CITY OF
MOAB
UTAH

WATER DISTRIBUTION AND STORAGE MASTER PLAN

(HAL Project No.: 380.09.100)

FINAL REPORT (UPDATED)

SEPTEMBER 2020

HANSEN ALLEN & LUCE INC
ENGINEERS

CITY OF MOAB

WATER DISTRIBUTION AND STORAGE MASTER PLAN

(HAL Project No.: 380.09.100)

Sept 29, 2020

PROFESSIONAL ENGINEER
No. 318761-2202
BENJAMIN D.
MINER
STATE OF UTAH

Benjamin D. Miner, P.E.
Project Engineer

HANSEN ALLEN & LUCE inc
ENGINEERS

September 2020

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ACKNOWLEDGMENTS

Successful completion of this study was made possible by the cooperation and assistance of many individuals, including the Mayor of the City of Moab, City Council Members, City Staff, and the Hansen, Allen & Luce project team as shown below. We sincerely appreciate the cooperation and assistance provided by these individuals.

City

Mayor

Emily Niehaus

City Council

Rani Derasary
Mike Duncan
Karen Guzman-Newton
Kalen Jones
Tawny Knuteson-Boyd

City Staff

Chuck Williams, City Engineer
Mark Jolissaint, Assistant City Engineer
Levi Jones, Water Superintendent

Hansen, Allen & Luce Project Team

Steven C. Jones, P.E. (Principal in Charge)
Benjamin D. Miner, P.E. (Project Manager/Project Engineer)

GLOSSARY OF TECHNICAL TERMS

Average Daily Flow: The average yearly demand volume expressed in a flow rate.

Average Yearly Demand: The volume of water used during an entire year.

Build-out: When the development density reaches maximum allowed by planned development.

Demand: Required water flow rate or volume.

Distribution System: The network of pipes, valves and appurtenances contained within a water system.

Drinking Water: Water of sufficient quality for human consumption. Also referred to as Culinary or Potable water.

Dynamic Pressure: The pressure exerted by water within the pipelines and other water system appurtenances when water is flowing through the system.

Equivalent Residential Connection: A measure used in comparing water demand from non-residential connections to residential connections.

Fire Flow Requirements: The rate of water delivery required to extinguish a particular fire. Usually it is given in rate of flow (gallons per minute) for a specific period of time (hours).

Head: A measure of the pressure in a distribution system that is exerted by the water. Head represents the height of the free water surface (or pressure reduction valve setting) above any point in the hydraulic system.

Head Loss: The amount of pressure lost in a distribution system under dynamic conditions due to the wall roughness and other physical characteristics of pipes in the system.

Peak Day: The day(s) of the year in which a maximum amount of water is used in a 24-hour period.

Peak Day Demand: The average daily flow required to meet the needs imposed on a water system during the peak day(s) of the year.

Peak Instantaneous Demand: The flow required to meet the needs imposed on a water system during maximum flow on a peak day.

Pressure Reducing Valve (PRV): A valve used to reduce excessive pressure in a water distribution system.

Pressure Zone: The area within a distribution system in which water pressure is maintained within specified limits.

Service Area: Typically, the area within the boundaries of the entity or entities that participate in the ownership, planning, design, construction, operation and maintenance of a water system.

Static Pressure: The pressure exerted by water within the pipelines and other water system appurtenances when water is not flowing through the system, i.e., during periods of little or no water use.

Storage Reservoir: A facility used to store, contain and protect drinking water until it is needed by the customers of a water system. Also referred to as a Storage Tank.

Transmission Pipeline: A pipeline that transfers water from a source to a reservoir or from a reservoir to a distribution system.

Water Conservation: Planned management of water to prevent waste.

ABBREVIATIONS

ac	acre
ac-ft	acre-feet
DDW	The State of Utah Division of Drinking Water
ERC	Equivalent Residential Connection
GIS	Geographic Information System
gpd	Gallons per Day
gpd/conn	Gallons per Day per Connection
gpm	Gallons per Minute
HAL	Hansen, Allen & Luce, Inc.
MG	Million Gallons
PRV	Pressure Reducing Valve
psi	Pounds per Square Inch
SCADA	Supervisory Control And Data Acquisition

CHAPTER 1 - INTRODUCTION

PURPOSE

The purpose of this master plan is to provide guidance to the City of Moab for decisions that will be made over the next 5 to 40 years in order to help the City provide adequate water to customers at a reasonable cost. Recommendations are based on City drinking water demand data and standards established by the Utah Division of Drinking Water (DDW).

SCOPE

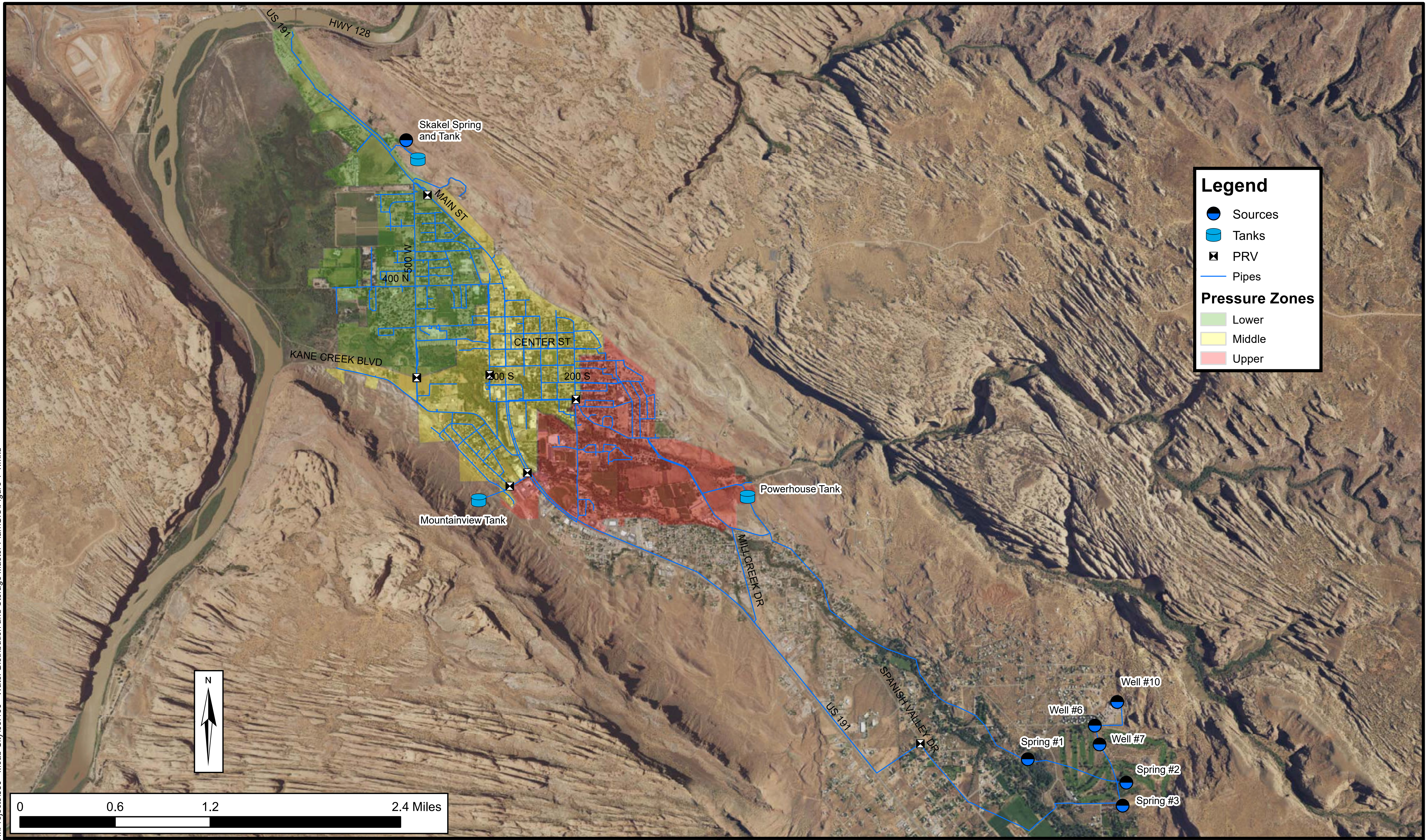
The scope of this master plan includes a study of the City's drinking water system and customer water use including: source production, storage volume, distribution system, energy use, water quality, and 2060 growth projections. From this study of the water system, an implementation plan with recommended improvements was prepared. The implementation plan includes conceptual level cost estimates and a recommended schedule.

The conclusions and recommendations of this study are limited by the accuracy of the development projections and other assumptions used in preparing the study. It is expected that the City will review and update this master plan about every 5 years as new information about development, system performance, or water use becomes available.

BACKGROUND

The City of Moab is located near the southern edge of Grand County in eastern Utah and is bounded on the north and west by the Colorado River. Settlement of Moab began around 1880 and Moab was incorporated as a town in 1902. Historically, mining was the dominant industry within the local economy. However, over the years Moab has experienced several economic cycles related to the changing demand for locally produced minerals. During the 1970's, tourism was identified as a potential growth opportunity that could reduce Moab's reliance on mining jobs. Since that time, Moab's popularity as a tourist destination has grown rapidly. As of 2017, it is estimated that over a million people visit Moab every year and tourism is now the dominant economic force. The U.S. Census Bureau estimated Moab's 2016 population to be 5,242.

The Moab water system contains about 52 miles of distribution pipes ranging in size from 4 to 21 inches in diameter. The City's water delivery network is comprised of three pressure zones. Throughout this report, the three zones will be referred to as the Lower, Middle, and Upper Zones, with the names corresponding to the relative elevations served by each pressure zone. In general, the topography in Moab slopes toward the Colorado River. Therefore, the Lower Zone is on the northwest side of the City, closest to the Colorado River, with the progressively higher Middle and Upper Zones located to the southeast. Figure 1-1 illustrates the extent of the Moab drinking water system and shows the locations of the pressure zones.



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EXISTING MOAB WATER DISTRIBUTION SYSTEM

FIGURE
1-1

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WATER SYSTEM MASTER PLANNING APPROACH

The Moab water distribution network is made up of a variety of components including pumps, storage facilities, valves, and pipes. The City water system must be capable of responding to daily and seasonal variations in demand, while concurrently providing adequate capacity for firefighting and other emergency needs. In order to meet these goals, each of the distribution system components must be designed and operated with these uses in mind. Furthermore, planning is required in order to ensure that the distribution system will be capable of meeting the City's needs over the next several decades.

Present and future needs were evaluated in preparation of this master plan. Present water needs were calculated according to Utah Division of Drinking Water (DDW) requirements and compared with actual water use records obtained from billing records and production data. Future water use projections were calculated by reviewing existing water use patterns for various land uses in Moab. Based on these existing water use patterns, future use was projected based on growth projections and planned future land use.

In order to facilitate the analysis of the Moab water system, a computer model of the system was prepared and analyzed in two parts. First, the performance of existing facilities with current water demands was analyzed. Next, projected future demands were input to the model and the analysis was repeated. Recommendations for system improvements were prepared based on the results of these analyses. In general, this report is organized to follow the DDW requirements found in section {R309-510 U.A.C.} entitled “Minimum Sizing Requirements”.

KEY SYSTEM DESIGN CRITERIA AND PERFORMANCE FINDINGS

Summaries of the key water system design criteria and performance findings for the Moab drinking water system are included in Table 1-1. These design criteria were used in evaluating system performance and in recommending future water system improvements. Criteria development is described in later chapters.

Table 1-2 presents the design flows analyzed for the distribution system modeling.

TABLE 1-1
KEY SYSTEM DESIGN CRITERIA

ELEMENT	BASIS FOR STANDARD	2017 EXISTING CRITERIA	ESTIMATED 2060 CRITERIA
EQUIVALENT RESIDENTIAL CONNECTIONS	Calculated	3,569	5,662
SOURCE			
Peak Day Demand	{R309-510-7(2) & (3) U.A.C.}	3,321 gpm	5,270 gpm
Average Yearly Demand	{R309-510-7(2) & (3) U.A.C.}	2,396 acre-ft	3,801 acre-ft
STORAGE			
Equalization	{R309-510-8(2) U.A.C.}	2.64 MG	4.18 MG
Fire Suppression	Total fire flow volume	1.00 MG	1.00 MG
Total		3.64 MG	5.18 MG
DISTRIBUTION MODELING			
Peak Instantaneous	1.70 x Peak Day Demand	5,646 gpm	8,959 gpm
Minimum Fire Flow	@ 20 psi	1,500 gpm	1,500 gpm
Max Operating Pressure	City Standard	120 psi	120 psi
Min. Operating Pressure	City Standard (peak day)	40 psi	40 psi

TABLE 1-2
DISTRIBUTION MODELING FLOW SUMMARY

DEMAND	DEMAND PER ERC (gpm)	TOTAL EXISTING DEMAND (gpm)	TOTAL 2060 DEMAND (gpm)	FLOW RATIO
Average Day	0.42	1,485	2,357	ADD/ADD = 1.00
Peak Day	0.93	3,321	5,270	PDD/ADD = 2.24
Peak Instantaneous	1.58	5,646	8,959	PID/ADD = 3.80

CHAPTER 2 - CONNECTIONS

EXISTING CONNECTIONS

According to connection information provided by the City of Moab, the Moab distribution network included 2,073 connections in 2016. Of that total, 1,575 were residential units, while 498 were commercial or multifamily units. An Equivalent Residential Connection (ERC) is a measure used in comparing the water demand of a typical single-family residential connection to other connection types. The number of ERCs served by the Moab drinking water system was calculated in accordance with guidelines provided by {R309-110-4 U.A.C.}. By definition, an average single-family residential connection represents 1 ERC. For convenience, connections will hereafter be categorized as either "residential" or "nonresidential". The term "residential" will be used to refer to single-family residential connections; all other connection types will be grouped as nonresidential connections.

The average demand per ERC was determined by dividing the total annual residential demand by the total number of residential connections. Using water use data submitted by Moab to the Utah Division of Water Rights, the total annual volume of water used by residential customers in 2016 was 800 acre-feet. Converting the annual volume to an average flow and dividing by the number of residential connections gives an average demand of 0.315 gpm/ERC. In order to express non-residential demand in terms of ERCs, the non-residential demand was divided by the average demand per residential connection. The total nonresidential demand was 1,012 acre-feet which corresponds to an average annual flow rate of 627 gpm. Based on these values, the total number of ERCs computed for the Moab system was 3,569. The raw data associated with the ERC calculations are included in Appendix A. ERCs were distributed geographically within the Moab service area based on billed usage. A zonal breakdown of the ERC distribution is shown in Table 2-1.

TABLE 2-1
EXISTING ERCS

ZONE	ERCs
Lower	1,436
Middle	1,367
Upper	766
TOTAL	**3,569**

FUTURE CONNECTIONS

Future ERCs were calculated by starting with the existing ERCs and adding the incremental amount of ERCs associated with future demands. The base assumption for projecting future

ERCs was that ERCs would increase proportionally with population. Population forecasts used for this master plan are based on data from the Moab Planning Commission and the Utah Governor's Office of Management and Budget. The forecasts were selected to match those used within the City's recently completed Sanitary Sewer Master Plan (Bowen Collins & Associates 2017). Through 2035, a growth rate of 1.10% was applied, and between 2035 and 2060 a growth rate of 1.02% was used. Table 2-2 presents a summary of the projected growth through 2060.

TABLE 2-2
PROJECTED POPULATION GROWTH

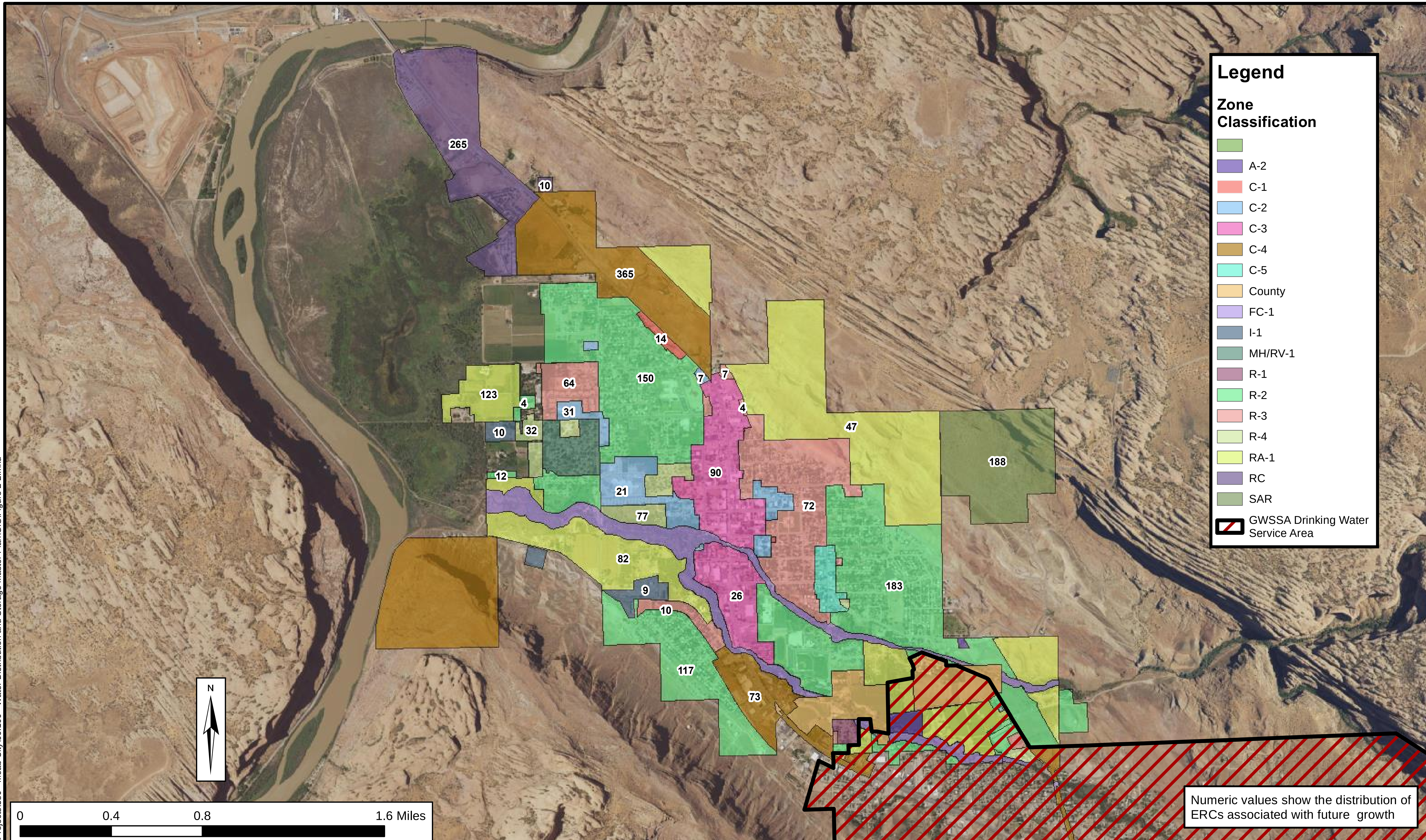
YEAR	POPULATION	Growth Rate	ERCs
2017	5,490	1.10%	3,569
2020	5,736	1.10%	3,728
2025	6,058	1.10%	3,938
2030	6,399	1.10%	4,159
2035	6,758	1.10%	4,393
2060	8,710	1.02%	5,662

In all, 2,093 ERCs were added to represent demands that will be added by 2060. These future ERCs were distributed throughout the Moab drinking water service area based on planned future land use (see Figure 2-1). Similar to population projections, the future land use projections were also selected to match the projections used within the City's Sanitary Sewer Master Plan. Additional data regarding the future ERC distribution can be found in Appendix A. A zonal breakdown of the projected 2060 ERC distribution is shown in Table 2-3.

TABLE 2-3
PROJECTED 2060 ERCS

ZONE	ERC
Lower	2,496
Middle	2,033
Upper	1,133
TOTAL	**5,662**

Each of the City's pressure zones is projected to experience significant growth. In absolute terms, the zone that is projected to have the largest growth is the Lower Zone. By 2060, the number of ERCs in the Lower Zone is projected to have increased by 1,060 ERCs, an increase



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WATER DISTRIBUTION AND STORAGE MASTER PLAN

FUTURE LAND USE & DISTRIBUTION OF FUTURE ERCS

FIGURE 2-1

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of 74%. For comparison, the Middle and Upper zones are projected to increase by just under 50%. Within the following chapters, the effects of this projected growth on source requirements, storage requirements, and distribution planning will be discussed.

CHAPTER 3 - SOURCES

EXISTING SOURCES

Moab currently uses several wells and springs to provide water to the City's drinking water system. A summary of the City's sources is provided in Table 3-1.

TABLE 3-1
SUMMARY OF MOAB WATER SOURCES

NAME	ZONE	CAPACITY (gpm)
Well 6	Upper	1,500
Well 10	Upper	700
Skakel Springs	Lower	440
Spring 1	Upper	350
Spring 2	Upper	
Spring 3*	Upper	350
TOTAL		3,340

*Spring 3 is also known as Birch Springs.

In addition to the sources listed in Table 3-1, the City also owns Well 7. Well 7 is operational but was not included in Table 3-1 because it is not currently used within the drinking water system. Well 7 has a capacity of about 350 gpm and the water is sold to the Moab Golf Club. Figure 3-1 presents a snapshot of Moab's drinking water production in 2016.

SPRING REDEVELOPMENT

Springs No. 1, 2 and 3 are functioning adequately, but it is anticipated that the wells will need to be redeveloped within the next decade in order to maintain the existing flowrate. For this reason, a spring redevelopment project has been added to the capital facilities plan.

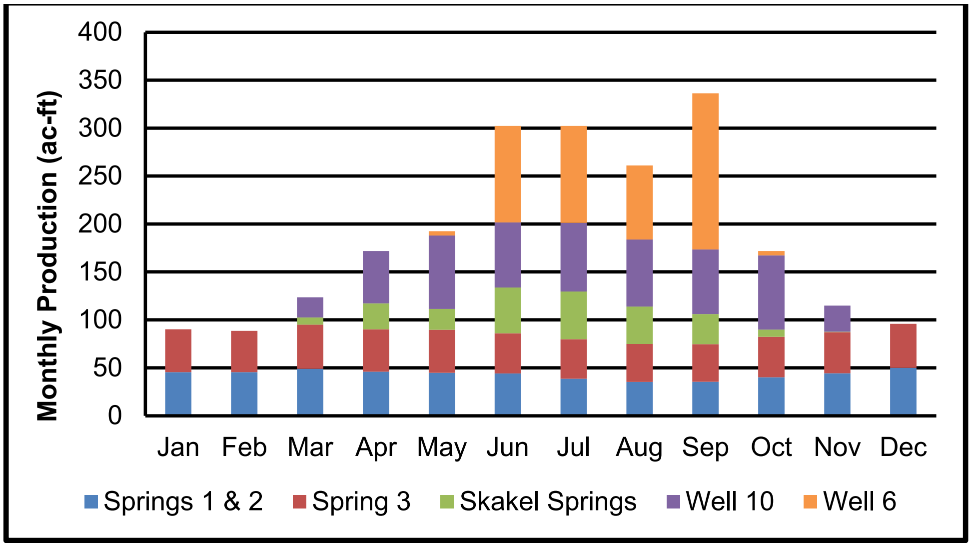


FIGURE 3-1: MOAB 2016 DRINKING WATER PRODUCTION

With regard to peak capacity, Well 6 is currently the City's largest source of drinking water. However, from Figure 3-1, it can be inferred that the City's current usage pattern is to rely on Springs 1, 2, and 3 to meet the City's base water demands and then to supplement with water from Skakel Springs and the City's two wells during times of higher demand. In 2016, the annual breakdown in production volume for each source was: 518 acre-feet for Springs 1 & 2, 516 acre-feet for Spring 3, 232 acre-feet for Skakel Springs, 534 acre-feet for Well 10, and 451 acre-feet for Well 6.

EXISTING SOURCE REQUIREMENTS

DDW standards require that distribution network water sources must be able to meet the expected water demand for two conditions: peak day demand and average yearly demand. These criteria will be addressed in the following paragraphs.

Existing Peak Day Demand

Peak day demand is the water demand on the day of the year with the highest water use and is used to determine the required source capacity. In accordance with rule {R309-510-7 U.A.C.}, the total source requirement is the sum of the peak day indoor and peak day outdoor demands. The peak day indoor requirement is defined as 800 gpd/ERC (see {R309-510-7(2) U.A.C.}). Based on 3,569 existing ERCs, the indoor source requirement for Moab City is 1,983 gpm.

The peak day outdoor requirement was calculated according to {R309-510-7(3) U.A.C.}. Accordingly, the peak day outdoor requirement was calculated by multiplying the state standard peak day requirement in gpm/acre by the City's irrigated acreage. Moab is located in Zone 5 of the map "Irrigated Crop Consumptive Use Zones and Normal Annual Effective Precipitation". As a result, the State Standard peak day irrigation demand for Moab is 4.52 gpm/irrigated acre. The irrigated acreage associated with an ERC, was determined by randomly selecting 20 residential lots and measuring the irrigable area. Using this process, the average irrigable area was 0.115 acres. However, landscaping was found to differ greatly from one lot to the next. Some residents choose to landscape in a traditional manner with much of the irrigable area covered by conventional grasses and/or trees. Other residents have chosen to employ low water use strategies in their landscaping. In order to account for this variation, each lot was also rated based on the effective irrigated area. After correcting for variation in landscaping practices, the average effective irrigable area was found to be 0.083 acres. Multiplying the effective acreage by the unit demand and total ERCs gives a total outdoor demand of 1,339 gpm. Summing the indoor and outdoor demand components gives a total peak day source requirement of **3,321 gpm** or about 0.93 gpm/ERC.

Actual metered source production data was available for the summer of 2017. The highest observed daily production flow reached 3,185 gpm (July 6, 2017), while the highest 3 day average was 2,754 gpm (June 23 to Jun 25, 2017). Based on these values, the State Standard peak day flow was judged to be reasonable. A per zone breakdown of the existing source requirements is shown in Table 3-2.

TABLE 3-2
EXISTING SOURCE REQUIREMENTS

Zone	ERCs	Zone Demand (gpm)	Existing Source Capacity (gpm)	PRV Flows				Remaining Source Capacity (gpm)
				In (gpm)	From	Out (gpm)	To	
Lower	1,436	1,336	440	896	Middle	0	NA	0
Middle	1,367	1,272	0	2,168	Upper	896	Lower	0
Upper	766	713	2,900	0	NA	2,168	Middle	19
Total	**3,569**	**3,321**	**3,340**	**3,064**		**3,064**		**19**

"Existing Source Capacity" is the capacity of the drinking water sources which supply water to the pressure zone. "PRV Flows" summarizes the flow in and out of each zone through PRVs. "In" and "Out" are the flows through the PRVs and "From" and "To" are the origination and destination zones of the flow. "Remaining Capacity" is the summation of all of the flows into the zone minus all of the flows out of the zone. Overall, the City has a total excess capacity of **19 gpm**.

Existing Average Yearly Demand

Water utilities must also be able to supply the average yearly demand. Average yearly demand is the average volume of water used during the course of one year. State Standards specify an annual requirement of 146,000 gallons per ERC for indoor use and 2.69 acre-feet per irrigated acre for outdoor use. Based on 3,569 ERCs and 0.083 irrigated acres per ERC, the State Standard average yearly demand for the Moab distribution system is **2,396 ac-ft**. The actual metered production volume from 2016 was 2,251 ac-ft.

FUTURE PROJECTED SOURCE REQUIREMENTS

Water demand is expected to increase as development within the City continues. As with existing water use, future water source needs were evaluated on the basis of peak day demand and average yearly demand. Each requirement is addressed separately in the following paragraphs.

Future Peak Day Demand

The projected total peak day demand is predicted to reach **5,270 gpm** by 2060.

Table **3-3** provides a summary of the 2060 source requirements for Moab City, with each column heading as previously defined. Based on the sources the City is currently utilizing, the projected deficit in source capacity is 1,930 gpm.

TABLE 3-3
PROJECTED 2060 SOURCE REQUIREMENTS

Zone	ERCs	Zone Demand (gpm)	Existing Source Capacity (gpm)	PRV Flows				Remaining Capacity (gpm)
				In (gpm)	From	Out (gpm)	To	
Lower	2,496	2,323	440	0	Middle	0	NA	-1,883
Middle	2,033	1,892	0	1,845	Upper	0	Lower	-47
Upper	1,133	1,055	2,900	0	NA	1,845	Middle	0
Total	**5,662**	**5,270**	**3,340**	**2,798**		**2,798**		**-1,930**

2060 Average Yearly Demand

Similar to the existing average yearly demand, state standards were also applied to calculate the 2060 average yearly demand. Based on values of 146,000 gallons per ERC for indoor use and 2.69 acre-feet per irrigated acre for outdoor use, the projected average yearly demand in 2060 is **3,801 ac-ft**, and the increase between the existing and 2060 conditions is projected to be 1,405 ac-ft.

SOURCE REDUNDANCY

In addition to meeting the peak day and annual source requirements, it is recommended that redundancy be incorporated into drinking water production. It is recommended that the water system have adequate capacity to meet all of the demand objectives with a major source unavailable. Based on the reviewed flow data, the largest source in the Moab system is Well 6, with a capacity of 1,500 gpm. This recommendation is not considered a deficiency since since the City sources are expected to be adequate for the existing needs.

SOURCE RECOMMENDATIONS

Under existing conditions, the City has an estimated surplus capacity of 19 gpm during peak day conditions with all sources in operation. However, in order for the City to have source redundancy such that no single drinking water source is indispensable, about 1,500 gpm of additional source capacity is needed. One potential option for the City to make up a portion of that deficit would be to use Well 7, or another City owned well that is not currently in service, within the drinking water system. In order for one of these wells to be a viable drinking water source, Moab will need to ensure that the well meets all state requirements. In addition, as water from Well 7 is currently sold to the Moab Golf Club, the City should verify that any agreements with the Golf Club would allow the City to divert the water into the drinking water system under an emergency scenario. With a capacity 350 gpm, Well 7 is not sufficient to provide full redundancy in the event of a loss of operation at Well 6. As an additional option, the City could consider working with Grand Water and Sewer Service Agency (GWSSA) to explore the feasibility of adding an interagency connection between the Moab and GWSSA drinking water systems. Depending on the capacity of the connection, it could potentially serve all or part of the needed redundancy. An interagency connection has the potential to aid both parties in supplying quality water to their respective customers. As another option, the City could also develop an additional water source. For planning purposes, it has been assumed that the City will construct a new well for source redundancy.

Under 2060 conditions, a source deficiency of 1,930 gpm is projected if no new sources are developed. In order to address this projected deficiency, it is recommended that the City develop an additional 1,930 gpm of source capacity. This is in addition to the capacity needed for existing system redundancy. It is not expected that the City will need to add all of this capacity in the immediate future. Instead, the City should periodically evaluate their source capacity and system demand and add capacity as needed. For the purpose of this master plan, it has been assumed that this future deficiency will be met through the construction of two new wells. One well should be constructed within the next two years if possible. The other well should be constructed in the future once it is needed to support growth.

TABLE 3-4
SOURCE RECOMMENDATIONS

Priority	Improvement
1	Develop an additional drinking water source to provide redundant capacity. Consider working with GWSSA to explore the feasibility of an interagency connection.
2	Meet future needs by developing new sources of at least 1,930 gpm. Two wells have been assumed for the purpose of projecting costs.

CHAPTER 4 - STORAGE

EXISTING STORAGE

The City's current drinking water system includes 3 storage facilities with a total capacity of 3.0 MG. The locations of storage facilities are shown on Figure 1-1. Table 4-1 presents a listing of the names and select attributes of the existing water storage tanks.

TABLE 4-1
EXISTING STORAGE TANKS

Name	Type	Dimensions (ft)	Volume (MG)	Outlet Level	Emergency Storage Level	Fire Suppression Level	Overflow/ Equalization Level
Skakel	Steel	72	1.0	5,156.8 (0 feet)	NA	NA	5,190.2 (33.4 feet)
Mountain View	Steel	72	1.0	5,304.0 (0 feet)	NA	5321.2 (17.2 feet)	5,337.4 (33.4 feet)
Powerhouse	Steel	72	1.0	5,305.6 (0 feet)	NA	5321.2 (15.6 feet)	5339.0 (33.4 feet)

Emergency storage levels and fire suppression levels were considered during the master planning process. The fire suppression levels set in Table 4-1 define the elevation at which the City's fire suppression storage begins. Defining fire suppression tank levels helps the City ensure that the storage volume dedicated to fire suppression is available to meet fire flow requirements at all times. Additional discussion regarding the fire suppression level is included with the "Fire Suppression Storage" subheading below.

DDW standards suggest that emergency storage can be considered in the sizing of storage facilities {R309-510-8(1)(c) U.A.C.}. Emergency storage is intended to provide a safety factor that can be used in the case of unexpectedly high demands, pipeline failures, equipment failures, electrical power outages, water supply contamination, or natural disasters. However, based on the City's history and discussions with City staff, no additional storage for emergencies is recommended. Accordingly, no tank levels were specified for emergency storage in Table 4-1.

EXISTING STORAGE REQUIREMENTS

According to DDW standards, storage tanks must be able to provide: 1) equalization storage volume to make up the difference between the peak day flow rate and the peak instantaneous; and 2) fire suppression storage volume to supply water for firefighting. A summary of the existing storage requirements for the drinking water system is shown in Table 4-2.

TABLE 4-2
EXISTING STORAGE REQUIREMENTS

PRESSURE ZONE	ERCs	REQUIRED STORAGE (MG)			EXISTING STORAGE (MG)	REMAINING (MG)
		Equalization (MG)	Fire Suppression (MG)	Total (MG)		
Lower	1,436	1.06	0	1.06	1.00	-0.06
Middle	1,367	1.01	0	1.01	0	-1.01
Upper	766	0.57	1.00	1.57	2.00	0.43
TOTAL	3,569	2.64	1.00	3.64	3.00	-0.64

Due to PRV interconnections between pressure zones, excess storage located in higher zones can be applied to zones that are lower. Therefore, the City has an existing deficit of 0.64 MG in drinking water storage capacity. Recommendations for addressing the storage deficit have been included at the end of this chapter.

Equalization Storage

The need for equalization storage is highest during the irrigation season on days of peak water use. Equalization storage is used to meet peak demands when demand exceeds the capacity of the sources. For the City of Moab, the required equalization storage was calculated according to the guidelines outlined by {R309-510-8(2) U.A.C.}. The equalization storage requirement includes an indoor and outdoor component. The indoor component is 400 gallons per ERC. The outdoor component is 4,081 gallons/irrigated acre. Based on 0.083 irrigated acres per ERC, the outdoor component is 339 gallons per ERC. Therefore the total equalization storage required for each ERC is 739 gallons. With 3,569 existing ERCs, the existing equalization storage requirement for the City of Moab was found to be **2.64 MG.**

Fire Suppression Storage

Fire suppression storage is required for water systems that provide water for firefighting. The Moab Valley Fire Protection District has jurisdiction over the City with Phillip Mosher serving as fire chief. The contact information for the Moab Valley Fire Protection District is as follows:

Phone: (435) 259-5557

Address: 45 South 100 East
Moab, UT 84532

The water system should be managed so that the storage volume dedicated to fire suppression is available to meet fire flow requirements when needed. This can be accomplished by designating minimum storage tank water levels that provide reserve storage equal to the required fire suppression storage. Although it is important to utilize equalization storage, typical daily water fluctuations in the tanks should never be allowed below the minimum established levels except during fire or emergency situations. Fire suppression tank levels are included in Table 4-1. The assigned tank levels assume that all of the fire suppression storage in the Moab system is provided by the Mountain View and Powerhouse tanks. Between the two tanks, a total volume of 1.0 MG has been allocated for fire storage, which is sufficient to provide a 4,000 gpm fire suppression flow over a duration of 4 hours.

FUTURE PROJECTED STORAGE REQUIREMENTS

The projected storage volumes required in 2060 are based on the same equalization, fire suppression, and operational storage requirements as were calculated for the existing conditions. The 2060 equalization storage will be higher than existing conditions because the number of ERCs is projected to increase. The City's future storage projections are presented in Table 4-3.

TABLE 4-3
2060 STORAGE REQUIREMENTS

PRESSURE ZONE	ERCs	REQUIRED STORAGE (MG)			EXISTING STORAGE (MG)	REMAINING (MG)
		Equalization (MG)	Fire Suppression (MG)	Total (MG)		
Lower	2,496	1.84	0	1.84	1.00	-0.84
Middle	2,033	1.50	0	1.50	0	-1.50
Upper	1,133	0.84	1.00	1.84	2.00	0.16
TOTAL	5,662	4.18	1.00	5.18	3.00	-2.18

The projected equalization storage requirement in 2060 is 4.18 MG, an increase of 1.54 MG over the existing condition. Although the storage requirements in Table 4-3 have been categorized by zone, the City is not required to address each zone on an individual basis. Storage located in higher zones can be applied to lower zones. As a result, the City has some flexibility in deciding where to locate future storage tanks.

Fire suppression requirements are not projected to increase over the existing scenario. Often, fire suppression requirements do not increase over time. Instead, as older buildings are replaced with newer buildings that conform to newer building codes, fire suppression requirements may decrease.

STORAGE RECOMMENDATIONS

In order to address the existing storage needs, it is recommended that the City construct a new storage tank with a capacity of up to 2.2 MG. The new tank will meet the City's existing needs while providing some additional capacity that would be allocated to future growth. It is recommended that the storage tank should be constructed east of the intersection of Spanish Valley Drive and Spanish Trail Road. The City already owns the property, and the location is advantageous for system hydraulics and energy. Further discussion on the benefits of the tank site is included within the optimization chapter of this report.

CHAPTER 5 - DISTRIBUTION SYSTEM

EXISTING DISTRIBUTION SYSTEM

The distribution system consists of all pipelines, valves, fittings, and other appurtenances used to convey water from the water sources and storage tanks to the water users. The existing water system contains about 52 miles of distribution pipe ranging in size from 4 to 21 inches in diameter. Figure 5-1 presents a summary of pipe length by diameter.

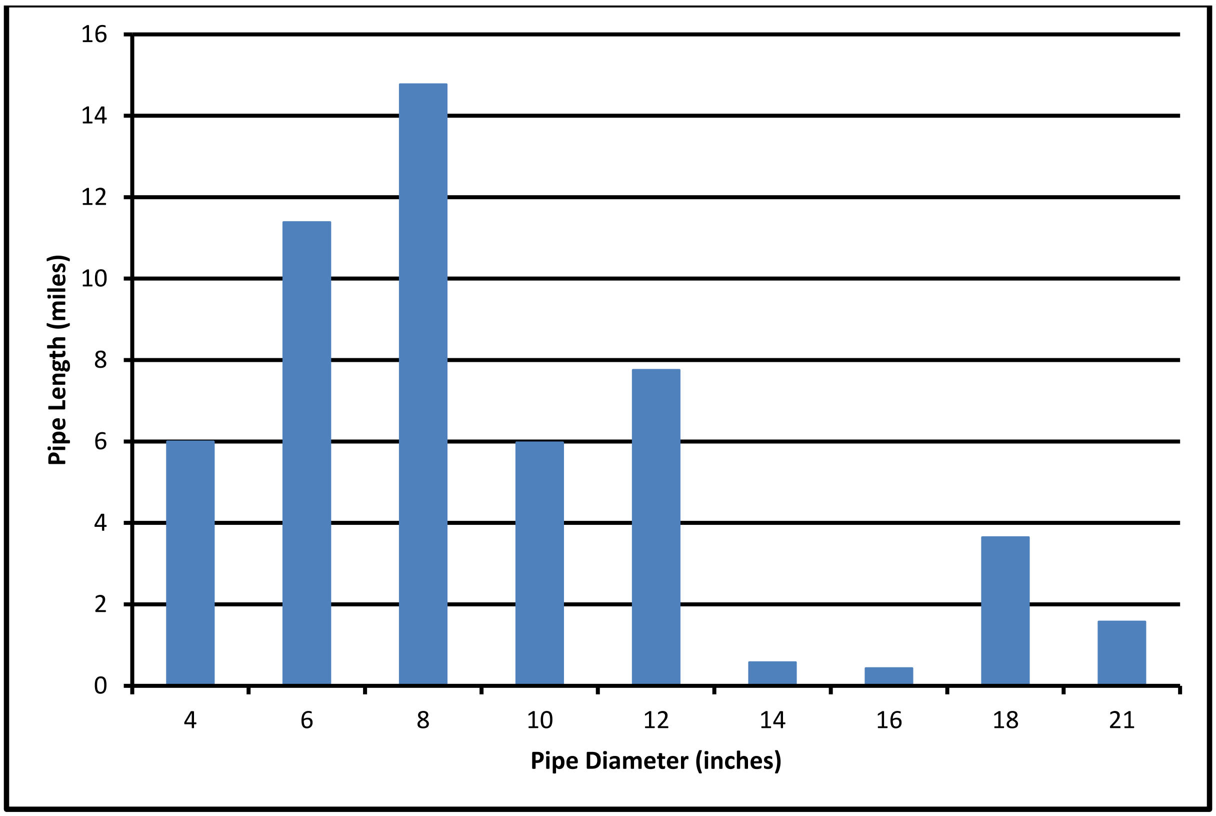


FIGURE 5-1: SUMMARY OF PIPE LENGTH BY DIAMETER

EXISTING DISTRIBUTION SYSTEM REQUIREMENTS

Rule {R309-105-9(1) U.A.C.} applies to existing systems approved prior to January 1, 2007 and requires that distribution systems be able to maintain 20 psi at all points in the system during normal operating conditions and during conditions of fire flow plus peak day demand. Rule {R309-105-9(2) U.A.C.} adds the following minimum water pressure constraints: (a) 20 psi during conditions of fire flow plus peak day demand; (b) 30 psi during peak instantaneous demand; and (c) 40 psi during peak day demand. Rule {R309-105-9(2) U.A.C.} applies to new systems approved after January 1, 2007 and to new areas or subdivisions of existing systems approved after the same date. Much of Moab is subject to {R309-105-9(1) U.A.C.}; however, new developments will need to meet the criteria outlined by {R309-105-9(2) U.A.C.}.

Existing Peak Instantaneous Demand

Peak instantaneous demand is the highest demand on the peak day. The pipes in the distribution system must be large enough to convey the peak instantaneous demand while maintaining a pressure at connections above 30 psi. The peak day instantaneous demand was determined based on the peak day flow of 3,321 gpm and a peaking factor of 1.70. Based on these values, the peak instantaneous flow rate is **5,646 gpm**.

Existing Peak Day Plus Fire Flow Demand

In accordance with DDW regulations, the distribution system must be capable of maintaining "20 psi during conditions of fire flow and fire demand experienced during peak day demand" (R309-105-9(2)). Based on discussions with Moab City personnel, a minimum fire flow criterion of **1,500 gpm** was selected for all locations in the distribution system. Larger fire flows may be required at larger structures throughout the system based on the International Fire Code and recommendations from the Moab Valley Fire Protection District. All fire flows were simulated under the state defined peak day demand conditions of 3,321 gpm as outlined by {R309-510-9(4) U.A.C.}.

FUTURE PROJECTED DISTRIBUTION SYSTEM REQUIREMENTS

The same performance standards used for the existing system also apply to the projected 2060 system. The performance of the 2060 system was evaluated for the following scenarios: peak day demands, peak instantaneous demands, and peak day plus fire flow demands.

2060 Peak Instantaneous Demand

The projected peak day demand for the 2060 distribution system was 5,270 gpm. Assuming the same peaking factor of 1.70 applies to the build-out peak day demand gives a 2060 peak instantaneous demand of **8,959 gpm**.

2060 Peak Day Plus Fire Flow Demand

The build-out peak day plus fire flow scenario was evaluated in a similar manner as compared to the existing peak day plus fire flow scenario. It was assumed that the fire flow requirements would not change between the existing and build-out conditions. Generally, this is a conservative assumption as, over time, older buildings are replaced with newer buildings constructed in accordance with updated building codes. The build-out fire flow scenario was evaluated with a model demand of 5,270 gpm.

COMPUTER MODEL

A computer model of the City's water distribution system was developed to analyze the performance of the existing and future distribution system and to prepare solutions for existing facilities that cannot meet the DDW or City criteria for water system pressures. The software used for the model was EPANET 2.0, which is a computer program that models the hydraulic behavior of piping networks.

Computer models were developed for three phases of water system development. The first phase was the development of a model of the existing system (existing model). This model was used for calibration and to identify deficiencies in the existing system. The geometry of the existing model was assembled using GIS data of distribution pipelines and facilities provided by Moab City. The model was calibrated based on SCADA data for Moab tanks and sources and based on additional communication with City personnel.

A second model was developed which was used to identify those corrections necessary to improve existing system deficiencies (corrected existing model). This model includes the improvements recommended for the existing system. The third phase was the development of a future model to indicate those improvements that will be necessary for the projected 2060 condition (future model).

MODEL COMPONENTS

The two basic elements of the computer model are pipes and nodes. A pipe is described by its inside diameter, overall length, minor friction loss factors, and a roughness value associated with friction head losses. A pipe can include elbows, bends, valves, pumps, and other operational elements. Nodes are the end points of a pipe and they can be categorized as junction nodes or boundary nodes. A junction node is a point where two or more pipes meet, where a change in pipe diameter occurs, or where flow is put in or taken out of the system. A boundary node is a point where the hydraulic grade is known (a reservoir or PRV).

The computer model of the water distribution system is not an exact replica of the actual water system. Efforts were made to make the model as complete and accurate as possible. Nonetheless, pipeline locations used in the model are approximate and some pipelines, particularly those smaller than 4 inches, may not be included in the model. Moreover, it is not necessary to include all of the distribution system pipes in the model to accurately simulate its performance.

Pipe Network

As indicated previously, the pipe network layout was based on GIS data proved to HAL. During model preparation, accuracy of the new model was verified by reviewing data through discussion with City personnel. Updates to the model were made by HAL throughout the master plan study.

Demands

Water demands were input to the model based on billing data from the summer of 2017. The peak demand month was determined from the billing data, and the billing addresses were geocoded in GIS in order to link the demands to a physical location. The geocoded demands were then assigned to the closest model demand node and the peak monthly flows were scaled to convert them into peak day flows.

Daily variation in demand was modeled by applying a typical diurnal demand curve to the model demands. The diurnal curve is used to scale the average peak day demand to the peak instantaneous demand. The non-dimensional demand curve used for Moab is shown in Figure 5-2

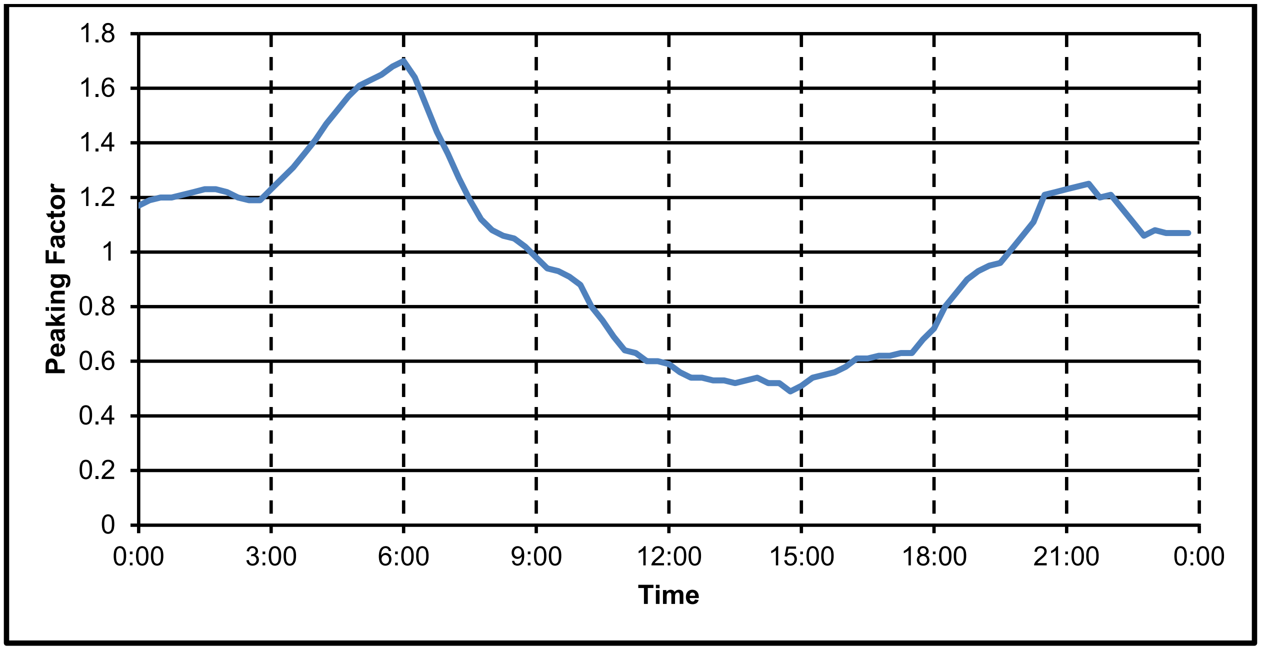


FIGURE 5-2: NON-DIMENSIONAL PEAK DAY DIURNAL CURVE

Based on the diurnal curve, the peak instantaneous demand occurs at 6:00 AM and the associated peaking factor is 1.70. Demand is elevated throughout the night as a result of automatic sprinkler irrigation. The high morning peak results from night time irrigation combined with high indoor use from people waking up and preparing for the day. The smaller evening peak is a result of evening irrigation and water use associated with people preparing for bed.

Sources and Storage Tanks

Moab's wells and springs serve as the drinking water sources in the model. The levels in the tanks are modeled in the extended period model scenario. The extended period model predicts the levels in the tanks as they fill from sources and empty to meet demand in the system.

MODEL CALIBRATION

A water system computer model should be calibrated before it may be relied on to accurately simulate the performance of the distribution system. Calibration was performed by comparing computer results with actual system performance. When the computer model does not match the field tests within an acceptable level of accuracy, the computer model is adjusted to match field conditions. Calibration is especially useful for identifying pipe sizes that are not correct and PRVs or isolation valves that are not operating as expected. Pipe roughness is an additional characteristic which may be adjusted during calibration.

The model was calibrated primarily through the use of SCADA data. Source flows and tank levels were provided to HAL and the model was calibrated by adjusting production volumes and PRV settings so that the overall behavior of the network was reproduced within the model. A Darcy-Weisbach roughness coefficient of 0.85 millifeet was used for most model pipes. Calibration results are included in Appendix B. The overall flow patterns in the model matched the observed values very well.

ANALYSIS METHODOLOGY

The EPANET model was used to analyze the performance of the water system for current and projected future demands under three main operating conditions: low flow (highest pressure) conditions, peak instantaneous conditions, and peak day plus fire flow conditions. Each of these conditions stresses the water system so that the performance of the distribution system may be analyzed for compliance with DDW and Moab City's requirements. The results of the model for each of the conditions are discussed below.

High Pressure Conditions

Low flow or static conditions are usually the worst case for high pressures in a water distribution system. In the winter time, water demand during night time hours is very low, tanks are nearly full, and movement of water through the system is minimal. Under these conditions, the water system approaches a static condition and water pressure in the distribution system is dependent only upon the elevation differences and pressure regulating devices. Another condition similar to static condition that can also cause high pressures in the City's water system occurs in the summer when demand is low and pumps are on to fill storage tanks. The highest pressures are reached when pumps are on, tanks are almost full, and demand is low. Both of these high pressure conditions were simulated with the model.

Peak Instantaneous Demand Conditions

Peak Instantaneous demand conditions can sometimes be the worst-case scenario for low pressures throughout a water distribution system. A water system often reaches peak instantaneous demand conditions during the hottest days of the summer when both indoor and outdoor water use is the highest. The high demand creates elevated velocities in the distributions pipes which reduces pressure. DDW requires the pipes in the distribution system be capable of delivering peak instantaneous demand to the entire service area and maintain a minimum pressure of 30 psi at any service connection within the distribution system.

Peak Day Demand Plus Fire Flow Conditions

Even though peak instantaneous conditions are the worst-case for the lowest pressure and highest demand for the entire system, the peak day plus fire flow is often the worst-case scenario for the lowest pressures for specific locations in the system. This condition occurs when fire hydrants are being used on a day of high water demand. The distribution system must be capable of delivering the required fire flow to the specified location within the system, while supplying the peak day demand to the entire distribution system. In accordance with the requirements outlined by {R309-105-9(4) U.A.C.}, the required fire flows must be delivered while maintaining 20 psi minimum residual pressure at the delivery point and to all service connections within the distribution system.

Peak Day Extended Period

The peak day extended period model was used to model the water system performance over time. An extended period model is actually a static model run several times for each time period. The peak day extended period model was used to set system conditions for the static models, calibrate zone-to-zone water transfers, analyze system controls and the performance of the system over time, analyze system recommendations for performance over time, and analyze the water system for optimization recommendations. The peak day extended period model was run for several days with the peak day demand curve repeating every 24 hours such that the model operated in a stable pattern. The model has reached stabilization when the filling and emptying cycles of the tanks repeat in a consistent pattern without running empty. System recommendations for existing conditions and future conditions at build-out were checked with the extended period model to confirm adequacy.

ANALYSIS RESULTS OF THE EXISTING SYSTEM

The model output primarily consists of the computed pressures at nodes and flow rates through pipes. The model also provides additional data related to pipeline flow velocity and head loss to help evaluate the performance of the various components of the distribution system. Results from the model are available as indicated in Appendix C. Due to the large number of pipes and nodes in the model, it is impractical to prepare a figure which illustrates pipe numbers and node numbers. The reader should refer to the model to review the full model output. Summary results for the various modeling scenarios are included below.

For nearly all areas of the City, the observed pressures were below the City's preferred maximum pressure of 120 psi. The lone exception is a small area along the east side of Main Street near the intersection with Kane Creek Boulevard. The maximum observed pressures at that location reach 125 psi, slightly higher than the City's standard. One option that would reduce pressures in the area would be to transfer supply for the area from the Upper Pressure Zone to the Middle Pressure Zone by changing isolation valves. The pressure zone change would reduce the maximum pressure to about 75 psi. However, since the peak pressures are only slightly higher than the City's standard it may be preferable to accept the elevated pressures. Water users become accustomed to their existing level of service and changes in pressure (increases or decreases) may lead to complaints. In addition, automatic sprinkler systems and irrigation systems are often designed based on available pressures. Changes to available pressures may cause poor irrigation system performance.

Minimum pressures were evaluated according to the 40 psi standard under peak day demand conditions and 30 psi under peak instantaneous demand conditions. One small area of the system was not able meet the peak day demand minimum pressure criterion. The modeled pressure at the far south end of David Court was about 39 psi during peak day demand. The most direct solution for increasing the pressures at that location is to make piping changes at the corner of David Court and Doc Allen Drive. Currently, the pipeline in David Court is part of the Middle Pressure Zone. However, there is an Upper Zone transmission pipeline in Doc Allen Drive that connects to the Mountain View Tank. Connecting the David Court pipe to the Upper Zone transmission pipeline in Doc Allen Drive would increase the peak day pressure at the south end of Doc Allen Drive to about 85 psi. Before making any changes, it is recommended that the City verify the pressures along David Court.

All other areas of the City's drinking water system are able to meet the 40 psi peak day minimum pressure standard. The area of the system with the second lowest pressure under peak day demands is along 100 South at about 550 East. Peak day pressures in this area are about 44 psi. The remainder of the system is generally able to maintain at least 50 psi under peak day demands conditions.

All areas of the system were able to meet the 30 psi minimum pressure under peak instantaneous demands. The two areas with lowest observed pressures were along David Court and 550 East 100 South. The minimum pressures at each location were 37 psi and 42 psi, respectively.

Using modeling, several locations were identified that are not able to provide the minimum fire suppression flow of 1,500 gpm under peak day demand conditions. The majority of the identified shortcomings result from 4-inch and 6-inch diameter pipelines in residential areas. Projects that address the fire flow capacity at these locations are included within the recommendations toward the end of this chapter.

Another distribution consideration relates to the Sunset Grill. Currently, it is connected to the City water system by way of a private individual booster pump. Typically, the Utah Division of Drinking Water does not approve private booster stations, unless through an "exception to rule". It is recommended that Moab City consult with the Division to determine if an exception is necessary.

ANALYSIS RESULTS OF THE FUTURE SYSTEM

The build-out system was analyzed based on the same parameters that were considered for the existing system. In general, the build-out model behaves similarly to the existing model. However, each of the pressure zones is expected to experience moderate growth. As a result of the growth, pressures within the future model are generally slightly lower and the pipeline velocities are slightly higher as compared to the existing model. A copy of the future model is included as Appendix C.

The area with the highest pressures remained unchanged within the future model as compared to the existing model. The peak observed pressure occurs in the small area along the east side of Main Street near the intersection with Kane Creek Boulevard. Within the build-out model the peak observed pressure was 121 psi. As with the existing recommendation, it is suggested that the City accept these slightly elevated pressures.

Regarding low pressures under peak day demand conditions, the area along David Court that had the lowest pressures in the existing model is assumed to be connected to the upper pressure zone within the future 2060 model. As a result, the observed pressure at that location will be about 75 psi during future peak day conditions. The lowest observed pressure within the future model occurred at about 550 East 100 North and is predicted to be 43 psi. Therefore, under 2060 peak day demand conditions, all locations within the future model are projected to meet the 40 psi minimum pressure standard.

Similar to the existing model, all areas within the future model were able to meet the 30 psi minimum standard under peak instantaneous demand conditions. The lowest observed pressure in the future model was 40 psi at 550 East 100 North.

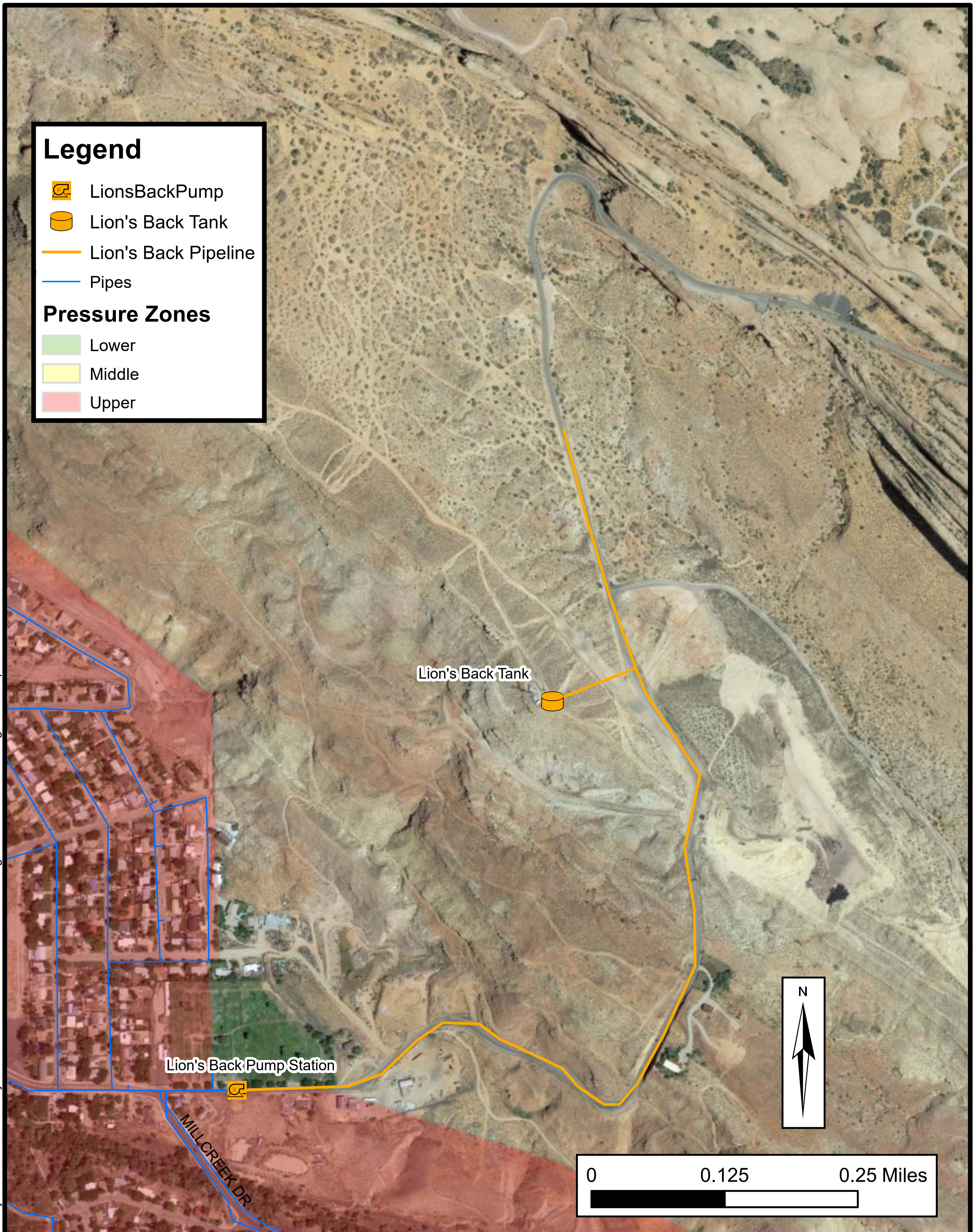
Fire suppression modeling was also conducted for the future model. In general, fire suppression capacity is slightly lower in the future model due to the higher future demands. However, assuming that projects recommended for the existing system will be completed, no future fire flow deficiencies were identified.

Lions Back Development

The Lion's Back Development is a proposed development located northeast of the City (see Figure 5-3). Water supply for the Development was analyzed while reviewing the future system. It is projected that the development will contribute about 230 ERCs to the future Moab system, with an associated peak day demand of 130 gpm. In order to supply water to the development, a pump station, transmission pipeline, and a storage tank will be needed.

The location of the proposed Development is somewhat higher in elevation than the existing Moab pressure zones. The highest elevation of any existing Moab service connection is about 4,195 feet. It is expected that the elevation of the Lion's Back Development will be at least 4,470 feet. In order to provide water to the development, it will be necessary to pump water from the existing Upper Pressure Zone into a future Lion's Back Zone. A logical water source to pump from is the existing 12-inch transmission pipeline that terminates at about 950 Sand Flats Road. The pump station will need to have at least two pumps, each with enough capacity to supply the peak day demand of the development. The peak day demand requirement should be verified once plans for the development have been finalized.

Water is assumed to be conveyed from the pump station to the development via a pipeline installed in Sand Flats Road. The pipeline configuration shown in Figure 5-3 includes about 6,200 feet of pipe. At a conceptually level, the lower portion of the pipeline starting from the pump station up to the point where the storage tank pipeline splits off will need to be an 8-inch



HANSEN ALLEN & LUCE INC ENGINEERS

CITY OF MOAB
WATER DISTRIBUTION AND
STORAGE MASTER PLAN

LION'S BACK DEVELOPMENT

FIGURE 5-3

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pipe. Larger pipe may be needed for the upper pipeline portion between the storage tank and the development; the sizing of that section will be governed by fire flow requirements. If an 8-inch pipe is installed between the tank and the development, modeling performed for this analysis indicates the fire suppression capacity will be about 1,500 gpm with a 20 psi residual pressure. Critical variables that affect fire flow capacity include the tank elevation, development elevation, and the distance between the tank and the development. The final determination for pipes sizes should be made during design.

The storage tank will need to have capacity for equalization storage and fire suppression storage. For each ERC, the required equalization storage is 739 gallons. As a result, the total equalization storage requirement for the development is projected to be about 170,000 gallons. The total volume of a 2 hour fire suppression flow of 1,500 gpm is 180,000 gallons. In addition, due to the isolated nature of the development, consideration may be given to allocating a portion of the storage volume as emergency storage. No emergency storage volume is included here, but could be considered during tank sizing. Summing the equalization and fire suppression storage gives a total storage volume of 350,000 gallons. Prior to construction of this tank, the fire official should be consulted to verify that the fire flow volume is still adequate.

Based on a review of the area's topography, the highest elevation that can be conveniently reached in constructing a storage tank is about 4,580 feet. Higher elevations are available, but only by significantly increasing the length of installed pipeline. If the tank is constructed with a floor elevation of 4,580 feet, a static pressure of 50 psi could be maintained to a connection at an elevation of 4,465 feet.

The purpose of this analysis is to provide a basic framework for the proposed Lion's Back Development. All values should be verified as development plans are being prepared. The developer may provide additional details during development planning which modify these values. It has been assumed that the City will require the developer to construct all of the improvements that are needed for the development. For this reason, no project costs have been included for Lion's Back Development.

EXISTING DISTRIBUTION SYSTEM RECOMMENDATIONS

Recommendations for improvement projects were based on the modeling, as outlined above, and guidance provided by Moab City personnel. Recommendations have been categorized as existing system projects or as build-out system projects. Table 5-1 lists the existing distribution system projects.

TABLE 5-1
EXISTING DISTRIBUTION SYSTEM PROJECTS

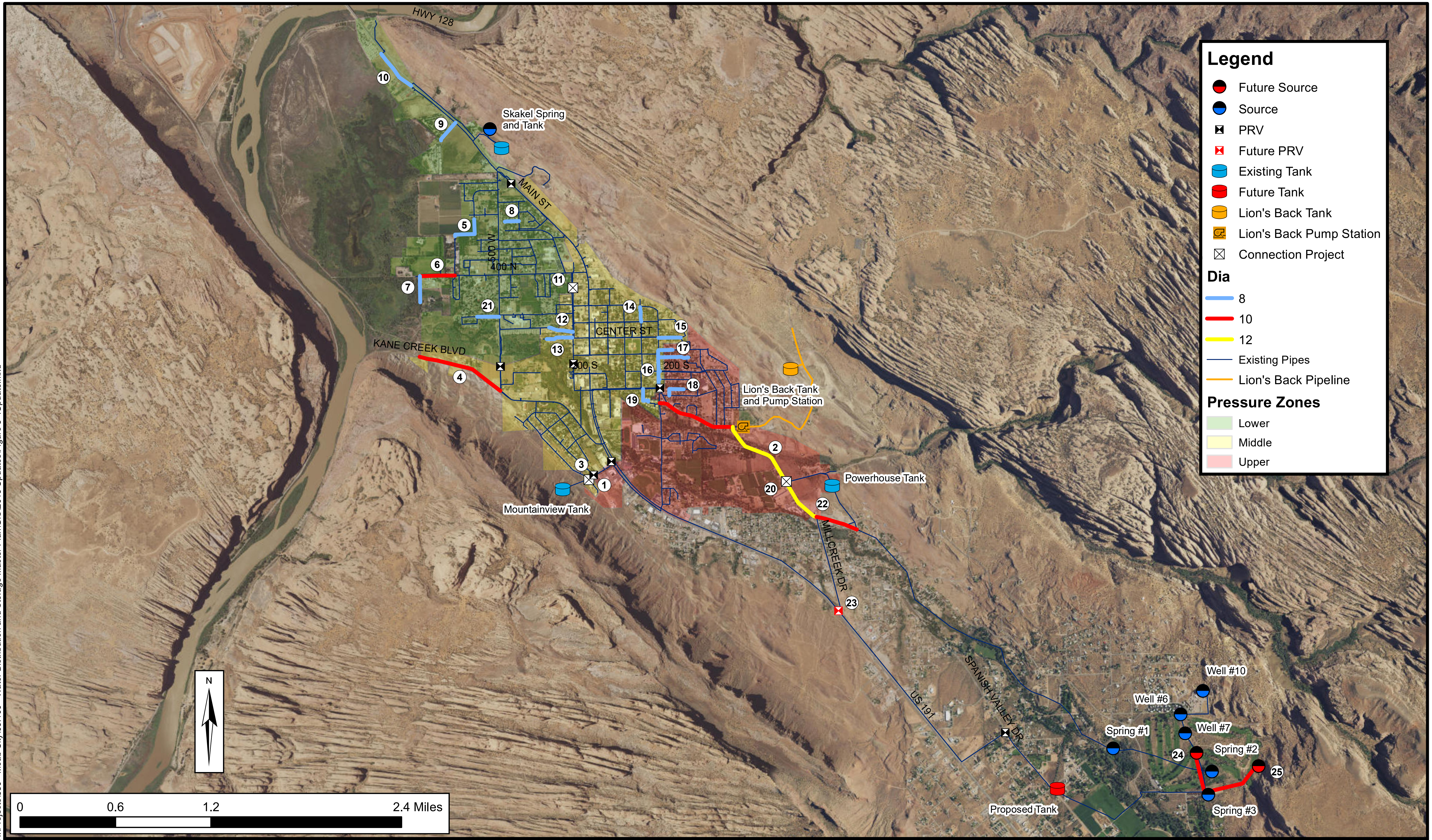
PROJ #	LOCATION	PROBLEM	SUGGESTED SOLUTION
1	970 David Court	Peak day pressure is less than 40 psi	Disconnect David Court pipeline from the Middle Zone at the intersection of David Court and Doc Allen Drive. Reconnect to Upper Zone transmission pipeline
2	Mill Creek Drive	Frequent leaks and ruptures	Replace 2,600 feet of 10-inch pipe and 2,700 feet of 12-inch pipe on Mill Creek Drive between Powerhouse Road and 400 East.
3	Southeast portion of Doc Allen Drive	Available fire flow is less than 1,500 gpm	Install 260 feet of 8-inch pipe in Dogwood Avenue between Mountain View Drive and Doc Allen Drive to connect existing Middle Zone pipelines
4	1000 West Kane Creek Boulevard	Available fire flow is less than 1,500 gpm	Install 3,000 feet of 10-inch pipeline in Kane Creek Boulevard between 500 West and 1000 West
5	Riversand Drive	Available fire flow is less than 1,500 gpm	Install 1,200 feet of 8-inch pipe to connect the pipeline in Riversand Road to the pipeline in Palisade Drive
6	1000 West 400 North	Available fire flow is less than 1,500 gpm	Install 1,200 feet of 10-inch pipe in 400 North between 750 West and 1000 West
7	200 North Stewart Lane	Available fire flow is less than 1,500 gpm	Install 850 feet of 8-inch pipe in Stewart Lane between 400 North and 200 North
8	470 West Carlos Court	Available fire flow is less than 1,500 gpm	Install 470 feet of 8-inch pipe in Carlos Court
9	1261 North Highway 191	Available fire flow is less than 1,500 gpm	Install 770 feet of 8-inch pipe in Rubicon Trail between Highway 191 and Portal RV Resort
10	1700 North Highway 191	Available fire flow is less than 1,500 gpm	Install 1,600 feet of 8-inch pipe on the south side of Highway 191 between 1500 North and 1700 North
11	300 North 100 West	Available fire flow is less than 1,500 gpm	The fire hydrant is connected to 4-inch pipeline. Swap connection to 12-inch pipeline
12	250 Williams Way	Available fire flow is less than 1,500 gpm	Install 820 feet of 8-inch pipe in Williams Way between 100 West and 250 Williams Way
13	264 West Center Street	Available fire flow is less than 1,500 gpm	Install 900 feet of 8-inch pipe in West Center Street between 100 West and 264 West Center Street

PROJ #	LOCATION	PROBLEM	SUGGESTED SOLUTION
14	194 North 300 East	Available fire flow is less than 1,500 gpm	Install 490 feet of 8-inch pipe in 300 East between 100 North and 194 North
15	521 East Center Street, 540 East 100 North	Available fire flow is less than 1,500 gpm	Install 800 feet of 8-inch pipe in Center Street between 400 East and 500 East
16	559 East to 672 East Nichols Lane	Available fire flow is less than 1,500 gpm	Connect to upstream side of 300 South 400 East PRV and install 1,280 feet of 8-inch pipe in 400 East between 300 South and Rosetree Lane and 1,050 feet of 8-inch pipe in Nichols Lane between 400 East and 674 East
17	498 East to 632 East Rosetree Lane	Available fire flow is less than 1,500 gpm	Install 500 feet of 8-inch pipe in Rosetree Lane between 400 East and 504 East
18	530 Bowen Circle	Available fire flow is less than 1,500 gpm	Install 680 feet of 8-inch pipe in Bowen Circle between 403 Bowen Circle and 530 Bowen Circle
19	350 East Pueblo Court	Available fire flow is less than 1,500 gpm	Install 910 feet of 8-inch pipe beginning at approximately 306 East 300 South to Pueblo Court
20	910 Powerhouse Lane	Available fire flow is less than 1,500 gpm	Disconnect fire hydrant from 8-inch pipe and reconnect to 12-inch pipe
21	730 Bartlett Avenue and 740 Bartlett Circle	Available fire flow is less than 1,500 gpm	Install 740 feet of 8-inch pipe in Bartlett Avenue between 500 West and 632 West

The projects listed in Table 5-1 represent existing deficiencies and should be addressed in the near future. A project map is included as Figure 5-4. One additional item for the City to consider is upsizing the pipeline in Red Devil Drive. There is currently a 6-inch pipeline in Red Devil Drive which provides drinking water service and fire suppression flow to Grand County High School. The 6-inch pipeline receives water from a 10-inch pipeline in 400 East. Under current conditions, a fire suppression flow of 1,500 gpm can be supplied to the fire hydrant near the southeast corner of the school. Increasing the size of the pipe in Red Devil Drive to 10 inches boosts the available fire flow to more than 4,000 gpm. The school's fire flow requirement was not available for this study. The City should consider a more extensive review of the fire suppression requirements for the school and increase the pipe size, if needed.

Recommended PRV Settings

During the course of analyzing the system, PRV settings were adjusted with the goal of maximizing the usage of equalization storage while minimizing pressure fluctuations and energy costs. Table 5-2 presents the recommended PRV settings.



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WATER DISTRIBUTION AND STORAGE MASTER PLAN

WATER SYSTEM CAPITAL PROJECT MAP

FIGURE 5-4

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TABLE 5-2
RECOMMENDED PRV SETTINGS

PRV Address	From Zone	To Zone	Elevation (ft)	Setting (psi)
300 South 400 East	Upper	Middle	4,070	76
890 Mountain View Drive	Upper	Middle	4,079	72
776 South Main Street	Upper	Middle	4,063	79
150 South 100 West	Middle	Middle	4,012	Open
983 North Main Street	Middle	Lower	4,021	63
170 South 500 West	Middle	Lower	3,992	76

The elevations and pressures given in Table 5-2 represent modeled values. Precise elevations were not available for the PRVs. As a result, it is expected that some adjustment will be needed for these values. The guiding principle in selecting PRV settings is that settings should be high enough to protect pressures in the lower zone, but not so high that tank levels are prevented from diurnal fluctuation.

FUTURE DISTRIBUTION SYSTEM RECOMMENDATIONS

Assuming that each of the existing recommendations is implemented, no pressure or fire flow deficiencies are projected to exist in the future system. Still, it is recommended that the City fund a pipeline replacement program. Pipelines should be scheduled for replacement based on priority, and in order to take advantage of road resurfacing projects and other situations of convenience. Pipelines smaller than 8-inches in diameter, older pipelines, and pipelines where frequent repairs have been needed should all be considered as high priority for replacement. The DDW has recommended that at least 5% of the annual drinking water budget be set aside for facility replacement. The City should evaluate the level of funding which is appropriate the water system.

CONTINUED USE OF THE COMPUTER PROGRAM

It is recommended that the City continue updating the model as the water system changes. Below is a list of ways in which the model could help the City with water system management. The computer model can assist City staff in determining:

- Effect on the system if individual facilities are added or taken out of service
- Selection of pipe diameters and location of proposed water mains
- Capacity of the water system to provide fire flows in specific areas
- Water age for water quality monitoring
- Residual chlorine and fluoride levels in the system

The computer model should be maintained for future use. Necessary data required for continued use of the program are:

- The location, length, diameter, pipe material, and ground elevation at each end of each new pipeline constructed
- Changes in water supply location and characteristics
- Location and demand for new large customers
- Changes in chlorine and fluoride dosing rates and procedures

CHAPTER 6 - OPTIMIZATION

OPTIMIZATION OVERVIEW

Three parameters drive the operation of a water system: system performance, water quality, and energy efficiency (Figure 6-1). Water systems can be characterized by any degree or combination of these three parameters. One system may perform well but incur high energy costs. Another may be energy efficient but is not sufficiently pressurized during peak demand. Still another may perform well hydraulically but fail to meet requirements for chlorine residual. System optimization is the process whereby a distribution network is evaluated in order to identify potential improvements that will allow the network to operate in the region where energy efficiency, system performance, and water quality are balanced.

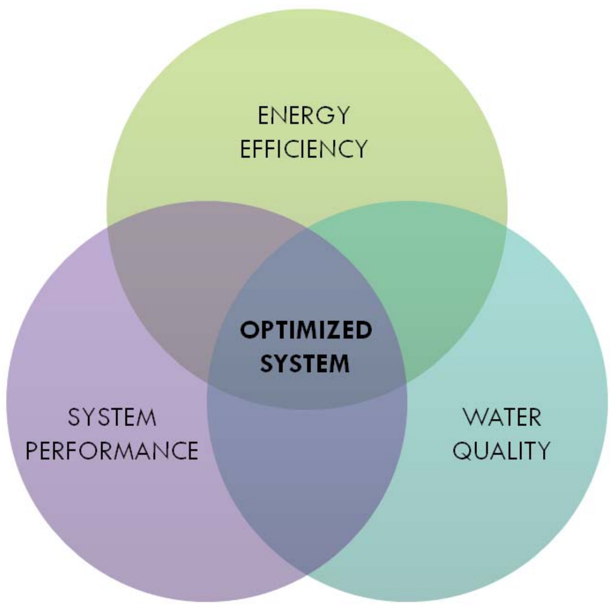

FIGURE 6-1: WATER SYSTEM OPTIMIZATION DIAGRAM

System optimization was considered throughout the development of this master plan. One of the basic principles used was to limit unnecessary energy losses. Energy losses have a direct impact on energy efficiency and system performance. Many of the changes that reduce energy losses also promote water circulation, which improves water quality. The following paragraphs describe how optimization was applied in the development of the recommendations included in this master plan to further optimize the system.

ENERGY AND SYSTEM PERFORMANCE

PRV settings are an ideal example for the application of optimization principles. PRVs can provide a useful means of reducing pressure fluctuations in lower zones by allowing water to flow to the lower zone during peak flow events. However, setting a PRV too high can have the opposite effect within the upper zone. High PRV flows elevate the flow velocity in the upper zone, which in turn increases pressure fluctuations. Furthermore, high PRV settings prevent the equalization storage in tanks from being fully utilized, leading to wasted energy. The solution is to set PRVs at a level where pressures in the lower zones are protected, but flow through the PRV is limited. The settings included within the previous chapter were chosen to keep daily pressure fluctuations under 20 psi while meeting minimum pressure standards for peak day, peak instantaneous, and emergency demand scenarios.

Another example of applying optimization principals during the development of this master plan is in selecting a location for the future drinking water storage tank. The location of the storage tank was selected in order to make use of existing facilities, while providing hydraulic and energy advantages. The proposed location is at an elevation that allows sources to gravity flow to the tank, but also preserves as much energy as possible. Because the tank is at a higher elevation than other existing tanks, the City will have additional flexibility to push water to lower pressure zones. It may even be possible to install an in-line generator or micro-hydro station that could convert excess head into electricity.

Pumping Costs

Producing, treating, and delivering high-quality water requires energy, which is usually a water utility's largest operational expense and can account for 30%–40% of municipal energy consumption (EPA 2015). Efforts to increase energy efficiency bring financial savings and can facilitate improvements in water quality and hydraulic performance. The City should prioritize water usage from sources with the lowest cost water. Springs 1, 2, and 3 are the cheapest sources because no pumping is needed. Moab's pumped sources should only be used during times when Springs 1, 2, and 3 cannot supply enough water to meet the City's demand.

As part of the optimization analysis HAL performed a qualitative review of the City's pumping facilities. Energy intensity describes the amount of energy needed to produce a unit volume of water and is often measured in kilowatt-hours per million gallons. Since energy use and pumping costs are directly related, energy intensity serves as a useful proxy for comparing the relative pumping costs of different sources. The energy intensity of a pumped source is proportional to the pump's lift, assuming efficiency is constant. Therefore, if two wells with identical pump efficiencies are considered, one that lifts water from a depth of the 500 feet, and one that lifts from a depth 1,000 feet. The well that lifts water 500 feet will have half the energy intensity of the other well, and produce water at half the cost in energy. Due to the relationship between pump lift and energy use, it is expected that the next City's next cheapest water source after Springs 1, 2, and 3 will be Skakel Springs. Although Skakel Springs requires pumping to lift water into Skakel Tank, the lift associated with pumping a spring is generally much less than the lift needed to pump a well. Wells 6 and 10 are expected to be the City's highest cost water sources and should be used when the flow of the Springs is not sufficient to meet the City's demand.

Based on Figure 3-1, the City is already utilizing sources quite efficiently. In 2016, Springs 1, 2, and 3 met the base demand for the City through the year. As demand increased, Skakel Springs and Well 6 were added in March, and Well 10 was added in May. One potential area of improvement is to focus on not utilizing Well 6 to the detriment of Skakel Springs. In Figure 3-1 Skakel Springs does not reach peak volume until June. Based on the data provided it is not clear whether this is due to water availability as a result of seasonal fluctuations in spring flow, or due to discretionary choices in source utilization. When possible, water from Skakel Springs should be utilized before water from the wells, and the wells should not be utilized until production from Skakel Springs has been maximized.

CHLORINE MODELING

Moab City provided chlorine field test results for locations within the distribution system that were collected during 2017. A comparison of the chlorine modeling data and field sampling results is included in Appendix D. The modeled concentrations were generally in good agreement with field concentrations. Figure 6-2 shows the model output from the chlorine modeling. Within the figure, pipes shown in blue represent locations with relatively low chlorine residual while areas shown in green represent comparatively high chlorine concentration. Areas with low chlorine residual include locations that are relatively far from chlorinated sources or else dead-end pipelines with low flow velocities.

Operational practices can help maintain good chlorine residuals. For example, water levels in storage tanks should be allowed to fluctuate throughout the day. Peak flows should be met by water from storage tanks rather than by increasing source production. Meeting peak flows with storage volume helps turnover the water in the tank, improving residual chlorine concentrations. As long as the water levels do not drop below the fire suppression levels outlined in Table 4-1, diurnal variation in tank level is beneficial.

WATER AGE AND DISINFECTION BYPRODUCTS

While chlorine is an effective disinfectant in controlling many microorganisms in drinking water, it reacts with natural material found in drinking water to form potentially harmful disinfection byproducts (DBPs). Accordingly, the Environment Protection Agency (EPA) has developed rules to balance the risks between microbial pathogens and DBPs. A drinking water system needs enough chlorine to destroy pathogens but also not produce excessive DBP.

The extended period model was used to predict the areas in the water system that have the highest potential for DBP production. The potential for DBP production is higher in warmer and older water. Consequently, a water age model provides valuable insight into areas with the highest potential for DBP production. Water age was calculated for every location in the system by running the model to simulate several days in the summer scenario. Figure 6-3 illustrates the results of the water age model scenario at 240 hours using the Existing Model.

Nearly all of the system receives fresh water every three days. Dead end lines with little to no demand have the worst circulation in the model. Areas located along the extremities of the system also tend to have higher water age. It is recommended that the City use the water age model to ensure DBP sampling is occurring at the locations with the highest DBP production potential.

SUMMARY OF OPTIMIZATION RECOMMENDATIONS

Based on the finding and observations presented above, the following recommendations are provided:

1. Set PRVs so that equalization storage is utilized while pressure fluctuations are controlled.
2. Prioritize usage of lower cost source water.
3. Monitor water quality test results. In particular, chlorine should be tested in areas the model identifies as having lower chlorine residual levels.
4. Monitor water quality in areas identified as having higher age.

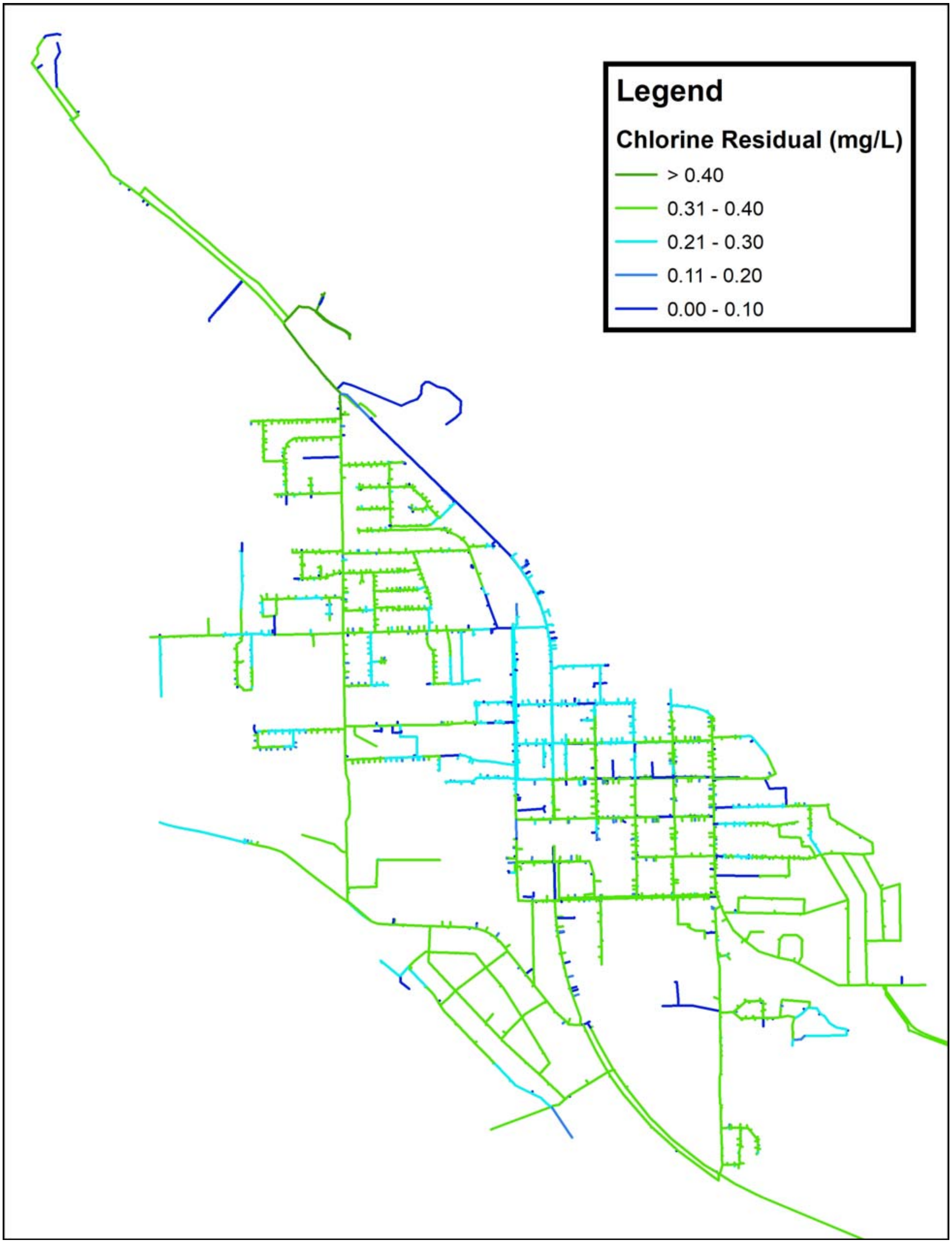

FIGURE 6-2: CHLORINE CONCENTRATIONS IN MOAB CITY

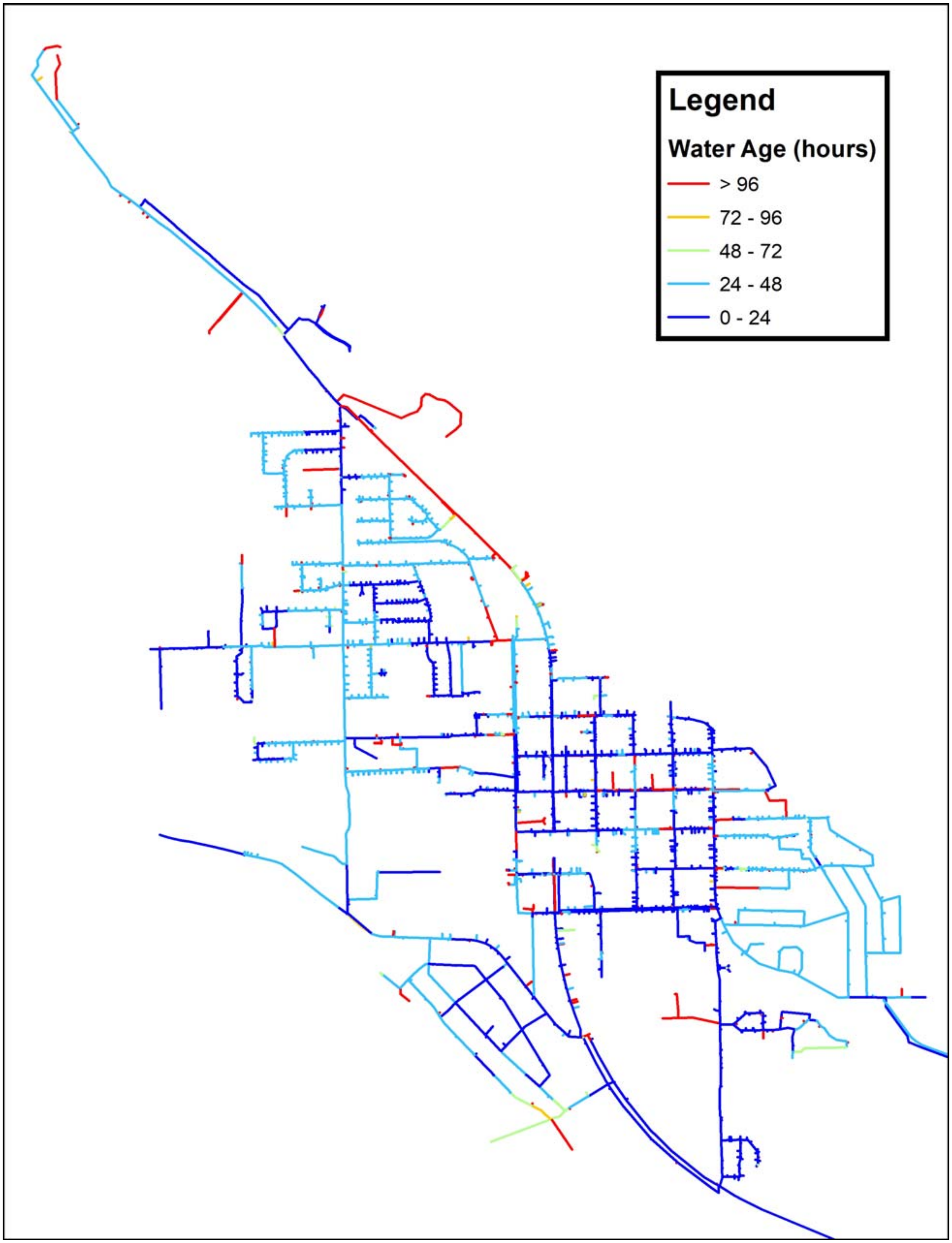

FIGURE 6-3: WATER AGE IN MOAB CITY

CHAPTER 7 - CAPITAL IMPROVEMENTS PLAN

Throughout the master planning process, the three main components of the City's water system (source, storage, and distribution) were analyzed to determine the system's ability to meet existing demands and the anticipated future demands at build-out. After identifying system deficiencies, possible solutions were studied by HAL for feasibility. Conceptual costs were developed for the most cost-effective solutions.

PRECISION OF COST ESTIMATES

When considering cost estimates, there are several levels or degrees of precision, depending on the purpose of the estimate and the percentage of detailed design that has been completed. Master planning level (sometimes referred to as conceptual or feasibility design level) costs are relatively simple as compared to costs developed based on preliminary design or final design. The purpose of master planning is to develop general sizing, location, cost, and scheduling information on a number of individual projects that may be designed and constructed over a period of many years. Master planning also typically includes the selection of common design criteria to help ensure uniformity and compatibility among future individual projects. Details such as the exact capacity of individual projects, the level of redundancy, the location of facilities, the alignment and depth of pipelines, the extent of utility conflicts, the cost of land and easements, the construction methodology, the types of equipment and material to be used, the time of construction, interest and inflation rates, permitting requirements, etc., are typically developed during the more detailed levels of design.

At the preliminary or 10% design level, some of the aforementioned information will have been developed. Major design decisions such as the size of facilities, selection of facility sites, pipeline alignments and depths, and the selection of the types of equipment and material to be used during construction will typically have been made.

After the project has been completely designed, and is ready to bid, all design plans and technical specifications will have been completed and nearly all of the significant details about the project should be known. Cost estimates at this level of design will be more precise as compared to master planning and preliminary design levels. However, there are still many factors that can heavily influence the cost of a project. A few of those include construction timing, contractor work backlog, the time of year in which bids are held, etc.

SYSTEM IMPROVEMENT PROJECTS

As discussed in previous chapters, several source, storage and distribution system deficiencies were identified during the system analysis. Project costs for water system improvements are presented in Table 7-1 with map IDs corresponding to the project locations shown in Figure 5-4. Each recommendation includes a conceptual cost estimate for construction.

Unit costs for the construction cost estimates are based on conceptual level engineering. Sources used to estimate construction costs include:

1. “Means Heavy Construction Cost Data, 2019"
2. Price quotes from equipment suppliers
3. Recent construction bids for similar work

All costs are presented in 2019 dollars. Recent price and economic trends indicate that future costs are difficult to predict with certainty. Engineering cost estimates provided in this study should be regarded as conceptual level for use as a planning guide. Only during final design can a definitive and more accurate estimate be provided for each project. A cost estimate calculation for each project is provided in Appendix E and Table 7-1 provides a cost summary for the recommended system improvements.

TABLE 7-1
PROJECT COSTS FOR SYSTEM IMPROVEMENTS
(Listed by Map ID order)

TYPE	MAP ID	RECOMMENDED PROJECT	COST
Source	NA	Develop source redundancy	$2,365,000
Source	NA	Redevelop Springs No. 1, 2 and 3	$563,000
Storage	NA	Construct a new storage tank with a capacity of 2.2 MG (Note: The City of Moab will seek grant and loan funding assistance for half of the tank cost.)	$3,438,000
Distribution	NA	Optimization and security of existing facilities*	$800,000
Distribution	1	Disconnect David Court pipeline from the Middle Zone at the intersection of David Court and Doc Allen Drive. Reconnect to Upper Zone transmission pipeline	$26,000
Distribution	2	Install 2,600 feet of 10-inch pipe and 2,700 feet of 12” pipe along Mill Creek Drive between Powerhouse Road and 400 East.	$1,871,538
Fire	3	Install 260 feet of 8-inch pipe in Dogwood Avenue between Mountain View Drive and Doc Allen Drive to connect existing Middle Zone pipelines	$46,000
Fire	4	Install 3,000 feet of 10-inch pipeline in Kane Creek Boulevard between 500 West and 1000 West	$630,000
Fire	5	Install 1,200 feet of 8-inch pipe to connect the pipeline in Riversand Road to the pipeline in Palisade Drive	$180,000

TYPE	MAP ID	RECOMMENDED PROJECT	COST
Fire	6	Install 1,200 feet of 10-inch pipe in 400 North between 750 West and 1000 West	$252,000
Fire	7	Install 850 feet of 8-inch pipe in Stewart Lane between 400 North and 200 North	$151,000
Fire	8	Install 470 feet of 8-inch pipe in Carlos Court	$83,000
Fire	9	Install 770 feet of 8-inch pipe in Rubicon Trail between Highway 191 and Portal RV Resort	$137,000
Fire	10	Install 1,600 feet of 8-inch pipe on the south side of Highway 191 between 1500 North and 1700 North	$284,000
Fire	11	The fire hydrant is connected to 4-inch pipeline. Swap connection to 12-inch pipeline at 300 North 100 West	$13,000
Fire	12	Install 820 feet of 8-inch pipe in Williams Way between 100 West and 250 Williams Way	$146,000
Fire	13	Install 900 feet of 8-inch pipe in West Center Street between 100 West and 264 West Center Street	$160,000
Fire	14	Install 490 feet of 8-inch pipe in 300 East between 100 North and 194 North	$87,000
Fire	15	Install 800 feet of 8-inch pipe in Center Street between 400 East and 500 East	$142,000
Fire	16	Connect to upstream side of 300 South 400 East PRV and install 1,280 feet of 8-inch pipe in 400 East between 300 South and Rosetree Lane and 1,050 feet of 8-inch pipe in Nichols Lane between 400 East and 674 East	$413,000
Fire	17	Install 500 feet of 8-inch pipe in Rosetree Lane between 400 East and 504 East	$89,000
Fire	18	Install 680 feet of 8-inch pipe in Bowen Circle between 403 Bowen Circle and 530 Bowen Circle	$121,000
Fire	19	Install 910 feet of 8-inch pipe beginning at approximately 306 East 300 South to Pueblo Court	$162,000
Fire	20	Disconnect fire hydrant from 8-inch pipe and reconnect to 12-inch pipe at Mill Creek Drive and Powerhouse Lane	$13,000

TYPE	MAP ID	RECOMMENDED PROJECT	COST
Fire	21	Install 740 feet of 8-inch pipe in Bartlett Avenue between 500 West and 632 West	$131,000
Distribution	22	Install 1,460 feet of 12-inch pipe and 1,510 feet of 10-inch pipe between connection project and existing pipeline	$656,000
Distribution	23	Construct new PRV station	$125,000
Source	24	Construct a new drinking water well and pipeline for future growth	$2,265,000
Source	25	Construct a new drinking water well and pipeline for future growth	$2,392,000
TOTAL			**$17,741,538**

*Staff identified project.

The above noted projects have been prioritized to provide the City guidance for which order the projects should be pursued. The fire flow projects were prioritized based on consultation with the City and available fire flow volume. The future projects were given lower priority since they provide for future growth and aren't immediately needed. It should be noted that the selection of criteria and priorities is subjective. As the City personnel evaluate project priorities, the City may wish to alter the order of the priorities.

TABLE 7-2
PROJECT COSTS FOR SYSTEM IMPROVEMENTS
(Listed in Priority order)

PRIORITY	MAP ID	RECOMMENDED PROJECT[1]	COST
1	NA	Develop source redundancy	$2,365,000
1	NA	Construct a new storage tank with a capacity of 2.2 MG (Note: The City of Moab will seek grant and loan funding assistance for half of the tank cost.)	$3,438,000
1	NA	Optimization and security of existing facilities	$800,000
2	2	Install 2,600 feet of 10-inch pipe and 2,700 feet of 12" pipe along Mill Creek Drive between Powerhouse Road and 400 East.	$1,871,538
3	17	Install 500 feet of 8-inch pipe in Rosetree Lane between 400 East and 504 East	$89,000
4	13	Install 900 feet of 8-inch pipe in West Center Street between 100 West and 264 West Center Street	$160,000

PRIORITY	MAP ID	RECOMMENDED PROJECT[1]	COST
5	8	Install 470 feet of 8-inch pipe in Carlos Court	$83,000
6	19	Install 910 feet of 8-inch pipe beginning at approximately 306 East 300 South to Pueblo Court	$162,000
7	18	Install 680 feet of 8-inch pipe in Bowen Circle between 403 Bowen Circle and 530 Bowen Circle	$121,000
8	14	Install 490 feet of 8-inch pipe in 300 East between 100 North and 194 North	$87,000
9	21	Install 740 feet of 8-inch pipe in Bartlett Avenue between 500 West and 632 West	$131,000
10	23	Construct a new drinking water well for future growth	$2,265,000
11	16	Connect to upstream side of 300 South 400 East PRV and install 1,280 feet of 8-inch pipe in 400 East between 300 South and Rosetree Lane and 1,050 feet of 8-inch pipe in Nichols Lane between 400 East and 674 East	$413,000
12	9	Install 770 feet of 8-inch pipe in Rubicon Trail between Highway 191 and Portal RV Resort	$137,000
13	5	Install 1,200 feet of 8-inch pipe to connect the pipeline in Riversand Road to the pipeline in Palisade Drive	$180,000
14	6	Install 1,200 feet of 10-inch pipe in 400 North between 750 West and 1000 West	$252,000
15	7	Install 850 feet of 8-inch pipe in Stewart Lane between 400 North and 200 North	$151,000
16	4	Install 3,000 feet of 10-inch pipeline in Kane Creek Boulevard between 500 West and 1000 West	$630,000
17	1	Disconnect David Court pipeline from the Middle Zone at the intersection of David Court and Doc Allen Drive. Reconnect to Upper Zone transmission pipeline	$26,000
18	3	Install 260 feet of 8-inch pipe in Dogwood Avenue between Mountain View Drive and Doc Allen Drive to connect existing Middle Zone pipelines	$46,000
19	11	The fire hydrant is connected to 4-inch pipeline. Swap connection to 12-inch pipeline at 300 North 100 West	$13,000
20	20	Disconnect fire hydrant from 8-inch pipe and reconnect to 12-inch pipe at Mill Creek Drive and Power House Lane	$13,000

PRIORITY	MAP ID	RECOMMENDED PROJECT[1]	COST
21	10	Install 1,600 feet of 8-inch pipe on the south side of Highway 191 between 1500 North and 1700 North	$284,000
22	15	Install 800 feet of 8-inch pipe in Center Street between 400 East and 500 East	$142,000
23	12	Install 820 feet of 8-inch pipe in Williams Way between 100 West and 250 Williams Way	$146,000
24	22	Install 1460 feet of 12-inch pipe and 1510 feet of 10-inch pipe between connection project and existing pipeline	$656,000
25	24	Construct a new drinking water well for future growth	$2,392,000
26	25	New pressure reducing valve station	$125,000
27	NA	Redevelop Springs No. 1, 2 and 3	$563,000
TOTAL			**$17,741,538**

The proposed future well projects address future source needs. The proposed storage tank, transmission lines and redundancy projects address a combination of future and existing needs. The existing system improvement projects are recommended to be completed within 6 years or as soon as funding allows. The City has identified projects with priorities 1 through 9 to be constructed within the next 6 years. A summary of the expected project costs, over the next 6 years, is shown in Table 7-3.

TABLE 7-3
SIX YEAR COST SUMMARY

Project	Cost
Fire Flow Projects:	$833,000
Distribution Projects:	$2,671,538
Source Projects:	$2,365,000
Storage Projects:	$3,438,000
Total	**$9,307,538**

FUNDING OPTIONS

Funding options for the recommended projects, in addition to water use fees, could include the following options: general obligation bonds, revenue bonds, State/Federal grants and loans, and impact fees. In reality, the City may need to consider a combination of these funding options. The following discussion describes each of these options.

With respect to water use fees, it is recommended that the City evaluate water rates periodically. Rates should be sufficient to cover the full cost of producing and delivering water and maintaining the system so that it is not necessary to subsidize the water system with other funding sources. Failure to perform proper maintenance and pipeline replacement may create an eventual significant financial burden on ratepayers. Old, unstable and leaky pipes cause significant inefficiency, interfere with conservation efforts, and increases the potential for a water quality health risk. Also, failure to collect the proper impact fees can also place a burden on user rates because once the new connections are on the system, the system upgrades cannot be paid for by impact fees. Charging customers for the true current cost of water reinforces the idea that water is a valuable commodity, and helps fund the system.

General Obligation Bonds

This form of debt enables the City to issue general obligation bonds for capital improvements and replacement. General Obligation (G.O.) bonds are debt instruments backed by the full faith and credit of the City, which would be secured by an unconditional pledge of the City to levy assessments, charges or ad valorem taxes necessary to retire the bonds. G.O. bonds are the lowest-cost form of debt financing available to local governments and can be combined with other revenue sources such as specific fees, or special assessment charges to form a dual security through the City's revenue generating authority. These bonds are supported by the City as a whole, so the amount of debt issued for the water system is limited to a fixed percentage of the real market value for taxable property within the City.

Revenue Bonds

This form of debt financing is also available to the City for utility related capital improvements. Revenue bonds are not backed by the City as a whole, but constitute a lien against the water service charge revenues of a Water Utility. Revenue bonds present a greater risk to the investor than do G.O. bonds, since repayment of debt depends on an adequate revenue stream, legally defensible rate structure and sound fiscal management by the issuing jurisdiction. Due to this increased risk, revenue bonds generally require a higher interest rate than G.O. bonds. This type of debt also has very specific coverage requirements in the form of a reserve fund specifying an amount, usually expressed in terms of average or maximum debt service due in any future year. This debt service is required to be held as a cash reserve for annual debt service payment to the benefit of bondholders. Typically, voter approval is not required when issuing revenue bonds.

State/Federal Grants and Loans

Historically, both local and county governments have experienced significant infrastructure funding support from state and federal government agencies in the form of block grants, direct grants in aid, interagency loans, and general revenue sharing. Federal expenditure pressures and virtual elimination of federal revenue sharing dollars are clear indicators that local government may be left to its own devices to fund infrastructure. However, state/federal grants and loans should be investigated as a possible funding source for needed water system improvements.

Impact Fees

Impact fees can be applied to water related facilities under the Utah Impact Fees Act. The Utah Impacts Fees Act is designed to provide a logical and clear framework for establishing new development assessments. It is also designed to establish the basis for the fee calculation which the City must follow in order to comply with the statute. However, the fundamental objective for the fee structure is the imposition on new development of only those costs associated with providing or expanding water infrastructure to meet the capacity needs created by that specific new development. Also, impact fees cannot be applied retroactively.

SUMMARY OF RECOMMENDATIONS

Several recommendations were made throughout the master report. The following is a summary of the recommendations organized by category.

Source

1. Develop an additional drinking water source to provide redundant capacity.
2. Meet future needs by developing new sources of at least 1,930 gpm. The firsts new source should be constructed in the next two years if possible.

Storage

1. Construct a new storage tank with a capacity of 2.2 MG.

Distribution

1. Construct all of the projects addressing existing deficiencies within 5 years if possible.
2. Maintain an updated model of the drinking water system.
3. Fund a pipeline replacement project.

Optimization

1. Set PRVs so that equalization storage is utilized while pressure fluctuations are controlled.

2. Prioritize usage of lower cost source water.
3. Monitor water quality test results. Chlorine should be tested in areas the model identifies as having lower chlorine residual levels.
4. Monitor water quality in areas identified as having higher age through disinfection byproduct testing.

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Utah Administrative Code R309-510. Facility Design and Operation: Minimum Sizing Requirements. rules.utah.gov/publicat/code/r309/r309-510.htm (accessed Sep. 28, 2017)

APPENDIX A
ERC Calculations

CLIENT City of Moab	SHEET 1 OF 2
PROJECT Water Distirbution and Storage Master Plan	
FEATURE ERC Calculations	COMPUTED RTC
PROJECT NO 380.09.100	DATE 2/24/18

Abbreviations:

AF = acre-feet
DWR = Utah Division of Water Rights
ERC = equivalent residential connection
GOMB = Governor's Office of Management and Budget
gpm = gallon per minute

Referenced DWR data can be found at:
https://www.waterrights.utah.gov/cgi-bin/wuseview.exe?Modinfo=Pwsview&SYSTEM_ID=1164

Key: Input | **Calculated Value**

Water Use and ERC Calculations

Moab service area population =	5,490	*(from 2016 use data reported to DWR)*	
Total water use =	1,812	AF *(See DWR 2016 annual use data)*	
Residential connections =	1,575	*(from 2016 DWR data)*	
Total Connections =	2,073	*(from 2016 DWR data)*	
Residential water use =	800	AF *(from 2016 DWR data)*	
Average Residential flow rate =	**496**	gpm	
Residential demand per ERC =	**0.315**	gpm/ERC	
Non residential water use =	**1,012**	AF	
Non residential water use =	**627**	gpm	*ERCs were calculated based on R309-110-4 of Utah Admin. Code*
Summation of ERCs from non-residential demands =	**1,994**	ERCs	
Total ERCs =	**3,569**	ERCs	

Existing State Standard Peak Day Flow Computation

Indoor Demand Calculations

Peak Day Indoor Demand =	800	gallons/day *(see R309-510-7)*
Total Peak Day Indoor Demand =	**1,983**	gpm

Outdoor Demand Back Calculating Using Production Data

July 2016 volume =	306.6	AF *(from DWR data)*	
July 2016 average flow =	**2,238**	gpm	
December 2016 volume =	97.3	AF *(from DWR data)*	
December 2016 avg. flow =	**710**	gpm	*This analysis assumes the difference between July and December demands is outdoor demand*
December 2016 Per ERC avg. demand =	**0.199**	gpm/ERC	
December 2016 daily volume per ERC =	**286.51**	gal/day	
Peak Month outdoor demand =	**1528**	gpm *(2,238 gpm-710 gpm)*	
Add 20% to estimate peak day	**1833**	gpm	
Outdoor demand per ERC =	**0.514**	gpm/ERC	

State Standards, outdoor demand =	4.52	gpm/irr acre *(see R309-510-7)*
Irrigated acres/ERC =	**0.114**	acres
Total irrigated acreage =	**406**	acres

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Outdoor Demand Calculated Based on Random Sample Lot Measurements

There is wide variation between lot sizes, and some clearly do not irrigate

Average irrigable acreage =	0.115	irr acre/ERC
Effective irrigated acreage =	0.083	irr acre/ERC
Total Outdoor Peak Day Demand =	1,339	gpm **THIS VALUE USED**
Outdoor demand per ERC =	0.375	gpm/ERC

Recommended Indoor Plus Outdoor Peak Day Demand

State standard total peak day demand =	3,321	gpm *(1,983 gpm+1,339 gpm)*
Total demand/ERC =	0.93	gpm/ERC

Indoor Plus Outdoor Average Day Demand

Indoor state standard demand =	146,000	gallons/ERC
=	0.448	AF/ERC
Outdoor state standard demand =	2.69	AF/irr. Acre
=	0.223	AF/ERC
State Standard Annual Demand =	2,396	acre-feet
State Standard Annual Demand =	1,485	gpm *(compare to 1,123 gpm)*

State standard values for annual average demand are defined within R309-510-7

Demands Based on Measured Production Volumes

Estimated peak day flow using production data (peak month+20%) =	2,946	gpm *(from Sep. 2016 DWR data)*
Demand per ERC using peak month+20% =	0.83	gpm/ERC
From daily meter readings, the overall highest value was	3,185	gpm (July 6, 2017)
From daily meter readings, the highest 3 day average was	2,754	gpm (June 23 to 25, 2017)
Peak Day/Average Day peaking factor =	2.62	(using peak month+20%)
Assumed Peak Instantaneous/Peak Day peaking factor =	1.7	(Based on HAL experience)
Calculated peak instantaneous flow =	1.40	gpm/ERC

Future Peak day Model Flow Computation

Existing Moab Population = 5,490

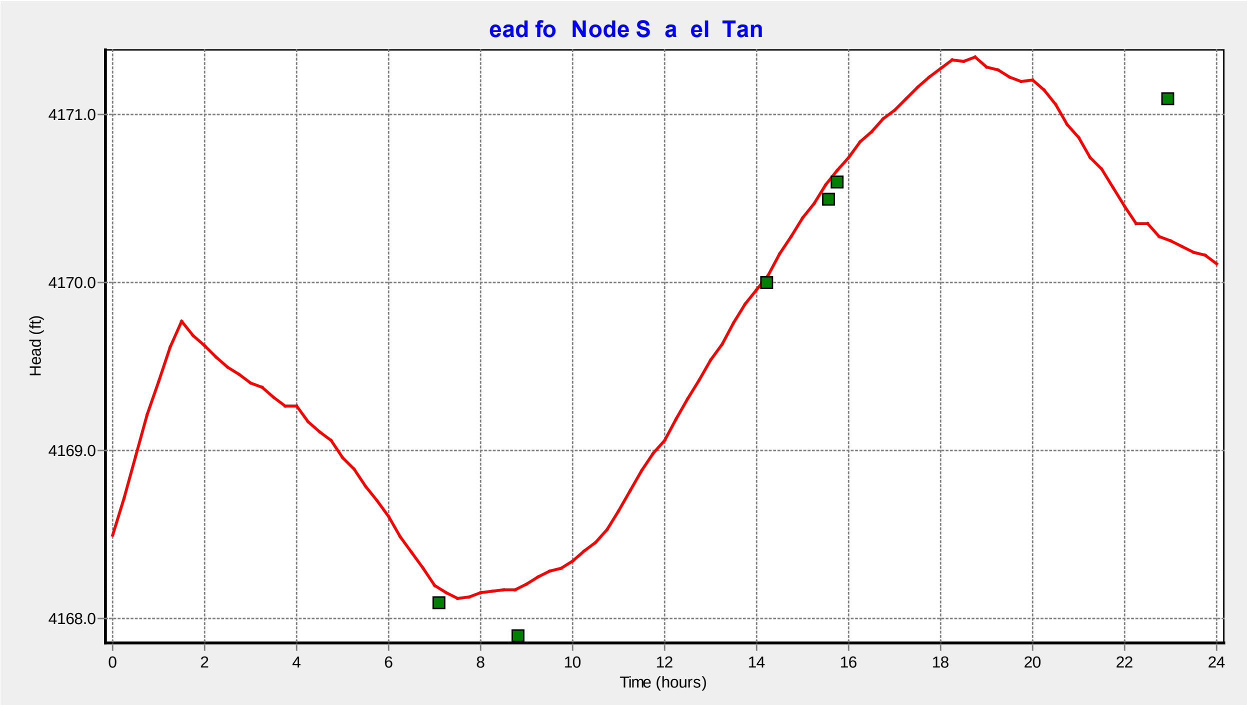
The recent update to Moab's sewer master plan used a growth rate of 1.1% through 2035 and 1.02% between 2035 and 2060. These values result in the following forecasts.

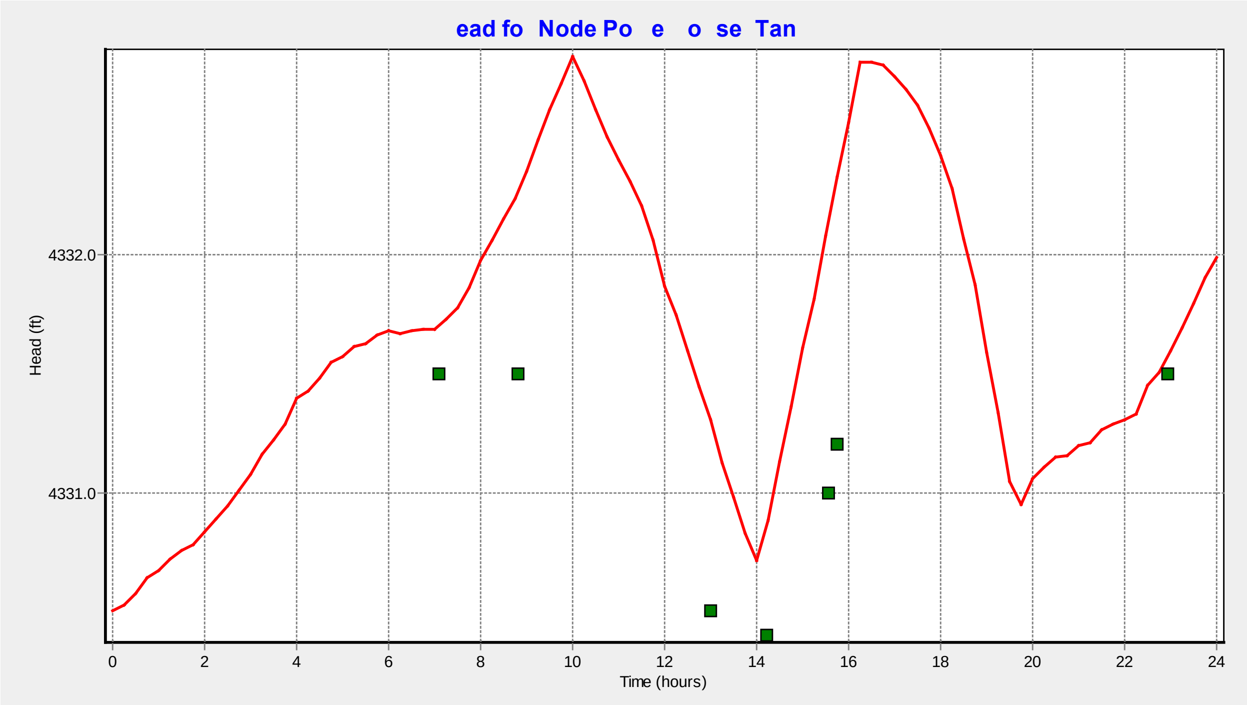
Year	Existing	2020	2025	2030	2035	2060
Population	5,490	5,736	6,058	6,399	6,758	8,710
ERCs	3,569	3,728	3,938	4,159	4,393	5,662

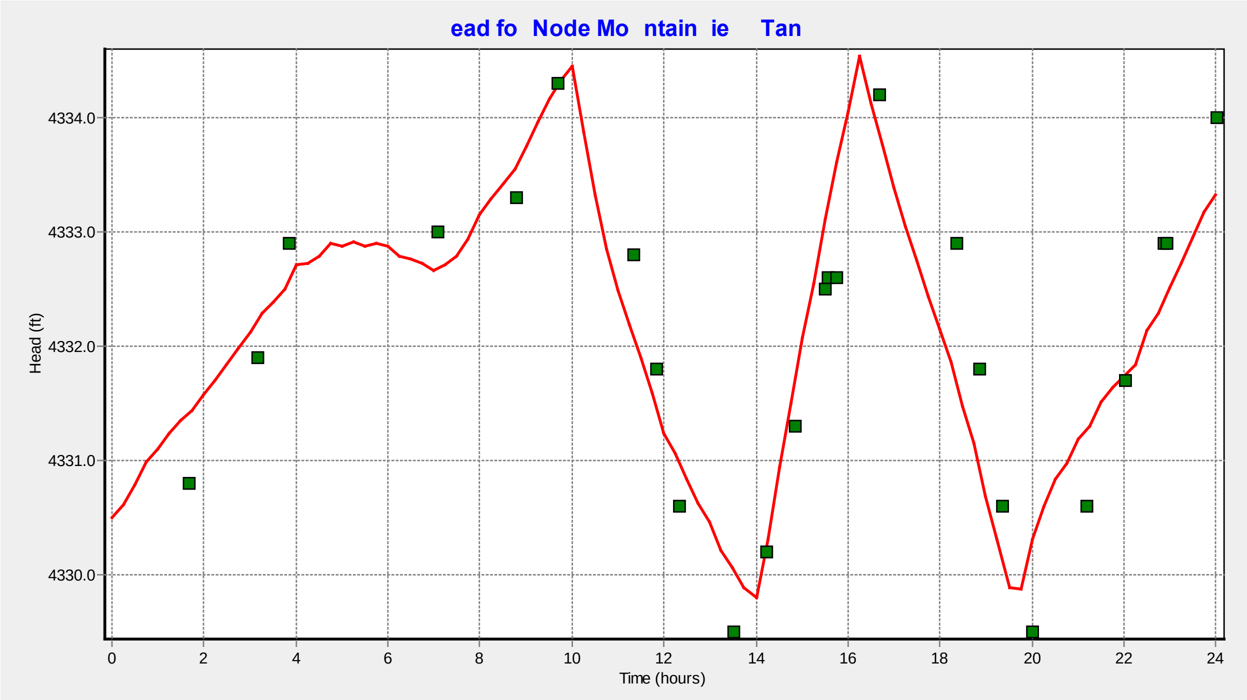
2060 ERCs =	5,662	ERCs
2060 Peak Day Demand =	5,269	gpm
2060 Average Day Demand =	2,356	gpm

APPENDIX B
Calibration Data

Tank Level Calibration Data







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4333.0
4332.0
4331.0
4330.0
Head (ft)
0 2 4 6 8 10 12 14 16 18 20 22 24
Time (hours)

APPENDIX C
Model Data

APPENDIX D
Water Quality Data

Comparison of Field Sampling and Modeled Chlorine Residuals

	Field Samping Results										Model Results			
Chlorine Sampling Location	Jan-17	Feb-17	Mar-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	High	Low	Avg.	Node
Public Works Shop	0.3	0.4			0.3		0.3		0.3		0.35	0.31	0.34	J8982
Riverside Plumbing	0.3			0.3		0.3		0.3		0.3	0.30	0.34	0.32	J4352
City Market	0.3	0.3			0.4		0.3		0.2		0.31	0.37	0.36	J6282
Grand County School District	0.3	0.4			0.3				0.3		0.33	0.35	0.34	J6582
Super 8 Motel	0.3	0.3			0.3		0.3		0.2		0.40	0.41	0.41	J1812
Western Spirit	0.3			0.4		0.4		0.3		0.3	0.36	0.32	0.35	J186
USU Extension Office	0.4				0.4		0.3		0.2		0.35	0.30	0.33	J170
Dr. Hackney Office	0.4				0.4		0.3		0.3		0.38	0.31	0.36	J6300
BLM Office Dog Wood	0.4				0.4		0.4		0.3		0.38	0.29	0.33	J1594
Grand Senior Center		0.4			0.3			0.2		0.2	0.34	0.30	0.33	J508
Sweet Cravings		0.3				0.3		0.3		0.3	0.28	0.25	0.26	J2024
Eastern Utah Credit Union		0.4				0.3		0.3		0.3	0.38	0.36	0.38	J1078
Grand County Credit Union			0.3			0.2		0.2		0.3	0.27	0.20	0.25	J3386
Moab City Hall				0.3		0.3		0.2		0.2	0.32	0.30	0.31	J928
Sleep Inn Motel				0.4		0.3		0.3		0.3	0.37	0.31	0.35	J6260
Shell Gas Station					0.3		0.3		0.2		0.28	0.27	0.27	J4778

Field results represent a snap shot of the day and time water samples were collected. The model results vary continuously and water moves through the system. For this reason a range is provided for the model results.

APPENDIX E
Cost Estimate Calculation

City of Moab - Water Distribution and Storage Master Plan
September 2020 Update
Cost Estimate

MAP ID	Project Description	UNIT	UNIT TYPE	UNIT COST	COST	Contingency (10%) and Engineering (15%)	TOTAL COST	Comment
NA	Develop Source Redundancy	1	each	$1,600,000	$1,600,000	$400,000	$2,000,000	Source Redundancy
NA	Install 2,000 feet of 10-inch pipeline	2,000	foot	$146	$292,000	$73,000	$365,000	Source Redundancy
NA	Springs No. 1, 2 and 3 Redevelopment	3	each	$150,000	$450,000	$112,500	$563,000	
NA	Construct a 2.2 MG Storage Tank	1	each	$2,750,000	$2,750,000	$687,500	$3,438,000	
1	Disconnect and reconnect pipeline	1	each	$21,000	$21,000	$5,250	$26,000	In street
2a	Install 2,600 feet of 10-inch pipe	2,600	foot				$1,871,538	Cost by City, In street
2b	Install 2,700 feet of 12-inch pipe	2,700	foot					See cost above
3	Intall 260 feet of 8-inch pipe	260	foot	$142	$36,920	$9,230	$46,000	In street
4	Install 3,000 feet of 10-inch pipe	3,000	foot	$168	$504,000	$126,000	$630,000	In street
5	Install 1,200 feet of 8-inch pipe	1,200	foot	$120	$144,000	$36,000	$180,000	Out of street
6	Install 1,200 feet of 10-inch pipe	1,200	foot	$168	$201,600	$50,400	$252,000	In street
7	Install 850 feet of 8-inch pipe	850	foot	$142	$120,700	$30,175	$151,000	In street
8	Install 470 feet of 8-inch pipe	470	foot	$142	$66,740	$16,685	$83,000	In street
9	Install 770 feet of 8-inch pipeline	770	foot	$142	$109,340	$27,335	$137,000	In street
10	Install 1,600 feet of 8-inch pipe	1,600	foot	$142	$227,200	$56,800	$284,000	In street
11	Disconnect and reconnect fire hydrant	1	each	$10,500	$10,500	$2,625	$13,000	In street
12	Install 820 feet of 8-inch pipe	820	foot	$142	$116,440	$29,110	$146,000	In street
13	Install 900 feet of 8-inch pipe	900	foot	$142	$127,800	$31,950	$160,000	In street
14	Install 490 feet of 8-inch pipe	490	foot	$142	$69,580	$17,395	$87,000	In street
15	Install 800 feet of 8-inch pipeline	800	foot	$142	$113,600	$28,400	$142,000	In street
16	Install 1,280 feet of 8-inch pipe	1,280	foot	$142	$181,760	$45,440	$227,000	In street
	Install 1,050 feet of 8-inch pipe	1,050	foot	$142	$149,100	$37,275	$186,000	In street
17	Install 500 feet of 8-inch pipeline	500	foot	$142	$71,000	$17,750	$89,000	In street
18	Install 680 feet of 8-inch pipe	680	foot	$142	$96,560	$24,140	$121,000	In street
19	Install 910 feet of 8-inch pipeline	910	foot	$142	$129,220	$32,305	$162,000	In street
20	Disconnect and reconnect fire hydrant	1	each	$10,500	$10,500	$2,625	$13,000	In street
21	Install 740 feet of 8-inch pipeline	740	foot	$142	$105,080	$26,270	$131,000	In street
22	Install 1460 feet of 12-inch pipeline	1,460	foot	$186	$271,560	$67,890	$339,000	In street
	Install 1510 feet of 10-inch pipeline	1,510	foot	$168	$253,680	$63,420	$317,000	In street
23	New Pressure Reducing Valve Sta.	1	each	$100,000	$100,000	$25,000	$125,000	In street
24	Construct new well and well house	1	each	$1,600,000	$1,600,000	$400,000	$2,000,000	$2,265,000
	Install 1450 feet of 10-inch transmission line	1,450	foot	$146	$211,700	$52,925	$265,000	Out of street
25	Construct new well and well house	1	each	$1,600,000	$1,600,000	$400,000	$2,000,000	$2,392,000
	Install 2150 feet of 10-inch transmission line	2,150	foot	$146	$313,900	$78,475	$392,000	Out of street
						TOTAL	**$16,941,538**	

APPENDIX F
Division of Drinking Water Certification

APPENDIX

CHECKLIST FOR HYDRAULIC MODEL DESIGN ELEMENTS REPORT

This hydraulic model checklist identifies the components included in the Hydraulic Model Design Elements Report for

Sept 14, 2020

PROFESSIONAL ENGINEER
No. 318761-2202
BENJAMIN D. MINER
STATE OF UTAH

City of Moab – Water Distribution and Storage Master
(Project Name or Description)

10003
(Water System Number)

City of Moab Water
(Water System Name)

September 14, 2020
(Date)

The checkmarks and/or P.E. initials after each item indicate the conditions supporting P.E. Certification of this Report.

1. At least 80% of the total pipe lengths in the distribution system affected by the proposed project are included in the model. *[R309-511-5(1)]* ☑ BM

2. 100% of the flow in the distribution system affected by the proposed project is included in the model. If customer usage in the system is metered, water demand allocations in the model account for at least 80% of the flow delivered by the distribution system affected by the proposed project. *[R309-511-5(2)]* ☑ BM

3. All 8-inch diameter and larger pipes are included in the model. Pipes smaller than 8-inch diameter are also included if they connect pressure zones, storage facilities, major demand areas, pumps, and control valves, or if they are known or expected to be significant conveyers of water such as fire suppression demand. *[R309-511-5(3)]* ☑ BM

4. All pipes serving areas at higher elevations, dead ends, remote areas of a distribution system, and areas with known under-sized pipelines are included in the model. *[R309-511-5(4)]* ☑ BM

5. All storage facilities and accompanying controls or settings applied to govern the open/closed status of the facility for standard operations are included in the model. *[R309-511-5(5)]* ☑ BM

9/14/2020

6. Any applicable pump stations, drivers (constant or variable speed), and accompanying controls and settings applied to govern their on/off/speed status for various operating conditions and drivers are included in the model. *[R309-511-5(6)]*

   ☑ [signature]

7. Any control valves or other system features that could significantly affect the flow of water through the distribution system (i.e. interconnections with other systems, pressure reducing valves between pressure zones) for various operating conditions are included in the model. *[R309-511-5(7)]*

   ☑ [signature]

8. Imposed peak day and peak instantaneous demands to the water system's facilities are included in the model. The Hydraulic Model Design Elements Report explains which of the Rule-recognized standards for peak day and peak instantaneous demands are implemented in the model (i.e., (i) peak day and peak instantaneous demand values per *R309-510, Minimum Sizing Requirements*, (ii) reduced peak day and peak instantaneous demand values approved by the Director per *R309-510-5, Reduction of Sizing Requirements*, or (iii) peak day and peak instantaneous demand values expected by the water system in excess of the values in *R309-510, Minimum Sizing Requirements*). The Hydraulic Model Design Elements Report explains the multiple model simulations to account for the varying water demand conditions, or it clearly explains why such simulations are not included in the model. The Hydraulic Model Design Elements Report explains the extended period simulations in the model needed to evaluate changes in operating conditions over time, or it clearly explains (e.g., in the context of the water system, the extent of anticipated fire event, or the nature of the new expansion) why such simulations are not included in the model. *[R309-511-5(8) & R309-511-6(1)(b)]*

   ☑ [signature]

9. The hydraulic model incorporates the appropriate demand requirements as specified in *R309-510, Minimum Sizing Requirements*, and *R309-511, Hydraulic Modeling Requirements*, in the evaluation of various operating conditions of the public drinking water system. The Report includes:
   - the methodology used for calculating demand and allocating it to the model;
   - a summary of pipe length by diameter;
   - a hydraulic schematic of the distribution piping showing pressure zones, general pipe connectivity between facilities and pressure zones, storage, elevation, and sources; and
   - a list or ranges of values of friction coefficient used in the hydraulic model according to pipe material and condition in the system. In accordance with Rule stipulation, all coefficients of friction used in the hydraulic analysis are consistent with standard practices.

   [R309-511-7(4)]

   ☑ [signature]

9/14/2020

10. The Hydraulic Model Design Elements Report documents the calibration methodology used for the hydraulic model and quantitative summary of the calibration results (i.e., comparison tables or graphs). The hydraulic model is sufficiently accurate to represent conditions likely to be experienced in the water delivery system. The model is calibrated to adequately represent the actual field conditions using field measurements and observations. *[R309-511-4(2)(b), R309-511-5(9), R309-511-6(1)(e) & R309-511-7(7)]* ☑

11. The Hydraulic Model Design Elements Report includes a statement regarding whether fire hydrants exist within the system. Where fire hydrants are connected to the distribution system, the model incorporates required fire suppression flow standards. The statement that appears in the Report also identifies the local fire authority's name, address, and contact information, as well as the standards for fire flow and duration explicitly adopted from *R309-510-9(4), Fireflow*, or alternatively established by the local fire suppression agency, pursuant to *R309-510-9(4), Fireflow.* The Hydraulic Model Design Elements Report explains if a steady-state model was deemed sufficient for residential fire suppression demand, or acknowledges that significant fire suppression demand warrants extended model simulations and explains the run time used in the simulations for the period of the anticipated fire event. *[R309-511-5(10) & R309-511-7(5)]* ☑

12. If the public drinking water system provides water for outdoor use, the Report describes the criteria used to estimate this demand. If the irrigation demand map in *R309-510-7(3), Irrigation Use,* is not used, the report provides justification for the alternative demands used in the model. If the irrigation demands are based on the map in *R309-510-7(3), Irrigation Use,* the Report identifies the irrigation zone number, a statement and/or map of how the irrigated acreage is spatially distributed, and the total estimated irrigated acreage. The indicated irrigation demands are used in the model simulations in accordance with Rule stipulation. The model accounts for outdoor water use, such as irrigation, if the drinking water system supplies water for outdoor use. *[R309-511-5(11) & R309-511-7(1)]* ☑

13. The Report states the total number of connections served by the water system including existing connections and anticipated new connections served by the water system after completion of the construction of the project. *[R309-511-7(2)]* ☑

14. The Report states the total number of equivalent residential connections (ERC) including both existing connections as well as anticipated new connections associated with the project. In accordance with Rule stipulation, the number of ERC's includes high as well as low volume water users. In accordance with Rule stipulation, the determination of the equivalent residential connections is based on flow requirements using the anticipated demand as outlined in *R309-510, Minimum Sizing Requirements*, or is based on alternative sources of information that are deemed acceptable by the Director. *[R309-511-7(3)]* ☑

9/14/2020

15. The Report identifies the locations of the lowest pressures within the distribution system, and areas identified by the hydraulic model as not meeting each scenario of the minimum pressure requirements in *R309-105-9, Minimum Water Pressure*. *[R309-511-7(6)]* ☑ BPM

16. The Hydraulic Model Design Elements Report identifies the hydraulic modeling method, and if computer software was used, the Report identifies the software name and version used. *[R309-511-6(1)(f)]* ☑ BPM

17. For community water system models, the community water system management has been provided with a copy of input and output data for the hydraulic model with the simulation that shows the worst case results in terms of water system pressure and flow. *[R309-511-6(2)(c)]* ☑ BPM

18. The hydraulic model predicts that new construction will not result in any service connection within the new expansion area not meeting the minimum distribution system pressures as specified in *R309-105-9, Minimum Water Pressure*. *[R309-511-6(1)(c)]* ☑ BPM

19. The hydraulic model predicts that new construction will not decrease the pressures within the existing water system to such that the minimum pressures as specified in *R309-105-9, Minimum Water Pressure* are not met. *[R309-511-6(1)(d)]* ☑ BPM
    See report assumptions

20. The velocities in the model are not excessive and are within industry standards. ☑ BPM
    See report assumptions