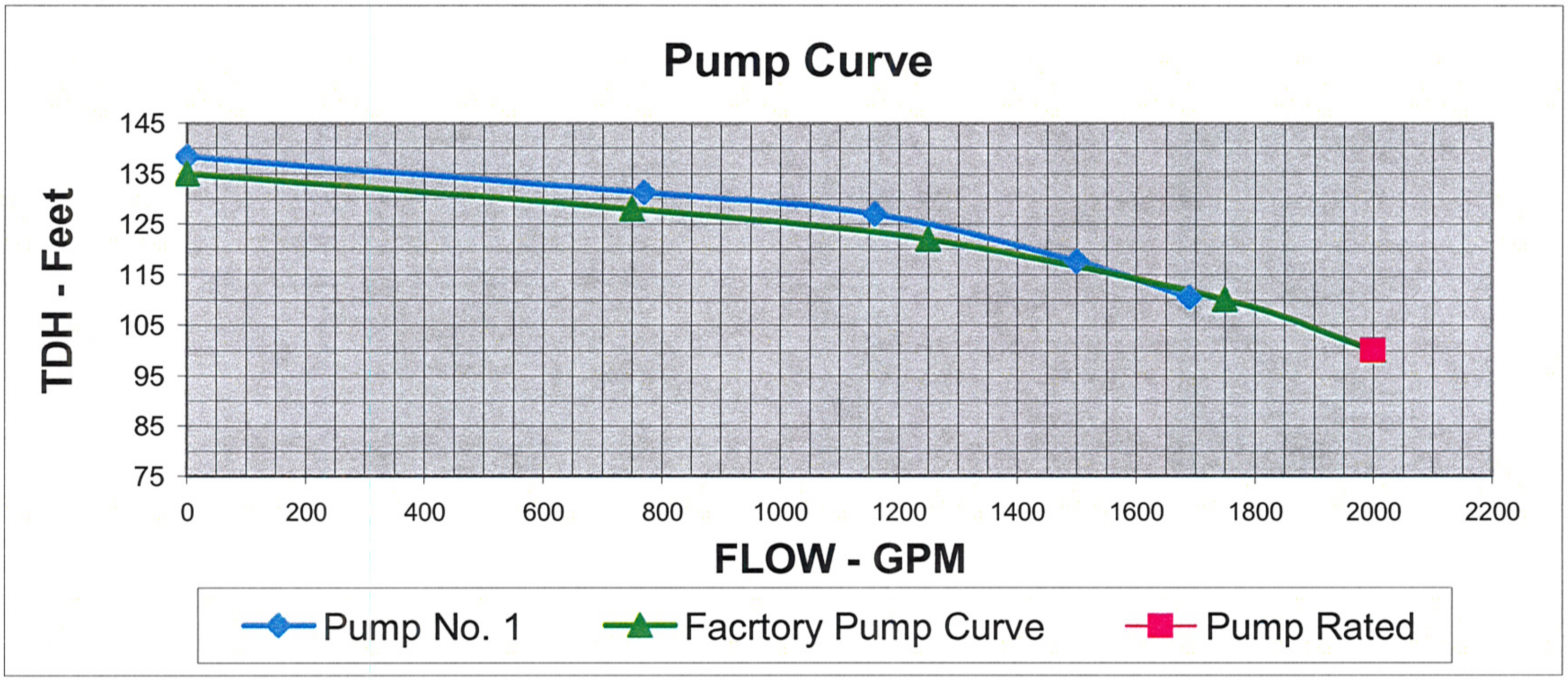
Test Data

Date of Test	-	October 6, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	1,690	1,500	1,160	770	0
Discharge Head-ft.	263	272	282	288	299
Suction Head-ft.	153	154	155	157	160
Total Dynamic Head-ft.	111	118	127	131	138
Horsepower Out-hp.	47	45	37	26	0
Station Meter Flow Rate (gpm)	1,724				
Percent Difference	2%				

Pump Performance Test
Piqua, Ohio
Ziegler Road Booster Station

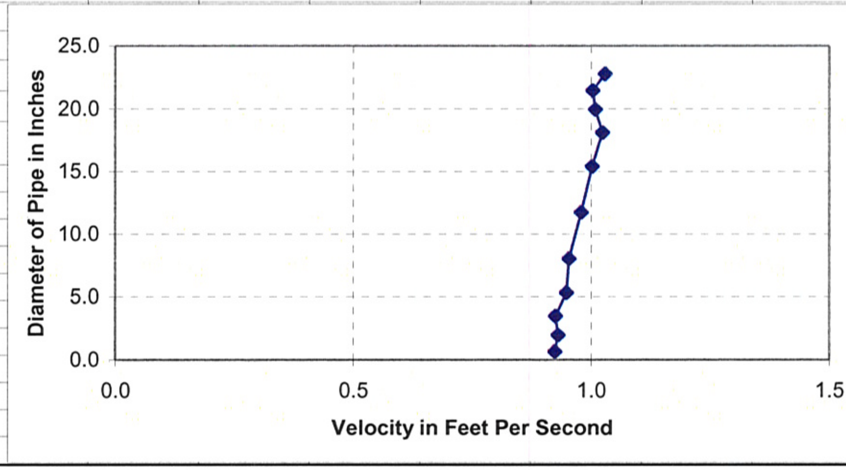
Test #	Pump No. 1			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1690	114	111	2000	100	2000	100
2	1500	118	118	1750	110		
3	1160	122	127	1250	122		
4	770	125	131	750	128		
5 - Valve Closed	0	130	138	0	135		



Piqua OH **Zeiglar BS**

Calipered Diameter:	23.375
Corp. Cock Proj.:	0.1875
Velocity Factor:	0.993
Flow Rate in mgd.:	1.87

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.600	0 5/8	0.211	2.940566	0.459	0.924
2	1.909	1 15/16	0.214	2.942838	0.463	0.931
3	3.423	3 7/16	0.211	2.945467	0.459	0.926
4	5.286	5 5/16	0.221	2.948701	0.470	0.948
5	7.992	7 16/16	0.223	2.953399	0.472	0.954
6	11.688	11 11/16	0.234	2.959816	0.484	0.979
7	15.383	15 3/8	0.244	2.966231	0.494	1.002
8	18.089	18 1/16	0.254	2.970928	0.504	1.024
9	19.952	19	0.246	2.974163	0.496	1.009
10	21.466	21 7/16	0.243	2.976791	0.493	1.004
11	22.775	22 3/4	0.255	2.979064	0.505	1.029



Piqua, Ohio
Ziegler Road Booster Station
Pump No. 2

Name Plate Data

Make	-	Aurora	
Head	-	100	feet
Speed	-	1,750	rpm.
Discharge	-	2,000	gpm.
Serial #	-	76-3852-2	

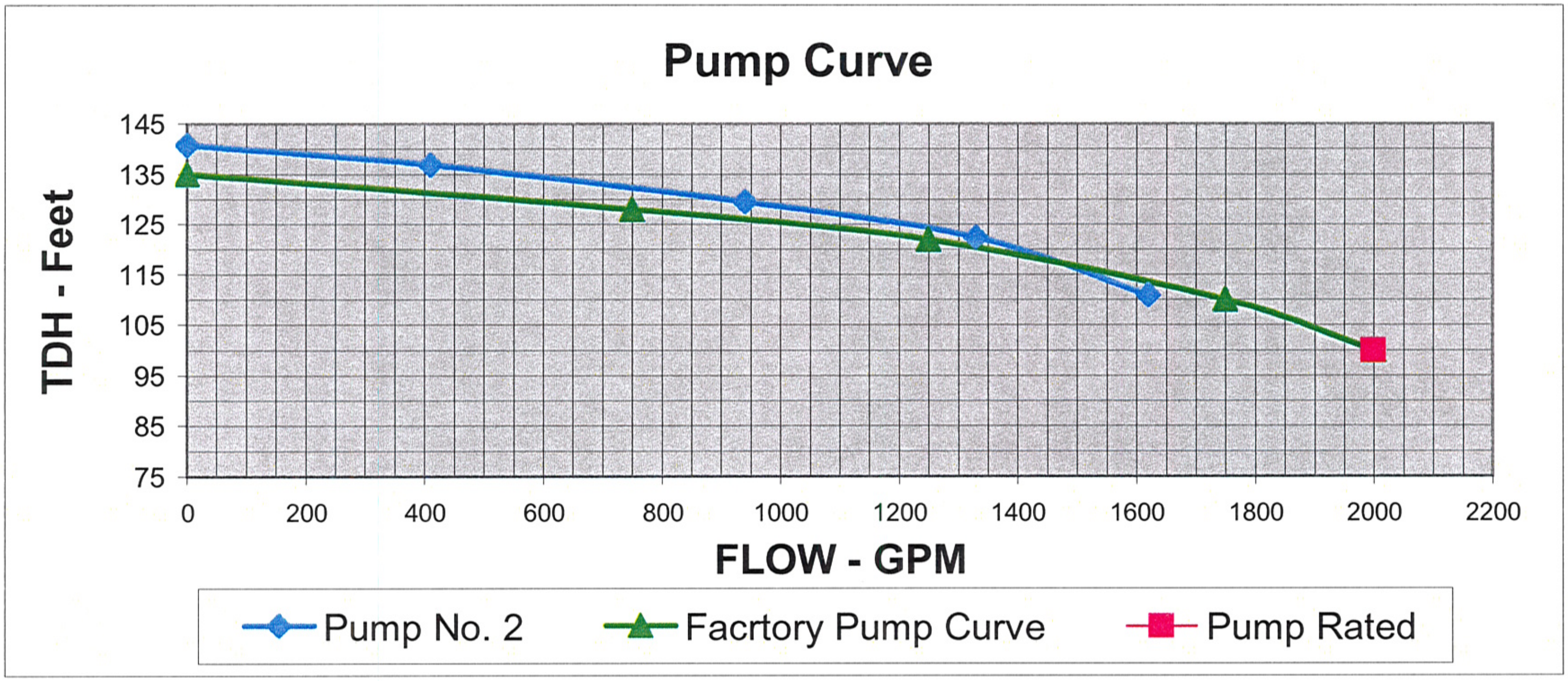
Test Data

Date of Test	-	October 6, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	1,620	1,330	940	410	0
Discharge Head-ft.	263	276	285	294	298
Suction Head-ft.	152	154	156	157	157
Total Dynamic Head-ft.	111	122	130	137	141
Horsepower Out-hp.	45	41	31	14	0
Station Meter Flow Rate (gpm)	1,580				
Percent Difference	-2%				

Pump Performance Test
Piqua, Ohio
Ziegler Road Booster Station

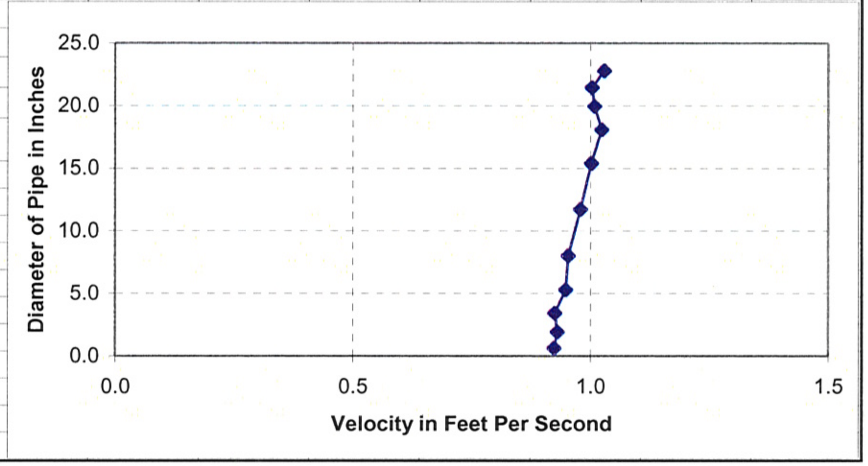
Test #	Pump No. 2			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1620	114	111	2000	100	2000	100
2	1330	120	122	1750	110		
3	940	124	130	1250	122		
4	410	127	137	750	128		
5 - Valve Closed	0	129	141	0	135		



Piqua OH **Zeiglar BS**

Calipered Diameter:	23.375
Corp. Cock Proj.:	0.1875
Velocity Factor:	0.993
Flow Rate in mgd.:	1.87

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.600	0 5/8	0.211	2.940566	0.459	0.924
2	1.909	1 15/16	0.214	2.942838	0.463	0.931
3	3.423	3 7/16	0.211	2.945467	0.459	0.926
4	5.286	5 5/16	0.221	2.948701	0.470	0.948
5	7.992	7 16/16	0.223	2.953399	0.472	0.954
6	11.688	11 11/16	0.234	2.959816	0.484	0.979
7	15.383	15 3/8	0.244	2.966231	0.494	1.002
8	18.089	18 1/16	0.254	2.970928	0.504	1.024
9	19.952	19	0.246	2.974163	0.496	1.009
10	21.466	21 7/16	0.243	2.976791	0.493	1.004
11	22.775	22 3/4	0.255	2.979064	0.505	1.029



Piqua, Ohio
Ziegler Road Booster Station
Pump No. 3

Name Plate Data

Make	-	Aurora	
Head	-	100	feet
Speed	-	1,750	rpm.
Discharge	-	2,000	gpm.
Serial #	-	76-3852-3	

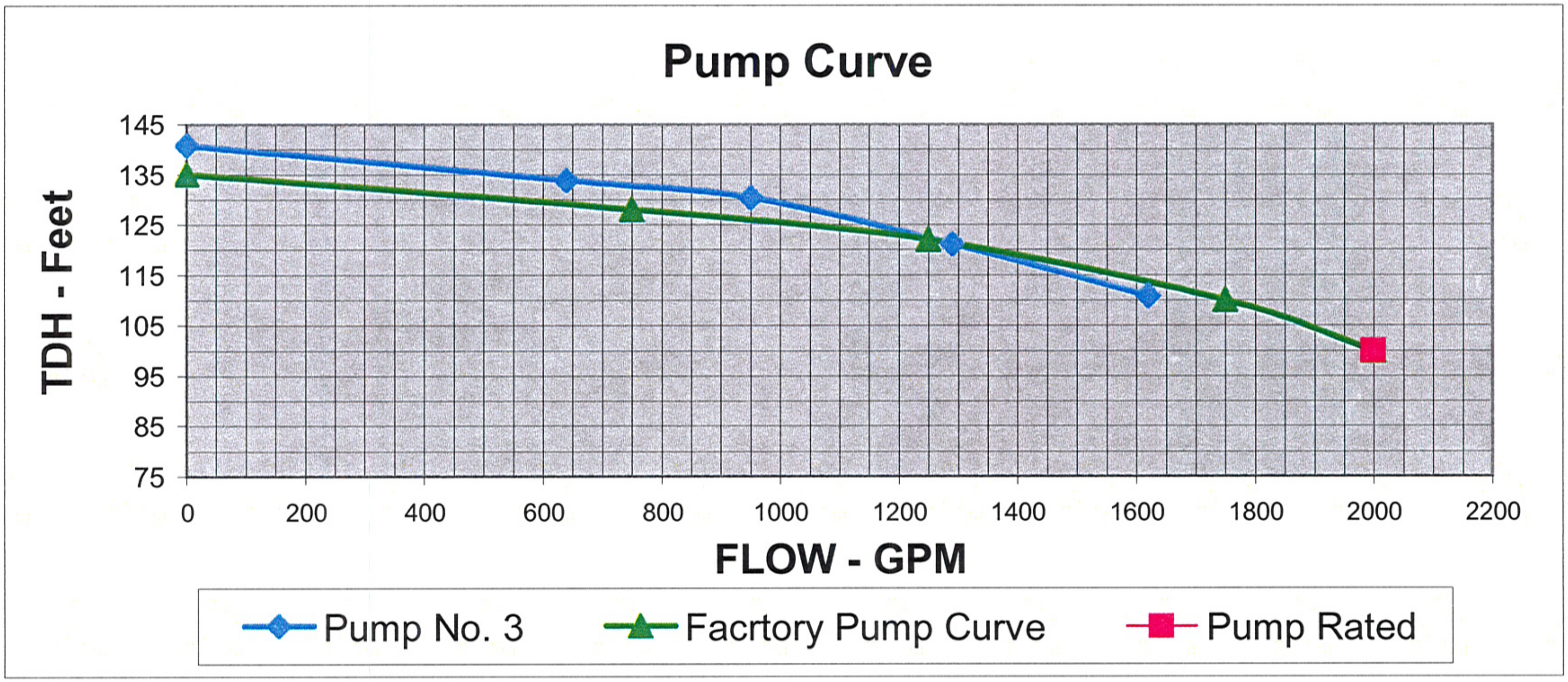
Test Data

Date of Test	-	October 6, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	1,620	1,290	950	640	0
Discharge Head-ft.	263	273	284	291	302
Suction Head-ft.	152	152	153	157	161
Total Dynamic Head-ft.	111	121	130	134	141
Horsepower Out-hp.	45	40	31	22	0
Station Meter Flow Rate (gpm)	1,660	1410	1050	710	
Percent Difference	2%	9%	11%	11%	

Pump Performance Test
Piqua, Ohio
Ziegler Road Booster Station

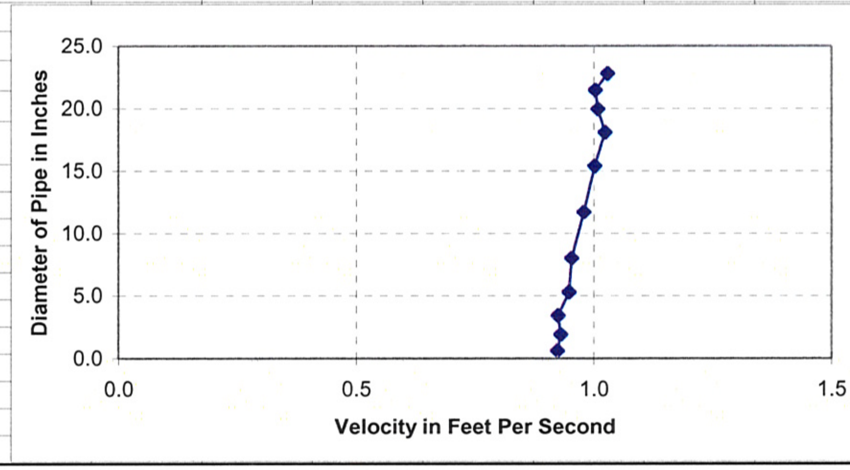
Test #	Pump No. 3			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1620	114	111	2000	100	2000	100
2	1290	119	121	1750	110		
3	950	123	130	1250	122		
4	640	126	134	750	128		
5 - Valve Closed	0	131	141	0	135		



Piqua OH **Zeiglar BS**

Calipered Diameter:	23.375
Corp. Cock Proj.:	0.1875
Velocity Factor:	0.993
Flow Rate in mgd.:	1.87

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.600	0 5/8	0.211	2.940566	0.459	0.924
2	1.909	1 15/16	0.214	2.942838	0.463	0.931
3	3.423	3 7/16	0.211	2.945467	0.459	0.926
4	5.286	5 5/16	0.221	2.948701	0.470	0.948
5	7.992	7 16/16	0.223	2.953399	0.472	0.954
6	11.688	11 11/16	0.234	2.959816	0.484	0.979
7	15.383	15 3/8	0.244	2.966231	0.494	1.002
8	18.089	18 1/16	0.254	2.970928	0.504	1.024
9	19.952	19	0.246	2.974163	0.496	1.009
10	21.466	21 7/16	0.243	2.976791	0.493	1.004
11	22.775	22 3/4	0.255	2.979064	0.505	1.029



Piqua, Ohio
Hetzler Road Booster Station
Pump No. 1

Name Plate Data

Make	-	No Name Plate
Head	-	- feet
Speed	-	- rpm.
Discharge	-	- gpm.
Serial #	-	

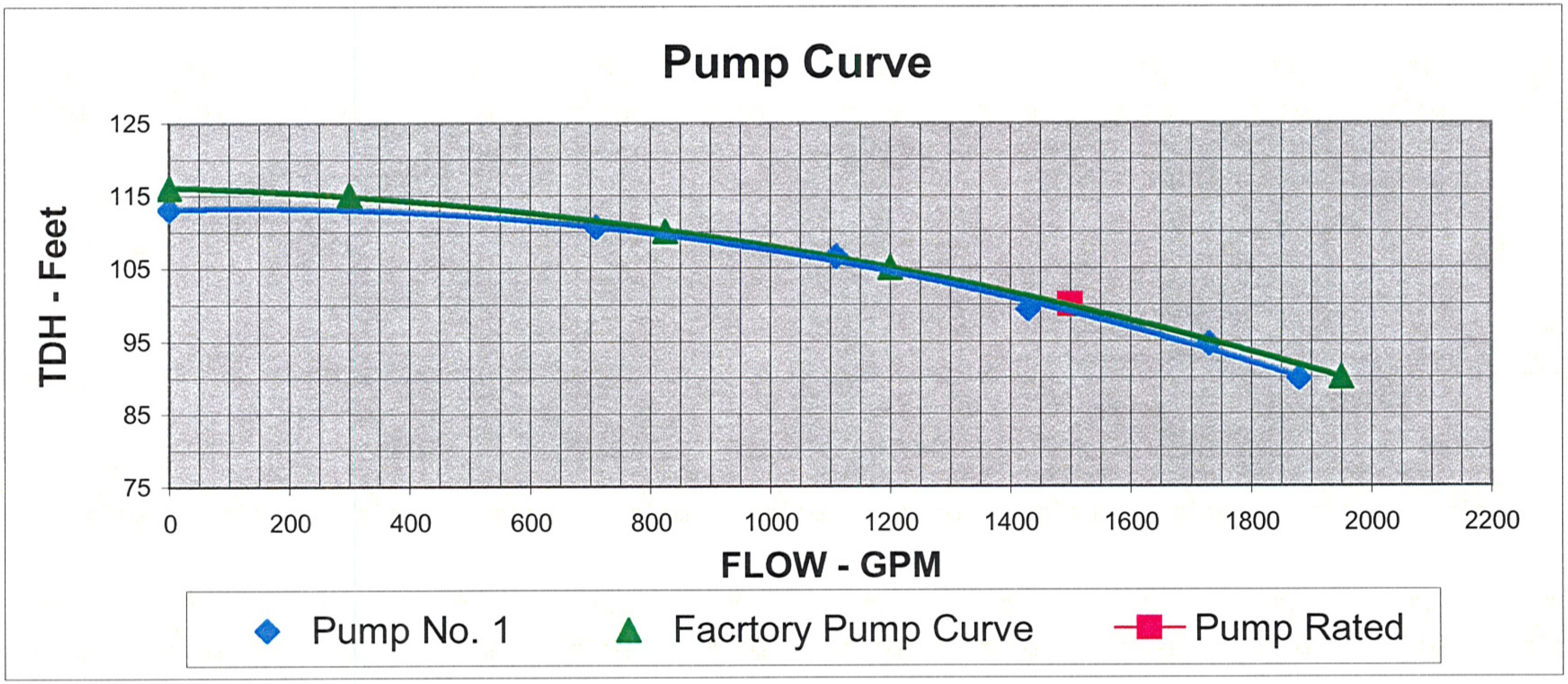
Test Data

Date of Test	-	October 6, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5	Test Point No. 6
Discharge - gpm.	1,880	1,730	1,430	1,110	710	0
Discharge Head-ft.	238	246	254	266	276	286
Suction Head-ft.	148	151	155	160	165	173
Total Dynamic Head-ft.	90	95	99	107	111	113
Horsepower Out-hp.	43	41	36	30	20	0
Station Meter Flow Rate (gpm)	1,850					
Percent Difference	-2%					

Pump Performance Test
Piqua, Ohio
Hetzler Road Booster Station

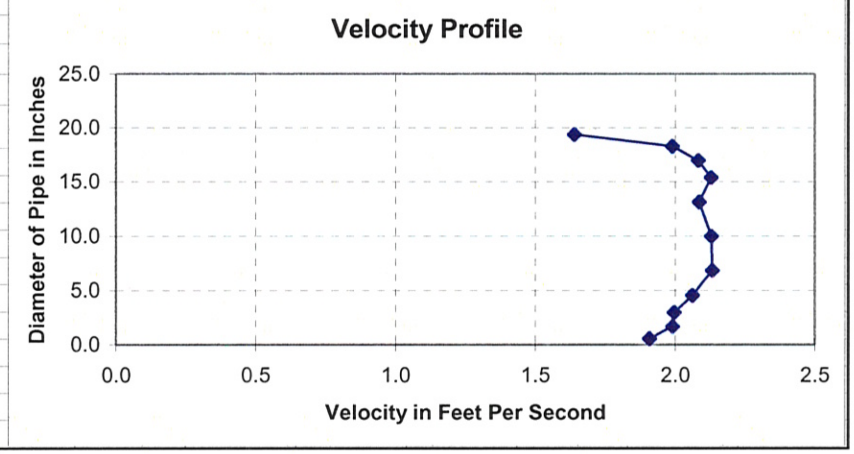
Test #	Pump No. 1			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1880	103	90	1950	90	1500	100
2	1730	107	95	1500	100		
3	1430	110	99	1200	105		
4	1110	115	107	825	110		
5	710	120	111	300	115		
6 - Valve Closed	0	124	113	0	116		



Piqua OH | **Hetzler BS**

Gauging Pt type	**1-in corp**
Nominal Diameter	**20**
Calipered Diameter:	**19.875**
Corp. Cock Proj.:	**0.25**
Velocity Factor:	**0.940**
Flow Rate in mgd.:	**2.78**

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.510	0 1/2	**0.906**	2.120861	0.952	1.910
2	1.623	1 5/8	**0.984**	2.122794	0.992	1.993
3	2.911	2 15/16	**0.988**	2.12503	0.994	1.999
4	4.495	4 1/2	**1.05**	2.12778	1.025	2.063
5	6.795	6 13/16	**1.12**	2.131773	1.058	2.135
6	9.938	9 15/16	**1.11**	2.137229	1.054	2.131
7	13.080	13 1/16	**1.06**	2.142684	1.030	2.087
8	15.380	15 3/8	**1.1**	2.146677	1.049	2.130
9	16.964	16 15/16	**1.05**	2.149427	1.025	2.084
10	18.252	18 1/4	**0.957**	2.151663	0.978	1.992
11	19.365	19 3/8	**0.648**	2.153596	0.805	1.640



Piqua, Ohio
Hetzler Road Booster Station
Pump No. 2

Name Plate Data

Make	-	Weinman 8L2	
Head	-	100	feet
Speed	-	1,750	rpm.
Discharge	-	1,500	gpm.
Serial #	-	700790-2	

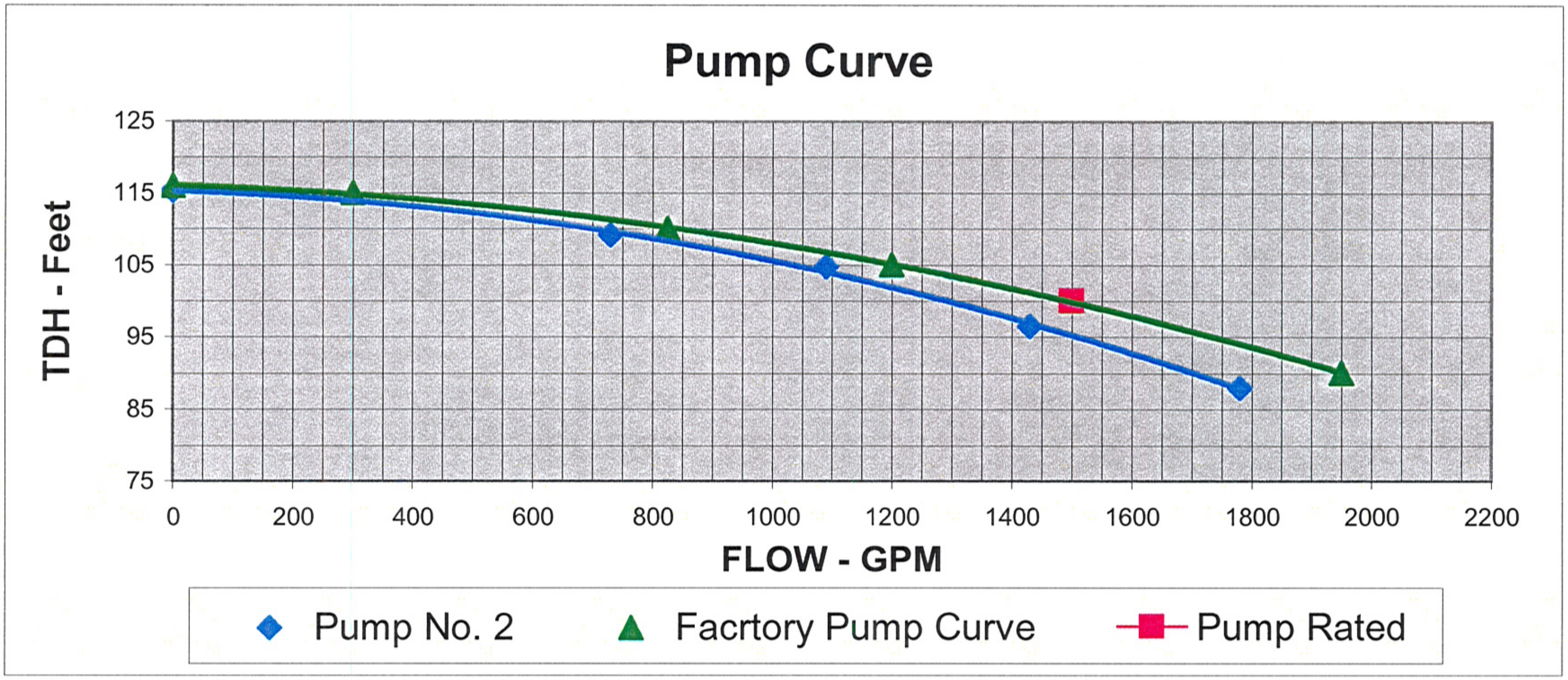
Test Data

Date of Test	-	October 6, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	1,780	1,430	1,090	730	0
Discharge Head-ft.	236	251	266	274	284
Suction Head-ft.	148	155	161	165	168
Total Dynamic Head-ft.	88	96	105	109	115
Horsepower Out-hp.	40	35	29	20	0
Station Meter Flow Rate (gpm)	1,730				
Percent Difference	-3%				

Pump Performance Test
Piqua, Ohio
Hetzler Road Booster Station

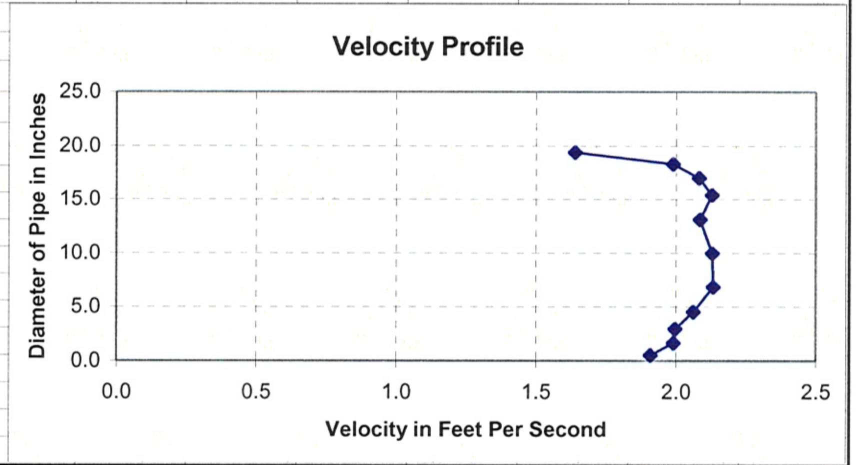
Test #	Pump No. 2			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1780	102	88	1950	90	1500	100
2	1430	109	96	1500	100		
3	1090	115	105	1200	105		
4	730	119	109	825	110		
5 - Valve Closed	0	123	115	300	115		
				0	116		



Piqua OH **Hetzler BS**

Gauging Pt type	1-in corp
Nominal Diameter	20
Calipered Diameter:	19.875
Corp. Cock Proj.:	0.25
Velocity Factor:	0.940
Flow Rate in mgd.:	2.78

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.510	0 1/2	0.906	2.120861	0.952	1.910
2	1.623	1 5/8	0.984	2.122794	0.992	1.993
3	2.911	2 15/16	0.988	2.12503	0.994	1.999
4	4.495	4 1/2	1.05	2.12778	1.025	2.063
5	6.795	6 13/16	1.12	2.131773	1.058	2.135
6	9.938	9 15/16	1.11	2.137229	1.054	2.131
7	13.080	13 1/16	1.06	2.142684	1.030	2.087
8	15.380	15 3/8	1.1	2.146677	1.049	2.130
9	16.964	16 15/16	1.05	2.149427	1.025	2.084
10	18.252	18 1/4	0.957	2.151663	0.978	1.992
11	19.365	19 3/8	0.648	2.153596	0.805	1.640



Piqua, Ohio
Water Treatment Plant
Pump No. 1

Name Plate Data

Make	-	Aurora - 411 BF
Head	-	200 feet
Speed	-	1,750 rpm.
Discharge	-	2,260 gpm.
Serial #	-	75-10844

Test Data

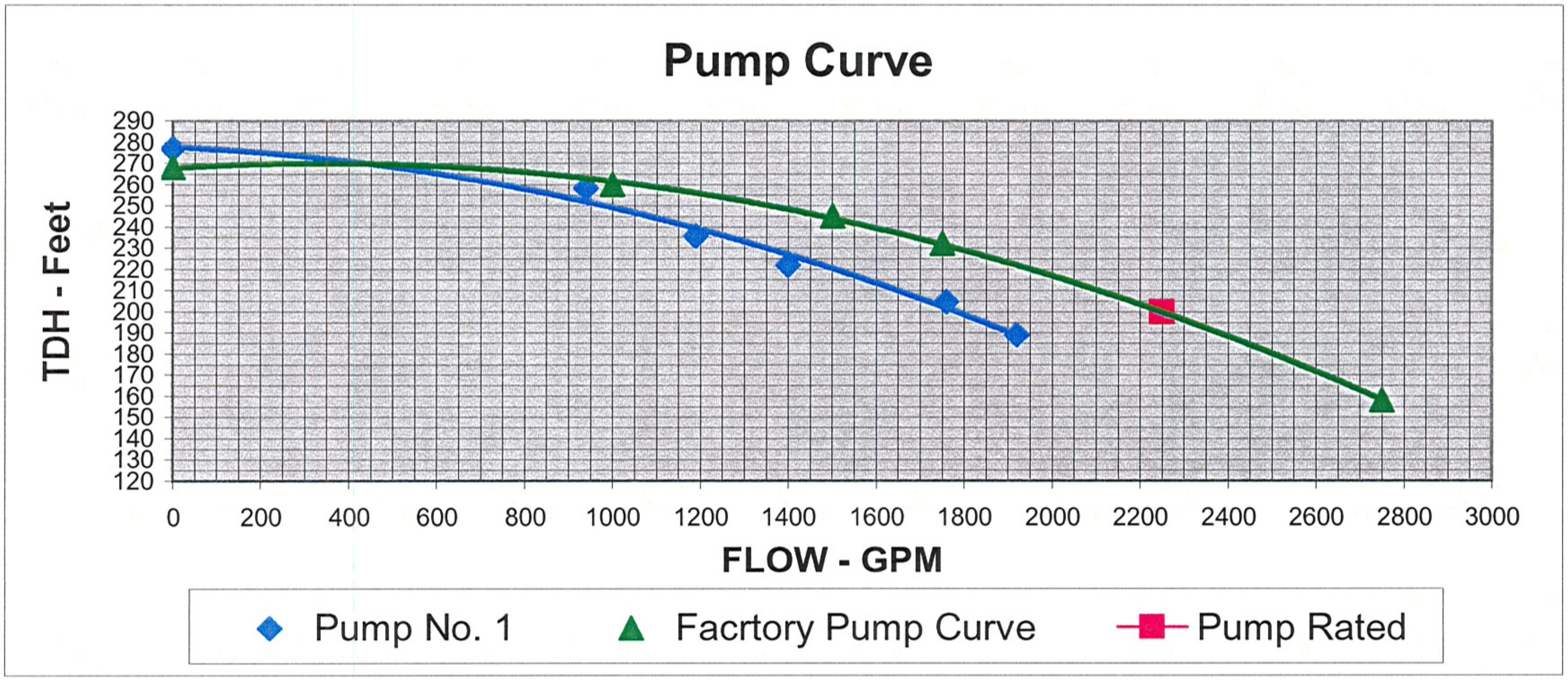
Date of Test	-	October 7, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5	Test Point No. 6
Discharge - gpm.	1,920	1,760	1,400	1,190	940	0
Discharge Head-ft.	180	196	215	230	254	272
Suction Head-ft.	-9	-8	-7	-6	-5	-5
Total Dynamic Head-ft.	189	205	222	236	258	277
Horsepower Out-hp.	92	91	79	71	61	0

Station Meter Flow Rate (gpm)	1,935
Percent Difference	1%

Pump Performance Test
Piqua, Ohio
Water Treatment Plant

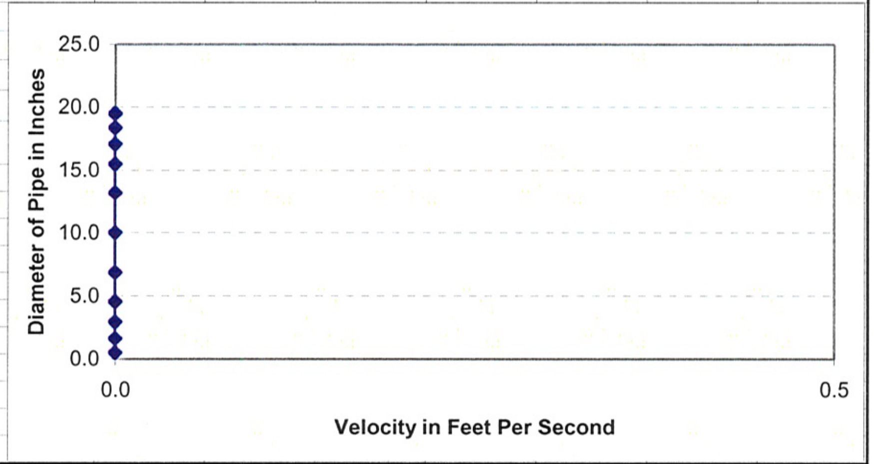
Test #	Pump No. 1			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1920	78	189	2750	158	2250	200
2	1760	85	205	2250	200		
3	1400	93	222	1750	232		
4	1190	100	236	1500	245		
5 - Valve Closed	940	110	258	1000	260		
	0	118	277	0	268		



Piqua OH | **Water Treatment Plant - Back Tap**

Calipered Diameter:	20
Corp. Cock Proj.:	0
Velocity Factor:	1.250
Flow Rate in mgd.:	0.00

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.513	0 1/2		2.147835	0.000	0.000
2	1.633	1 5/8		2.14978	0.000	0.000
3	2.929	2 15/16		2.15203	0.000	0.000
4	4.523	4 1/2		2.154797	0.000	0.000
5	6.838	6 13/16		2.158816	0.000	0.000
6	10.000	10		2.164306	0.000	0.000
7	13.162	13 3/16		2.169795	0.000	0.000
8	15.477	15 1/2		2.173814	0.000	0.000
9	17.071	17 1/16		2.176582	0.000	0.000
10	18.367	18 3/8		2.178832	0.000	0.000
11	19.487	19 1/2		2.180776	0.000	0.000



Piqua, Ohio
Water Treatment Plant
Pump No. 2

Name Plate Data

Make	-	Worthington 6CLBS	
Head	-	na	feet
Speed	-	na	rpm.
Discharge	-	na	gpm.
Serial #	-	735856	

Test Data

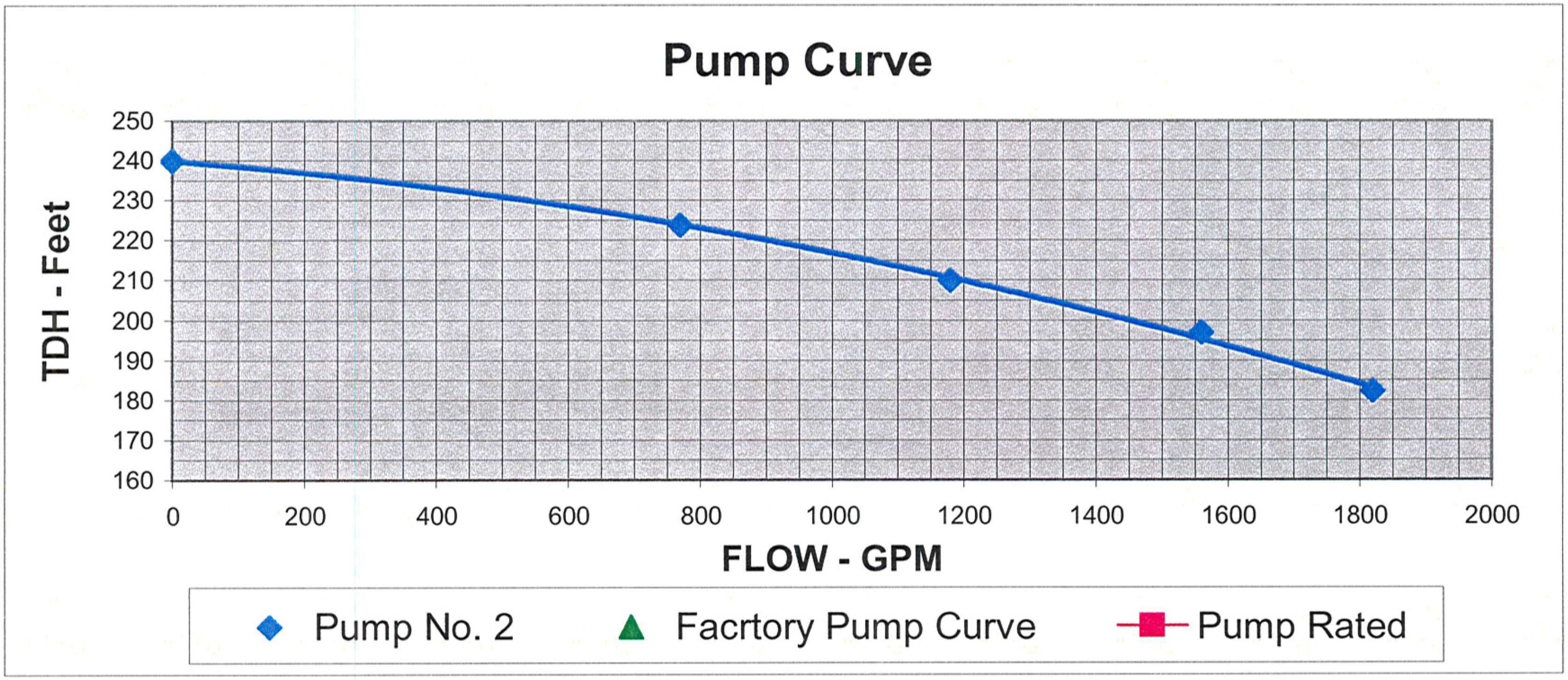
Date of Test	-	October 7, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	1,820	1,560	1,180	770	0
Discharge Head-ft.	180	196	209	224	240
Suction Head-ft.	-2	-1	-1	0	0
Total Dynamic Head-ft.	182	197	210	224	240
Horsepower Out-hp.	84	78	63	44	0

Station Meter Flow Rate (gpm)	Meter Dead
Percent Difference	na

Pump Performance Test
Piqua, Ohio
Water Treatment Plant

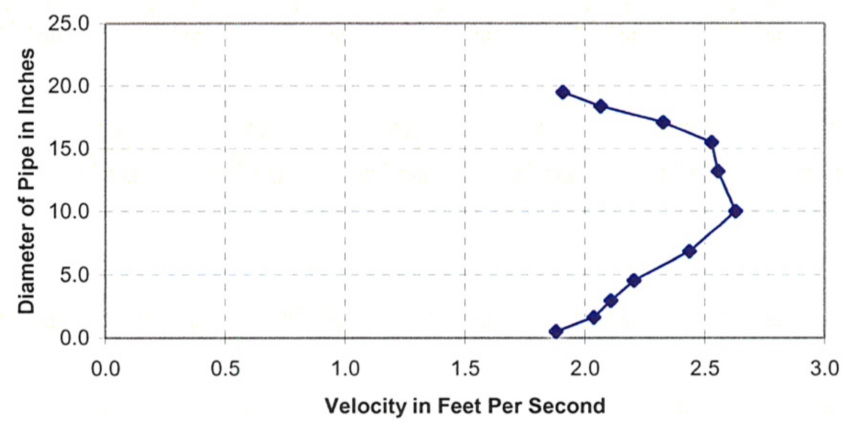
Test #	Pump No. 2			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	1820	78	182				
2	1560	85	197	No Factory Curve Available		No Factory Curve Available	
3	1180	91	210				
4	770	97	224				
5 - Valve Closed	0	104	240				



Piqua OH — **Water Treatment Plant - Front Tap**

Calipered Diameter:	20
Corp. Cock Proj.:	0
Velocity Factor:	0.839
Flow Rate in mgd.:	3.10

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.513	0 1/2	0.878	2.147835	0.937	1.881
2	1.633	1 5/8	1.03	2.14978	1.015	2.039
3	2.929	2 15/16	1.1	2.15203	1.049	2.109
4	4.523	4 1/2	1.2	2.154797	1.095	2.206
5	6.838	6 13/16	1.46	2.158816	1.208	2.438
6	10.000	10	1.69	2.164306	1.300	2.629
7	13.162	13 3/16	1.59	2.169795	1.261	2.557
8	15.477	15 1/2	1.55	2.173814	1.245	2.529
9	17.071	17 1/16	1.31	2.176582	1.145	2.328
10	18.367	18 3/8	1.03	2.178832	1.015	2.066
11	19.487	19 1/2	0.878	2.180776	0.937	1.909



Piqua, Ohio
Water Treatment Plant
Pump No. 3

Name Plate Data

Make	-	Crane - BF	
Head	-	200	feet
Speed	-	1,750	rpm.
Discharge	-	3,500	gpm.
Serial #	-	DC-525 347	

Test Data

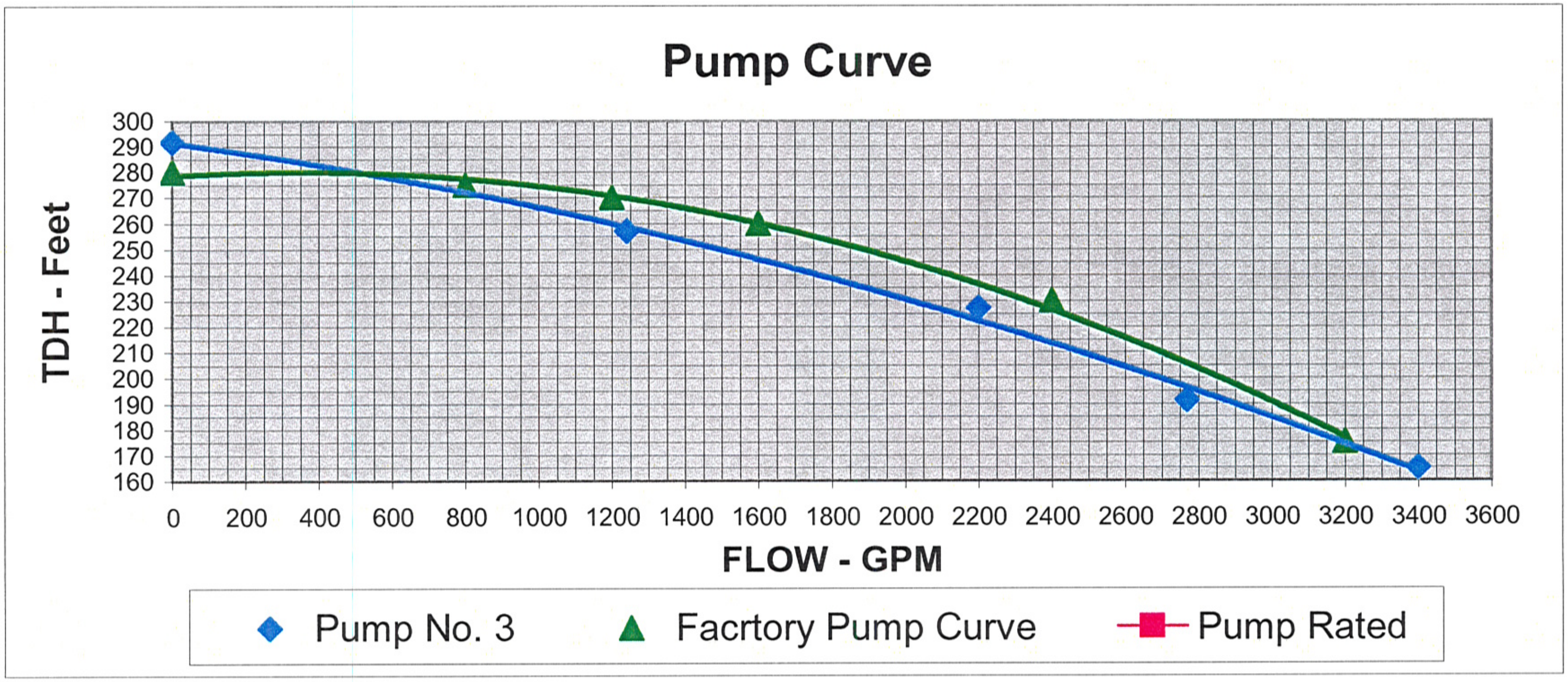
Date of Test	-	October 7, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	3,400	2,770	2,200	1,240	0
Discharge Head-ft.	158	185	221	253	288
Suction Head-ft.	-7	-7	-6	-5	-3
Total Dynamic Head-ft.	165	191	227	257	292
Horsepower Out-hp.	142	134	126	81	0

Station Meter Flow Rate (gpm)	Meter Dead
Percent Difference	na

Pump Performance Test
Piqua, Ohio
Water Treatment Plant

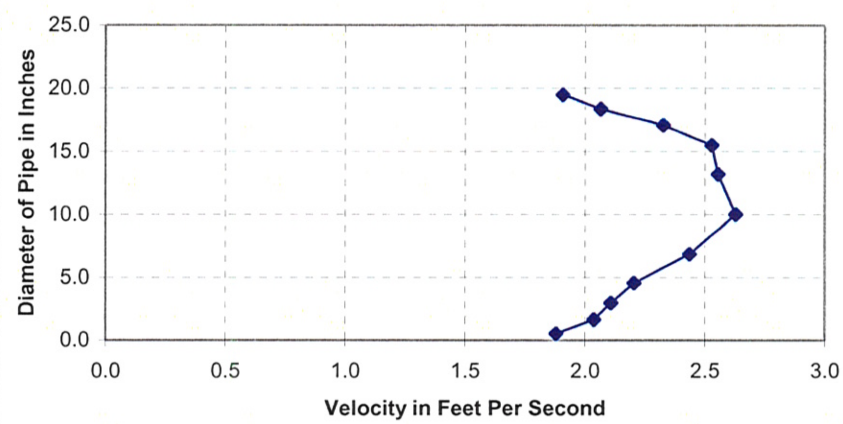
Test #	Pump No. 3			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	3400	69	165	3200	175		
2	2770	80	191	2400	230		
3	2200	96	227	1600	260		
4	1240	110	257	1200	270		
5 - Valve Closed	0	125	292	800	275		
				0	280		



Piqua OH — Water Treatment Plant - Front Tap

Calipered Diameter:	20
Corp. Cock Proj.:	0
Velocity Factor:	0.839
Flow Rate in mgd.:	3.10

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.513	0 1/2	0.878	2.147835	0.937	1.881
2	1.633	1 5/8	1.03	2.14978	1.015	2.039
3	2.929	2 15/16	1.1	2.15203	1.049	2.109
4	4.523	4 1/2	1.2	2.154797	1.095	2.206
5	6.838	6 13/16	1.46	2.158816	1.208	2.438
6	10.000	10	1.69	2.164306	1.300	2.629
7	13.162	13 3/16	1.59	2.169795	1.261	2.557
8	15.477	15 1/2	1.55	2.173814	1.245	2.529
9	17.071	17 1/16	1.31	2.176582	1.145	2.328
10	18.367	18 3/8	1.03	2.178832	1.015	2.066
11	19.487	19 1/2	0.878	2.180776	0.937	1.909



Piqua, Ohio
Water Treatment Plant
Pump No. 4

Name Plate Data

Make	-	Allis Chalmers 18VTO
Head	-	195 feet
Speed	-	1,750 rpm.
Discharge	-	4,200 gpm.
Serial #	-	69198T

Test Data

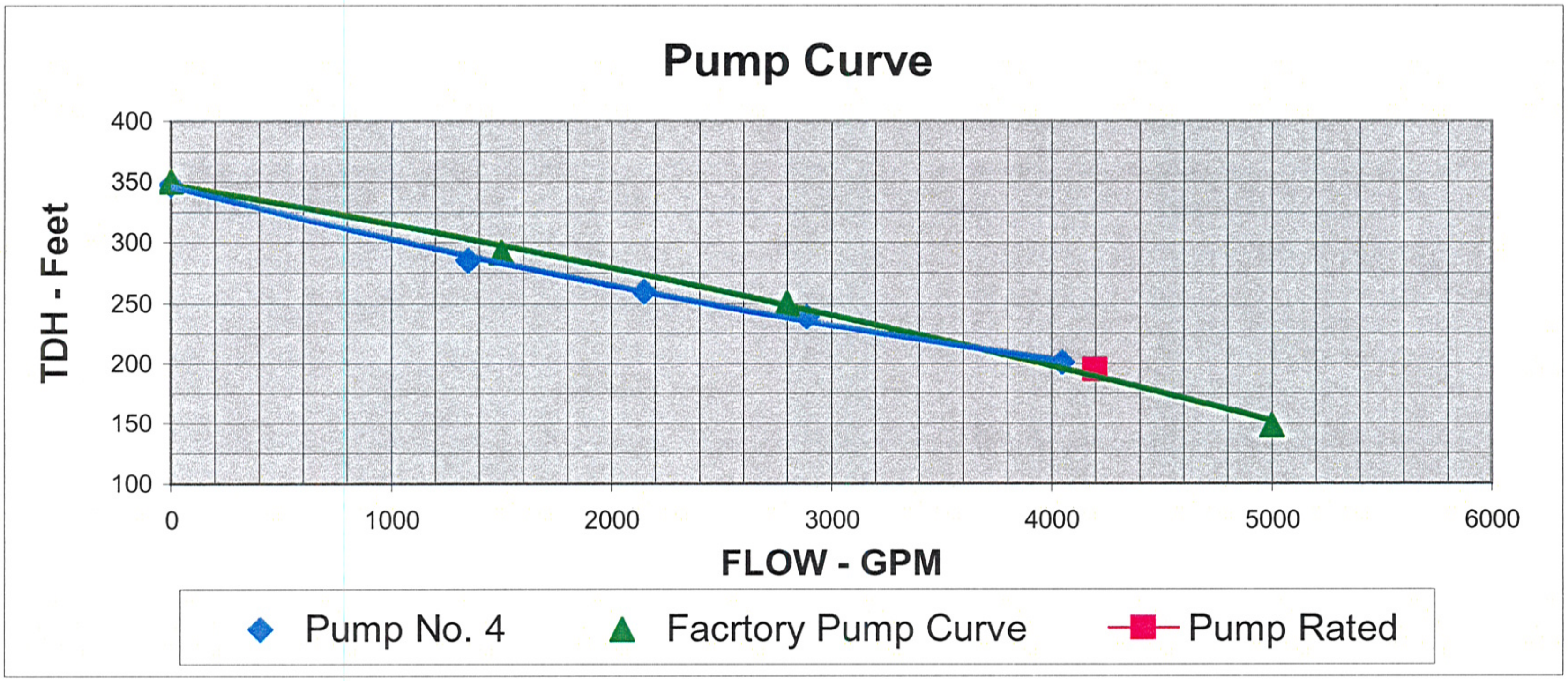
Date of Test	-	October 7, 2011
Test Condition	-	Normal
Engineer/Tech	-	Calder / Fisher

	Test Point No. 1	Test Point No. 2	Test Point No. 3	Test Point No. 4	Test Point No. 5
Discharge - gpm.	4,050	2,890	2,150	1,350	0
Discharge Head-ft.	195	233	254	279	341
Suction Head-ft.	-6	-6	-6	-6	-6
Total Dynamic Head-ft.	201	239	260	285	348
Horsepower Out-hp.	205	174	141	97	0

Station Meter Flow Rate (gpm) Meter Dead
Percent Difference na

Pump Performance Test
Piqua, Ohio
Water Treatment Plant

Test #	Pump No. 4			Facrtory Pump Curve		Pump Rated	
	Flow-gpm	Press. - psi	TDH-ft	Flow-gpm	TDH-ft	Flow-gpm	TDH-ft
1 - Valve Open	4050	85	201	5000	148	4200	195
2	2890	101	239	4200	195		
3	2150	110	260	2800	250		
4	1350	121	285	1500	292		
5 - Valve Closed	0	148	348	0	350		



Piqua OH — **Water Treatment Plant - Front Tap**

Calipered Diameter:	20
Corp. Cock Proj.:	0
Velocity Factor:	0.839
Flow Rate in mgd.:	3.10

Reading #	Position	Setting	PCR-in.			Vel., fps
1	0.513	0 1/2	0.878	2.147835	0.937	1.881
2	1.633	1 5/8	1.03	2.14978	1.015	2.039
3	2.929	2 15/16	1.1	2.15203	1.049	2.109
4	4.523	4 1/2	1.2	2.154797	1.095	2.206
5	6.838	6 13/16	1.46	2.158816	1.208	2.438
6	10.000	10	1.69	2.164306	1.300	2.629
7	13.162	13 3/16	1.59	2.169795	1.261	2.557
8	15.477	15 1/2	1.55	2.173814	1.245	2.529
9	17.071	17 1/16	1.31	2.176582	1.145	2.328
10	18.367	18 3/8	1.03	2.178832	1.015	2.066
11	19.487	19 1/2	0.878	2.180776	0.937	1.909