Water Master Plan

Lee's Summit, Missouri

October 24, 2006

Bartlett & West Project Number 14706.001

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EXECUTIVE SUMMARY

Lee's Summit continues to grow at a pace that challenges the water supply capacity during the summer demand season. This Water Master Plan updates the 2002 Plan by using current population projections and a hydraulic model calibrated against 2005 demand and system data. The results include recommendations for capital improvements to meet customer needs for the next 10 years and ultimate build-out. The goals in developing these improvements were to provide an orderly plan, improve reliability, simplify operations and maximize the use of existing facilities.

The maximum day demand in the summer of 2006 was 25.4 MGD. The total contracted supply capacity was 21.5 MGD. Planned improvements over the next several years will increase the supply capacity in two phases to 27.5 MGD and then 34.5 MGD. Maximum day demands are projected to increase by 0.9 MGD per year. If growth and demand patterns continue as projected, additional supply will be needed by 2010, 2013 and 2024.

The opinion of probable cost for the recommended improvements over the next 10 years is summarized in Table 1.

Table 1 - Opinion of Probable Costs Next 10 Years

Description	Opinion of Probable Cost	Percent of Total
Tap Fee (Lee's Summit)	$48.2 million	70%
Tap Fee (Water District 14)	$4.2 million	6%
Road Projects	$10.7 million	16%
Maintenance	$5.6 million	8%
Total	$68.7 million	

Recommendations are summarized as follows:

1) Encourage water conservation through public education and rates.

2) Complete negotiations with Kansas City to develop the East Terminal supply projects. The transmission line, pump station and storage facilities are needed by 2013.

3) Complete these significant projects in the next 10 years (additional projects are included on Table 9):

    a. North System Supply Improvements by 2007

    b. South Terminal East Discharge by 2007

    c. KCMO Phase III by 2007

    d. Low Head Storage at South Terminal by 2008

    e. Phase IV by 2010

    f. East Leg and East Terminal by 2013

    g. Internal transmission projects by 2013

4) As the Lee's Summit Road corridor project develops, obtain easements for the transmission lines indicated on Figures 7 and 8.

5) Pursue additional water supplies for 2024. Evaluate three alternatives by the end of 2007. Select the best alternative by the end of 2008. Negotiate an agreement by 2010.

6) Leverage new and developing resources in the City's geographical information system and data management software to quantify and predict renewal needs.

7) Monitor the assumptions made in this analysis. Update the demand and population projections annually. Update this Master plan as necessary to incorporate new information or deviations from the assumptions and projections.

INTRODUCTION

This report fulfills the requirements of the City of Lee's Summit (City), Agreement RFP 05-175. This report, written by Bartlett & West Engineers (Bartlett & West), is an evaluation of water system facilities as they exist today and as proposed to meet future demands. In summary, the scope of items included in this report is as follows:

- Update the existing water system computer model.
- Update the 2002 Master Plan.
- Make population projections consistent with other City departments, for future growth.
- Make recommendations for water supply and distribution system improvements required to meet existing service needs and future service needs for the next ten years.
- Provide phasing recommendations and opinions of probable cost for these improvements.

The goals in developing recommended improvements include:

- Provide an orderly plan for constructing water system facilities to accommodate a rapidly growing population.
- Increase reliability, simplify operation and maximize the value of existing facilities.

EXISTING SYSTEM

Lee's Summit's water distribution system is divided into three systems including the Supply System, North System and South System. Figure 1 is a schematic drawing of all three systems. Lee's Summit also supplies water to Water District 14 along it's southeastern border.

The Supply System includes the metered connections to the water supplies from the Kansas City and Independence and the transmission lines within Lee's Summit that supply water to the North and South Systems. The transmission lines are shown on Figure 1. Physical data describing the supply connections are summarized in Table 2.

Table 2 – Existing Supply Facilities

Name	Current Function	Quantity (MGD)	Supplier	HGL[1] (ft)
May brook Road	Supply North System and Chipman and Douglas Reservoirs	7.5	Independence	1040
Veil Road	Supply North System and Chipman and Douglas Reservoirs		Independence	1040
Lakewood Blvd.	Supply North System and Chipman and Douglas Reservoirs	7.0	Kansas City	1115
Gregory Blvd.	Supply North System and Chipman and Douglas Reservoirs		Kansas City	1075
Lee's Summit Road	Supply Chipman and Douglas Reservoirs		Kansas City	1075
South Terminal	Supply South Terminal	7.0	Kansas City	1040
Scherer Road	South System (Seasonal)	Emergency	Kansas City	1185
Highway 150	South System (Seasonal)	Emergency	Kansas City	NA
Sampson Road	South System (Seasonal)	Emergency	Kansas City	NA
Unity Village	Abandoned	No Data	Kansas City	NA

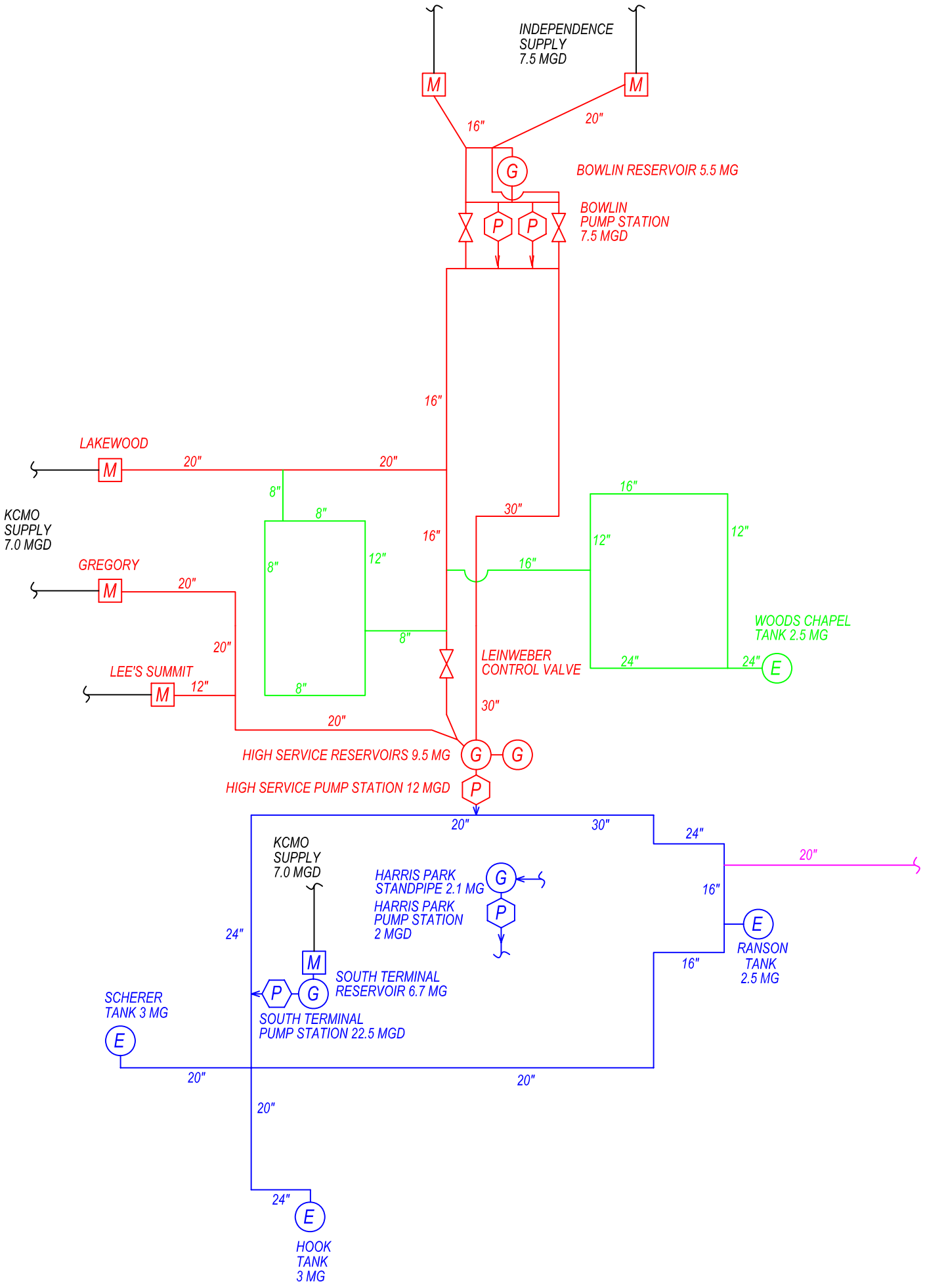
Notes: 1. HGL = Hydraulic Grade Line.

LEGEND

- G — GROUND STORAGE
- E — ELEVATED STORAGE
- P — PUMP
- M — MASTER METER
- CONTROL VALVE
- FACILITY BELONGING TO OTHERS
- SUPPLY SYSTEM
- NORTH SYSTEM
- SOUTH SYSTEM
- WATER DISTRICT 14

N

NO SCALE



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Existing System Schematic

Figure

1

Water is supplied to the North System from Kansas City and Independence. The Kansas City supply is delivered through the Lakewood meter near Lakewood Boulevard and Lee's Summit Road. The Independence supply is delivered through the Bowlin Road pump station located at the toe of the West Lake dam through two meters located near Anderson Road and Maybrook Road. Equalizing and emergency storage are provided by the Woods Chapel Elevated Tank, just east of I-470. The Bowlin Road Pump Station operates to maintain the level in the Woods Chapel Tank. Any excess water not used in the North System can be fed to the South System through the Leinweber Control Valve. Supply from either the Lakewood Meter or the Bowlin Road Pump Station can also be diverted directly to the South System via transmission lines feeding the reservoirs at Chipman and Douglas.

Water is supplied to the South System from Kansas City and Independence. The Kansas City supply is delivered through two meters along Lee's Summit Road and a meter at the South Terminal Pump Station and Storage Facility near Persels and Ward Roads. The meters along Lee's Summit Road are located at the intersections with Gregory Boulevard and the City boundary south of Strother Road. Water delivered to the High Service Pump Station is first stored in the 4.0 million gallon (MG) and 5.5 MG storage reservoirs at Chipman and Douglas. Water delivered to the South Terminal Pump Station is first stored in the 6.7 MG ground storage tank at the South Terminal Pump Station and Storage Facility. All the water supplied to the South System is pumped through the High Service Pump Station and the South Terminal Pump Station to maintain the levels in three elevated tanks. The three elevated tanks include the 2.5 MG tank on Ranson Road, the 3.0 MG tank on Scherer Road and the recently completed 3.0 MG tank on Hook Road. The Harris Park Pump Station and Standpipe provides supplemental equalizing and emergency storage.

Physical data on the storage and pumping facilities in both the North and South Systems are summarized in Tables 3 and 4. The total storage volume is 31.8 MG.

Table 3 – Existing Storage Facilities

Name	Size (MG)	Facility Type	Overflow Elevation	Diameter (ft)	Head Range (ft)	Current Status	In Service (Year)
Harris Park	2.1	Standpipe	1183[1]	54	127	Seasonal	1960
Chipman and Douglas	4.0	Ground	1052	167	25	Active	1970
Chipman and Douglas	5.5	Ground	1052	194	25	Active	1979
Bowlin	5.5	Ground	853	140	48	Standby	1980
Ranson	2.5	Elevated	1213	108	44	Active	1991
Woods Chapel	2.5	Elevated	1120	105	45	Active	1999
Scherer	3.0	Elevated	1213	124	40	Active	2000
South Terminal	6.7	Ground	1035	120	35	Active	2002
Hook	3.0	Elevated	1213	124	40	Active	2006

Notes: 1. Fill pipe elevation in the standpipe is 1174.

Table 4 - Existing Pumping Facilities

Pump Station	Pump No.	Flow (gpm)	Nominal Discharge HGL (ft)	TDH[1] At Rated Flow (ft)	Firm Capacity[2] (MGD)	Motor H.P.	Notes
High Service	1	5,000	1,260	218	20	350	Fills Ranson Tank and Harris Park Standpipe from the Chipman and Douglas Reservoirs. Constructed in 1970. Upgraded in 1999.
	2	5,000	1,260	218		350	
	3	5,000	1,260	218		350	
	4	5,000	1,260	218		350	
Harris Park	1	2,000	1,260	150	3	125	Pumps water from Harris Park Standpipe during peak demand periods. Constructed in 1991. Rehabilitated in 1998.
	2	2,000	1,260	150		125	
Bowlin Road	1	2,800	1,160	55	4	75	Pumps from Independence to the Woods Chapel Elevated Tank.
	2	2,800		55		75	
	3	4,800		330		500	
South Terminal	1	5,000	1,235	200	20	500	Pumps from South Terminal Reservoir to Scherer Tank and Hook Tank. Constructed in 2002.
	2	5,000	1,235	200		500	
	3	5,000	1,235	200		500	
	4	5,000	1,235	200		500	

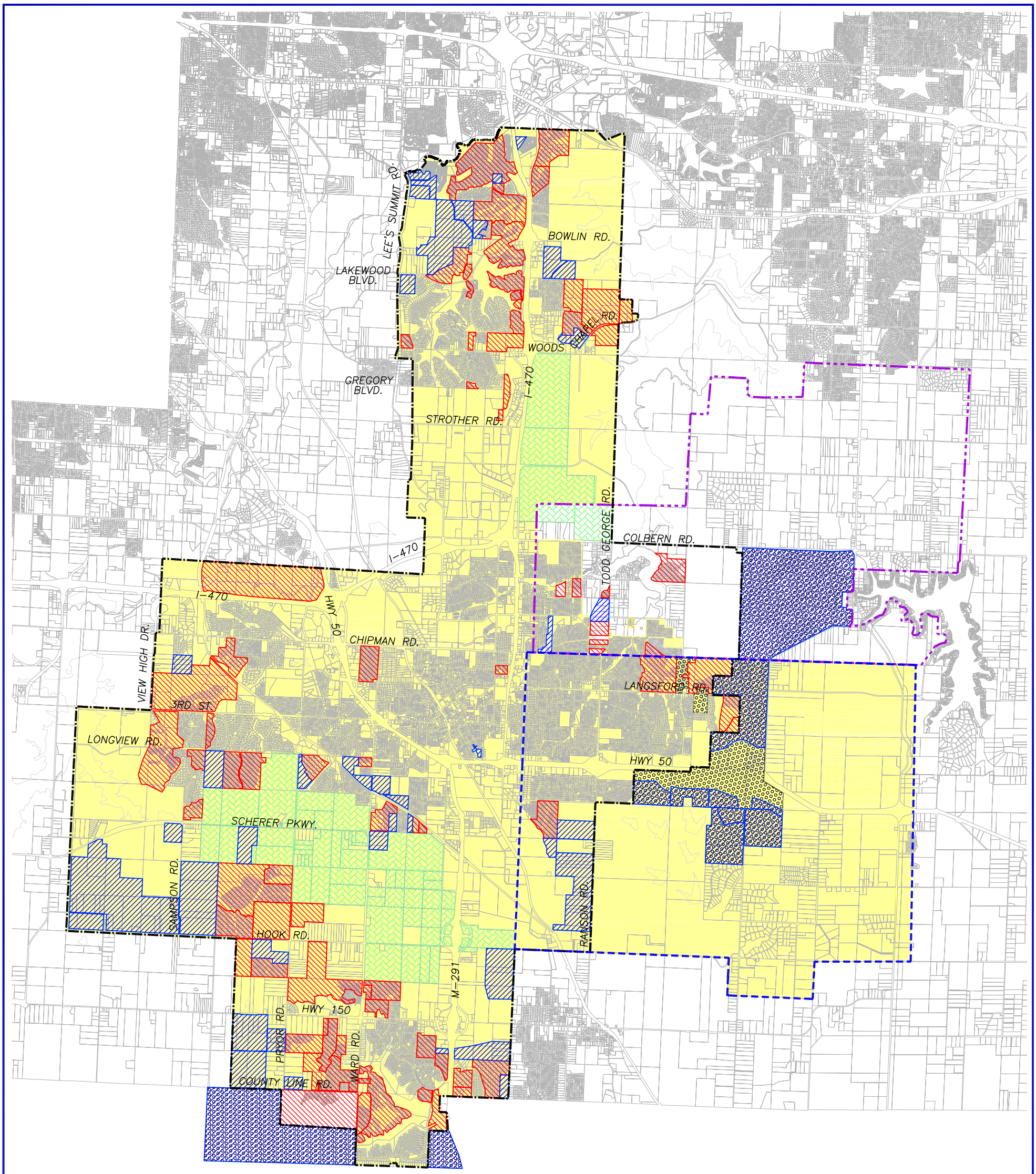
Notes: 1. TDH = Total Dynamic Head.

2. Defined as the total capacity with the largest pump out of service.

STUDY AREA

The area considered in this report includes the present corporate boundaries of Lee's Summit and the current boundaries of Jackson County Public Water Supply District No. 14 (District 14) as indicated on Figure 2. Overlapping areas of Jackson County Public Water Supply District No. 13 (District 13) and the City not currently served by the City are assumed to be served by District 13. Actual negotiations between the City and District 13 may require updates to this assumption in future Master plans. The City's Planning and Development Department compiled a map titled *Growth Projections to 2015 and Build-out* dated May 2006 along with an accompanying data spreadsheet.

Each area is labeled on Figure 2 as PRI property, Active Residential Area, Annexation Potential or Future Build-out Projection Area. All of these areas were included in the study area except the areas in District 13 and the areas for potential annexation south of County Line Road and west of Ward Road which are served by Cass County Public Water Supply District No. 3 (Cass 3). Note that the study area differs significantly from the city limits. The study area includes only those areas with potential water consumption from the Lee's Summit water distribution system. This includes some areas outside of the city limits and does not include some areas within the city limits.



Map Legend

- STUDY AREA
- LEE'S SUMMIT CITY LIMITS
- WATER DISTRICT 14
- WATER DISTRICT 13
- PRI PROPERTY
- ACTIVE RESIDENTIAL AREA
- ANNEXATION POTENTIAL
- FUTURE BUILDOUT PROJECTION AREA

NO SCALE

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Study Area

Figure 2

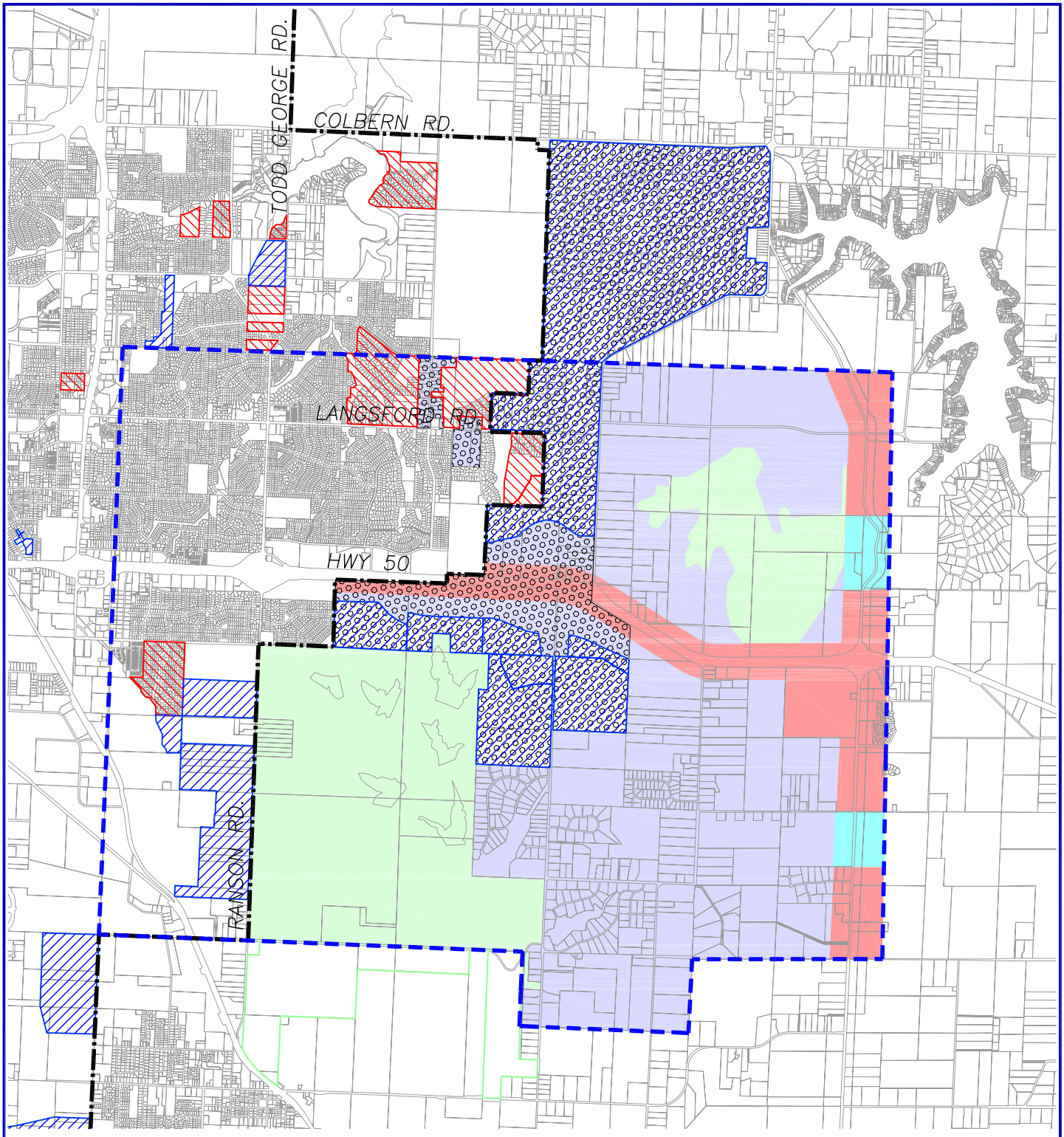
PLANNING CRITERIA

The basic information needed for this report relates to water use for consumption, irrigation, domestic use and fire protection. Population projections and growth patterns determine where the water is needed. Projected maximum day demands and the fire flow requirements determine the amounts of water needed.

Population Projections

Population projections and development patterns within Lee's Summit and potential annexation areas are described in the City's map titled *Growth Projections to 2015 and Build-out* and the accompanying spreadsheet dated May 2006. Lee's Summit also supplies water and operational support to Public Water Supply District 14 which is not fully considered in the City's growth projections. This report considers all populations served water by the City. Some of that population lies outside of the city limits (primarily District 14) and some of the population within the city limits is not served water by the City (portions of District 13). For the purposes of this document, the future population and land use of Water District 14 outside of Lee's Summit is assumed to be as shown on Figure 3. Other information considered included the current zoning maps and interviews with the Planning and Development staff and the Development Coordinator.

Table 5 compiles population and maximum day water demand information from 1998 to the ultimate build-out population. It is understood that the PRI property will not be developed in the foreseeable future but that eventually it may be developed. Population numbers shown in Table 5 do not include development of the PRI property until ultimate build-out (last line of Table 5). The PRI property represents a potential 27,000 additional residents. The population projections are used along with per capita demand estimates and maximum day to average day ratios to project maximum day water demands. In Lee's Summit, these demands are influenced by population,



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Water District 14 Land Use Map

Figure

3

Table 5 - Population and Water Demands (MGD)

			Actual Data			Projections					
Year	Population[1]	Usage GPCD[5]	Avg. Day (MGD)	Max. Day (MGD)	Max-Avg Ratio	North & South[2] (MGD)[9]	Wholesale Contracts[7] (MGD)	Technology Campus[8] (MGD)	Avg. Day (MGD)	Max. Day (Low)[3] (MGD)	Max. Day (High)[4] (MGD)
1998	65,139	---		16.0							
1999	68,101	---		18.0							
2000	71,064	135	9.6	17.6	1.83						
2001	74,026	124	9.2	18.7	2.03						
2002	76,989	142	10.9	20.5	1.88						
2003	79,951	131	10.5	25.6	2.44						
2004	82,913	110	9.1	15.4	1.69						
2005	85,876	125		19.7		10.7	0.3	1.0	12	23	28
2006	88,838	125		25.4		11.1	0.3	1.0	12	24	29
2007	91,801	125				11.5	0.0	1.0	12	24	29
2008	94,763	125				11.8	0.0	1.0	13	25	30
2009	97,726	125				12.2	0.0	1.0	13	25	31
2010	100,688	125				12.6	0.0	1.0	14	26	32
2011	103,650	125				13.0	0.0	1.0	14	27	33
2012	106,613	125				13.3	0.0	1.0	14	28	33
2013	109,575	125				13.7	0.0	1.0	15	28	34
2014	112,538	125				14.1	0.0	1.0	15	29	35
2015	115,500	125				14.4	0.0	1.0	15	30	36
2016	118,462	125				14.8	0.0	1.0	16	31	37
2017	121,425	125				15.2	0.0	1.0	16	31	38
2018	124,387	125				15.5	0.0	1.0	17	32	39
2019	127,350	125				15.9	0.0	1.0	17	33	40
2020	130,312	125				16.3	0.0	1.0	17	34	41
2021	133,274	125				16.7	0.0	1.0	18	34	41
2022	136,237	125				17.0	0.0	1.0	18	35	42
2023	139,199	125				17.4	0.0	1.0	18	36	43
2024	142,162	125				17.8	0.0	1.0	19	37	44
2025	145,124	125				18.1	0.0	1.0	19	37	45
2026	148,087	125				18.5	0.0	1.0	20	38	46
2027	151,049	125				18.9	0.0	1.0	20	39	47
2028	154,011	125				19.3	0.0	1.0	20	40	48
2029	156,974	125				19.6	0.0	1.0	21	40	49
2030	159,936	125				20.0	0.0	1.0	21	41	49
Ult.[11]	**184,500**	**125**				**23.1**	**0.0**	**1.0**	**24**	**47**	**57**
Ult.[12]	**211,500**	**125**				**26.4**	**0.0**	**1.0**	**27**	**54**	**65**

Notes:

1. Population projection based on the Lee's Summit Planning & Development "Growth Projections to 2015 and Buildout" map.
2. Includes Water District 14
3. Assuming a Maximum Day to Average Day ratio of 2.0
4. Assuming a Maximum Day to Average Day ratio of 2.4 and 1.5 MGD (full contract amount) at the Lee's Summit Technology Campus.
5. The Usage in Gallons per capita per day for 1998 was shown based on actual data. Per capita demands after 2005 are assumed to increase by 1 gpcd and then level off at 125 gpcd.
6. Information provided by City Staff.
7. Assuming that connections to wholesale customers are discontinued
8. Maximum = 1.5 MGD, Minimum = 0.4 MGD (375,000 gallons per day).
9. MGD = Million Gallons Per Day
10. GPCD = Gallons Per Capita Per Day
11. Without PRI property included. All demands thru 2030 do not include PRI property development.
12. With PRI property included

development and irrigation practices. The projected annual water demands for Lee's Summit are listed in Table 5.

Water Usage

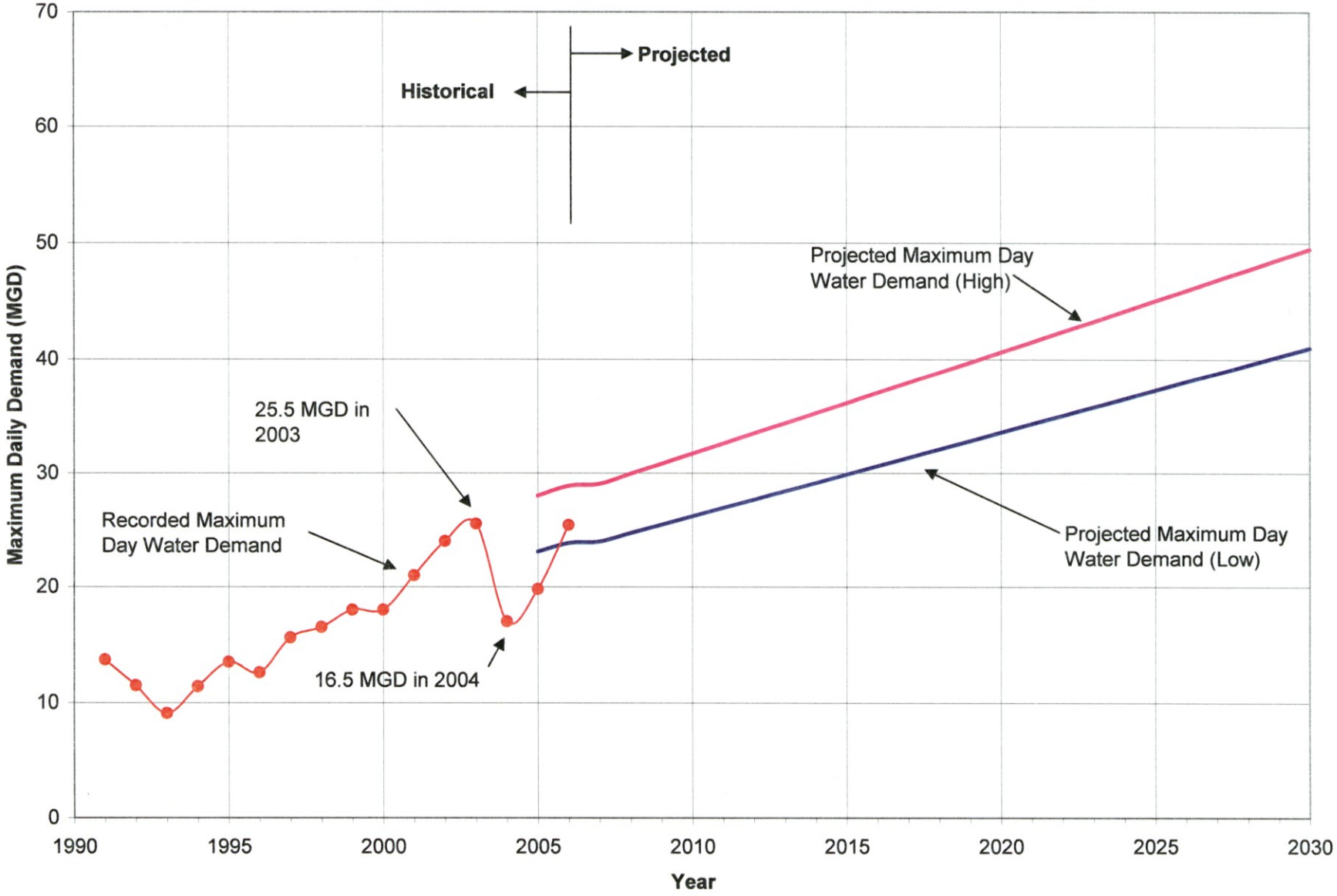
Figure 4 plots the historical and projected maximum day water demands. The steady increase in water demands over time relates directly to the steady population growth during the same time period. Erratic fluctuations in the actual maximum day demands relate to rainfall and temperature patterns in the summer months from May to September. These influences are demonstrated in comparing the actual summer demands between 2003 and 2004. The summer of 2003 was relatively hot and dry resulting in a maximum day water demand of 25.6 MGD. The summer of 2004 was relatively wet and cool resulting in a maximum day demand of 15.4 MGD.

The projections are presented in a range to account for these historical influences. The early projections immediately after 2005 are flat because the loss of wholesale customers offsets the increase in population growth. Actual demands can vary significantly depending on the actual growth rates, weather patterns and types of development, especially large water using industries. These maximum day demand ranges are 6 to 10 MGD higher than projections completed in 2004 *Water Supply Alternatives Study* by Bartlett & West Engineers for two reasons:

- The *Growth Projections to 2015 and Build-out* map indicates higher density development within Lee's Summit as compared to prior planning documents.
- This plan assumes medium density (10 people per acre) development in Water District 14 where prior plans have assumed low densities (5 people per acre). The revised assumption is more consistent with recent development proposals.

Another aspect of water demand to be considered as part of the planning criteria is fire flow. The required fire flow for a given area is based on zoning. Areas with a potential for larger fires require a greater minimum available fire flow for longer

Figure 4 - Historical and Projected Maximum Day Demands



duration. The fire flow criteria used for each of the zoning types are indicated in Table 6. Every parcel of land in the study area was classified as either residential, commercial, or industrial. Areas that could not meet the fire flow criteria in the table were identified using the model.

Table 6 – Fire Flow Criteria

Zoning	Fire Flow (gpm)	Duration (hours)
Residential	1,000[1]	1
Commercial	1,500[1]	2
Industrial	3,500[2]	3

Notes: 1. Source: Lee's Summit Design and Construction Manual.
2. Source: Highest fire flow considered by the Insurance Services Office
3. gpm is the abbreviation for gallons per minute.

As actual events occur that differ from the assumptions in this report, the plan should be updated. Examples of changes include new wholesale customers, revisions to current zoning plans, changes in the service arrangements to Water District 14, etc.

Water Supply

Lee's Summit is supplied water from the Cities of Independence and Kansas City, Missouri. Since the early 1990's, increases to the overall supply have come from the City of Kansas City. As the population continues to grow, additional supplies will be needed in 2010, 2013 and 2024. Kansas City continues to offer the most economical and readily available opportunity to increase water supplies in the next 10 years. Beyond the next 10 years, other viable supply sources include the City of Independence and Tri-County Water Authority (TCWA).

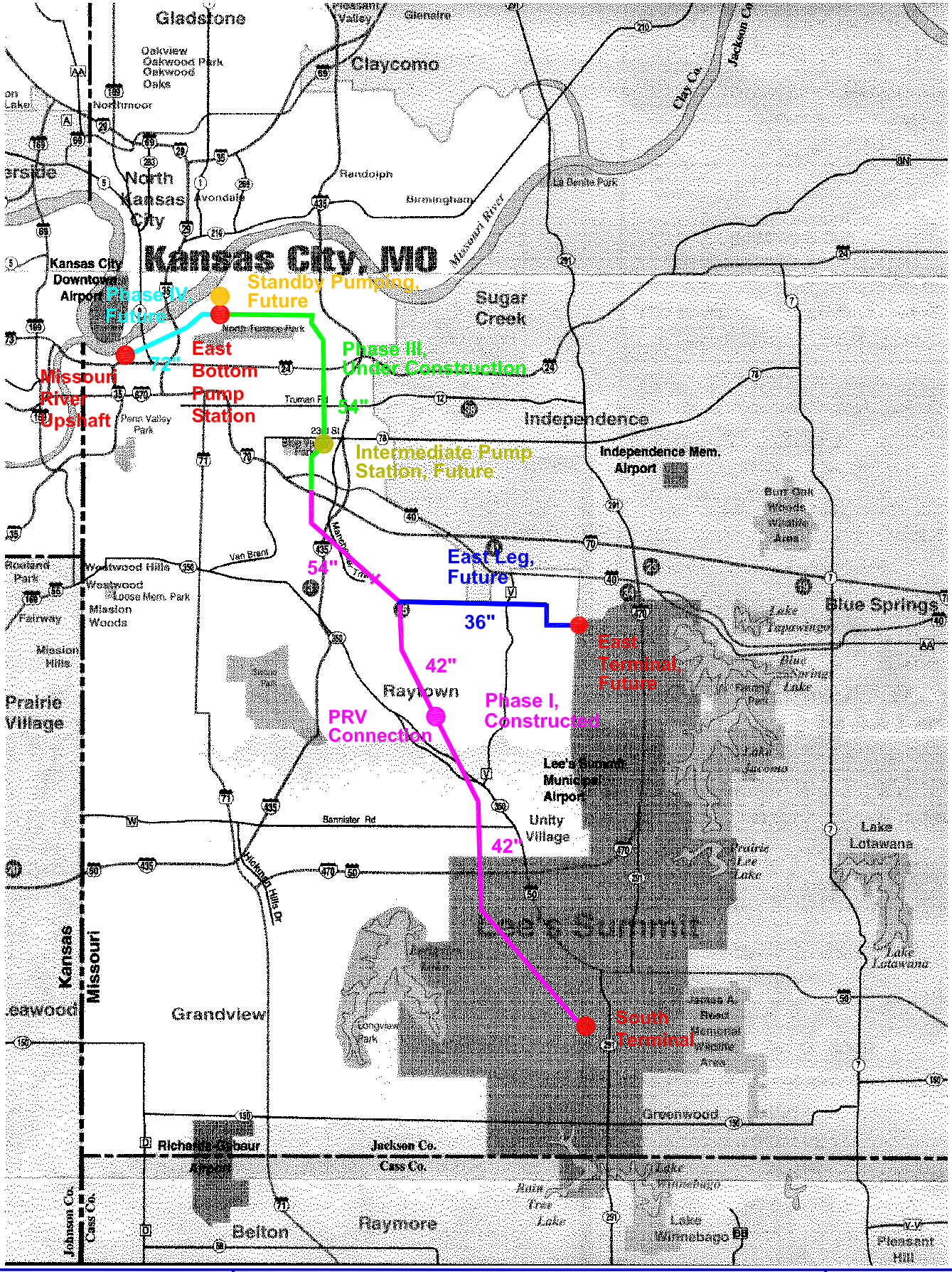
Lee's Summit's total water supply capacity in 2006 is 21.5 MGD. This includes 7.5 MGD from the City of Independence, 7.0 MGD from the City of Kansas City along Lee's Summit Road and 7.0 MGD from Kansas City at the South Terminal Pump

Station. The water purchase agreement with Independence was signed on January 4, 2001 and is valid for 20 years and renewable with notification 120 days prior the expiration. The water purchase agreement with Kansas City was signed on May 6, 2002 and is valid for 33 years with two renewal options, each for an additional 33 years. Future supply opportunities described in the *Water Supply Alternatives Evaluation* report by Bartlett & West Engineers, dated September 2004 include:

- The City of Kansas City, Missouri (KCMO)
- The City of Independence, Missouri
- Tri-County Water Authority (TCWA)

The 1999 Cooperative Agreement for Transmission System Improvements (Cooperative Agreement) with Kansas City includes Phase I, II, III and IV of the Jackson-Cass Transmission System and the South Terminal Pump Station as shown on Figure 5. Phase I included a 54" and 42" pipeline along the old Rock Island Rail Road alignment from I-70 to Ward Road and a connection to existing transmission lines near 75th and Woodson. The existing transmission lines feed into Lee's Summit to three locations along Lee's Summit Road between the airport and Lakewood Boulevard. Phase II included a tie back into the Kansas City system. This was an intermediate project intended to get more water to Lee's Summit while the remaining phases of the transmission system were developed. This project was later abandoned in favor of moving forward on Phase III. Phase III includes a 54" pipeline that will connect Phase I to Kansas City's East Bottoms Pump Station. This project is under construction and scheduled for completion by mid 2007.

Another alternative to Phase IV called the Cross Town Transmission Line was evaluated in 2005. The Cross Town Transmission Line was proposed to take advantage of excess pumping capacities in the western portion of the Kansas City system. The availability of excess pumping capacity on the western side of the Kansas City system did not overcome the long term operational, reliability and economic advantages of the



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Jackson Cass Transmission System

Figure

5

Phase IV project, based on evaluations by Kansas City. In December 2005, the Cross Town Transmission Line was abandoned in favor of the Phase IV project. Phase IV includes a 72" transmission line from the south end of the river tunnel to the East Bottoms Pump Station. The timing to complete this project is being finalized.

Other projects shown on Figure 5 but not included in the Cooperative Agreement include:

- Future East Leg of the Jackson-Cass Transmission System.
- Future East Terminal storage and pump station to deliver this supply into Lee's Summit.
- Future Standby Pumping improvements at the East Bottoms Pump Station.
- Future Intermediate Booster Pump Station improvements to the Jackson-Cass Transmission System.

Table 7 summarizes the impacts of the planned improvements to the total capacity of the Jackson-Cass Transmission System. Today, the system can deliver 10.5 MGD to the South Terminal Pump Station. Of this 10.5 MGD, 7.0 MGD is designated for Lee's Summit in the Cooperative Agreement. Adding Phases III and IV as defined in the Cooperative Agreement increases Lee's Summit's share to 13 MGD and 20 MGD at the South Terminal Pump Station, respectively. Adding a Standby Pumping Station to the East Bottoms Pump Station will increase the supply to South Terminal to 36 MGD. When the East Leg and East Terminal Pump Station are added Kansas City will not be able to supply both the East Terminal and the meters along Lee's Summit Road. This results in a gain of 21 MGD but a loss of 7 MGD for a net gain of 14 MGD. The total transmission system capacity will increase to 52 MGD but the supply to South Terminal will decrease from 36 MGD to 31 MGD. Adding an Intermediate Booster Pump Station will increase the transmission system capacity to 75 MGD.

Lee's Summit's share of any additional supply after the addition of Standby Pumps at the East Bottoms Pump Station is undefined at this time. All the information in Table

7 is based on the assumption that no flow is being diverted to Kansas City's South System through the Raytown Road Pump or through the 24" inter-connect near 75th and Woodson. The potential impacts of these operational conditions are not well defined at this time. Kansas City is continuing to develop a final operations plan for the entire Jackson-Cass Transmission System.

Additional information gathered on the Kansas City supply in 2006 supplements this report but does not alter the basic conclusion that maximizing the Kansas City Supply is the most economical alternative to the year 2024. Table 8 summarizes the projected changes to Lee's Summit's water supply capacity. Figure 6 superimposes water demands over the water supply capacity for the period of 1991 to 2030. After 2024, there are three choices for additional water supplies: Kansas City, Independence or Tri-County Water Authority (TCWA). This Master Plan assumes that supplies after 2024 will come from TCWA for these reasons:

- TCWA offers a third source of supply for increased reliability.
- With existing supplies from the north (Kansas City and Independence) and west (Kansas City) a TCWA supply delivers water to a strategic location on Lee's Summit's eastern border.

The timing to increase water supply capacities relates directly to risk management. Figure 6 indicates that in seven of the last nine years, the supply systems delivered supplies greater than the capacities included in the water supply agreements with Kansas City and Independence. These successes have occurred as a result of dedication and collaboration among the staffs of all three communities. The projects needed to increase the water supply capacity are highly complex multi-jurisdictional projects that require several years to plan, negotiate, design and construct. Ideally, the contractual supply capacity should always exceed the projected demands. Table 8 and Figure 6 present a sequence of recommended events to maintain a supply capacity 10 percent greater than the projected maximum day demand after 2013.

Figure 6 - Projected Demand and Supply (MGD)

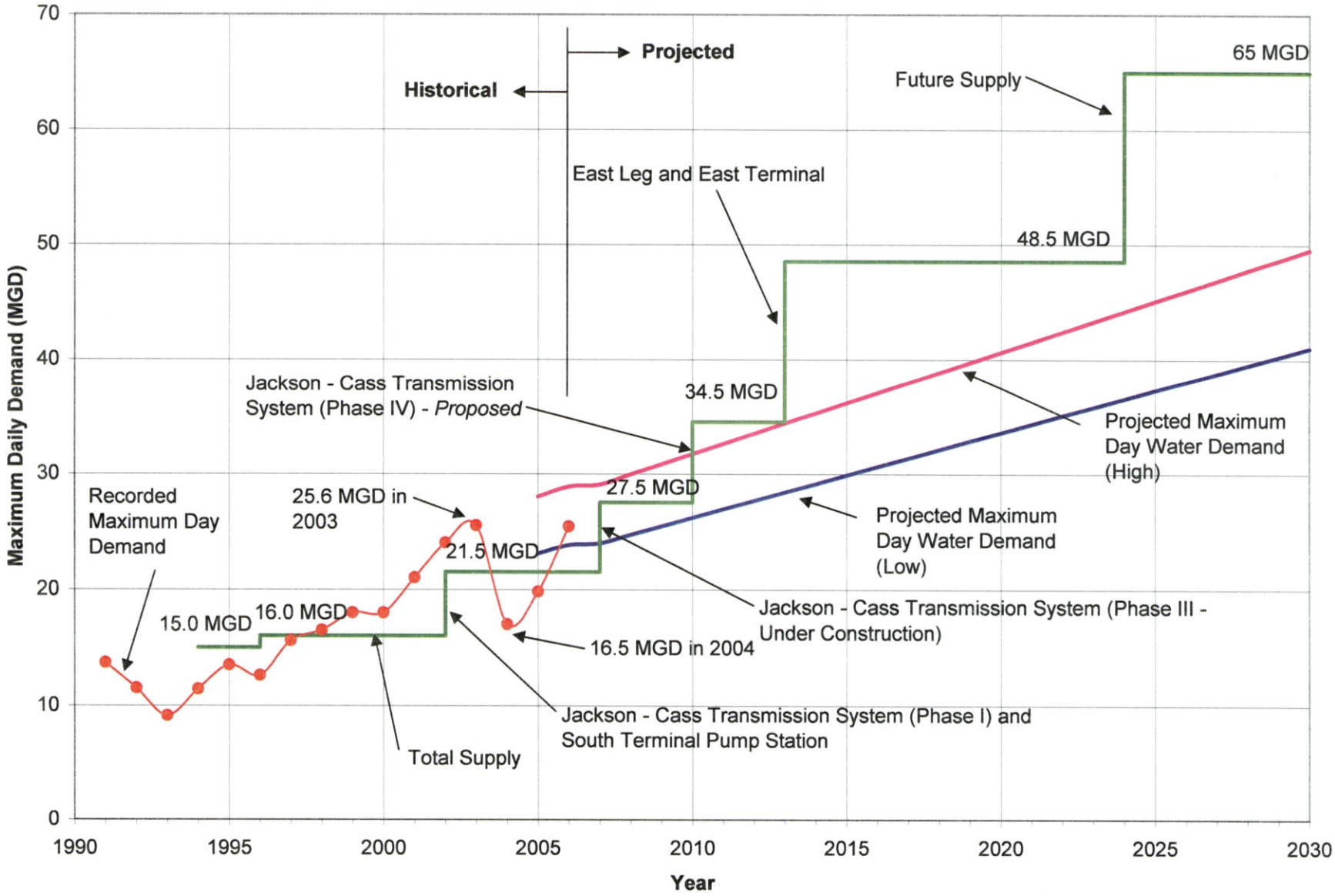


Table 7 – Capacity of the Jackson-Cass Transmission System (MGD)

Jackson-Cass Improvements[1]	Total Supply to South Terminal	Total Supply to East Terminal	Total Supply to Jackson-Cass System	Lee's Summit Share of Jackson-Cass System	Comments
Phase I	10.5[4]	0	10.5	7[5]	Completed in 2001
Add Ph III (54")	22[3]	0	22	13[6]	Completion by May 2007
Add Phase IV (72")	22[3] 27[7]	0	27	20[7]	See Note 8
Add Standby Pump to East Bottoms PS[2]	36[3]	0	36	20[7]	See Note 8
Add the East Leg and East Terminal PS	31[3]	21[3]	52	41	Assumes expanding the Cooperative Agreement
Add Intermediate Booster PS	50[3]	25[3]	75	41	Assumes expanding the Cooperative Agreement

Notes:

1. All phasing references are described in the 1999 Cooperative Agreement for Transmission System Improvements between Kansas City and Lee's Summit (Cooperative Agreement). These projects are listed in chronological order.
2. PS is an abbreviation for pump station.
3. Presentation of the draft *Jackson-Cass Transmission System Operational Plan* (Operational Plan) by Black and Veatch, December 6, 2005.
4. Cooperative Agreement, Page 8, Article III, Paragraph 3.
5. Cooperative Agreement, Page 8, Article III, Paragraph 4.
6. Cooperative Agreement, Page 13, Article VI, Paragraph 5.
7. Cooperative Agreement, Page 14, Article VII, paragraph 4.
8. According to the draft Operational Plan, the standby pumping needs to be added to the East Bottoms Pump Station at the same time Phase IV is completed to meet the terms of the Cooperative Agreement.
9. Under certain operational circumstances, water from the Jackson-Cass Transmission System may feed Kansas City's South System via the Raytown Road Pump Station and/or the 24" interconnect at 75th and Woodson.
10. Kansas City's other wholesale customers fed through the South Terminal include the Cities of Raymore, Pleasant Hill, Greenwood and the Aries power plant.

Table 8 – Projected Water Supply Capacity

Year	Water Supply Description/Changes (MGD)	Total Supply (MGD)
2005	• Independence: 7.5 • KCMO at Lee's Summit Road: 7.0 • KCMO at South Terminal Pump Station: 7.0	21.5
May 2007	• Add Phase III of Jackson-Cass System: +6.0	27.5
May 2010	• Add Phase IV of Jackson-Cass System: +7	34.5
2013	• Add Standby Pumping, East Leg and East Terminal Pump Station: +21 • Delete KCMO at Lee's Summit Road: -7 • Net increase is 14	48.5
2024 to 2030	• Gain additional supply from TCWA, Independence or KCMO: +16.5	65

In this plan, Lee's Summit's total supply capacity will need to be increased to 48.5 MGD to satisfy the projected maximum day demand to the time frame of 2025 to 2030. The water supply assumptions used for the remainder of this report include:

- The Jackson-Cass Transmission System will continue to develop and ultimately deliver 20 MGD to the South Terminal Pump Station and then 21 MGD to a future East Terminal Pump Station. All other connections to Kansas City will be abandoned or used as emergency connections only.
- Independence will continue to deliver 7.5 MGD to Lee's Summit's northern boundary.
- Tri-County Water Authority, Independence or Kansas City could eventually deliver another 16.5 MGD to Lee's Summit to meet the ultimate build-out, maximum day demand of 65 MGD.

HYDRAULIC MODEL

An existing computer model was provided to Bartlett & West from the Public Works Department. Bartlett & West modified the model to reflect current operations, updated the demand distributions and conducted several field measurements for calibration. The result is a calibrated model to be used by City staff to evaluate current development proposals and operational impacts. The calibrated model was also used to determine recommended improvements to meet projected demands.

Model Calibration

Calibrating the model is necessary to generate accurate results. The model is calibrated by conducting field measurements, collecting information from the supervisory control and data acquisition (SCADA) system and then adjusting the model to produce similar results.

Over 40 fire hydrant flow tests were performed at strategic locations throughout the City with assistance from the Water Utilities Department staff. The locations provided a representative sampling of pipe ages, diameters and types. The purpose of these tests was to record pressure drops with known flows at a specific fire hydrant. These recorded flows were then added to the model at their corresponding locations.

SCADA data were acquired for times when flow testing was performed and used as input to the model. Since an extensive effort was made during the previous study to determine values for the Hazen Williams "C" factor (pipe roughness) for all system piping, they were not adjusted as part of this calibration effort. A majority of the hydrant tests were performed during the early summer months, so the modeled demands were globally adjusted to reflect system demands during that period. The goal of the calibration effort was to provide a model that would confidently predict pressures within 6.5 psi (15 feet).

The resulting static and flow pressures were then compared to those observed in the field. Some tests were removed from the sample set for reasons such as obvious errors in field readings, uncertainty of actual system conditions at the time of a test, and the relative positioning of the hydrants used in a test did not meet the requirements defined before testing. The results of the fire hydrant flow tests are included in Appendix B.

A comparison of the modeled hydrant flow tests from this calibration effort to those of the last report reveals similar results. Generally, the pressure differences in the North System and District 14 were greater that those observed in the South System. The model accurately predicted static pressures throughout the entire distribution system within 6.5 psi at over 95% of the tested locations. Results during high flows, however, were within the allowed margin in just 74% of the tests. Overall, the model accurately predicted system pressures within 6.5 psi for 85% of the pressure comparisons.

Distribution of Existing Demands

The distribution of existing demands was accomplished using water meter route usage data. Water meter records were obtained from the City and average day demands were calculated for each route. These demands were then distributed in the model to one or more junctions lying within their respective meter routes. This accounts for the varying intensity of water use throughout the City and also reduces the amount of effort required to update existing demands for future analyses.

In addition to static water demands, fire flow demands were assigned throughout the model as described in the Planning Criteria section. An analysis of model results was then made to identify locations were it was not possible to meet the minimum required fire flow during maximum demand conditions. Although these instances were limited, they generally occurred in areas of the system where a lower

design criterion was in effect (near the airport, within District 14, and older areas of town) or a pipeline was sized for domestic flow only. In a few cases, specific improvements have been proposed to improve available fire flow. The other cases have been remedied through improvements proposed as a result of future growth.

Distribution of Proposed Demands

Proposed demands within the city limits were assigned based on the information complied by the Planning and Development Department, which they have summarized on their *Growth Projections to 2015 and Build-Out* map and accompanying data spreadsheet. These materials highlight both "active residential areas", or areas that will be completely developed by the Year 2015, and "future build out projection areas", or areas that will are not currently being developed, but ultimately will be. Demands were assigned to each area based on a maximum demand of 60 gpd per capita for medium residential areas, and 2800 gpd per acre for commercial areas and 3600 gpd per acre for industrial areas. This is not to be confused with the 125 gpd average per capita use in Table 5 which takes into account all water use, including commercial and industrial use, and divides it over the listed population.

As discussed in the previous section of this report, future residential demands projected for District 14 were assigned assuming medium density development. Areas of potential commercial and industrial development were identified and assigned demands of 2,800 gallons per day per acre (GPDA) and 3,600 GPDA, respectively.

Criteria

A number of criteria, including minimum pressures, maximum pipeline head losses, and maximum pipeline velocities, have been established to serve as indicators as to when system improvements are warranted. Some of these criteria differ from the last study to reflect changes in the most recent edition of the City's Design and Construction

Manual (September 2004). System improvements were made to the model based on satisfying the following criteria:

- Peak hour minimum pressures greater than 40 psi.
- Maximum day plus fire flow minimum pressures greater than 30 psi.
- Minimum residential and public/semi-public fire flow of 1,000 gpm.
- Minimum commercial fire flow of 2,500 gpm.
- Minimum industrial fire flow of 3,500 gpm.
- Maximum pipeline velocity of 5.0 feet per second (fps) in transmission mains 16 inches in diameter and larger.
- Maximum pipeline headloss of 3.0 feet per hundred feet in transmission mains 16 inches in diameter and larger.
- Maximum pipeline headloss of 5.0 feet per hundred feet in mains smaller than 16 inches in diameter.

The criteria for minimum pressures and fire flows were used as very stringent guidelines for determining system improvements. The velocity and headless criteria were viewed as desirable, but not mandatory criteria. The reason for this is that there are several areas in the existing system where the desired criteria for velocity and headless are not met, and it is not economical to replace all of the piping necessary to meet these criteria. With the recommended improvements in place, however, the minimum pressure and fire flow criteria are satisfied in these areas even though the velocity and headless criteria may still be exceeded.

System piping included in the model, as shown on Figures 7 and 8 in the Appendix are generally those lines that are 12 inches in diameter and larger. In some cases, smaller pipelines were included when they formed a loop or where only smaller lines exist.

CONCLUSIONS

This Master Plan provides an orderly plan that accommodates growth, road construction, maintenance and replacement needs for the next ten years and beyond. Any changes in the assumptions, planning criteria or projections used for this plan will modify the resulting conclusions. Conclusions based on the stated assumptions, projections and analyses in this Master Plan include:

1) There are three viable water suppliers within reasonable proximity to Lee's Summit including the City of Kansas City, City of Independence and Tri-County Water Authority.
2) The existing supply and distribution systems are successfully and reliably meeting current demands, with the exception of District 14 where a few areas experience pressure below 40 pounds per square inch (psi) on the peak demand day and most of the area does not meet the fire flow criteria.
3) Additional supplies are anticipated to be needed by 2010, 2013 and 2024.
4) Lee's Summit has a Cooperative Agreement with Kansas City to develop the Jackson-Cass Transmission System through Phase IV. The Phase IV improvements to the Jackson-Cass Transmission System are needed by the year 2010.
5) The East Leg and East Terminal improvements to the Jackson-Cass Transmission System are being developed. These projects are needed to increase Lee's Summit's water supply by the year 2013.
6) Additional improvements are being developed by Kansas City for the Jackson-Cass Transmission System to achieve an ultimate capacity of 75 MGD to the South Terminal and East Terminal facilities.
7) Kansas City, Independence and Tri-County Water Authority continue to offer viable alternatives for meeting Lee's Summit's demand beyond the year 2024.

Tri-County Water Authority offers the advantage of providing a third supply source at a strategic point in the system.

8) Postponing development plans for the PRI properties in Lee's Summit defers about 3 MGD of average day demand and approximately 8 MGD of maximum day demand. The greatest impact is to delay the need for about 8 MGD of supply. Impacts to the distribution system are minimal.

9) Maximum day demands are projected to continue increasing by about 0.9 MGD per year. These maximum day demands are driving the need for capital improvements.

10) The Bowlin Road Storage Reservoir is nearing the end of its useful life. Replacement options include another ground storage tank or an elevated tank. The elevated tank has a higher capital cost and the ground tank has a higher energy cost for pumping. Assuming a new tank is constructed on the same sited as the existing, the payback for the operational savings over the higher capital cost for an elevated tank is more than 45 years. A ground storage tank appears to be the best choice for life cycle cost and aesthetics. With increased maintenance, the existing tank may be kept in service for a few more years while the replacement project is developed.

11) Additional pumping capacity will be needed at the High Service Pump Station by 2013.

12) Several water system projects are needed to support growth, accommodate road construction projects (as described in the 2006 *Thoroughfare Master Plan*), maintain or replace existing facilities.

13) Every new development in Water District 14 has the potential to further degrade service to existing customers. Significant improvements are needed to accommodate future growth and to add fire flow protection.

14) The 10 year project costs in 2006 dollars are:

a.	Tap fee projects (Lee's Summit)	$48.2 million (70%)
b.	Tap fee projects (WD 14)	$ 4.2 million (6%)
c.	Road projects	$10.7 million (16%)
d.	Maintenance	$ 5.6 million (8%)
e.	**Total**	**$68.7 million**

15) Among the $48.2 million in tap fee projects, $42.2 million is for supply related improvements and $6 million is for distribution system.

16) Future decisions about water supply will impact the sizing of at least five major projects proposed to be constructed in the next 10 years. The total value of these projects is $14.7 million. The two projects impacted before 2010 are the South Terminal Discharge Main and the 9 MG Low Head Storage Tank at South Terminal. Spending $50,000 per year for replacement/repair of the existing system is a relatively low value for a system the size of Lee's Summit's. The estimated useful life of water system components is:

a. Storage tanks at 40 to 50 years.
b. Pump stations and electrical gear at 20 to 25 years.
c. Ductile iron pipe at 40 to 80 years.
d. Polyvinylchloride pipe at 40 plus years.

RECOMMENDATIONS

Table 9, Figure 7 and Figure 8 (Appendix C) provide summary references for the priorities, descriptions, opinions of probable cost and locations of each recommended improvement. Table 9 lists the recommended in service date for each project. Other significant recommendations include:

1) Encourage water conservation through public education and rates.
2) Complete negotiations with Kansas City to develop the East Terminal supply projects. The transmission line, pump station and storage facilities are needed by 2013.
3) Complete these significant projects in the next 10 years (additional projects are included on Table 9):
    a. North System Supply Improvements by 2007
    b. South Terminal East Discharge by 2007
    c. KCMO Phase III by 2007
    d. Low Head Storage at South Terminal by 2008
    e. Phase IV by 2010
    f. East Leg and East Terminal by 2013
    g. Internal transmission projects by 2013
4) As the Lee's Summit Road corridor project develops, obtain easements for the transmission lines indicated on Figures 7 and 8.
5) Pursue additional water supplies for 2024. Evaluate three alternatives by the end of 2007. Select the best alternative by the end of 2008. Negotiate an agreement by 2010.
6) Leverage new and developing resources in the City's geographical information system and data management software to quantify and predict renewal needs.
7) Monitor the assumptions made in this analysis. Update the demand and population projections annually. Update this Master plan as necessary to

Table 9 - City of Lee's Summit Water Master Plan Proposed Projects

Figure 7/8 Reference	Project Description [1]	Facility Description	Opinion of Probable Cost [3] Tap Fund LS	Tap Fund Dist. 14	Construction Fund Road	Construction Fund Maint.	Year In Service	Justification
1	Hook Rd Tank (remaining cost)	3.0 MG Elev. Storage Tank	400				2006	Provides peaking storage and fire flow to the rapidly growing southwest portion of Lee's Summit.
2	North System Supply Improvements	Pipe Line Interconnects	1,300				2007	Improves supply reliability and efficiency by maximizing the water supply from Independence, City's most economical supply source.
3	Woods Chapel Rd Transmission Main (Lakewood Way to Georgian Dr)	4,800 feet of 12 inch pipe 2,800 feet of 16 inch pipe	1,729				2007	Improves fire flow and provides supply to future development along Woods Chapel Road.
4[9]	South Terminal East Discharge Main	3,900 feet of 36 inch pipe	1,685				2007	Necessary to utilize the increased supply resulting from the KCMO Phase III & IV improvements.
NA	KCMO Phase III Improvement (remaining cost, see Fig. 5)	36,000 feet of 54 inch pipe	3,100				2007	Increases supply to the South Terminal Pump Station by 6 MGD.
5	High Service Reservoir Rehabilitation (5.5 MG Steel Tank)					1,000	2007	Maintains investment in existing infrastructure.
6[9]	Low Head Storage at South Terminal Pump Station	9.0 MG Ground Storage	8,100				2008	Provides additional low head storage during the peak demand season. Contingent on KCMO delivery conditions.
Cr	Current CIP Projects (Road Construction)	Several Projects			1,320		2008	Replaces or constructs new water lines in association with road construction.
Cm	Current CIP Projects (Maintenance)	Several Projects				1,742	2008	Improves service to existing customers.
NA	KCMO Phase IV Improvement (see Fig. 5)	12,700 feet of 72 inch pipe	8,000				2010	Increases supply to the South Terminal Pump Station and completes the pipeline projects included in the cooperative agreement with KCMO.
7	Pryor Rd Transmission Main (Scherer Rd to Eagle View Dr.) [5]	4,000 feet of 16 inch pipe	384				2010	Transmits water to the rapidly growing southwest portion of Lee's Summit.
8	Woods Chapel Tank Recoating					300	2011	Maintains investment in existing infrastructure.
9	High Service Pumping	Additional Pump Capacity	80				2013	Maximizes High Service Pump Station capacity to 20 MGD.
10	East Terminal Transmission Main	17,500 feet of 36 inch pipe	7,560				2013	Transmits new 21 MGD supply from KCMO to East Terminal Pump Station.
11	East Terminal Pump Station and Storage [2]	21 MGD Pump Station 5 MG Storage Tank	13,650				2013	Pumps additional 21 MGD supply to Lee's Summit.
12	East Terminal Transmission Main	6,000 feet of 24 inch pipe	1,728				2013	Transmits new 21 MGD supply from KCMO to East Terminal Pump Station.
13	Bowlin Tank	2.0 MG Ground Storage				1,800	2013	Provides control volume
T	City's Share for Growth/Upsizing of Water Lines in Lee's Summit [6,7]	13,890 feet of 12 inch pipe	1,000				As Needed	Primarily 12" piping to be installed as development dictates
T14	WD 14's Share for Growth/Upsizing Along Hwy's in WD 14[6]							Primarily 12" piping to be installed as development dictates
	Hwy 50 Transmission Main (Church Rd. to Smart Rd.)	7,000 feet of 20 inch pipe		840			As Needed	Portion of the link to transmit water to WD 14 area and Hwy 7 Tank
	Hwy 50 Transmission Main (Smart Rd. to Hwy 7)	11,500 feet of 16 inch pipe		1,104			As Needed	Portion of the link to transmit water to WD 14 area and Hwy 7 Tank
	Hwy 7 Tank	1.5 MG Elevated Storage		1,125			As Needed	Provides peaking storage, fire protection and pressure stabilization (higher minimum pressures).
	Hwy 7 Transmission Main (Hwy 50 to Herring Rd.)	5,300 feet of 20 inch pipe		636			As Needed	Portion of the link to transmit water to WD 14 area and Hwy 7 Tank
	Miscelaneous 12" Water Lines	6,500 feet of 12 inch pipe		468			As Needed	Primarily 12" piping to be installed as development dictates
NA	Replacement/Repair[8]	12 inch pipe and smaller				500	As Needed	Replaces and/or repairs problematic small diameter piping.
NA	Water Lines Integral to Road Construction Projects	See Thoroughfare Master Plan			9,422		As Needed	Projects and costs are identified in the 2006 Thoroughfare Master Plan
NA	Annual Updates to the Water Master Plan					300	As Needed	Updates the planning criteria, projects and cost estimates.
		2016 Subtotals	**48,216**	**4,173**	**10,742**	**5,642**		
14	Lee's Summit Rd Transmission Main (Gregory to Lakewood Dr)	8,000 feet of 20 inch pipe	1,920				2018	Allows the capacity of East Terminal (21 MGD) to be recieved into the water system.
15	Pryor Rd Transmission Main (Scherer Rd to Longview Rd)	5,400 feet of 20 inch pipe	1,296				2020	Extends transmission capacity to the southwest
NA	Tank Painting/Rehabilitation (Scherer, Hook, Ranson)					1,000	2021	Maintains investment in existing infrastructure.
16[9]	Hook Rd Transmission Main (Hook Tank to M-291)	7,000 feet of 30 inch pipe	2,520				2022	Transmits water from the Hook Road Tank to southeast
17[9]	Blackwell Rd Transmission Main (Scruggs Rd to Coblem Rd)	5,300 feet of 36 inch pipe	2,290				2024	Transmits TCWA supply to the system.
18[9]	Scruggs Rd Transmission Main (Blackwell Rd to Jason Ave)	2,200 feet of 16 inch pipe	422				2024	Transmits TCWA supply to the system.
19[9]	Blackwell Rd Transmission Main (Langsford Rd to Scruggs Rd)	5,300 feet of 30 inch pipe	1,908				2024	Transmits TCWA supply to the system.
20[9]	Colbern Rd Pump Station	16.5 MGD Pump Station	6,600				2024	Pumps additional 16.5 MGD supply from TCWA into Lee's Summit.
21[9]	Colbern Rd Ground Storage	5.0 MG Ground Storage	4,500				2024	Stores the water that TCWA supplies.
22[9]	Langsford Rd Transmission Main (Todd George to Blackwell)	6,000 feet of 20 inch pipe	1,440				2024	Transmits TCWA supply to the system.
23[9]	Langsford Rd Transmission Main (Blackwell to Milton Thompson)	6,200 feet of 16 inch pipe	1,190				2024	Transmits TCWA supply to the system.
NA	TCWA Well Field and Treatment Plant	16.5 MGD Wells and Plant	46,200				2024	Provides raw water source for new 16.5 MGD supply from TCWA.
NA	TCWA Transmission Main upsizing	90,000 feet of 36 inch pipe	38,880				2024	Transmits 16.5 MGD from TCWA to I-70.
NA	TCWA Transmission Main	70,000 feet of 30 inch pipe	25,200				2024	Transmits 16.5 MGD from I-70 to Colbern Road Pump Station.
T	City's Share for Growth/Upsizing of Water Lines in Lee's Summit [6]	114,000 feet of 12 inch pipe	8,208				As Needed	Primarily 12" piping to be installed as development dictates.
T14	WD 14's Share for Growth/Upsizing in WD 14[6]	69,500 feet of 12 inch pipe		5,004			As Needed	Primarily 12" piping to be installed as development dictates
NA	Replacement/Repair[8]	12 inch pipe and smaller				1,700	As Needed	Replaces and/or repairs problematic small diameter piping 8" and less.[8]
NA	Water Lines Integral to Road Construction Projects	See Future Thoroughfare Master Plan			11,540		As Needed	Supports water line construction for new and existing roads.
NA	Annual Updates to the Water Master Plan					900	As Needed	Updates the planning criteria, projects and cost estimates.
		Ultimate Development Subtotals	**142,574**	**5,004**	**11,540**	**3,600**		

Notes

1. Projects are shown when needed to meet projected demand increases.
2. East Terminal adds 21 MGD but 7 MGD is lost at the Lee's Summit Rd. meters (Lakewood Blvd., Gregory Blvd., and Lee's Summit Rd.) for a net increase in supply of 14 MGD.
3. The opinions of probable cost are based on $12/inch/foot for pipe, $400,000/MGD for pumping, $0.90/gallon for ground storage and $1.50 /gallon for elevated storage. These include administration, land, engineering and construction.
4. September 2006 ENR Construction Cost Index for Kansas City is 8521.19. Future costs should be escalated using future ENR indexes.
5. Estimated cost is City's share of the upsizing from 8" to 16".
6. These projects are driven by the development market. The City or Water District 14 share is assumed at 50% of the total project cost. Values shown are just the City's or Water District 14's share of the total cost.
7. The value shown is based on historical upsizing costs from 1996 to 2006 of approximately $100,000 per year.
8. Cost shown is based on current budgetting of $50,000 per year.
9. Project is impacted if 2024 supply is different from TCWA near Colbern Road.

incorporate new information or deviations from the assumptions and projections.

8) Plan future projects using the typical time frames listed in Table 10.

Table 10 – Recommended Typical Schedule for Water System Projects (Months)

Project Type	Preliminary Design	Land Acquisition	Final Design	Construction[1]	Total Duration
Transmission Pipeline	3	9	3	8[1]	23
Tank or Pump Station	3	12	3	18[1]	36
Multi-jurisdictional	24	12	12	24[2]	72

Notes:

1. Includes 60 days for advertising and contract review.
2. Includes 90 days for advertising and contract review.

Appendix A

Abbreviations

ABBREVIATIONS TABLE

DIP	Ductile Iron Pipe
EPS	Extended Period Simulation
FPS	Feet Per Second
Gals/Mo.	Gallons per Month
GPCD	Gallons Per Capita Day
GPDA	Gallons per Day per Acre
gpm	Gallons Per Minute
HGL	Hydraulic Grade Line
MG	Million Gallons
MGD	Million Gallons per Day
psi	pounds per square inch
PVC	Polyvinylchloride
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head
USGS	United States Geological Survey

Appendix B

Model Calibration

Test Number and Pressure Gauge Location	Computer Model Node	*No Flow at Fire Hydrant*					*High Flow at Fire Hydrant*				
		Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)	Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)
TEST 4 SOUTH HYDRANT	**2773**	**112**	**107.4**	**-4.7**	**-10.7**	**10.7**	**101**	**98.8**	**-2.2**	**-5.0**	**5.0**
TEST 4 NORTH HYDRANT	**2767**	**107**	**102.6**	**-4.4**	**-10.2**	**10.2**	**95**	**95.0**	**0.0**	**-0.1**	**0.1**
TEST 5 WEST HYDRANT	5080	102	100.4	-1.6	-3.7	3.7	94	94.8	0.8	1.7	1.7
TEST 5 EAST HYDRANT	5076	99	97.4	-1.6	-3.8	3.8	87	93.1	6.1	14.0	14.0
TEST 6 NORTH HYDRANT	**5094**	**78**	**75.1**	**-2.9**	**-6.8**	**6.8**	**68**	**64.8**	**-3.2**	**-7.3**	**7.3**
TEST 6 SOUTH HYDRANT	**5090**	**89**	**91.6**	**2.6**	**5.9**	**5.9**	**78**	**82.5**	**4.5**	**10.4**	**10.4**
TEST 8 NORTH HYDRANT	5102	147	146.5	-0.5	-1.1	1.1	122	106.3	-15.7	-36.3	36.3
TEST 8 SOUTH HYDRANT	5098	144	144.8	0.8	1.8	1.8	116	105.8	-10.2	-23.6	23.6
TEST 9 EAST HYDRANT	**5110**	**128**	**122.8**	**-5.2**	**-12.0**	**12.0**	**118**	**107.9**	**-10.1**	**-23.4**	**23.4**
TEST 9 WEST HYDRANT	**5106**	**128**	**122.4**	**-5.6**	**-13.0**	**13.0**	**115**	**106.4**	**-8.6**	**-19.8**	**19.8**
TEST10 SOUTH HYDRANT	5114	96	96.5	0.5	1.2	1.2	87	88.78	1.8	4.1	4.1
TEST10 NORTH HYDRANT	**5118**	**100**	**99.1**	**-0.9**	**-2.1**	**2.1**	**89**	**91.2**	**2.2**	**5.0**	**5.0**
TEST11 NORTH HYDRANT	**561**	**92**	**97.3**	**5.3**	**12.2**	**12.2**	**73**	**73.9**	**0.9**	**2.1**	**2.1**
TEST11 SOUTH HYDRANT	2916	88	93.5	5.5	12.8	12.8	68	73.5	5.5	12.7	12.7
TEST12 EAST HYDRANT	**5128**	**116**	**115.0**	**-1.0**	**-2.3**	**2.3**	**70**	**56.2**	**-13.9**	**-32.0**	**32.0**
TEST12 WEST HYDRANT	**5124**	**122**	**122.0**	**0.0**	**-0.1**	**0.1**	**75**	**60.9**	**-14.1**	**-32.5**	**32.5**
TEST13 SOUTH HYDRANT	4234	94	99.7	5.7	13.2	13.2	85	93.3	8.3	19.1	19.1
TEST13 NORTH HYDRANT	4236	95	101.0	6.0	13.9	13.9	82	94.7	12.7	29.3	29.3
TEST14 WEST HYDRANT	**5138**	**92**	**91.4**	**-0.6**	**-1.5**	**1.5**	**84**	**87.7**	**3.7**	**8.4**	**8.4**
TEST14 EAST HYDRANT	**5134**	**90**	**89.2**	**-0.8**	**-1.8**	**1.8**	**84**	**85.9**	**1.9**	**4.4**	**4.4**
TEST16 SOUTH HYDRANT	2824	98	92.0	-6.0	-13.9	13.9	85	78.4	-6.6	-15.1	15.1
TEST16 NORTH HYDRANT	2818	85	85.5	0.5	1.1	1.1	65	70.6	5.6	12.9	12.9
TEST17 NORTH HYDRANT	**101**	**74**	**72.2**	**-1.8**	**-4.2**	**4.2**	**69**	**69.3**	**0.3**	**0.6**	**0.6**
TEST17 SOUTH HYDRANT	**5148**	**74**	**70.7**	**-3.3**	**-7.7**	**7.7**	**69**	**68.0**	**-1.0**	**-2.3**	**2.3**
TEST18 SOUTH HYDRANT	5150	94	91.7	-2.3	-5.2	5.2	70	88.6	18.6	42.9	42.9
TEST18 NORTH HYDRANT	5154	100	94.4	-5.6	-12.9	12.9	68	90.9	22.9	52.9	52.9
TEST19 SOUTH HYDRANT	**5156**	**100**	**98.0**	**-2.0**	**-4.7**	**4.7**	**72**	**71.8**	**-0.2**	**-0.6**	**0.6**
TEST19 WEST HYDRANT	**5158**	**94**	**92.8**	**-1.2**	**-2.9**	**2.9**	**64**	**72.8**	**8.8**	**20.4**	**20.4**
TEST20 NORTH HYDRANT	5166	93	93.5	0.5	1.1	1.1	88	87.2	-0.8	-1.9	1.9
TEST20 SOUTH HYDRANT	5162	88	91.0	3.0	7.0	7.0	82	85.3	3.3	7.7	7.7
TEST21 SOUTH HYDRANT	**5168**	**111**	**113.3**	**2.3**	**5.3**	**5.3**	**108**	**107.5**	**-0.5**	**-1.2**	**1.2**
TEST21 NORTH HYDRANT	**5172**	**113**	**111.1**	**-1.9**	**-4.3**	**4.3**	**109**	**104.4**	**-4.6**	**-10.6**	**10.6**
TEST22 WEST HYDRANT	5174	87	89.9	2.9	6.7	6.7	83	87.4	4.4	10.2	10.2
TEST22 EAST HYDRANT	5178	85	83.8	-1.2	-2.7	2.7	75	81.0	6.0	13.8	13.8
TEST23 WEST HYDRANT	**5180**	**87**	**87.4**	**0.4**	**0.8**	**0.8**	**81**	**78.2**	**-2.8**	**-6.5**	**6.5**
TEST23 EAST HYDRANT	**5184**	**85**	**85.7**	**0.7**	**1.6**	**1.6**	**79**	**74.8**	**-4.2**	**-9.6**	**9.6**
TEST27 EAST HYDRANT	5204	94	88.0	-6.0	-13.8	13.8	84	85.1	1.1	2.6	2.6
TEST27 WEST HYDRANT	5206	81	81.5	0.5	1.1	1.1	66	78.2	12.2	28.1	28.1
TEST28 WEST HYDRANT	**5212**	**108**	**103.3**	**-4.7**	**-10.9**	**10.9**	**94**	**88.0**	**-6.0**	**-13.9**	**13.9**
TEST28 EAST HYDRANT	**5208**	**89**	**90.3**	**1.3**	**3.0**	**3.0**	**72**	**76.3**	**4.3**	**10.0**	**10.0**

Test Number and Pressure Gauge Location	Computer Model Node	*No Flow at Fire Hydrant*					*High Flow at Fire Hydrant*				
		Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)	Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)
TEST29 WEST HYDRANT	4818	78	80.8	2.8	6.4	6.4	76	77.3	1.3	3.0	3.0
TEST29 EAST HYDRANT	5506	74	76.9	2.9	6.7	6.7	67	73.6	6.6	15.3	15.3
TEST30 WEST HYDRANT	**5218**	**87**	**92.7**	**5.7**	**13.2**	**13.2**	**76**	**76.4**	**0.4**	**1.0**	**1.0**
TEST30 EAST HYDRANT	**5222**	**95**	**99.2**	**4.2**	**9.8**	**9.8**	**79**	**64.8**	**-14.2**	**-32.7**	**32.7**
TEST32 EAST HYDRANT	5236	91	95.4	4.4	10.1	10.1	75	86.8	11.8	27.2	27.2
TEST32 WEST HYDRANT	5232	102	104.0	2.0	4.7	4.7	87	97.2	10.2	23.5	23.5
TEST33 NORTH HYDRANT	**5244**	**112**	**113.3**	**1.3**	**3.0**	**3.0**	**90**	**93.3**	**3.3**	**7.7**	**7.7**
TEST33 SOUTH HYDRANT	**5248**	**110**	**119.8**	**9.8**	**22.6**	**22.6**	**88**	**101.4**	**13.4**	**30.9**	**30.9**
TEST34 SOUTH HYDRANT	5250	90	91.7	1.7	3.9	3.9	84	83.6	-0.5	-1.0	1.0
TEST34 NORTH HYDRANT	5254	91	91.7	0.7	1.5	1.5	84	84.1	0.1	0.1	0.1
TEST36 EAST HYDRANT	**5266**	**128**	**130.7**	**2.7**	**6.1**	**6.1**	**122**	**123.2**	**1.2**	**2.8**	**2.8**
TEST36 WEST HYDRANT	**5264**	**113**	**115.5**	**2.5**	**5.8**	**5.8**	**107**	**108.9**	**1.9**	**4.3**	**4.3**
TEST37 SOUTH HYDRANT	5270	95	98.1	3.1	7.2	7.2	87	87.2	0.2	0.4	0.4
TEST37 NORTH HYDRANT	4109	98	102.9	4.9	11.2	11.2	86	94.2	8.2	19.0	19.0
TEST39 WEST HYDRANT	**5290**	**86**	**87.8**	**1.8**	**4.1**	**4.1**	**68**	**68.9**	**0.9**	**2.0**	**2.0**
TEST39 NORTH HYDRANT	**5294**	**96**	**96.5**	**0.5**	**1.2**	**1.2**	**79**	**79.8**	**0.8**	**1.8**	**1.8**
TEST42 WEST HYDRANT	5302	124	124.3	0.3	0.6	0.6	114	113.2	-0.8	-1.8	1.8
TEST42 EAST HYDRANT	4051	108	108.3	0.3	0.6	0.6	99	101.8	2.8	6.5	6.5
TEST44 SOUTH HYDRANT	**5316**	**70**	**74.5**	**4.5**	**10.4**	**10.4**	**67**	**71.1**	**4.1**	**9.5**	**9.5**
TEST44 NORTH HYDRANT	**5312**	**64**	**65.8**	**1.8**	**4.2**	**4.2**	**55**	**62.0**	**7.0**	**16.1**	**16.1**
TEST46 WEST HYDRANT	5520	78	79.2	1.2	2.7	2.7	70	66.5	-3.5	-8.0	8.0
TEST46 NORTH HYDRANT	5516	85	86.1	1.1	2.5	2.5	76	74.5	-1.5	-3.6	3.6
TEST47 NORTH HYDRANT	**5528**	**72**	**74.0**	**2.0**	**4.7**	**4.7**	**70**	**70.1**	**0.1**	**0.3**	**0.3**
TEST47 SOUTH HYDRANT	**5524**	**77**	**77.7**	**0.7**	**1.5**	**1.5**	**71**	**75.2**	**4.2**	**9.7**	**9.7**
TEST48 NORTH HYDRANT	5534	86	89.1	3.1	7.1	7.1	80	77.2	-2.8	-6.4	6.4
TEST48 WEST HYDRANT	5530	89	92.6	3.6	8.2	8.2	78	80.8	2.8	6.5	6.5
TEST49 SOUTH HYDRANT	**5544**	**74**	**77.1**	**3.1**	**7.2**	**7.2**	**63**	**65.7**	**2.7**	**6.3**	**6.3**
TEST49 NORTH HYDRANT	**5548**	**74**	**79.7**	**5.7**	**13.2**	**13.2**	**65**	**67.0**	**2.0**	**4.6**	**4.6**
TEST15R EAST HYDRANT	4706	104	107.46	3.5	8.0	8.0	100	101.08	1.1	2.5	2.5
TEST15R WEST HYDRANT	5142	110	113.53	3.5	8.1	8.1	99	107.07	8.1	18.6	18.6
TEST41R WEST HYDRANT	**5298**	**114**	**110.89**	**-3.1**	**-7.2**	**7.2**	**96**	**93.76**	**-2.2**	**-5.2**	**5.2**
TEST41R EAST HYDRANT	**5300**	**99**	**100.93**	**1.9**	**4.5**	**4.5**	**89**	**85.45**	**-3.6**	**-8.2**	**8.2**
TEST43R SOUTH HYDRANT	5310	110	113.77	3.8	8.7	8.7	104	103.71	-0.3	-0.7	0.7
TEST43R NORTH HYDRANT	5308	100	109.44	9.4	21.8	21.8	92	98.12	6.1	14.1	14.1
TEST26R WEST HYDRANT	**5498**	**96**	**93.97**	**-2.0**	**-4.7**	**4.7**	**88**	**88.14**	**0.1**	**0.3**	**0.3**
TEST26R SOUTH HYDRANT	**5502**	**102**	**102.59**	**0.6**	**1.4**	**1.4**	**94**	**96.44**	**2.4**	**5.6**	**5.6**
TEST24R EAST HYDRANT	5196	87	91.95	5.0	11.4	11.4	68	65.6	-2.4	-5.5	5.5
TEST24R WEST HYDRANT	5192	78	88.17	10.2	23.5	23.5	60	63.26	3.3	7.5	7.5
TEST25R NORTH HYDRANT	**5200**	**99**	**103.9**	**4.9**	**11.3**	**11.3**	**82**	**77.52**	**-4.5**	**-10.3**	**10.3**
TEST25R SOUTH HYDRANT	**5202**	**98**	**97.83**	**-0.2**	**-0.4**	**0.4**	**68**	**62.02**	**-6.0**	**-13.8**	**13.8**

Test Number and Pressure Gauge Location	Computer Model Node	*No Flow at Fire Hydrant*					*High Flow at Fire Hydrant*				
		Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)	Field Measured Pressure (psi)	Computer Modeled Pressure (psi)	Computer Minus Field Pressure (psi)	Difference (feet)	Absolute Difference (feet)
TEST31R WEST HYDRANT	5224	92	84.72	-7.3	-16.8	16.8	84	81.39	-2.6	-6.0	6.0
TEST31R NORTH HYDRANT	5228	84	89.04	5.0	11.6	11.6	80	85.75	5.8	13.3	13.3
TEST35R SOUTH HYDRANT	**5260**	**106**	**110.35**	**4.3**	**10.0**	**10.0**	**84**	**83.34**	**-0.7**	**-1.5**	**1.5**
TEST35R EAST HYDRANT	**5256**	**110**	**112.50**	**2.5**	**5.8**	**5.8**	**93**	**80.66**	**-12.3**	**-28.5**	**28.5**
TEST40R NORTH HYDRANT	5762	98	97	-0.6	-1.4	1.4	88	93.04	5.0	11.6	11.6
TEST40R SOUTH HYDRANT	5764	86	89	2.7	6.2	6.2	80	84.67	4.7	10.8	10.8
TEST 3R NORTH HYDRANT	**5760**	**104**	**103**	**-1.4**	**-3.3**	**3.3**	**96**	**90.3**	**-5.7**	**-13.2**	**13.2**
TEST 3R SOUTH HYDRANT	**5060**	**110**	**113**	**3.4**	**7.9**	**7.9**	**94**	**100.82**	**6.8**	**15.7**	**15.7**
TEST 7R EAST HYDRANT	2752	93	95	1.7	4.0	4.0	88	91.06	3.1	7.1	7.1
TEST 7R WEST HYDRANT	642	102	96	-5.7	-13.2	13.2	90	92.6	2.6	6.0	6.0

Percentage of static tests for which the field and modeled pressures are within 15 feet = 95.6%

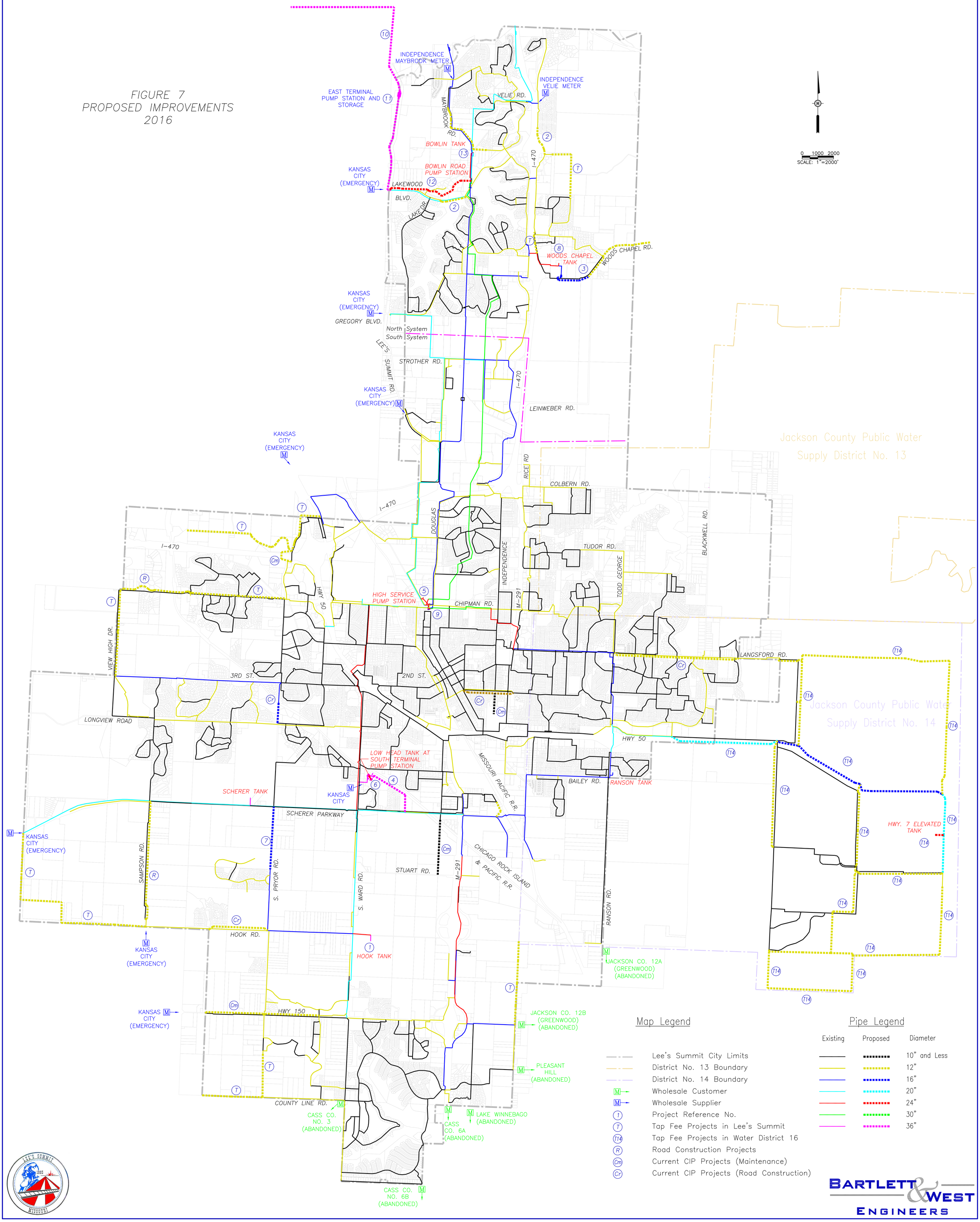
Percentage of high flow tests for which the field and modeled pressures are within 15 feet = 74.4%

Percentage of all tests for which the field and modeled pressures are within 15 feet = 85.0%

Appendix C

Recommended Improvements Map
Ultimate System

FIGURE 7
PROPOSED IMPROVEMENTS
2016



Map Legend

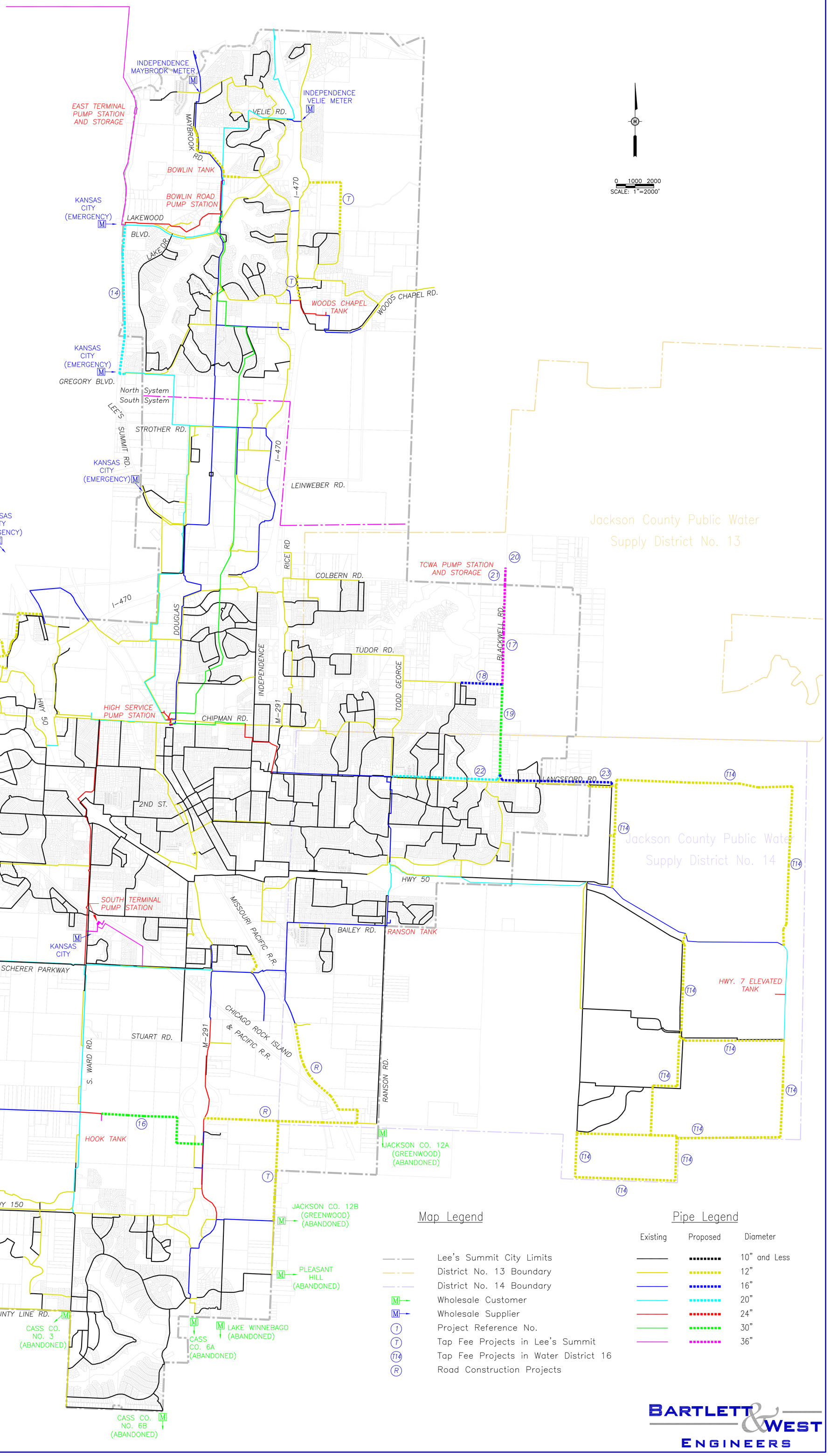
- Lee's Summit City Limits
- District No. 13 Boundary
- District No. 14 Boundary
- M → Wholesale Customer
- M → Wholesale Supplier
- (1) Project Reference No.
- (T) Tap Fee Projects in Lee's Summit
- (T14) Tap Fee Projects in Water District 16
- (R) Road Construction Projects
- (Cm) Current CIP Projects (Maintenance)
- (Cr) Current CIP Projects (Road Construction)

Pipe Legend

Existing	Proposed	Diameter
		10" and Less
		12"
		16"
		20"
		24"
		30"
		36"

BARTLETT & WEST ENGINEERS

FIGURE 8
PROPOSED IMPROVEMENTS
ULTIMATE BUILDOUT



Map Legend

- Lee's Summit City Limits
- District No. 13 Boundary
- District No. 14 Boundary
- Wholesale Customer
- Wholesale Supplier
- (1) Project Reference No.
- (T) Tap Fee Projects in Lee's Summit
- (T14) Tap Fee Projects in Water District 16
- (R) Road Construction Projects

Pipe Legend

Existing	Proposed	Diameter
		10" and Less
		12"
		16"
		20"
		24"
		30"
		36"

LEE'S SUMMIT 1865 MISSOURI

BARTLETT & WEST ENGINEERS

Appendix D

Compact Disc

Includes:
Model Data Files in MWH Soft H2O Map Water GIS for these scenarios:

- Existing System
- 2016 System
- Ultimate System

Report Text and Figures in Adobe Acrobat PDF format