Chapter 10
Water System Resiliency

2020 City of Billings Water Master Plan
(Draft)

City of Billings, MT

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Introduction

A public drinking water system is a critical component of a city. Resiliency of the overall water system is important so that a high level of service can be maintained for as much as the system as possible during conditions such as: water main breaks, construction projects, maintenance, and power outages. This chapter evaluates:

- Resiliency in each pressure zone.
- Options for providing a second waterline and additional water storage above the Rims.
- Ability to move water from a given zone to a lower zone by pressure reducing stations (PRS).
- Capability to deliver water in the distribution system as well as the existing Water Treatment Plant (WTP) in a long-term area wide power outage.

Pressure Zone Resiliency

Most pressure zones will have a waterline or small area that is a dead-end (doesn't loop around to another area of the pressure zone or connect to another pressure zone). Some are unavoidable and some are short sections of waterline or small areas where it is not cost effective to provide looping or redundancy. All services are important, but some are more critical than others such as hospitals, high volume industrial customers and large commercial areas. The City has to analyze the risk of a service or service area being temporarily out of water versus the cost of additional redundancy for services.

The sections below evaluate redundancy by pressure zone. The evaluation includes how water is supplied to the zone, identifies areas of the zone that lack redundancy or looping and provides potential ways to increase resiliency for the zone.

Zone 1

Zone 1 is a critical zone as it includes the hospitals, downtown, industry and significant commercial area. Zone 1 is normally supplied directly from the High Service Pump Station (HSPS) via the 36-inch Zone 1N and 30-inch Zone 1S waterlines. Zone 1 can also be supplied by Zone 2 and 3E at three locations:

1. Willett Pump Station (Zone 2) – electrical actuated butterfly (remote/local) valve on a 14-inch pipe between the discharge and the suction. Approximate capacity – 7 mgd (capacities based on velocity of 10 feet per second).
2. High Service Pump Station (Zone 2) – 16-inch sleeve valve connecting 30-inch Zone 2 waterline to 24-inch Zone 1 South. Approximate capacity – 9 mgd.
3. Walter Pump Station (Zone 3E) – pressure reducing valve (PRV) on an 8-inch connection between Zone 3E discharge header and Zone 1. Approximate capacity – 2.3 mgd.

If the Zone 1 Swords Park Reservoir is constructed as recommended in Chapter 9, the reservoir would provide storage volume at the northeast portion of Zone 1 which would increase resiliency to the east portion of the pressure zone in the event of a water main break.

There is good looping of waterlines throughout the pressure zone with some dead-end waterlines at dead-end streets or at the boundary of the pressure zone. There are no specific areas identified that need additional redundancy.

Zone 2

Zone 2 is a long zone that stretches from the northeast to the very southwest part of the service area and includes significant commercial areas. Zone 2 is normally supplied directly from HSPS via a 42-inch transmission main that extends to the West End and by pumps at Willett Pump Station pumping from Zone 1. In the future Zone 2 will also be supplied by the West End Water Treatment Plant (WEWTP). Zone 2 can also be supplied by upper zones including Zone 3, Zone 3S, Zone 4 and 4S:

1. Staples Pump Station (Zone 3) – PRV on a 6-inch pipe between the Zone 3 discharge and the Zone 2 suction. Approximate capacity – 1.3 mgd.
2. Thomas Pump Station (Zone 3S) – PRV on a 4-inch connection between Zone 3S discharge and Zone 2 suction. Approximate capacity – 0.6 mgd.
3. Staples Pump Station (Zone 4) – PRV on a 6-inch pipe between the Zone 4 discharge and the Zone 2 suction. Approximate capacity – 1.3 mgd.
4. Thomas Pump Station (Zone 4S) – PRV on a 4-inch connection between Zone 4S discharge and Zone 2 suction. Approximate capacity – 0.6 mgd.

The supplies from Zone 3S and 4S have small capacities as these two zones have very limited storage and there is no other supply to these zones other than Zone 2.

There is good looping throughout the core of the pressure zone. On the fringes there are some dead-end waterlines with small demands. The area south of the Interstate 90 (I-90) on either side of Mullowney Ln is a high growth area that is separated from most of the system by I-90. However, two waterline crossings of I-90 east of Mullowney Ln (connecting to the waterline in Midland Rd) and one west of Mullowney Ln (from 24th St W to East Ln) provide good redundancy to this portion of Zone 2.

One significant Zone 2 area that has one water supply and no looping is a residential area east of N 27th St. that extends for 10 blocks and has one 12-inch waterline from west of N 27th St. to meet demands. An option to provide a second supply would be to incorporate the north block of Zone 1 in Zone 2. See Figure 10-1. This would result in a second 12-inch water supply from the west side of N 27th St. to the east side creating a loop. Moving these waterlines into Zone 2 would result in higher pressure and as a result would need to be coordinated with the customers to determine if the pressure would be too high and if individual PRVs would be required. Pressure divisions valves may also need to be added to assure isolation between Zone 2 and Zone 1. Adding this additional Zone 1 area to Zone 2 is a low-cost solution and is recommended.

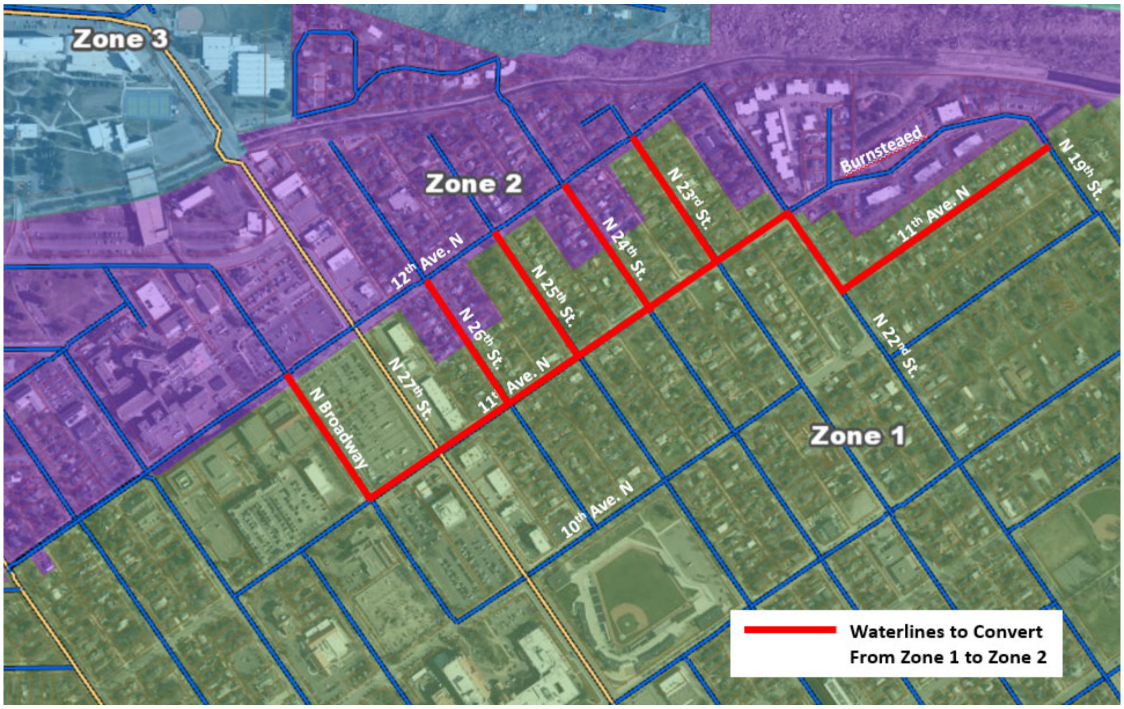

Figure 10-1. Potential Zone 2 Resiliency Improvements

Zone 2E

Zone 2E is the HWD and the City's largest customer. A 16-inch and a 24-inch water line supply the HWD from the Walter Pump Station site. These pipelines are normally fed by a 30-inch waterline directly from the HSPS. The HWD can also be supplied from Zone 1 via Walter Pump Station into either of the 16-inch and 24-inch waterlines. Walter also has a PRV to safely allow water to go from Zone 3E to 2E. In an emergency water could also be supplied to the HWD from Zone 3E via a 12-inch waterline in Wicks Ln at Babock Ln (this waterline does not have flow measurement).

If Zone 3E is fed from a location other than Walter Pump Station, another emergency connection from Zone 3E to 2E might be applicable. One possible location would be west of Hilltop Reservoir where a Zone 3E 20-inch waterline is located. A 16-inch waterline could be installed from the 20-inch waterline near Antelope Tr. and Crestline Dr to the Hilltop Reservoir which is served by a 16-inch waterline. A pressure reducing type valve would be required to lower water pressure from Zone 3E to Zone 2E and a flow meter would be needed to measure the flow going to HWD. See Figure 10-2. The primary benefit of this option along with the redundant feed to Zone 3E is that it provides a means to supply Zone 2E that doesn't go through Walter Pump Station.

Another upgrade if Zone 3E gets a redundant water supply would be to upsize the Zone 3E to Zone 2E PRV (or replace the PRV with a larger electric actuated valve) in Walter Pump Station to allow more water to back feed Zone 2E. This upgrade along with the Zone 1 feed to Walter Pump Station would allow Zone 1 and Zone 3E to meet Zone 2E 2030 maximum day demands in a case where the 30-inch Zone 2E waterline from HSPS is out of service. The redundant supply to Zone 3E would be meeting Zone 3E demands and partial Zone 2E demands.

Upsizing the Zone 3E to Zone 2E PRV connection and the connection to Hilltop reservoir are recommended with the trigger being the redundant water supply from Zone 5 (Airport water system) to Zone 3E.

Figure 10-2. Potential Zone 2E Resiliency Improvements

Zone 3

Zone 3 has a large residential/commercial customer base and is expanding to the west. Zone 3 is normally supplied from Zone 2 via Voelker and Staples Pump Stations and from Zone 1 via Leavens Pump Station during high demands in the summer. In the future Zone 3 will also be supplied by the WEWTP.

There is good looping throughout most of the pressure zone. As major waterlines extend west, however, looping of these mains will be poor or non-existent. A waterline along 48th St W in the future will connect these east-west mains which will provide looping. The majority of the waterlines extending north of Rimrock Rd are also dead-end mains. To connect these dead-end problems, waterlines would need to go through backyards. Looping of these waterlines is not seen as a priority. The Montana State University–Billings (MSUB) area and Mountain View Blvd have only one supply from the Zone 3 waterline at Rimrock Rd and Normal Ave. MSUB does have a Zone 1 emergency connection in Rimrock Rd, but this would be low pressure. The waterlines in Rimrock Rd and Normal Ave and the Zone 3 service to MSUB have recently been replaced to improve resiliency. To provide a second supply to the MSUB area at Zone 3 pressure, a waterline with a booster pump could be routed from the intersection of 12th Ave N and N 22nd St (Zone 2) to Mountain View Blvd (Zone 3). The booster pump could be permanent, or connections provided and a portable pump and generator used in an emergency. The waterline would need to cross the BBWA Irrigation Canal. See Figure 10-3. If fire flow protection is desired from this second water supply the 6-inch waterline in 12th Ave N between N 22nd St and N 23rd St should be upsized from 6-inch to 8-inch and booster pump sized to meet the fire demand.

Based on the recent improvements to the waterlines in the MSUB area, the limited benefit and booster pumping requirement, this connection from Zone 2 to Zone 3 is not currently recommended.

Figure 10-3. Potential MSUB Area Resiliency Improvements

Zone 3E

Zone 3E is supplied only from Walter Pump Station but it can be supplied from Zone 1 or the Zone 2E waterline that comes directly from the HSPS. Zone 3E has good looping with minimal dead-ends. As a waterline is extended up Alkali Creek Rd it will become more isolated. If water service is provided along the Inner Belt Loop (IBL) the Alkali Creek Rd waterline could connect to the Zone 4N waterline along the IBL with a PRV.

Another concept for providing water to Zone 3E would be from Zone 5 via a waterline coming from Zone 5 north to Zone 3E at Alkali Creek Rd. This option is discussed more in the section on Redundancy and Storage Above the Rims later in this Chapter.

A third means to provide a supply to Zone 3E would be to use Zone 2E stored water. Currently the normal Zone 2E feed through Walter Pump Station has check valve so that water from the HWD cannot backflow into the Billings water system. However, in an emergency situation the check valve could be bypassed to allow water to move from Zone 2E to the Zone 3E pumps in Walter Pump Station. The bypass should include flow measurement to know how much flow was coming back from the HWD.

The bypass of the check valve in Walter is recommended as an immediate project. The redundant waterline from Zone 5 to Zone 3E is also recommended. The priority of this project is discussed in the Redundancy and Storage Above the Rims section.

Zones 3S and 4S

Zones 3S and 4S are isolated from the rest of the water distribution system. A 16-inch waterline from Zone 2 runs south on South Billings Blvd, across the bridge on the Yellowstone River, and continues on Blue Creek Rd to supply Thomas Pump Station. Thomas Pump Station then pumps to Zone 3S and 4S. Zone 3S is essentially Cedar Park and Zone 4S is Briarwood. Each subdivision has several dead-end waterlines that would be difficult to connect to another waterline. The following are options that could increase the resiliency of the water supply:

1. A second waterline across the Yellowstone River – a waterline from Songbird Dr could be open cut or directionally drilled under the Yellowstone River and then routed to Blue Creek Rd and supply Thomas Pump Station. Figure 10-4 shows potential routing of this waterline.
2. A second waterline across the bridge on Yellowstone River – the existing waterline attached to the bridge is likely the most vulnerable portion of the supply to Thomas Pump Station. A second pipe on the bridge would provide some measure of redundancy.
3. A second waterline to Briarwood – a waterline could be routed along the emergency road access to Briarwood that goes from Blue Creek Rd along Colleen Dr to Glengarry Ct. This would provide benefit as a second source to Briarwood, but it would still come from the single waterline on Blue Creek Rd.
4. A second waterline to Cedar Park – a waterline could be routed from the existing waterline in Colleen Dr (or second waterline to Briarwood if constructed) through open terrain to the backside of Zone 3S at the Cedar Park Reservoirs. A PRV would be needed to reduce pressure.

The last two options are shown in Figure 10-5. All of these options would be expensive, and most would involve difficult construction. Also, these waterlines have limited potential for additional services. Based on these reasons none of these redundant options are currently recommended.

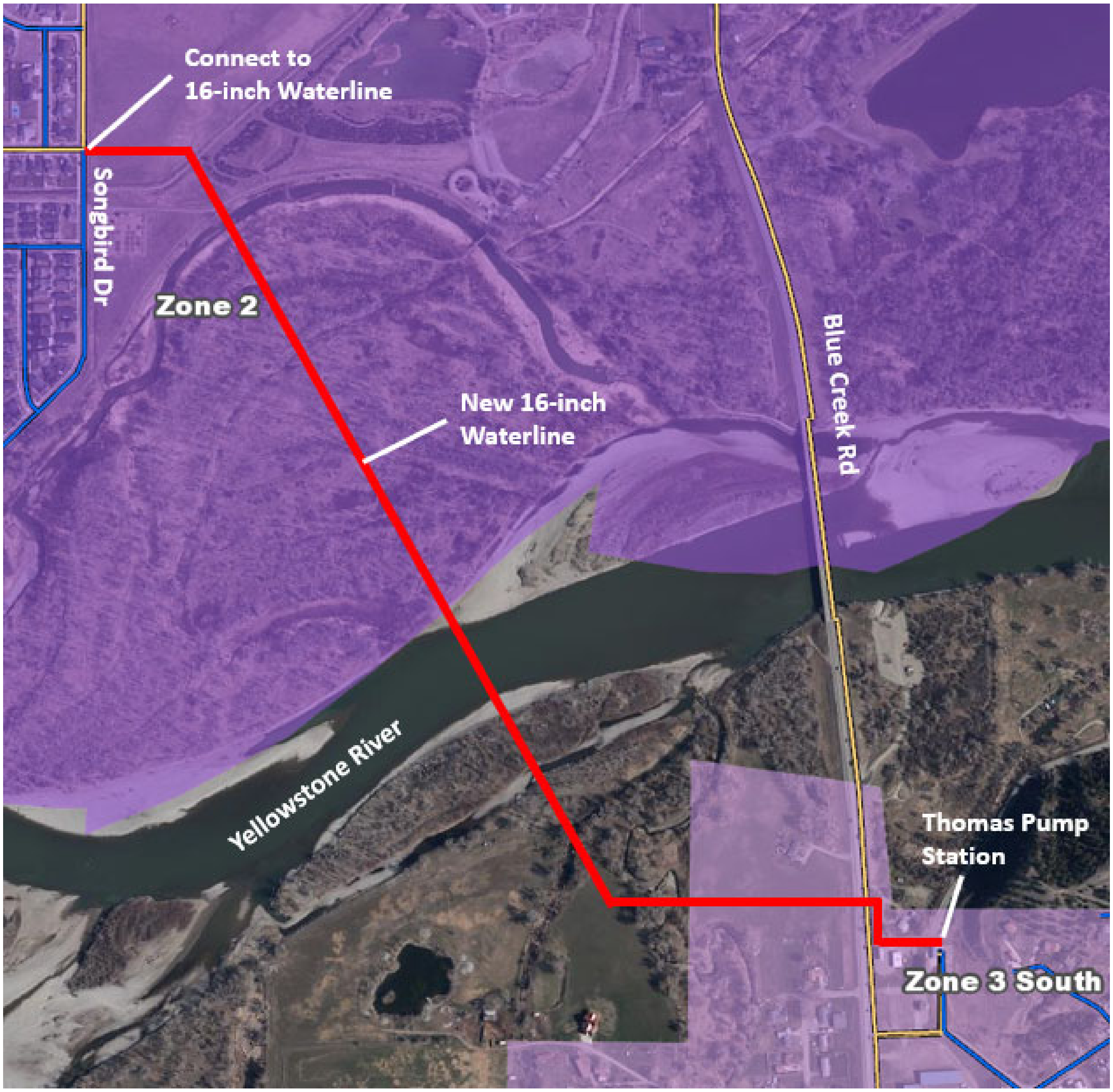

Figure 10-4. Redundant Water Supply Option to Zone 3S/4S

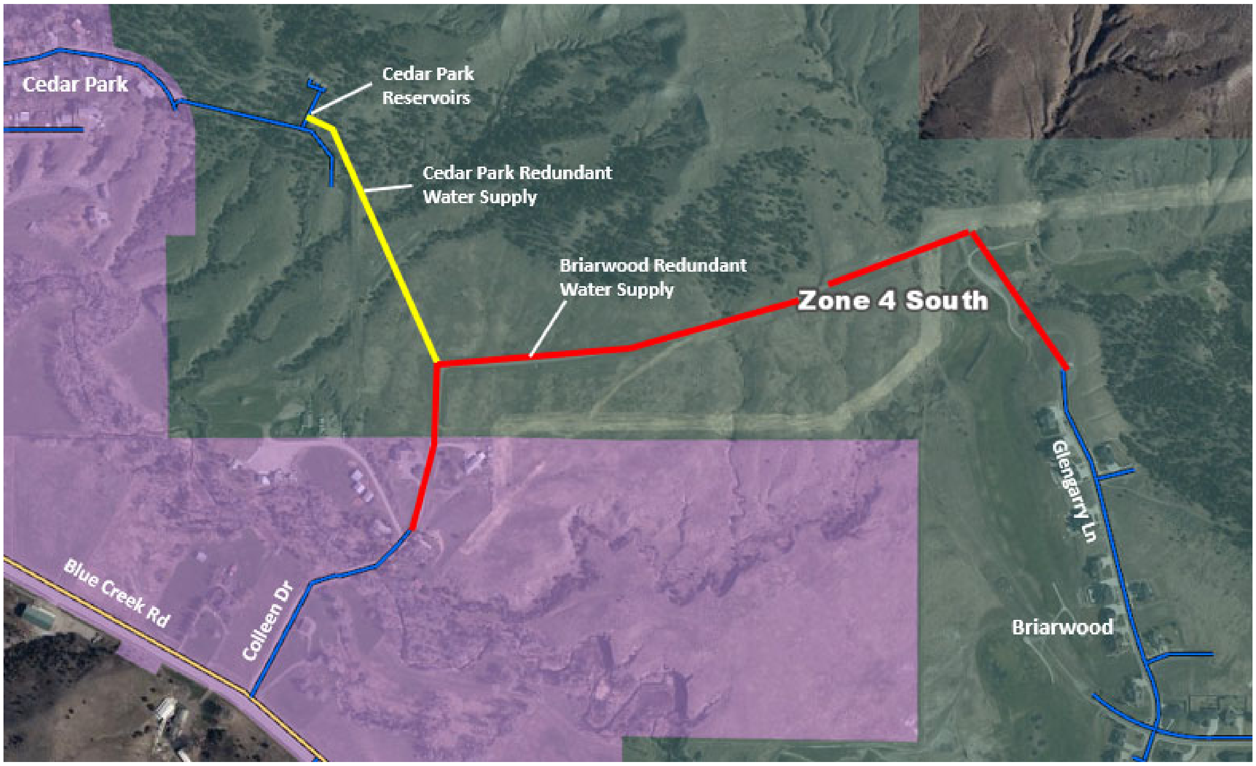

Figure 10-5. Redundant Water Supplies to Cedar Park and Briarwood

Zone 4

Zone 4 stretches along the base of the Rims and is supplied by Staples Pump Station via Zone 2 and Chapple Pump Station via Zone 3. There is good looping of waterlines through subdivisions throughout the zone. The Ironwood and Copper Ridge areas are somewhat isolated due to being at the end of the pressure zone. The Ironwood Reservoir provides a significant water source to Ironwood in an emergency. Similarly, the planned Zone 4 Phipps Park reservoir would provide a supply to Copper Ridge. Two additional water supply considerations to Zone 4 include:

1. The Ironwood Loop – this option would back feed Zone 4 from Zone 6 via a waterline from the Ironwood Reservoir to on top of the Rims and then to Zone 6. This is discussed more in the Redundancy and Storage Above the Rims section below.
2. West End Zone 4 Pump Station – this option would pull from a Zone 3 waterline extended along Grand Ave and pump to the existing Zone 4 waterlines at 70th St W and Rimrock Rd. The pump station could be located near the Zone 3/Zone 4 pressure zones border which would maximize the benefit of new Zone 4 services along its entire discharge. If the pump station isn't built until the new West End Zone 3 reservoir is constructed, the pump station could be located closer to the Zone 3 reservoir depending on the reservoir location. See Figure 10-6 for pump station location options. Another benefit of the Zone 4 pump station is that it would allow the proposed Phipps Park Zone 4 Reservoir to float better with the Zone 4 Ironwood Reservoir without upsizing Zone 4 piping along Rimrock Rd and 70th St W.

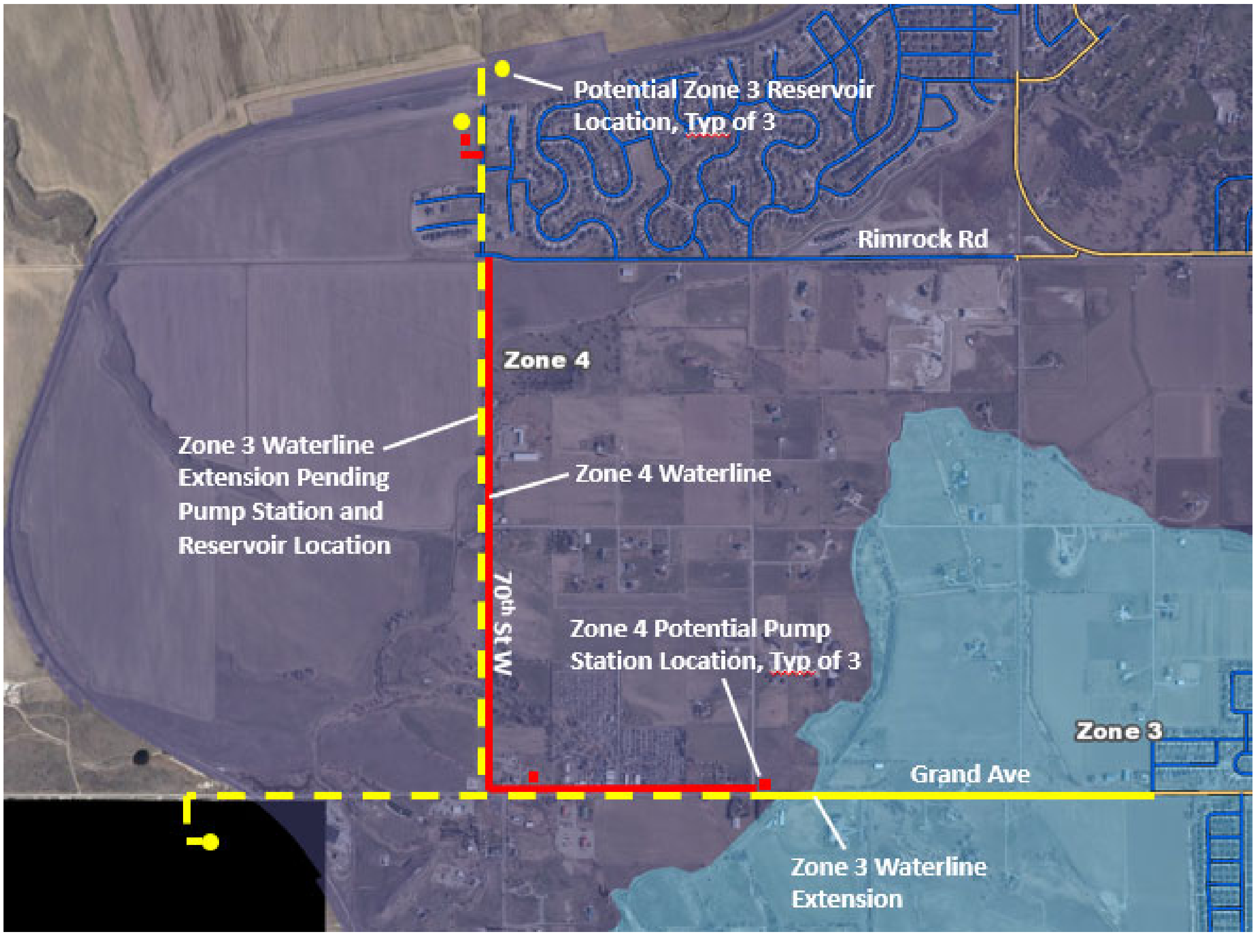

Figure 10-6. West End Zone 4 Pump Station Potential Locations

A West End Zone 4 pump station is recommended not only for redundancy but to also meet increasing demands in Zone 4 on the West End. Based on current peak hour demands in Zone 4 which require all Chapple Pumps to operate, a West End Zone 4 pump station could be an immediate need. Options instead of another pump station would be using more Staples Zone 4 pumps or increasing the capacity of the Chapple pumps. In order o increase the resiliency to a rapidly growing West End, another Zone 4 pump station is recommended in the next 5 years.

Zones 4N and 4E

Zones 4N and 4E located in the NW part of the Heights are served from Zone 3E. Fox Pump Station pumps from Zone 3E to Zone 4N and Terrace Estates Pump Station pumps from Zone 3E to Zone 4E with Zone 4E being the Terrace Estates subdivision. Zone 4N and Terrace Estates subdivision have good looping of waterlines with only a few short dead-ends.

Zone 4N and 4E will eventually combine into one pressure zone as development is planned between the two zones. This will provide redundancy in terms of pumping from Zone 3E. If water service is provided along the IBL, eventually water could be supplied to

Zone 4N from Zone 3E at Alkali Creek Rd and/or Zone 5N via Zone 6. See Chapter 9 for more information on IBL water service and connections.

Zone 5 and 6

Zone 5 consists of the Airport water system. Zone 6 runs along the top of the Rims and includes the Rehberg Ranch subdivision. Zone 5 is fed from Waldo Pump Station via Zone 4 and Waldo Reservoir. Zone 6 is fed from Zone 5 by Christensen Pump Station. The waterline up through the Rims to Waldo Reservoir and Pump Station has recently been repaired at the base of the Rims. The vulnerability of this waterline results in Zone 5 and 6 being considered the highest risk in the distribution system. Options to provide additional water supply to these zones is included in the Redundancy and Storage Above the Rims section below.

Zone 5W

Zone 5W is small pressure zone in the upper part of Ironwood subdivision that has limited growth potential. The zone is fed only from Z4 via Ironwood Pump Station. There are numerous dead-end waterlines that are on dead-end streets at the base of the Rims. These waterlines could be looped together through backyards but there are so few houses on each of these waterlines that the cost is not warranted.

Redundancy and Storage Above the Rims

As discussed earlier there is one waterline that feeds Zone 5 above the Rims and Zone 5 then supplies water to Zone 6. This waterline goes from Staples Pump Station up to Waldo Reservoir and Pump Station. There have been leaks in this waterline recently requiring emergency repairs. Also as discussed in Chapter 8, Logan Reservoir with a storage capacity of 100,000 gallons is the only water storage on top of the Rims. The storage volume is inadequate especially in the situation of fire in Zone 5 or 6.

Previously evaluations have looked at the following options for a second water supply to serve above the Rims:

1. A second parallel line directionally drilled from Staples Pump Station to Waldo Pump Station/Reservoir or directly to Zone 5. For the latter option a Zone 5 pump would be added to Staples Pump Station.
2. A waterline from Ironwood Reservoir (directionally drilled to get up the Rims) to existing Zone 6 waterline near Zimmerman Trail. The pedestal of Ironwood Reservoir is set up for a Zone 6 pump station. The City has already obtained easements for the waterline route from Ironwood to Indian Cliffs, see Figure 9-10. Potential waterline routes from an Indian Cliffs Reservoir to Zone 6 are shown in Figure 8-5.
3. A waterline from Walter Pump Station along Airport Rd to the airport water system (Zone 5). Walter Pump Station is set up to add Zone 5 pumping.
4. A waterline directionally drilled up through the Rims from Rimrock Rd to just west of the Airport entrance connecting into Airport water system. A pump station would be needed near Rimrock Rd.

5. A waterline (open cut) coming from Alkali Creek up the backside of the Airport connecting into the airport water system. A pump station would be required to supply Zone 5 from Zone 3E. This option is shown in Figure 10-7.

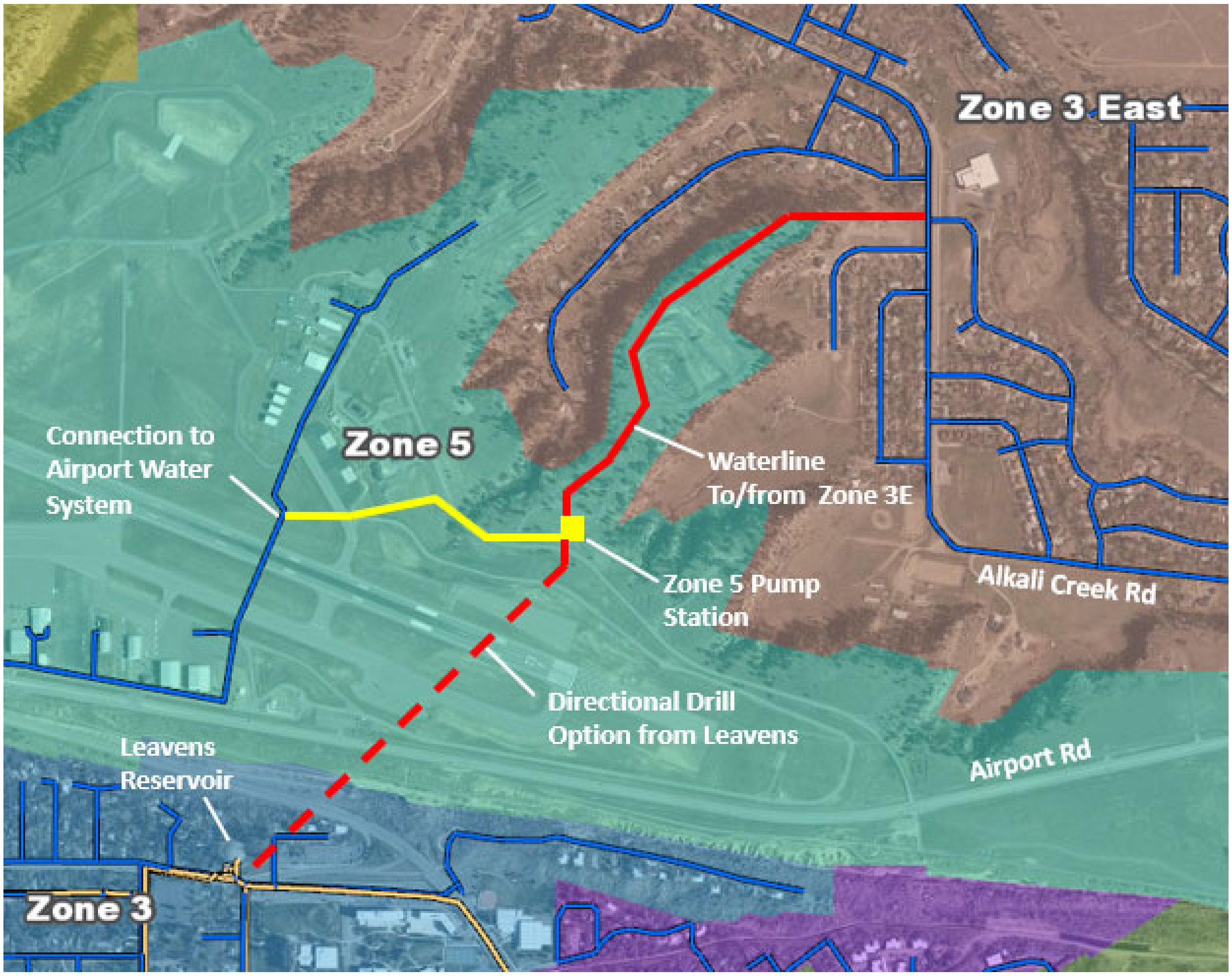

Figure 10-7. Redundant Waterline to top of Rims Options

A recent option (Option 6) developed is directionally drilling a waterline from the Leavens site to the backside of the Airport north of the main runway and then continuing with an open cut waterline down to Alkali Creek connecting into the existing 12-inch waterline. This waterline would connect Zone 3 at Leavens to Zone 3E in Alkali Creek. A pump station located on the north side of the Airport would pump water from this Zone 3 to 3E interconnect into the Airport distribution system. This would then also provide an alternate supply to Zone 6 via Zone 5. Figure 10-7 shows potential waterline routing.

Options 1 and 4 would be difficult to construct and there is concerns of potentially causing rocks along the Rims to fall if directional drilling is used. Option 2 is the most expensive, but when combined with a Zone 6 reservoir provides additional benefits. Option 3 is viable but the length of the waterline results in high costs with no ability to provide service along the route. Option 5 is the most cost effective and provides additional benefit of an emergency supply for Zone 3E and 2E. Option 6 has the most risk with the long directional drilling but provides a lot of benefit by providing second water supplies to Zone 3E and

Zone 5 and indirectly to Zones 2E and 6. The directional drilling adjacent to the Rims and residents could be a concern with this option as well.

The following options for additional storage for Zone 5 or 6 have been considered:

1. A composite Zone 5 elevated reservoir next to Logan.
2. Sites along Rod & Gun Club for a Zone 5 reservoir at grade, partially buried or buried depending on the location.
3. A buried Zone 5 reservoir in Zimmerman Park.
4. An elevated composite Zone 6 reservoir at the west end of Zimmerman Park.
5. A Zone 6 ground storage reservoir at Indian Cliffs subdivision.

Options 1 and 5 with elevated composite reservoirs are the most expensive. Zone 5 is likely limited in growth due to the airport which reduces the long-term benefit of Zone 5 storage. Also, a Zone 5 waterline along Highway 3 from Rod & Gun Club Rd or Zimmerman Park back to Zone 5 is difficult to construct. Option 5 is the least expensive and provides the most benefit for potential future IBL/Zone 6 growth, provides allocated storage for Zone 5 and would benefit a potential Zone 7 pressure zone.

Chapter 8 recommends Zone 6 storage at Indian Cliffs. Assuming this reservoir option is constructed the most cost-effective way to provide a redundant water supply to the top of Rims would be a connection from Ironwood Reservoir to the proposed Zone 6 reservoir. The cost estimate for this connection would be $1,400,000 which does not include an access road along the waterline route. This option would be recommended along with the Indian Cliffs Zone 6 reservoir. Other cost information is included below.

- Connection from Zone 3E to Airport water system with no pump station - $1,100,000
- Pump station to pump from Zone 3E to Airport water system - $1,500,000
- Bore through Rims from Zone 3 to Zone 3E with no pump station - $6,500,000

The Zone 3E to Airport water system and pump station is recommended if/when the waterline through the Rims from Staples Pump Station to Waldo Reservoir/Pump Station fails. This new connection would then maintain two sources of water to the top of the Rims.

Pressure Reducing Stations

The ability to move water from a higher zone to a lower zone is important for distribution system redundancy and resiliency. PRSs are also relied on to move water from a zone with excess storage to a lower zone in a need of stored water. The City has four types of valves at locations where water can move from a higher zone to a lower zone.

1. Manual valve – these valves would need to be operated manually on site. Often the conditions are that the pressure is not known upstream or downstream and there is no flow measurement. Pressure drop is achieved by headloss from high velocities through the partially opened valve.
2. Electric actuated butterfly valve – Willett Pump Station has an electric actuated valve than can be operated locally or remote. Pressure indication is available on the pump suction and discharge headers. No flow measurement is available. Pressure drop for this option is also achieved by high velocities through the partially open valve.

3. Electric actuated sleeve valve – the HSPS has a sleeve valve that can be operated local or remote. This installation has pressure transmitters upstream and downstream of the sleeve valve and a flow meter so the operator knows how much water is being transferred and that the lower zone is not being over pressurized. Pressure drop in this system is achieved through small perforated holes within the valve body.
4. Pressure reducing valves – PRVs are located in numerous locations in the distribution system but primarily in pump stations where the higher zone has water storage. Pressure drop is also achieved within the valve. Most locations would have pressure indication available from pump suction and discharge headers. None of the connections with PRVs have a dedicated flow meter. The PRVs could be used to automatically open and move water if the pressure in the lower zone got too low but in the past the City has found small pressure drops in the lower zone opens the valves unnecessarily. As a result, the PRVs are typically closed off by isolation valves. If water is needed to be moved between zones, then the isolation valves are manually opened and PRVs are allowed to operate.

A sleeve valve with pressure indication and flow measurement is the most reliable means to move water between zones. The pressure and flow indication would allow an operator to safely operate the valve remotely. However, the sleeve valve is an expensive valve and is not recommended in every location where water can be moved between zones. Sleeve valves with pressure and flow indication are recommended where storage in an upper zone is allocated to a lower zone. An operator could then safely move water remotely to a lower zone in an emergency such as a fire in the lower zone.

No new PRSs are currently recommended. Future PRSs, the type of valve and the trigger for the station, are summarized below:

- Zone 3 to Zone 2 at Staples Pump Station – sleeve valve with flow meter (use existing pressure indication). Trigger – only if required when the WEWTP is the only plant operating. See Chapter 6.
- Zone 6 to Zone 5 at Christensen Pump Station – sleeve valve with flow meter (use existing pressure indication). Trigger – when Zone 6 storage is added prior to any additional Zone 5 storage. This would allow adequate storage availability/allocation for Zone 5 including in the event of a fire.
- Zone 6 to Zone 5W at Ironwood Pump Station – electric actuated valve with flow meter and pressure indication on the Zone 6 side (use existing pressure indication on Zone 5W). Trigger – when Zone 6 storage is added. This valve would provide a second source of water to Zone 5W. The Zone 5W pump station is on backup power so the new PRS would be a second backup and therefore a sleeve valve is not warranted.
- Zone 6 to Zone 4 at Ironwood Pump Station – sleeve valve with flow meter (use existing pressure indication on Zone 4 side and same pressure indication on Zone 6 as indicated above). Trigger – when Zone 6 storage is added. This valve would be needed for storage allocation to Zone 4 if Zone 6 storage is added before Zone 4. The other situation would be if there is an emergency water supply needed in Zone 3 or Zone 4 which would likely mean a significant amount of water would be needed.

Based on pressure dropping two pressure zones and the potential for a large flow of water a sleeve valve is recommended.

Water System Backup Power

Overview

Power loss can have devastating impacts on drinking water utilities. If pumps and other facilities are inoperable the system can lose pressure, fire protection can be diminished or lost, and the City can eventually run out of drinking water. The purpose of this section is to analyze the City's water treatment and distribution system to determine if any improvements to backup power are required.

In the past 15 years, the City has transitioned from a system with little to no backup power to a system with 11 stationary generators and 4 portable generators. Today, the system is capable of meeting average day demands during a wide power outage using the onsite generators and the portable generators.

For the analysis in this section the ability to meet current average day demands (ADD) will be verified and the requirements to meet maximum day demands (MDD) will be assessed. The overall ADD and MDD for evaluation are presented in Table 10-1. It is difficult to make predictions about water requirements during a power outage; while there may be a decrease in water use, there may also be a need to increase water use for other emergency related needs such as firefighting.

Table 10-1. Current Water Demands

Average Day Demand (MGD)	Maximum Day Demand (MGD)
20.0	48.6

The Water Treatment Plant (WTP) and pump stations that serve the distribution system pressure zones were analyzed using average day demands and maximum day demands while pump stations that serve closed loop pressure zones were analyzed for peak hour demands for that zone. See Table 3-6 for demand breakdowns by zone.

In both cases the analysis was completed assuming existing water demands. Construction of the West End Reservoir and WEWTP will significantly change the operation of the entire system. These are major components that will add redundancy and resiliency to the system and may shift demands and use of other system components; therefore, predicted *future* water demands were not analyzed in terms of backup power supplies at this time.

Each component of the system was examined to determine the following:

- Is it critical or needed to deliver water?
- Is it operating during average day demands?
- Is it operating during maximum day demands?
- Is it operating during peak hour demands for closed loop situations?
- What are the horsepower requirements to meet these demands?
- Is standby power currently available and can it meet the demands?

Portable Generators

The evaluation below includes making use of the City's portable generators that are available to the water system. The diesel engine generators are mounted on trailers and are stored at the WTP. The sizes of the generators are 130 kW, 200 kW and two at 350 kW. Each generator includes at least one breaker with cabling connected to the breaker. The cables can be plugged into docking stations or receptacles and can supply power to motor control centers (MCC) at strategic locations.

Facility Evaluation

Water Treatment Plant

The WTP has two separate power feeds commonly referred to as Line 1 and Line 2, and the plant can operate on either feed. Therefore, this analysis assumes an outage for both power feeds.

The L-Structure, Sedimentation Basin 1, Screening Building, Control Structure, and Low Service Pump Station (LSPS) 1 are all served by the MCC in LSPS 1. There is an existing docking station for a portable generator connection that powers the LSPS 1 MCC. A Kirk Key interlock system will only allow power from either the docking station or the transformer that normally powers the MCC. To meet ADD, the City can run both rapid mixers at the L-Structure and 1 of the 200 horsepower (Hp) pumps to produce 23 mgd using one of the 350 kW portable generators. To meet MDD, the City would run both mixers, two of the 200 Hp pumps and one 60 Hp pump to produce 55 MGD. The 350 kW generator would not be able to meet the power requirement of the additional pumps. An 800 kW generator would be needed to meet MDD. Table 10-2 summarizes LSPS 1 MCC facilities and associated power requirements to meet ADD and MDD.

Table 10-2. Facilities Powered from Low Service Pump Station 1 MCC

Location	Primary Equipment	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
L-Structure	Mixer	125		Yes	Yes
L-Structure	Mixer	125		Yes	Yes
Sedimentation Basin 1	Flocculator	3			
Sedimentation Basin 1	Flocculator	3			
Sedimentation Basin 1	Flocculator	3			
Screening Building				Yes	Yes
Control Structure				Yes	Yes
LSPS 1	Pump 1	200	21.6		
LSPS 1	Pump 2	60	8.6		
LSPS 1	Pump 3	60	8.6		Yes[1]
LSPS 1	Pump 4	200	23		Yes[1]
LSPS 1	Pump 5	200	23	Yes	Yes

[1]Equipment needed to meet MDD but not sufficient generator capacity

The L-Structure, Intake 2, LSPS 2, Sedimentation Basin 2, and the Mixer Building are all served by the MCC in LSPS 2. The L-Structure can be fed from either the LSPS 1 or LSPS 2 MCCs. For this evaluation it is assumed the L-Structure is fed from LSPS 1. The LSPS 2 backup power system includes a docking station to connect to a portable generator and a Kirk Key interlock to transfer power to the LSPS 2 MCC. To meet the ADD, the City can operate one jet mixing pump (if needed for chemical addition) at the mixer building, flocculators in Sedimentation Basin 2, and one 200 Hp pump at the LSPS 2 to produce 22 mgd using one 350 kW generator. To meet the MDD, the City would need to operate one pump (if needed for chemical addition) at the mixer building, flocculators in Sedimentation Basin 2, and three 200 Hp pumps at the LSPS 2 which would produce more than 60 mgd. The 350 kW portable generator would only be able to power two of the 200 Hp pumps. As a result 40 MGD could be supplied to the system, but with no chemical mixing or flocculation. An 800 kW generator would be required to meet MDD. Table 10-3 summarizes LSPS 2 MCC facilities and associated power requirements to meet ADD and MDD.

Table 10-3. Facilities Powered from Low Service Pump Station 2 MCC

Location	Primary Equipment	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Intake 2					
Mixer Building	Pump 1	125		If Needed	If Needed
Mixer Building	Pump 2	125			
Sediment Basin 2	Flocculator	3		Yes	Yes[1]
Sediment Basin 2	Flocculator	3		Yes	Yes[1]
Sediment Basin 2	Flocculator	3		Yes	Yes[1]
LSPS 2	Pump 1	200	20	Yes	Yes
LSPS 2	Pump 2	200	20		Yes
LSPS 2	Pump 3	200	20		Yes[1]
LSPS 2	Pump 4	200	20		

[1]Equipment needed to meet MDD but not sufficient generator capacity

The Filter Building MCCs are served by a 230 kW generator that includes an ATS for switching to backup power. Aside from the Filter Building, the MCCs supply power to the Chemical Building and the Operations Building. The generator has sufficient capacity to provide power to all facilities in these buildings with components at full capacity.

The High Service Pump Station (HSPS) and UV building are powered by the 5 KV switchgear in the HSPS. This switchgear has manual backup power provisions from a 2000 kW medium voltage onsite generator that utilizes a Kirk Key interlock system to transfer power. The existing generator can supply adequate power to the two UV reactors, Transfer Pumps H1 or H5 and H3 or H4, and High Service Pumps H1-3 and H2-3 for a total of 30 MGD. These conditions are adequate to meet the ADD, but not the MDD. A second 2000 kW generator would be required to meet MDD. Table 10-4 summarizes HSPS facilities and associated power requirements to meet ADD and MDD.

Table 10-4. Facilities Powered from High Service Pump Station 5 KV Switchgear

Location	Primary Equipment	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD[1]
HSPS Transfer	H1	250	15		Yes
HSPS Transfer	H2	450	25		Yes
HSPS Transfer	H3	350	20	Yes	
HSPS Transfer	H4	350	20		Yes
HSPS Transfer	H5	250	15		
UV Building				Yes	Yes
HSPS Zone 1	H1-1	700	16.2		
HSPS Zone 1	H1-2	300	10	Yes	Yes
HSPS Zone 1	H1-3	700	20		Yes
HSPS Zone 2	H2-1	1250	21.2		Yes
HSPS Zone 2	H2-2	1250	21.2		
HSPS Zone 2	H2-3	900	11.6	Yes	
HSPS Zone 2	H2-4	900	14.4		

[1]Pumps needed to meet MDD but insufficient generator capacity to run all the required pumps

In summary for the WTP, all facilities required for treatment and delivery of treated water from the WTP have backup power provisions. LSPS 1 is the limiting factor with a 23 MGD delivered capacity on generator backup power, HSPS is next limiting at 30 mgd and then LSPS 2 is at 40 mgd (with no mixing or flocculation). The future new WEWTP is projected to have a delivered capacity of 18 MGD. If two separate power feeds are provided to the new WTP and it is on full backup generator power, the new WTP would have similar power provision resiliency as the existing WTP and together would meet a 40 mgd demand. Facilities and options for meeting the MDD at the existing WTP only are summarized below:

- Provide 800 kW permanent backup generators at LSPS 1 and LSPS 2. An alternative to this would be to bypass LSPS 2 and Sedimentation Basin 2 and pump directly to the filters from LSPS 1. This would require only one additional 800 kW generator. Counting on this alternative would be risky during late summer when the WTP needs to meet MDDs during low river levels which means short detention times in Sedimentation Basin 1. The result could be poor water quality going on top of the filters and increasing the amount of backwashing required resulting in even lower detention time and even worse quality water in Sedimentation Basin 1.
- Provide a second medium voltage 2000 kW generator at the HSPS. One generator could feed one side of the 5 KV switchgear and the second generator feed the other side of the switchgear. An option to this would be to provide a low voltage 1250 kW generator to power the 480 volt switchboard in the HSPS and switch Transfer Pump H4 to be fed from the 480 volt switchboard instead of the 5 KV switchgear. This would allow the new generator/480 volt switchboard to provide backup power to the UV Building, Transfer Pumps H2 and H4, High Service Pump H1-2 and the ancillary power of the HSPS. The 2000 kW generator would then power High Service pumps.

H1-3 and H2-1 and Transfer Pump H1. The combination of pumps could supply approximately 51 MGD.

Willett Pump Station and Reservoir

The Willett site backup power provisions include a docking station for use of a portable generator and a Kirk Key interlock system for transferring power from the generator. Also included is a small 120 volt natural gas generator with an automatic transfer switch for providing backup power to the control panel. An uninterruptable power supply (UPS) in the control panel will provide instantaneous power transfer on loss of utility power and the generator/ATS will provide transfer of power soon after utility loss of power. This setup allows for long-term backup power provisions for the control panel automatically and therefore doesn't require City staff to tend to or maintain the site during a power outage. The other benefit of the continuous power to the control panel is the reservoir level signal is also available which is important for operating the Zone 1 pumps at the HSPS. No pump operation is required at the Willett Pump Station to meet the ADD. One pump is required to meet the MDD. The 200 kW portable generator would adequate for the power requirement.

No changes are currently recommended for the Willett Pump Station. There are enough portable generators to have one dedicated to the Willett Pump Station in a system wide power outage. In the future when the WEWTP is on-line, the Willett Pump Station may play a more important role depending how the overall system is operated. In this situation, permanent backup power should be considered at the Willett Pump Station. Table 10-5 summarizes Willett facilities and associated power requirements to meet ADD and MDD.

Table 10-5. Willett Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 1	200	5		Yes
Pump 2	200	5		

Walter Pump Station

The Walter Pump Station has a 550 kW permanent generator plus the same setup as the Willett Pump Station with a docking station and small natural gas generator. The utility power and the permanent generator are connected to an ATS to power the MCC. The docking station is Kirk Key interlocked with the MCC main breaker. The City can meet the ADD and the MDD by running either Pump 2 or Pump 4. The 550 kW generator is sufficient to meet the power requirements of both these pumps. Table 10-6 summarizes Walter facilities and associated power requirements to meet ADD and MDD.

Table 10-6. Walter Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 1	250	5		
Pump 2	125	5	Yes	Yes
Pump 4	125	5		
Pump 6	125	3.75		

Terraces Estates Pump Station

Terrace Estates in not currently equipped with backup power. If needed, the 130 kW portable generator could run all three pumps in the pump station. A receptable for the generator would need to be added. To power the entire pump station a small 120 volt generator and transfer switch would be required. Table 10-7 summarizes Terrace Estates facilities and associated power requirements to meet peak hour demand.

Table 10-7. Terrace Estates Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet Peak Hour Demand
Pump 1	20	0.72	Yes
Pump 2	20	0.72	
Pump 3	5	0.09	

Fox Pump Station and Reservoirs

The Fox Pump Station is equipped with backup power supplied from a permanent 150 kW generator and an ATS. The Fox Pump Station pumps into a closed system with no reservoir, therefore it is critical that pumps are running immediately in a power outage and the pumps must meet the peak hour demand. Any pumps running at the pump station during a power transfer from utility to generator will shut off, however once power is restored the pumps should re-start independently. To meet peak hour demands Pump 4 is required and the existing 150 kW generator is sufficient to meet this power need. In case of a fire and a power outage, Pumps 5 or 6 would be needed, and the existing generator is adequate to operate one of these pumps. No changes to backup power provisions at Fox Pump Station are recommended. Table 10-8 summarizes Fox facilities and associated power requirements to meet peak hour demand and fire demands.

Table 10-8. Fox Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet Peak Hour	Operated to Meet Fire Demand
Pump 1	5	0.09		
Pump 2	7.5	0.18		
Pump 3	15	0.36		
Pump 4	30	0.79	Yes	
Pump 5	75	2.34		Yes
Pump 6	75	2.34		

Thomas Pump Station

The Thomas Pump Station is equipped with backup power supplied from an existing 250 kW generator located at the site. In the event of a power outage, the generator will automatically start and transfer power via an ATS. To meet the ADD, the City can run Pump 4 to serve Briarwood and one of the Cedar Park pumps. To meet the MDD, the City can run Pump 2 or 3 to serve Briarwood one of the Cedar Park pumps. The Thomas Pump Station can meet the ADD and the MDD with backup power. In the event of a fire and a power outage, the 200 Hp pump may be needed and the generator is adequate to power this pump. Additional backup power provisions are not required at this site at this time. Table 10-9 summarizes Thomas facilities and associated power requirements to meet ADD and MDD.

Table 10-9. Thomas Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD	Operated to Meet Fire Demand
Pump 1 Briarwood	200	2.16			Yes
Pump 2 Briarwood	75	0.86		Yes	
Pump 3 Briarwood	75	0.86			
Pump 4 Briarwood	20	0.22	Yes		
Pump 1 Cedar Park	7.5	0.29			
Pump 2 Cedar Park	7.5	0.29	Yes	Yes	

Leavens Pump Station and Reservoir

Backup power provisions for the Leavens site are the same as the Willett Pump Station. The Leavens Pump Station pumps are occasionally operated in the summer for peak demands but are not required. Staples and Voelker can provide additional pumping to Zone 3. No change to the backup power provisions is recommended. Table 10-10 summarizes Leavens' pumps' power requirements.

Table 10-10. Leavens Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 1	150	3		
Pump 2	250	5		
Pump 3	400	7.2		

Voelker Pump Station

The Voelker Pump Station is equipped with backup power supplied from a 400 kW onsite generator with an ATS. The ADD can be supplied by running any one of the four pumps and the MDD can be supplied by running two of the 200 Hp pumps (Pump 2, 3, or 4). The generator can supply adequate power to the pumps to meet the ADD and the MDD. No change to backup power provisions is recommended. Table 10-11 summarizes Voelker facilities and associated power requirements to meet ADD and MDD.

Table 10-11. Voelker Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 1	175	4.3	Yes	
Pump 2	200	5		Yes
Pump 3	200	7		Yes
Pump 4	200	5		

Staples Pump Station and Reservoirs

The Staples site is equipped with backup power supplied from a 500 kW onsite generator and ATS. The station also has a docking station for a portable generator. The portable generator via the docking station and the permanent generator, supply a manual transfer switch. The manual transfer switch and utility power supply the ATS to power the pump station MCC. To meet the ADD, Pump 3-2 or 3-3 and Pump 4-2 are required. For the MDD, Pumps 3-2, 3-3, and Pump 4-2 are required. The 500 kW generator is capable of powering the pumps required to meet the ADD and the MDD. No change to the backup power provisions is recommended. Table 10-12 summarizes Staples facilities and associated power requirements to meet ADD and MDD.

Table 10-12. Staples Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 3-2	100	3	Yes	Yes
Pump 3-3	100	3		Yes
Pump 3-4	200	5		
Pump 4-2	250	3	Yes	Yes
Pump 4-3	250	3		
Pump 4-4	250	3		

Chapple Pump Station and Reservoirs

The Chapple Pump Station is equipped with backup power supplied from a 300 kW natural gas onsite generator and ATS. To meet the ADD, one of the pumps is needed and for the MDD two pumps are needed. The 300 kW generator is capable of meeting the ADD and the MDD however meeting the MDD with the two pumps is marginal. Staples Zone 4 pumps can also be used to meet demand in Zone 4. No change to the backup power provisions is recommended. Table 10-133 summarizes Chapple facilities and associated power requirements to meet ADD and MDD.

Table 10-133. Chapple Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD
Pump 1	150	3	Yes	Yes
Pump 2	150	3		Yes
Pump 3	150	3		

Ironwood Pump Station and Reservoir

The Ironwood site is equipped with backup power supplied from a 250 kW onsite generator and an ATS. The Ironwood Pump Station supplies a closed system and therefore must always be operable to maintain pressure. Pump 3 or 4 is needed to meet peak hour demands. In the case of a power outage and a fire, Pump 5 would be required. The generator is capable of powering all of these pumps. No change is recommended to the backup power provisions at this site. Table 10-144 summarizes Ironwood facilities and associated power requirements to meet peak hour demand and fire demand.

Table 10-144. Ironwood Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet Peak Hour	Operated to Meet Fire Demand
Pump 1	7.5	0.13		
Pump 2	15	0.25		
Pump 3	20	0.5	Yes	
Pump 4	20	0.5		
Pump 5	100	2.5		Yes

Waldo Pump Station and Reservoir, Christensen Pump Station and Logan Reservoir

The Waldo Pump Station and Christensen Pump Station backup power provisions include one 300 kW onsite generator located at the Waldo site and an ATS at each pump station. If utility power is lost at either pump station the generator will start and the associated ATS will switch to generator power. For the Waldo Pump Station to meet the ADD, Pump 4 is needed and for the MDD Pumps 2 and 4 are required. The Waldo Pump Station supplies Zone 5 and Zone 6 is supplied from Zone 5. Since the Logan Reservoir has a volume of only 100,000 gallons, Pump 3 is required if there is a fire in either pressure zone. The Christensen Pump Station supplies Zone 6 which is a closed loop and pumps must operate continuously to meet the peak hour demand and maintain pressure. To meet peak hour demand, Pumps 2, 3 or 4 are required. In the event of a fire and power loss, Pump 5 would be needed. The 300 kW generator is adequate to meet the ADD and the MDD at the Waldo Pump Station and the peak hour demand at the Christensen Pump Station. In the event of a fire the generator is also sufficient to simultaneously power Pump 3 at the Waldo Pump Station and Pump 5 at the Christensen Pump Station. As a result, no change is recommended for backup power provisions. Table 10-155 summarizes the Waldo facilities associated power requirements to meet Zone 5 ADD and MDD and Zone 6 fire demand.

Table 10-166 summarizes the Christensen facilities and associated power requirements to meet Zone 6 peak hour demand and fire demand.

Table 10-155. Waldo Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet ADD	Operated to Meet MDD	Operated to Meet Zone 6 Fire Demand
Pump 1	60	1.4			
Pump 2	20	0.36		Yes	
Pump 3	150	3.6			Yes
Pump 4	25	0.36	Yes	Yes	

Table 10-166. Christensen Pump Station

Pump ID	Horsepower	Capacity (MGD)	Operated to Meet Peak Hour	Operated to Meet Fire Demand
Pump 1	7.5	0.14		
Pump 2	30	0.5	Yes	
Pump 3	30	0.5		
Pump 4	30	0.5		
Pump 5	75	2.4		Yes

Portable Generator Distribution

In the event of system wide power outage including both power feeds at the WTP the distribution of the four power portable generators would be as follows:

- One 350 kW generator at LSPS 1.
- One 350 kW generator at LSPS 2.
- 200 kW generator at Willett Pump Station if needed.
- 130 kW generator at Terrace Estates once receptacle is installed.

Backup Power Provisions Recommendations

The scope of the water system backup power provisions evaluation is a high-level approach. When or if improvements are planned for any of these facilities, a more detailed analysis of actual power usage of the site plus projected power usage of equipment needed to meet the ADD and MDD should be completed. Below is a summary of the recommendations.

Average Day Demand

The only potential improvement required to meet average demand in a system wide power outage would be a 120 kW permanent generator at Terrace Estates. Terrace Estates previously was supplied directly from Zone 3E at Zone 3 pressure and so the subdivision could still have adequate water supply in the event of a power outage, it would just be a lower pressure. Therefore, no improvements are recommended.

Maximum Day Demand

The booster pumps stations can meet maximum day demand in a system wide power outage without any improvements assuming Terrace Estates is operating on Zone 3E pressure. The existing WTP can only deliver about 20 mgd without utility power. Three additional generators would be required for the WTP to meet MDD on backup power. It is recommended to not do any backup power improvements at the existing WTP now and to evaluate the WEWTP backup power provisions/delivered capacity do determine an overall backup power approach for the two WTPs.

Miscellaneous

The following summarizes additional backup power recommendations:

- Voelker Pump Station: Once the new West End WTP is on-line, consideration should be given to moving the existing 400 kW generator and ATS to the Willett Pump Station. The Willett Pump Station docking station and 120 volt generator could be relocated to the Voelker Pump Station or a new docking station and small generator could be purchased.
- Complete controls and wiring upgrades to pump stations as required so that on loss of power alarms can be cleared and pumps restarted remotely.
- Continue replacement of UPSs in control panels throughout the system with the new City standard UPS.

Summary of Recommendations

A summary of the recommendations provided above, the associated trigger and cost estimates follows:

- Conversion of upper Zone 1 (11th Ave N from N Broadway to N 19th St) to Zone 2. Trigger – current need. The only required cost would be to connect the 12-inch waterline at 11th Ave N and 22nd St N to the 6-inch waterline in Burnstead. Potential additional costs would be adding additional pressure zone isolation valves on the south side of 11th Ave N and individual PRVs if customers in the modified area feel their pressure is too high. Worst case estimate cost is $74,000.
- Upsize Zone 3E to Zone 2E PRS at Walter Pump Station. Trigger – connection from Zone 3E to the Airport water system. Estimated cost assuming an electrical actuated butterfly valve - $50,000.
- Connection of Zone 3E to Hilltop Reservoir. Trigger – connection from Zone 3E to the Airport water system. Estimated cost - $570,000.
- Bypass of check valve in Walter Pump Station. Tigger – current need. Estimated cost - $113,000.
- West End Zone 4 Pump Station. Trigger – would be beneficial now but recommended within 5 years. Cost estimate assuming pump station is built on Grand Ave where Zone 3 transitions to Zone 4 - $6,000,000.
- Zone 6 pumping at Ironwood Pump Station and waterline from Ironwood to Indian Cliffs. Trigger – construction of the Zone 6 reservoir at Indian Cliffs. Cost Estimate - $1,400,000.
- Connection from Zone 3E/Alkali Creek Rd to the Airport water system including a pump station. Trigger – failure of waterline from Staples to Waldo. Cost Estimate - $3,600,000.
- New PRS at Staples Pump Station from Zone 3 to Zone 2. Trigger – requirement of Zone 3 water transferring to Zone 2 when testing WEWTP to supply the entire distribution system. Cost Estimate - $180,000.

- PRS at Christensen Pump Station from Zone 6 to Zone 5. Trigger – Zone 6 storage. Cost Estimate - $180,000.
- PRS at Ironwood Pump Station from Zone 6 to Zone 5W. Trigger – Zone 6 storage. Cost Estimate - $50,000.
- PRS at Ironwood Pump Station from Zone 6 to Zone 4. Trigger – Zone 6 storage if Zone 6 storage is before Zone 4 storage. Cost Estimate - $180,000.
- Move Voelker Pump Station generator and ATS to Willett Pump Station. Move docking station and small generator at Willett Pump Station to Voelker Pump Station. Cost Estimate - $70,000.
- Complete controls and wiring upgrades at pump stations for restarting pumps remotely on loss of power. Replace UPSs in control panels with new standard UPS. Trigger – current need. Cost Estimate – internal projects.