CITY OF BRENTWOOD, TENNESSEE

BRENTWOOD WATER SERVICES
DEPARTMENT

WATER SYSTEM MASTER PLAN

2016 MASTER PLAN UPDATE

AUGUST 2016

Smith Seckman Reid, Inc.

Water System Master Plan

2016 Master Plan Update

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SSR Project No.:
14-41-003.0

Date:
AUGUST 2016

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1 Executive Summary

In 2008, the City of Brentwood Water Department authorized the development of a water system master plan for the following purposes:

- Evaluate the existing potable water sources and infrastructure to meet the current water demands and projected water needs of the service area.
- Identify potential water system improvements required to meet current and projected water needs.
- Identify potential water system improvements that could potentially reduce operational expenses, increase water availability, and optimize system operations.
- Evaluate available conservation methodologies to help absorb peak water demands.
- Create a working document that will be utilized as a tool by the Brentwood Water Department to consider necessary capital improvements.

Since 2008, various changes have occurred with the City of Brentwood that necessitated an update of the 2008 Water System Plan (2008 Plan). Changing rate structures and water source availability are the primary drivers for re-evaluating the capital improvement projects identified in the 2008 Plan.

The 2016 update to the Master Plan includes the following:

- Coordination with the City's two main sources of drinking water (i.e. Harpeth Valley Utility District and Metro Water Services).
- Consideration of the impacts associated with the potential development of the Turner property.
- Consideration of the impacts associated with changing rate structures of Harpeth Valley Utility District (HVUD) and Metro Water Services (MWS)
- Consideration of the impacts associated with Mallory Valley Utility District (MVUD) supplying as much as 2.0 MGD.
- Revisions to the capital improvement projects

Current demands on the system consist mainly of residential costumers, including a significant seasonal water demand for irrigation purposes. Since the 2008 Plan was completed, the average daily flow pumped by the City of Brentwood is 5.12 million gallons (MG). This represents a 13.8% increase in the average daily flow pumped between 2003 and 2008. Since the 2008 Plan, the maximum flow pumped

in a single day was 12.18 MG. This value is roughly equal to the maximum flow pumped in a single day between 2003 and 2008. A comparison of the demand breakdown of the 2008 Plan and 2016 Update is shown in the table below.

Table 1.1 – Projected Demand Comparison, MGD

	2008 Master Plan		2016 Update	
Demand Type	**Annual Average**	**Max Day**	**Annual Average**	**Max Day**
Current	4.51	12.27[1]	5.12	12.18
Developing and Vacant Parcels	0.88	2.63	1.62	3.85
Cal Turner Property	0.00	0.00	0.60	1.42
Open Space Irrigation	0.01	0.03	0.02	0.05
Total System Demand	**5.40**	**14.93[2]**	**7.36**	**17.50**

Notes:

1. The Current Max Day flow was incorrectly reported in the 2008 Master Plan and has been adjusted in this table.
2. Total System Demand in this table has been adjusted based upon the revised Max Day flow for the period between 2003 and 2008. Improvements listed in 2008 Master Plan were based upon a Max Day demand of 16.1 MGD.

Projected average day demands were adjusted as part of the 2016 Plan to more closely reflect historical water use across seven different planning areas. The 2008 Plan assumed an annual average day demand of 650 gallons per day (GPD) across the entire system. For the 2016 Plan, billing records were placed within one of the seven planning areas based up street address, and a corresponding daily use was calculated for each area by averaging monthly billings for all records located in the area. The analysis showed that average daily use within these planning areas can vary from 585 GPD to as much as 2,035 GPD. The annual average demand for each planning area was applied to the developing and vacant parcels located in each zone to revise the projected water use in the 2016 Plan. Given the revised average demands and consideration to the development of the Cal Turnery property, projected total system demand has increased approximately 1.4 MGD from the projected Max Day in 2008 Plan (i.e. 16.1 MGD).

The City was offered the opportunity to purchase as much as 2.0 million gallons per day (MGD) from MVUD at the south extents of the distribution system. Much of the anticipated growth is centralized in and around the southeastern portion of the distribution system (i.e. along Split Log Road and Raintree Parkway). Given that several improvements identified in the 2008 Plan focused on delivering water from the City's two sources located at the opposite boundary of the distribution system, purchasing water from MVUD could eliminate the necessity of some these improvements.

Based upon the revised demand projections and hydraulic analysis conducted as part of the 2016 Update, the option of connecting to MVUD does not appear to carry a positive financial benefit to the City. Though capital expenditures on waterline improvements would decrease, the potential cost

savings are offset by the higher purchase costs. A summary of the impacts of the MVUD purchase agreement on the cost of water is provided on a 20-Year Net Present Value in the table below.

Table 1.2 – Cost Implications of MVUD Connection

Avoided Capital Costs	-$10,144,000
New Capital Projects Required	$1,892,000
Operating Cost	$18,234,000
Total Net Present Value of MVUD Connection	$9,580,000

Given the financial impacts of the MVUD connection and the changing purchase agreements of the City with its two water suppliers, purchasing water from HVUD to the furthest extent possible appears to be in the best financial interest of the City. Consequently, the 2016 Plan continues to focus on moving water from the northwest portion of the system to the southeast portion of the service area, while minimizing the need of purchasing water from Metro Water Services under normal conditions. Table 1.3 summarizes the total waterline needs identified in the 2016 Plan.

Table 1.3 – Pipe Lengths for New Construction

Size	Length
8”	430 ft*
12”	13,100 ft*
16”	3,100 ft*
18”	5,600 ft*

*Linear feet estimated from GIS, actual lengths may vary.

Using unit costs for projects recently constructed in the City of Brentwood, construction costs for each improvement included in the 2016 Plan was calculated. The total cost of all improvements is estimated at approximately $15.0 million dollars. Compared to the total cost of all improvements identified in the 2008 Plan, the 2016 Plan offers an estimated savings of approximately $13.1 million dollars.

2 Purpose and Need

With the City of Brentwood experiencing continued growth in water demands within its service area and variations in the rate structures of wholesale purchases from HVUD, MWS, and the offer to purchase from MVUD, the City needed to re-evaluate the costs and benefits of the improvements identified in its 2008 Plan. The City requested that Smith Seckman Reid, Inc. (SSR) prepare a revised Water Master Plan with the goal of revising the Capital Improvement Plan (CIP) based upon the changing dynamics of the City's distribution system and source water suppliers.

3 General Information

3.1 Water Consumption

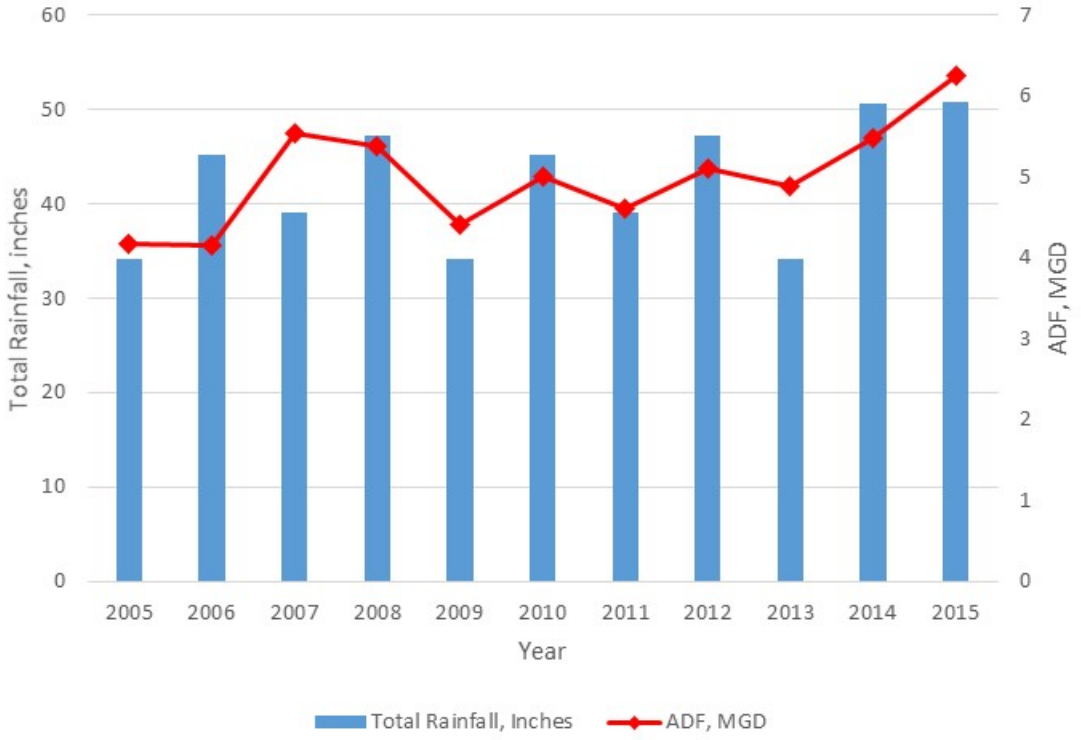
Water consumption from 2009 through 2015 was compared to the consumption rates used in the 2008 Master Plan (i.e. 2003 thru 2008). The data shows the total consumption over the last six years has increased by 13.2% over the period between 2003 and 2008 with significant increases through the summer months. The table below summarizes the comparison of total monthly volume of water pumped by the City of Brentwood.

Table 3.1 – Comparison of Total Volume Pumped, MGD

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann. Avg.
2009 – 2015 Average	98	88	99	116	160	215	240	236	212	181	114	105	1,865
2003 – 2008 Average	92	84	94	107	142	182	200	209	177	160	106	96	1,648
Change, %	6.5	5.2	5.3	8.4	13.1	18.3	20.4	13.0	19.8	13.7	6.9	9.2	13.2

Based upon the annual pumped volume, average daily flows were calculated. The figure below summarizes the average daily flow (ADF) into the City over the last eleven years. Because irrigation demands are a significant contributor to the overall system demand, the total recorded precipitation for each year is shown alongside the average daily flow.

Figure 3.1 – Comparison of Average Daily Flow and Total Rainfall



3.2 Peaking Factors

Peaking factors express the ratio of the max day flow to the annual average day flow. Since the 2008 Master Plan, the single max day has remained relatively unchanged over the last five years. Between 2003 and 2008, the max day flow (i.e. volume pumped from all sources), was 12.27 MGD. Between 2009 and 2013, the max day flow was 12.18 MGD. With stagnant max day flows and higher annual average flows over the last five years, the daily peaking factor has seen a slight decrease from the factor calculated as part of the 2008 Master Plan. The max day peaking factor utilized in the 2008 Plan was 2.72. The daily peaking factor used as the basis for calculating the projected max day flow was 2.38, or approximately 12% lower than the 2008 Master Plan.

Though max day flows have remained relatively consistent over the last eleven years, the City is seeing longer periods of higher water consumption during the warmer months. As evident in the Table 3.1, the total water consumption for months June through September have seen a sharp increase since the 2008 Plan. In some months, the average daily consumption over the entire month has increased by as much as 1.0 MGD. This analysis is consistent with the calculated reduction in daily peaking factor and is important to bear in mind. Where instantaneous demands haven't increased, more water is being demanded for longer periods of time, and the infrastructure will need to handle these prolonged periods of higher flows.

3.3 Population Data and Projections

The City continues to see growth in its resident population. In 1994, the City of Brentwood had a population of slightly over 19,000. In ten years, a certified special census revealed that the City's population had grown to around 31,000. The 2010 U.S. Census data reported a total population of 37,060. In short, in roughly twenty years, the City's population has nearly doubled.

Since the 2008 Plan, the City saw an increase in new construction of single-family residences coming out of the recession of 2009. Between 2011 and 2015, new starts leveled off around 250 new starts per year. A historical comparison of the new construction starts in Brentwood is summarized in the table below. Because of the large irrigation component of its costumer's daily water use, growth in new building starts is a better indicator of changing water needs than growth in population.

Table 3.2 – New Construction Starts

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Permits Issued, Annual Total	462	495	283	105	68	140	239	257	229	252	245

3.4 Drinking Water Supplies

Much of this update is centered on water availability from various sources surrounding the City. Purchasing 100% of the water consumed by its customers from wholesale suppliers, the City currently relies solely on HVUD and MWS to meet its water demands. Therefore, improvements previously identified in the 2008 Plan were based upon the existing water agreements and rate structures with HVUD and MWS in place at the time when the Plan was drafted. Changes in water agreements and rate structures, as well as the potential of establishing a third source of supply (i.e. MVUD) were accounted for in developing these revisions to the 2008 Plan.

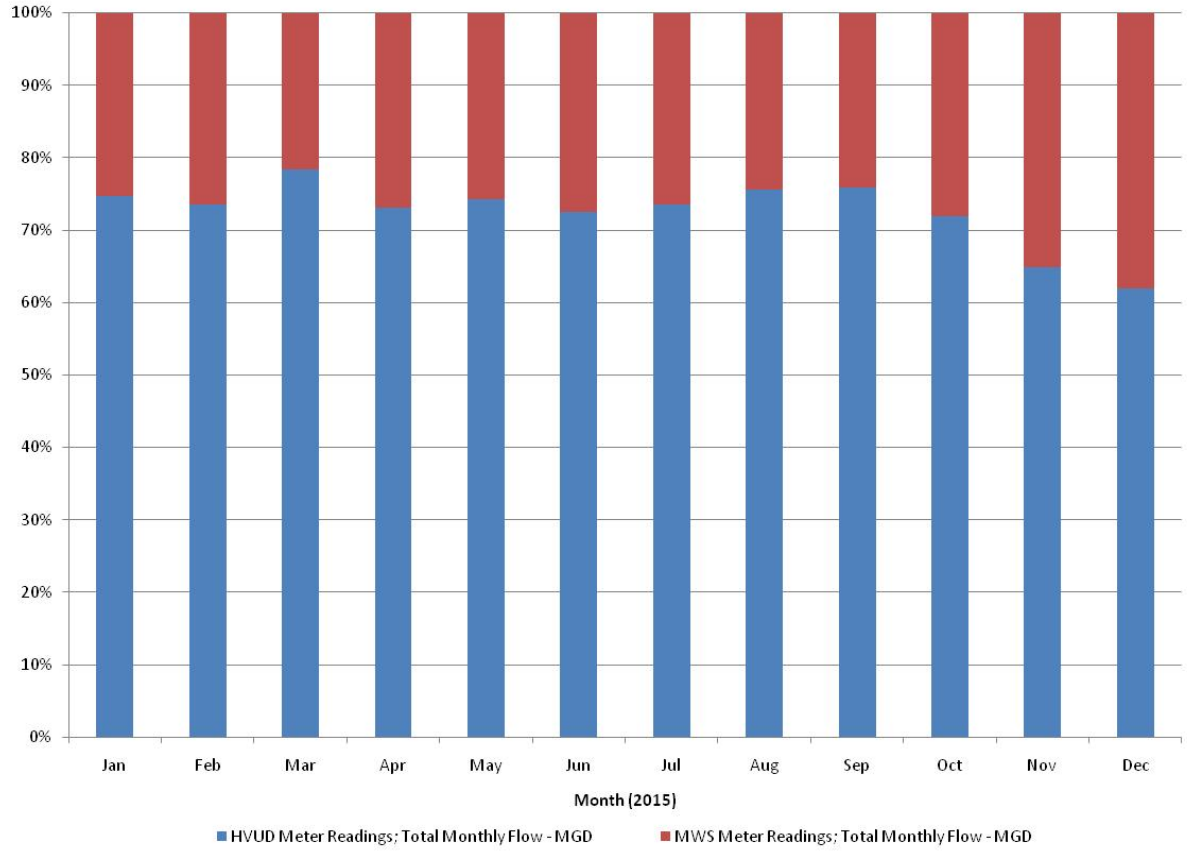
The table below summarizes the comparison of the two primary drinking water sources for the City over the last six years compared to the time period immediately preceding the 2008 Plan report (2003 thru 2008). Note the minimum and maximum days listed below for each source may not have occurred on the same calendar day.

Table 3.3 – Comparison of Source Production, MGD

Year	MWS	HVUD	MWS	HVUD	MWS	HVUD
	Min Day		Average Day		Max Day	
2003 – 2008	0.00	1.24	0.92	3.48	3.64	9.77
2009 – 2015	0.02	1.06	0.88	4.24	2.79	10.30

Figure 3.2 summarizes the monthly percentage pumped from each source for calendar year 2016.

Figure 3.2 – Source Water Percentages



3.5 Water Agreements and Rate Structures

The City purchases water from two wholesale suppliers, HVUD and MWS. The City's contractual arrangement with MWS currently requires the City to purchase at least 24.32 MG of water per month up to a maximum daily volume of 2.5 MGD. As of October 2014, MWS bills the City of Brentwood at a rate of $2.44 per 1,000 gallons. A minimum monthly charge of $652.55 is billed regardless of the actual amount purchased and includes the first 1,500 gallons. Above 2.5 MGD, the purchase rate doubles to $4.88 per 1,000 gallons.

The City's contractual agreement with HVUD requires a minimum purchase equal to the average monthly purchase for the 12-months preceding the current billing cycle. If this volume is not physically pumped by the City, the City is still charged a minimum bill equal to this volume. As of January 2016, the current 12-month average water consumption for the City is approximately 4.23 MGD. The rate

structure with HVUD has been simplified from the descending rate in place at the time of the 2008 Plan. Currently HVUD charges the City a flat rate of $2.55 per 1,000 gallons.

A third source of water is available, and this update considers the impact of connecting to Mallory Valley Utility District and purchasing at least 1.0 MGD. The City's wholesale purchase agreement with MVUD would stipulate that up to 2.0 MGD could be purchased by the City. MVUD does not treat its own water. Like the City, MVUD purchases water from HVUD. Consequently, the purchase of water from MVUD would be at a cost equal to the rate charged by HVUD, plus an additional charge applied by MVUD. The existing proposal offered by MVUD sets the rates for wholesale water purchase as follows:

- HVUD Cost + $0.45 per 1,000 gallons for up to 1 MGD (or $3.00 per 1,000 gallons).
- HVUD Cost + $0.38 per 1,000 gallons between 1 MGD and 2 MGD (or $2.93 per 1,000 gallons).

Though the above rates would be the highest incurred by the City, purchasing water from MVUD offers benefits that were evaluated against the increased rate. Because of where growth is expected to occur (i.e. along Split Log Road), the majority of the improvements listed in the 2008 Plan are aimed at moving water from the City's connections to HVUD along Murray Lane and Johnson Chapel southeast toward Split Log Road. The proposed connection to MVUD would be located in the general vicinity of Split Log Road near the Carriage Hills tanks. This offers two potential benefits. First, the City would not incur the pumping cost of pumping 1 MGD from HVUD to Split Log Road. Second, some of the 2008 Plan improvements would no longer be necessary.

If the City agrees to purchase water from MVUD, the City would be obligated to purchase a minimum of 1.0 MGD. If the City does not purchase at least 1.0 MGD during a monthly billing cycle, the City incurs a minimum monthly bill equal to 1/12 of the annual minimum purchase amount, or 30.41 million gallons. Under the current rate structure, this equates to a minimum monthly bill of $91,250.

4 2008 Master Plan

This update considers the original Water System Master Plan developed by Smith Seckman Reid, Inc. in 2008 with the City of Brentwood Water Services Department. The major improvements identified in the 2008 Master Plan included the following:

1. General System Improvements: The 2008 Master Plan report outlined several general system improvements including removal and replacing PVC waterline and continued replacement of aging infrastructure. In both instances, the material and/or age of the water infrastructure had led to repeated failures. Proceeding with a routine annual improvement plan targeting this infrastructure was recommended to reduce the likelihood of future failures. These

improvements were not critical in nature and could be completed over multiple years based upon the capital improvement budget.

2. Improvement of the Murray Lane and Johnson Chapel pump stations: Given the increase in water consumption, the main source water supplies for the South pressure zone have reached their capacity. The 2008 Master Plan report recommended increasing the capacity of both these stations. In addition to the capacity improvements at the pump stations, the discharge line for the Johnson Chapel station along Belle Rive Drive required additional capacity to carry the increased flows pumped from the station. A 20-inch waterline was proposed for this capacity improvement. These pump station and waterline improvements are currently under construction. See below for more detailed discussion of the improvements and new capacities of the Murray Lane and Johnson Chapel pump stations.

3. Hydraulically Connect Murray Lane and Johnson Chapel pump stations: The two largest water sources for the City were hydraulically disconnected. This increased the criticality of the distribution system along Murray Lane and McGavock Road. To remediate these concerns, the 2008 Master Plan recommended the construction of a new 16-inch waterline along Granny White Pike between Belle Rive Drive and Murray Lane. This reduces the flow and criticality of the existing 14-inch waterline along McGavock Pike. This improvement is currently under construction.

4. Construction of the "Southwest Transmission Main": The Southwest Transmission Main aimed to reduce the required pressures to pump water from the Murray Lane and Johnson Chapel pump stations to the Split Log Road pressure zone. Given the open and available farm land along Split Log Road, this pressure zone in the southeast most portion of the distribution system is expected to see the most residential and irrigation growth. This location is physically and hydraulically furthest from the source water pump stations in the northwest portion of the system. With higher demands projected in this area, substantial increases in discharge pressures at the pump stations would be required to pump this volume of water to the Split Log zone if no additional improvements were constructed. The Southwest Transmission Main effectively increases the capacity of the distribution system to the southeast. Routing for portions of this transmission main are currently being considered by the City, and this update considers the financial and operational impacts of the various route alternatives. This update also considers the implication of the potential connection to MVUD impacts on the necessity of these improvements.

5. Improvements to the River Oaks pump station and discharge line: At the time of the 2008 Master Plan report, the rate structures charged by MWS and HVUD were different from what they are at the time of this update. In 2008, the rates charged by MWS were higher than those charged by HVUD. Given the rates structures in place at that time, the improvements at the River Oaks pump station were aimed at allowing more water to be purchased from

HVUD through this station pumping water into the North pressure zone. This would reduce the volume purchased from MWS and generate operational cost savings. Currently, rates from HVUD exceed those of MWS. Consequently, purchasing more water from HVUD through the River Oaks pump station does not offer the same financial incentive. Given demands in the North pressure zone aren't expected to increase substantially in the foreseeable future, the operation of the source supplies of the North pressure zone can continue as they have historically. The improvements to the River Oaks pump station and discharge line should be re-evaluated if rates charged by MWS exceed those charged by HVUD.

4.1 Murray Lane and Johnson Chapel Pump Station Improvements

The 2008 Plan recommended increasing the capacity of the Murray Lane and Johnson Chapel pump stations. Located along Murray Lane and Johnson Chapel Road, these two stations pump most of the water the city uses on a daily basis. The 2008 Plan recommended an increase in capacity to 4,500 gpm (~ 6.5 MGD) and 3,600 gpm (~ 5.1 MGD) at the Murray Lane and Johnson Chapel pump stations, respectively. The increased capacity of these two stations would meet the projected peak day demand of the South pressure zone.

The design of these improvements began in 2012 and the pumps were installed in early 2015. The new pump characteristics for each station are summarized in the table below. Certified pump curves are included in the Appendix.

Table 4.1 – New Pump Characteristics

Parameter	Murray Ln	Johnson Chapel
Pump Type	Vertical	Horizontal
Pump Manufacturer	Peerless	Cornell
Pump Model	18HXB	8H
Serial Number	7081406A	193768
	7081406B	193769
Stages	2	---
Speed	1,770	1,800
Operating Point	4,600 gpm @ 177'	3,600 gpm @ 191'
Efficiency at Operating Point	81.45%	88.23%
Power at Operating Point	253.75	196.42

4.2 Additional 2008 Plan Improvements

Since the adoption of the 2008 Plan, these improvements have been completed: Murray Lane and Johnson Chapel's pump stations, WL-01, WL-02, WL-04, WL-06, and a portion of WL-07 from Wikle Road West to Mallory Park Lane (See Appendix F).

4.3 Other Improvements Constructed

Where not specifically tied to one of the main objectives of the 2008 Master Plan outlined above, the City has constructed or begun the design of additional infrastructure to address other needs and improve the operations of the distribution system.

4.3.1 Plymouth Drive Pump Station and Waterline

The existing Plymouth Drive pump station is used to maintain tank levels in the Willowick storage reservoir. This original station utilized full voltage starters and constant speed motors. This method of operation does not provide for gradual pump acceleration and can cause detrimental hydraulic surges in the downstream piping. This phenomenon was experienced with this original design, forcing repeated repairs on the downstream PVC piping.

To alleviate the repeated failures in this area, the City updated the pump station with new pumps, inverter duty rated (variable speed) motors, and adjustable frequency drives. The improved electrical and pump station equipment now allow the pumps to start and stop gradually, virtually eliminating the common hydraulic surges. In addition to the station improvements, the PVC pipe downstream of the pump station was replaced with a stronger and higher pressure class ductile iron pipe. These improvements in combination have eliminated the recurring maintenance issues in this area of the system, leading to improved operational efficiencies.

4.3.2 Twin Springs Waterline Replacement

The City experienced repeated waterline failures on the 8-inch PVC line installed along Twin Springs Road between Concord Road and Wilson Pike. To address the recurring maintenance issues and increase the capacity of the system toward the Split Log pressure zone, the 2008 Master Plan recommended replacement of this line with a 12-inch ductile iron pipe. This replacement was installed and placed into operation. This improvement has improved the operational efficiency and reduced the impacts of a hydraulic limitation existing under the railroad along Wilson Pike.

4.3.3 Stonehenge Phases 1, 2, and 3

The City is experiencing low pressures in higher elevations within the Stonehenge neighborhood. To improve system pressures in this area, the City is currently designing additional waterline improvements

that will allow these areas of low pressure to be connected to the higher Robert E. Lee pressure zone. All phases have been designed, constructed and are in service.

5 Water Demand Projections

New home construction is the primary factor driving water demand projections. Water consumption, especially max day consumption, is driven primarily by residential irrigation uses during the warmer and dryer summer months. Because irrigation plays a larger role in max daily demand than domestic use, projected water use is more directly connected to the number of housing units and not a total population. As new homes and new developments are connected to the distribution system, water demand is expected to grow more quickly than the resident population.

5.1 Residential Water Demands

To project water consumption, this update considered the number of vacant platted lots and undeveloped (but planned) lots for the various residential developments within the City's water service area. Additionally, large undeveloped tracts within the City's service area were also included in the revised residential water projections. The currently developing properties and large undeveloped tracts have been placed into one of six planning areas delineated by the City's planning department.

An estimated annual average water use per lot was calculated for each planning area by averaging historical water consumption of surrounding residential properties within the respective planning area. This annual average demand was then applied to each of the lots to be developed. To calculate the additional consumption on a max day basis, the annual average consumption was multiplied by the daily peaking factor (i.e. 2.38). The table below summarizes the projected water demand associated with undeveloped residential lots and large tracts that could be developed in the future. A listing of all subdivisions, their respective planning area designation, and the remaining lots to be developed is included in the Appendix. A map showing the projected residential water demand growth has also been included in the Appendix.

Table 5.1 – Projected Residential Demands

Planning Area	Additional Lots to Be Developed	Annual Average Demand per Lot, GPD	Additional Average Demand, GPD	Additional Max Day Demand, GPD
1	9	2,035	18,315	43,590
2	4	1,450	5,800	13,804
3	43	585	25,155	59,869
4	72	1,050	75,600	179,928
4A	247	1,210	298,870	711,311
5	811	1,400	1,135,400	2,702,252
6	40	1,400	56,000	133,280
Totals	**1,226**	**---**	**1,615,140**	**3,844,033**

5.2 Cal Turner Property

The Cal Turner property is an expansive agricultural farmland located in the heart of the City's water service area. The property consists of roughly 567 acres of prime land located along two major transportation corridors (i.e. Concord Road and Franklin Road). The 2015 update to Brentwood's 2020 Plan polled the community in regards to the desired use of this large tract of land. Of the development scenarios offered by the survey, respondents were most supporting of overall 1-acre residential zoning, with larger lots located along Concord and Franklin Roads. As an alternative to development, the survey polled the support of the City purchasing the property and preserving all or large portions of it as open green space. Sixty-four percent (64%) of the respondents were either very supportive or somewhat supportive. Given the nature of water consumption within the City, the extent of development of the Cal Turner Property will have a significant impact on the City's water consumption of this concept. The influence of the level of development of this property on additional demand is evaluated in the table below.

Table 5.2 – Impact of Cal Turnery Property on Projected Consumption

Acres	Percent Land Developed	Developed Land	Density	Number of New Units	Annual Average Demand per Unit, GPD	Additional Average Demand, GPD	Additional Max Day Demand, GPD
567	0%	0	1	0	1,400	0	0
567	25%	141.75	1	142	1,400	198,800	473,144
567	50%	283.50	1	284	1,400	397,600	946,288
567	75%	425.25	1	426	1,400	596,400	1,419,432
567	100%	567.00	1	567	1,400	793,800	1,889,244

As shown in the table above, additional residential water consumption could be as little as 475,000 gallons or as much as 1.9 million gallons depending on the final housing density. For the purpose of this update, we assumed 75% of the Cal Turner property was utilized for residential development. Therefore, a max day demand of 1.42 MG was incorporated into the projected consumption rates.

5.3 Public Landscape Irrigation

Demand for irrigation of public spaces or commercial developments are more difficult to accurately predict. As part of the 2008 Plan, billing records for Homeowners Associations (HOA) were reviewed to estimate the demand associated with irrigating public spaces in residential developments. From the small sample of HOA data available, larger HOAs can demand as much as 2,100 gpd during the summer months while smaller associations may only demand 300 gpd. For the purpose of demand projections used in the 2008 Plan and 2016 update, a demand of 430 gpd/residential development was utilized to project irrigation demands for public spaces. In total, a projected public landscape irrigation demand of 0.05 MGD was utilized.

5.4 Total Projected Consumption

The existing consumption records were combined with the forecasted demands calculated for future residential development (including the Cal Turner property) and open space irrigation. The table below summarizes the total projected demands for the City of Brentwood.

Table 5.3 – Total Projected Demands, MGD

Demand Type	Annual Average	Max Day
Current	5.12	12.18
Developing and Vacant Parcels	1.62	3.85
Cal Turner Property	0.60	1.42
Open Space Irrigation	0.02	0.05
Total System Demand	**7.36**	**17.50**

6 Water System Analysis

6.1 Approach

Based on sound engineering practice, large water systems (average flows above 10 MGD) should plan their infrastructure around the max day demand. This condition places the system under its most challenging circumstances as the total flow must be provided by the sources without using storage.

6.2 Procedure

As part of this update, the City's existing hydraulic model was converted from Innovyze's stand-alone platform (H2OMap) to a GIS-based platform (InfoWater) within Innovyze's product offering. This model utilized the City's GIS features to spatially locate waterlines, pump stations, storage reservoirs, control valves, and water meters. Improvements identified in the 2008 Plan that have been constructed or are currently under construction were added to the model and applied to the base (i.e. existing) condition. Calibration and operational data sets compiled during the original model creation were applied to the updated model.

Water consumption rates were spatially located by connecting a database table exported from the City's billing software to the GIS water meters. The modeling software utilized this combination of data to allocate the existing water consumption at the proper geographic location. Projected demands were located within the boundaries of each subdivision.

6.3 Existing Distribution System

The existing water distribution system in the City of Brentwood is comprised of pipelines ranging from 2-inches to 24-inches in diameter, as well as pump stations, system valves, and a number of storage tanks providing the storage capacity to meet peak and fire protection demands. .

6.3.1 Waterlines

The existing distribution system consists of 2-inch lines up to 24-inch ductile iron pipe (DIP) transmission mains. The existing distribution system also includes pressure PVC pipeline. Table 3.3 summarizes the length of each size of pipe and the general capacity of the waterline at a velocity of 5 feet per second (fps).

Table 6.1 - Existing Pipe Sizes, Lengths and Theoretical Capacity

Waterline Size (inches)	Total Length within Water Service Area (ft)	Capacity at 5 fps (gpm)
24	26,858	7,050
20	9,997	4,900
16	9,954	3,133
14	30,354	2,399
12	156,476	1,762
10	18,224	1,224
8	436,733	783
6	423,815	441
4	9,057	196
2	14,149	49

6.3.2 Storage Facilities

The City of Brentwood currently operates ten ground storage facilities. The existing storage tanks and storage capacity currently installed within the City distribution system are shown in the table below.

Table 6.2 – Existing Storage Tanks

Tank Name	Installation Date	Tank Type	Overflow Elevation	Pressure Zone	Tank Capacity
Skyline Drive #1	1984	Ground	875.00	North	2,000,000
Skyline Drive #2	2000	Ground	875.00	North	2,000,000
Carriage Hills #1	1987	Ground	925.00	South	3,000,000
Carriage Hills #2	2001	Ground	925.00	South	2,000,000
Chenoweth	1986	Ground	925.00	South	2,000,000
Willowick	1989	Ground	1,150.00	Willowick	185,000
Robert E. Lee	1988	Ground	1,155.00	Robert E. Lee	238,000
Raintree #1	1991	Ground	989.43	Raintree North	103,000
Split Log Road	2006	Ground	1,056.00	Split Log Road	2,500,000

7 Assessment Procedure

Hydraulic considerations are often times the most important components to any water facilities assessment. Water providers must be able to supply water to their end users in a reliable manner such that minimum requirements are met. Minimum requirements for the City are set by TDEC. To optimize a distribution system, potable water must also be delivered in the most cost effective way. The

total cost to deliver a gallon of water to an end user can be influenced significantly by the hydraulics of the system. Itemized in the table below is the hydraulic assessment criteria utilized on the existing facilities.

Table 7.1 – Hydraulic Assessment Criteria

Waterlines	**Velocity**	**Headloss**	**Other**
D < = 16"	< 5.0 fps	< 6' / 1,000 LF	Opportunity to Loop
D > 16"	< 5.0 fps	< 2' / 1,000 LF	Opportunity to Loop
Pressure	**Min Pressure Goal**	**Max Pressure Goal**	**Other**
All Junctions	40	80	> 20 psi @ Fire Flow; < 100 psi where possible
Storage	**Min Volume**		**Other**
All Tanks	= Avg. Day Flow		Promote adequate tank turnover rates to promote lower water ages
Pump Stations	**Min Flow**	**Discharge Pressure**	**Other**
All Station	= Max Day Flow	< 120	Provide redundancy on critical pump stations

8 Mallory Valley Utility District Assessment

As noted previously in this report, the City has the opportunity to connect to MVUD and purchase water from a third source. The available connection point for MVUD is geographically closest to the area with the greatest potential for future development (i.e. Split Log Road). Multiple improvements identified in the 2008 Plan were aimed at delivering water from the City's existing connections along Murray Lane and Johnson Chapel Road to the Split Log Road pressure zone. Consequently, if the City elects to connect to MVUD and purchases water from this third source, the necessity of some improvements identified in the 2008 Plan may be eliminated.

To evaluate the MVUD connection, improvements originally identified to carry water to the Split Log Road pressure zone from the existing connections with HVUD were revised with recent unit costs from past City of Brentwood waterline projects. A new model scenario was created to determine which, if any, of these improvements were no longer needed. To determine if a positive return on investment existed, the cost associated with connecting to MVUD and purchasing water at a higher rate was compared to the capital expenditures avoided.

The table below summarizes the comparative analysis completed and the calculated payback period.

Table 8.1 – Economic Impact of Mallory Valley UD Connection

Capital Projects Avoided	2008 MP Designation	2016 Estimated Construction Cost
Old Brooks Waterline	WL-7	$3,731,000
Southeast Transmission Main – Phase 1	WL-8A	$2,305,000
Alamo Road Water Line	WL-10	$717,000
Southeast Transmission Main – Phase 2	WL-11A	$3,391,000
New Capital Projects Required	**2016 MP Designation**	**2016 Estimated Construction Cost**
MVUD Meter Vault and Waterline	MV-01	$1,059,000
Wilson Pike Water Main	ST-02	$833,000
Operating Cost	**Annual Cost**	
Water Purchase		
1.0 MGD	$931,800	
Pumping		
1.0 MGD	-$20,100	
Change in Operating Cost (HVUD – MVUD)		
1.0 MGD	$911,700	

Based upon the values calculated in the table above, a 20-year net present value analysis was completed to estimate the long term cost implications of connecting to MVUD. The results of this analysis are provided below and indicate the city would incur increased costs if connected to MVUD.

Table 8.2 – 20-Year Net Present Value of MVUD Connection

Avoided Capital Costs	-$10,144,000
New Capital Projects Required	$1,892,000
Operating Cost	$18,234,000
Total Net Present Value of MVUD Connection	$9,580,000

Given the financial impacts of the MVUD connection, purchasing water from MVUD at this location does not appear to provide the City a return on its investment. Based upon the present value analysis, purchasing water from HVUD to the furthest extent possible appears to be in the best financial interest of the City. Consequently, the recommended improvements identified below continue to focus on moving water from the northwest portion of the system to the southeast portion of the service area, and alleviating the need of purchasing water from Metro Water Services when operating under normal conditions.

9 Assessment of Need and Recommended Improvements

9.1 Immediate Improvements (Max Day 12.18 MGD)

The City of Brentwood received an updated water purchasing agreement from Metro Water Services (MWS) which increases the City's purchase costs. The cost increase from MWS has caused the City to look at different alternatives to meet the demand of their consumers. This change primarily has a large effect on supplying the North Pressure Zone, and all Immediate Improvements recommended focus on the City's ability to meet the max day demands of this zone using water purchased from HVUD.

9.1.1 Granny White PRV (IM-01)

Installation of an 8-inch water line and a PRV across the Little Harpeth River, along Granny White Pike, will give The City the ability to back feed the North Pressure Zone. The model indicates a 120 psi set point on the PRV will be sufficient to meet the max day demands and keep the Skyline tanks within normal operating conditions. This option was evaluated because of the close proximity of the North and South Pressure Zones.

9.1.2 Old Smyrna Pump Station PRV (IM-02)

Utilization of existing infrastructure within the Old Smyrna Pump Station will add additional support to keep the Skyline Tanks operational. The model suggests a downstream set point of 55 psi will add additional capacity for the North Pressure Zone and provide the necessary turnover in the Chenoweth Tank. Through multiple model iterations this PRV does not have any adverse effects on the South Pressure Zone.

9.2 Short Term Improvements (Max Day 14.20 MGD)

9.2.1 River Oaks Pump Station Improvements (ST-01)

Under future max day conditions, the existing pumps at the River Oaks pump station cannot maintain tank levels in the Skyline Tanks. As such, the existing pumps will need to be replaced with higher capacity pumps. Depending on the motor size and impeller size, these improvements could be as simple as increasing the impeller diameter within the existing pump casing. When demands in the North Pressure zone necessitate the pump improvements, a more detailed engineering evaluation of the potential to increase the capacity without replacing the pumps should be completed.

Based upon the model simulations, as max day demands increase the River Oaks Pump Station will need to pump as much as 1,000 gpm. The existing station is sized at 700 gpm.

9.2.2 Mallory Park Lane Water Main (ST-02)

As noted previously, most of the anticipated residential growth is located in the Split Log Road zone. The City has already begun improvements within the Mallory Park Lane area as suggested in the recent Master Plan updates for the Southeast Transmission main. To alleviate the hydraulic limitations imposed by the existing 10-inch line, an additional 12-inch line should be constructed to connect Wikle Road West and Mallory Park Lane. This will allow The City to abandon the current 10-inch water line and improve the hydraulics for future demands with in the southeast portion of the South Pressure Zone.

9.3 Long Term Improvements (Max Day 16.98 MGD)

9.3.1 Southeast Transmission Main 2016 (LT-01A, LT-01B, and LT-01C)

The long term max day demands within the southeast portion of the South Pressure Zone causes hydraulic limitations on the system. The model suggests an extensive improvement that begins with upsizing the existing 14-inch water line, beginning at the intersection of Murray Ln and Franklin Rd, to an 18-inch water line continuing in a southern direction terminating at the intersection of Concord Rd and Franklin Rd (LT-01A). The proposed 18-inch water line will tie into the exiting 12-inch water line, continuing along Franklin Rd. The second portion of this improvement begins by upsizing the 8-inch water line, just south of Longstreet Dr, to a 12-inch water line which will continue south then head east along Wikle Rd (LT-01B) terminating at the beginning of ST-02. The final improvement to complete the Southeast Transmission Main, includes upsizing the existing water line under I-65 to a 12-inch water line. Upsizing additional lines to 12-inch water line will continue to just past the Alamo Rd and Knox Dr intersection. Additionally a new 12-inch line will need to be constructed between Covington Dr and Gordon Petty Dr (LT-01C). These improvements are projected to provide the necessary capacity to maintain operational levels in the Carriage Hills Tanks and meeting the demands in the Split Log Pressure Zone.

9.3.2 Wilson Pike Water Main (LT-02)

The existing 12-inch waterline along Wilson Pike between Twin Springs Drive and Crockett Road becomes hydraulically limiting under long term planning conditions. The model indicates this section of pipe has a headloss per 1,000LF of 7.21. The existing water line should be upsized to a 16-inch water line. This line will promote flow from north to south toward the Carriage Hills Tanks and the Split Log Pressure Zone.

9.3.3 Split Log Pump Station Improvements

Under future max day conditions, the existing pumps at the Split Log pump station cannot maintain tank levels in the Split Log Road reservoir. As such, the existing pumps will need to be replaced with higher capacity pumps. Depending on the motor size and impeller size, these improvements could be as simple

as increasing the impeller diameter within the existing pump casing. When demands in the Split Log Road zone necessitate the pump improvements, a more detailed engineering evaluation of the potential to increase the capacity without replacing the pumps should be completed.

9.4 Split Log Zone Improvements

The 2004 Plan outlined a general approach to the waterline improvements within the Split Log Road pressure zone. The approach called for a looped network as individual parcels developed and minimizing the number of long, dead-end lines. As new developments apply for water availability, the system needs should be identified on a case-by-case basis. The improvements identified in the 2004 Plan and reported below convey the conceptual plan for water mains in this zone. However, these improvements should be re-evaluated as parcels develop and modifications to the plan should be made for project specifics.

The following waterline improvements were identified in the 2004 Master Plan:

9.4.1 Northumberland Extension (SL-01)

This improvement extends an 8-inch waterline between Teri Sells Lane or Midlothian Drive in the Northumberland development and the 12-inch waterline filling the Split Log tank. The total length of the extension is estimated at 3,000 lf, though the final selected route will dictate the actual length of the extension. This line provides redundancy to the 12-inch line along Split Log Road and reduces the flow through this 12-inch section, as well as improving the fire protection capacity in the Northumberland and Raintree developments. This line will also provide infrastructure west of Ragsdale Road for future developments in this area of the zone.

9.4.2 Ragsdale Road Extension (SL-02)

The improvement extends a 12-inch waterline from the existing 12-inch waterline filling the Split Log tank east towards Ragsdale Road, extending through the Bellasara development and connecting to the existing 8-inch waterline in the Tuscany Hills development. The improvement would also include extending a 12-inch waterline north along Ragsdale Road to the zone's boundary. The improvements will provide infrastructure for future developments east of Ragsdale Road.

9.4.3 Tuscany Hills Extension (SL-03)

The improvement extends the existing 8-inch waterline in the Tuscany Hills development north and connecting to the Ragsdale Road extension described previously. This improvement provides a looped system for the developments east of Ragsdale Road and north of Split Log Road.

9.4.4 Charity Drive Extension (SL-04)

This improvement extending from the 8-inch waterline east from the termination of the existing Charity Drive waterline within the Inglehame development to the Pleasant Hill extension described below has been partially completed as development of Morgan Farms (formerly Azalea Park), Traditions, and Taramore continue to develop. The remainder of the extension ultimately connecting to a proposed line along Pleasant Hill Road could be completed and undertaken by developers as the system develops in this area. This waterline aims to provide redundancy to the areas south of Split Log Road and provide a looped system for the developments described above.

9.4.5 Pleasant Hill Extension (SL-05)

This improvement would extend an 8-inch waterline from the termination of the existing 12-inch waterline along Split Log Road. The new waterline will extend south from Split Log Road and connect to the Charity Drive Extension described previously. This waterline would provide infrastructure that will allow additional parcels west of Pleasant Hill Road to develop. This also completes a larger looped system for the entire pressure zone constructed with the intent of improving available fire protection capacity for the developing areas and reducing the potential to create stagnant water in the zone.

9.5 Raintree Parkway Regional Storage Tank

A water availability request in 2014 for the parcel located at 9315 Crockett Road (submitted as Holt Crest) showed that fire protection could not be sustained by the existing infrastructure for the entirety of the property. Some locations within the proposed development required a higher hydraulic grade to meet minimum pressure requirements under high flow conditions. The analysis evaluated the potential of serving these higher areas of the development from the existing Raintree Tank No. 1 with an overflow elevation of 989.43'. However, pressure losses between the tank and the proposed development precluded the viability of this option.

As a result of these findings, a larger hydraulic analysis of this area was included in the 2016 Update. This analysis considered the construction of a regional tank that could serve the proposed development and other areas like it along Raintree Parkway that could not be served by the City's main pressure zone. The analysis considered the potential parcels that could see development and accounted for those areas that would be limited by hillside protection overlay.

The hillside protection overlay was adopted with the intent of maintaining the natural, topographic character of the land as development continues. The overlay protects steep grades from being developed and requires that density of the housing units be no denser than one (1) unit per every three (3) acres. Much of the area that was considered in the hydraulic analysis is included in the hillside protection overlay. Consequently, development will be limited in scope within the area along Raintree Parkway.

Table 9.1 – Raintree Parkway Region Demand Calculations

Parcel No.	Total Area, Acres	Area Included in Hillside Protection Overlay, Acres	Potential Units Developed, Qty.	Annual Average Demand, GPD	Max Day Demand, GPD
054 03704	53	26	35	44,350	105,553
035 02200	266	47	247	300,870	716,070
Totals	**319**	**73**	**282**	**345,220**	**821,623**

The proposed tank was sized to provide equalization storage, fire protection storage, and emergency storage. Equalization storage was calculated at 30% of the total average daily demand (ADD). This percentage typically ranges between 20 and 40% of the ADD. A fire flow of 2,000 gpm was utilized as the desired fire flow. Emergency storage is also typically calculated based upon a percentage of the ADD. Our calculations utilized a factor of 20%. Tank sizing calculations are summarized in the table below.

Table 9.2 – Raintree Parkway Regional Tank Sizing

Annual Average Demand, GPD	Equalization Storage (30% of ADD), Gal	Fire Protection Storage (2,000 gpm @ 120 mins), Gal	Emergency Storage, (20% of ADD), Gal	Total Storage, Gal
345,220	103,600	240,000	69,000	412,600

Based upon the hydraulic analysis, constructing a new 0.5 MG storage tank within the proposed Holt Crest development (Red Connector, Raintree Pkwy Tank project sheet) appears to be the first logical step in creating a larger high pressure zone surrounding Raintree Parkway. This tank could be constructed with an overflow elevation equal to the overflow elevation of the existing Raintree No. 1 tank. Constructing the new tank to operate at similar water surface elevations will provide sufficient pressure to the higher locations within the area in question while preventing excessive pressures from being developed at lower elevation. Additionally, similar hydraulic grade lines could allow the two tanks to be hydraulically linked (Purple Connector, Raintree Pkwy Tank project sheet) to create a larger higher pressure zone in the future as development in the area requires it. This larger pressure zone (Yellow Boundary, Raintree Pkwy Tank project sheet) would likely require transitioning the low pressure line along Raintree Parkway to the high pressure zone to help serve other developing areas in the region.

A new pump station designed to fill the new storage tank would be required. This station would initially be sized to provide 650 gpm at a total dynamic head of 75'. Space for increasing the station capacity could be provided to meet future demands as they occur.

10 Landscape and Turf Grass Irrigation

Landscape and turf grass irrigation of private residential homes is a driving factor on daily system consumption, especially during the warmer summer months. Reviewing historical annual billing data, irrigation rates equal to 1,800 to 2,300 gpd per residence have been consumed in the past in areas of new residential construction. Conversely, typical domestic water consumption per residence in the City's service area is 310 gpd. As such, landscape and turf grass irrigation plays a more significant role in determining the necessary improvements of the distribution system.

As part of the 2008 Plan, the residential irrigation rates within the City of Brentwood were compared to a theoretical irrigation rate based upon the EPA's WaterSense® approach. This method calculates an estimated amount of water that is needed to maintain healthy landscape plantings and turf grass based upon the type of plantings/turf, the specific environmental conditions of the site, and a percentage of the precipitation received at the site. Evapotranspiration is the loss of water from the ground surface caused by evaporation and plant transpiration. In short, this method determines the additional water needed by the site by balancing "lost" water through evaporation and plant transpiration with the water "gained" by useful precipitation.

Most of middle Tennessee resides in a humid continental region with warm summers. We obtained on evapotranspiration rates and precipitation for the City of Brentwood using the EPA's Water Budget Data Finder (database of evapotranspiration and precipitation data between 1961 and 1990). Review of this data set June as the peak watering month for the City of Brentwood. The peak watering month is defined as the month where the difference in evapotranspiration and precipitation is the greatest. In June, the monthly evapotranspiration and precipitation are 6.39 and 3.31 inches/month, respectively. This results in a net shortage of water, meaning the landscape requires additional water to meet its needs.

We assumed a cool season turf grass (i.e. Kentucky bluegrass, tall fescue, or similar) with a medium water requirement to calculate a conservative irrigation rate for a typical 1-acre residence in Brentwood's developing areas. This irrigation rate varies based upon the extent of non-vegetated softscape, plant types, useful rainfall allowed, and efficiency of the irrigation system. The table below presents the outcome of using EPA's WaterSense® method and compares the calculated rates to the historical rates experienced by the City.

Table 10.1 – Residential Landscape and Turf Irrigation Rates

Historical Irrigation Rates, gpd	Calculated Irrigation Rates[1]			
	25% Useful Rainfall 65% Irrigation Efficiency	50% Useful Rainfall 65% Irrigation Efficiency	25% Useful Rainfall 70% Irrigation Efficiency	50% Useful Rainfall 70% Irrigation Efficiency
1,800 – 2,300 gpd	4,000 gpd	3,075 gpd	3,715 gpd	2,855 gpd

Notes:

1. Assumes that 82% percent of the 1-acre lot is irrigated to some degree. 76% of the entire 1-acre lot is assumed to be turfgrass with medium water requirements.
2. Useful rainfall is defined as the percentage of the monthly rainfall that is used by turfgrass, trees, and plantings within the landscape. This assumes that some percentage of rainfall cannot be used by the landscape because of heavy rainfall events that exit the landscape prior to infiltrating the soil.

Based upon the estimated water requirements using EPA's WaterSense tool, the calculated irrigation rates exceed the historical rates. Consequently, the irrigation rates experienced by the City do not appear to be excessive for a 1-acre lot in middle Tennessee. However, a number of variables and assumptions have been made to arrive at the calculated rates. Changes in these variables, especially the percentage of turfgrass irrigated, will have a noticeable impact on these calculated irrigation rates.

More importantly, the calculation suggests that irrigation rates assumed within the 2016 Plan are appropriate, and though the City may see some reduction of these rates by implementing some public awareness programs or limiting the frequency of irrigation, the City should be prepared to improve the water infrastructure as necessary to meet the historical irrigation rates.

11 Drought Management Plan

The City of Brentwood utilizes a drought management plan aimed at managing water supply resources on a city-wide and regional basis during periods of water supply shortages. The plan originally adopted in March of 2011 has four phases of response based upon the severity of the water supply shortages. Following a drought event, regardless of what phase is reached, the Water Service Department director will review all conditions and activities immediately preceding the drought event. This review will aim at identifying necessary updates or modifications to the drought management plan.

The plan also distinguishes between critical uses and optional uses to ensure that water is available for human consumption, in particular for those residing in elderly care and assisted living facilities. The four phases and associated triggerpoints, communications, and monitoring activities are summarized in the table below.

Table 11.1 – Summary of Drought Management Plan

Phase	Triggerpoint (Supply)	Triggerpoint (Demand)	Reduction Goal	Customer Communication	Monitoring Activities
Drought Alert	Cheatham Reservoir level falls to 382.00' for over 48 hours.	Daily demand is >90% of projected peak day demand for 2 or more days	None	• Post notice on City website • Communicate daily with suppliers	• Refer to Drought Monitor Website for updates and information • Review customer billing records to determine largest irrigation users • Monitor USACE website for changes in Cheatham Reservoir level
Voluntary Reduction	Cheatham Reservoir level falls to 381.50' for over 48 hours.	Daily demand is >100% of projected peak day demand for 2 or more days	Reduce to projected peak day demand. No additional specific reduction unless mandated by HVUD	• Post notice on City website • Notify largest irrigation users that the City has entered into the Voluntary • Reduction Phase of its Drought Management Plan. • Communicate daily with suppliers	• Refer to Drought Monitor Website for updates and information • Review customer billing records to determine largest irrigation users • Monitor USACE website for changes in Cheatham Reservoir level • Contact adjoining water systems regarding the possibility of supplementing supply through temporary measures.
Mandatory Reduction	Cheatham Reservoir level falls to 381.00' for over 48 hours.	Daily demand is >110% of projected peak day demand for 2 or more days	Reduce to 90% projected peak day demand.	• Post notice on City website • Notify local media • Notify all users that outdoor watering / non-essential use is limited to Tuesday, Thursday and Sunday • Communicate daily with suppliers	• Refer to Drought Monitor Website for updates and information • Review customer billing records to determine largest irrigation users • Monitor USACE website for changes in Cheatham Reservoir level • Contact adjoining water systems regarding the possibility of supplementing supply through temporary measures. Implement as feasible and necessary. • Maintain contact with TDEC.

Table 11.1 – Summary of Drought Management Plan

Phase	Triggerpoint (Supply)	Triggerpoint (Demand)	Reduction Goal	Customer Communication	Monitoring Activities
Emergency	Cheatham Reservoir level falls to 378.50' for over 48 hours.	Not Applicable. Will be directed by HVUD and/or MWS	Reduce to 80% projected peak day demand.	• Post notice on City website • Place notification call to all customers using reverse 911 system • Notify all users that outdoor watering / non-essential use is limited to Tuesday, Thursday and Sunday • Communicate daily with suppliers	• Refer to Drought Monitor Website for updates and information • Review customer billing records to determine largest irrigation users • Monitor USACE website for changes in Cheatham Reservoir level • Contact adjoining water systems regarding the possibility of supplementing supply through temporary measures. Implement as feasible and necessary. • Maintain contact with TDEC. • Activate TN WARN system • Obtain supplemental water if feasible from adjoining systems

Notes:

1. Taken from City of Brentwood Drought Management Plan. Source: https://brentwood-tn.org/modules/showdocument.aspx?documentid=3323

12 Total Cost of Master Plan

The table below compares the total cost of all master plan improvements as originally proposed in 2008 and within the 2016 update. All estimated construction costs for 2008 Plan improvements have been revised to reflect current pricing.

Table 12.1 – Estimated Total Cost of Master Plan

Improvements	2008 Master Plan[1]	Improvements	2016 Master Plan Update
WL-07A	$6,277,000	IM-01	$155,000
WL-08A	$2,998,000	IM-02	$0
WL-09	$3,018,000	ST-01	$390,000
WL-10	$868,000	ST-02	$868,000
WL-11	$3,398,000	LT-01A	$2,292,000
SL-01	$642,000	LT-01B	$1,585,000

Table 12.1 – Estimated Total Cost of Master Plan

Improvements	2008 Master Plan	Improvements	2016 Master Plan Update
SL-02A	$1,431,000	LT-01C	$2,382,000
SL-02B	$408,000	LT-02	$2,063,000
SL-03	$493,000	SL-01	$642,000
SL-04	$1,783,000	SL-02	$1,431,000
SL-05	$872,000	SL-03	$493,000
IM-01	$862,000	SL-04	$1,783,000
IM-02	$325,000	SL-05	$872,000
IM-03	$272,000		---
IM-04	$688,000		---
River Oaks PS Improvements	$390,000		---
Estimate Total Cost of Master Plan	$24,725,000		$14,956,000
Change in Total Cost (2008 to 2016)	(-$9,769,000)		

The following notes and clarifications are offered for the total cost calculates summarized above:

- All 2008 Plan improvement costs have been adjusted to reflect current 2016 pricing.
- Improvements WL-07A and WL-08A are alternate routes for the improvements originally identified in the 2008 Plan as WL-07 and WL-08. These revised routes attempt to minimize construction cost by coinciding the installation of the waterlines with scheduled road-widening projects along Franklin Road. The revised routes maintain the original concepts outlined in the original plan.
- The cost of improving the River Oaks Pump Station does not include the cost for acquiring additional land. If the new station will be relocated from its existing site, purchase of additional land will increase the total cost of the project.
- Split Log Road improvements (SL-01, -02, -03, -04, -05) were not changed by updates to the population and demand projections. As such, they appear in the total cost of both plans.
- Split Log Road improvement SL-02 was divided into two sections in the 2008 Report (i.e. SL-02A and SL-02B). During analysis of the Split Log Zone as part of the 2016 Update, the second phase (-02B) included in the 2008 Report was no longer deemed necessary. As such, only the cost of SL-02A (designated simply by SL-02) is included in the 2016 Plan total.
- The improvements listed under the 2016 Master Plan Update does not include a price for the Old Smyrna PS PRV (IM-02) because all the infrastructure is in place.

- The Split Log improvements are still within the update and have been revised for 2016 construction costs.

- The total cost of the 2008 and 2016 Plans do not incorporate the cost of improvements identified in the 2008 Plan that have been completed or currently being constructed.