Memorandum

To: *City of Franklin IWRP Team*

From: *CDM Smith*

Date: *January 2012*

Subject: *City of Franklin Integrated Water Resources Plan (IWRP)*
Water Distribution System Improvements Modeling (79935.T1.WDIST)

Executive Summary

As part of the development of its Integrated Water Resources Plan (IWRP), the City of Franklin (COF) has undertaken an evaluation of its water distribution system. This evaluation included a review of the existing water distribution system hydraulic model, primarily focusing on reducing the high water age in portions of the COF system, as well as a long-term review of the hydraulic capacity of the system under build-out demand conditions.

As part of the water age review, both operational and infrastructure recommendations have been included in this technical memorandum. CDM Smith has recommended a total of nine (9) projects for implementation to reduce the water age to less than a week, based on 2010 average day demand conditions, in efforts to maintain compliance with disinfection by-product (DBP) regulations. The estimated cost of implementation of these recommended improvements is $2.1M. In addition to these improvements, CDM Smith installing a new, comprehensive SCADA system, which would allow the COF to improve the monitoring and operation of the distribution system. The estimated cost of a new system-wide SCADA system is approximately $830,000.

Distribution system improvements have also been recommended to provide adequate transmission for long-term demands in the southern section of the service area. The total estimated cost of these projects is $5.9M. The timing of these hydraulic improvements will be based on the continued development and population growth in the southern portion of the City.

Finally, in addition to providing a more economical water supply, an upgrade to the existing water treatment plant (WTP) from a maximum capacity of 2.1 million gallons per day (MGD) to 4 MGD, in conjunction with implementing the treatment upgrades recommended in the CDM Smith technical memorandum dated August 2011, *Review of CTE Design Report: Franklin Water Treatment Plant dated July 2006*, would improve water quality in the central and southern extents of the distribution system. This would also provide the operators greater flexibility when operating the distribution system. The increased capacity of the WTP would provide a greater level of in the event the Harpeth Valley Utility District (HVUD) water supply was not available.

1.0 Introduction

As part of the development of its Integrated Water Resources Plan (IWRP), the City of Franklin (COF), with the assistance of CDM Smith, has undertaken an evaluation of its water distribution system. The evaluation consisted of two primary tasks:

- Review of the existing water distribution system, primarily focusing on reducing the high water age within the COF system. The COF water system has exceeded limits for haloacetic acids at sampling locations in more than one quarterly sample over the past two years and has until October 2012 to reduce these concentrations to remain compliant with Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 D/DBPR). The Stage 2 D/DBPR was promulgated in January 2006 and required systems to first conduct an Initial Distribution System Evaluation (IDSE) to identify compliance monitoring sites for the Disinfection Byproduct Maximum Contaminant Levels (DBP MCLs). The Stage 2 D/DBPR will apply the current compliance standards of running annual average (RAA) of 80 micrograms per liter (µg/L) for TTHMs and 60 µg/L of the sum of the five regulated haloacetic acids (HAA5) to individual locations in the distribution system. The change to a location-specific basis for regulating DBPs will have a potential effect on the measures required to achieve compliance, because each location must comply with the DBP MCLs. The water distribution system experiences high water age throughout the year contributing to the formation of excessive DBPs. The Stage 2 D/DBPR is discussed in greater detail in the technical memorandum *Review of CTE/AECOM Design Report: Franklin Water Treatment Plant, dated July 2006*, from CDM Smith,
- Assess the long-term hydraulic capacity of the distribution system for future projected demands.

This technical memorandum presents the findings and recommendations of both tasks. These evaluations were conducted using an existing computer hydraulic model of the water distribution system, previously calibrated by CTE in 2009 to tracer testing. The existing model is represented in the WaterGEMS V8i platform. WaterGEMS is a proprietary software produced by Bentley Systems, Incorporated.

2.0 Distribution System Overview and Operation

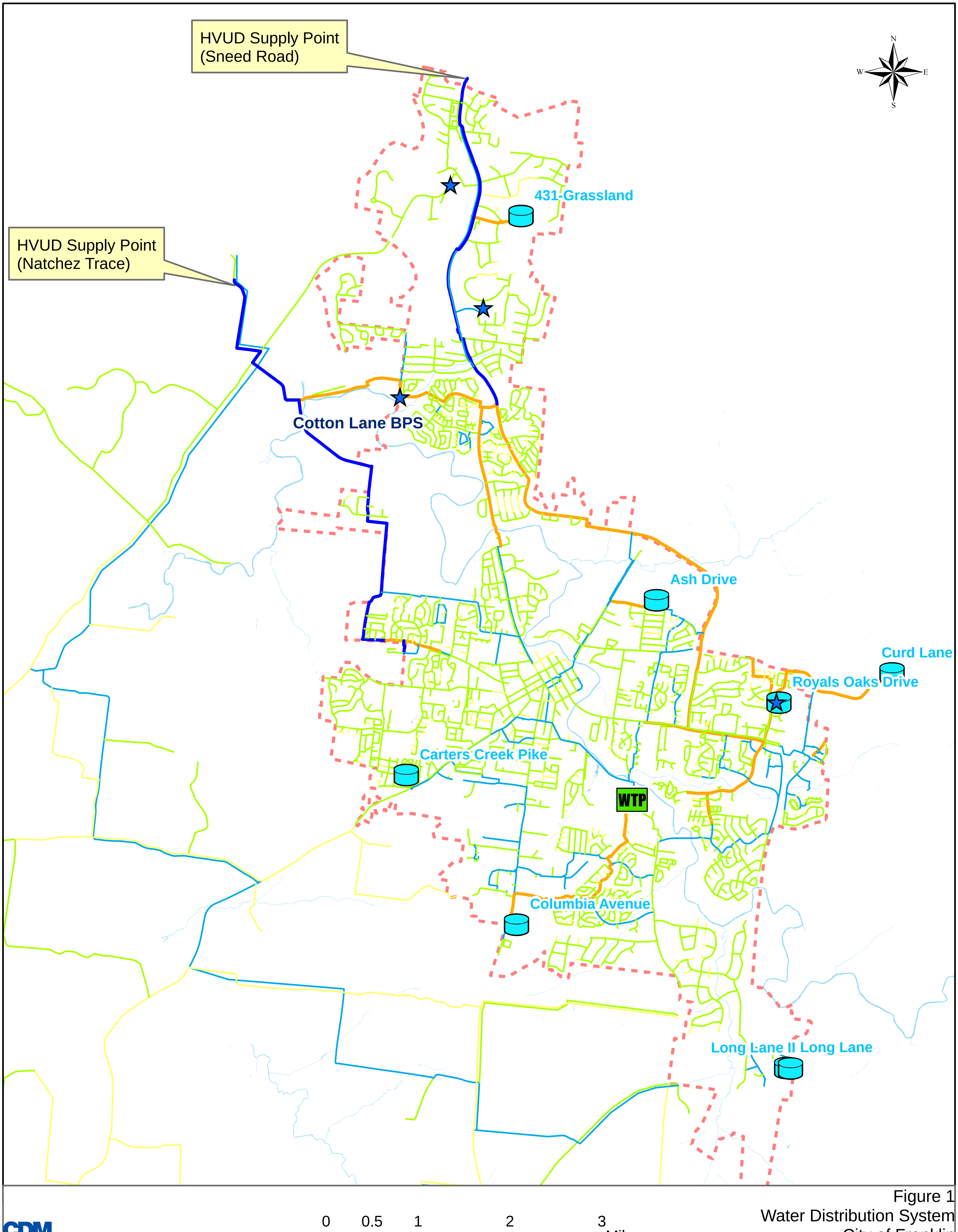
The COF water distribution system is located in Williamson County, Tennessee, and spans approximately 19,300 acres. The 2010 average day and maximum day water demands were 6.3 and 8.5 MGD, respectively. The system is comprised of nearly 500 miles of ¾-inch to 36-inch diameter mains. The Franklin water treatment plant, rated at a maximum capacity of 2.1 MGD, is located near the center of the distribution system, along the Harpeth River on Lewisburg Highway (State Road 431). To meet the demands of the system, water is also provided by a wholesale utility, Harpeth Valley Utility District (HVUD), through two connection points located at the northern end of the system. An overview of the COF distribution system as well as a hydraulic profile of the system is provided in **Figures 1** and **2**, respectively.

The majority of the COF distribution system is well looped with 12-inch to 36-inch diameter trunk transmission mains. The central portion of the system contains smaller diameter trunk mains, mainly 12-inch and 16-inch, which convey water from the Franklin WTP. The northern portion of the system contains the larger diameter trunk mains (20-inch to 36-inch) which convey water from the HVUD connection points into the remaining portions of the CoF system. The Cotton Lane booster pump station (BPS) is utilized to boost flow from the western HVUD connection point (Natchez Trace connection point) to the rest of the distribution system; the Cotton Lane BPS is primarily used during summer months when the COF is experiencing high demand periods.

There are 7 ground storage tanks with a total system storage capacity of 10 million gallons (MG). There are plans to replace the existing Long Lane 0.5-million-gallon storage tank with the new Long Lane II 2-million-gallon storage tank in early 2012, which will result in a total system storage capacity of 11.5 MG.

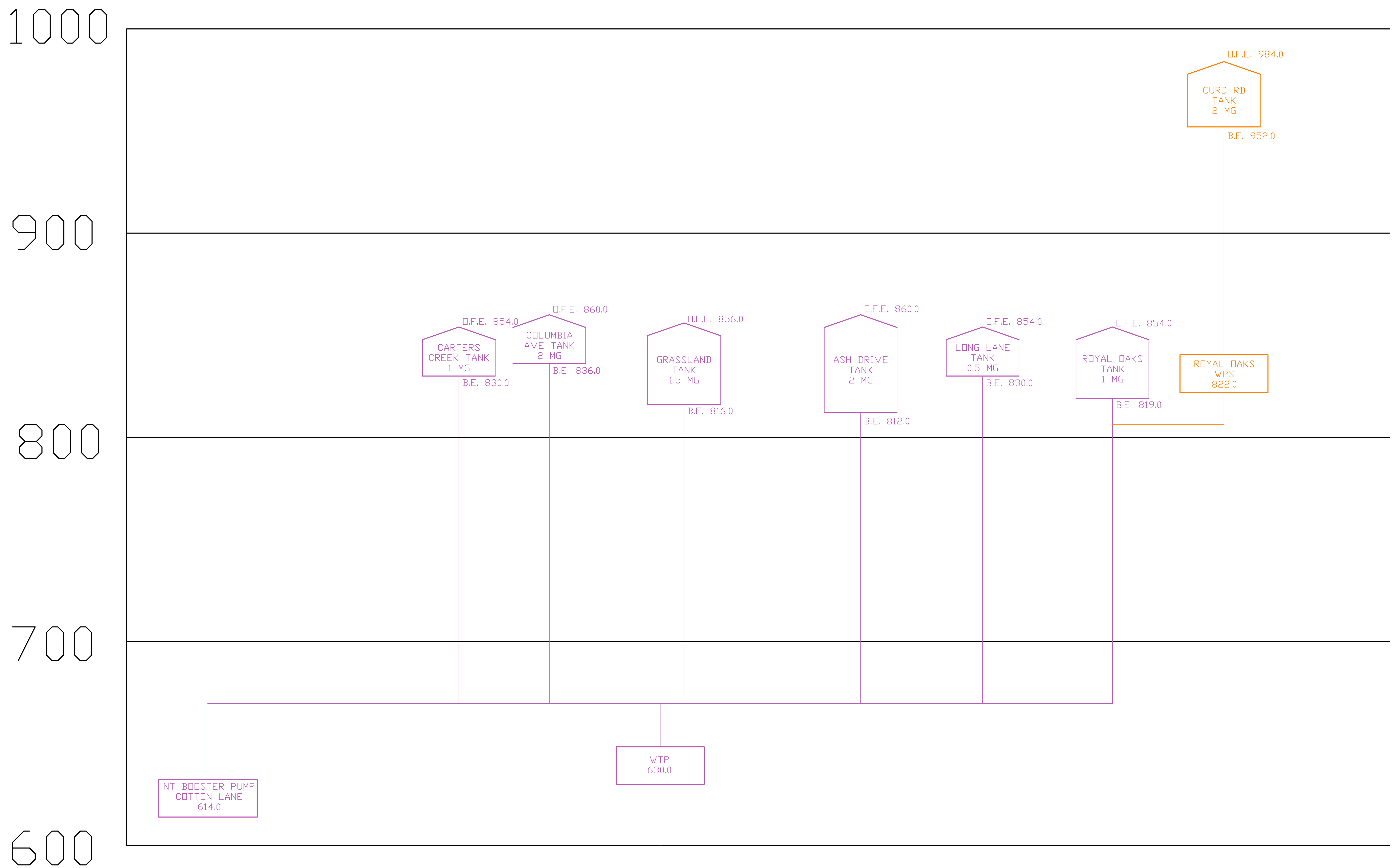
The COF system has two primary pressure zones: a low pressure zone and high pressure zone. The majority of the system is maintained on the same hydraulic gradeline in the low pressure zone; six storage tanks with a combined capacity of 8 MG are located in the low pressure zone. The storage tanks have overflow elevations ranging from 854 feet to 860 feet.

The high pressure zone is served by a single pump station, Royal Oaks Drive, which is used to lift flow from the low pressure zone to the Curd Road Tank. The 2 MG Curd Road Tank serves the eastern portion of the COF service area has an overflow elevation of 984 feet. Two smaller pump stations, Legends Ridge BPS and Hidden River BPS, are located toward the northern portion of the system and are used to boost flow from the low pressure zone to isolated neighborhoods. There are no storage tanks are used in these areas.



CDM

Figure 1
Water Distribution System
City of Franklin



REV. NO.	DATE	DRWN	CHKD	REMARKS

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APPROVED BY:
DATE: 10-4-10

CDM Camp Dresser & McKee Inc.
consulting engineering construction operations

HYDRAULIC GRADIENT CHART
FRANKLIN WATER DISTRIBUTION SYSTEM

PROJECT NO.
FILE NAME:

SHEET NO.
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3.0 System Water Age Conditions

High water age is one of the conditions, and most directly correlated parameters leading to excessive DBP formation. This factor is considered the primary indicator for evaluating DBP formation potential in a water distribution system. In the COF distribution system, high water age is due to several related factors:

- Purchased water from HVUD is delivered to the COF distribution system at a higher hydraulic grade line elevation than the COF tank overflow elevations. Discharge pressures at both HVUD metered supply points are controlled by a partially closed, manually operated valve to increase headloss between the two utilities to reduce pressure. The amount of headloss resulting from this operation is not systematic or measured. The current valve setting results in a downstream hydraulic grade line elevation that is higher than the operating level of the storage tanks, thus hindering tank turnover.

- The COF system has a high storage to demand ratio (11.5 MG of storage compared to 6.3 MGD average daily demand) which limits tank turnover and little usage of the stored volume. This, along with aged water entering the system from HVUD combine to cause high water age in portions of the system and an increased DBP formation potential.

Information on the HVUD distribution system was limited at the time of this study; therefore the specific age of the water supplied from that system is unknown. Based on field testing results conducted in 2007, and 2008 cited in the July 2009 draft report titled <u>Drinking Water Quality Evaluation and Recommendations</u>, developed by Metcalf & Eddy/AECOM, in conjunction with Hazen and Sawyer, the total trihalomethanes (TTHM) and HAA5 concentration measured at the HVUD supply points are near or exceed the 60-percent Rule established by the Tennessee Department of Environment and Conservation (TDEC), in November 2008. The 60-percent Rule applies to utilities supplying water to neighbors through wholesale connection points to limit the TTHM and HAA5 concentration to 60 percent of the maximum contaminant limit (MCL), or 0.048 mg/L TTHM and 0.036 mg/L HAA5. Because the TTHM and HAA values have been measured close to, or exceeding 60 percent of the MCL, it was assumed water from HVUD had already aged by the time it reached the COF connection points. It is recommended that regular testing be conducted at these two connection points to better define the DBP concentrations entering the COF distribution system from HVUD.

With regard to tank storage, water age depends on turnover and mixing in the tank. To minimize water age, storage tanks are typically operated such that they feed peak demands during the day and are replenished during the night with a minimum of 20 percent to 30 percent of their tank volume cycled daily. To accomplish this, the storage volume in the system should approximate the average daily demand (ADD) in the system. Storage of at least one day of ADD is required by TDEC and stated in TDEC Community Public Water Design Criteria [Section 8.3.1],

> "The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems, a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage. In the absence of an acceptable engineering study of the amount of water the system needs to meet the customer demand and provide for fire emergencies, the projected 24-hour demand at the end of the planning period will be the minimum requirement for elevated storage. This requirement may be reduced when the source, treatment facilities, and pumps have sufficient capacity with standby power capability to supplement peak demands of the system."

The current COF distribution system allows flow from HVUD to directly feed a majority of the system demands. This mode of operation reduces the need for tanks to satisfy demand, thus resulting in minimal turnover. Because the storage to demand ratio is already high, this results in high water age in the storage tanks and their corresponding demand zones.

Figures 3 through 8 illustrate SCADA tank levels recorded in February, April, and August of 2010. These graphs show the limited occurrence of the drain/fill cycle in each tank. Altitude valves are currently used in most tanks to control tank volume. This is evident on the graphs because some tanks never achieve a maximum level (100-percent full) because the altitude valves effectively create a reduced overflow elevation which the tank level should not exceed.

As shown on Figures 3 through 8, the existing achieve minimal turnover over a 30-day period. Based on similar distribution systems in Tennessee, tank levels are typically operated to fluctuate enough to turn over the entire tank volume in 3 to -5 days, equating to approximately 20 - 30 percent daily turnover of the tank maximum volume. However, because of the large volume of aged water the COF system receives from HVUD, tanks in the COF system should be operated to achieve a recommended turnover rate closer to 40 percent, in a given 24-hour period, based on modeling results.

Figures 3 through 8 show gradually increasing tank levels during the month of February and portions of August, indicating the tanks did not empty or drain during that time. Additionally, some of the figures show a sharp drop in tank levels which is caused by the manually induced turnover emptying the tanks.

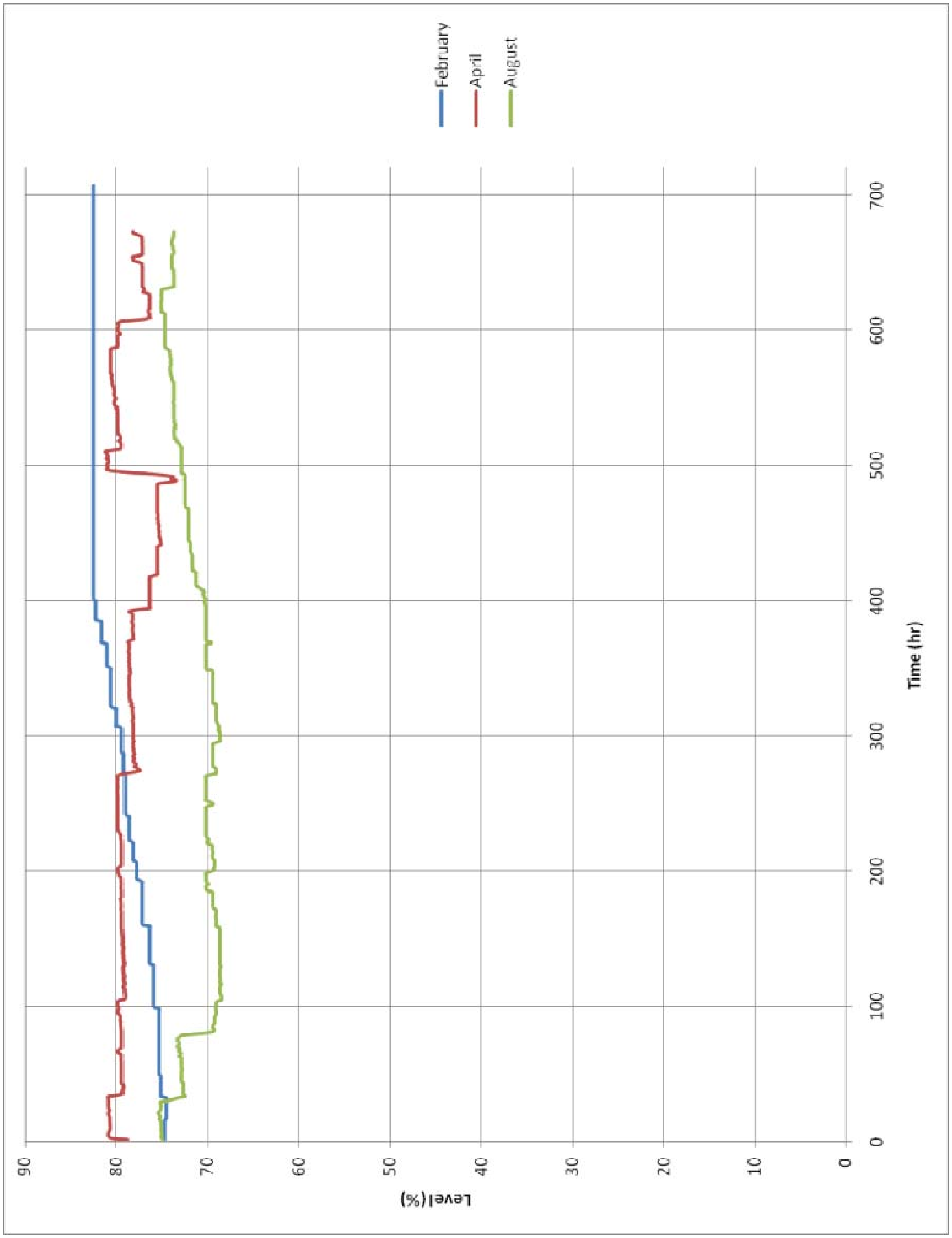


Figure 3
Ash Drive SCADA Recorded Tank Levels

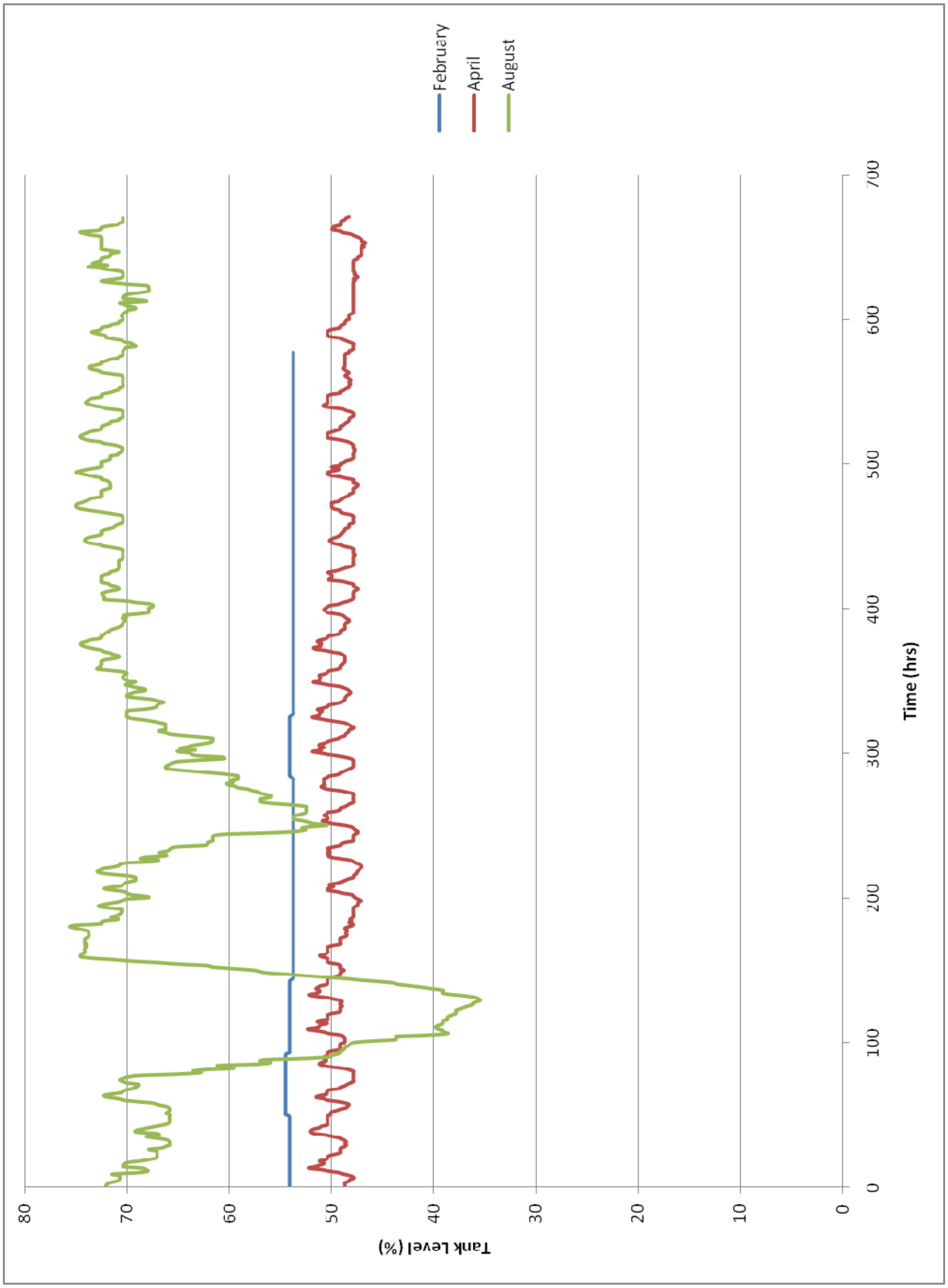


Figure 4
Grassland SCADA Recorded Tank Levels

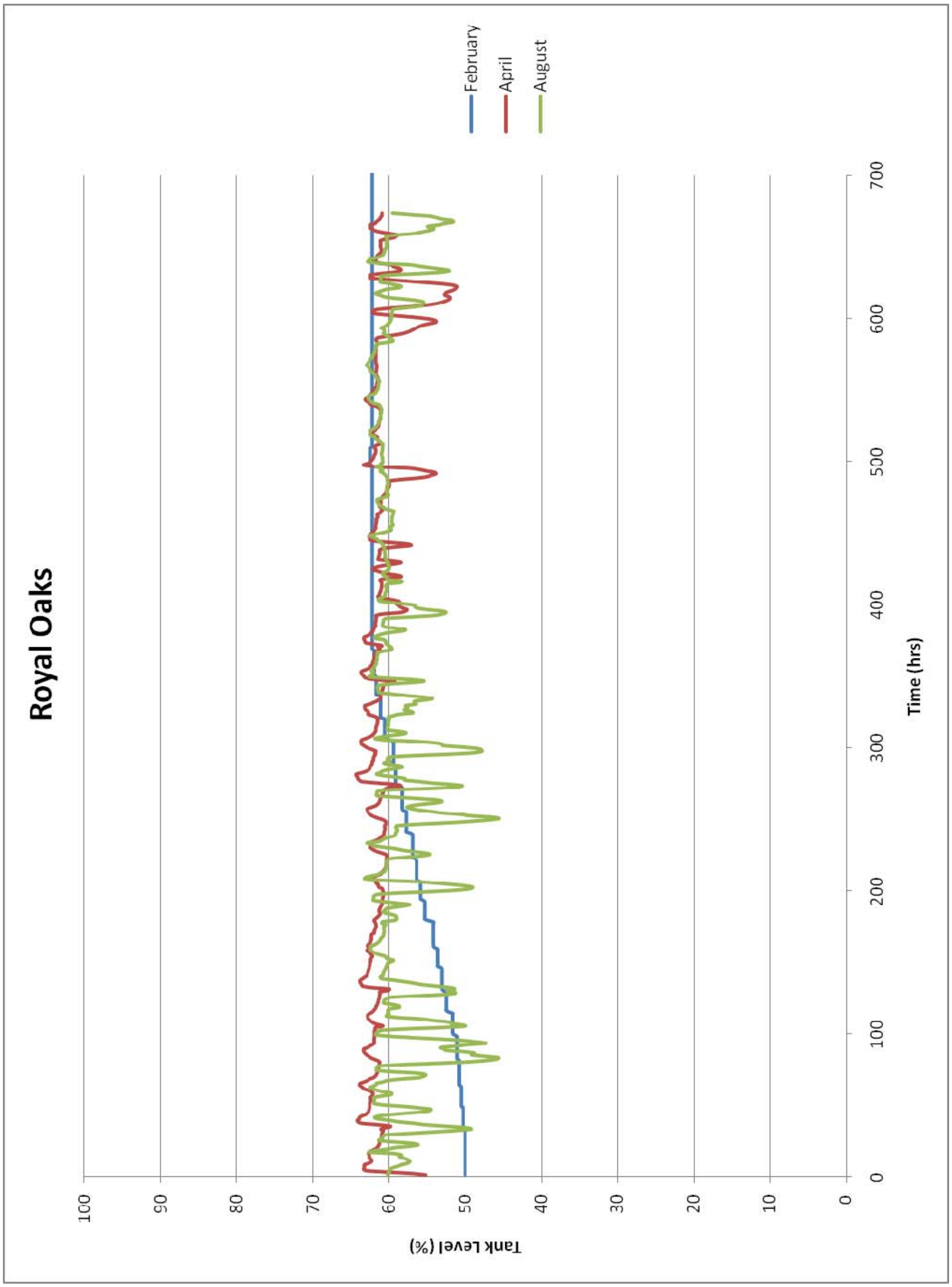


Figure 5
Royal Oaks SCADA Recorded Tank Levels

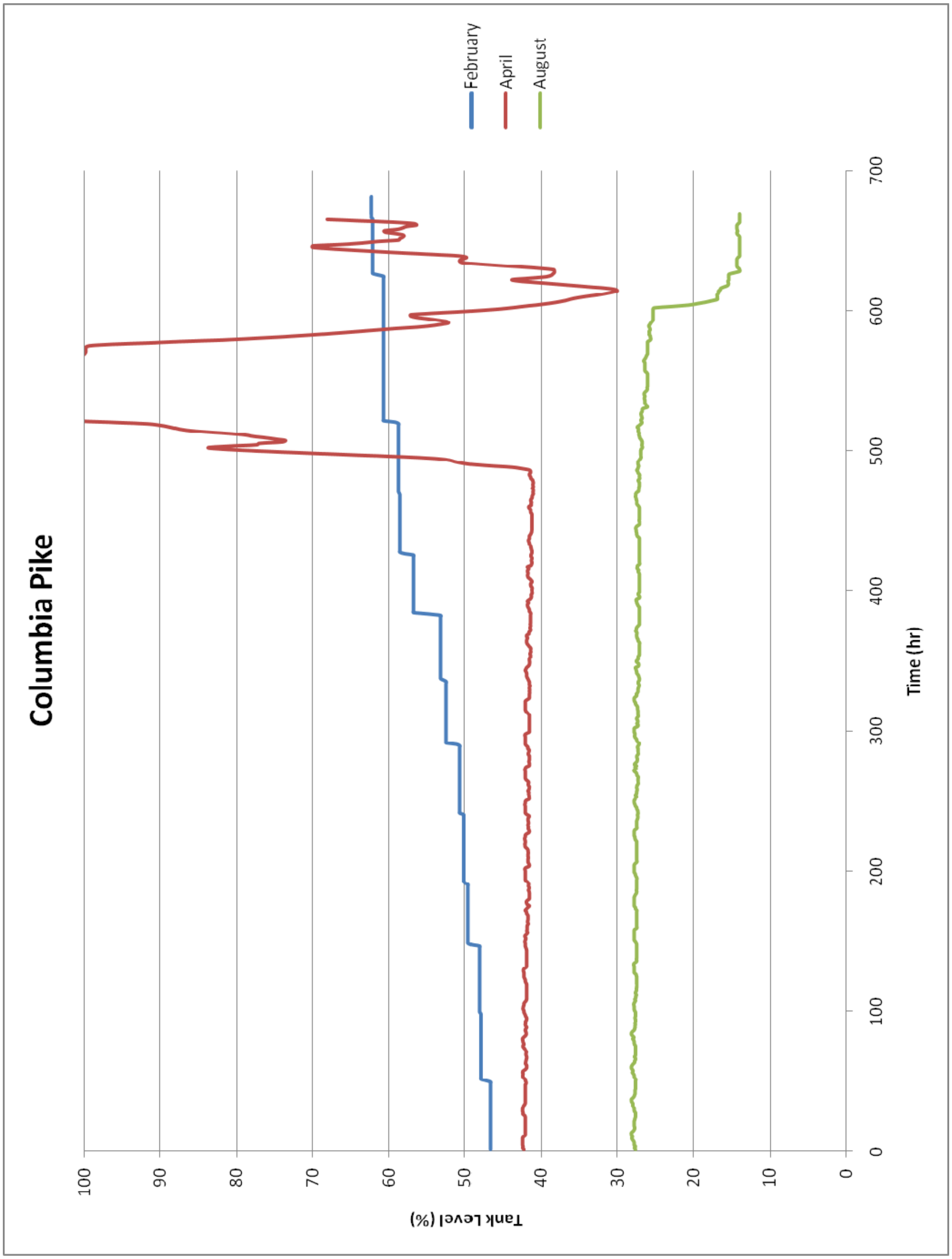


Figure 6
Columbia Avenue SCADA Recorded Tank Levels

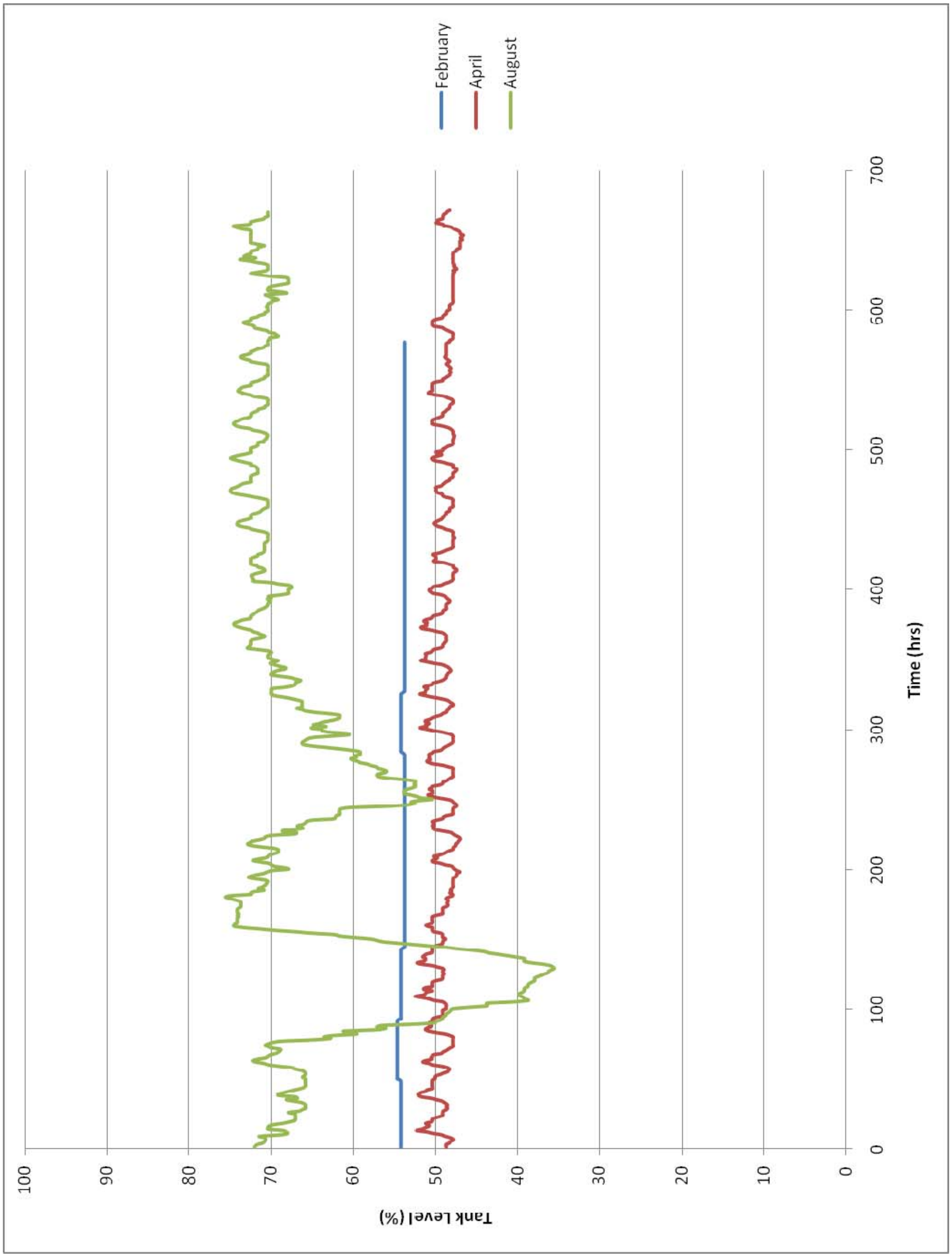


Figure 7
Carters Creek SCADA Recorded Tank Levels

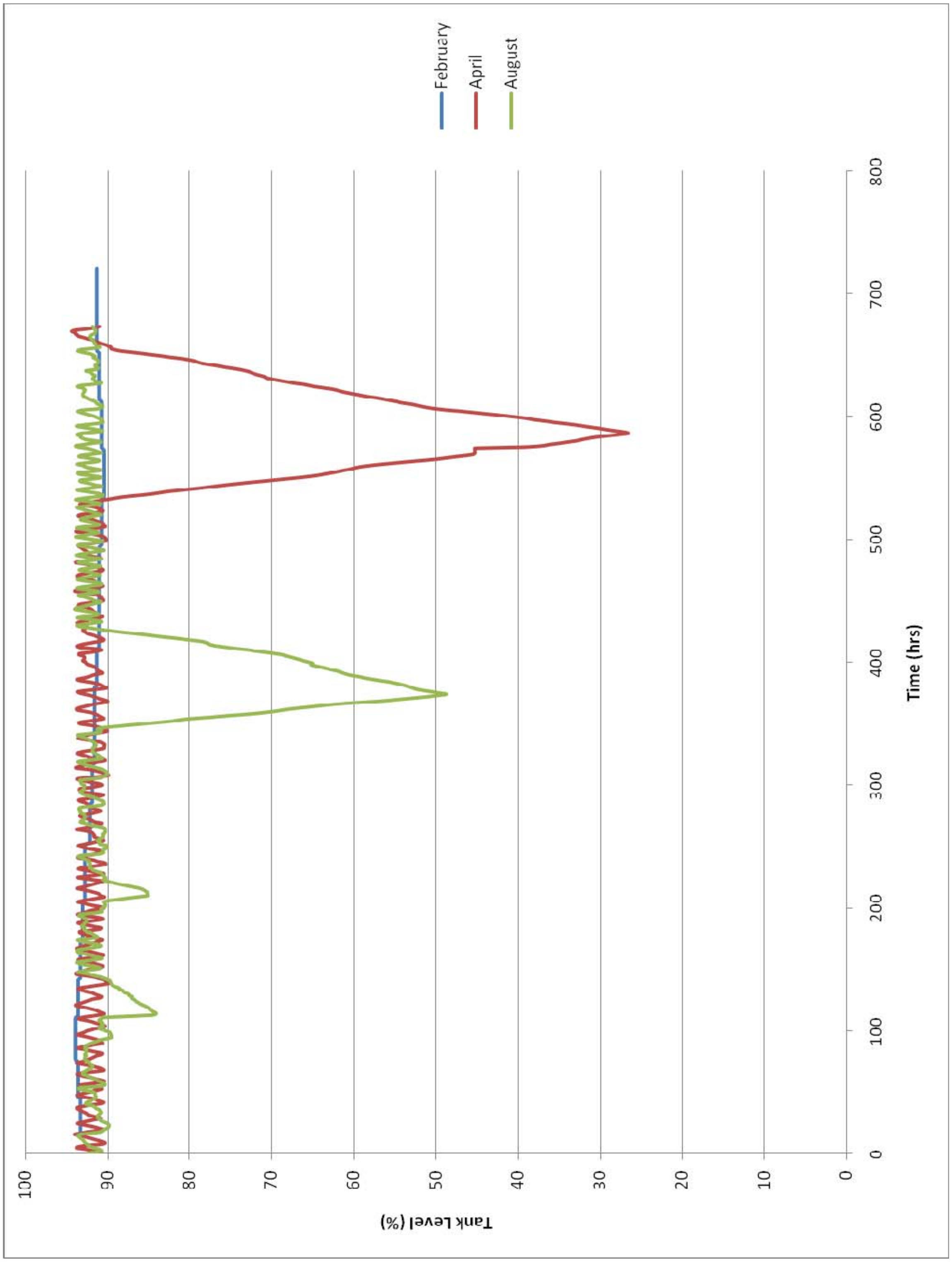


Figure 8
Curd Lane SCADA Recorded Tank Levels

4.0 Existing Water Age Analysis

The Franklin water distribution system model, in Bentley WaterGEMS software platform, was provided to CDM Smith by the COF for modeling the water age reduction alternatives. The model was originally developed by CTE for 2008 conditions and was used in the 2009 Report, *Drinking Water Quality Evaluation and Recommendations*. The COF hydraulic model was developed and calibrated by CTE in 2009. Based on customer billing data and recent SCADA data, demands in the system have not significantly changed since the 2009 calibration. It was assumed, as part of this study, that this model is accurate and no testing or calibration would be performed as directed by the client and documented in the IWRP project scope. However, several newly installed mains were added to the model in February 2011 because COF staff was able to provide information regarding these distribution system improvements, completed since 2008.

The water age analysis was conducted based on the existing (2010) average daily demand (ADD) of 6.3 MGD, assuming that water in the storage tanks is completely mixed, i.e., new water entering the tank is mixed with older water already existing in the tank. A review of the tank inlet/outlet configuration is recommended to ensure short circuiting is not occurring. An analysis of water age within the storage facilities was not included in this scope of work. It was also assumed that water entering the COF system from the HVUD supply points is 3-days old at the time of entry. This assumption may be low based on the testing results discussed in the 2009 CTE report *Drinking Water Quality Evaluation and Recommendations,* which indicated DBPs recorded during 2007 and 2008 at the HVUD supply points were close to, or exceeded 60 percent of the MCL. It was assumed, in the modeling analysis, that HVUD has taken steps to address the aging water and has reduced the water age since the 2007 and 2008 sampling, in an effort to comply with the 60-percent Rule.

Model simulations were conducted to simulate a 2-week period of average demand. Tank levels were compared to SCADA during ADD periods to verify that model tank and pump station operation is similar to field operation. Existing system water age was then analyzed based on the results of these simulations. Metrics utilized to evaluate existing water age included average system water age, number of pipes with maximum water age over 168 hours (7 days), ratio of storage to demand, and percent daily turnover in the storage tanks. Seven days was used as the criteria for maximum water age based on an industry standard for maximum DBP formation potential as described in Section 5710 of *Standard Methods for the Examination of Water and Wastewater (1998).*

Figure 9 illustrates the model predicted water age in the existing COF distribution system. As shown, areas of water age exceeding 1-week are located in the vicinity of the Ash Drive, Long Lane, Curd Lane, and Columbia Avenue storage tanks. As stated previously, the likely cause of high water age in these areas is already aged water entering the system from HVUD, higher hydraulic grade line from HVUD limiting tank turnover, and the large storage to demand. Additionally, isolated mains are shown with high water age in Figure 9; these are typically dead-end mains and may have very low demands applied to them in the model. This may not be representative of the actual demands in these areas and it is recommended to review recent billing data and re-allocate the demands in the model, if necessary, to verify that the correct parcel/meter demands are assigned to the correct main.

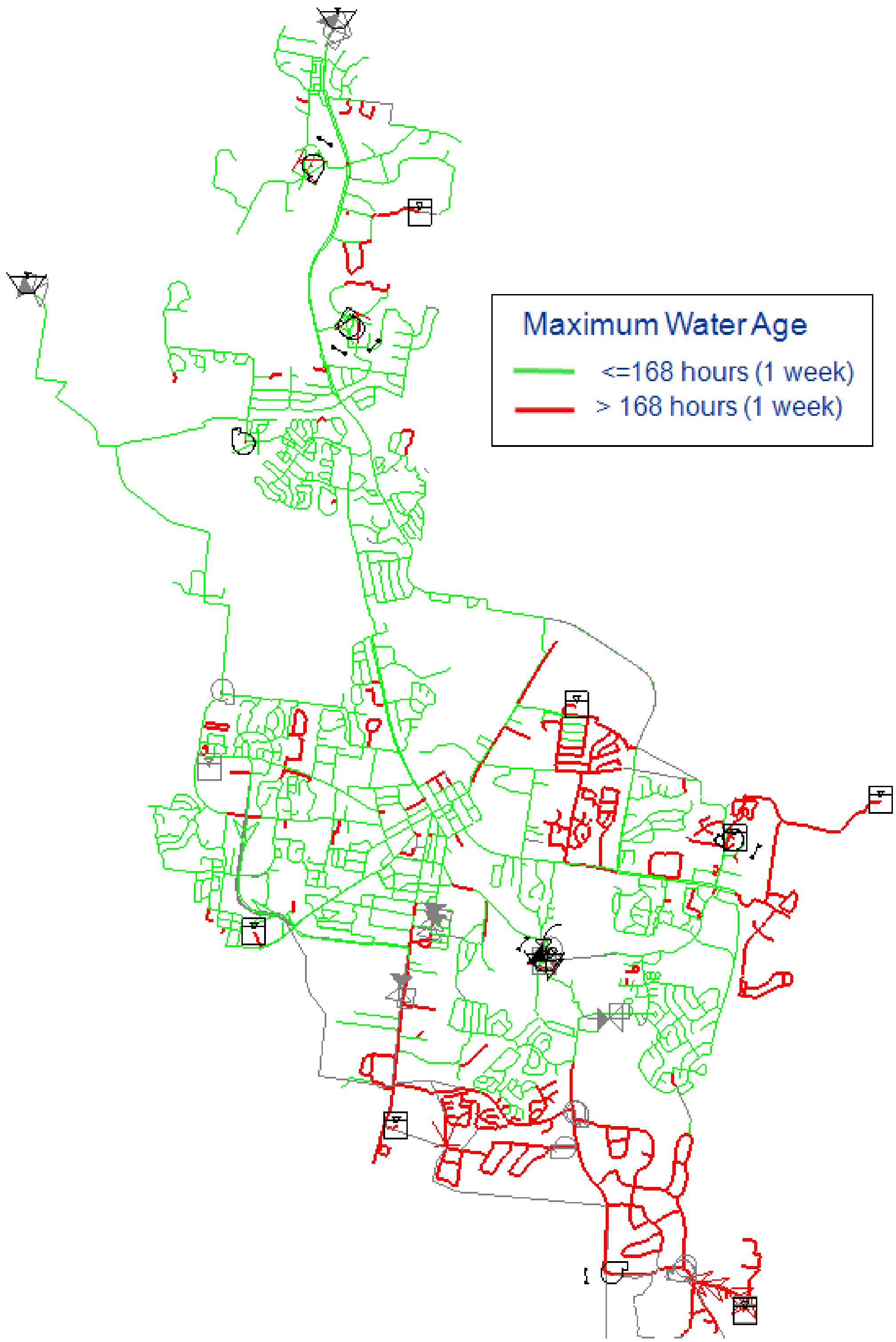


Figure 9 – Existing System Model Predicted Water Age

5.0 Water Age Reduction Modeling and Methodology

The COF's existing hydraulic water distribution system model was used to assess the estimated water age in the distribution system under various demand scenarios as well as develop potential solutions to reduce the estimated age. In addition to model evaluation, a review of the CTE water age evaluation titled "Drinking Water Quality Evaluation and Recommendations," dated July 2009 was conducted. Recommendations were developed from both analyses. The analyses were based on evaluation criteria, which were established based on discussions with the COF:

a. Maintain system pressure greater than 20 psi under all flow conditions TDEC Community Public Water Design Criteria [Section 9.0.1.c].

b. Maintain fire flows of at least 500 gpm with system pressure at minimum 20 psi, based on TDEC requirements (Chapter 324, Paragraph (18) of Rule 1200-5-1-17 Operations and Maintenance).

c. Maintain storage capacity equal to or exceeding 6.3 MG (equal to seasonal existing average daily demand). Based on the TDEC Community Public Water Design Criteria [Section 8.3.1], system storage shall equal or exceed the ADD. This provides emergency storage for one full day of ADD while minimizing hydraulic residence time and water age less than 168 hour.

d. Water age less than 168 hours in all pipes based on 7-day standard for maximum DBP formation potential [Section 5710 of *Standard Methods for the Examination of Water and Wastewater (1998]).*

e. Maintain average pipe velocity less than 5 feet per second (fps) and peak velocity less than 10 fps, based on AWWA guidelines which recommend a maximum design velocity of 10 fps, with velocities less than 5 fps as the desirable range.

To improve water age in the areas shown on Figure 9, the following goals were established:

a. Reduce the hydraulic grade line elevation from the two HVUD feeds in a controlled and measurable fashion to improve the hydraulic effectiveness of the existing storage facilities

b. Decrease the storage to demand ratio by either removing tanks which do not receive adequate turnover, operating them at lower levels (decrease storage), or by increasing the zone of influence of existing tanks (increase demand on individual tanks)

c. Increase the volume of new water to the southern extents of the COF system

The following options were evaluated in effort to reduce the water age in the COF's water distribution system without compromising other system parameters (pressure, fire flows):

a. Removal of tanks from service during low demand periods to reduce the storage to demand ratio. With seasonal demands varying on average from 79 percent of ADD in April to 135 percent ADD in the peak summer season, storage volumes could be regulated proportionally. Because demands are lower in winter, storage capacity could be reduced during winter months low and increased accordingly during late summer when demand is highest. This could be accomplished by removing select tanks from service and/or substantially reducing the maximum level in the tanks by lowering the system pressure head. These tanks could be temporarily returned to service during seasonal high demand periods as needed; however, this would require re-disinfecting prior to returning the tanks to service

b. Installation of pressure reducing valves at the two HVUD connection points to reduce downstream hydraulic grade line elevation to increase turnover and improve the hydraulic effectiveness of the existing storage facilities

c. Control of flow entering distribution system from HVUD connection points to allow the tanks to satisfy the peak demands, forcing them to drain and fill

d. Add transmission mains to minimize headloss in flow conveyance to tanks in the southern extent of the system; and install connector pipes to close localized loops at existing dead-end pipes

e. Add flushing at distal ends of dead-end pipes which would require greater than 100 ft of new pipe to connect back to the system via a loop

f. Install additional mains or add booster pump to improve tank filling on the southern end of the system and serve the elevated area around the Royal Oaks tank

g. Create pressure zones along the north-south split to allow operational pressure zones to isolate HVUD supply source from Franklin WTP supply source and vary tank operation based on supply pressures

6.0 Water Age Improvement Recommendations

Based on a combination of recommended improvements that were previously identified (Section 5.0) to improve water age in the system, it is anticipated that the COF can make significant improvements to the overall water age in the distribution system. The following improvements, shown on **Figure 11**, need to be implemented in sequential order, as presented, to effectively decrease water age:

1. *Reduce pressures from HVUD supply points.* Replace existing valves with pressure reducing valves (PRV) at the two HVUD supply points to regulate pressures in a controlled and measurable fashion. The PRVs should be adjustable so that the downstream pressure can be varied depending on the time of day. A reduction in the hydraulic grade line elevation of the HVUD supply improves the hydraulic effectiveness of the storage facilities. By decreasing HVUD pressures during the day (high demand period) and increasing HVUD pressures at night (low demand period), the PRVs allow storage tanks to naturally drain a percentage of storage during the day and fill from HVUD at night. An example of the PRV pressure variation over a day with the recommended PRV improvement implemented, is shown in **Figure 10**.

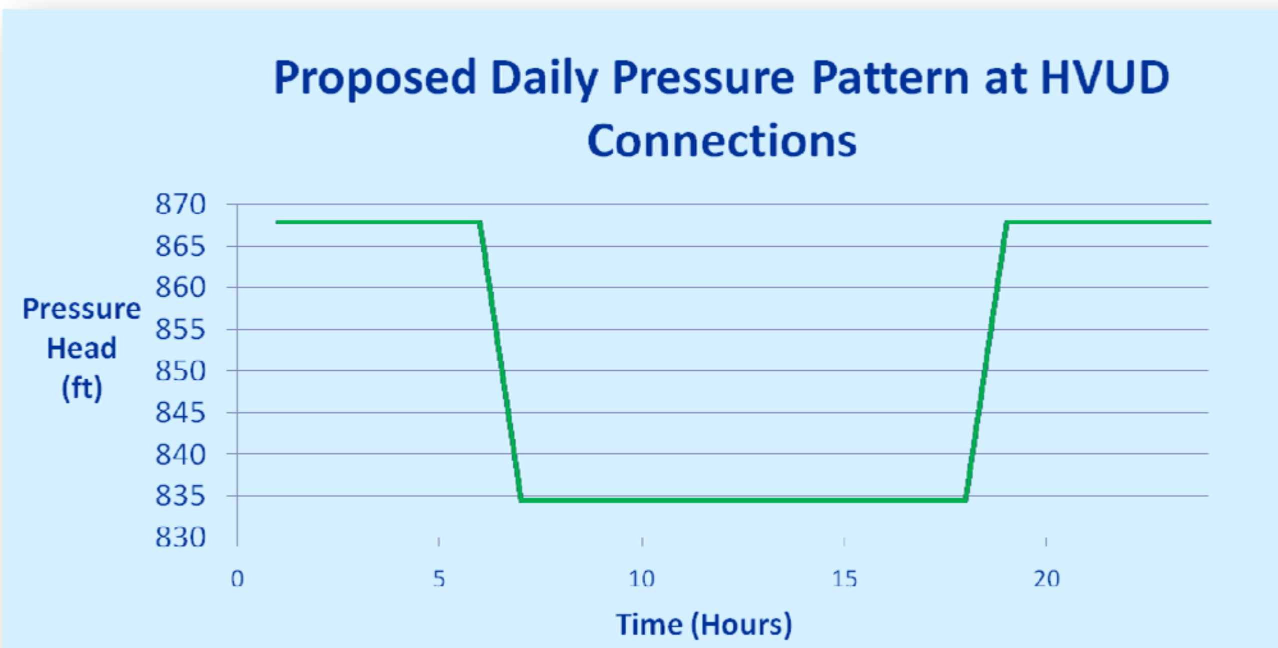


Figure 10
PRV Pressure Variation

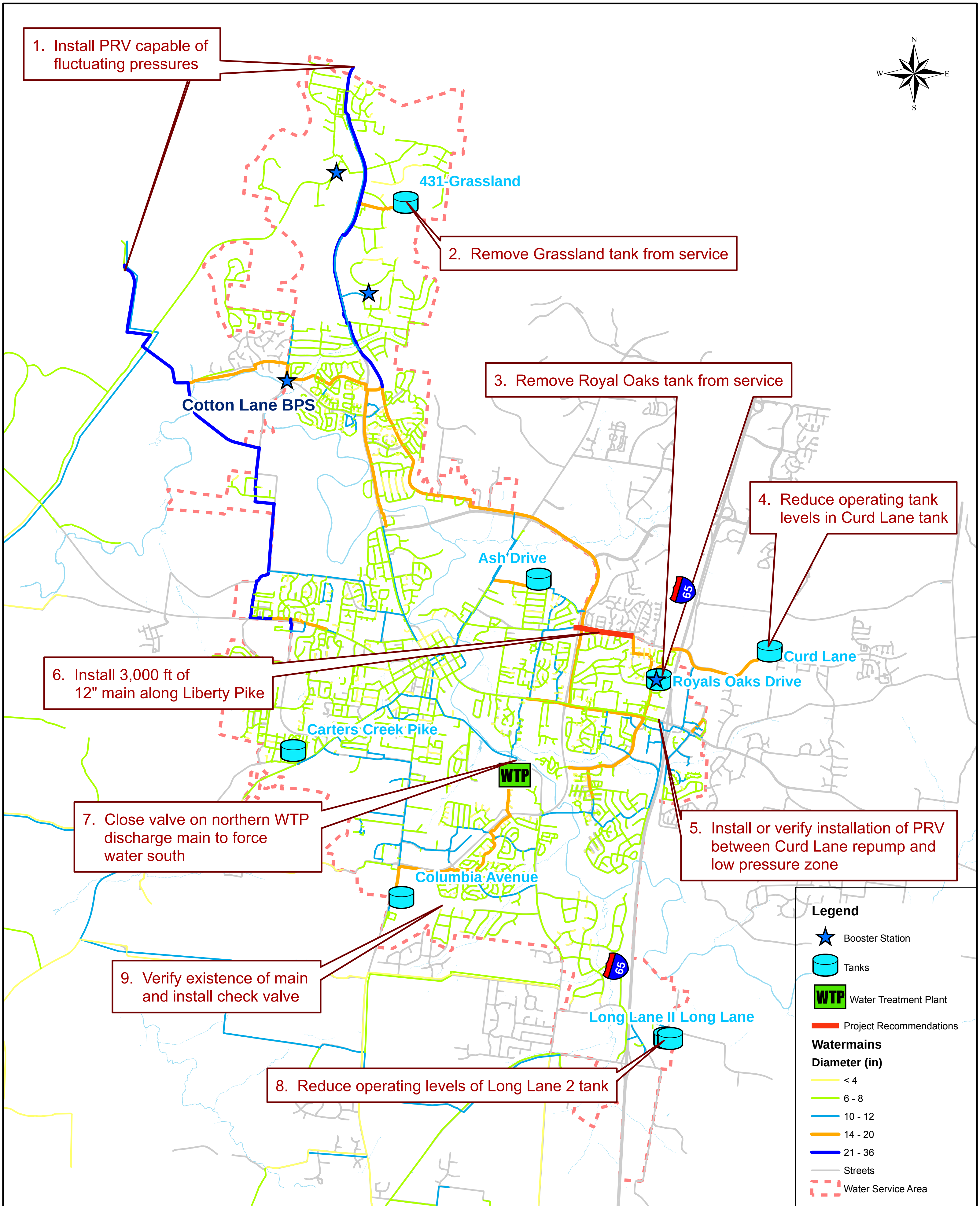
2. *Remove the Grassland storage tank from service*. Due to the close proximity of Grassland to the Sneed Road (also known as Hillsboro Road HVUD supply point), the tank will not experience adequate turnover and will distribute aged water to the area immediately around the tank once HVUD pressures are reduced. Due to these concerns and lack of operational benefit from the tank, the Grassland storage tank should be removed from service.

3. *Remove the Royal Oaks tank from service*. This tank shows a limited zone of influence in the model, due to its close proximity to the Ash Drive and Curd Lane tanks. The Royal Oaks BPS draws flow from this tank and therefore, induces turnover. However, because it is pumping directly to the Curd Lane tank, it causes high water age in the Curd Lane repump zone. By removing the Royal Oaks tank from service, the Royal Oaks Drive BPS can draw flow as an in-line BPS and reduce water age in the Curd Lane repump zone. It may be possible to utilize the Royal Oaks tank in the reclaimed water system because as a major main is planned to loop near the tank along Interstate 65.
4. *Reduce tank levels in the Curd Lane tank*. While removing the Royal Oaks tank decreases the water age to the Curd Lane repump zone, it does not reduce the water age to less than a week. It is necessary to achieve higher turnover in the Curd Lane tank to decrease the water age in the area and as a result, it is recommended to maintain this tank at no more than 50-percent full, and let the tank drain to about 23-percent full before the Royal Oaks BPS is programmed to fill up to 50-percent again. Because this recommended improvement reduces the amount of available emergency storage to this repump area, which serves the hospital, it is recommended to maintain the existing emergency fire pump and install backup power generation at the Royal Oaks BPS for emergencies.

   It is also recommended that the COF identify and install emergency interconnections to Milcrofton Utilities on the eastern border of this repump zone in an effort to supply more water to this area in the event of an emergency. This recommendation is not anticipated to reduce the system pressures at the hospital to unacceptable pressures. When the tank is at 23-percent full, the pressure at the ground floor of the hospital is anticipated to be close to 75 psi; however, a pressure drop to approximately 60 psi is anticipated when Recommendation 5 is implemented and the PRV opens to circulate flow. Lowering the tank levels may also lower system pressures at the apartment buildings along Royal Oaks, north of Murfreesboro Road. The pressure at the ground elevation at the apartment site is expected to close to 50 psi. If the apartment complex requires higher pressures, it may be desirable to install a private pump to boost pressure for tenants.
5. *Install or verify installation of PRV connecting Curd Lane repump zone to Low Pressure zone*. In order to expand the service area of the Curd Lane storage tank, it is necessary to allow it to feed the low pressure zone, as well as the existing Curd Lane repump zone. To do this, a PRV must be installed between the Curd Lane repump zone and low pressure zone boundaries. COF staff believes there is an existing PRV (currently not in operation) near the Royal Oaks BPS. It is recommended that staff verify existence of this PRV and model its effects on this area to ensure it allows the needed circulation of water between pressure zones. If this PRV does not exist or does not allow provide circulation, it is recommended to install a PRV along Highway 96 between the two zones. Operational controls should allow the PRV to close when the Royal Oaks BPS is in operation to reduce flow recirculation.

6. *Install main near the Ash Drive tank to enlarge demand zone of the tank*. Approximately 3,000 feet of 12-inch diameter main is necessary along Liberty Pike to tie into the existing 10-inch diameter main at Hillhaven Lane and the existing 16-inch diameter main at Liberty Hills Drive. This main allows circulation of water and limits the amount of stagnant water within that area.
7. *Direct new WTP production south.* Close valve on WTP northern discharge main to force flow from the WTP south to the Columbia Avenue and Long Lane tanks. Closing this valve increases the volume of newly produced water in the southern extent of the service area. It also expands the service area of the Ash Drive tank by eliminating a competing source of water for the customers north located north of the WTP and south of the Ash Drive tank.
8. *Reduce levels and expand initial service area of new Long Lane II tank.* The COF is planning to replace the current Long Lane tank (500,000-gallon capacity) with the Long Lane II tank (2- million-gallon capacity) at a higher elevation (overflow elevation of 915 feet) than the existing tank. The new tank will be filled using an in-line BPS along Old Peytonsville Road near the intersection of Lewisburg Pike, essentially creating a new pressure zone. It is recommended that until more development results in increased demands on the tank, this tank should be maintained between 7 feet and 14 feet, out of a maximum operating range of zero feet to 35 feet in order to reduce the volume of water aging in the tank.
9. *Install a check valve to limit Long Lane II tank service area*. Install a check valve on the 8-inch diameter main along Lewisburg Pike between Holly Hill Drive and Donelson Creek Parkway. This will allow the new Long Lane II tank to serve a larger service area and to drain and fill more efficiently. The model indicates there is a 16-inch diameter main running north and south between Oakwood Drive and Wisteria Drive; however, it is not identified in the COF geographic information system (GIS) database. This is a cross country main that does not follow a street path and if this main does not exist, it is recommended to install this 1,400-foot stretch of 16-inch diameter main. This main allows Long Lane II some ability to feed back into the COF Low Pressure zone to increase the demand on the tank. Its distance from the tank will limit flow but it will be able to service a portion of the zone. This main will be necessary in the future as demand increases in the southern portion of the service area.

Locations of the recommended improvements are illustrated in **Figure 11;** model results (**Figure 12**) indicate that implementing these nine recommendations reduces the average water age throughout the system to less than 1-week except for a minimal number of dead-end mains, based on 2010 ADD conditions. In the case of the dead-end mains, it is recommended that looping these dead-ends back into the system be incorporated in the long-term goals of the COF. In the short-term, periodic flushing of these mains is recommended to limit the water age.



CDM

Figure 11
Water Age Project Recommendations
City of Franklin

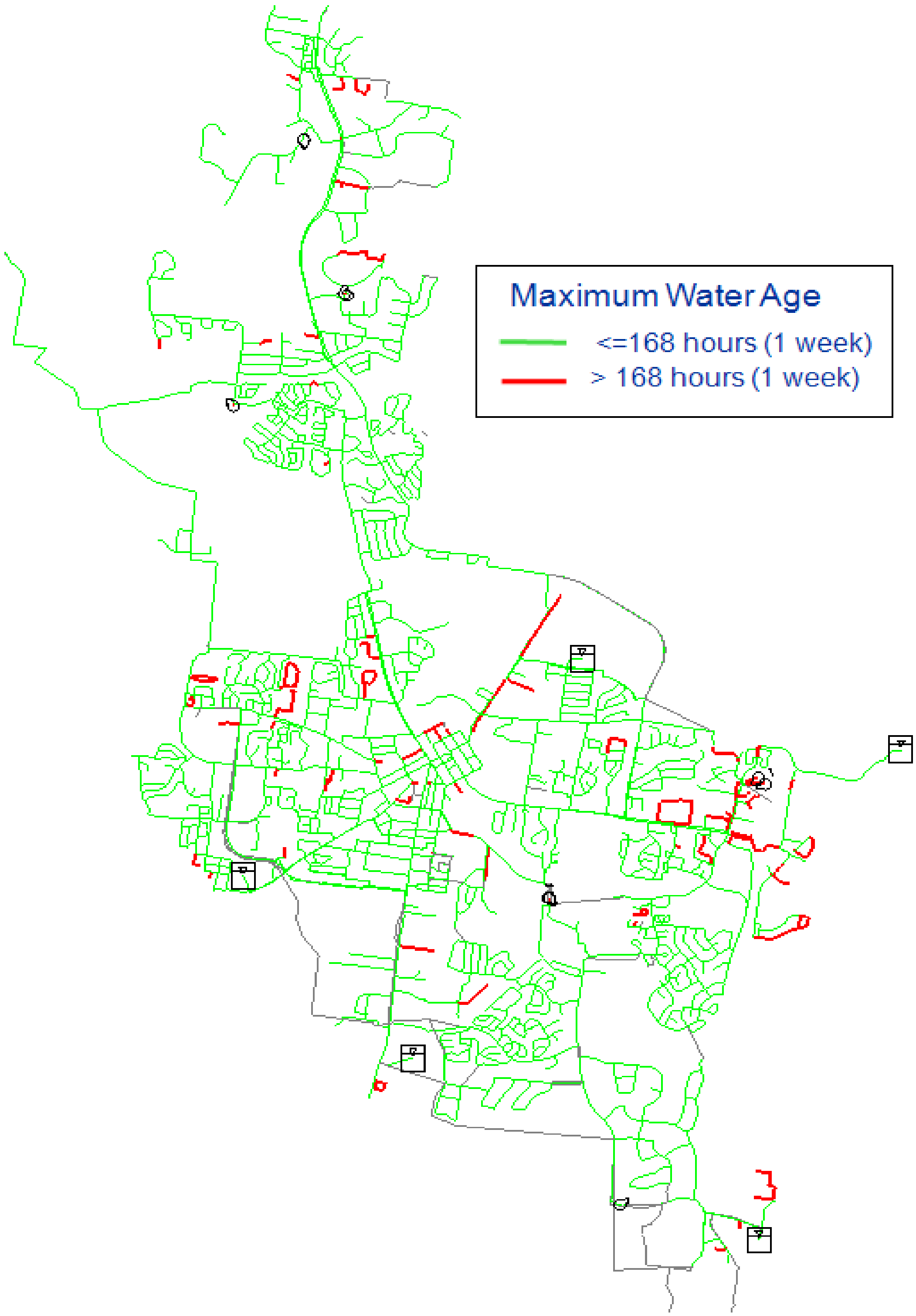


Figure 12
Modeled Water Age After Recommendations

In addition to these operational and infrastructure improvements, it is recommended that COF install a new, comprehensive SCADA system to improve monitoring and control the new PRVs, tank levels, BPS and WTP high service pump (HSP) flow and pressure, as well as system pressures and any other actuated valves within the system. This is critical to maintaining an efficiently-operated and controlled distribution system.

From a water quality perspective, it would be beneficial for the COF to increase the maximum capacity of the WTP from 2.1 MGD to the maximum possible capacity of 4 MGD based on the limitation of the Harpeth River supply source, effectively doubling the current capacity of the WTP. By increasing the water produced from the COF WTP, the system would naturally decrease the amount of aging water required to be purchased from HVUD. This would decrease the water age in the COF system, particularly in the southern extents of the system. By decreasing the overall age of the water entering the system, the operational constraints and tank turnover recommendations listed above can be relaxed in some areas because they are no longer forced to compensate for the high amount of aging water from HVUD. The closer proximity of the COF supply to the demand reduces the water age. Conceptual cost estimates for upgrading the WTP as well as greater discussion regarding increasing the capacity of the WTP is found in the CDM Smith technical memorandum dated August 2010, *Review of CTE/AECOM Design Report: Franklin Water Treatment Plant dated July 2006*.

Water Age Recommendation Cost Estimate

In general, the recommendations have been focused on operational changes rather than infrastructure capital expenditures. Planning level costs were developed for the infrastructure recommendations and unit costs were developed by the CDM Smith construction division, CCI, unless quoted directly from a vendor. In the case of the recommended PRVs, CDM Smith requested a quote from Southern Sales, Inc., in which an electronic actuated pressure reducing valve with manual hydraulic bypass (Cla-Val model 390-07BW) was recommended. Costs for the PRVs include installation of a vault to house the units and SCADA integration. The planning-level cost estimates (**Table 1**) include a 30-percent construction contingency and a 25-percent allowance for legal, administration, and engineering fees.

Table 1 – Water Age Improvements Planning-Level Cost Estimates

Recommendation Number	Item Description	Unit	Quantity	Unit Cost	Material Cost
1	24" PRV at HVUD supply vault	LS	1	$ 200,000	$ 200,000
1	36" PRV at HVUD supply vault	LS	1	$ 350,000	$ 350,000
2	Demolition of Grassland Tank	LS	1	$ 200,000	$ 200,000
3	Remove Royal Oaks Tank from Service†	n/a	n/a	n/a	n/a
4	Reduce Tank Levels in Curd Lane Tank	n/a	n/a	n/a	n/a
5	Install PRV between Curd Lane repump and Low Pressure zone	LS	1	$ 100,000	$ 100,000
6	12-inch DIP on Liberty Pike	LF	3,000	$130	$ 390,000
7	Close valve on northern discharge from WTP	n/a	n/a	n/a	n/a
8	Reduce Tank Levels in Long Lane II Tank	n/a	n/a	n/a	n/a
9	8" Check Valve on Lewisburg Pike	LS	1	$ 10,000	$ 10,000
Material Subtotal					$ 1,300,000
30 percent Construction Contingency					$ 390,000
25 percent Engineering, Legal, Administration Fees††					$ 420,000
Total Cost					**$ 2,100,000**

† Additional costs would be incurred if the tank was incorporated into the reclaim water system.
††Engineering, Legal, and Administrative fees are applied to the Material Subtotal plus the Construction Contingency

* All costs are rounded to two significant figures and expressed in 2011 dollars.

7.0 Growth Related Capacity Analysis

A long-term capacity analysis was also conducted to evaluate future demand projections of the COF system. This section provides a discussion of the methodology for developing the future water demands, model analysis under future demand conditions, and project recommendations for the system to adequately meet future demands.

7.1 Demand Projections

CDM Smith's teaming partner, Smith Seckman Reid, Inc (SSR), assisted with development of long-term demands of the COF system. Because the water distribution system service area is bounded on all sides by existing utilities, the COF does not anticipate a geographical expansion of the service area. Potential increases in demand are projected through development of open land and the possibility of infill within the existing service area boundaries. Population projections and assumptions made during the development process were based on the 2011 Development Report from the COF Planning Department. Where developments were previously defined and approved, the actual proposed number of residential units was used to develop the number or density of units within a development. Where open land, excluding parks or designated recreation areas, was found with no current plan for development, raw acreage, less 15 percent for roads and public areas, was assumed with a density of 2.5 units per acre, based on discussions with the Planning Department. Additionally, open land with slopes in excess of 15 percent, or land within the flood plain was assumed undevelopable and was eliminated from this analysis.

Once the total number of residential units was developed for a build-out condition within the COF service area, future population was developed by assuming a conversion factor of 2.95 people per unit; this number was verified by COF personnel. A per capita demand factor was applied to develop the future average daily demand for the service area, based on current total WTP production and HVUD purchased water in the existing COF service area, divided by the total number of people within the service area. The unit demand factor was applied to the future population to determine the future average daily demand. To develop a maximum day demand (MDD) under build-out conditions, a peaking factor of 1.5, based on the 10 State Standards for demand peaking factors, was applied to the average daily demand. **Table 2** illustrates the current and build-out demand conditions developed using the above described process and utilized during the model analysis.

Table 2 – CoF Water System Customers and Water Demand Estimate

Scenario	Customers	ADD (MGD)	MDD (MGD)
2010 (Existing)	38,200	6.3	9.45
2040 (Build-Out)	50,700	8.3	12.45

After demand projections were developed, a point shapefile was created utilizing GIS software to geographically locate the demand resulting from future developments. The demand point shapefile was applied to the WaterGEMS model in a separate scenario to represent build-out

ADD. The MDDs were also assigned under build out conditions and future demands were not assigned to smaller neighborhood mains including 6-inch or 8-inch in diameter. This is critical because smaller mains could create a bottleneck and a restriction that would not effectively illustrate the total hydraulic capacity of the distribution system. Therefore, demands were assigned to the closest large diameter distribution or transmission main in order to assess the overall hydraulic capacity of the system and its ability to convey these future flows. **Figure 13** illustrates the assigned locations of the build-out average daily demands within the hydraulic model.

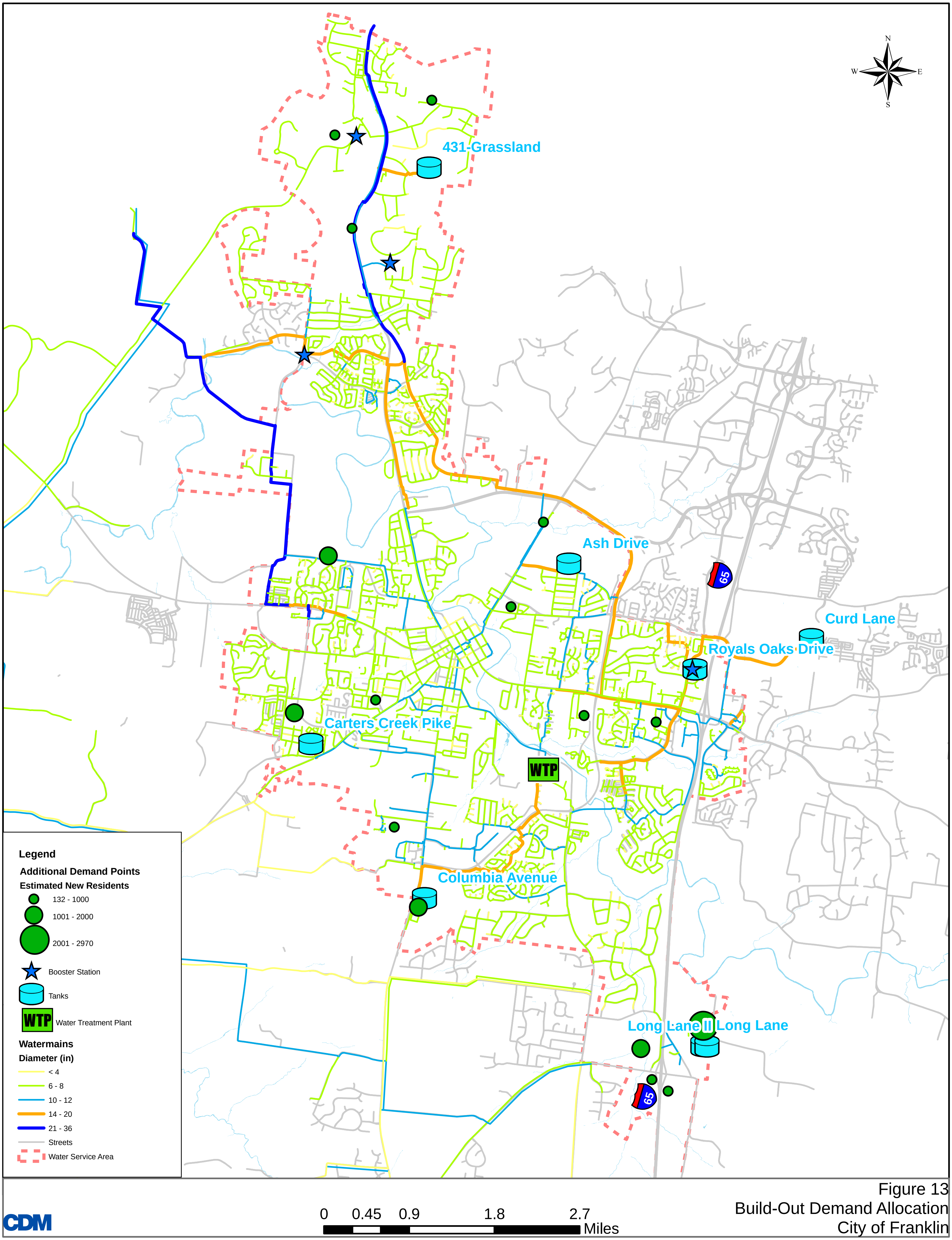


Figure 13
Build-Out Demand Allocation
City of Franklin

7.2 Hydraulic Capacity Analysis

After future ADD and MDD were assigned in the model, it was run for an extended period simulation. The following criteria were used to assess the ability of the existing distribution system to service the customer base under future demand conditions:

a. Maintain system pressure greater than 20 psi under all flow conditions TDEC Community Public Water Design Criteria [Section 9.0.1.c].

b. Maintain fire flows of at least 500 gpm with system pressure at minimum 20 psi, based on TDEC requirements (Chapter 324, Paragraph (18) of Rule 1200-5-1-17 Operations and Maintenance).

c. Maintain storage capacity equal to or exceeding 6.3 MG (equal to seasonal existing average daily demand). Based on the TDEC Community Public Water Design Criteria [Section 8.3.1], system storage shall equal or exceed the ADD. This provides emergency storage for one full day of ADD while minimizing hydraulic residence time and water age less than 168 hour.

d. Water age less than 168 hours in all pipes based on 7-day standard for maximum DBP formation potential [Section 5710 of *Standard Methods for the Examination of Water and Wastewater (1998])*.

e. Maintain pipe velocity less than 5 feet per second (fps) and peak velocity less than 10 fps, based on AWWA guidelines which recommend a maximum design velocity of 10 fps, with velocities less than 5 fps as the desirable range.

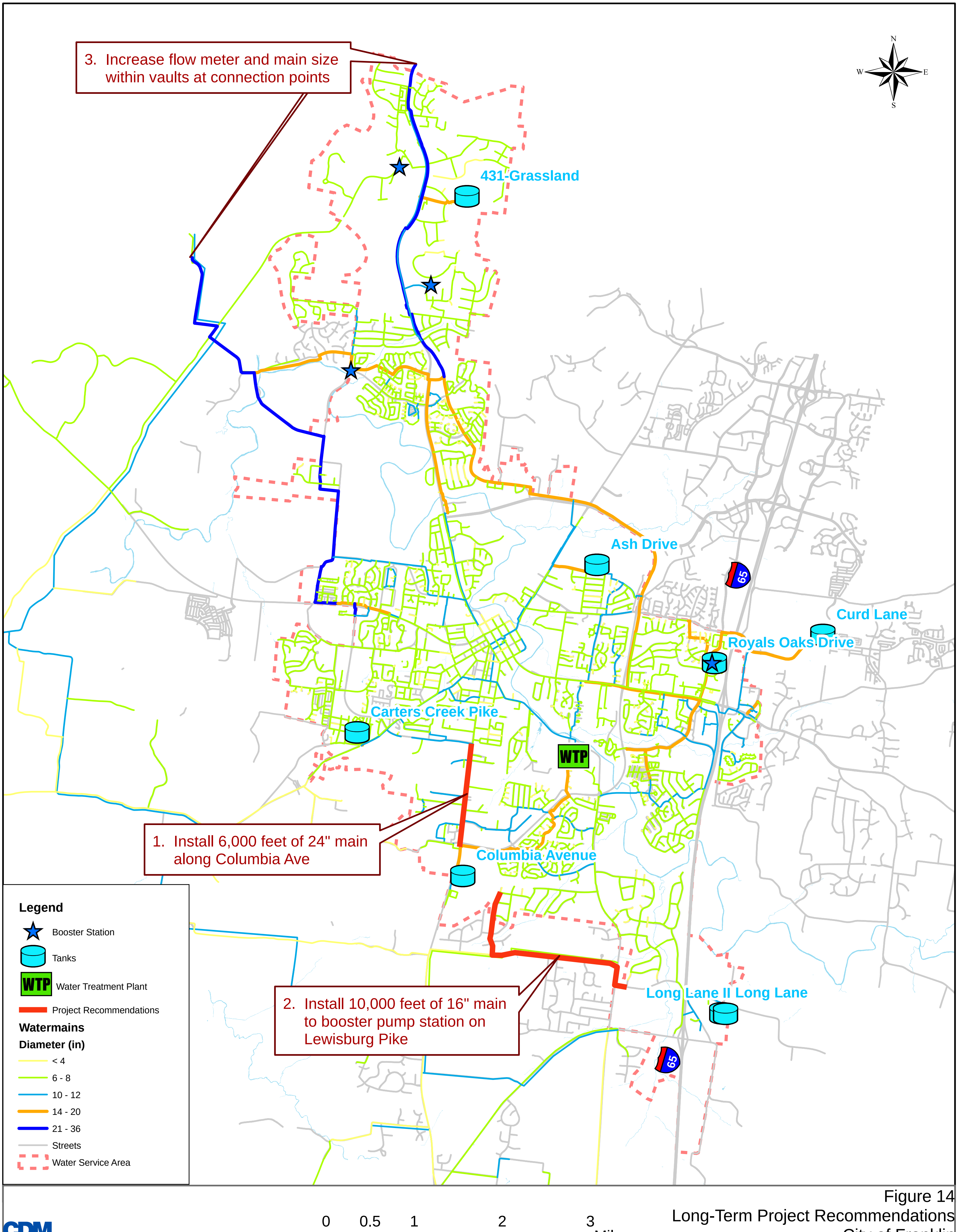
In general, the model indicates the system has difficulty conveying flow from HVUD supply points in the north to the southern extents of the service area. To increase conveyance capacity to the southern extents of the system, the following projects are recommended:

a. Install approximately 6,000 feet of 24-inch main along Columbia Avenue which would connect the 24-inch main on Downs Boulevard that feeds into the 16-inch main tying into Columbia Avenue tank. This main is necessary under 2040 ADD conditions to convey flow to maintain necessary tank levels in the Columbia Avenue tank; it is, however adequate under 2040 MDD, peak hour conditions.

b. Install approximately 10,000 feet of 16-inch main along Oakwood Drive, Henpeck Lane, and Lewisburg Pike to connect into the 16-inch main running north and south between Oakward Drive and Wisteria Drive, (water age recommendation 9). This 16-inch main should feed the suction side of the new BPS along Lewisburg Pike, feeding the Long Lane II tank. The discharge side of the Lewisburg Pike BPS should also be a 16-inch main until it reaches the Long Lane II tank; however, this main is already in the planning stages by the COF and is planned to be a 16-inch main.

c. Install larger flow meters and associated piping in the HVUD vaults. These meters and short lengths of associated 10-inch and 12-inch mains may be creating excessive headloss under future maximum day scenarios. This recommendation should be reevaluated as demands in the COF system increases over time.

These three projects, recommended to improve hydraulic capacity under long-term demand projections, are shown in **Figure 14**. It should be noted that the projects focus on major transmission mains required to meet projected future demands. In some areas, including Goose Creek, additional distribution mains will be necessary as development is planned and becomes active within the system. It is recommended to assess these developments utilizing the hydraulic model as information becomes available; as a result the COF should maintain, update, and calibrate the hydraulic model so that it continues to represent accurate system conditions.



CDM

Figure 14
Long-Term Project Recommendations
City of Franklin

7.4 Build-Out Capacity Recommendation Cost Estimate

Planning-level costs were developed for the infrastructure recommendations necessary to meet projected future demands. Unit costs were developed by the CDM Smith construction division, CCI, unless quoted directly from a vendor. The planning-level cost estimates include a 30-percent construction contingency and a 25-percent allowance for legal, administration, and engineering fees which is applied to the sum of the materials subtotal and construction contingency. **Table 3** lists the planning-level costs for the long-term improvements recommended in the COF system.

Table 3 – Long-Term Improvements Cost Estimate

Recommendation Number	Item Description	Unit	Quantity	Unit Cost	Material Cost
1	20" DIP - Columbia Ave	LF	6,000	$ 220	$ 1,300,000
2	16" DIP - Long Lane Connector	LF	10,000	$ 175	$ 1,800,000
3	Upsize HVUD Vaults	LS	2	$ 250,000	$ 500,000
Material Subtotal					$ 3,600,000
30 percent Construction Contingency					$ 1,100,000
25 percent Engineering, Legal, Administration Fees††					$ 1,200,000
Total Cost					**$ 5,900,000**

*All costs are rounded to two significant digits and presented in 2011 dollars.
††Engineering, Legal, and Administrative fees are applied to the Material Subtotal plus the Construction Contingency.

8.0 Summary

As part of the IWRP, CDM Smith was tasked with assessing the COF distribution system with regard to water age in the existing system and hydraulic capacity under build-out conditions. Operational changes, as well as multiple infrastructure capital projects, are recommended to decrease the water age throughout the COF system. The total cost to implement these projects is approximately $2.1M. CDM Smith also recommends the COF upgrade their existing SCADA system to improve overall operation and maintenance of the distribution system. It is estimated the cost of this upgrade is approximately $830,000.

Finally, it is recommended that the COF upgrade their existing WTP from a maximum capacity of 2.1 MG to a maximum capacity of 4 MG. This would improve water quality in the system by increasing the volume of water from the WTP; and therefore, decreasing the volume of aging water the system purchases from HVUD. The total estimated cost to implement the water age recommendations listed in this document including SCADA integration is approximately $2.9M.

Infrastructure projects were recommended to address the long-term growth needs and hydraulic capacity of the distribution system. These improvements will help convey water to the southern extents of the COF service area, where a large majority of future customer demand will be located. The total cost of the three recommended system improvements is estimated at $5.9M. The project recommendations and associated costs reflect the analysis that can be conducted from the distribution system model and do not account for modeling of water ages within tanks. These recommendations are intended to increase tank turnover to reduce the overall system water age. It is possible that additional projects are needed to reduce water age in selected tanks; however, this is unknown without implementation of the recommended projects.

It is recommended that the COF conduct regular testing at the HVUD supply points to better quantify the quality of water entering their system. It is recommended to conduct testing to determine the age at which the COF and HVUD water are expected to exceed the regulatory limits on DBPs to better correlate model data with field data.