Culinary Water Master Plan

December 2019

Prepared for:

St.George

Prepared by:

BOWEN COLLINS & ASSOCIATES

CULINARY WATER MASTER PLAN

December 2019

PROFESSIONAL ENGINEER
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Prepared for:

St.George

Prepared by:

BOWEN COLLINS
& ASSOCIATES

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EXECUTIVE SUMMARY

INTRODUCTION

The City of St. George (City) contracted the services of Bowen, Collins & Associates, Inc. (BC&A) to complete a Culinary Water System Master Plan. The purpose of this study is to provide the City with an updated plan to maintain a viable and efficient water system capable of meeting the future demands of its service area and meeting customer expectations.

SERVICE AREA

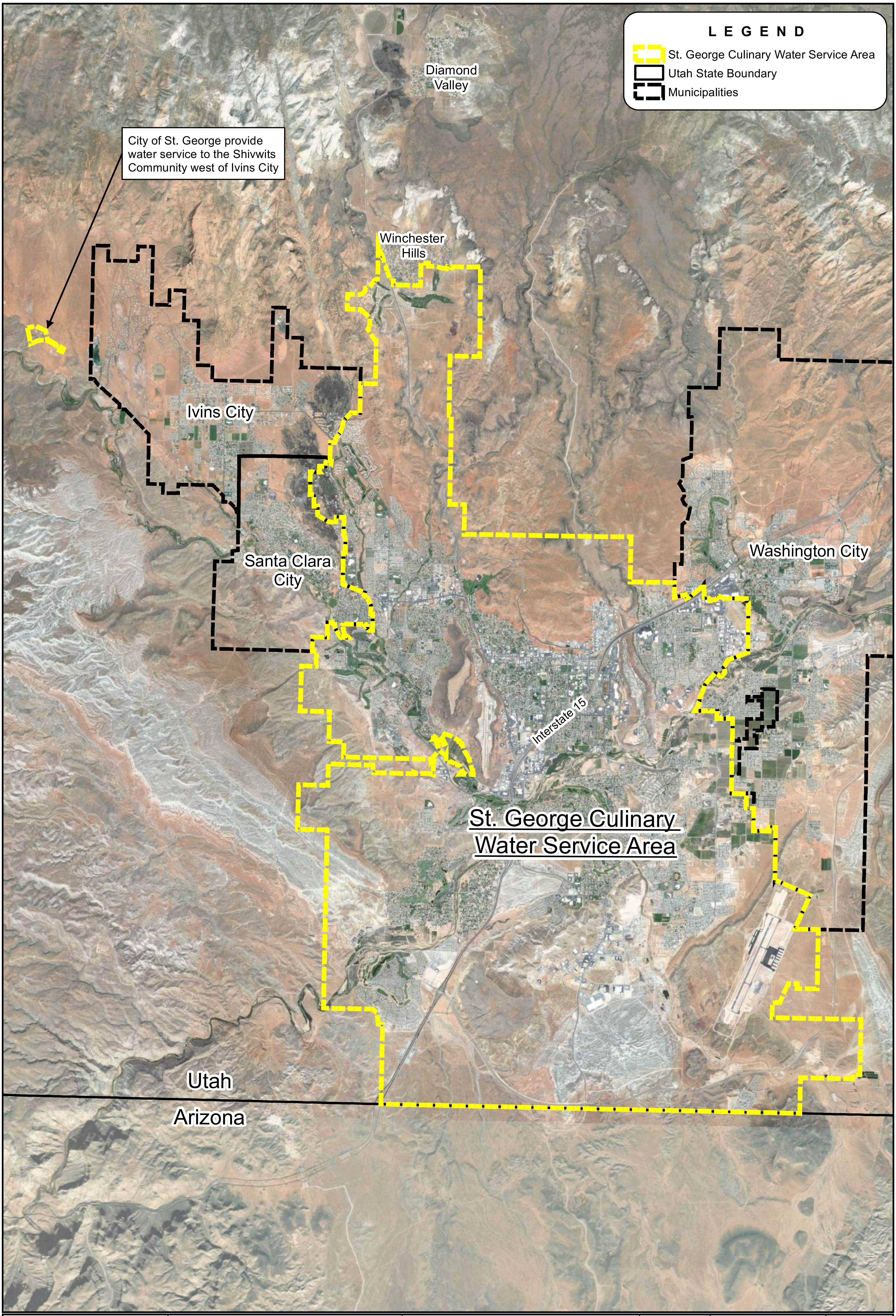
The City of St. George culinary water system service area is shown in Figure ES-1.

PROJECTED GROWTH AND WATER USE

Culinary water system growth projections were developed using the City's current land use and zoning plans in conjunction with population projections developed by the Governor's Office of Management and Budget. To project future system water use, historical water use records were evaluated to determine the amount of water used by different customer classes. These customer classes were then converted into Equivalent Residential Units (ERUs), providing a method of evaluating all user types as if they represented an equivalent residential population. The results of this evaluation are shown in Table ES-1. The values shown in Table ES-1 are based on the anticipated extent to which the secondary irrigation system will be expanded (see St. George Secondary Irrigation Master Plan).

10-YEAR CAPITAL FACILITIES PLAN

Using the water use estimates for existing and future conditions, the different components of the City's secondary irrigation system (sources, storage tanks, transmission and distribution lines, and pump stations) were evaluated. With the aid of a hydraulic computer model, projects were identified to address existing and future deficiencies in the system. Using the results of this analysis, a 10-Year Capital Facilities Plan was developed, which outlines the capital facilities projects that will be needed over the next 10 years to service existing and future customers. Table ES-2 provides a summary of the projects included in the 10-Year Capital Facilities Plan.



BOWEN COLLINS & ASSOCIATES	CITY OF ST. GEORGE CULINARY WATER MASTER PLAN	EXISTING CULINARY WATER SERVICE AREA	NORTH:	SCALE: 0 3,750 7,500 Feet	FIGURE NO. ES-1

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure ES-1 - St. George Culinary Water Service Area.mxd aanderson 12/27/2019

Table ES-1
City of St. George Water Use Projections

Year	Overall Residential Growth %	Overall Non-Residential Growth %	Total St. George Residential ERUs	Total St. George Non-Residential ERUs	Total Water System ERUs (Culinary and Irrigation)	Total Residential Culinary Water ERUs	Indoor Residential Culinary ERUs	Outdoor Residential Culinary ERUs	Total Non-Residential Culinary Water ERUs	Indoor Non-Residential Culinary ERUs	Outdoor Non-Residential Culinary ERUs	Total Culinary Water System ERUs	Annual Culinary Water System Demand (acre-ft/year)	Annual Culinary Indoor Demand (acre-feet/year)	Annual Culinary Outdoor Demand (acre-feet/year)	Peak Day Culinary Indoor Demand (gal/day)	Peak Day Culinary Outdoor Demand	Combined Peak Day Culinary Water System Demand
2017			29,010	17,532	46,542	28,744	14,215	14,529	9,568	6,015	3,553	38,312	27,337	13,395	13,942	14,948,014	34,015,075	48,963,089
2018	2.81%	2.81%	29,825	18,025	47,850	29,552	14,614	14,938	10,061	6,256	3,804	39,613	28,265	13,820	14,445	15,421,580	35,243,438	50,665,018
2019	2.85%	2.85%	30,675	18,538	49,214	30,394	15,031	15,363	10,574	6,508	4,066	40,969	29,232	14,262	14,970	15,915,337	36,524,396	52,439,734
2020	3.00%	3.00%	31,596	19,094	50,690	30,887	15,482	15,405	11,111	6,774	4,337	41,997	29,966	14,737	15,230	16,445,134	37,156,871	53,602,005
2021	3.61%	3.61%	32,736	19,784	52,520	31,486	16,041	15,445	11,736	7,091	4,645	43,223	30,841	15,317	15,524	17,092,512	37,874,776	54,967,288
2022	3.61%	3.61%	33,918	20,498	54,416	32,106	16,620	15,486	11,473	7,125	4,348	43,579	31,095	15,723	15,372	17,545,244	37,504,656	55,049,899
2023	3.61%	3.61%	35,142	21,238	56,380	32,748	17,220	15,529	12,213	7,487	4,725	44,961	32,081	16,360	15,721	18,256,575	38,356,627	56,613,202
2024	3.61%	3.61%	36,411	22,005	58,416	33,410	17,841	15,569	12,266	7,632	4,633	45,676	32,591	16,867	15,724	18,822,860	38,362,097	57,184,956
2025	3.61%	3.61%	37,726	22,799	60,525	34,096	18,486	15,610	13,037	8,014	5,023	47,133	33,631	17,547	16,084	19,580,954	39,241,189	58,822,143
2026	3.61%	3.61%	39,087	23,622	62,709	34,804	19,153	15,652	13,837	8,410	5,427	48,642	34,708	18,251	16,457	20,366,611	40,150,766	60,517,377
2027	3.61%	3.61%	40,499	24,475	64,973	35,534	19,844	15,689	14,667	8,821	5,847	50,201	35,820	18,980	16,840	21,180,827	41,084,732	62,265,560
2028	3.61%	3.61%	41,961	25,358	67,319	36,294	20,561	15,733	15,528	9,246	6,282	51,822	36,976	19,737	17,240	22,024,553	42,061,218	64,085,771
2029	3.61%	3.50%	43,475	26,246	69,721	37,148	21,303	15,845	16,331	9,654	6,678	53,479	38,159	20,498	17,661	22,874,210	43,088,667	65,962,877
2030	3.61%	3.50%	45,045	27,164	72,209	38,056	22,072	15,984	17,166	10,076	7,089	55,222	39,403	21,287	18,115	23,754,914	44,197,512	67,952,426
2031	3.50%	3.00%	46,621	27,979	74,601	38,992	22,844	16,148	17,908	10,452	7,456	56,900	40,600	22,048	18,553	24,603,533	45,264,414	69,867,947
2032	3.40%	3.00%	48,206	28,819	77,025	39,955	23,621	16,334	18,675	10,840	7,835	58,630	41,835	22,819	19,016	25,464,103	46,394,511	71,858,614
2033	3.40%	2.50%	49,845	29,539	79,385	40,972	24,424	16,547	19,336	11,174	8,162	60,307	43,031	23,571	19,460	26,304,009	47,477,559	73,781,568
2034	3.30%	2.50%	51,490	30,278	81,768	42,013	25,230	16,782	20,014	11,516	8,498	62,027	44,258	24,332	19,926	27,152,566	48,615,151	75,767,717
2035	3.30%	2.50%	53,190	31,035	84,224	43,108	26,063	17,045	20,711	11,868	8,843	63,818	45,536	25,116	20,421	28,027,462	49,821,796	77,849,258
2036	3.10%	2.50%	54,838	31,810	86,649	44,189	26,871	17,318	21,426	12,228	9,198	65,616	46,819	25,890	20,929	28,890,994	51,062,379	79,953,373
2037	3.00%	2.00%	56,484	32,447	88,930	45,285	27,677	17,608	22,014	12,525	9,490	67,300	48,020	26,620	21,401	29,705,492	52,213,391	81,918,882
2038	3.00%	2.00%	58,178	33,096	91,274	46,431	28,507	17,923	22,615	12,827	9,788	69,046	49,266	27,370	21,897	30,542,466	53,423,331	83,965,797
2039	3.00%	2.00%	59,923	33,758	93,681	47,627	29,362	18,264	23,229	13,136	10,093	70,856	50,558	28,140	22,418	31,402,545	54,693,848	86,096,393
2040	3.00%	2.00%	61,721	34,433	96,154	48,876	30,243	18,632	23,856	13,451	10,405	72,731	51,896	28,932	22,964	32,286,375	56,026,635	88,313,010
2041	3.00%	2.00%	63,573	35,121	98,694	50,178	31,151	19,027	24,496	13,773	10,723	74,674	53,283	29,746	23,536	33,194,621	57,423,434	90,618,055
2042	3.00%	1.75%	65,480	35,736	101,216	51,536	32,085	19,451	25,069	14,060	11,008	76,605	54,660	30,555	24,105	34,097,614	58,810,025	92,907,639
2043	3.00%	1.75%	67,444	36,361	103,806	52,951	33,048	19,904	25,652	14,353	11,299	78,603	56,086	31,387	24,699	35,025,217	60,261,138	95,286,356
2044	1.70%	1.75%	68,591	36,998	105,589	53,787	33,610	20,177	26,246	14,651	11,595	80,033	57,106	31,956	25,150	35,660,668	61,360,524	97,021,193
2045	1.60%	1.75%	69,688	37,645	107,333	54,591	34,147	20,444	26,852	14,955	11,897	81,443	58,112	32,513	25,599	36,282,374	62,455,737	98,738,111
2046	1.00%	1.75%	70,385	38,304	108,689	55,105	34,489	20,616	27,468	15,264	12,204	82,573	58,919	32,944	25,975	36,763,148	63,372,643	100,135,791
2047	0.80%	1.75%	70,948	38,974	109,923	55,522	34,765	20,757	28,096	15,579	12,517	83,618	59,664	33,335	26,329	37,199,651	64,237,208	101,436,859
2048	0.70%	1.50%	71,445	39,559	111,004	55,890	35,008	20,882	28,645	15,854	12,791	84,535	60,319	33,678	26,640	37,582,505	64,996,543	102,579,047
2049	0.60%	1.50%	71,874	40,152	112,026	56,209	35,218	20,991	29,202	16,133	13,069	85,411	60,944	34,002	26,942	37,943,924	65,731,546	103,675,470
2050	0.50%	1.50%	72,233	40,755	112,988	56,477	35,394	21,083	29,768	16,416	13,352	86,245	61,539	34,306	27,232	38,283,474	66,441,077	104,724,552
2051	0.40%	1.35%	72,522	41,305	113,827	56,693	35,536	21,157	30,286	16,675	13,611	86,979	62,062	34,572	27,490	38,579,523	67,070,557	105,650,079
2052	0.40%	1.25%	72,812	41,821	114,633	56,910	35,678	21,232	30,772	16,919	13,854	87,682	62,564	34,827	27,737	38,864,299	67,671,909	106,536,207
2053	0.30%	1.25%	73,030	42,344	115,374	57,073	35,785	21,288	31,265	17,165	14,100	88,338	63,032	35,061	27,971	39,125,469	68,243,235	107,368,704
2054	0.30%	1.00%	73,250	42,767	116,017	57,237	35,892	21,345	31,664	17,365	14,299	88,902	63,434	35,264	28,170	39,352,353	68,728,233	108,080,586
2055	0.29%	0.49%	73,462	42,977	116,439	57,397	35,996	21,400	31,862	17,464	14,398	89,259	63,689	35,399	28,290	39,502,319	69,022,023	108,524,343

Table ES-2
City of St. George 10-Year Culinary Water System Capital Facilities Plan[1]

Project Identifier	Project Description	Estimated Total Cost (2018 Dollars)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total Inflated Project Cost
W1	Homestead Well Development	$1,000,000				$1,082,000							$1,082,000
S1	Warner Valley Tank (No Cost to St. George)	$0											$0
S2	Gap Zone/Gunlock Zone Valve Improvements	$60,000			$64,000								$64,000
S3	Northern Gap Tank	$3,622,500			$3,844,000								$3,844,000
S4	Country Club Tank Replacement	$2,070,000					$2,241,000						$2,241,000
S5	Airport Redevelopment (Tech Ridge) Tank	$2,070,000							$2,378,000				$2,378,000
C1	City Creek to Ledges Pipeline	$2,731,300		$2,842,000									$2,842,000
C2	Ledges Main Line	$499,100		$519,000									$519,000
C3	The Lakes North Loop	$1,405,500			$1,492,000								$1,492,000
C6	Plantations Drive to Dixie Drive Waterline	$724,500							$832,000				$832,000
C7	Gap Tank Feed Line	$4,475,200						$5,040,000					$5,040,000
C8	Indian Hills Transmission Line	$600,900									$718,000		$718,000
C9	Indian Hills/Airport Redevelopment (Tech Ridge) Transmission Line	$295,000									$353,000		$353,000
C10	Foremaster Ridge Transmission Line Relocation	$724,500					$800,000						$800,000
C11	Riverside to Hilton Drive Transmission Line	$3,835,300								$4,494,000			$4,494,000
C14	Desert Color Southwest Loop	$1,495,600			$1,587,000								$1,587,000
C21	Sand Hollow Regional Pipeline - Washington Fields Road to 3000 E	$2,162,000			$2,294,000								$2,294,000
C22	Sand Hollow Regional Pipeline - Airport Connection	$1,256,700		$1,307,000									$1,307,000
C28	Southern Parkway Loop - 14" Pipeline	$1,196,000							$1,374,000				$1,374,000
C29	Desert Canyons Reach 1	$1,196,000				$1,295,000							$1,295,000
P1	City Creek to Ledges Pump Station	$1,293,750		$1,346,000									$1,346,000
P2	Indian Hills Pump Station	$805,000								$943,000			$943,000
P3	Airport Redevelopment (Tech Ridge) Pump Station	$1,104,000									$1,319,000		$1,319,000
P4	Dixie Drive Pump Station - Gunlock 1A to Gap Zone	$172,500			$183,000								$183,000
P6	Bloomington Hills Pump Station Upgrade	$124,200	$127,000										$127,000
	Total Improvements	**$34,919,550**	**$127,000**	**$6,014,000**	**$9,464,000**	**$2,377,000**	**$3,041,000**	**$5,040,000**	**$4,584,000**	**$5,437,000**	**$2,390,000**	**$0**	**$38,474,000**

[1]A 2% annual inflation rate has been applied to estimated future project costs.

CHAPTER 1
INTRODUCTION

INTRODUCTION

The City of St. George (City) has retained Bowen Collins & Associates (BC&A) to prepare a master plan update for the City's water system. The purpose of this water master plan report is to evaluate the different components of the City's water system and identify improvements that will resolve existing deficiencies and accommodate the growing needs of the system.

SCOPE OF SERVICES

The general scope of this project involved a thorough analysis of the City's water production, storage, transmission, and distribution system and its ability to meet the current and future water needs of its customers. As part of the Water Master Plan, BC&A completed the following tasks.

Task 1: Collect and review data needed to develop the master plan

Task 2: Update population projections for the City and estimate buildout population

Task 3: Evaluate current water use patterns and project future system water demands

Task 4: Evaluate City Water Supplies

Task 5: Evaluate City Storage Facilities

Task 6: Update and calibrate hydraulic computer model/evaluate the water distribution system

Task 7: Identify existing system deficiencies

Task 8: Identify projected future operating deficiencies

Task 9: Evaluate system improvement projects to resolve identified deficiencies

Task 10: Develop water system capital facilities plan

Task 11: Document results from previous tasks

This master plan is a working document. The recommended improvements identified in this report are based on the assumption that development will occur in a particular manner. If future growth or development patterns change significantly from those assumed and documented in this report, the recommendations may need to be revised in a future master plan update. The City should plan to update this master plan every three to five years.

ACKNOWLEDGMENTS

The BC&A team wishes to thank the following individuals from the City of St. George for their cooperation and assistance in completing this report:

Scott Taylor	Water Services Director
Kade Bringhurst	Special Projects Manager
John Willis	Community Development Director
Wes Jenkins	Planning and Zoning
David Evans	GIS Administrator
Jeff Lance	Irrigation Manager

PROJECT STAFF

This project was performed by the BC&A team members listed below. Team members' roles on the project are also listed. The project was completed in BC&A's St. George, Utah office. Questions may be addressed to Todd Olsen or Aaron Anderson at (435) 656-3299.

Keith Larson	Principle-in-Charge
Todd Olsen	Project Manager
Aaron Anderson	Project Engineer
Mike Hilbert	Clerical

CHAPTER 2
EXISTING SYSTEM FEATURES

INTRODUCTION

The City's water system is made up of several different components which work together to produce, treat, and deliver water to customers. The purpose of this chapter is to provide a summary of the existing facilities within the St. George City culinary water system. This chapter is intended to be used as a quick reference for City personnel regarding key system information. Included is information regarding wells, storage tanks, pressure zones, pressure regulating valves, transmission and distribution pipelines, and booster stations.

SERVICE AREA

The St. George City water service area encompasses all of St. George City as well as the Shivwits Community located to the west Ivins City along Old Highway 91, as shown in Figure 2-1. The total service area encompasses over 49,000 acres of land and borders the State of Arizona to the south. Population estimates from the Governor's Office of Management and Budget (GOMB) estimate a 2018 population of over 90,000 residents, and due to the attractive nature of the City as a tourist/vacation destination, temporary occupancy of the City can be significantly higher. In addition to permanent residents, the City provides water service to a number of golf courses, resorts, and many other commercial, industrial, and institutional entities.

EXISTING SYSTEM COMPONENTS – CULINARY WATER SYSTEM

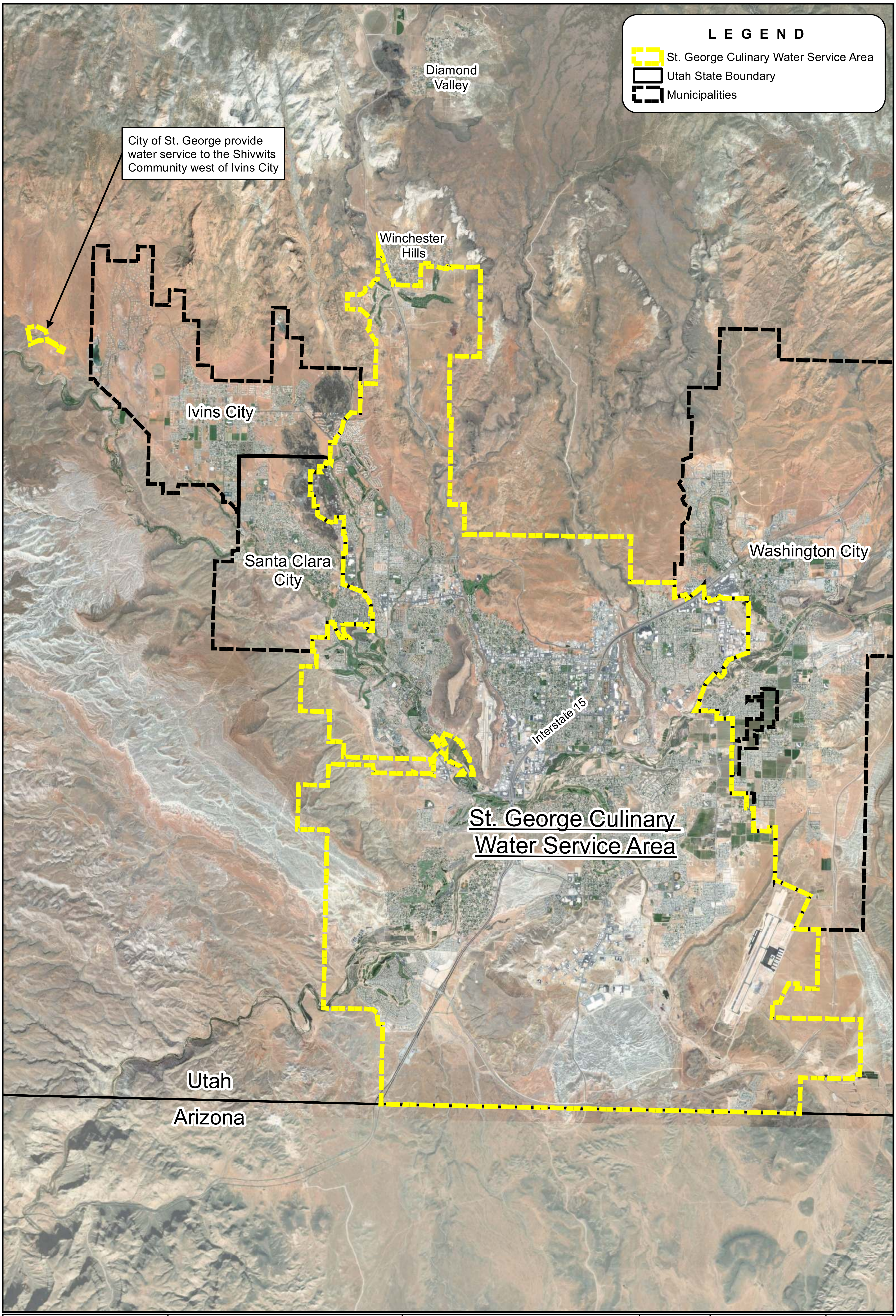
The following sections provide a description of the existing facilities which make up the City's culinary water production and distribution system. A map of the City's existing facilities is shown in Figure 2-2, and Figure 2-3 provides an operational schematic of the City's facilities (developed by the St. George Water Department).

SUPPLY SOURCES

St. George City has 23 wells in its water supply system along with 16 spring sources. The City is also supplied with treated surface water from Quail Creek Reservoir and Sand Hollow Reservoir through the Quail Creek Water Treatment Plant (WTP) owned by Washington County Water Conservancy District (WCWCD). Water is delivered to St. George from the Quail Creek WTP via a 60-inch and 36-inch Regional Pipeline. A detailed discussion of each source and its yield can be found in Chapter 4 – Source Evaluation.

WELLS

St. George City owns 23 wells located throughout the system. Table 2-1 summarizes the characteristics of each existing well source. It should be noted that several Gunlock Wells are currently not in use due to arsenic levels that do not meet EPA water quality standards. The City is currently in the process of adding an arsenic treatment facility near Gunlock Reservoir to bring these wells back into culinary water service.



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

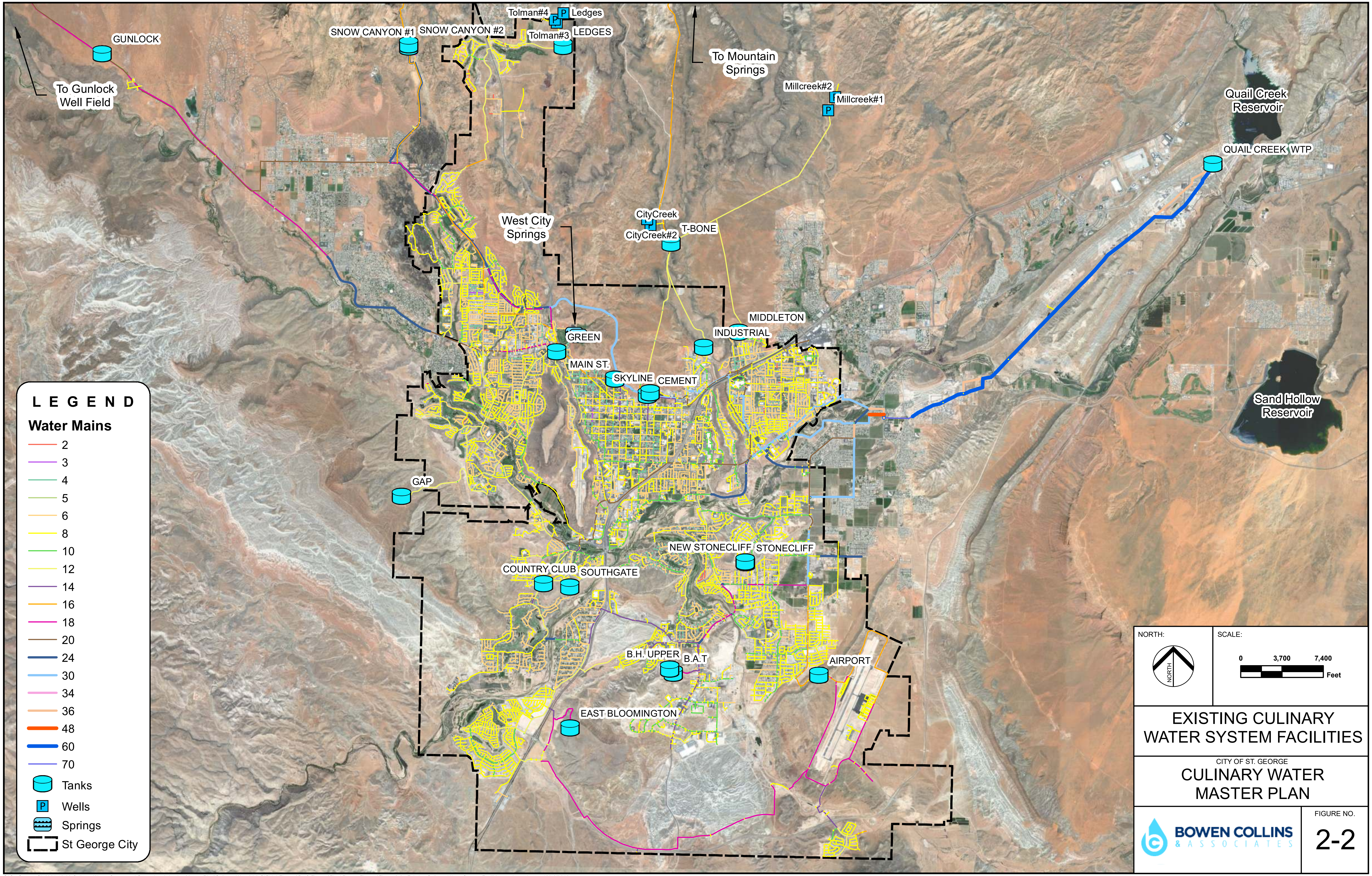
EXISTING CULINARY WATER SERVICE AREA

NORTH:

SCALE: 0 3,750 7,500 Feet

FIGURE NO. 2-1

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 2-1 - St. George Culinary Water Service Area.mxd aanderson 12/13/2019



EXISTING CULINARY WATER SYSTEM FACILITIES

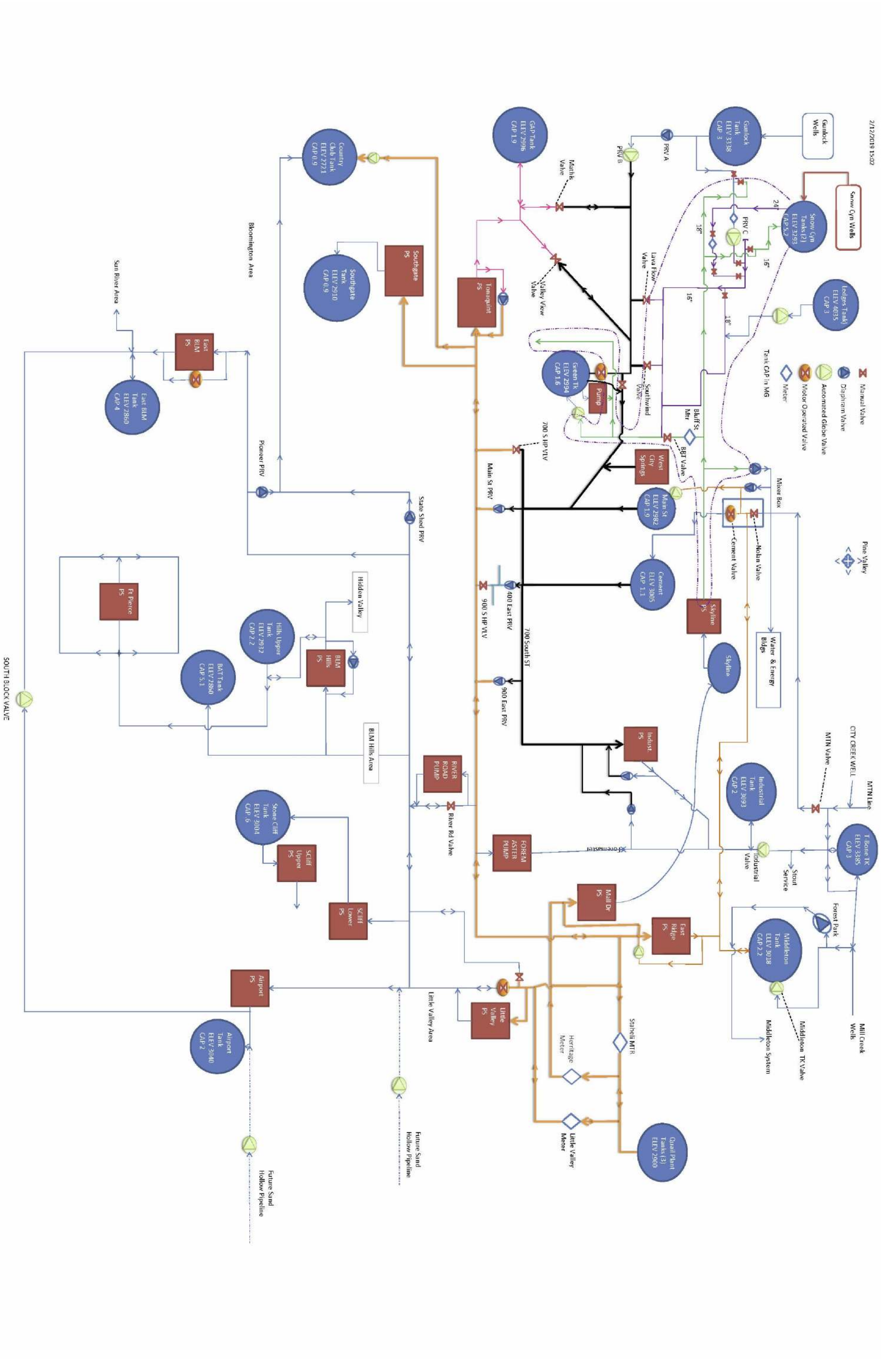
CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.
2-2

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 2-2 - Existing Culinary Water System Facilities.mxd aanderson 12/13/2019

*Schematic Provided Courtesy of City of St. George Water Department



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

EXISTING CULINARY WATER SYSTEM SCHEMATIC

NORTH:

SCALE: N/A

FIGURE NO. 2-3

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 2-3 - Existing Culinary Water System Schematic.mxd aanderson 12/13/2019

Table 2-1
Existing St. George City Well Sources

Name	Installation Date	Well Casing Size (inches)	Well Depth (feet)	Peak Production Capacity (gpm)
City Creek #1*	NA	NA	NA	NA
City Creek #2	NA	NA	NA	1,200
Gunlock #1***	1962	16	990	1,000
Gunlock #2**	1967	16	800	600
Gunlock #3***	1966	16	625	750
Gunlock #4***	1970	16	800	1,250
Gunlock #5**	1976	16	560	900
Gunlock #6**	1986	12	680	300
Gunlock #7**	1995	16	800	700
Gunlock #8**	1995	16	800	1,100
Gunlock #9**	2000	16	1,000	700
Gunlock #10**	2000	16	1,020	800
Gunlock #11**	2000	16	1,000	500
Ledges	2005	16	1,500	750
Millcreek #1	NA	16	800	700
Millcreek #2	1983	16	500	600
Snow Canyon #2	1996	16	1,000	382
Snow Canyon #3	1984	12	700	255
Snow Canyon #3A	2002	16	1,000	255
Snow Canyon #4	1984	16	800	287
Snow Canyon #5	2002	16	610	96
Tolman #3	1986	12	1,026	200
Tolman #4	1995	16	1,120	350
			TOTAL	**10,675**

*City Creek #1 currently not in operation (not equipped).
**Current production capacity of Gunlock Wells used in the culinary water system is 2,000 gpm, but capacity will increase to 5,600 gpm with the completion of the Gunlock Arsenic Treatment Plant.
***Gunlock Well #1, #3, and #4 are used for irrigation and are not included in the total.

SPRINGS

St. George City operates 16 mountain spring sources, 14 of which are located near the Pine Valley Mountains about 13 miles north of the City. Three additional springs are located within the City near Red Cliffs Golf Course, two of which are used in the culinary water system. The City's current spring sources are summarized in Table 2-2 with the combined capacity in acre-feet per year (AF/year) and gallons per minute (gpm).

Table 2-2
Summary of Existing Spring Sources

Name	**Annual Spring Capacity (AF/year)**	**Reliable Spring Flow Capacity* (gpm)**
Mountain Springs	**3,117**	**2,000**
Big Pine Lower #1		
Big Pine Lower #2		
Big Pine Middle		
Big Pine Upper		
Carter Lower		
Carter Middle		
Carter Upper		
Cottonwood Spring		
Lower Spring		
Quaking Aspen Middle		
Quaking Aspen Upper		
Slide Spring		
Sullivan Spring		
West Fork Spring		
West City Springs		
West City Spring (Culinary)	**564**	**350**
Total Spring Capacity	**3,681**	**2,350**

*Based on historical production rates

QUAIL CREEK WATER TREATMENT PLANT (WCWCD)

The Quail Creek WTP is operated by the WCWCD and provides water to several communities in the County, including St. George, Washington City, Santa Clara, and Ivins. The WTP has a treatment capacity of 48 Million Gallons per Day (MGD) and a total storage capacity of 25 Million Gallons (MG). Water is delivered to St. George and other communities through a 60-inch and 36-inch transmission line. The WTP treats water from Quail Creek Reservoir and Sand Hollow Reservoir.

STORAGE FACILITIES

St. George City currently has 49.5 MG of combined storage (including the City's storage facilities at the Quail Creek WTP) in 21 storage tanks. The 0.5 MG Skyline Tank serves as intermediate storage between the Mall Drive Pump Station and Skyline Pump Station (essentially as a wet well for the Skyline Pump Station) and does not provide operational storage for the system. This considered, the City's total operational storage is 49 MG. A summary description of the City's tanks is shown in Table 2-3.

Table 2-3
St. George Water Storage Facilities

Tank Name	Size of Tank (Million Gallons)	Tank Diameter (ft)	Construction Material	Pressure Zone(s) Served By Tank	Base Elevation (ft)	Tank Height (ft)	Overflow Elevation (ft)	Max Depth (ft)
Airport Tank	2	140x100	Concrete	Airport	3040	20	3058	18
B.A.T	5.1	210	Steel	Bloomington Hills	2860	21.5	2879.5	19.5
B.H. Upper	2.2	100	Steel	Bloomington Hills Upper, Fort Pierce Industrial	2932.2	40	2970.2	38
Cement	1.1	120	Concrete	Gunlock 1A, 1B, 2A, 2B, 3B	3005	15	3018	13
Country Club	0.9	75	Steel	County Club	2721	30	2749	28
East Bloomington	4	200	Concrete	East Bloomington	2859.6	20	2877.6	18
Gap	1.9	120	Steel	Gap 1, Gap 2	2996	24	3018	22
Green	1.6	120	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	2994	21	3013	19
Gunlock	3	120	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	3338	38	3374	36
Industrial	2	103	Hypalon	Industrial, Foremaster	3093	22	3113	20
Ledges	3	170	Concrete	Ledges	4035.6	20	4053.6	18
Main St.	1.9	100	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	2982	35	3015	33
Middleton	2.2	100	Steel	Eastridge 1, Eastridge 2	3018	40	3056	38
New Stonecliff	0.3	54	Concrete	Stonecliff Upper	0	20	18	18
Quail Creek WTP	10	275	Steel	Regional	2900	22.5	2920.5	20.5
Skyline	0.5*	75	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	0	18	17	17
Snow Canyon #1	1.8**	165	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	3293	18	3309	16
Snow Canyon #2	1.8**	165	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	3293	18	3309	16
Southgate	0.9	103	Steel	Southgate	2910	16	2924	14
Stonecliff	0.3	53	Steel	Stonecliff	3004	18	3020	16
T-Bone	3	120	Steel	Millcreek 1, Millcreek 2, Mountain	3385.4	38	3421.4	36
Total	**49.5**							

*The Skyline Tank does not provide operational storage to the system.
**The total storage volume of each Snow Canyon Tank is 3.0 MG, but the City's legal allocation is 60% of each tank, or 1.8 MG from each tank.

SYSTEM PRESSURE ZONES

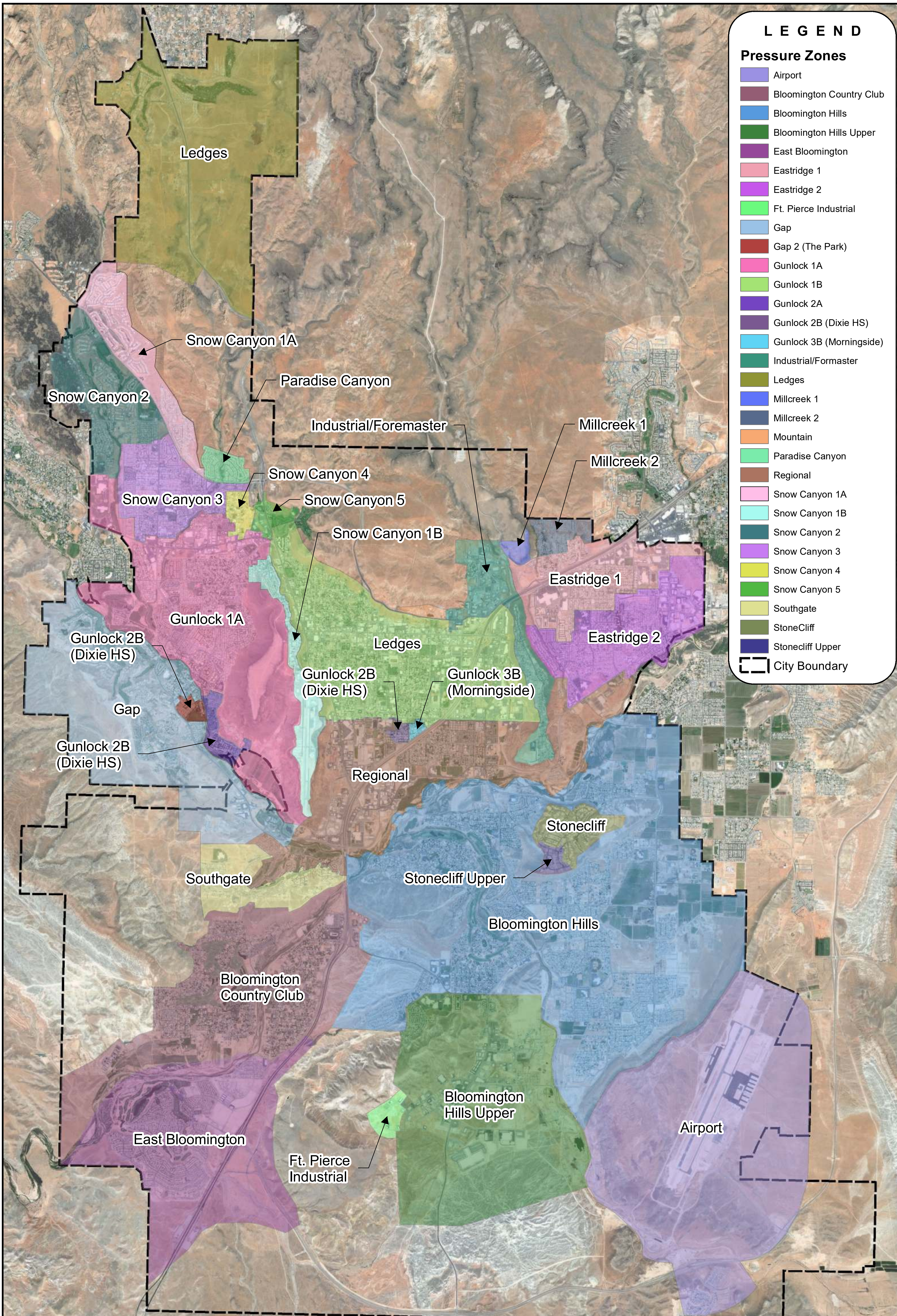
The St. George water system contains 31 different pressure zones. These pressure zones are established by the topography of the service area and the elevation/location of storage tanks. The City's pressure zones are shown in Figure 2-4.

PIPELINES

The City's water system is composed of over 3.8 million feet of distribution and transmission piping. Pipe sizes range from 2-inch distribution lines to 36-inch transmission lines. Table 2-4 provides a summary of the City's existing pipe network. As shown in the table, well over half of the City network is comprised of 6-inch and 8-inch distribution lines.

Table 2-4
City of St. George System Piping

Pipe Diameter (inches)	Total Length (ft)	Percentage of Network
2	9,123	0.24%
3	2,563	0.07%
4	73,949	1.98%
6	929,328	24.87%
8	1,572,636	42.08%
10	257,518	6.89%
12	296,447	7.93%
14	61,107	1.64%
16	161,282	4.32%
18	173,729	4.65%
20	116,550	3.12%
24	29,389	0.79%
30	20,251	0.54%
34	124	0.00%
36	33,272	0.89%
Total	**3,737,267**	**100%**



BOWEN COLLINS & ASSOCIATES	CITY OF ST. GEORGE CULINARY WATER MASTER PLAN	EXISTING CULINARY WATER PRESSURE ZONES	NORTH:	SCALE: 0 2,500 5,000 Feet	FIGURE NO. 2-4

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 2-4 - Existing Culinary Water Pressure Zones.mxd aanderson 12/13/2019

CHAPTER 3
WATER USE EVALUATION AND GROWTH PROJECTIONS

INTRODUCTION

A key aspect of the master planning process is developing projections of population growth within the City's service area. Population projections have a direct impact on important components of the master plan, including the projected timing of capital improvements. Over-estimating population growth projections may lead to poorly timed capital improvement projects for the City, which could result in aggressive future rate increases that may not actually be necessary. The opposite is true for under-estimating growth, which could leave the City without the necessary financial backing to carry out required capital improvements as well as not providing sufficient lead time for projects.

The purpose of this chapter is to develop growth projections for the City by analyzing historical growth trends as well as reviewing population projections developed by local planning authorities and other national and state planning agencies. These projections, together with an analysis of existing water use trends and needs, have been used to project future water demand on the City's system.

HISTORICAL GROWTH TRENDS

The City of St. George has seen significant growth in the last few decades. Table 3-1 summarizes population growth for St. George from the year 1990 to 2010 based on data available from the United States Census Bureau.

Table 3-1
U.S. Census Bureau Historical Population Growth for St. George

Year	City of St. George Population	% Growth
1990	28,572	
2000	49,663	73.8%
2010	72,897	46.8%

As shown in Table 3-1, the City of St. George saw a significant boom in growth from 1990 to 2000, continuing on into the following decade. Using the information provided in Table 3-1, Table 3-2 shows the average yearly growth rate for St. George over each respective decade.

Table 3-2
Average Annual Growth Rate[1] in St. George from 1990 to 2010

Time Period	Average Annual Growth Rate[1]
1990-2000	5.7%
2000-2010	3.3%

[1]Represents the average annual growth rate based on U.S. Census records

While the data from the census provides a reliable, high-level overview of growth information for the City in historic 10-year increments, historic annual growth in the area can be monitored in more detail by looking at the increase in new service connections each year (determined by the City approving building permits). Multiplying the number of new service connections by the average household size in the City provides an estimate for population growth from year to year. The most recent U.S. Census Bureau estimate for average household size in St. George is 2.88 persons/household. To see how this compares to other communities near St. George, Table 3-3 provides a summary of average household size estimates for other cities in the Southern Utah/Southern Nevada area. As shown in the table, St. George is just below the average for household size in the region.

Table 3-3
Average Household Size Comparison

City	U.S. Census Estimate for Average Household Size
St. George, UT	**2.88**
Washington City, UT	2.99
Ivins City, UT	2.78
Hurricane, City, UT	2.9
Santa Clara City, UT	3.75
Cedar City, UT	3.0
Mesquite, NV	2.34
Average	**2.95**

Table 3-4 shown below shows the records of new building permits issued within the City from 2014 to 2018.

Table 3-4
Building Permits Issued in the City of St. George (2014 – 2018)

	2014	2015	2016	2017	2018
Single Family	576	741	790	944	942
Townhomes	110	46	46	102	274
Apartment/Duplex	2	2	1	15	11
Mobile Homes	1	3	1	1	6
Condos	12	0	1	35	20
Commerical/Industrial	119	109	25	117	201
Miscellaneous/Additions*	655	685	900	742	805
Hospital/Interior Finish	0	1	2	3	18
Institutes/Schools/Day Care	1	1	0	0	0
Public/Airport/Parks	12	6	16	1	3
Religious	0	3	1	1	2
Subtotal – All Permits	**1,488**	**1,597**	**1,783**	**1,961**	**2,282**
Residential	701	792	839	1,097	1,253
Non-Residential	132	120	44	122	224
Total, Excluding Home Add.	**833**	**912**	**883**	**1,219**	**1,477**

*Miscellaneous/Home Additions were not included in total number considering that they typically do not represent an increase in the population or water use.

Detailed water meter records from the City and data from the Washington County Recorder indicate that at the end of 2017 there were a total of 33,107 residential connections and 2,293 permanent non-residential connections (commercial, industrial, institutional, etc.). Using the U.S. Census Bureau estimate for household size in St. George, the estimated total residential population in St. George as of 2017 was:

$$33{,}107\ residential\ connection\ x\ 2.88\,\frac{persons}{household} = \mathbf{95{,}349\ residents}$$

Note that this estimate does include the transient population in the area (i.e. second homes, short term rental units, etc.), but for the purposes of water system master planning, all of these units will be treated as if they were a primary residence. It should be noted that, based on County Recorder records, St. George is home to over 6,500 secondary residences that may be occupied for only a portion of the year. However, when comparing water use between primary residences and secondary residences, meter data records indicate that secondary homes use only 10% less water over the course of the year than primary residences, which supports the approach of treating all connections as if they were primary residences.

Table 3-5 outlines the estimated growth rate for St. George from the 2014-2018.

Table 3-5
Summary of Recent Historical Growth in the City of St. George (2014 – 2018)

Year	2014	2015	2016	2017	2018
New Residential Connections	701	792	839	1097	1253
Total Residential Connections	30,379	31,171	32,010	33,107	34,360
Growth Rate		**2.6%**	**2.7%**	**3.4%**	**3.8%**
New Non-Residential Connections	132	120	44	122	224
Non-Residential Connections	2,037	2,157	2,201	2,323	2,547
Growth Rate		**5.89%**	**2.04%**	**5.54%**	**9.6%**

As shown in Table 3-5, the residential growth rate steadily increased over the past 4 years, with an estimated rate of 3.43% from 2016 - 2017 and 3.8% from 2017 - 2018, while non-residential growth fluctuated from year to year. Growth in St. George recently caught national attention as it was identified as the fastest growing metropolitan area in the country, in which the US Census estimated a 4% growth rate from 2016 – 2017 (which included not only St. George but also the majority of Washington County).

Considering that there are a number of large developments currently planned or under construction in the area, including the large master-planned South Block area, it is reasonable to assume that the City will continue to grow at a relatively aggressive rate into the foreseeable future. Through correspondence with City management, the City has elected to use the population projections developed for the Governor's Office of Management and Budget (GOMB), which match historical growth trends relatively well. Table 3-6 summarizes the growth projections from the GOMB for St. George. These projections form the basis of growth projections used in this report, with a minor modification that is discussed in the following section.

Table 3-6
GOMB Growth Projections for St. George City

Year	2010	2020	2030	2040	2050	2060
St. George Population	72,897	103,851	148,078	196,206	249,421	307,037
Average Annual Growth Rate		3.60%	3.61%	2.85%	2.43%	2.10%

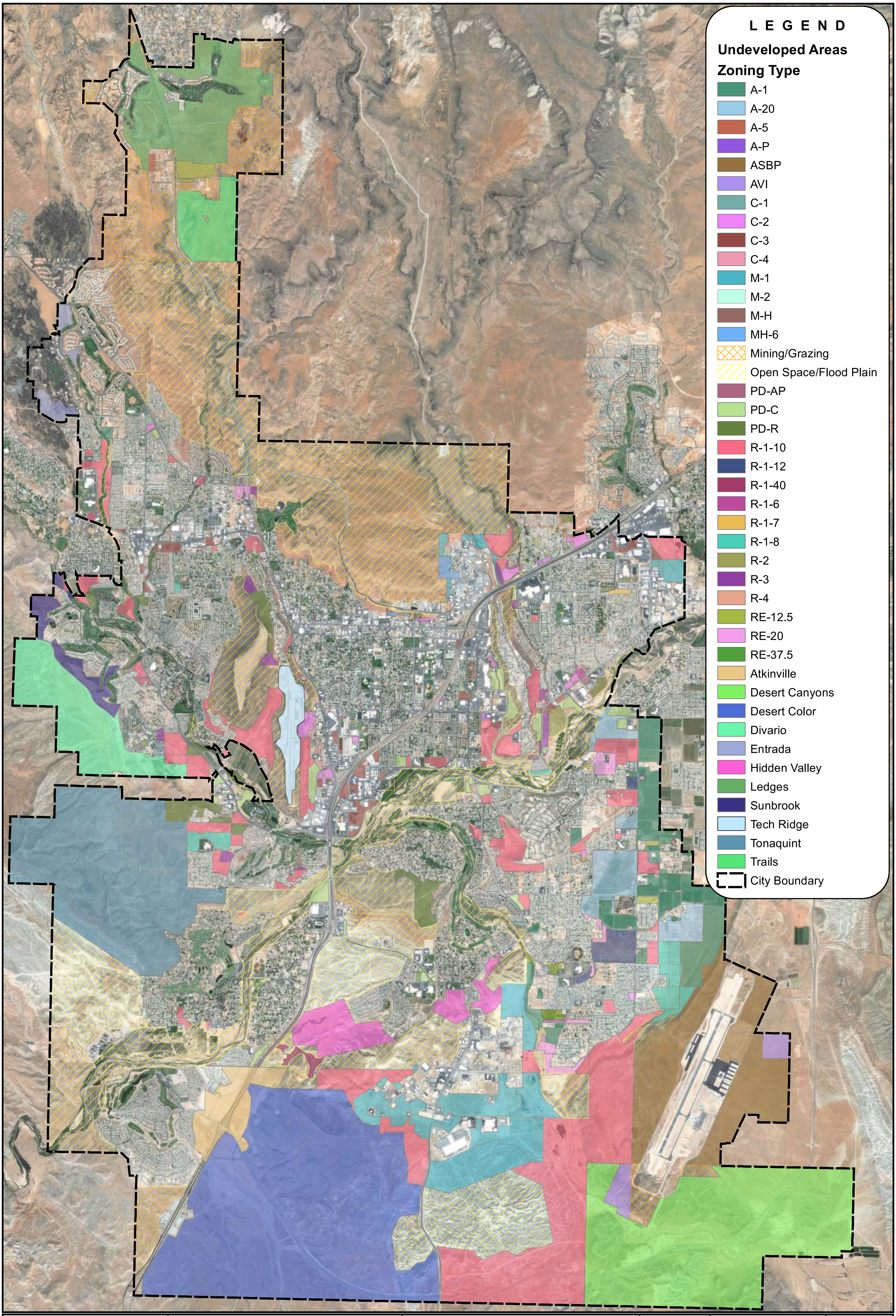
ESTIMATED BUILDOUT POPULATION

The build-out population (the population when all developable land in the City has been developed) of St. George has been estimated using the City's current land use and zoning plans. The land use and zoning plans identify the location and type of development that has been approved for specific areas throughout the City. The City's General Plan describes the difference between the zoning map and land use map:

The Zoning Map…and the Land Use Plan…work hand-in-hand with each other. The Land Use Plan indicates general density ranges and indicates how development is to be located on the land, with special regard to preserving special natural features. The Zones in the Zoning Map are legal designations that assign a specific overall density to a specific tract of land.

Through coordination with City management, the buildout population estimate for St. George was developed using portions of each plan. In some areas, the Land Use Plan provides a more accurate representation of future development density, while the Zoning Plan provides more detailed information in other areas. In this sense, buildout population estimates were developed using a "composite" land use/zoning plan. In addition to the general Land Use and Zoning plans, another component considered in this analysis are Planned Development Areas, or "PD"s, which are specific areas of the City that have an established and approved number of development units. PDs have been accounted for in the estimation of buildout population.

In order to estimate the service area population at full buildout for the City, the currently undeveloped areas of the City needed to be identified and separated from the currently developed areas. This was done using Geographic Information System (GIS) mapping tools to "clip out" areas of the City which are currently developed from the overall land use and zoning plan, leaving only the undeveloped areas with their associated land use and zoning type and respective area. This is illustrated in Figure 3-1 (colored areas are those have are yet to be developed or that represent permanent open space or other preservation areas. Using the result of this exercise, Table 3-7 provides a summary of the estimated service area population that will added when all undeveloped land in the City is developed.



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

CURRENTLY UNDEVELOPED AREAS OF ST. GEORGE

NORTH:
NORTH

SCALE:
0 2,500 5,000 Feet

FIGURE NO.
3-1

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 3-1 - Currently Undeveloped Areas of St. George.mxd aanderson 12/13/2019

Table 3-7
Evaluation of Undeveloped Land by Land Use/Zoning Category

Zoning Code	Development Description	Area (Acres)	Density (Units Per Acre)	Number of Units	Estimated Added Residential Population[1]
A-1	Agricultural Use, Min. 40,000 SF	776.3	1.00	776.3	2,236
A-20	Agricultural Use, Min 20 Acres	408.4	0.05	20.4	59
A-5	Agricultural Use, Min 5 Acres	10.3	0.20	2.1	6
A-P	Administrative and Professional, No Min Area	4.0	5.00	19.8	0
ASBP	Airport Supporting Business Park	1,118.4	2.00	2,236.7	0
AVI	Airport Vicinity Industrial	134.1	1.00	134.1	0
C-1	Commercial, No Min Area	5.7	2.00	11.5	0
C-2	Commercial, No Min Area	99.4	2.50	248.5	0
C-3	Commercial, No Min Area	161.3	3.00	483.9	0
C-4	Commercial, No Min Area	0.0	3.50	0.2	0
M-1	Manufacturing, No Min Area	1,025.9	0.50	513.0	0
M-2	Manufacturing, Min 40,000 SF	0.1	7.50	0.7	0
M-H	Mobile Home	2.3	6.00	13.8	40
MH-6	Mobile Home Min 6,000 SF	33.3	6.00	199.9	576
Mining_Grazing	Mining/Grazing, No Area Min	1,252.9	0.00	0.0	0
OS	Open Space, No Min Area	9,824.6	0.00	0.0	0
PD-AP	Planned Development - Admin & Professional Office	12.9	2.00	25.9	0
PD-C	Planned Development - Comm	239.2	2.00	478.3	0
PD-R	Planned Development - Res	341.9	4.00	1,367.5	3,938
R-1-10	Single Family Res. Min 10,000 SF	3,044.7	3.20	9,743.1	28,060
R-1-12	Single Family Res. Min 12,000 SF	130.7	2.80	366.1	1,054
R-1-40	Single Family Res. Min 40,000 SF	39.0	1.00	39.0	112
R-1-6	Single Family Res. Min 6,000 SF	7.0	7.00	49.0	141
R-1-7	Single Family Res. Min 7,000 SF	9.6	6.00	57.5	166
R-1-8	Single Family Res. Min 8,000 SF	216.0	3.70	799.0	2,301
R-2	Multi-Unit Res. Min 6,000 SF	32.9	7.00	230.0	663
R-3	Multi-Unit Res. Min 6,000 SF	97.5	13.00	1,267.3	3,650
R-4	Multi-Unit Res. Min 6,000 SF	0.0	20.00	0.0	0
RE-12.5	Residential Estate Min 12,500 SF	113.7	3.00	341.1	982
RE-20	Residential Estate Min 20,000 SF	132.3	2.00	264.5	762
	Vacant Lots Not in a Planned Development	NA	NA	758	2,183
	TOTAL	**19,275**		**20,447**	**46,929**
Atkinville	Planned Development	Not Applicable	varies	1,057	3,044
Desert Canyons	Planned Development	Not Applicable	varies	7,267	18,193
Desert Color	Planned Development	Not Applicable	varies	10,108	26,173
Entrada	Planned Development	Not Applicable	varies	324	933
Hidden Valley	Planned Development	Not Applicable	varies	400	1,152
Ledges	Planned Development	Not Applicable	varies	2,125	6,120
Stone Cliff	Planned Development	Not Applicable	varies	211	608
Sunbrook	Planned Development	Not Applicable	varies	593	1,708
Sun River	Planned Development	Not Applicable	varies	100	288
Tech Ridge (Old Airport)	Planned Development	Not Applicable	varies	3,500	6,912
The Lakes	Planned Development	Not Applicable	varies	3,196	9,204
Tonaquint	Planned Development	Not Applicable	varies	1,445	4,162
Trails	Planned Development	Not Applicable	varies	923	2,658
	TOTAL			**31,249**	**81,156**
	GRAND TOTAL			**51,696**	**128,085**

[1]Non-residential land use do not represent an increase is residential population. However, non-residential development does increase water use, which is accounted for using the ERU methodology

As shown in Table 3-7, the remaining areas of the City to be developed are estimated to increase the City population by **128,085**, resulting in a total build-out population of:

$$95{,}349\ residents\ (existing) + 128{,}085\ (future) = \mathbf{223{,}434\ residents}$$

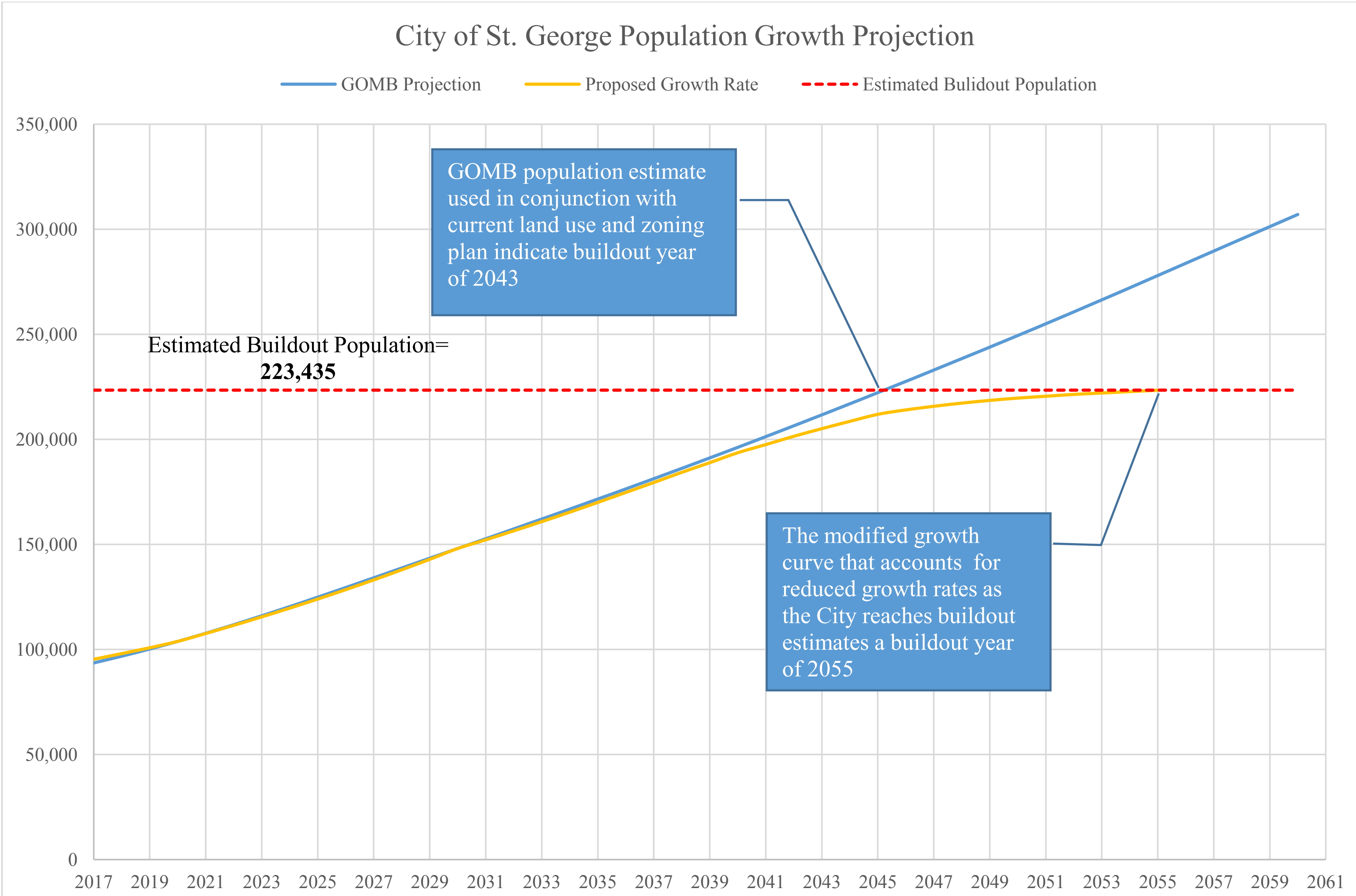
Using this build-out population estimate, Table 3-8 and Figure 3-2 provide the estimated population growth projection for the City. As previously mentioned, the City has elected to utilize the population projections development for the GOMB. Based on the GOMB growth estimates and the City's current land use plan, St. George would reach its full buildout capacity by approximately 2043. However, in reality, population growth tends to slow as it reaches its full carrying capacity (i.e. growth does not abruptly stop at full buildout; the growth rate will gradually slow as buildout is approached). This considered, Table 3-8 and Figure 3-2 display 2 growth curves for reference:

- **Governor's Office of Management and Budget**: This growth curve displays the actual growth projection developed for the GOMB. As shown, the full buildout population is reach by the year 2043. Based on the current land use evaluation for the City, it appears that the GOMB growth projections may over-estimate the total buildout population of the City, so some adjustment of the projection as it reaches the estimated buildout population is necessary.
- **Modified GOMB Project Adjusted after 2030 (Recommended for Planning):** This modified growth curve uses the growth projections developed for the GOMB through the year 2030 followed by a gradual decrease in the annual growth rate to produce a more realistic outlook through buildout. Using this approach, it is estimated that the City will reach buildout by the year 2055. It should be emphasized that buildout estimates are just that – an estimate. Changes in land use and zoning plans, City annexations, etc. will all influence how large the City will actually become. For this reason, master plans should be updated frequently enough to keep up with revised development plans in the City.

Table 3-8
St. George Population Growth Estimate

Year	Population
2017	95,349
2018	98,028
2019	100,822
2020	103,851
2021	107,600
2022	111,484
2023	115,509
2024	119,679
2025	123,999
2026	128,475
2027	133,113
2028	137,919
2029	142,898
2030	148,056
2031	152,202
2032	156,463
2033	160,844
2034	165,348
2035	169,978
2036	174,737
2037	179,455
2038	184,300
2039	188,908
2040	193,631
2041	197,503
2042	201,453
2043	205,079
2044	208,566
2045	211,903
2046	214,022
2047	215,734
2048	217,244
2049	218,548
2050	219,640
2051	220,519
2052	221,401
2053	222,065
2054	222,731
2055	223,434

Figure 3-2
Population Growth Projections for the City of St. George



EVALUATION OF HISTORICAL WATER USE IN THE CITY

In order to estimate and project future water demands for St. George City, historical water use data was analyzed in order to determine per capita demands. Like most public water systems, St. George provides service to both residential and non-residential customers. This considered, the residential population of the City only represents a portion of the demand on the system. For this reason, it often makes sense to represent and evaluate water demand in terms of Equivalent Residential Units (ERUs, also referred to as Equivalent Residential Connections, or ERCs)) rather than on the basis of population (i.e. per capita demand). An Equivalent Residential Unit represents the water usage of a typical single family residential connection. Upon defining the amount of water used by 1 ERU, non-residential water users, such as hotels, retail outlets, restaurants, industrial facilities, etc. can be converted into ERUs based on their respective water usage. In essence, using the ERU as a demand measurement allows the City to convert non-residential water users into an "equivalent" residential population.

As will be discussed in greater detail in Chapter 4 of this report, State of Utah regulations require public water sources to be evaluated for 2 specific demand scenarios:

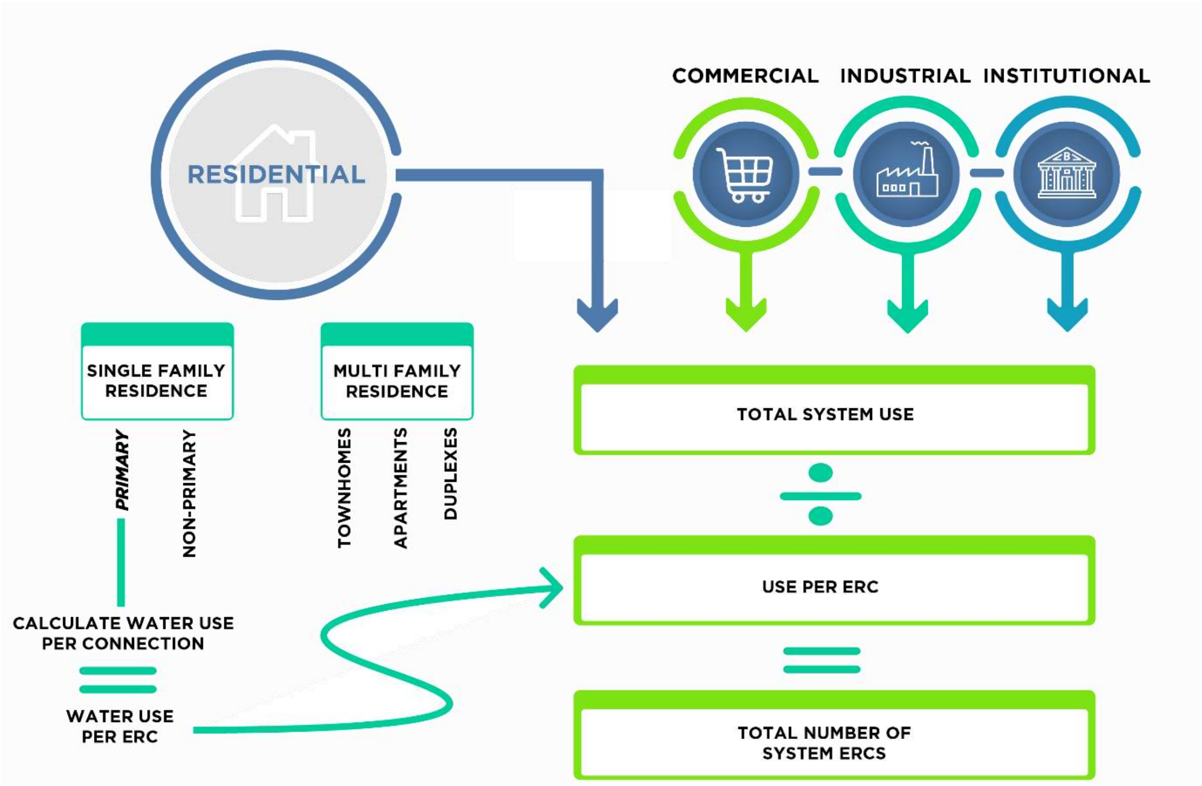
1. **Average Annual Demand**: Water system sources must be capable of producing sufficient water to meet average annual demands.
2. **Peak Day Demand**: Water system sources must be capable of providing enough water to meet peak day demand. Peak day demand is defined as the total demand on the system over the course of the highest water usage day of the year.

The following sections identify the methodology used to estimate average and peak water use per ERU to be used as a source sizing value for this master plan.

AVERAGE DAILY & AVERAGE ANNUAL DEMAND

In order to provide an estimate for the total number of ERUs in the St. George system, it is first necessary to identify the demand associated with 1 ERU using residential water use records. The general methodology used for this evaluation is illustrated in Figure 3-3. Per definition, the ERU represents the water demand for a typical single family housing unit. Because the City of St. George's "residential" meter classification includes apartments, townhomes, duplexes, and master-metered residential subdivisions (all of which do not fit this definition), the data needed to be sorted to include only those connections to a single family residential unit. The data was then further sorted to include only *primary* single family residences using a land ownership database provided by the Washington County Recorder. Based on historical water use data, non-primary residences in St. George use approximately 10% less water than a typical primary single family residence. In order to provide the City with a source sizing standard that reflects the actual potential water use for 1 ERU, second homes were excluded from this calculation. These tasks yielded a sample set of single family homes for the calculation of water use per ERU.

Figure 3-3



General Methodology for ERU Water Use Calculation

The sample set of single family residential meters was then evaluated, looking at average annual demand, average daily demand, and peak month demand for each account. Table 3-9 summarizes the results of this evaluation. Data from the year 2016 – 2019 was used in this evaluation.

Table 3-9
Summary of Annual and Average Daily Metered Water Use for Single Family Residential Connections, 2016-2019

Year	Number of Single Family Residential Meters Evaluated[1]	Average Annual Metered Water Use per Connection (gal/year)	Average Metered Daily Use per Connection (gal/day)
2016	13,812	191,251	524
2017	14,281	206,464	566
2018	14,014	202,078	554
2019	14,153	188,337	516

[1]The sample set of single family homes was developed using a meter data set from 2017. This same set of meters was then queried out of the meter data sets from 2016, 2018, and 2019. The City switched its metering software in 2018, which resulted in some incomplete meter records and hence less overall meters in the sample set for that year. The 2019 data set contains fewer samples than 2017 because either a) the home was converted from a primary residence to secondary residence or b) the home was sold to a new owner in that year resulting in a duplicate meter read which was filtered out of the data set.

The values shown in Table 3-9 represent the metered water delivered to customers and do not account for system loss. In order to estimate system loss, the total metered usage and total water produced for the system as a whole as reported to the Utah Division of Water Rights was compared. Table 3-10 provides a summary of this data comparison.

Table 3-10
Total Metered Culinary Water Use and Total Culinary Water Produced/Purchased, 2016–2019

Year	2016	2017	2018	2019
Total Metered Retail Usage (acre-feet)	23,010	24,205	24,945	23,816
Total Metered Wholesale Usage (acre-feet)	2,268	2,653	2,624	2,366
Total Water Produced (acre-feet)	27,496	30,255	29,674	28,753
Non-Revenue Water (acre-feet)	2,218	3,397	2,105	2,571
Estimated System Loss	***8.06%***	***11.23%***	***7.09%***	***8.94%***

As indicated in the table, system losses over the past 4 years have ranged from about 8% up to about 12%. Incorporating these estimated system losses into the metered usage shown in Table 3-9, Table 3-11 summarizes the *total* estimated water use per single family residential connection, or ERU.

Table 3-11
Summary of Total Annual and Average Daily Water Use per Single Family Residential Connection, 2016-2019

Year	Average Annual Metered Use per ERU (gal/year)	Metered Average Daily Use per ERU (gal/day)	Estimated % Water Loss (Based on UDWR Water Use Report)	Total Annual Use per ERU (gal/year)	Total Average Daily Use per ERU (gal/day)
2016	191,251	524	8.06%	**208,017**	**570**
2017	206,464	566	11.23%	**232,583**	**637**
2018	202,078	554	7.09%	**217,499**	**596**
2019	188,337	516	8.94%	**206,827**	**567**

Based on the estimated water use per ERU and the total system wide usage from the year 2017, Table 3-12 displays the approximate total number of culinary water system ERUs throughout the City. Note that this value is associated with culinary water use only; secondary water use is discussed in detail in the Secondary Irrigation Master Plan.

Table 3-12
Historic St. George City ERUs, Culinary Water System

Year	Estiamted Residential Culinary Water ERUs	Estimated Non-Residential Culinary ERUs	Total ERUs
2017	28,744	9,568	38,312
2018	29,552	10,061	39,613
2019	30,395	10,574	40,969

PEAK MONTH AND PEAK DAY DEMAND

Water sources must not only have capacity to meet demands on an average annual and average day basis, but must also possess adequate capacity to meet peak month and peak day demands. Since residential meter records only provide usage data on a monthly basis, peak day demand per ERU has been estimated using the measured peaking characteristics of the system as a whole. The City began measuring peak day demand in 2017 using its SCADA system to record total demand on the system. However, upon reviewing the results of this data collection effort, it is believed that the results are erroneous and not representative of actual peak day system demands. In 2018 and 2019, the City manually read each source meter, greatly improving the accuracy and reliability of the data. This considered, the peak day data from 2018 and 2019 has been used to estimate the peaking characteristics of an ERU.

By comparing the metered peak day source production data from 2018 and 2019 with the metered monthly source production data from the same sources during the same month, the ratio between peak day demand and the average daily demand during the same month can be calculated. This ratio can then be used to estimate the peak daily use for an ERU based on the average daily metered use during the peak month. Table 3-13 displays the metered peak day source production and average daily source production for the month in which the peak day occurred.

Table 3-13
Peak Month and Peak Day Source Production, 2018-2019

Year	Metered Peak Day Source Production (MGD)	Date of Peak Production Day	Total Source Production for Month in which Peak Day Demand Occurred (MG)	Average Daily Source Production During Month in which Peak Day Occurred (MGD)	Ratio of Peak Day Source Production to Average Day Source Production During the Same Month
2018	49.78	7/10/2018	1,271.32	41.01	1.21
2019	47.03	8/26/2019	1,359.79	43.86	1.07

As shown in Table 3-13, the ratio of peak day source production to the average daily source production of the same month varies significantly between the 2 years of data. This variation may be attributed to several factors, but it provides an indication that peak day demand has the potential to vary significantly from year to year. Based on the data available from these 2 years, it is recommended that peak day demand per ERU be estimated using the higher of the 2 ratios presented in Table 3-13. Using the lower ratio or even an average of the 2 ratios would not be prudent for planning as it could result in insufficient capacity to meet needs. Table 3-14 provides the estimated source demand per ERU (including non-revenue water) for the City of St. George.

Table 3-14
Peak Month and Peak Day Source Production, 2016 – 2019

Year	Total Average Daily Use Per ERU (gallons per day)[1]	Total Average Day, Peak Month Demand (gallons per day)[1]	Total Peak Day Demand (Average Day, Peak Month x 1.21[2]) (gallons per day)[1]
2016	570	951	1,151
2017	637	1,056	1,278
2018	596	997	1,206
2019	567	1,024	1,239

[1]Value includes estimated percentage of water loss.
[2]The peak day source production data from 2018 was used to estimate peak day demand per ERU for each year.

PROPOSED AVERAGE ANNUAL & PEAK DAY SOURCE DEMAND PER ERU

In conjunction with the new source sizing requirements established by the Utah Legislature, the UDDW has provided guidelines as to how the source sizing standard will be calculated (in the absence of an engineering study) using a minimum of 3 years of historical water use data submitted by a water provider. The guidelines include the calculation of a "system variation factor" that is used to determine the source sizing standard. The steps involved in the calculation are as follows:

1. Determine per ERU water usage values from a minimum of 3 years.
2. Select the highest value from the data set.
3. Apply a "system-specific variation factor" (or % buffer) to the highest value in the data set using the formula below:

$$Variation\ Factor\ (\%) = \frac{Highest\ Year\ Value - Lowest\ Year\ Value}{Lowest\ Year\ Value}$$

Table 3-15 displays how the system variation factor would be calculated for St. George using the 4 years of data presented in this study.

Table 3-15
Calculation of System Variation Factor per UDDW Guidelines

Year	Average Annual Demand per ERU (gal/yr)	Peak Day Demand per ERU (gallons per day)
2016	208,017	1,151
2017	232,583	1,278
2018	217,499	1,206
2019	206,827	1,239
Maximum Value	**232,583**	**1,278**
System Variation Factor	**12.5%**	**11.0%**
Minimum Source Sizing Value per ERU	***261,546***	**1,419**

As shown in Table 3-15, the formula suggests that a buffer of at least 12.5% is justified for source sizing on an annual basis and 11.0% for source sizing on a peak day basis. Through discussions with St. George City, there is concern that these system variation factors do not provide an adequate buffer for source sizing. This concern is driven primarily by:

- Potential variation in annual and peak demand not captured in the limited 4 year data sample.
- Fluctuation in yield of water sources in Southern Utah is greater than represented in this variation factor.
- Substantial and somewhat unpredictable increases in tourism in Southern Utah.

These points are further discussed in the following sections.

VARIATION IN SYSTEM DEMAND NOT CAPTURED BY 4 YEAR SAMPLE

Water use data collection and analysis has seen a significant improvement over the past 5 – 10 years. Advancements in metering technology have come a long way over recent years, increasing the efficiency and accuracy of data collection. While the data analyzed in this study is believed to be as accurate as it has ever been, the sample size is still relatively limited and may not be fully representative of the potential variation in demand that will be experienced in St. George moving forward.

Variation in annual and peak day water use is driven primarily by outdoor water demand. This claim is supported by looking at historical water use records from the month of January (when users are not irrigating). Average single family residential water use reads from January for 2016 -2019 are shown in Table 3-16. As shown in the table, the magnitude of variation in estimated indoor demand from year to year is relatively small.

Table 3-16
Average January Water Use

Year	Average Daily January Water Use for Single Family Residential Users (gal/day)
2016	177
2017	184
2018	202
2019	189
4-Year Average	**188**

Climate conditions have the potential to represent a significant impact on water use from year to year. The U.S. Geological Survey published a report in 2018 titled, "Assessment of Managed Aquifer Recharge at Sand Hollow Reservoir, Washington County, Utah, Updated to Conditions Through 2016"[1]. This report summarizes 15 years of research at Sand Hollow Reservoir that included the collection and analysis of groundwater level data, reservoir level data, and meteorological data. This data was used to estimate evaporation rates from the reservoir. While the study dealt specifically with evaporation rates on the reservoir, the data can reasonably be used to estimate how evapotranspiration rates may vary from year to year. Simply stated, dryer and hotter years will result in higher evapotranspiration rates, which in turn may lead to water users irrigating more often and for longer durations. The total annual estimated evaporation from the reservoir from 2003 through 2018, as reported in the USGS study, is shown in Table 3-17.

Table 3-17
Estimated Evaporation Rates at Sand Hollow Reservoir, 2003-2018

Year	Evaporation (ft/yr)	Year	Evaporation (ft/yr)
2003	5.11	2011	5.37
2004	5.19	2012	5.72
2005	4.96	2013	6.08
2006	5.04	2014	6.42
2007	5.46	2015	6.34
2008	5.43	2016	6.50
2009	5.33	2017	6.44
2010	4.89	2018	6.55
		Min	4.89
		Max	6.55
		% Variation	**34%**

*Data for 2002 was only collected for a portion of the year.

As shown in Table 3-17, estimated evaporation rates over the 16 year period varied by as much as 34%. While this data does not necessarily suggest that water use per ERU has the potential to vary

[1] Marston, T.M., and Nelson, N.C., 2018, Assessment of managed aquifer recharge at Sand Hollow Reservoir, Washington County, Utah, updated to conditions through 2016: U.S. Geological Survey Open-File Report 2018-1140, 38 p., https://doi.org/10.3133/ofr20181140

by as much as 34% per year, it does provide perspective into how the climate varies from year to year in Southern Utah and how these variations in climate could directly affect irrigation patterns for the system. Planning for this potential variation in demand is critical for St. George in order to ensure that the water system is able to satisfy demands from year to year.

While evaporation rates provide one indication of potential water use variation from year to year, precipitation rates are equally important to consider. Southern Utah is a desert watershed, characterized by short, high intensity bursts of precipitation followed by extended periods of little to no rainfall. In 2019, St. George experienced a relatively wet spring followed by 155 days without measurable rainfall, breaking the previous record of 121 days set in 1929. Lower natural precipitation is generally compensated for with increased irrigation from the water system. While 2019's period of no rainfall may simply be an anomaly, climate change introduces uncertainty for water system managers. For this reason, it is recommended that the City of St. George maintain adequate demand buffer estimates for planning.

FLUCTUATION IN SOURCE YIELD

Many of the factors that may influence water demand, such as precipitation and evaporation, are also connected to the condition and yield of water sources. The Virgin River provides the majority of water for St. George and for Washington County as a whole. To illustrate the variability of the Virgin River, stream flow data available from USGS was evaluated. Table 3-18 shows the average annual stream flow in cubic feet per second for the Virgin River at the stream gauge in Virgin, UT for the last 30 years. The stream gauge is located just upstream of the Washington County Water Conservancy District's (WCWCD) primary diversion to Quail Creek Reservoir and Sand Hollow Reservoir. WCWCD provides the majority of water for the City of St. George.

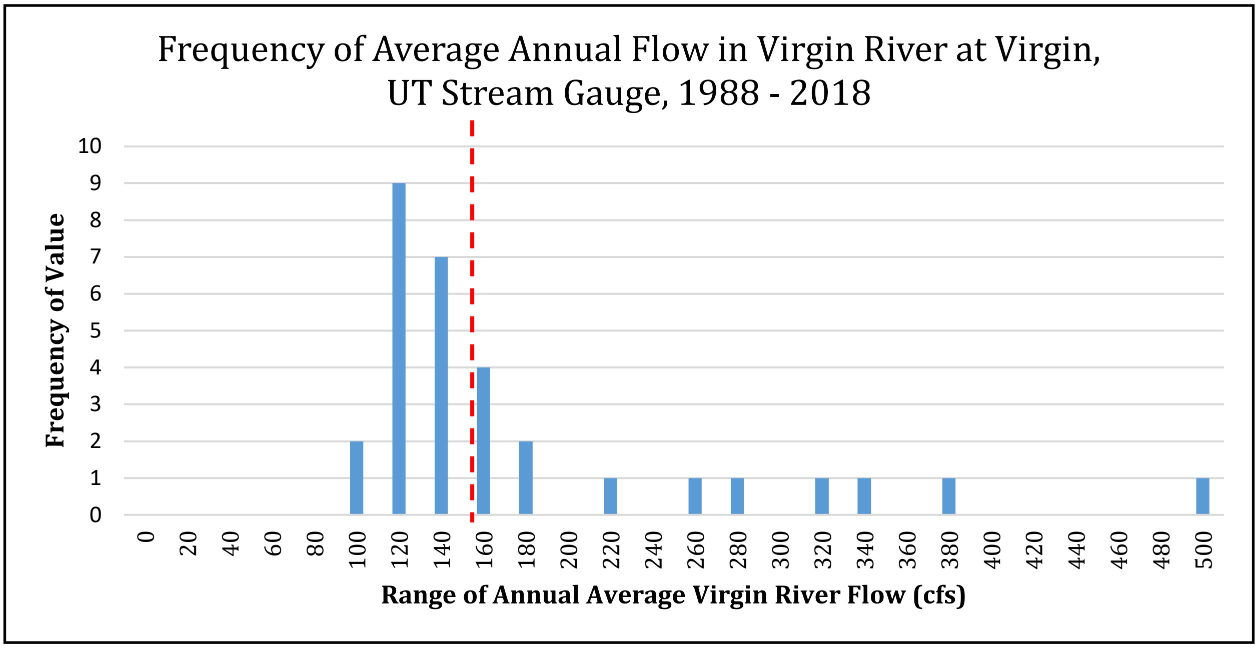
Table 3-18
Virgin River Average Annual Stream Flow at Virgin, UT Stream Gauge

Year	Mean Annual Flow (cfs)	Year	Mean Annual Flow (cfs)
1988	165.2	2005	**496.3**
1989	109.4	2006	163.5
1990	96.8	2007	107.0
1991	110.3	2008	129.3
1992	141.9	2009	126.8
1993	368.4	2010	253.4
1994	131.1	2011	323.3
1995	304.4	2012	114.1
1996	114.8	2013	125.7
1997	153.3	2014	108.3
1998	266.9	2015	111.2
1999	126.6	2016	156.9
2000	129.1	2017	216.6
2001	131.5	2018	110.1
2002	**89.1**	**30-Year Average**	**158.0**
2003	101.5	**Standard Deviation**	**79**
2004	145.2		

The annual variability of the data shown in Table 3-18 is better demonstrated through the use of a statistical frequency chart. Figure 3-4 displays the frequency of the occurrence of a flow value that falls within a given range. In statistics, a “normal” distribution of data is one in which the majority of values fall closely to the mean value. This type of distribution is often referred to as a ”bell curve”. The data shown in Figure 3-4 does not follow a normal distribution, which is what makes it problematic for water providers. As shown in Table 3-18, the average river flow over the 30 year period is 158 cfs (mean), but when compared to the frequency plot in Figure 3-4, the majority of values fall below this average value (i.e. the median value is lower than the mean). What this means is that, in any given year, there is a higher probability of the river having below-average flow and a relatively low probability of having an above average flow. This is typical for desert watersheds which are often characterized by extended periods of low precipitation followed by short bursts of heavy precipitation.

The potential for source yield variation is further illustrated by looking at the mean annual river flow from the year 2002 to 2005. Over the course of 4 years, the mean annual river flow went from being a little over ½ of the 30-year average (89.1 cfs) to over 3x the 30-year average (496.3 cfs). This magnitude of source yield variation further supports the need of adequate demand buffers estimates for planning.

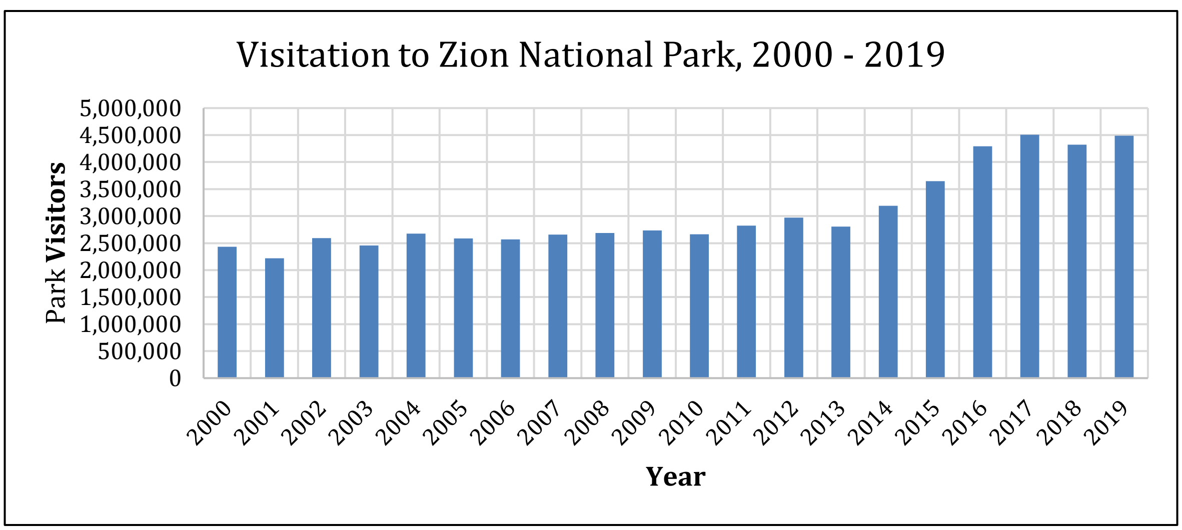
Figure 3-4



SERVICING A LARGE TRANSIENT POPULATION

Attractions such as Zion National Park, Snow Canyon State Park, and countless other outdoor activities make St. George a popular tourism destination. Visitors come from all over the world to visit National Parks in Southern Utah, and this surge in the transient population puts stress not only on St. George's water system, but also its roadway and housing infrastructure. Visitation to Zion National Park has increased dramatically over the last 20 years; over 4 million people visited the park each year from 2016 – 2019 (see Figure 3-5), which is almost double the visitation from the early 2000's. Servicing a large number of visitors to Southern Utah has been and will continue to be a challenge for St. George, and further illustrates the need to maintain water supply planning values that are adequate to accommodate the potential demands associated with these visitors.

Figure 3-5



PROPOSED SOURCE SIZING STANDARD

This evaluation has presented both quantitative data and qualitative discussion points to be considered when determining the source sizing standard for St. George. Ultimately, it is difficult to quantify how each of these factors should influence the variation/buffer included in the source sizing standard per ERU. What is clear is that the City of St. George faces a number of unique challenges that introduce a good deal of uncertainty pertaining to both water demand and supply in the future. Considering these factors, and based on discussions with the St. George Water Department, it is strongly recommended that a system variation factor of at least 20 percent be used in calculating the sizing standard for annual usage per ERU and peak day usage per ERU from the 4 year data set. Based on this recommendation, Table 3-19 provides the proposed source sizing standard for St. George, including the recommended 20% buffer.

Table 3-19
Proposed Source Sizing Standard per ERU

Year	Average Annual Demand per ERU (gal/yr)	Peak Day Demand per ERU (gallons per day)
2016	208,017	1,151
2017	232,583	1,278
2018	217,499	1,206
2019	206,827	1,248
Maximum Value	232,583	1,278
Recommended Variation Factor	**20%**	**20%**
Minimum Source Sizing Value per ERU	***279,100***	**1,534**

Peak Hour Demand

Peak hour demand is the projected highest planning demand the system sees over the course of year[2]. This demand typically occurs during the highest water usage period on the peak water usage day of the year (usually when a large percentage of the system is irrigating at the same time). Sizing of distribution piping is usually governed by either peak hour demand or fire flow demands during peak day demand, whichever creates the greater need for capacity. To estimate the ratio of the system's peak hour demand to peak day demand, SCADA records from the City's water system were evaluated. The volatility of the flow records make it difficult to identify a precise peak hour water usage, but the data trends support the use of a peak hour factor of between 1.7 and 2.0. For this study, a conservative peak day to peak hour multiplier of 2.0 has been selected.

[2] This is also sometimes referred to as peak instantaneous demand. While not technically the same thing, peak hour and peak instantaneous can be considered identical for planning purposes as discussed here.

PROJECTED FUTURE WATER USE IN ST. GEORGE CITY

Using the ERU water demand estimates in conjunction with the City's land use and zoning plans, Table 3-20 provides a summary of the estimated number of water system ERUs that will be added to the system through buildout. Table 3-21 provides an overall projection of new system ERUs with the respective total average daily demand and peak day demand of users within the St. George City service area. The values shown in the table reflect the *expected* demand on the system based on historical usage from the year 2017, which was the highest usage year from 2016 – 2019. As discussed previously, it is recommended that, from a source sizing stand point, an additional 20% buffer should be included when comparing existing and future demands with available source capacity. This recommended safety buffer is included in the supply source analysis found in Chapter 4, but the values in Table 3-21 are intended to provide the City with the actual anticipated demands on the system through buildout without additional buffers. The demands shown in Table 3-21 take into account the planned expansion of the St. George secondary irrigation system (see Secondary Irrigation Master Plan for details).

Table 3-20
Estimated Number of ERUs Remaining to be Developed in St. George (Baseline 2017)

Zoning Code	Development Description	Area (Acres)	Density (Units Per Acre)	Number of Units	Estimated ERUs per Unit[1]	Total Estimated ERUs
A-1	Agricultural Use, Min. 40,000 SF	776.3	1	776	0.97	753
A-20	Agricultural Use, Min 20 Acres	408.4	0.05	20	0.97	19
A-5	Agricultural Use, Min 5 Acres	10.3	0.2	2	0.97	2
M-H	Mobile Home	2.3	6	14	1	14
MH-6	Mobile Home Min 6,000 SF	33.3	6	200	1	200
PD-R	Planned Development - Res	341.9	4	1,367	1	1,367
R-1-10	Single Family Res. Min 10,000 SF	3,044.7	3.2	9,743	1	9,743
R-1-12	Single Family Res. Min 12,000 SF	130.7	2.8	366	1	366
R-1-40	Single Family Res. Min 40,000 SF	39	1	39	1	39
R-1-6	Single Family Res. Min 6,000 SF	7	7	49	1	49
R-1-7	Single Family Res. Min 7,000 SF	9.6	6	58	1	58
R-1-8	Single Family Res. Min 8,000 SF	216	3.7	799	1	799
R-2	Multi-Unit Res	32.9	7	230	1	230
R-3	Multi-Unit Res	97.5	13	1,267	1	1,267
R-4	Multi-Unit Res	0	20	0	1	0
RE-12.5	Residential Estate Min 12,500 SF	113.7	3	341	1	341
RE-20	Residential Estate Min 20,000 SF	132.3	2	265	1	265
RE-37.5	Residential Estate Min 37,500 SF	0	1.2	0	1	0
Atkinville	Planned Development	NA	varies	1,057	1	1,057
Desert Canyons	Planned Development	NA	varies	6,317	1	6,317
Desert Color	Planned Development	NA	varies	9,088	1	9,088
Entrada	Planned Development	NA	varies	324	1	324
Hidden Valley	Planned Development	NA	varies	400	1	400
Ledges	Planned Development	NA	varies	2,125	1	2,125
Stone Cliff	Planned Development	NA	varies	211	1	211
Sunbrook	Planned Development	NA	varies	593	1	593
Sun River	Planned Development	NA	varies	100	1	100
Tech Ridge	Planned Development	NA	varies	2,400	1	2,400
The Lakes	Planned Development	NA	varies	3,196	1	3,196
Tonaquint	Planned Development	NA	varies	1,445	1	1,445
Trails	Planned Development	NA	varies	923	1	923
Existing Vacant Lots	Vacant Lots not in PD	NA		758	1	758
Total Residential ERUs						**44,449**
A-P	Administrative and Professional, No Min Area	4	5	20	3.26	65
ASBP	Airport Supporting Business Park	1,118.40	2	2,237	3.26	7,293
AVI	Airport Vicinity Industrial	134.1	1	134	15.8	2,117
C-1	Commercial, No Min Area	5.7	2	11	3.26	36
C-2	Commercial, No Min Area	99.4	2.5	249	3.26	812
C-3	Commercial, No Min Area	161.3	3	484	3.26	1,578
C-4	Commercial, No Min Area	0	3.5	0	3.26	0
M-1	Manufacturing, No Min Area	1,025.90	0.5	513	15.8	8,105
M-2	Manufacturing, Min 40,000 SF	0.1	7.5	1	15.8	16
Mining & Grazing	Mining/Grazing, No Area Min	1,252.90	0	0	0	0
OS	Open Space, No Min Area	9,824.60	0	0	0	0
PD-AP	Planned Development - Admin & Professional Office	12.9	2	26	3.26	85
PD-C	Planned Development - Comm	239.2	2	478	3.26	1,558
Desert Canyons	Planned Development	NA	varies	950	1	950
Desert Color	Planned Development	NA	varies	1,020	1	1,020
Tech Ridge	Planned Development	NA	varies	1,100	1	1,100
Entrada[2]	Planned Development	NA	Varies	1	714	714*
Total Non-Residential ERUs						**25,449**
Total ERUs Remaining to be Developed						**69,898**

[1]Based on comparison of meter records for various user types
[2]The Entrada PD has approximately 450 AF of reuse water that will be used for a future golf course.

Table 3-21
St. George City Water Use Projections

Year	Overall Residential Growth %	Overall Non-Residential Growth %	Total St. George Residential ERUs	Total St. George Non-Residential ERUs	Total Water System ERUs (Culinary and Irrigation[1])	Total Residential Culinary Water ERUs	Indoor Residential Culinary ERUs[2]	Outdoor Residential Culinary ERUs[3]	Total Non-Residential Culinary Water ERUs	Indoor Non-Residential Culinary ERUs[2]	Outdoor Non-Residential Culinary ERUs[2]	Total Culinary Water System ERUs	Annual Culinary Water System Demand (acre-ft/year)	Annual Culinary Indoor Demand (acre-feet/year)[3]	Annual Culinary Outdoor Demand (acre-feet/year)[3]	Peak Day Culinary Indoor Demand (gal/day)	Peak Day Culinary Outdoor Demand	Combined Peak Day Culinary Water System Demand
2017			29,010	17,532	46,542	28,744	14,215	14,529	9,568	6,015	3,553	38,312	27,337	13,395	13,942	14,948,014	34,015,075	48,963,089
2018	2.81%	2.81%	29,825	18,025	47,850	29,552	14,614	14,938	10,061	6,256	3,804	39,613	28,265	13,820	14,445	15,421,580	35,243,438	50,665,018
2019	2.85%	2.85%	30,675	18,538	49,214	30,394	15,031	15,363	10,574	6,508	4,066	40,969	29,232	14,262	14,970	15,915,337	36,524,396	52,439,734
2020	3.00%	3.00%	31,596	19,094	50,690	30,887	15,482	15,405	11,111	6,774	4,337	41,997	29,966	14,737	15,230	16,445,134	37,156,871	53,602,005
2021	3.61%	3.61%	32,736	19,784	52,520	31,486	16,041	15,445	11,736	7,091	4,645	43,223	30,841	15,317	15,524	17,092,512	37,874,776	54,967,288
2022	3.61%	3.61%	33,918	20,498	54,416	32,106	16,620	15,486	11,473	7,125	4,348	43,579	31,095	15,723	15,372	17,545,244	37,504,656	55,049,899
2023	3.61%	3.61%	35,142	21,238	56,380	32,748	17,220	15,529	12,213	7,487	4,725	44,961	32,081	16,360	15,721	18,256,575	38,356,627	56,613,202
2024	3.61%	3.61%	36,411	22,005	58,416	33,410	17,841	15,569	12,266	7,632	4,633	45,676	32,591	16,867	15,724	18,822,860	38,362,097	57,184,956
2025	3.61%	3.61%	37,726	22,799	60,525	34,096	18,486	15,610	13,037	8,014	5,023	47,133	33,631	17,547	16,084	19,580,954	39,241,189	58,822,143
2026	3.61%	3.61%	39,087	23,622	62,709	34,804	19,153	15,652	13,837	8,410	5,427	48,642	34,708	18,251	16,457	20,366,611	40,150,766	60,517,377
2027	3.61%	3.61%	40,499	24,475	64,973	35,534	19,844	15,689	14,667	8,821	5,847	50,201	35,820	18,980	16,840	21,180,827	41,084,732	62,265,560
2028	3.61%	3.61%	41,961	25,358	67,319	36,294	20,561	15,733	15,528	9,246	6,282	51,822	36,976	19,737	17,240	22,024,553	42,061,218	64,085,771
2029	3.61%	3.50%	43,475	26,246	69,721	37,148	21,303	15,845	16,331	9,654	6,678	53,479	38,159	20,498	17,661	22,874,210	43,088,667	65,962,877
2030	3.61%	3.50%	45,045	27,164	72,209	38,056	22,072	15,984	17,166	10,076	7,089	55,222	39,403	21,287	18,115	23,754,914	44,197,512	67,952,426
2031	3.50%	3.00%	46,621	27,979	74,601	38,992	22,844	16,148	17,908	10,452	7,456	56,900	40,600	22,048	18,553	24,603,533	45,264,414	69,867,947
2032	3.40%	3.00%	48,206	28,819	77,025	39,955	23,621	16,334	18,675	10,840	7,835	58,630	41,835	22,819	19,016	25,464,103	46,394,511	71,858,614
2033	3.40%	2.50%	49,845	29,539	79,385	40,972	24,424	16,547	19,336	11,174	8,162	60,307	43,031	23,571	19,460	26,304,009	47,477,559	73,781,568
2034	3.30%	2.50%	51,490	30,278	81,768	42,013	25,230	16,782	20,014	11,516	8,498	62,027	44,258	24,332	19,926	27,152,566	48,615,151	75,767,717
2035	3.30%	2.50%	53,190	31,035	84,224	43,108	26,063	17,045	20,711	11,868	8,843	63,818	45,536	25,116	20,421	28,027,462	49,821,796	77,849,258
2036	3.10%	2.50%	54,838	31,810	86,649	44,189	26,871	17,318	21,426	12,228	9,198	65,616	46,819	25,890	20,929	28,890,994	51,062,379	79,953,373
2037	3.00%	2.00%	56,484	32,447	88,930	45,285	27,677	17,608	22,014	12,525	9,490	67,300	48,020	26,620	21,401	29,705,492	52,213,391	81,918,882
2038	3.00%	2.00%	58,178	33,096	91,274	46,431	28,507	17,923	22,615	12,827	9,788	69,046	49,266	27,370	21,897	30,542,466	53,423,331	83,965,797
2039	3.00%	2.00%	59,923	33,758	93,681	47,627	29,362	18,264	23,229	13,136	10,093	70,856	50,558	28,140	22,418	31,402,545	54,693,848	86,096,393
2040	3.00%	2.00%	61,721	34,433	96,154	48,876	30,243	18,632	23,856	13,451	10,405	72,731	51,896	28,932	22,964	32,286,375	56,026,635	88,313,010
2041	3.00%	2.00%	63,573	35,121	98,694	50,178	31,151	19,027	24,496	13,773	10,723	74,674	53,283	29,746	23,536	33,194,621	57,423,434	90,618,055
2042	3.00%	1.75%	65,480	35,736	101,216	51,536	32,085	19,451	25,069	14,060	11,008	76,605	54,660	30,555	24,105	34,097,614	58,810,025	92,907,639
2043	3.00%	1.75%	67,444	36,361	103,806	52,951	33,048	19,904	25,652	14,353	11,299	78,603	56,086	31,387	24,699	35,025,217	60,261,138	95,286,356
2044	1.70%	1.75%	68,591	36,998	105,589	53,787	33,610	20,177	26,246	14,651	11,595	80,033	57,106	31,956	25,150	35,660,668	61,360,524	97,021,193
2045	1.60%	1.75%	69,688	37,645	107,333	54,591	34,147	20,444	26,852	14,955	11,897	81,443	58,112	32,513	25,599	36,282,374	62,455,737	98,738,111
2046	1.00%	1.75%	70,385	38,304	108,689	55,105	34,489	20,616	27,468	15,264	12,204	82,573	58,919	32,944	25,975	36,763,148	63,372,643	100,135,791
2047	0.80%	1.75%	70,948	38,974	109,923	55,522	34,765	20,757	28,096	15,579	12,517	83,618	59,664	33,335	26,329	37,199,651	64,237,208	101,436,859
2048	0.70%	1.50%	71,445	39,559	111,004	55,890	35,008	20,882	28,645	15,854	12,791	84,535	60,319	33,678	26,640	37,582,505	64,996,543	102,579,047
2049	0.60%	1.50%	71,874	40,152	112,026	56,209	35,218	20,991	29,202	16,133	13,069	85,411	60,944	34,002	26,942	37,943,924	65,731,546	103,675,470
2050	0.50%	1.50%	72,233	40,755	112,988	56,477	35,394	21,083	29,768	16,416	13,352	86,245	61,539	34,306	27,232	38,283,474	66,441,077	104,724,552
2051	0.40%	1.35%	72,522	41,305	113,827	56,693	35,536	21,157	30,286	16,675	13,611	86,979	62,062	34,572	27,490	38,579,523	67,070,557	105,650,079
2052	0.40%	1.25%	72,812	41,821	114,633	56,910	35,678	21,232	30,772	16,919	13,854	87,682	62,564	34,827	27,737	38,864,299	67,671,909	106,536,207
2053	0.30%	1.25%	73,030	42,344	115,374	57,073	35,785	21,288	31,265	17,165	14,100	88,338	63,032	35,061	27,971	39,125,469	68,243,235	107,368,704
2054	0.30%	1.00%	73,250	42,767	116,017	57,237	35,892	21,345	31,664	17,365	14,299	88,902	63,434	35,264	28,170	39,352,353	68,728,233	108,080,586
2055	0.29%	0.49%	73,462	42,977	116,439	57,397	35,996	21,400	31,862	17,464	14,398	89,259	63,689	35,399	28,290	39,502,319	69,022,023	108,524,343

[1]See Chapter 3 of Secondary Irrigation Master Plan.
[2]"Indoor" and "Outdoor" ERUs represent the estimated distribution of annual water usage between indoor and outdoor usage. These values are separated for the purpose of applying the appropriate peaking factor to each type of water use. This is particularly helpful when evaluating water use for connections with both a culinary and secondary irrigation connection. On a systemwide basis, indoor water use accounts for 49% of annual usage and outdoor use accounts for the remaining 51%.
[3]Note that the ratio of indoor to outdoor demand on the culinary water system is expected to shift in the future toward the more indoor water use than outdoor. This shift is created by the proposed expansion of the secondary irrigation system which will free up culinary water system capacity to be used indoors. While the indoor water usage per ERU is not reduced, the overall ratio of indoor to outdoor water use on the culinary system will change.

LOCATION OF GROWTH OVER 10 YEAR PLANNING WINDOW

To the extent possible, it is helpful in planning to understand the timing and location of growth within the service area, particularly within the 10-year growth window. While it is impossible to predict the exact location and timing of all growth which will occur in the City, reasonable estimates can be made by evaluating recent growth trends and identifying "hotspots" in the system (areas experiencing development). Through discussions with City staff, hotspots within the City service area have been identified and growth has been divided between different regions. The estimated distribution of growth is shown in Table 3-22. As indicated in Table 3-22, the number of ERUs estimated to be added to the system over the next 10 years is:

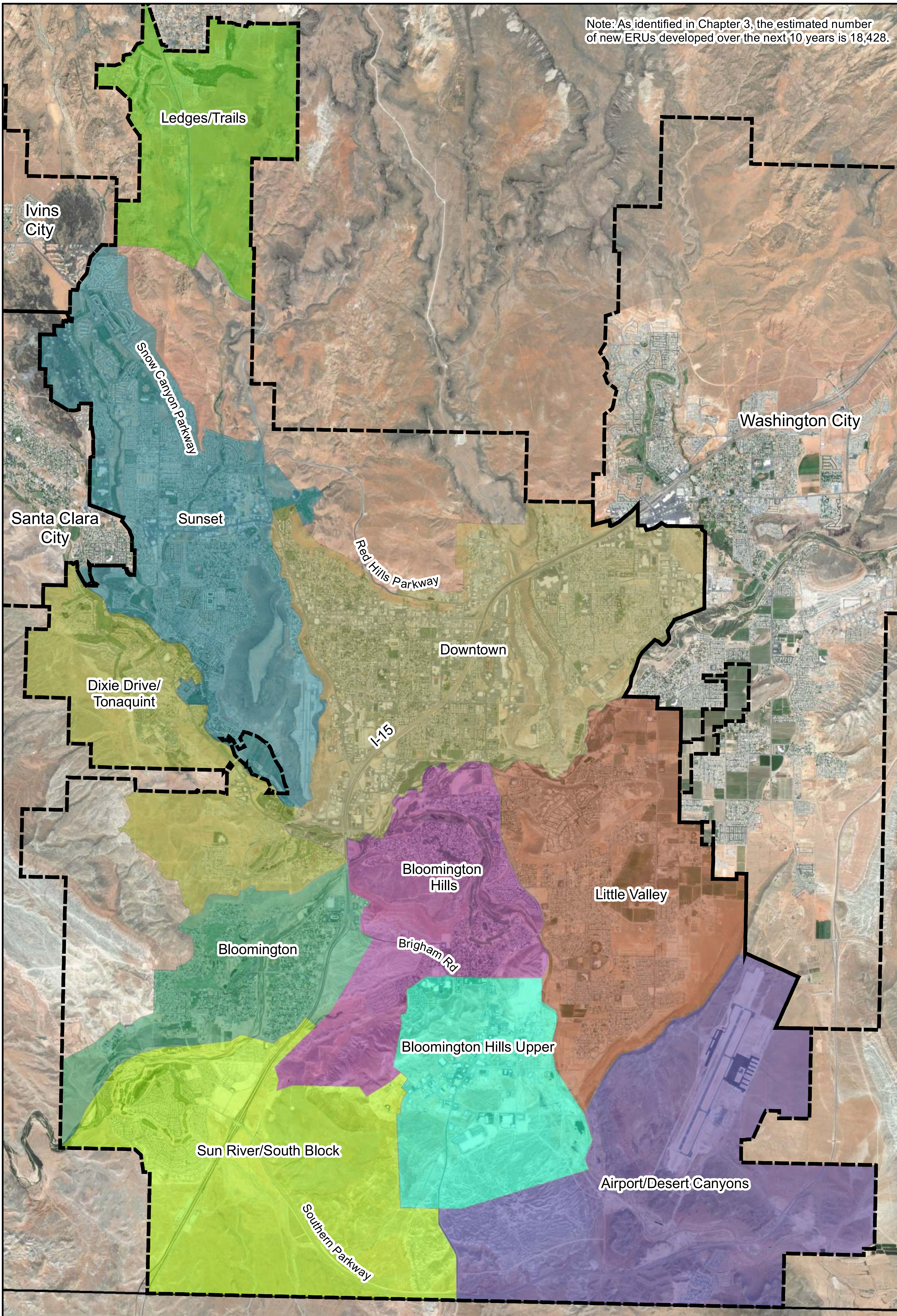
$$67{,}319\ (2028\ total\ ERUs) - 47{,}850\ (2018\ total\ ERUs) = \mathbf{19{,}469\ ERUS}$$

The regions shown in Table 3-22 are represented in Figure 3-6. Note that the ERUs shown in Table 3-22 will be served by a combination of culinary and secondary irrigation water.

Table 3-22
Estimated Distribution of Growth over 10-Year Planning Window

Region	10 Year Growth in ERUs	Added Culinary ERUs	Added Secondary Irrigation ERUs[2]	% of 10 Year Growth
Airport	4,000	2,694	1,306	21%
Bloomington	100	100	0	1%
Bloomington Hills	350	172	178	2%
Bloomington Hills Upper	1,200	1,200	0	6%
Dixie Drive	2,200	1,547	653	11%
Downtown	2,200	1,434	66	11%
Ledges	650	(573)[1]	1,223	3%
Little Valley	3,069	1,907	1,162	16%
South Block/Sun River	4,500	2,664	1,836	23%
Sunset	1,200	1,064	836	6%
Total	**19,469**	**12,209**	**7,260**	

[1] Culinary demands to be converted to secondary irrigation.
[2]See St. George Secondary Irrigation Master Plan for more information.



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

GROWTH DISTRIBUTION REGIONS

NORTH:

SCALE: 0 2,500 5,000 Feet

FIGURE NO.
3-6

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 3-6 - Growth Distribution Regions.mxd aanderson 9/25/2020

CHAPTER 4
WATER SUPPLY EVALUATION

INTRODUCTION

Water supply sources are the foundation of the City's water system. Maintaining reliable sources and developing new sources as necessary are critical for the success of the City's water system. The purpose of this chapter is to provide a detailed description of the City's existing sources, evaluate their ability to meet existing and future demands, and provide recommendations regarding the need for additional source capacity in the future.

HISTORIC SOURCE UTILIZATION

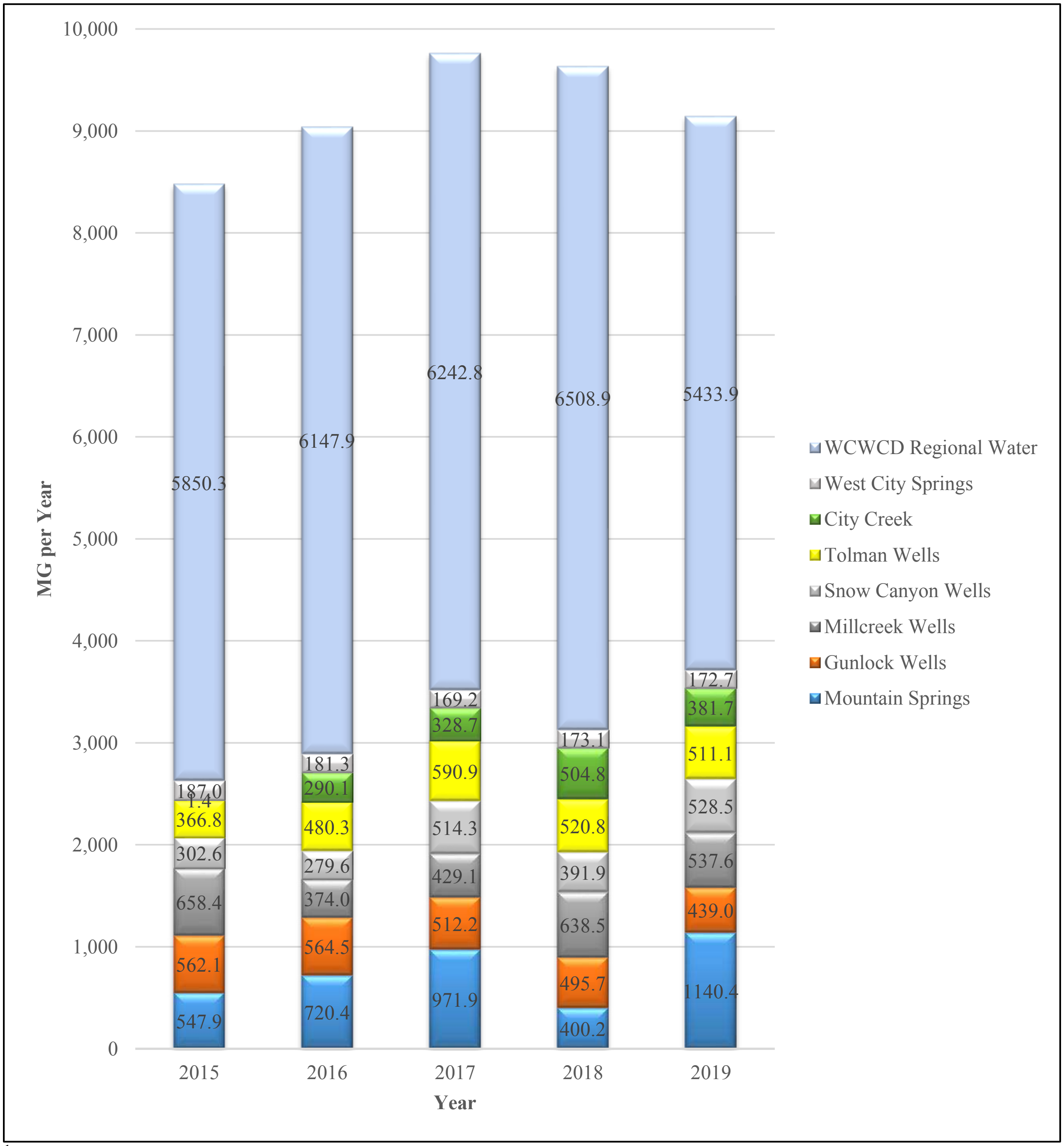
The City obtains its water from a combination of City-owned groundwater wells and springs in addition to water supplied by the WCWCD via the Regional Pipeline from Quail Creek Reservoir/Sand Hollow Reservoir. Table 4-1 and Figure 4-1 provide a summary of annual source production from 2015 to 2019. Note that the data shown in the table includes water used in Ivins, Santa Clara, and Snow Canyon State Park. The table is primarily intended to provide a general overview of the historical utilization of different water sources.

Table 4-1
Historic Annual Source Utilization (Million Gallons/Year)

Year	Mountain Springs	Gunlock Wells	Millcreek Wells	Snow Canyon Wells	Tolman Wells	City Creek[1]	West City Springs	WCWCD Regional Water	Total Water Produced
2015	547.9	562.1	658.4	302.6	366.8	1.4	187	5,850.3	8,476.4
2016	720.4	564.5	374	279.6	480.3	290.1	181.3	6,147.9	9,038.1
2017	971.9	512.20	429.1	514.3	590.9	328.7	169.2	6,242.8	9,759.1
2018	400.2	495.7	638.5	391.9	520.8	504.8	173.1	6,508.9	9,633.9
2019	1140.4	439	537.6	528.5	511.1	381.7	172.7	5,433.9	9,144.9
Annual Average	756.2	514.7	527.5	403.4	494.0	301.3	176.7	6,036.8	9210.5
% of Water Produced	**8%**	**6%**	**6%**	**4%**	**5%**	**3%**	**2%**	**66%**	

[1]City Creek Well was not in operation for the majority of 2015

Figure 4-1
Historic Annual Source Utilization[1]



[1]Includes water produced for Ivins, Santa Clara, and Snow Canyon State Park

As shown in Table 4-1 and Figure 4-1, St. George produces approximately 1/3 of its total water demand from its own sources, while the majority of water provided to the City comes from the WCWCD. Note that the City is currently working on the addition of an arsenic treatment plant in the Gunlock Well field which will add a significant amount of water to the City's culinary water portfolio.

CITY OF ST. GEORGE WATER RIGHTS

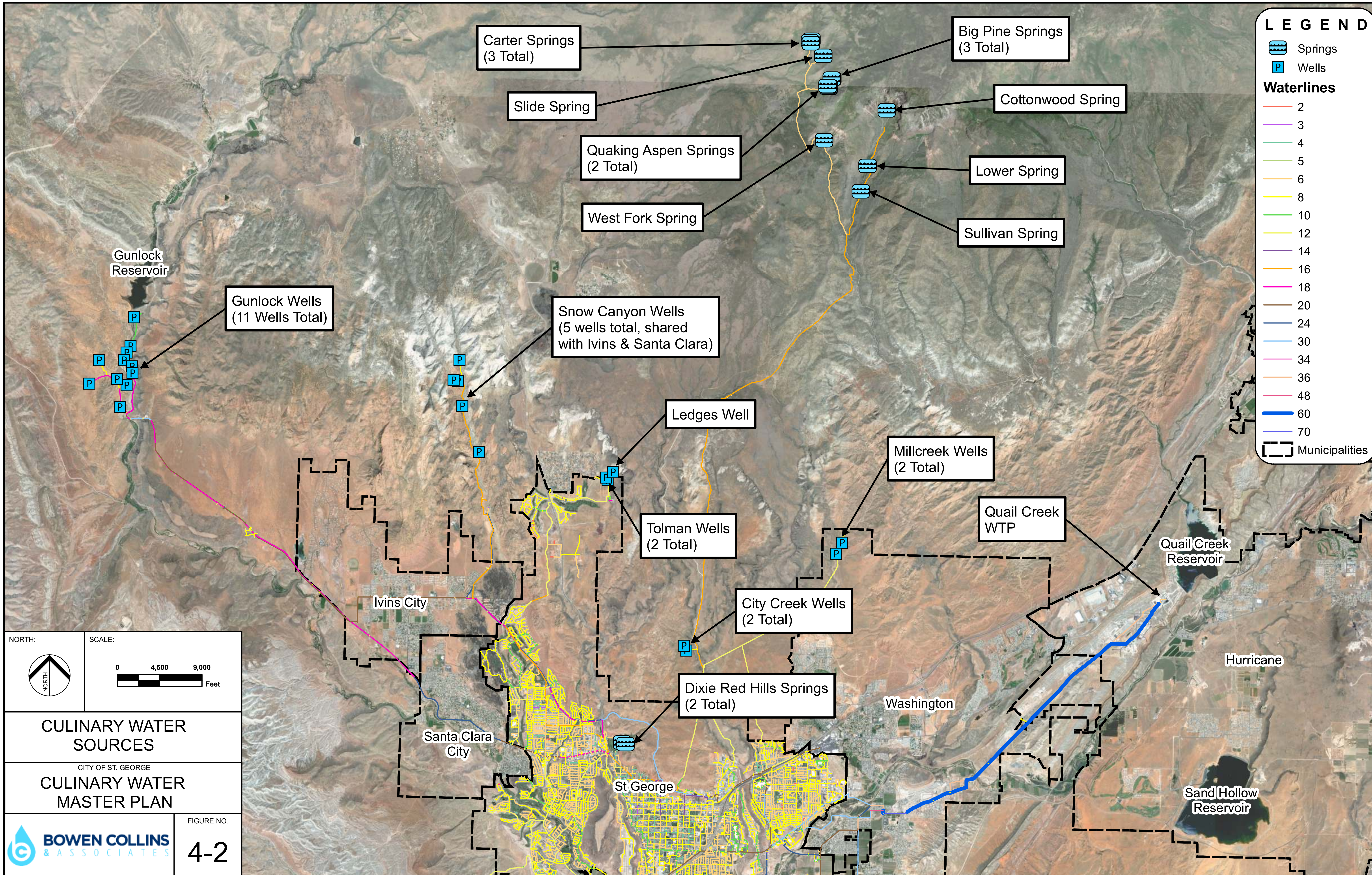
The City holds a number of water rights in groundwater wells and mountain springs. Figure 4-2 displays the location of the each of the City-owned water sources. Table 4-2 provides a summary of the City's current culinary water rights. Table 4-2 ties water rights to a specific source, but in actuality, the water rights under the City Creek, Millcreek, and Ledges Wells can be used from any of these well sources. Water rights in the Gunlock Well Field, Snow Canyon Wells, and Mountain Springs are tied to a specific point of diversion at the location of the source.

Table 4-2
Summary of St. George City Culinary Water Rights

Source	Water Right No.	Flow (cfs)	Annual Allowance (Acre-Feet)
Mountain Springs	81-1131	0.6	441.6
	81-1132	8	5,791.7
	Total	***8.6***	***6,233.3***
West City Springs[1]	81-3753	0.78	564
	Total	***0.78***	***564***
City Creek Well #1 and #2	81-293	1.1	796.4
	81-319	1.5	1,086.0
	81-481	0.1	5.6
	81-528	0.5	333
	81-627	1	300
	81-1428	0.8	590.9
	Total	***5***	***3,111.9***
Millcreek Well #1 and #2	81-577	2.2	1,597.30
	81-1777	0.01	6
	81-626	0.7	122.8
	81-646	0.1	70
	81-1678	0.2	142
	81-2895	0.3	240
	Total	***3.5***	***2,178.1***
Ledges Wells	81-1428	0.1	90
	81-2229	0.05	30
	81-3929	0.05	30
	Total	***0.2***	***150***
Gunlock Wells[2]	81-451	7.65	5,536.0
	81-4390	6	4,343.8
	Total	***13.65***	***9,879.8***
Snow Canyon Wells	81-845	2	1,440.0
	Total	***2***	***1,440.0***
	GRAND TOTAL	**33.73**	**23,557.1**

[1]West City Springs has a total water right of 1.54 cfs (691 gpm), but only 350 gpm (0.78 cfs) is used in the culinary water system.
[2]The Gunlock Wells have a total water right of 13,031.4 af/year and 18 cfs between 2 water rights. Of this total amount, 9,879.8 af/year and 13.65 cfs is allocated to the culinary water system. The remaining water right is allocated to irrigation.

As shown in Table 4-2, the City holds approximately 23,500 AF in municipal water rights between its well and spring sources. This represents the legal water use limit for the City, sometimes



S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 4-2 - St. George Water Sources.mxd aanderson 12/16/2019 referred to as "paper water". In reality, the actual amount of water available in underground aquifers or mountain springs (referred to as "wet water") may vary based on seasonal temperatures, precipitation, etc. For this reason, the water supply analysis in this chapter will utilize the estimated "wet water" available to the City, which will be referred to as the "reliable yield".

WCWCD REGIONAL WATER SUPPLY AGREEMENT

The City of St. George entered into a Regional Water Supply Agreement in 2006 with the WCWCD that includes Washington City, Ivins, Hurricane, Santa Clara, Toquerville, La Verkin, Virgin, Leeds, and Apple Valley. This agreement puts the responsibility of new source acquisition and development on the WCWCD.

REQUIRED SOURCE CAPACITY

Minimum source capacity requirements for a public water system are established by *Utah Administrative Code R309-510 – Facility Design and Operation: Minimum Sizing Requirements*. Based on the requirements set forth in the code, sources must be capable of meeting the following criteria:

- **Annual Demand:** Sources must have the capacity to provide one full year's worth of supply. In essence, sources must be able to produce the needed water throughout the course of the entire year.
- **Peak Day Demand:** Sources must be capable of meeting demand which is exerted on the system on the peak day of usage, otherwise known as peak day demand. Peak day demand is defined as the total water usage on the highest water usage day of the year, which typically occurs during the summer when irrigation demands are the highest.

Chapter 3 provides an evaluation of water use per ERU along with recommended source sizing standard per ERU on an average annual demand and peak day demand basis. The recommended source sizing standard is shown in Table 4-3.

Table 4-3
Proposed Source Sizing Standard per ERU

Year	Average Annual Demand per ERU (gal/yr)	Peak Day Demand per ERU (gallons per day)
2016	208,017	1,151
2017	232,583	1,278
2018	217,499	1,206
2019	206,827	1,248
Maximum Value	232,583	1,278
Recommended Variation Factor	**20%**	**20%**
Minimum Source Sizing Value per ERU	***279,100***	**1,534**

EFFECTS OF WATER CONSERVATION

Water conservation has been a priority for the City of St. George and will continue to be a priority moving forward. As part of the water use projections presented in this report, it has been assumed that the City will achieve a 10% reduction in annual water use per ERU by the year 2030, and that this reduced water use per ERU will be sustained into subsequent years. Based on the recommended source sizing standard per ERU shown in Table 4-3 and the assumed percentage of water conservation in the future, Table 4-4 provides a required source sizing projection through buildout for St. George City. The values shown in the table account for the proposed expansion of the secondary irrigation system, which will provide a reduction in future culinary water system usage.

Table 4-4
Recommended Culinary Water Source Sizing through Estimated Buildout

Year	Total Culinary System ERUs	Expected Annual Culinary Water System Demand, No Conservation (acre-feet/year)	Expected Annual Culinary Water System Demand, with Conservation (acre-feet/year)	Expected Peak Day Culinary System Demand[1] (gal/day)	Recommended Average Annual Source Capacity with Safety Buffer (acre-feet/year)	Recommended Peak Day Source Capacity with Safety Buffer[1] (acre-feet/year)
2017	38,312	27,337	27,337	48,963,089	32,804	58,755,707
2018	39,613	28,265	28,029	50,665,018	33,635	60,798,022
2019	40,969	29,232	28,747	52,439,734	34,497	62,927,681
2020	41,997	29,966	29,223	53,602,005	35,068	64,322,406
2021	43,223	30,841	29,825	54,967,288	35,791	65,960,746
2022	43,579	31,095	29,821	55,049,899	35,785	66,059,879
2023	44,961	32,081	30,510	56,613,202	36,612	67,935,842
2024	45,676	32,591	30,737	57,184,956	36,884	68,621,948
2025	47,133	33,631	31,453	58,822,143	37,744	70,586,571
2026	48,642	34,708	32,190	60,517,377	38,628	72,620,853
2027	50,201	35,820	32,944	62,265,560	39,533	74,718,671
2028	51,822	36,976	33,725	64,085,771	40,469	76,902,925
2029	53,479	38,159	34,513	65,962,877	41,416	79,155,453
2030	55,222	39,403	35,462	67,952,426	42,555	81,542,912
2031	56,900	40,600	36,540	69,867,947	43,848	83,841,536
2032	58,630	41,835	37,651	71,858,614	45,181	86,230,337
2033	60,307	43,031	38,728	73,781,568	46,474	88,537,882
2034	62,027	44,258	39,832	75,767,717	47,799	90,921,261
2035	63,818	45,536	40,983	77,849,258	49,179	93,419,109
2036	65,616	46,819	42,137	79,953,373	50,564	95,944,048
2037	67,300	48,020	43,218	81,918,882	51,862	98,302,659
2038	69,046	49,266	44,340	83,965,797	53,208	100,758,956
2039	70,856	50,558	45,502	86,096,393	54,602	103,315,671
2040	72,731	51,896	46,707	88,313,010	56,048	105,975,612
2041	74,674	53,283	47,954	90,618,055	57,545	108,741,666
2042	76,605	54,660	49,194	92,907,639	59,033	111,489,167
2043	78,603	56,086	50,477	95,286,356	60,573	114,343,627
2044	80,033	57,106	51,396	97,021,193	61,675	116,425,431
2045	81,443	58,112	52,301	98,738,111	62,761	118,485,733
2046	82,573	58,919	53,027	100,135,791	63,632	120,162,949
2047	83,618	59,664	53,698	101,436,859	64,437	121,724,230
2048	84,535	60,319	54,287	102,579,047	65,144	123,094,857
2049	85,411	60,944	54,849	103,675,470	65,819	124,410,564
2050	86,245	61,539	55,385	104,724,552	66,462	125,669,462
2051	86,979	62,062	55,856	105,650,079	67,027	126,780,095
2052	87,682	62,564	56,307	106,536,207	67,569	127,843,449
2053	88,338	63,032	56,729	107,368,704	68,075	128,842,445
2054	88,902	63,434	57,091	108,080,586	68,509	129,696,703
2055	89,259	63,689	57,320	108,524,343	68,784	130,229,211

[1]Conservation assumed to reduce annual average water use, but peak usage has been conservatively assumed to remain unchanged.

ANNUAL SUPPLY EVALUATION

The first supply standard which must be met by the City's water system is having sufficient source capacity to meet total annual demands on the system. As discussed previously, there are two components of supply which must be considered in this evaluation: "paper water" and "wet water". This evaluation will consider the City's estimated wet water (which cannot exceed the City's legal "paper water" rights). The following are assumptions regarding annual source supply for the City's system:

- **Wells (underground aquifers)**: Based on discussion with management at the City Water Department, the reliable yield from groundwater sources has been assumed to be equal to the City's paper water right.
- **Mountain Springs**: Water production from mountain springs is heavily dependent on the climate conditions including precipitation (particularly snow pack), temperature, and other considerations. City Water Department management have reported that spring production has fluctuated significantly from year to year. In wet years, the springs have been observed to produce more than 4,000 gpm, while in dry years the springs produce significantly less flow. This considered, the reliable yield from the City's mountain springs has been assumed to be 1/2 of the City's paper water right.

Table 4-5 provides a breakdown of the estimated reliable yield of the City's sources, and Figure 4-3 compares the City's current annual source capacity with the projected water use through buildout. In accordance with the Regional Water Supply Agreement with WCWCD, the majority of source capacity needed to meet future demands will be provided by WCWCD, with a portion coming from the additional well capacity in the Gunlock Well Field as a result of the new arsenic treatment plant (indicated by the increase in capacity in the Gunlock Wells shown in Figure 4-3 in 2020). It should also be noted that St. George holds an additional 6,868 AF in underground water rights near the Virgin River, but due to the water quality in these areas (which would require advanced reverse osmosis treatment to meet drinking water standards), these sources are not economically feasible to develop at this time. As sources become scarcer in the area, the cost to develop and operate these additional 6,868 AF of water may become viable.

Table 4-5
Reliable Annual Yield of St. George City Culinary Water Sources

Source	Reliable Annual Yield (AF/year)
Mountain Springs	3,116.7
West City Springs	564
City Creek, Millcreek, Ledges Wells	5,439.9
Gunlock Wells	3,225/9,879.8*
Snow Canyon Wells	1,440
Total	**13,785.6/20,440.4**

*With the completion of the Gunlock Arsenic Treatment Plant, the reliable annual yield of the Gunlock Well Field will increase to 9,879.8 acre-feet per year.

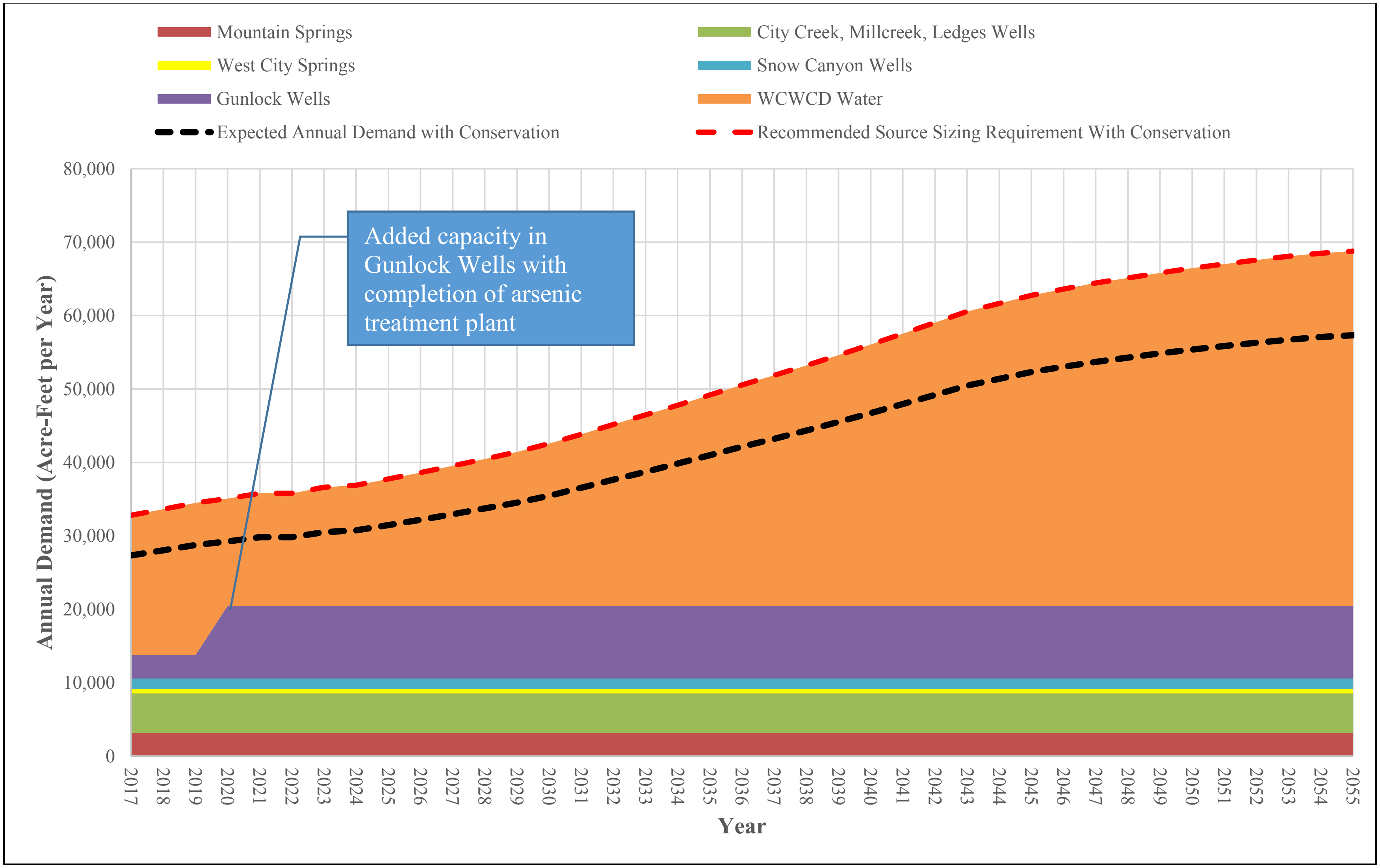
Including the annual source capacity to be added with the completion of the Gunlock arsenic treatment plant, Table 4-6 provides a summary of the City's future annual source capacity needs.

Table 4-6
Summary of Annual Source Capacity Requirements through Buildout

Scenario	Annual Culinary System Demand (AF/year)	City-Owned Annual Source Capacity (AF/year)[1]	Source Capacity Provided by WCWCD (AF/year)
10-Year Growth (2028)	40,469	20,440.4	***20,028.6***
Buildout (2055)	68,784	20,440.4	***48,343.6***

[1]Includes added capacity from Gunlock Well Field with completion of arsenic treatment plant.

Figure 4-3
Projected Annual Demand vs Annual Source Capacity[1]



[1]Projection accounts for expected conservation in the future.

PEAK DAY SUPPLY EVALUATION

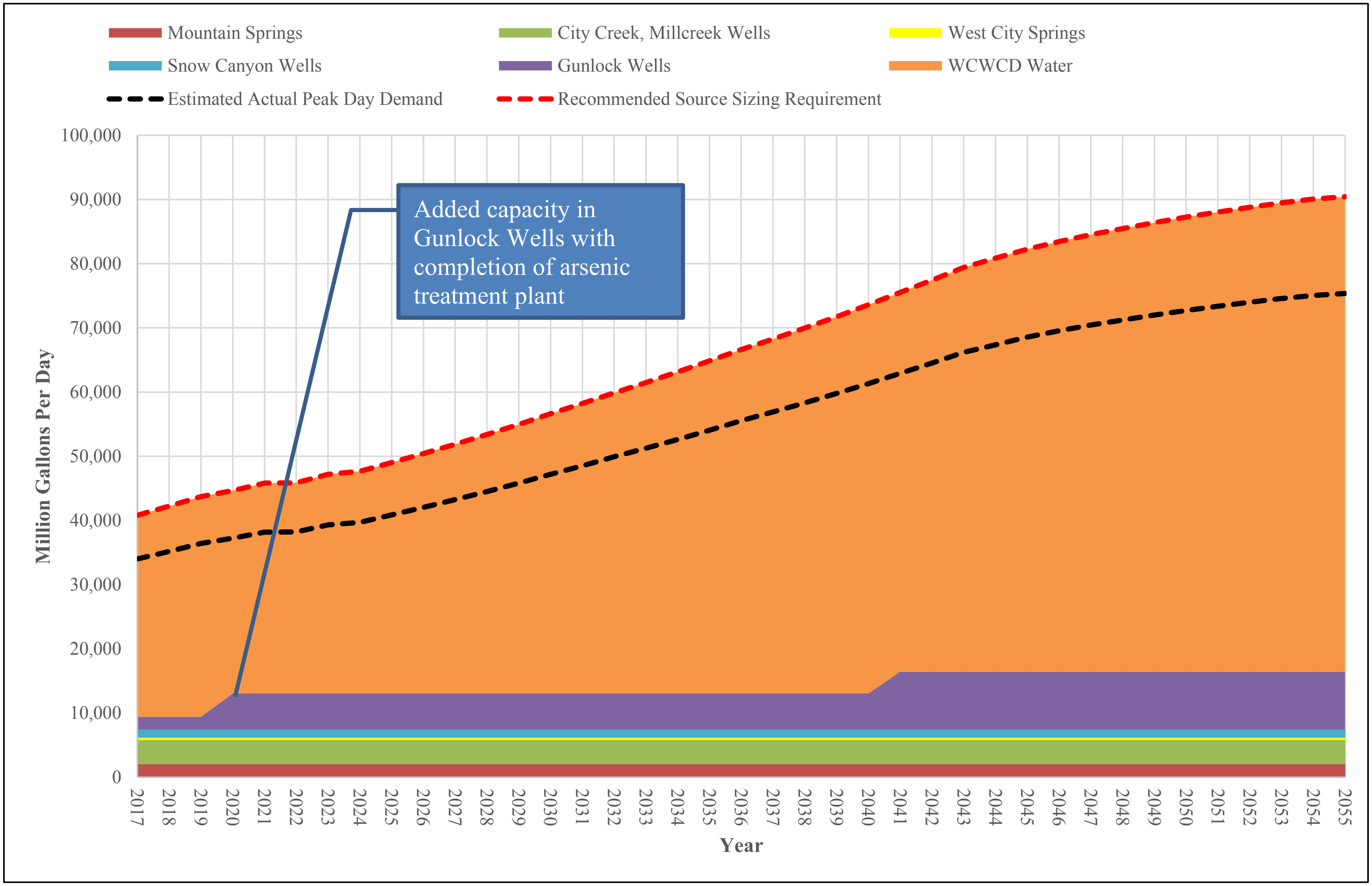
In addition to ensuring that the City has sufficient source capacity to meet average annual water demand over the course of an entire year, it is equally important to possess adequate source capacity in place to satisfy peak demands on the system. Peak day demand represents the daily demand exerted on the system during the peak usage day of the year. Peak day production capacity of each existing well source is given in Table 4-7. Figure 4-4 compares the City's current peak source production capacity with projected future water use through buildout.

Table 4-7
Existing Source Production Capacity

Source	Peak Production Capacity (gpm)
Wells	
City Creek #1	1,000 (Out of Service)
City Creek #2	1,200
Gunlock #1**	1,000
Gunlock #2*	600
Gunlock #3**	750
Gunlock #4**	1,250
Gunlock #5*	900
Gunlock #6*	300
Gunlock #7*	700
Gunlock #8*	1,100
Gunlock#9*	700
Gunlock #10*	800
Gunlock #11*	500
Ledges	750
Tolman #3	200
Tolman #4	350
Millcreek #1	700
Millcreek #2	600
Snow Canyon #2	382
Snow Canyon #3	255
Snow Canyon #3A	255
Snow Canyon #4	287
Snow Canyon #5	96
Mountain Springs	
Mountain Springs	2,000
West City Spring	350
Total	**13,025**

*Only 2,000 gpm of capacity is currently available from the Gunlock Well Field. With the completion of the Gunlock Arsenic Treatment Facility, the well field will return to a capacity of 5,600 gpm for the culinary water system (the City will continue to utilize Well #1, #3, and #4 in the secondary irrigation system).
**Well used for irrigation.

Figure 4-4
Projected Peak Day Culinary Water Use through Buildout



The following are important notes regarding Figure 4-4:

- As shown, the majority of future source capacity has been assumed to be provided by the Washington County Water Conservancy District. Supplying sufficient water to meet the needs of future growth is heavily dependent on the WCWCD supplying this needed water.
- The figure shows 2 increases in source capacity in the Gunlock Well Field. The first increase is associated with the completion of the Gunlock Arsenic Treatment Plant (an increase to 5,600 gpm in 2020). The increase shown in 2040 is linked to a tentative plan to construct additional wells in the Gunlock Well Field in the future, adding an additional 3,400 gpm of peak production capacity, bringing the total peak production capacity to 9,000 gpm.

The City's future peak day source needs are summarized in Table 4-8.

Table 4-8
Summary of Peak Day Source Capacity Requirements through Buildout

Scenario	Peak Day Demand (gpm)	City-Owned Annual Source Capacity (gpm)	Source Capacity Provided by WCWCD (gpm)
10-Year Growth (2028)	53,404.8	13,025	***40,379.8***
Buildout (2055)	90,436.9	16,425	***74,011.9***

Estimated Distribution of Future Source Requirements

To help guide capital facility planning, it is important to not only understand the magnitude of annual and peak system demands, but also the location of demands. Using the zoning and land use information described in Chapter 3, Table 4-9 outlines the projected system demand for the different regions of the City (refer to Figure 3-6 from Chapter 3 for the location of each region).

Table 4-9
Projected Annual and Peak Day Demand on Culinary Water System per Region, Expected Demands[1,2,3,4]

Source Region	Existing Culinary Water ERUs (2018)	Existing Annual Culinary Water Demand (acre-ft/year)	Existing Peak Day Culinary Demand (gal/day)	10-Year Growth Added Culinary ERUs[2]	Total 2028 Culinary ERUs	2028 Annual Culinary Water Demand (acre-ft/yr)	2028 Peak Day Culinary Demand (gal/day)	Added Culinary ERUs at Buildout	Total Buildout Culinary ERUs	Buildout Annual Culinary Demand (acre-ft/yr)	Buildout Peak Day Culinary Demand (gal/day)
Airport	159	113	203,892	2,694	2,853	1,857	3,528,657	14,795	14,955	9,604	18,182,244
Bloomington	2,237	1583	2,861,502	100	2,337	1,521	2,890,427	118	2,355	1,512	2,863,114
Bloomington Hills	2,622	1855	3,354,071	172	2,794	1,819	3,455,727	662	3,284	2,109	3,992,810
Bloomington Hills Upper	1,146	810	1,465,517	1,200	2,346	1,527	2,900,968	7,962	9,108	5,849	11,073,845
Dixie Drive	4,117	2912	5,265,332	1,547	5,664	3,686	7,004,094	3,650	7,766	4,987	9,442,700
Downtown	11,650	8243	14,900,200	1,434	13,084	8,515	16,180,230	4,767	16,417	10,543	19,960,448
Ledges	1,303	922	1,666,520	-573	730	476	902,749	577	1,880	1,207	2,285,264
Little Valley	4,819	3410	6,163,756	1,907	6,726	4,377	8,317,963	3,411	8,230	5,285	10,006,548
South Block/Sun River	1,121	793	1,434,161	2,664	3,785	2,464	4,681,094	5,946	7,067	4,538	8,592,321
Sunset	10,438	7385	13,350,067	1,064	11,502	7,486	14,223,862	7,759	18,197	11,686	22,125,052
TOTAL	**39,613**	**28,029**	**50,665,018**	**12,209**	**51,822**	**33,725**	**64,085,771**	**49,646**	**89,259**	**57,320**	**108,524,343**

[1]Refer to Figure 3-6 for a visual reference of the location of each respective region of the City.
[2]Projected location of growth over the next 10 years was estimated through coordination with the City Planning and Zoning Department and Water Department.
[3]Demands shown take into account the proposed expansion of the City's secondary irrigation system as outlined in the Secondary Irrigation Master Plan.
[4]Table provides *expected* demands by region, accounting for projected water conservation. The numbers do not include the recommended source and system reliability buffers, and they are intended to provide the water department with an estimate for the actual expected demands in the future by region.

ADDITIONAL SOURCE DEVELOPMENT RECOMMENDATIONS

While the majority of future water supply for St. George will be provided by WCWCD, the City is exploring the possibility of developing a new well source north of the T-Bone Tank (the City has named this potential project the "Homestead Well"). Any additional source capacity that the City can add to the system is beneficial, assuming that the project is not cost prohibitive. At the direction of the City, the Homestead Well project will be included in the 10-year Capital Facilities Plan found in Chapter 8 of this report.

CHAPTER 5
STORAGE CAPACITY EVALUATION

Storage facilities play a vital role in the operation of a water system. They provide an important buffer between sources and the distribution system as well as store water for emergencies and fire suppression. New State legislation (HB 303) requires that storage sizing requirements be evaluated for each particular system. The purpose of this chapter is to evaluate the City's existing water storage facilities and evaluate future storage needs that will arise as a result of growth in the City.

STORAGE EVALUATION CRITERIA

Regulations regarding required system storage are found in Section R309-510-8 of the Utah Administrative Code. The code outlines the types of storage that are required for a public water system:

- **Equalization Storage:** The storage required to buffer the difference between system demand and source production capacity.
- **Fire Flow Storage:** The storage required to provide fire suppression as required by the local fire code official.
- **Emergency Storage:** The storage needed (as deemed necessary by the water supplier) to satisfy system demand in an emergency situation, such as a power failure or other event that may affect the ability of a water source to produce water.

Prior to the passing of House Bill 303, equalization storage needed for indoor and outdoor water use could be calculated using values provided in R309-510-8. However, the passage of the new bill requires individual communities to determine what their specific storage needs are based on actual data. The following sections outline the recommended evaluation criteria for the City's water storage facilities.

Equalization Storage

Equalization storage is the water needed to supply the system for periods when demand exceeds supply capacity. Figure 5-1 shows the demand pattern for a typical high demand period (month of July). As shown in the figure, water demand peaks in the early morning from 4:00 am to 8:00 am when irrigation demands are the highest. Demand then drops off significantly during the day as water use is primarily limited to indoor water use.

While system demands vary significantly during the day, the same is not true for most supply sources. It is typically most economical to size sources, major transmission pipelines, and pump stations to produce water at a relatively constant rate. This is especially true for major surface water treatment facilities, such as the Quail Creek WTP, that have a difficult time changing production rates rapidly. As a result, most sources are designed to supply water at a relatively constant rate throughout the course of the day. Equalization storage is used to satisfy any demand that exceeds the constant rate of supply.

This is further illustrated by Figure 5-2 which displays the water depth in the BAT (Bloomington Hills) Tank over a 24-hour period of a high demand day. Based on the data plotted in Figure 5-1, the volume of equalization storage needed to meet demands is equal to approximately 15% of the total demand over the course of the peak day. However, it is important to note that the demand curve shown in Figure 5-1 represents a 1-hour average from the raw demand data provided by the City's data collection software (the raw data readings are volatile and are recorded in 1-second increments). This considered, the "peaks" and "valleys" in the data line have been dampened, meaning that the area both above and below the daily average are likely both respectively larger. Based on this data, it is recommended that the City's equalization storage be equal to 100% of average day system demand, which is approximately equal to 50% of peak day system demand. This is consistent with historic guideline from UDDW regarding storage requirements and is adequate to satisfy observed fluctuations in demand with a reasonable safety factor. Based on this recommendation, the required equalization storage for the system under existing conditions is **25,234,000 gallons.**

Fire Flow Storage

Fire flow storage requirements are defined by the State Code as follows:

1. Fire flow storage shall be provided if fire flow is required by the local fire code official or if fire hydrants intended for fire flow are installed.
2. Water system shall consult with the local fire code official regarding needed fire flows.
3. When direction from the local fire code official is not available, the water system shall use Appendix B of the International Fire Code, 2015 edition, for guidance. Unless otherwise approved by the local fire code official the fire flow and fire flow duration shall not be less than 1,000 gallons per minute for 60 minutes.

At the direction of the City, the fire flow standard for this master plan is 1,500 gpm with a duration of 2 hours, which equals 180,000 gallons of storage. The City has elected to maintain this volume of fire flow storage in each tank in the system.

Figure 5-1
Diurnal Demand Plot

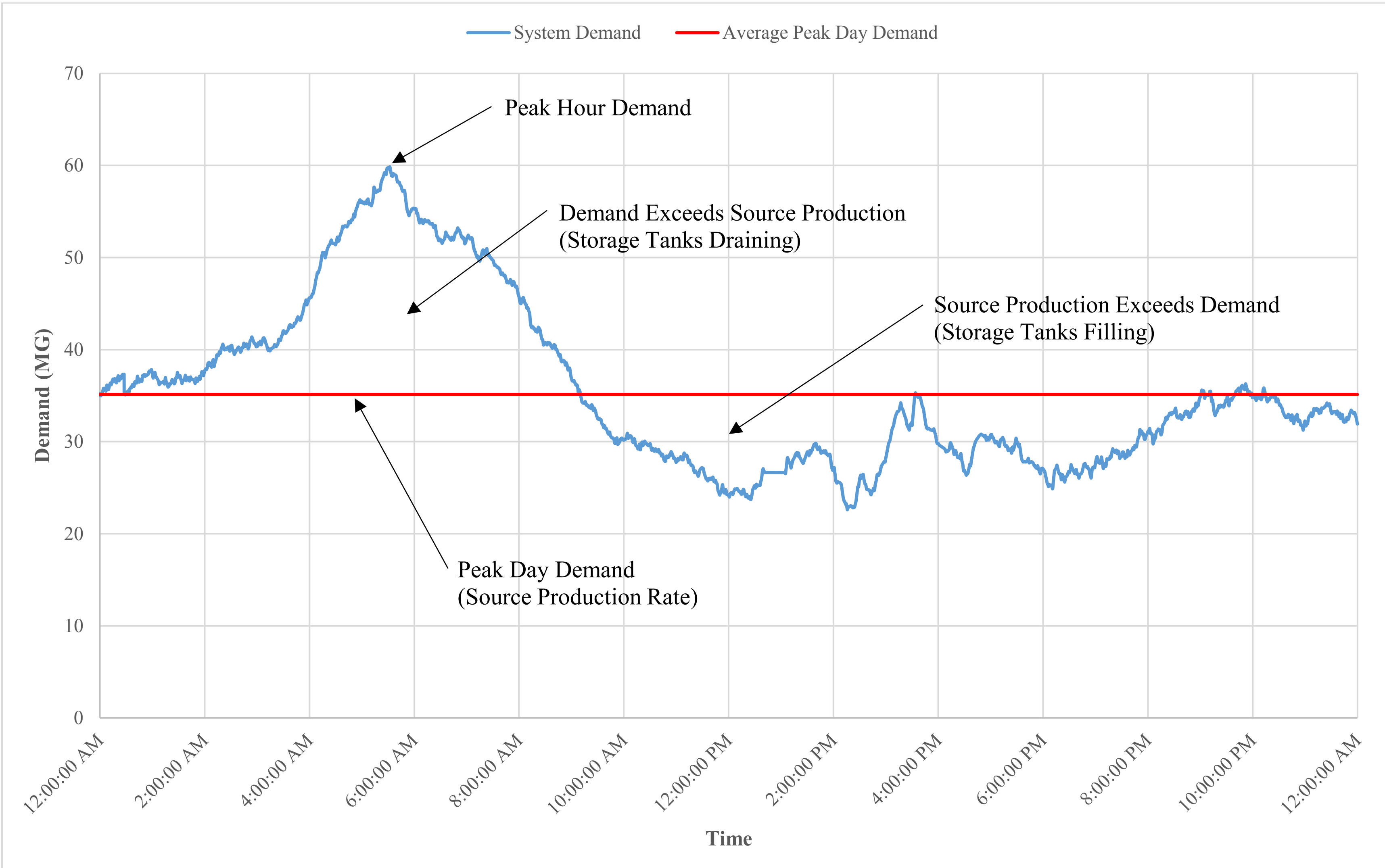
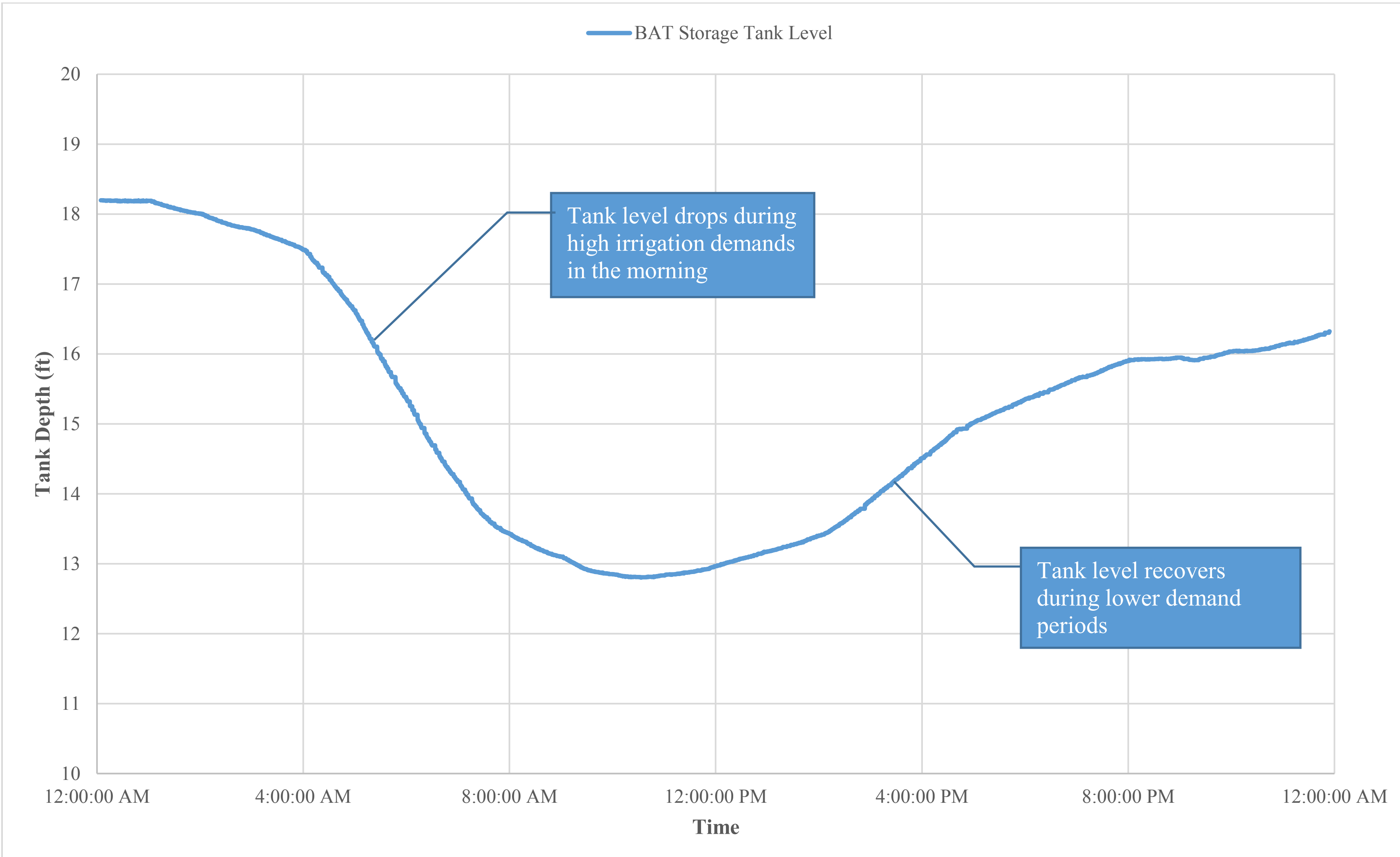


Figure 5-2
Typical Water Tank Level Variation, BAT (Bloomington Hills) Storage Tank



Emergency Storage

Emergency storage is the volume of water required to meet water demand during an emergency situation (other than a fire flow event). Emergency storage requirements are defined in the code as follows:

"Emergency storage shall be considered during the design process. The amount of emergency storage shall be based upon an assessment of risk and the desired degree of system dependability. The Director may require emergency storage when it is warranted to protect public health and welfare."

No specific requirement is given for emergency storage in the code. The determination of required emergency storage is left largely to the entity designing and operating the water system. In St. George City, the most common water supply emergencies relative to storage analysis would be power outages. During a power outage, pump stations, wells, or treatment plants may not be able to operate and provide water for the system. While some water delivery during a power outage can be accomplished through backup power supplies, it is prudent to include some additional emergency water in storage reservoirs. St. George relies heavily on the Quail Creek WTP, and if the treatment plant were to go offline unexpectedly, it may be difficult to meet city-wide demands.

Based on discussions with City personnel, it is recommended that the system include emergency storage equal to 20% of average day demand. This results in an existing emergency storage requirement of **5,047,000 gallons**.

Combined Emergency/Equalization Storage

With the volume of recommended emergency storage identified above, the combined equalization/emergency storage required for St. George City is **30,281,000 gallons**.

Existing Storage Facilities

The City's existing water storage facilities are summarized in Table 5-1.

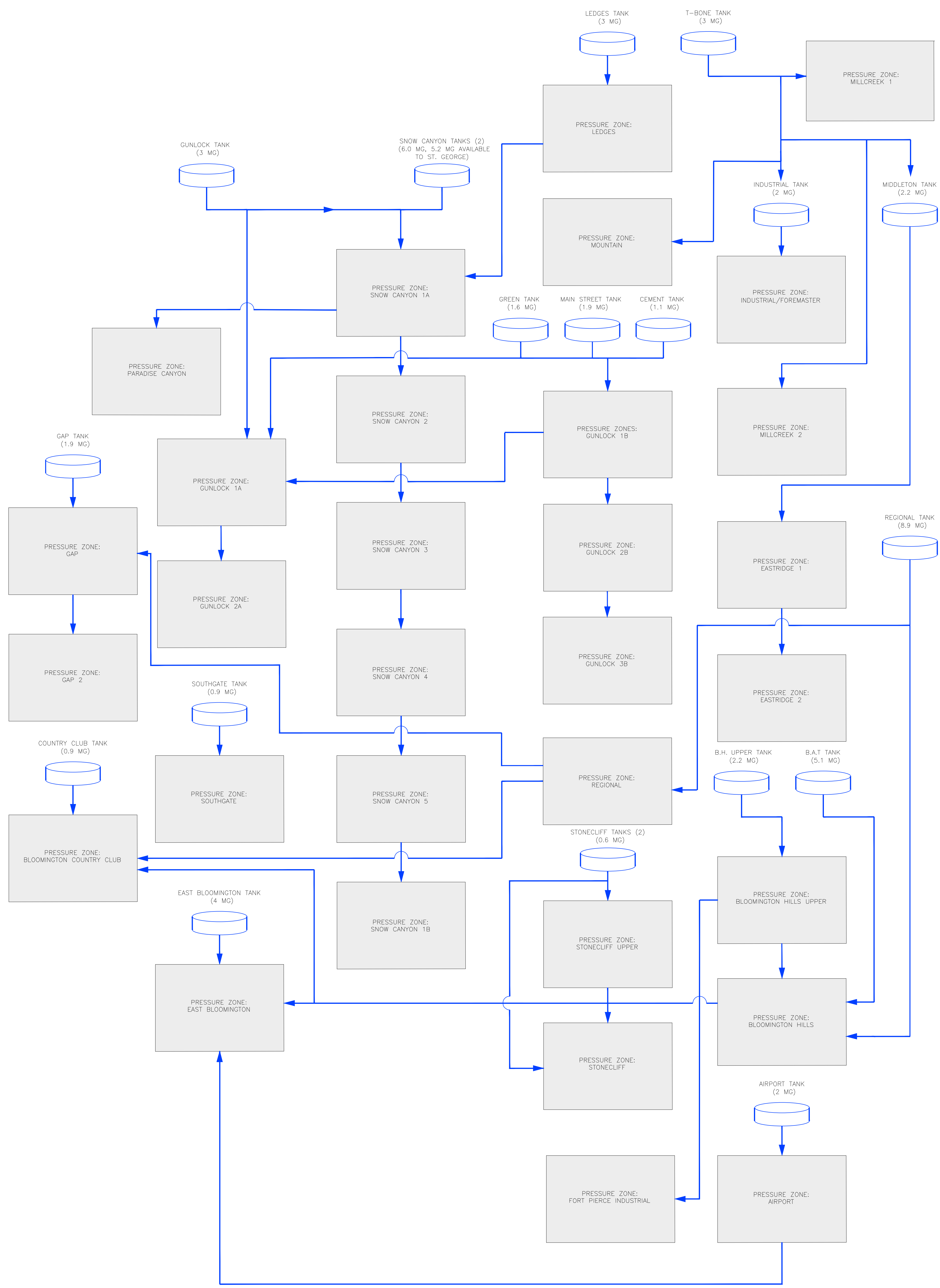
Table 5-1
City of St. George Existing Storage Facilities

Tank Name	Size of Tank (Million Gallons)	Tank Diameter (ft)	Construction Material	Pressure Zone	Base Elevation (ft)	Tank Height (ft)	Overflow Elevation (ft)	Max Depth (ft)
Airport Tank	2	140x100 Rect	Concrete	Airport	3040	20	3058	18
B.A.T	5.1	210	Steel	Bloomington Hills	2860	21.5	2879.5	19.5
B.H. Upper	2.2	100	Steel	Bloomington Hills Upper, Fort Pierce Industrial	2932.2	40	2970.2	38
Cement	1.1	120	Concrete	Gunlock 1A, 1B, 2A, 2B, 3B	3005	15	3018	13
Country Club	0.9	75	Steel	County Club	2721	30	2749	28
East Bloomington	4	200	Concrete	East Bloomington	2859.6	20	2877.6	18
Gap	1.9	120	Steel	Gap 1, Gap 2	2996	24	3018	22
Green	1.6	120	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	2994	21	3013	19
Gunlock	3	120	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	3338	38	3374	36
Industrial	2	103	Hypalon	Industrial, Foremaster	3093	22	3113	20
Ledges	3	170	Concrete	Ledges	4035.6	20	4053.6	18
Main St.	1.9	100	Steel	Gunlock 1A, 1B, 2A, 2B, 3B	2982	35	3015	33
Middleton	2.2	100	Steel	Eastridge 1, Eastridge 2	3018	40	3056	38
New Stonecliff	0.3	54	Concrete	Stonecliff Upper	0	20	18	18
Quail Creek WTP	10	275	Steel	Regional	2900	22.5	2920.5	20.5
Skyline[1]	0.5	75	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	0	18	17	17
Snow Canyon #1	1.8	165	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	3293	18	3309	16
Snow Canyon #2	1.8	165	Concrete	Snow Canyon 1A, 1B, 2, 3, 4, 5, Paradise Canyon	3293	18	3309	16
Southgate	0.9	103	Steel	Southgate	2910	16	2924	14
Stonecliff	0.3	53	Steel	Stonecliff	3004	18	3020	16
T-Bone	3	120	Steel	Millcreek 1, Millcreek 2, Mountain	3385.4	38	3421.4	36
Total	**49.5**							

[1]Skyline Tank provides intermediate storage between two pump stations and does not provide operational storage for the system.

Evaluation of Existing and Future Storage Requirements

Similar to the evaluation of the City's sources, storage facilities have been evaluated by looking at individual pressure zones in the system. Tables 5-2 through 5-4 provide a summary of the storage evaluation for the existing system, the system 10 years in the future, and the system at full buildout, respectively. The tables compare the City's existing storage facilities against projected future demands. An operational schematic of the City's existing water storage facilities is shown in Figure 5-3.



BOWEN COLLINS & ASSOCIATES

CULINARY WATER MASTER PLAN

ST. GEORGE WATER STORAGE SCHEMATIC

FIGURE NO. 5-3

Table 5-2
City of St. George Storage Capacity Evaluation – Existing Conditions

Tank Service Area	Pressure Zones Included	Estimated Average Daily Demand (gallons)	Equalization Storage Required (gallons)	Emergency Storage Required (gallons)	Fire Flow Storage Required (gallons)	Total Storage Required (gallons)	Available Storage (gallons)	Total Storage Surplus (Deficit) by Service Area
Gunlock Tank, Green Tank, Main Street Tank, Cement Tank	Gunlock 1A, Gunlock 1B, Gunlock 2A, Gunlock 2B, Gunlock 3B	6,869,261	6,869,261	1,373,852	720,000	8,963,114	7,600,000	(1,363,114)
Ledges Tank	Ledges	677,697	677,697	135,539	180,000	993,237	3,000,000	2,006,763
Snow Canyon #1, Snow Canyon #2	Snow Canyon 1A, Snow Canyon 1B, Snow Canyon 2, Snow Canyon 3, Snow Canyon 4, Snow Canyon 5, Paradise Canyon	3,131,383	3,131,383	626,277	180,000	3,937,659	3,600,000	(337,659)
Gap Tank	Gap 1, Gap 2	2,164,758	2,164,758	432,952	180,000	2,777,710	1,900,000	(877,710)
T-Bone Tank	Millcreek 1, Millcreek 2, Mountain	130,170	130,170	26,034	180,000	336,205	3,000,000	2,663,795
Industrial Tank	Industrial/ Foremaster	269,773	269,773	53,955	180,000	503,727	2,000,000	1,496,273
Middleton Tank	Eastridge 1, Eastridge 2	2,011,748	2,011,748	402,350	180,000	2,594,097	2,200,000	(394,097)
Quail Creek WTP Tanks	Regional	1,870,615	1,870,615	374,123	180,000	2,424,738	10,000,000	7,575,262
Southgate Tank	Southgate	395,789	395,789	79,158	180,000	654,947	900,000	245,053
Country Club Tank	County Club	1,425,340	1,425,340	285,068	180,000	1,890,408	900,000	(990,408)
Stonecliff Tanks	Stonecliff, Stonecliff Upper	299,321	299,321	59,864	180,000	539,185	600,000	60,815
Bloomington Hills Upper	Bloomington Hills Upper, Fort Pierce Industrial	732,242	732,242	146,448	180,000	1,058,691	2,200,000	1,141,309
BAT	Bloomington Hills	4,441,595	4,441,595	888,319	180,000	5,509,914	5,100,000	(409,914)
East Bloomington	East Bloomington	712,113	712,113	142,423	180,000	1,034,535	4,000,000	2,965,465
Airport	Airport	101,561	101,561	20,312	180,000	301,873	2,000,000	1,698,127
Totals		**25,233,366**	**25,233,366**	**5,046,673**	**3,240,000**	**33,520,039**	**49,000,000**	

[1]Each tank needs to hold a fire flow storage of 180,000 gallons, for a total storage volume of 720,000 gallons
[2]Snow Canyon Tank #1 and #2 are located next to each other and only need to hold 180,000 gallons of fire flow storage between the two facilities.

Table 5-3
City of St. George Storage Capacity Evaluation – 10-Year Growth

Tank Service Area	Pressure Zones Included	Estimated Average Day Demand (gallons)	Equalization Storage Required (gallons)	Emergency Storage Required (gallons)	Fire Flow Storage Required (gallons)	Total Storage Required (gallons)	Available Storage (gallons)	Total Storage Surplus (Deficit) by Service Area
Gunlock Tank, Green Tank, Main Street Tank, Cement Tank	Gunlock 1A, Gunlock 1B, Gunlock 2A, Gunlock 2B, Gunlock 3B	6,964,811	6,964,811	1,392,962	720,000	9,077,774	7,600,000	(1,477,774)
Ledges Tank	Ledges	312,696	312,696	62,539	180,000	555,236	3,000,000	2,444,764
Snow Canyon #1, Snow Canyon #2	Snow Canyon 1A, Snow Canyon 1B, Snow Canyon 2, Snow Canyon 3, Snow Canyon 4, Snow Canyon 5, Paradise Canyon	3,809,151	3,809,151	761,830	180,000	4,750,981	3,600,000	(1,150,981)
Gap Tank	Gap 1, Gap 2	2,955,912	2,955,912	591,182	180,000	3,727,095	1,900,000	(1,827,095)
T-Bone Tank	Millcreek 1, Millcreek 2, Mountain	130,170	130,170	26,034	180,000	336,205	3,000,000	2,663,795
Industrial Tank	Industrial/ Foremaster	269,773	269,773	53,955	180,000	503,727	2,000,000	1,496,273
Middleton Tank	Eastridge 1, Eastridge 2	2,511,156	2,511,156	502,231	180,000	3,193,387	2,200,000	(993,387)
Quail Creek WTP Tanks	Regional	2,189,115	2,189,115	437,823	180,000	2,806,938	10,000,000	7,193,062
Southgate Tank	Southgate	590,074	590,074	118,015	180,000	888,089	900,000	11,911
Country Club Tank	County Club	1,489,040	1,489,040	297,808	180,000	1,966,848	900,000	(1,066,848)
Stonecliff Tanks	Stonecliff, Stonecliff Upper	331,171	331,171	66,234	180,000	577,405	600,000	22,595
Bloomington Hills Upper	Bloomington Hills Upper, Fort Pierce Industrial	1,528,492	1,528,492	305,698	180,000	2,014,191	2,200,000	185,809
BAT	Bloomington Hills	5,734,068	5,734,068	1,146,814	180,000	7,060,881	5,100,000	(1,960,881)
East Bloomington	East Bloomington	2,377,231	2,377,231	475,446	180,000	3,032,677	4,000,000	967,323
Airport	Airport	1,817,639	1,817,639	363,528	180,000	2,361,166	2,000,000	(361,166)
Totals		**33,010,499**	**33,010,499**	**6,602,100**	**3,240,000**	**42,852,599**	**49,000,000**	

Table 5-4
City of St. George Storage Capacity Evaluation – Buildout Growth

Tank Service Area	Pressure Zones Included	Estimated Average Day Demand (gallons)	Equalization Storage Required (gallons)	Emergency Storage Required (gallons)	Fire Flow Storage Required (gallons)	Total Storage Required (gallons)	Available Storage (gallons)	Total Storage Surplus (Deficit) by Service Area
Gunlock Tank, Green Tank, Main Street Tank, Cement Tank	Gunlock 1A, Gunlock 1B, Gunlock 2A, Gunlock 2B, Gunlock 3B	8,758,750	8,758,750	1,751,750	720,000	11,230,500	7,600,000	(3,630,500)
Ledges Tank	Ledges	1,197,560	1,197,560	239,512	180,000	1,617,072	3,000,000	1,382,928
Snow Canyon #1, Snow Canyon #2	Snow Canyon 1A, Snow Canyon 1B, Snow Canyon 2, Snow Canyon 3, Snow Canyon 4, Snow Canyon 5, Paradise Canyon	6,240,052	6,240,052	1,248,010	180,000	7,668,062	3,600,000	(4,068,062)
Gap Tank	Gap 1, Gap 2	4,195,955	4,195,955	839,191	180,000	5,215,146	1,900,000	(3,315,146)
T-Bone Tank	Millcreek 1, Millcreek 2, Mountain	279,643	279,643	55,929	180,000	515,572	3,000,000	2,484,428
Industrial Tank	Industrial/ Foremaster	626,808	626,808	125,362	180,000	932,170	2,000,000	1,067,830
Middleton Tank	Eastridge 1, Eastridge 2	2,883,699	2,883,699	576,740	180,000	3,640,439	2,200,000	(1,440,439)
Quail Creek WTP Tanks	Regional	3,178,630	3,178,630	635,726	180,000	3,994,356	10,000,000	6,005,644
Southgate Tank	Southgate	832,559	832,559	166,512	180,000	1,179,071	900,000	(279,071)
Country Club Tank	County Club	1,500,135	1,500,135	300,027	180,000	1,980,162	900,000	(1,080,162)
Stonecliff Tanks	Stonecliff, Stonecliff Upper	484,120	484,120	96,824	180,000	760,944	600,000	(160,944)
Bloomington Hills Upper	Bloomington Hills Upper, Fort Pierce Industrial	6,534,346	6,534,346	1,306,869	180,000	8,021,215	2,200,000	(5,821,215)
BAT	Bloomington Hills	6,850,298	6,850,298	1,370,060	180,000	8,400,358	5,100,000	(3,300,358)
East Bloomington	East Bloomington	3,769,129	3,769,129	753,826	180,000	4,702,955	4,000,000	(702,955)
Airport	Airport	9,526,335	9,526,335	1,905,267	180,000	11,611,602	2,000,000	(9,611,602)
Totals		**56,858,019**	**56,858,019**	**11,371,604**	**3,240,000**	**71,469,623**	**49,000,000**	

STORAGE FACILITY DISCUSSION AND RECOMMENDATIONS

Tables 5-2 through 5-4 provide an evaluation of storage facilities for existing, 10-year growth, and buildout conditions. The following sections provide additional discussion and recommendations based on the information found in the tables.

Existing Conditions

Gunlock Tank, Green Tank, Main St. Tank, Cement Tank System

As indicated in Table 5-2, this tank service area is shown having an existing deficiency of approximately 1.4 MG. As shown in Figure 5-3, this tank group can be fed by the T-Bone tank, which has more than 2.6 MG of excess storage capacity. While relying on excess storage from a higher zone is not ideal from an operational standpoint, the excess capacity in the T-Bone tank can be used to cover this storage deficiency for the near future. As a long-term solution, it is recommended that the City replace the existing Green Tank (which the City has indicated is in poor condition) with a new 4.5 MG facility capable of meeting existing and future system needs.

Snow Canyon Tanks

The analysis indicates that there is a moderate existing deficiency in the zones serviced by the Snow Canyon Tanks. It is recommended that the City construct a new 2.0 MG storage facility to eliminate this deficiency and provide additional capacity for new growth. The majority of new growth in this tank service area will occur at Tech Ridge, the redevelopment of the old St. George Airport site. This considered, it is recommended that a storage tank be constructed at or near Tech Ridge. Based on the topographic characteristics of Tech Ridge, the new storage tank will need be built at or below the elevation of the development and will require a booster pump on the discharge side in order to provide adequate pressure in the system.

Gap Tank

The storage analysis indicates that there is a deficiency in the Gap Tank Service Area. As shown in Figure 2-3, the Gap Tank is fed primarily through the Tonaquint Pump Station which draws out of the Regional Pressure Zone which is fed from the tanks at the WCWCD WTP. The Gap Pressure Zone is also connected by an isolation valve to the Gunlock 1A pressure zone (this is an emergency connection and is not used under normal operation). This storage deficiency means that the Tonaquint Pump Station may at times need to provide more flow than it ideally should in order to meet demand during high usage periods.

In order to address this storage deficiency, it is recommended that a new storage facility be constructed to service the Gap Pressure Zone. The ideal location of this new storage facility is at the north end of the future Divario development. Based on projected future storage needs, this new tank should have volume of 3.5 MG.

As an intermediate solution, and to provide greater operational flexibility in the system, it is also recommended that the City modify the valve connection between the Gunlock 1A pressure zone and the Gap pressure zone to provide the Gap Zone with supplemental storage capacity from Gunlock 1A (Gunlock Tank, Green Tank, Main St. Tank, or Cement Tank). This could be accomplished by installing a valve controlled by SCADA which opens when the level in Gap Tank drops to a pre-determined level.

Middleton Tank

The Middleton Tank provides storage capacity for the Eastridge 1 and Eastridge 2 pressure zones. As indicated in Table 5-2, the existing storage requirement for these zones exceeds the capacity of the Middleton Tank. However, this does not reflect a true system deficiency. As shown in Figure 5-3, the T-Bone Tank, which has ample excess storage, feeds into the Middleton Tank and can be used to supplement any deficiencies in the Middleton Tank. Therefore, no additional storage is recommended to be constructed in the Middleton Tank service area.

Country Club Tank

As shown in Table 5-2, the County Club Tank service area shows a significant storage deficiency. As shown in Figure 2-3, the Country Club Tank is fed in two ways:

- Via the WTP tanks (Regional Pressure Zone) through an automated valve.
- Via the BAT tank through the State Shed PRV or Pioneer PRV.

It is not recommended that the excess storage in the WTP tanks be counted toward the deficiency in the County Club Tank due to the large distance between the facilities (which would put excess peaking stress on the City's transmission pipeline through the Regional Pressure Zone). Additionally, the BAT Tank does not have excess storage available to help serve the County Club area. Therefore, even though there is not significant growth potential in this pressure zone, it is recommended that the Country Club storage tank be replaced and upsized to 2.0 MG to meet existing and future storage needs.

BAT Tank

While the BAT Tank is shown having an existing deficiency, this shortfall is covered by excess capacity in the East Bloomington Tank and Bloomington Hills Upper Tank. In addition, the WCWCD is planning to construct a new storage tank as part of the Sand Hollow Regional Pipeline (called the Warner Valley Tank). This storage facility will be utilized by St. George and will provide storage into the Bloomington Hills Pressure Zone.

10-Year Growth Conditions

Gunlock Tank, Green Tank, Main St. Tank, Cement Tank System

As discussed in the "Existing Conditions" section, this tank group will need additional storage capacity to meet future needs. It is recommended that the Green Tank be replaced and upsized to meet existing and future storage needs.

Snow Canyon Tanks

As indicated in the "Existing Conditions" section, it is recommended that a new storage tank be constructed at Tech Ridge. This new facility will meet the City's storage needs through projected 10-year growth.

Gap Tank

The proposed 3.5 MG Northern Gap Tank will satisfy the storage needs for the Gap Pressure Zone through the 10-year growth window.

Middleton Tank

Similar to the Middleton Tank discussion in the "Existing Conditions" section, excess available capacity in the T-Bone tank provides storage coverage for the Middleton Tank.

Country Club Tank

As indicated previously, it is recommended that the County Club Tank be replaced and upsized. This project will provide sufficient capacity through the 10-year planning window.

BAT Tank

The Warner Valley Tank was discussed in the "Existing Conditions" section. This new storage facility will provide the needed capacity for the Bloomington Hills pressure zone through the 10-year planning window.

Airport Tank

While the demand in the Airport Tank service area is currently very low, future growth in the area is anticipated to accelerate rapidly in the coming years. The storage evaluation indicates that the Airport Tank service area will need an additional 360,000 gallons by the end of the 10-year planning window. This future system need will be satisfied by the new WCWCD Warner Valley storage tank and will require a line to be constructed off of the 36-inch Regional line to deliver flow into the Airport Zone.

Buildout Growth Conditions

Gunlock Tank, Green Tank, Main Street, Cement Tank Group

When the system reaches full buildout, it is anticipated that the Gunlock/Green/Main Street/Cement Tank service area will have a total storage deficiency of 3.7 MG. The proposed replacement of the Green Tank will provide adequate capacity to remediate this projected storage deficiency in this tank service area.

Snow Canyon Tanks

At full buildout, demand in the Snow Canyon Pressure Zones is projected to require over 4 MG of additional storage capacity. With 2 MG of storage being added with the Tech Ridge storage tank, it is recommended that the remaining storage capacity needed for this part of the system (2.3 MG) be constructed next to the existing Snow Canyon Tanks.

Gap Tank

The "Existing Conditions" section introduces a recommendation for a new storage tank to service the Gap Pressure Zone. This proposed 3.5 MG storage tank will provide sufficient storage capacity to meet the demand of growth through projected buildout.

Southgate Tank

With future growth slated for the western region of the Tonaquint area, additional storage will be needed. As indicated in Table 5-4, the Southgate Tank service area shows a 279,000-gallon shortfall at buildout. Without increased storage, the Southgate Pump Station would need to make up the difference in peaking capacity. As development in the Tonaquint PD moves west and north toward the Gap Pressure Zone, it is recommended that the two zones be connected through a PRV. This connection will provide the Tonaquint area with supplemental storage from the Gap Pressure Zone. Based on this plan, it is not recommended that the City construct a new storage facility for the Southgate Pressure Zone.

Middleton Tank

The buildout storage analysis in Table 5-4 indicates that there will be a 1,440,000-gallon storage deficiency in the Middleton Tank service area. However, as previously identified, the T-Bone tank has enough storage capacity to make up for this deficiency. Therefore, no storage improvements are recommended for the Middleton Tank service area.

Country Club Tank

As discussed in the "Existing Conditions" evaluation of this chapter, it is recommended that the City replace and upsize the existing Country Club Tank to provide adequate storage capacity for existing and future growth. The recommended 2 MG tank will provide the storage volume needed through buildout.

Stonecliff Tanks

The storage analysis for full buildout shows a small storage deficiency in the Stonecliff Pressure Zones. Because the deficiency is relatively small, it is not recommended that the City construct any additional storage for this area of the system.

Bloomington Hills Upper Tank

The Bloomington Hills Upper Tank, which services the Bloomington Hills Upper Zone and the Fort Pierce Industrial Zone (which currently pumps out of the Bloomington Hills Upper Zone and does not have a gravity fed storage tank into the zone), is comprised of a mixture of commercial, industrial and residential land use designations. The water use from one industrial connection to another can vary significantly, so the projected water use in these areas can be difficult to estimate accurately. Based on the evaluation from this master plan which projected water use based on historical water use trends for different type of connections, the Bloomington Hills Upper Tank service area will have a 5.8 MG storage shortfall at buildout. Based on current water use projections, it is recommended that a 1 MG gallon tank be constructed to service the Fort Pierce Industrial Zone (which will also service a portion of the Desert Color development) and that a 2.8 MG tank be constructed to service new development in the Bloomington Hills Upper Zone. The City has already selected a future tank site for the Bloomington Hills Upper Zone located on White Dome. As development continues in these two pressure zones, the City will have a better feel for what kind of demand will occur in the zones and plan for additional storage capacity if it is ultimately needed.

BAT Tank

As discussed in the “10-Year Growth Conditions” section, the recommended solution to the future storage needs in the BAT zone is the new WCWCD Sand Hollow Regional Pipeline storage tank. Depending upon how much storage is eventually built at the Warner Valley site, this new tank(s) may be capable of meeting most or all of the future storage needs in the BAT service area. However, storage from the Warner valley Tank could also potentially be used to service the Airport Region of the City. Over the next 10 years, the City will need approximately 1.5 MG of the storage in the new WCWCD Tank based on the following assumptions:

- BAT Tank: **1,960,881-gallon total shortfall with 967,323-gallon available surplus in East Bloomington for a net 993,558 shortfall.**
- Airport Tank: **361,166-gallon shortfall**
- **Total 10-Year Need = 1,354,725 gallons**

This 10-year growth need is covered by the first tank constructed at the Warner Valley Site (3 MG total, 2 MG available to St. George).

However, looking beyond the 10-Year planning window through buildout, the storage needed for the BAT and Airport Zone becomes:

3,30,358 (BAT) + 9,611,602 (Airport) = **12,911,960 gallons of storage**

Future development around the St. George Airport is very similar to that of the Bloomington Hills Upper/Fort Pierce Industrial area in that it represents a large undeveloped area with a wide range of potential water use applications. For this reason, it is recommended that the City phase in storage improvements rather than build one very large facility that is potentially oversized. Assuming that the Warner Valley Tank site will eventually hold 8 MG gallons of storage (3 MG phase 1 tank and 5 MG phase 2 tank) and that St. George will have access to 5 MG of this storage, the City would need to construct an additional 8 MG of storage to service the Airport region.

Because of the high level of uncertainty surrounding future water use around the Airport, it is recommended that the City construct a 2 MG tank near the Desert Canyons development that is expandable to 4 MG in the Airport Pressure Zone. As development occurs in the Airport region, the City can reassess whether or not storage beyond what is recommended in this report is needed to service new growth.

East Bloomington

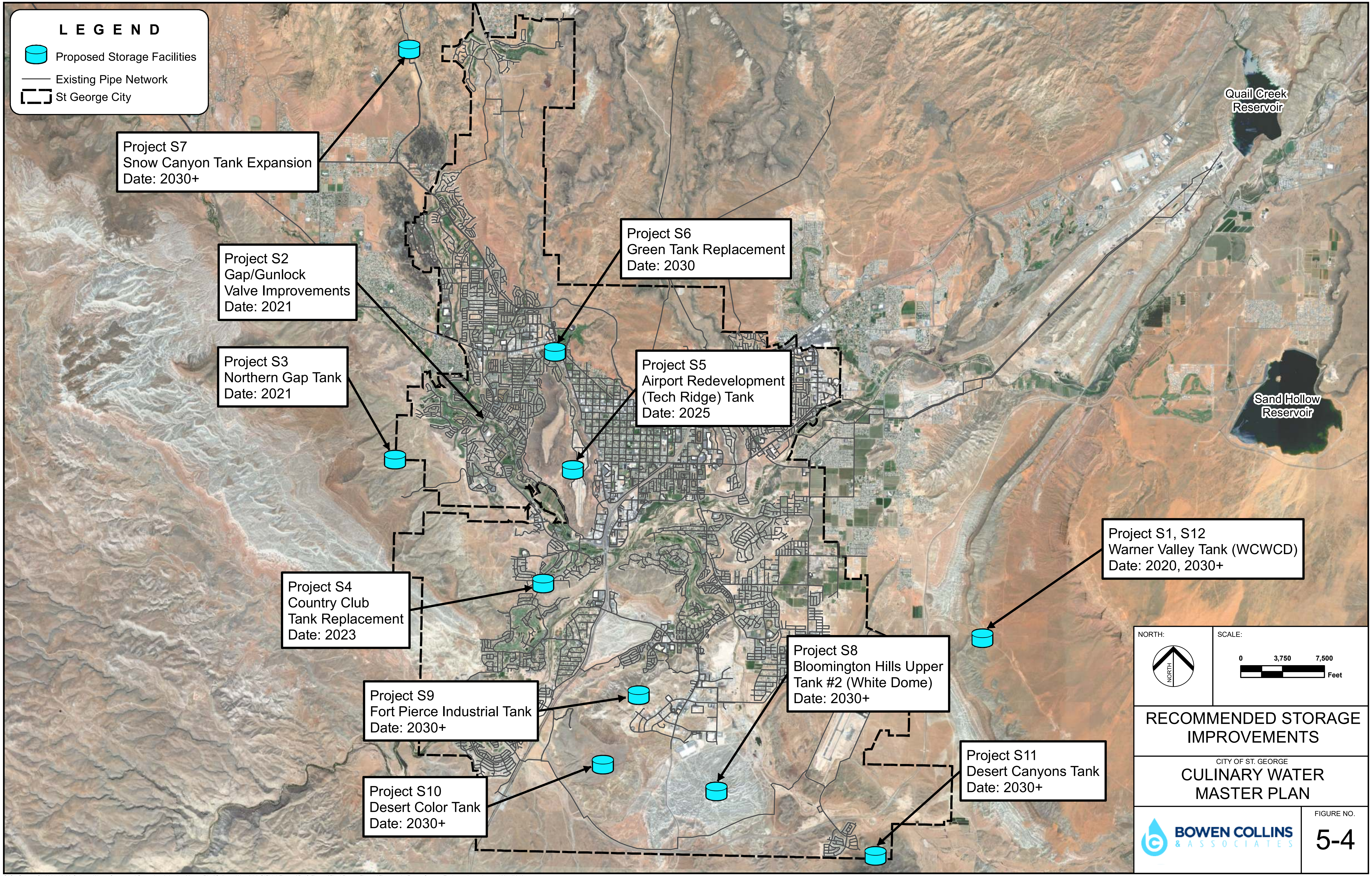
The East Bloomington pressure zone covers Sun River as well as the proposed Desert Color master planned community. As shown in Table 5-4, development in this area will utilize all remaining capacity in the East Bloomington Tank and will require an additional storage facility. Based on the results of this analysis, the City should plan to construct a storage tank in Desert Color that is at least 1 MG in volume. The City may elect to make this tank larger if deemed necessary in the future.

Airport Tank

As presented in the discussion of the BAT Tank, it is recommended that the City construct a 4 MG tank in Desert Canyons area to provide additional storage capacity for future growth. Depending on the type of development that eventually comes in around the Airport, the City can re-evaluate demands and add additional storage capacity if needed.

Recommended Storage Improvements through Buildout

The recommended storage improvements for the City through buildout are shown in Table 5-5. The table provides the estimated construction cost in 2018 dollars as well as the recommended construction year. Figure 5-4 provides a map reference for the location of the recommended storage projects.



RECOMMENDED STORAGE IMPROVEMENTS

CITY OF ST. GEORGE

CULINARY WATER MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.

5-4

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 5-4 - Future Storage Tanks.mxd aanderson 12/17/2019

Table 5-5
Recommended Storage Construction Plan through Buildout

Recommended Storage Improvement Project	Project ID	Storage Volume (MG)	Construction Cost per Gallon, 2018 Dollars ($/gallon)	Engineering, Legal, Admin. (15% of Construction Cost)	Construction Date	Estimated Construction Cost to St. George (2018 Dollars)
Warner Valley Tank (WCWCD)	S1	2	$0.90	$270,000	2020	$2,070,000
Gap Zone/Gunlock Zone Valve Improvements	S2	0	NA	$0	2021	$60,000
Northern Gap Tank	S3	3.5	$0.90	$472,500	2021	$3,622,500
Country Club Tank Replacement	S4	2	$0.90	$270,000	2023	$2,070,000
Airport Redevelopment (Tech Ridge) Tank	S5	2	$0.90	$270,000	2025	$2,070,000
Green Tank Replacement	S6	4.5	$0.90	$607,500	2030	$4,657,500
Snow Canyon Tank Expansion	S7	2.2	$0.90	$297,000	2030+	$2,277,000
Bloomington Hills Upper Tank #2 (White Dome Site)	S8	2	$0.90	$270,000	2030+	$2,070,000
Fort Pierce Industrial Tank	S9	1	$0.90	$135,000	2030+	$1,035,000
Desert Color Tank	S10	1	$0.90	$135,000	2030+	$1,035,000
Desert Canyons Tank	S11	2	$0.90	$270,000	2030+	$2,070,000
Warner Valley Tank Expansion (Additional 3 MG)	S12	3	$0.90	$405,000	2030+	$3,105,000
Total[1]		**25.2**		**$2,727,000**		**$20,967,000**

[1]Totals do not include the facilities constructed by WCWCD.

CHAPTER 6
HYDRAULIC MODELING APPROACH

INTRODUCTION

A hydraulic computer model is a valuable tool which allows the user to simulate and evaluate the operation and performance of a water distribution network. Information such as system pressure and pipeline flow velocities can be accurately estimated through the use of a hydraulic computer model. As part of this master plan, the City's existing water model was updated and expanded to provide additional system detail. The model has been calibrated using recent pressure readings at various points in the system. The hydraulic model was developed using Innovyze's InfoWater software which is integrated with Geographic Information System (GIS) technology. The purpose of this chapter is to present a summary of the methodology used to develop, calibrate, and run the hydraulic model.

WATER SYSTEM MODEL

A hydraulic computer model is a digital representation of physical features and characteristics of the water system, including pipes, valves, storage tanks and pumps. Key physical components of a water system are represented by a set of user-defined parameters that represent the characteristics of the system (such as PRV settings or pipe roughness coefficients). Computer model output includes pressures at each model node, flow rate for each pipe in the water system, etc.

The City's existing water system hydraulic model was updated by BC&A for this study using available GIS data in conjunction with historic demand and production data provided by City staff. The model was set up to run a "steady state" simulation and is primarily intended to identify pressure and pipe deficiencies in the distribution system, such as undersized water lines and excessively low/high pressure areas. The steady state model does not track dynamic, time-dependent variables, such as the depth of water in a storage tank throughout the course of a day.

GIS DATA

The GIS data used to update the water system model included:

- Pipeline locations, diameters, and lengths.
- Water system valves, pumps, and water tanks.
- Elevation contours and Digital Elevation Models (DEM)

CALIBRATION

Calibration is the task of adjusting hydraulic model parameters so that model output results correlate with actual observed conditions in the water system. Model calibration was achieved by checking model pressure outputs against field measured pressure readings at a number of locations throughout the system. A few assumptions regarding the calibration of the model are listed below:

- **Pipe Roughness –** Pipe roughness in the distribution system was assigned a Hazen-Williams coefficient of 130.
- **Pipe Size Data –** Pipe diameters and locations in the model were assigned based on the City's GIS data and through communication with City staff.
- **Node Elevation –** Junction elevations in the model were assigned using current DEMs of the City that were created through Lidar survey data collected by Washington County. Nodes that fall outside of the boundary of the County survey were assigned elevations from a USGS 10-meter resolution DEM. While not as accurate as the County Lidar data, this data is adequate for the purpose of modeling the water system in currently undeveloped areas.

MODEL DEMANDS AND DEMAND DISTRIBUTION

A key component in hydraulic modeling is the development of system demands. There are two components to consider when developing the demands for the model: total system demands and distribution of demands. Total system demands are discussed in Chapter 3 of this report. For modeling purposes, the demand scenarios of most concern are those that represent the highest flow demands on the system. These scenarios are peak day demand, peak hour (instantaneous) demand, and peak day demand with a simultaneous fire flow event.

As determined in Chapter 3, a peak day to peak hour demand factor (i.e. the ratio of the peak hour demand on the system to the average demand over the course of the peak day of water usage) of 2.0 has been used for this study. Total model flows for peak day and peak hour demand are shown in Table 6-1.

Table 6-1
Projected Peak Demands

Year	Peak Day Demand (mgd)	Peak Day Demand (gpm)	Peak Hour (Instantaneous) Demand (gpm)
2018	50.7	35,184	70,368
2020	53.6	37,223	74,446
2025	58.8	40,848	81,696
2028	64.1	44,504	89,008
2030	67.9	47,189	94,378
2035	77.8	54,061	108,122

The distribution of system demands was accomplished with the aid of water meter data provided by the City. Metered water use from the month of July 2017 was used to estimate the distribution of peak day demand on the system. Using tools available from the Utah Automated Geographic Reference Center (AGRC), geospatial coordinates were developed using the account addresses in the meter data set, yielding a GIS layer that displays the location and magnitude of water demand throughout the City for the month of July. These meter reads were then used to distribute the total system demand to the various nodes in the model. Future system demands were assigned to the model based on the City's Land Use and Zoning Plan.

CHAPTER 7
TRANSMISSION AND DISTRIBUTION SYSTEM EVALUATION

INTRODUCTION

Transmission and distribution infrastructure is a critical component of the City's water system. Assuring that the water transmission and distribution system is adequately sized and appropriately maintained will help provide reliable service to customers. The City's water transmission and distribution network has been evaluated under existing and projected future conditions using a hydraulic computer model. This chapter documents the results of the hydraulic modeling evaluation and provides recommendations for future projects.

MODEL SCENARIOS

Chapter 6 outlines the methodology and approach to modeling the City's culinary water system. The following model simulations were evaluated for existing conditions:

1. **Static (Winter Nighttime) Demand** – This scenario simulates the maximum pressure experienced by the distribution system, which typically occurs during the winter months at night when storage tanks are full. This simulation identifies locations in the system with potentially high pressure during low demand periods when pipe friction losses are minimal.
2. **Peak Day Demand** – This scenario represents the average demands on the system during the peak water usage day of the year (typically a day in July or August).
3. **Peak Hour Demand** – This scenario represents the peak hour demand on the system during the peak usage day. Peak hour demand is estimated to be 2.0 times greater than peak day demand.
4. **Peak Day Demand with Fire Flow** – This scenario evaluates the ability of the water distribution system to meet fire flow demand during peak day demand. The method used to calculate available fire flow evaluates each model node one at a time (assuming that water for fire suppression is only needed at a single hydrant at a given time).

Future system conditions were modeled under peak day demand and peak hour demand scenarios.

DISTRIBUTION SYSTEM EVALUATION CRITERIA

Utah Administrative Code R309-510 establishes requirements for minimum system pressures in a public water system. The following system pressure criteria were used to evaluate the City's system under existing and future demands conditions:

The water system pressure shall be:

- At least 20 psi during conditions of fire flow and fire demand experienced during peak day demand
- At least 30 psi during peak hour (instantaneous) demand
- At least 40 psi during peak day demand

In addition to avoiding low system pressures, it is also important to prevent the system from reaching undesirably high pressures (occurring during low demand scenarios). The City does have a significant length of “high-pressure” transmission lines which are intended to experience consistently high pressures, with the bigger concern being high pressure on distribution piping. When system pressures frequently exceed 150 psi, service laterals and mains are more prone to leakage and failure. To the extent possible, the City should limit high pressures in the system to reduce the probability of line breaks. High pressure areas do not necessarily represent a system deficiency, but it is important that water operators be aware of areas prone to high pressures.

In addition to these pressure requirements, high head losses in the system should be minimized by maintaining flow velocities to less than 8 feet per second under all flow conditions other than fire flow. Pipes that experience peak flow velocities in excess of 8 fps do not necessarily warrant an immediate replacement but will likely have a shorter service life.

SYSTEM EVALUATION RESULTS

Existing System Evaluation

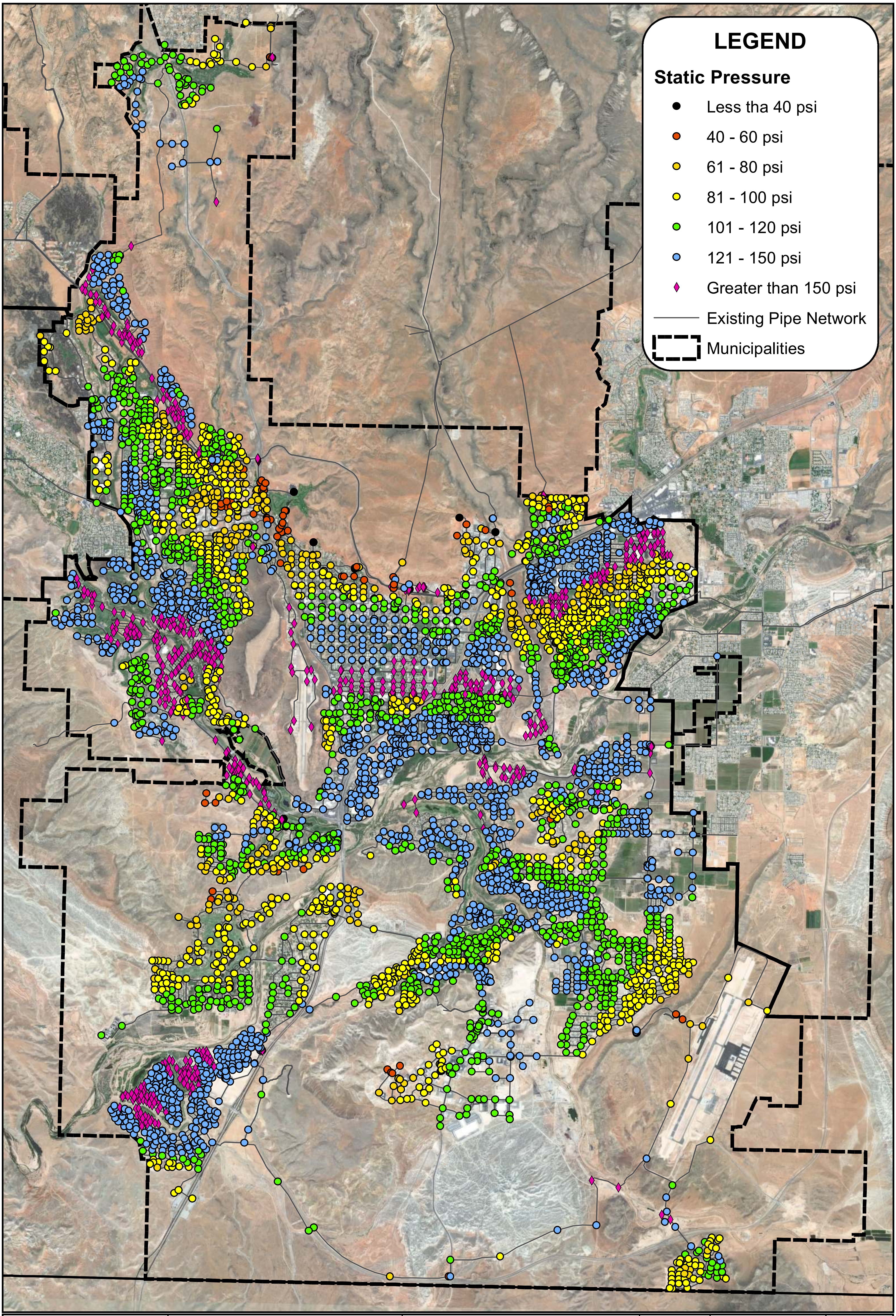
The hydraulic computer model was used to simulate system conditions for the Existing Static Demand, Existing Peak Day Demand, Existing Peak Hour Demand, and Existing Fire Flow with PDD demand scenarios. Model results for these scenarios are discussed below with the following model output figures as a reference:

1. Figure 7-1 shows pressures for the Existing Static Demand Scenario
2. Figure 7-2 shows pressures for the Existing Peak Day Demand Scenario
3. Figure 7-3 shows pressures for the Existing Peak Hour Demand Scenario
4. Figure 7-4 shows the available fire flow in conjunction with Existing Peak Day Demand

Static Demand Scenario (Winter Nighttime Conditions): As shown in Figure 7-1, there are a few areas of the City situated at the low ends of pressure zones that experience high static pressure (above 150 psi). While these areas do not necessarily represent a system deficiency, water system management and operators should be aware of these areas that are regularly subjected to high pressure.

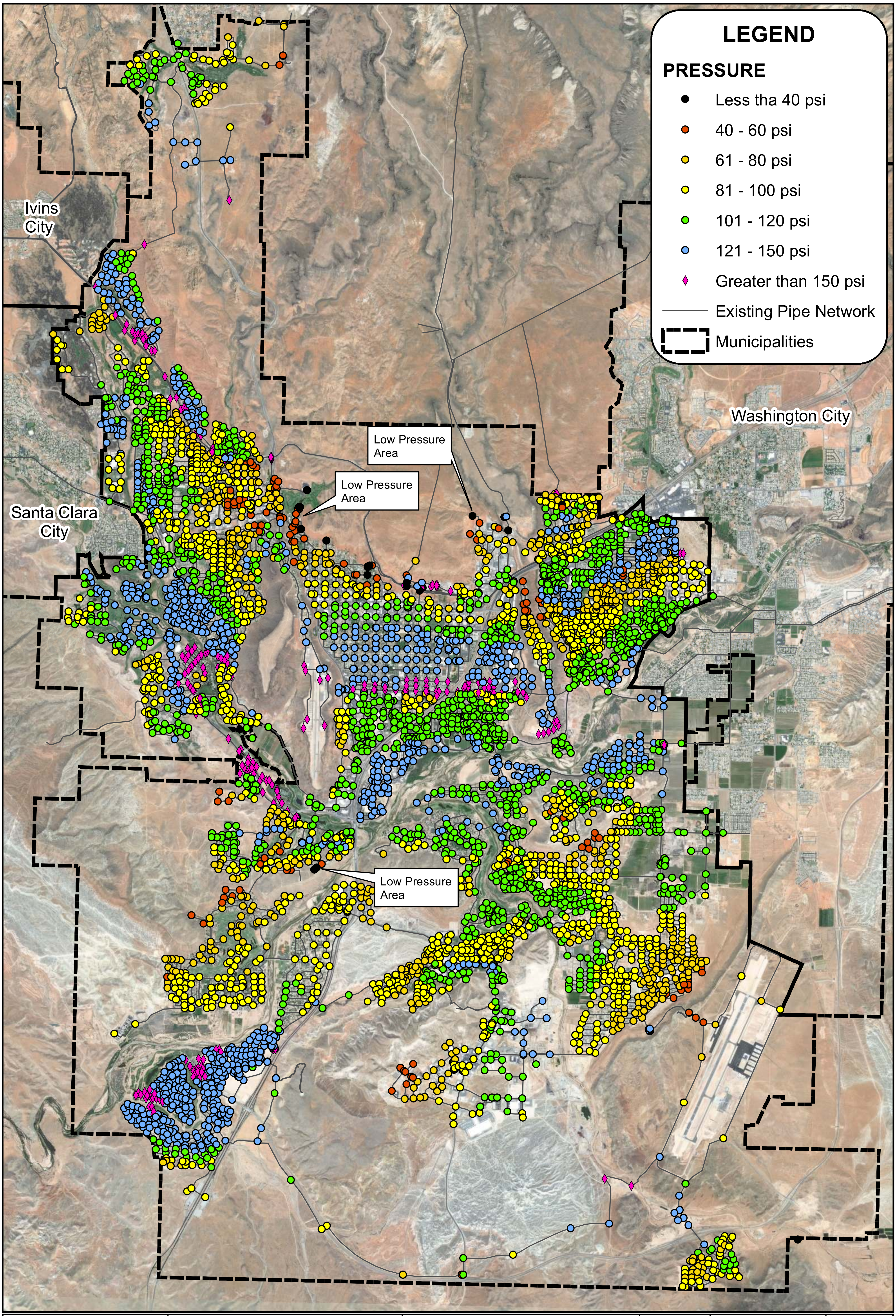
Peak Day Demand Scenario: As shown in Figure 7-2, the vast majority of the City’s water system is capable of meeting peak day demands at the required minimum pressures. There are, however, a few areas that have simulated operating pressures below 40 psi (as indicated in the figure). These low pressures are caused primarily by undersized water lines (6-inch). While it is not recommended that the City immediately replace these lines, the City should plan to replace these lines as other projects occur in the area, such as road resurfacing projects.

Peak Hour Demand Scenario: As shown in Figure 7-3, there are a few isolated areas throughout the City that have simulated peak hour pressures below 30 psi. While some of these areas are the same as those identified as having a peak day demand pressure deficiency, this model simulation identified a few other locations in the City that may experience peak hour pressures below 30 psi. The model results indicate that some areas in the Gap Zone as well as a few isolated areas in Little Valley may experience peak hour pressures below 30 psi. As previously discussed, the pressure



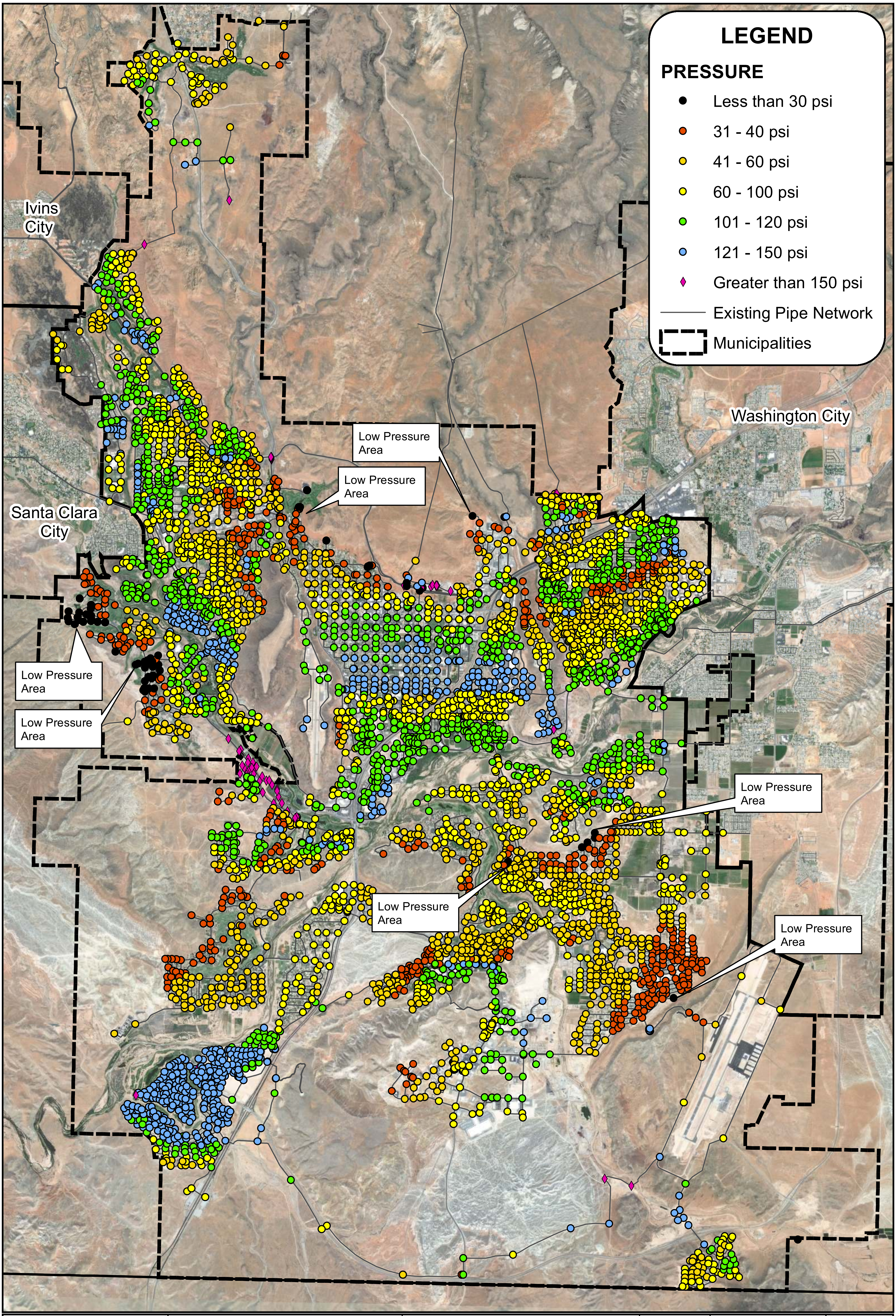
BOWEN COLLINS & ASSOCIATES	CITY OF ST. GEORGE CULINARY WATER MASTER PLAN	EXISTING STATIC PRESSURE	NORTH: NORTH	SCALE: 0 2,500 5,000 Feet	FIGURE NO. 7-1

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 7-1 - Existing Static Demand.mxd aanderson 12/13/2019



BOWEN COLLINS & ASSOCIATES	CITY OF ST. GEORGE CULINARY WATER MASTER PLAN	EXISTING PEAK DAY DEMAND PRESSURE	NORTH:	SCALE: 0 2,500 5,000 Feet	FIGURE NO. 7-2

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 7-2 - Existing PDD Pressures.mxd aanderson 12/13/2019



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

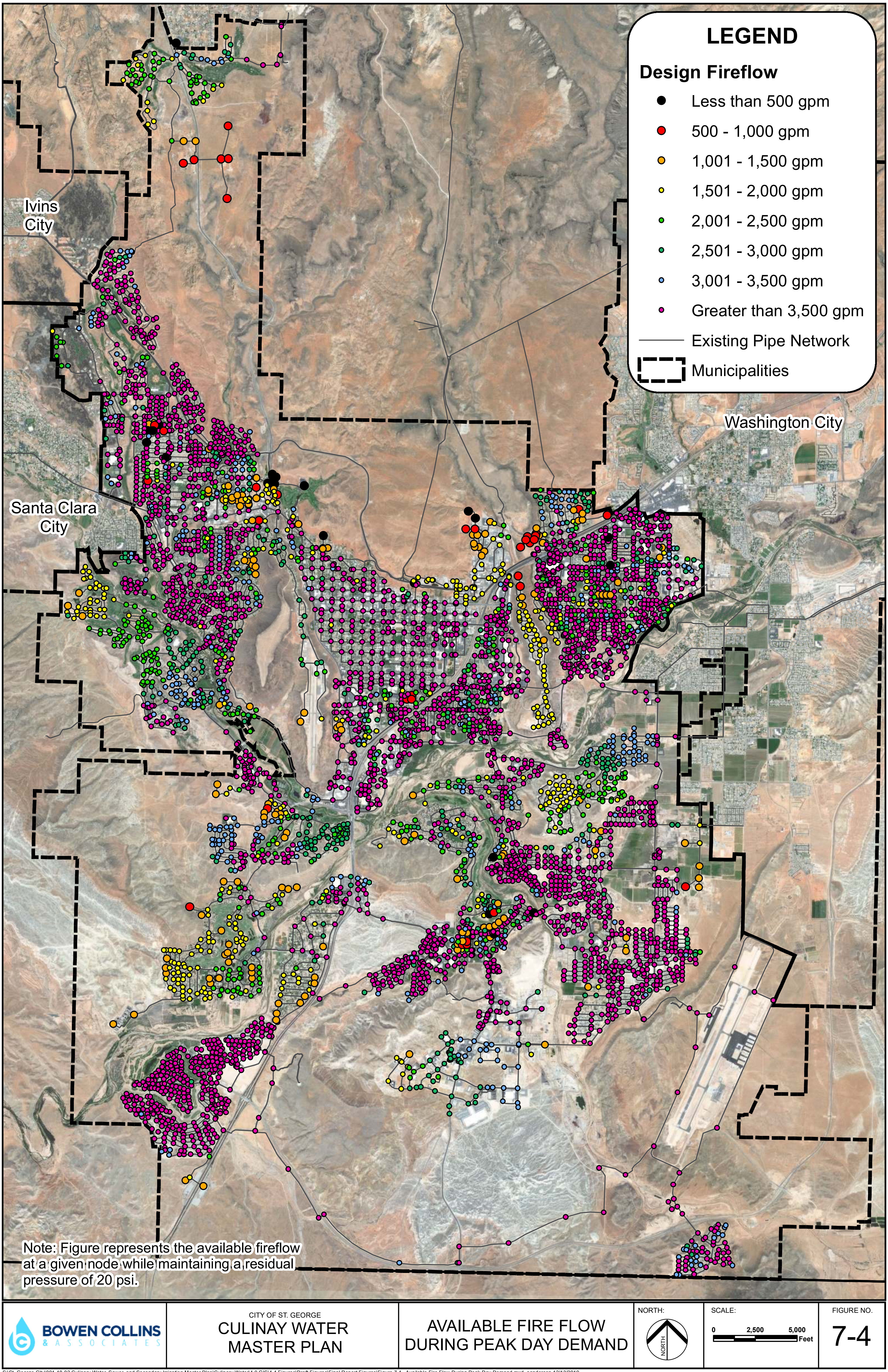
EXISTING PEAK HOUR DEMAND PRESSURE

NORTH:

SCALE: 0 2,500 5,000 Feet

FIGURE NO. 7-3

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Figure 7-3 - Existing PHD Pressures.mxd aanderson 12/13/2019



BOWEN COLLINS & ASSOCIATES	CITY OF ST. GEORGE CULINAY WATER MASTER PLAN	AVAILABLE FIRE FLOW DURING PEAK DAY DEMAND	NORTH:	SCALE:	FIGURE NO. 7-4

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 7-4 - Available Fire Flow During Peak Day Demand.mxd aanderson 12/13/2019 deficiencies shown on the north end of the downtown area should be remediated as the City performs other road/utility projects in the vicinity. The deficiencies simulated in the Gap Zone and Little Valley will be remediated by the recommended improvements outlined later in this chapter.

Peak Day Demand with Fire Flow: Figure 7-4 shows the available fire flow at each model node as calculated by the hydraulic model. The model calculates the available fire flow at a hydrant by iteratively increasing fire flow until the model indicates residual pressure has decreases to 20 psi at either the hydrant being flowed or at another "critical node" in the system. The "critical node" is a location in the system which would limit the ability of a hydrant to produce any additional flow while still meeting the system residual pressure requirement of 20 psi. In essence, the model simulation will produce as much flow as possible at a given hydrant until a) the hydrant reaches 20 psi, or b) another node in the system reaches 20 psi, at which point the hydrant will not produce any more flow. In reality, the system is physically capable of flowing more water than what is shown in Figure 7-4 (if the "critical node" were allowed to approach 0 psi), but this would potentially leave customers without water for the duration of the fire flow event and could cause other issues in the system, and hence is not recommended for this evaluation. For planning purposes, the available fire flow at each area of the system is as shown in Figure 7-4.

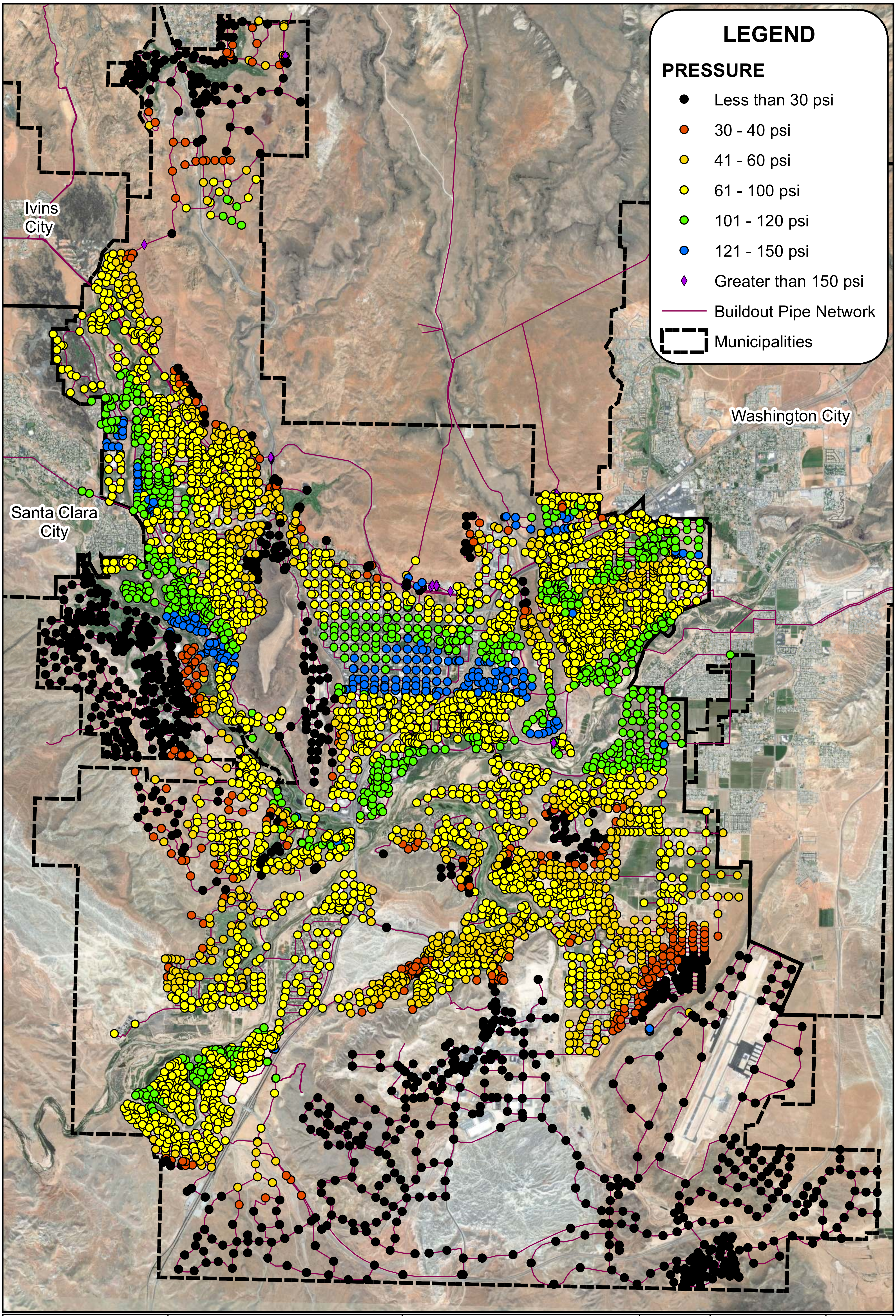
As shown in Figure 7-4, the majority of the service area has adequate fire flow coverage. A few areas of the City do show available fire flows of less than 1,500 gpm (as indicated by a black, red, or orange node in Figure 7-4), which is the required fire flow established by the City. These fire flow deficiencies are primarily caused by undersized waterlines (2-inch, 4-inch and 6-inch lines) and long sections of dead-end pipe. The fire flow capacity of these areas should be increased by upsizing and looping waterlines. The City should plan to coordinate with the local fire flow authority to prioritize needed improvements in these deficient areas are and plan accordingly to make improvements.

System Evaluation through Buildout

A hydraulic model for a "buildout" scenario was developed with the aid of the City's current land use and zoning maps. Buildout demands were added to the model without modifying the size of existing infrastructure, but new lines were added to extend water service to new areas of the system. This was done to identify which parts of the system will require increased capacity by the time the service area is fully built out. The results of the buildout model simulation for future peak hour demands are shown in Figure 7-5 (peak day demand model simulation results provide a similar result). As illustrated in the figure, the existing storage, transmission and distribution system is not able to meet the needs of the future system. In order to determine what improvements will be needed to service the system at buildout, pipes and tanks were added to the model until the system was capable of meeting projected demands. This exercise yielded a list of transmission and distribution improvements which are discussed in the following section.

RECOMMENDED CONVEYANCE SYSTEM IMPROVEMENTS

Based on the results of the hydraulic computer model simulations as well as through coordination with City staff, recommended transmission and distribution system improvements have been identified through build-out. The recommended improvements, along with a "Project ID", are



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

BUILDOUT PEAK HOUR DEMAND PRESSURE WITHOUT IMPROVEMENTS

NORTH: NORTH

SCALE: 0 2,500 5,000 Feet

FIGURE NO. 7-5

shown in Figure 7-6, and the estimated project costs and construction years are shown in Table 7-1. The recommended system improvements shown are for all pipes of 10” diameter or greater. While smaller diameter pipes were included in the model, any pipe under 10” diameter has been assumed to be a project level improvement (funded completely by individual developers). Note that a number of projects in the list are designated as an “upsize” project. For these projects, the developer will be responsible for the installation of an 8-inch pipe (standard minimum size for water distribution system) and the City will pay the cost to “upsize” the line to the diameter identified in this report.

The following is a description of the culinary water conveyance projects identified in Figure 7-6 (not listed in any particular order; projects to be completed within the 10-year planning window are identified in Chapter 8). Fire flow improvements are not included explicitly in the following project descriptions; fire flow deficient areas of the system were identified previously and will be remediated over time following priority established by City management and the local fire authority. Since these improvements are not included specifically in the improvement list, the City will need to make sure funds are budgeted separately for this purpose.

As discussed in previous chapters of this report, water use projections for the industrial areas of the Blooming Hills Upper Zone and the Airport Zone are difficult to project and have been estimated based on historical water use characteristics for industrial and commercial connections. Since water use for industrial/commercial connections varies significantly from one connection to another, projects identified for these areas of the City are highly conceptual. This considered, as development moves forward in these areas, the City should plan to reevaluate and confirm the size and location of the proposed improvements outlined in this report.

Pipeline Projects

C1. City Creek to Ledges Pipeline

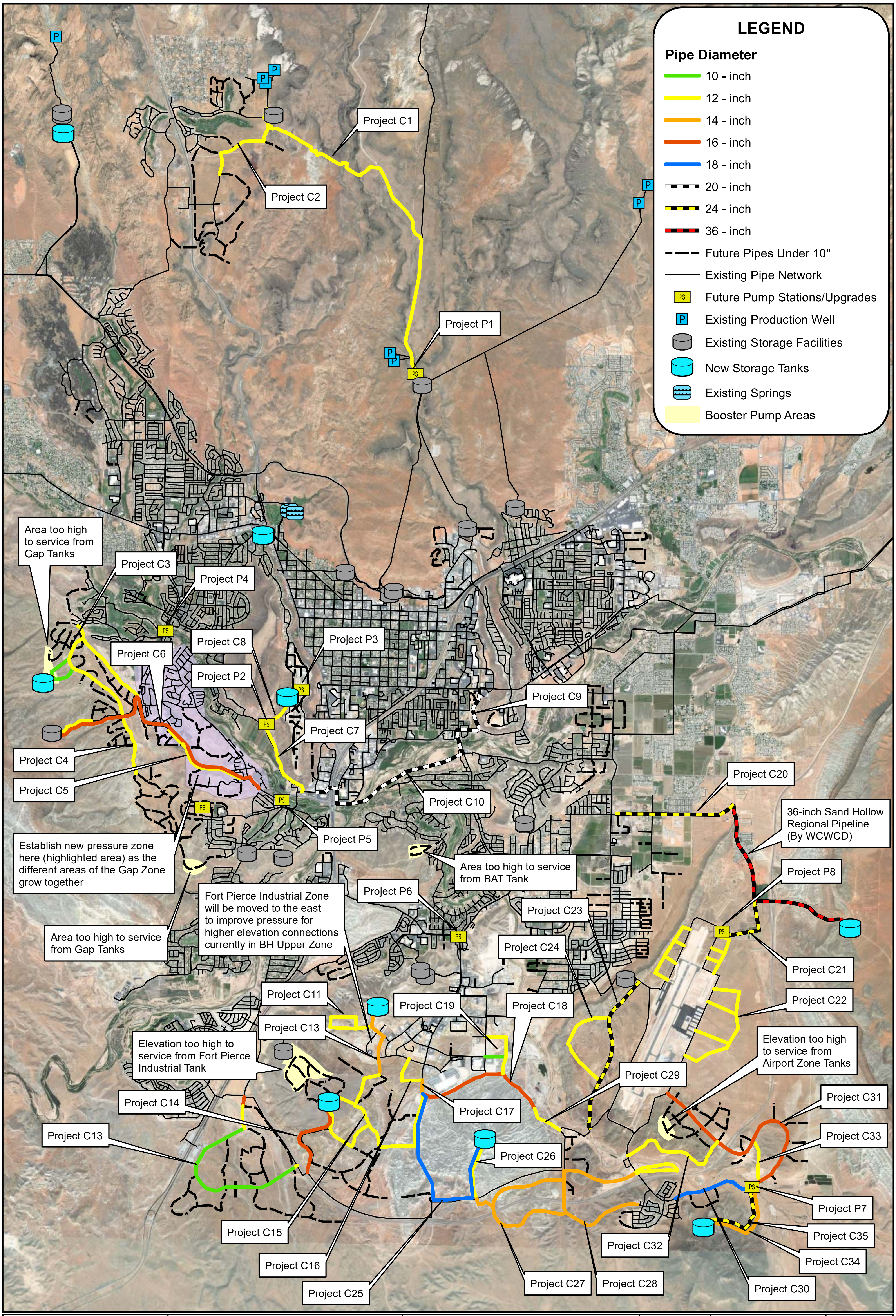
To provide additional source capacity to The Ledges, approximately 25,000 feet of 12-inch pipe will be constructed from the T-Bone Tank to the Ledges Tank. This pipeline will provide the necessary transmission capacity to service The Ledges/Trails through buildout and will provide valuable source redundancy for the system.

C2. The Ledges Main Line

To convey water to new development in the southern region of the The Ledges and Trails, approximately 6,200 feet of 12-inch pipeline will be installed along a future road alignment on the southwest side of The Ledges Golf Course.

C3. The Lakes Northern Loop/New Gap Tank Connection

To develop the backbone of the northern region of The Lakes, a series of pipe projects should be constructed. This project includes the construction of approximately 760 feet of 12-inch pipe from the North Gap Tank down to a 3,500-foot 10-inch loop that connects into a 13,200 foot 12-inch loop which ties into the existing line from the Gap Tank in Canyon View Drive.



BOWEN COLLINS & ASSOCIATES

CITY OF ST. GEORGE
CULINARY WATER MASTER PLAN

RECOMMENDED CONVEYANCE SYSTEM IMPROVEMENTS

NORTH:

SCALE: 0 2,750 5,500 Feet

FIGURE NO. 7-6

S:\St. George City\001-18-02 Culinary Water, Sewer, and Secondary Irrigation Master Plan\Culinary Water\4.0 GIS\4.4 Figures\Draft Figures\Final Report Figures\Figure 7-6 - Recommended Conveyance System Improvements.mxd aanderson 12/16/2019

C4. The Lakes Southwest Connection to Tonaquint

This project includes the construction of 4,200 feet of 12-inch pipe from the distribution line out of the Gap Tank into the undeveloped western region of the Tonaquint area (passing near the existing substation). This project will connect the western region of the Tonaquint area into the Gap Pressure Zone.

C5. Plantation Drive to Dixie Drive

This project involves the installation of 6,000 feet of 12-inch pipe to connect the existing 12-inch pipe on Plantation Drive to the existing 12-inch pipe near Dixie Drive, connecting water service through this currently undeveloped area.

C6. Gap Zone Feed Line

As growth continues in the Gap Zone, particularly in The Lakes and the western area of Tonaquint, additional transmission capacity will be required. To provide additional source capacity into the Gap Zone and the Gap Tanks, 18,100 feet of 18-inch pipe should be installed starting at the existing 20-inch pipe in Dixie Drive and running up Plantation Drive and connecting to the piping below the existing Gap Tank.

C7. Indian Hills Transmission Line

To convey water to the proposed Airport Redevelopment (Tech Ridge), 5,500 feet of 12-inch line will be installed along Indian Hills Drive from Hilton Drive to the proposed Indian Hills Pump Station. This pump station will deliver water to a new storage tank located on Tech Ridge.

C8. Indian Hills to Tech Ridge Transmission Line

This project works in conjunction with Project C7, connecting the proposed Indian Hills Pump Station to the Proposed Tech Ridge Tank. This project includes the construction of approximately 2,700 feet of 12-inch pipe.

C9. Foremaster Ridge Transmission Line Relocation

Currently, a 20-inch transmission line connects the Regional Pipeline into the Regional pressure zone. This line runs through Foremaster Ridge, but does not follow the alignment of Foremaster Road. City staff have indicated that this pipe is in need of replacement, and it is proposed that a new 3,000 foot segment of 20-inch line be installed from Riverside Drive to 700 South along the west side of Foremaster Ridge to replace the existing portion through Foremaster Hill.

C10. Riverside Drive to Hilton Drive Transmission Line

To increase transmission capacity and provide valuable system redundancy from Regional (WCWCD) water supplies to the west side of the City, a new 20-inch transmission line will be installed from the existing 20-inch line in Riverside Drive to Hilton Drive, following the general alignment shown in Figure 7-6. The alignment shown follows the general alignment of the new road/bridge which is planned to connect 1450 South to Dixie Drive. The line installation will include boring underneath I-15 near the Dixie Convention Center and tying into the system at the intersection of Hilton Drive and Blackridge Drive. The alignment shown will require approximately 14,500 feet of pipe.

C11. Fort Pierce Industrial Transmission Loop

To service future development to the west of the Fort Pierce Industrial Zone, this project provides a general alignment for a 12-inch waterline loop through the area. The alignment shown includes approximately 5,800 feet of pipe.

C12. Fort Pierce Industrial Tank Transmission Line

This project involves the installation of 5,000 feet of 14-inch pipe from the proposed Fort Pierce Industrial Upper Tank into the Desert Color development. This line will also provide service to any additional development along the pipe alignment.

C13. Desert Color Southwest Loop

As the backbone of the distribution system through the southwest area of Desert Color, a loop consisting of 16-inch, 12-inch, and 10-inch pipe should be constructed through the development. This loop will connect to the existing transmission line in the Southern Parkway and includes the following approximate pipe lengths:

- **10-inch pipe:** 12,000 feet
- **12-inch pipe:** 1,850 feet
- **16-inch pipe:** 600 feet

C14. Desert Color Tank Feed Line

As development advances in the Desert Color development, additional transmission capacity will be needed into the area. 6,300 feet of 16-inch pipe will be installed from the Southern Parkway to the proposed Desert Color storage tank, connecting the existing transmission line in the Southern Parkway to the proposed tank.

C15. Desert Color Northern Loop

This project involves the construction of the distribution backbone through the northern area of the Desert Color development. It includes approximately 18,500 feet of 12-inch pipe running through the development as shown in Figure 7-6.

C16. Bloomington Hills Upper Zone Loop – Reach 1

To expand service into the Bloomington Hills Upper Zone, additional distribution piping should be installed. This project involves the first reach of the project, running 2,800 feet of 12-inch pipe from Enterprise Drive to South River Road.

C17. Bloomington Hills Upper Zone Loop – Reach 2

The next reach of this loop through the Bloomington Hills Upper Zone includes the installation of about 1,000 feet of 14-inch pipe in South River Road near the Family Dollar Distribution Center.

C18. Bloomington Hills Upper Zone Loop – Reach 3

The third reach of this project includes the installation of 8,700 feet of 16-inch pipe along the north side of White Dome. Like other projects in the Bloomington Hills Upper Zone, the size of future lines is based on current water use projections. If water use trends in the industrial area change, the required infrastructure will need to be resized or otherwise revised.

C19. Bloomington Hills Upper Zone Loop – Reach 4

The last reach of this loop includes the installation of 3,750 feet of 12-inch pipe and 1,400 feet of 10-inch pipe on the east side of the Bloomington Hills Upper Zone near the Fort Pierce Wash.

C20. Sand Hollow Regional Pipeline – Washington Fields Road to 3000 E

As part of the Sand Hollow Regional Pipeline, WCWCD will run a 36" pipeline from the new Warner Valley Tank to the intersection of 4200 S and Washington Fields Road. From this point, the City will construct 8,000 feet of 24-inch pipe to connect the Sand Hollow Regional Pipeline to the St. George system at the intersection of 4200 S and 3000 E.

C21. Sand Hollow Regional Pipeline – Airport Connection

To connect the proposed Sand Hollow Regional Pipeline to the Airport Zone, 4,650 feet of 24-inch pipe will be installed to connect the Regional line to existing pipes near the St. George Airport. This line will feed WCWCD water into new development in the Airport Zone and further west into the White Dome/ Desert Color area via the Southern Parkway.

C22. Airport Vicinity Distribution Piping

This project includes the conceptual distribution piping around the north/east side of the St. George Airport. This conceptual layout includes approximately 25,000 feet of 12-inch pipe running through the undeveloped area around the Airport.

C23. West Airport Transmission Line

This project provides water service and transmission capacity from the Airport Tank to the Airport Zone and East Bloomington Zone (Desert Color). Installing 10,700 feet of 24-inch pipe along the west side of the Airport will provide the needed capacity to service future growth in the southern region of the City.

C24. West Airport Distribution Loop

This project provides a concept-level waterline loop into the far west region of the Airport Zone coming off of the proposed West Airport Transmission Line. As currently laid out, this project will involve the installation of approximately 6,900 feet of 12-inch pipe.

C25. White Dome Tank Transmission Line

As growth occurs in the Bloomington Hills Upper Zone, so will the need for additional storage and transmission capacity. 13,900 feet of 16-inch pipe will run south from the future tank site on White Dome, west along the Southern Parkway, and north on River Road, connecting to the south end of Project C17.

C26. White Dome Feed Line

The proposed White Dome Tank will be fed via the 18-inch line in Southern Parkway. This project consists of installing a 12-inch line from the Southern Parkway to the proposed tank site (approximately 4,000 feet).

C27. Southern Parkway Loop

This project establishes the backbone of the distribution system in the area around the Southern Parkway near White Dome. This project includes the installation of about 13,000 feet of 14-inch pipe connecting and looping the system through this area.

C28. Desert Canyons Reach 1

This project provides the major distribution infrastructure in the southwest region of Desert Canyons, looping the existing piping through the undeveloped area. The project consists of installing approximately 13,000 feet of 14-inch pipe throughout this part of the system

C29. Airport/Bloomington Hills Upper Interconnection

To provide a supplemental connection from the Airport Zone into the Bloomington Hills Upper Zone, a 2,300-foot section of 12-inch pipe and a PRV should be installed between the existing 18-inch Southern Parkway Line and the future Project C18.

C30. Desert Canyons Reach 2

This project connects the existing development in Desert Canyons to the proposed distribution main coming from the proposed Desert Canyons Tank. The project will require approximately 5,200 feet of 18-inch pipe.

C31. Desert Canyons Reach 3

The final reach to loop the Desert Canyons Development consists of installing approximately 15,400 feet of 16-inch pipe from bottom of the Desert Canyons Tank outlet piping (Project C35) to the existing infrastructure at the Airport. This project will complete the water system backbone throughout the east side of Desert Canyons.

C32. Desert Canyons Interconnection 1

This project extends service into additional areas of Desert Canyons, providing additional looping through the system. This project includes connecting 7,700 feet of 12-inch pipe on the north side of Fort Pierce Wash, as well as looping 5,600 feet of 12-inch pipe through the area south of the wash and north of the Southern Parkway.

C33. Desert Canyons Interconnection 2

To provide additional connectivity through the Desert Canyons development, approximately 2,800 feet of 12-inch pipe will be installed in the east side of the development.

C34. Desert Canyons Tank Feed

To provide a feed into the proposed Desert Canyons Tank, a 14-inch fill line should be installed from the proposed Desert Canyons booster pump station to the tank.

C35. Desert Canyons Tank Distribution Line

To provide flow capacity out of the proposed Desert Canyons Tank, 6,000 feet of 24-inch pipe will be constructed from the tank to the connection point below in the Desert Canyons distribution system.

Pump Station Projects

P1. City Creek to Ledges Pump Station

This pump station, constructed near the existing T-Bone Tank, will provide up to 1,800 gpm of pumping capacity from the T-Bone Tank to the Ledges Tank.

P2. Indian Hills Pump Station

The Indian Hills Pump Station will deliver up to 2,500 gpm from Indian Hills Drive to the Tech Ridge area to the east.

P3. Airport Redevelopment (Tech Ridge) Pump Station

Due to limitations for storage tank locations to service Tech Ridge, a storage tank is proposed to be constructed at grade or below grade on the hilltop. This booster pump will then deliver water from the tank to the distribution system. The pump will be equipped to deliver up to 5,000 gpm.

P4. Dixie Drive Pump Station – Gunlock 1A to Gap Zone

With the completion of the Gunlock Arsenic Treatment Plant, additional source capacity will become available for the west side of the City. To convey water from Gunlock into the Gap Zone, it is recommended that a 1,000 gpm pump station be constructed on Dixie Drive near Mathis Bridge over the Santa Clara River (at the boundary between the Gunlock 1A and Gap Zones). This pump will operate in conjunction with an automated valve, sending water into the Gap Zone during high demand periods and remaining closed during low demand periods.

P5. Upgrade to Tonaquint Pump Station

In order to increase pumping capacity from the Regional Zone into the Gap Zone, the Tonaquint Pump Station should be upgraded with 2 additional pumps (total of 4 duty, 1 reserve) for a total capacity of 5,300 gpm.

P6. Upgrade Bloomington Hills Pump Station

To meet future system demands in the Bloomington Hills Upper Zone, the pump station on Brigham Road should be upgraded to include an additional pump. As stated previously, many improvements related to servicing the Bloomington Hills Upper Zone are subject to change based on the type of manufacturing or commercial development that comes into the City.

P7. Desert Canyon Pump Station

In order to fill the proposed Desert Canyon Tank, a pump station will be required. The booster pump should be capable of pumping up to 2,800 gpm.

P8. North Airport Pump Station

As demand out of the Warner Valley Tank via the Sand Hollow Pipeline increases in the future, increased head loss in the system is expected to limit the Warner Valley Tank's ability to fill the Airport Tank and deliver adequate pressure into the Airport and East Bloomington Pressure Zones. As usage in the Sand Hollow Regional Pipeline increases, a pump station will be needed to boost pressure from the pipeline into the Airport/East Bloomington Zones. Current water use projections at buildout would suggest that this pump station would need a capacity of over 15,000 gpm.

However, because of the high level of uncertainty surrounding future demands in the Airport Zone, it is recommended that the City include a 5,000 gpm pumping facility in this master plan, understanding that the size of the facility will be refined as development matures in the Airport Pressure Zone.

ESTIMATED COST OF CONVEYANCE PROJECTS

Table 7-1 provides a comprehensive summary of all recommended conveyance system improvements along with the estimated construction cost (in 2018 dollars). This list represents the recommended transmission, distribution, and pumping projects through projected buildout of the City.

Table 7-1
Recommended Conveyance System Improvements

Pipeline Projections					
Project ID	**Project Description**	**Length (ft)**	**$/foot**	**Engineering, Admin, etc. (15% of Construction Cost)**	**Total Estimated Cost (2018 Dollars)**
C1	City Creek to Ledges Pipeline - 12" Pipeline	25,000	$95	$356,250	$2,731,300
C2	Ledges Main Line - 12" Pipeline (Upsize)	6,200	$70	$65,100	$499,100
C3	The Lake North Loop - 10", 12" Pipeline (Upsize)	17,460	$70	$183,330	$1,405,500
C4	The Lakes SW Connection to Tonaquint - 12" Pipeline (Upsize)	4,200	$70	$44,100	$338,100
C5	Plantations to Dixie Drive - 12" Pipeline (Upsize)	6,000	$105	$94,500	$724,500
C6	Gap Tank Feed Line - 18" Pipeline	18,100	$215	$583,725	$4,475,200
C7	Indian Hills Transmission Line - 12" Pipeline (Upsize)	5,500	$95	$78,375	$600,900
C8	Indian Hills/Airport Redevelopment Transmission Line - 12" Pipeline (Upsize)	2,700	$95	$38,475	$295,000
C9	Foremaster Ridge Transmission Line Relocation - 20" Pipeline	3,000	$210	$94,500	$724,500
C10	Riverside Drive to Hilton Drive Transmission Line - 20" Pipeline	14,500	$230	$500,250	$3,835,300
C11	Fort Pierce Industrial Transmission Loop - 12" Pipeline (Upsize)	5,800	$70	$60,900	$466,900
C12	Fort Pierce Industrial Tank Transmission Line - 14" Pipeline (Upsize)	5,000	$80	$60,000	$460,000
C13	Desert Color Southwest Loop - 10", 12", 16" Pipeline (Upsize)	14,450	$90	$195,075	$1,495,600
C14	Desert Color Tank Feed Line - 12" Pipeline	6,300	$130	$122,850	$941,900
C15	Desert Color Northern Loop - 12" Pipeline (Upsize)	18,500	$70	$194,250	$1,489,300
C16	Bloomington Hills Upper Zone Loop (Reach 1) - 12" Pipeline (Upsize)	2,800	$70	$29,400	$225,400
C17	Bloomington Hills Upper Zone Loop (Reach 2) - 14" Pipeline (Upsize)	1,000	$80	$12,000	$92,000
C18	Bloomington Hills Upper Zone Loop (Reach 3) - 16" Pipeline (Upsize)	8,700	$95	$123,975	$950,500
C19	Bloomington Hills Upper Zone Loop (Reach 4) - 12" Pipeline (Upsize)	3,750	$70	$39,375	$301,900
C20	Sand Hollow Regional Pipeline - Washington Fields Road to 3000 E - 24" Pipeline	8,000	$235	$282,000	$2,162,000
C21	Sand Hollow Regional Pipeline - Airport Connection - 24" Pipeline	4,650	$235	$163,910	$1,256,700
C22	Airport Vicinity Distribution Piping - 12" Pipeline (Upsize)	25,000	$70	$262,500	$2,012,500
C23	West Airport Transmission Line - 24" Pipeline	10,700	$235	$377,175	$2,891,700
C24	West Airport Distribution Loop - 12" Pipeline (Upsize)	6,900	$70	$72,450	$555,500
C25	White Dome Tank Transmission Line - 18" Pipeline	13,900	$195	$406,575	$3,117,100
C26	White Dome Feed Line - 12" Pipeline	4,000	$130	$78,000	$598,000
C27	Southern Parkway Loop - 14" Pipeline (Upsize)	13,000	$80	$156,000	$1,196,000
C28	Desert Canyons Reach 1 - 14" Pipeline (Upsize)	13,000	$80	$156,000	$1,196,000
C29	Airprort/Bloomington Hills Upper PRV Interconnection - 12" Pipeline & PRV	2,300	$140	$48,300	$370,300
C30	Desert Canyons Reach 2- 18" Pipeline	5,200	$185	$144,300	$1,106,300
C31	Desert Canyons Reach 3 - 16" Pipeline	15,400	$175	$404,250	$3,099,300
C32	Desert Canyons Interconnection 1 - 12" Pipeline (Upsize)	13,300	$70	$139,650	$1,070,700
C33	Desert Canyons Interconnection 2 - 12" Pipeline (Upsize)	2,800	$70	$29,400	$225,400
C34	Desert Canyons Tank Feed - 14" Pipeline	6,000	$145	$130,500	$1,000,500
C35	Desert Canyons Tank Distribution Line - 24" Pipeline	6,000	$210	$189,000	$1,449,000
			TOTAL	**$5,916,440**	**$45,359,900**
Pumping Improvements					
Project ID	**Project Description**	**Capacity (gpm)**	**$/hp**	**Engineering, Admin, etc. (15% of Construction Cost)**	**Total Estimated Cost (2018 Dollars)**
P1	City Creek to Ledge Pump Station (~375 hp)	1,800	$3,000	$168,750	$1,293,750
P2	Indian Hills Pump Station (~200 hp)	2,500	$3,000	$105,000	$805,000
P3	Airport Redevelopment Pump Station (~320 hp)	5,000	$3,000	$144,000	$1,104,000
P4	Dixie Drive Pump Station (Gunlock 1A to Gap Zone) (~90 hp)	1,000	$1,670	$22,500	$172,500
P5	Tonaquint Pump Station Upgrade (~150 hp each pump)	2,650	$1,100	$49,500	$379,500
P6	Bloomington Hills Pump Station Upgrade (~90 hp)	1,000	$1,200	$16,200	$124,200
P7	Desert Canyons Pump Station (~230 hp)	2800	$3,000	$103,500	$793,500
P8	North Airport Pump Station[1]	5,000	$3,000	$144,000	$1,104,000
			TOTAL	**$753,450**	**$5,776,450**
			GRAND TOTAL	***$6,669,890***	***$51,136,350***

[1]See project description. Size of pump station to be refined as development matures in the Airport Pressure Zone.

CHAPTER 8
CAPITAL FACILITIES PLAN

A Capital Facilities Plan (CFP) has been developed to serve as a guideline for the budgeting and implementation of recommended system improvements over the next 10 years. The purpose of this chapter is to present recommendations regarding levels of funding for system maintenance, renewal, and capital improvement projects.

RECOMMENDED CAPITAL IMPROVEMENT BUDGET

Before establishing a 10-year Capital Facilities Plan, it is important to determine how much funding should be set aside each year for capital improvements. One of the best ways to identify a recommended level of funding is to consider the estimated service life of the system. As with all utilities, each component of a water system has a finite service life. If adequate funds are not set aside for regular system renewal, the water system has the potential to fall into a state of disrepair and be incapable of providing the level of service that the City's customers have come to expect. To determine the target level of yearly spending on the system, the replacement value of the current system was estimated using current construction cost estimates. The results of the analysis are shown in Table 8-1. The total cost to replace all City pipelines, sources, storage tanks, and pump stations is estimated to be approximately $669 million based on current construction costs.

Individual components of the water system have a different expected service life. When installed correctly, waterlines can last upward of 60 years, while other system components such as pumps and other equipment will have a much shorter life span. Taking this into account, Table 8-2 presents the ideal level of annual funding which should be invested into each component of the system. In essence, these values represent how much annual funding should either be invested in the system or set aside to be invested at a later date.

Table 8-1
Estimated Replacement Value of Existing City of St. George Water System

System Component	Quantity	Unit Replacement Price	Estimated Replacement Value
Transmission/Distribution Pipes	***Length (ft)***	***$/lf***	
2-inch[1]	9,123	$145	$1,322,797
3-inch[1]	2,563	$145	$371,571
4-inch[1]	73,949	$145	$10,722,565
6-inch[1]	929,328	$145	$134,752,513
8-inch	1,572,636	$145	$228,032,249
10-inch	257,518	$155	$39,915,312
12-inch	296,447	$165	$48,913,703
14-inch	61,107	$175	$10,693,780
16-inch	161,282	$185	$29,837,258
18-inch	173,729	$195	$33,877,094
20-inch	116,550	$210	$24,475,439
24-inch	29,389	$235	$6,906,427
30-inch	20,251	$290	$5,872,793
34-inch	124	$350	$43,500
36-inch	33,272	$370	$12,310,653
		Subtotal	**$588,048,000**
Sources	***Capacity (gpm)***	***$/gpm***	
Mountain Springs	1050	$200	$210,000
West City Springs	400	$200	$80,000
City Creek #1	1,200	$1,000	$1,200,000
City Creek #2*	1,000	$1,000	$1,000,000
Gunlock #1	1,000	$1,000	$1,000,000
Gunlock #2	600	$1,000	$600,000
Gunlock #3	750	$1,000	$750,000
Gunlock #4	1,250	$1,000	$1,250,000
Gunlock #5	900	$1,000	$900,000
Gunlock #6	300	$1,000	$300,000
Gunlock #7	700	$1,000	$700,000
Gunlock #8	1,100	$1,000	$1,100,000
Gunlock#9	700	$1,000	$700,000
Gunlock #10	800	$1,000	$800,000
Gunlock #11	600	$1,000	$600,000
Ledges	750	$1,000	$750,000
Millcreek #1	800	$1,000	$800,000
Millcreek #2	700	$1,000	$700,000
Snow Canyon #2	600	$1,000	$600,000
Snow Canyon #3	400	$1,000	$400,000
Snow Canyon #3A	400	$1,000	$400,000
Snow Canyon #4	500	$1,000	$500,000
Snow Canyon #5	150	$1,000	$150,000
Tolman #3	200	$1,000	$200,000
Tolman #4	350	$1,000	$350,000
		Subtotal	**$16,040,000**
Storage Facilities	***Volume (MG)***	***$/gallon***	
Airport Tank	2	$1.00	$2,000,000
B.A.T	5.1	$1.00	$5,100,000
B.H. Upper	2.2	$1.00	$2,200,000
Cement	1.1	$1.00	$1,100,000
Country Club	0.9	$1.00	$900,000
East Bloomington	4	$1.00	$4,000,000
Gap	1.9	$1.00	$1,900,000
Green	1.6	$1.00	$1,600,000
Gunlock	3	$1.00	$3,000,000
Industrial	2	$1.00	$2,000,000
Ledges	3	$1.00	$3,000,000
Main St.	1.9	$1.00	$1,900,000
Middleton	2.2	$1.00	$2,200,000
New Stonecliff	0.3	$1.00	$300,000
Quail Creek WTP	10	$1.00	$10,000,000
Skyline	0.5	$1.00	$500,000
Snow Canyon #1	1.8	$1.00	$1,800,000
Snow Canyon #2	1.8	$1.00	$1,800,000
Southgate	0.9	$1.00	$900,000
Stonecliff	0.3	$1.00	$300,000
T-Bone	3	$1.00	$3,000,000
		Subtotal	**$49,500,000**
Booster Pump Stations	Capacity (gpm)	$/gpm	
West City Springs	700	$300.00	$210,000
Skyline	10,000	$300.00	$3,000,000
Industrial	1,500	$300.00	$450,000
Tonaquint	3,000	$300.00	$900,000
Southgate	1,600	$300.00	$480,000
Brigham Road	2,400	$300.00	$720,000
Little Valley	9,500	$300.00	$2,850,000
East Ridge	4,800	$300.00	$1,440,000
Mall Drive	8,000	$300.00	$2,400,000
Stone Cliff Lower	250	$300.00	$75,000
Green Tank Booster	500	$300.00	$150,000
Stone Cliff Upper	1,500	$300.00	$450,000
Fort Pierce Industrial	1,500	$300.00	$450,000
Airport	1,700	$300.00	$510,000
East Bloomington	1,750	$300.00	$525,000
		Subtotal	**$14,610,000**
		GRAND TOTAL	**$668,198,000**

[1]Since 6-inch and smaller pipes would be replaced with 8-inch pipes, the replacement value for these pipes is shown with the unit cost for 8-inch pipe.

Table 8-2
Recommended Annual Water System Budget

System Component	Estimated Service Life	Estimated Replacement Cost	Recommended Annual Budget[1]
Transmission/Distribution Waterlines	60 Years	$588,048,000	$9,800,800
Sources (Wells & Springs)[2]	60 years	$16,040,000	$267,300
Storage Facilities	60 years	$49,500,000	$825,000
Booster Pump Stations	40 years	$14,610,000	$365,200
TOTAL		**$668,198,000**	**$11,258,300**

[1]Calculated by dividing the total estimated replacement cost by the estimated service life of the facility.
[2]Wells and springs are composed of different components, each with a variable service life. The service life shown in the table is the estimated overall service life of the facility (i.e. pumps will last for a shorter period of time while the source itself will last for a longer period of time before requiring rehabilitation or replacement).

As shown in Table 8-2, the ideal level of annual system funding is about $11.3 million, which equates to about 1.75% of the total estimated system replacement value. However, because the City has a large portion of relatively new infrastructure, an $11.3 million annual funding level may be excessive at this point in time. However, the City should set an adequate budget which allows money to be set aside for future system replacement and rehabilitation. Based on this, BC&A recommends that the City aim for an annual funding level of 1.3% - 1.4% of the total system replacement value, which is about $8.7 - $9.3 million dollars per year (in today's dollars). This value is expected to increase in the future due to the effects of inflation.

10-YEAR CAPITAL FACILTIES PLAN

Based on the City's identified project needs and recommended level of capital investment, BC&A has developed a Capital Facilities Plan covering the next 10 years. Table 8-3 provides a detailed outlay of the recommended projects to be completed in the next 10 years. The projects included in the CFP are those projects that are anticipated to be needed within the next 10 years based on the estimated distribution of future growth in the City. If growth patterns deviate from what was assumed in this report, the CFP should be revised and updated to meet the City's needs.

Table 8-3
City of St. George 10-Year Water System Capital Facilities Plan - Water[1]

Project Identifier	Project Description	Estimated Total Cost (2018 Dollars)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total Inflated Project Cost
W1	Homestead Well Development	$1,000,000				$1,082,000							$1,082,000
S1	Warner Valley Tank (No Cost to St. George)	$0											$0
S2	Gap Zone/Gunlock Zone Valve Improvements	$60,000			$64,000								$64,000
S3	Northern Gap Tank	$3,622,500			$3,844,000								$3,844,000
S4	Country Club Tank Replacement	$2,070,000					$2,241,000						$2,241,000
S5	Airport Redevelopment (Tech Ridge) Tank	$2,070,000							$2,378,000				$2,378,000
C1	City Creek to Ledges Pipeline	$2,731,300		$2,842,000									$2,842,000
C2	Ledges Main Line	$499,100		$519,000									$519,000
C3	The Lakes North Loop	$1,405,500			$1,492,000								$1,492,000
C6	Plantations Drive to Dixie Drive Waterline	$724,500							$832,000				$832,000
C7	Gap Tank Feed Line	$4,475,200						$5,040,000					$5,040,000
C8	Indian Hills Transmission Line	$600,900									$718,000		$718,000
C9	Indian Hills/Airport Redevelopment (Tech Ridge) Transmission Line	$295,000									$353,000		$353,000
C10	Foremaster Ridge Transmission Line Relocation	$724,500					$800,000						$800,000
C11	Riverside to Hilton Drive Transmission Line	$3,835,300								$4,494,000			$4,494,000
C14	Desert Color Southwest Loop	$1,495,600			$1,587,000								$1,587,000
C21	Sand Hollow Regional Pipeline - Washington Fields Road to 3000 E	$2,162,000			$2,294,000								$2,294,000
C22	Sand Hollow Regional Pipeline - Airport Connection	$1,256,700		$1,307,000									$1,307,000
C28	Southern Parkway Loop - 14" Pipeline	$1,196,000							$1,374,000				$1,374,000
C29	Desert Canyons Reach 1	$1,196,000				$1,295,000							$1,295,000
P1	City Creek to Ledges Pump Station	$1,293,750		$1,346,000									$1,346,000
P2	Indian Hills Pump Station	$805,000								$943,000			$943,000
P3	Airport Redevelopment (Tech Ridge) Pump Station	$1,104,000									$1,319,000		$1,319,000
P4	Dixie Drive Pump Station - Gunlock 1A to Gap Zone	$172,500			$183,000								$183,000
P6	Bloomington Hills Pump Station Upgrade	$124,200	$127,000										$127,000
	Total Improvements	**$34,919,550**	**$127,000**	**$6,014,000**	**$9,464,000**	**$2,377,000**	**$3,041,000**	**$5,040,000**	**$4,584,000**	**$5,437,000**	**$2,390,000**	**$0**	**$38,474,000**

[1]A 2% annual inflation rate has been applied to estimated future projects costs.

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