Sewer Master Plan

February 2016

Prepared by:

Bowen Collins & Associates, Inc.
CONSULTING ENGINEERS

Prepared for:

OREM

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CHAPTER 1
INTRODUCTION

INTRODUCTION

Orem City has retained Bowen Collins & Associates (BC&A) to prepare a master plan for the City's wastewater collection system. The purpose of this sewer master plan report is to identify recommended improvements that will resolve existing and projected future deficiencies in the wastewater collection system throughout the City's service area. The results of this study will be incorporated into a Rate Study that will be used to establish wastewater user rates for the City.

SCOPE OF SERVICES

The general scope of this project involved a thorough analysis of the City's sewer collection system and its ability to meet the present and future wastewater needs of its residents. As part of the Sewer Master Plan, BC&A completed the following tasks.

Task 1: Collected information as needed to develop the sewer master plan based on the City's general plan and existing facilities.

Task 2: Updated population projections and estimated growth in sewer flow to evaluate future growth needs.

Task 3: Developed a hydraulic computer model of the Orem City collection system to evaluate existing and projected future system deficiencies. This included calibrating the model using data from the City's existing GIS database and water meter data from the City.

Task 4: Identified existing operating deficiencies.

Task 5: Identified projected future operating deficiencies.

Task 6: Evaluated alternative improvements for resolving deficiencies identified in Tasks 4 and 5. This included evaluating alternatives looking at diversion locations and reuse opportunities.

Task 7: Developed a comprehensive capital facilities plan incorporating all required improvements identified for the collection system.

Task 8: Documented results of the previous tasks in a report with additional memoranda as needed. As part of this task, BC&A also made presentations to the City's public advisory committee and City Council in meetings throughout the project.

In association with the master planning process, BC&A performed several additional evaluations relative to the Orem City sewer system. The results of these evaluations are contained in technical memoranda attached at the end of this report. This included the following:

- A struvite evaluation at the wastewater reclamation facility
- An evaluation of maintenance and manpower requirements in the City

In conjunction with the master plan, a rate study was also completed by BC&A's financial subconsultant, Lewis Young Robertson & Burningham. The results of their activities are documented in a separate report.

This document is a working document. Some of the recommended improvements identified in this report are based on the assumption that development and/or potential annexation will occur in a certain manner. If future growth or development patterns change significantly from those assumed and documented in this report, the recommendations may need to be revised. The status of development should be reviewed at least every five years. This report and the associated recommendations should also be updated every five years.

ACKNOWLEDGMENTS

The BC&A team wishes to thank the Public Works Advisory Committee as well as the following individuals from Orem City for their cooperation and assistance in working with us in preparing this report:

Chris Tschirki	Public Works Director
Neal Winterton	Water Resources Division Manager
Joseph Jamison	GIS Specialist / Sewer Collection Project Manager
Lawrence Burton	Water Reclamation Section Manager
Tom Phelps	Information Technology

PROJECT STAFF

The project work was performed by the BC&A's team members listed below. Team member's roles on the project are also listed. The project was completed in BC&As' Draper, Utah office. Questions may be addressed to Keith Larson, Project Manager at (801) 495-2224.

Mike Collins	Principle in Charge
Keith Larson	Project Manager
Andrew McKinnon	Project Engineer
Aaron Anderson	Staff Engineer, Sewer Modeling
Mike Hilbert	Clerical

CHAPTER 2
EXISTING SYSTEM FEATURES

INTRODUCTION

As part of this Master Plan, BC&A has assembled an inventory of existing infrastructure within the sewer collection system. The purpose of this chapter is to present a summary of the inventory of Orem City's existing sewer collection system that can be used as a reference for future studies.

SERVICE AREA

The Orem City sewer system service area as shown in Figure 2-1 is approximately 20 square miles and is bordered by the following: Mount Timpanogos to the east, Utah Lake and Vineyard to the west, Lindon City to the north, and Provo City to the south and east. The service area generally follows the corporate boundaries of the City; however, there are some areas that deviate from this general conclusion as a result of topography limitations and historic development patterns. This includes areas of Lindon City (to the north) and the Town of Vineyard (to the west) that are served by the Orem City collection system. There are also small areas at the south end of Orem City that flow to the Provo City wastewater treatment plant. There are even a few small areas of Orem City's collection system that flow through parts of Lindon's collection system on their way to Orem's treatment plant. The areas where each of these situations apply are identified on Figure 2-1.

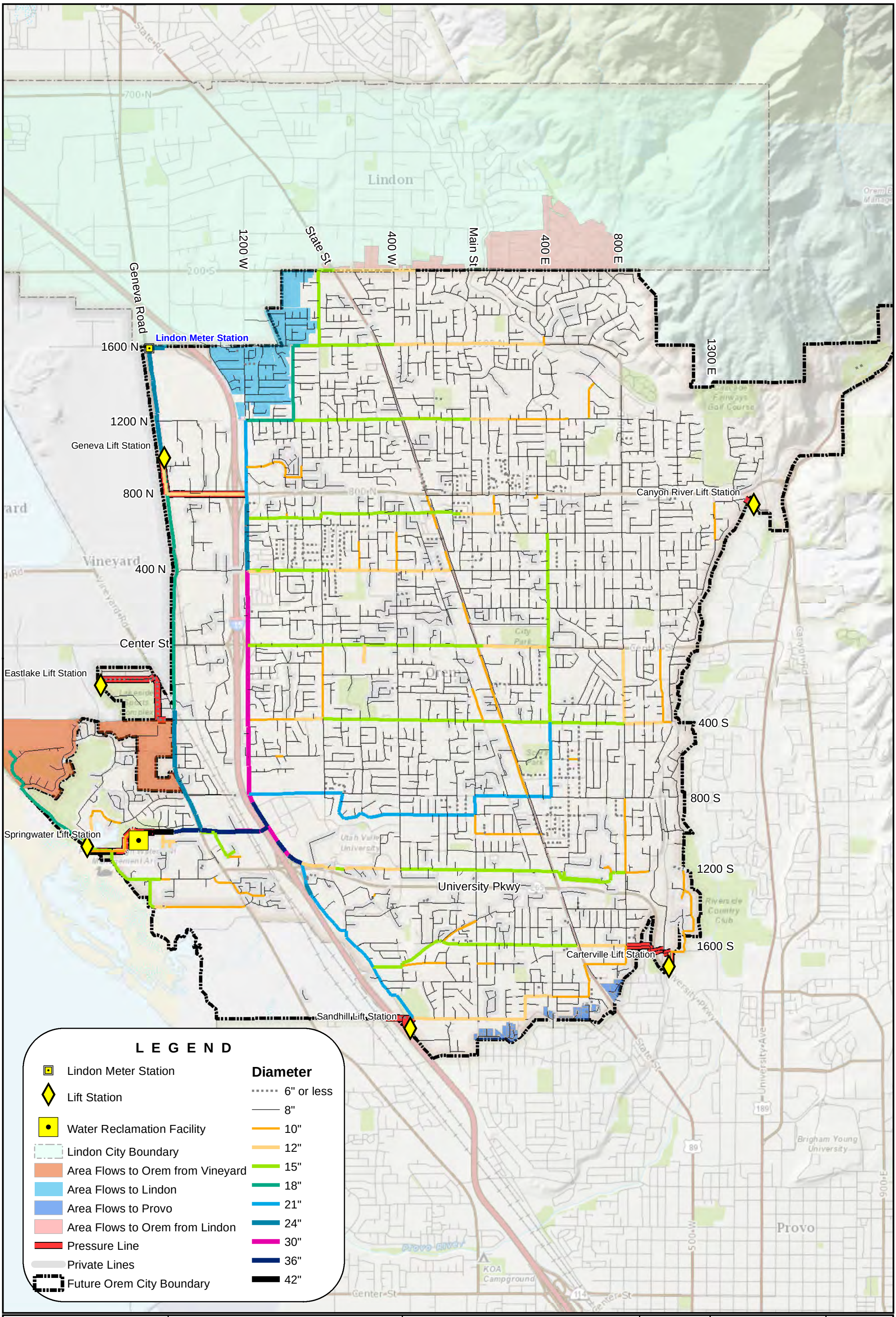
Wastewater from the City's collection system service area is treated at the Orem City Water Reclamation Facility. Additionally, the reclamation facility treats all of Lindon City's existing wastewater, most of which is metered at the Lindon Meter Station indicated in Figure 2-1. In 2014, the total population served by the reclamation facility included approximately 90,000 permanent residents in Orem City with an additional 10,000 permanent residents from Lindon City. In addition to permanent residents, the City also serves the Utah Valley University student and faculty population along with many other commercial, industrial, and institutional entities. The east side of the City is largely residential and is mostly built out. The west side of the City includes significant commercial/industrial, with some large areas still available for future development.

TOPOGRAPHY

The topography of the City generally slopes from northeast to southwest with the City's treatment plant located at the southwest edge of the City (next to Utah Lake). Most of the City collection system flows by gravity to the treatment plant, but a few areas do require lift stations (6 total). All of the wastewater flow from Lindon must be pumped through the City's largest lift station on Genene Road.

COLLECTION SYSTEM

Major attributes of the various components of the collection system are summarized in the following sections.



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OREM CITY
SEWER MASTER PLAN

EXISTING COLLECTION SYSTEM

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 2-1

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Sewer Collection Pipes

There are about 1.5 million feet (286 miles) of sewer pipe and over 6,400 manholes in the Orem City Sewer System that are cataloged in the GIS database. Table 2-1 contains a summary of the sewer pipes for the Orem City sewer collection system. As can be seen in the table, 80 percent of the pipe in the system is 8 inches in diameter. This represents the vast network of small collection mains in neighborhoods throughout the City.

Table 2-1
Sewer Collection System Sizes and Lengths

Diameter	Length (ft)	Length (mi)	Percentage
4*	3,982	0.75	0.3%
6	64,888	12.29	4.3%
8	1,193,295	226.00	78.9%
10	59,253	11.22	3.9%
12	43,472	8.23	2.9%
15	74,131	14.04	4.9%
18	18,182	3.44	1.2%
21	24,777	4.69	1.6%
24	12,040	2.28	0.8%
27	834	0.16	0.1%
30	9,495	1.80	0.6%
33	2,209	0.42	0.1%
36	3,169	0.60	0.2%
42	2,493	0.47	0.2%
Total	**1,512,219**	**286.41**	**100.0%**

*Service laterals are not included in the collection system lengths.

Table 2-2 provides a summary of the pipeline materials used in the City's wastewater collection system. As indicated in the table, concrete pipe is the most common pipe material in the system. There is also a large portion of the system where pipeline material is unknown. Given the age of the areas where pipeline material is unknown, it is suspected that most of this pipe is also concrete. In the end, as much as 80 percent of the collection system may be concrete pipe.

The high percentage of concrete pipe in the City collection system may create some challenges in the future. While concrete is generally a durable, long lasting material, it is extremely susceptible to corrosion associated with hydrogen sulfide gas. As part of the City's long term maintenance plans, it will likely need to perform extensive rehabilitation to protect its existing concrete pipelines from hydrogen sulfide related corrosion. This is discussed in greater detail in subsequent chapters of this report.

Because of its resistance to hydrogen sulfide related corrosion, PVC is now the preferred material of construction for most new sewer mains. As the City continues to rehabilitate and replace older existing lines, it is anticipated that the percentage of PVC will gradually increase.

Table 2-2
Sewer Collection System Materials

Pipe Material	Percentage
Concrete	42.1%
Unknown	39.6%
PVC	15.8%
Other*	2.5%

*Clay, ADS, cast iron, resin liners

Diversions

The City has a single diversion near UVU and I-15 that uses an overflow weir to send excess flow through a parallel pipe underneath I-15 and the UTA and Union Pacific railroad tracks. The overflow is not used under dry weather flow conditions, but may function during wet weather to prevent surcharging conditions. In addition to this diversion, there are a number of manholes in the City that have potential overflow pipes that are primarily used for flushing lines and maintenance. These overflow diversions are discussed more in Chapter 4.

Sewer Lift Stations

There are 6 sewer lift stations in the Orem City sewer collection system that are owned and operated by Orem City. The City's lift stations range in capacity from 300 to 1,200 GPM. Where possible, pump curves and as built drawings were collected for each lift station and are included in Appendix A. A summary of the lift station data is listed in Table 2-3.

Table 2-3
Summary of Sewer Lift Stations

Name	Address	Capacity (gpm)*	Wet Well Volume (cf)	Power (HP)	No. Pumps
Carterville Lift Station	1720 S 1030 E	500	350	40	2
Geneva Lift Station - to Geneva Road	1002 N Geneva Rd	833	1,851	10	2
Geneva Lift Station - to 1200 West	1002 N Geneva Rd	1,187		75	2
Springwater Lift Station	2100 W 1000 S	850	300	23	2
Eastlake Lift Station	1991 W 180 S	300	175	15	2
Canyon River Lift Station	155 N 1550 E	300	280	25	2
Sandhill Lift Station	2082 S Sandhill Rd	300	211	10	2

*each lift station is also equipped with a variable frequency drive to reduce pump cycles and limit stagnation.

Note that the Geneva Lift station can discharge to two different gravity mains (1200 West and Geneva Road) that flow to the City's reclamation facility. For normal dry weather flow, the City normally discharges to Geneva Road. However, for wet weather conditions, inflow from Lindon can significantly exceed normal dry weather flows. For these conditions, the City may pump to 1200 West using a separate set of pumps and force main.

OREM CITY WATER RECLAMATION FACILITY

The Orem City Water Reclamation Facility (WRF) is located at 1797 West 1000 South and was first constructed in 1958. The WRF includes a pretreatment headworks that screens the raw influent prior to pumping it to the main treatment plant for secondary treatment. The secondary treatment process includes primary clarifiers, aerobic and anaerobic digesters, secondary clarifiers, and dissolved air flotation. Solids handling facilities at the WRF include gravity thickeners, an oxidation ditch, return and waste activated sludge, and a belt press. Effluent is treated with ultraviolet disinfection prior to discharging to the Powell Slough toward Utah Lake. The WRF has a peak month, average day capacity of 13.5 mgd, with a peak hydraulic capacity of 21.6 mgd.

These capacities are based upon cursory review of data provided by City personnel. It is recommended that a Facility Study for the entire treatment process be completed. The Facility Study will provide a comprehensive look at the entire treatment process, and would identify cost effective alternatives for meeting the future needs of Orem City.

CHAPTER 3
FUTURE GROWTH AND FLOW PROJECTIONS

INTRODUCTION

Before attempting to hydraulically model and evaluate the City's sewer collection facilities, one must first have an accurate understanding of wastewater flows. This includes an estimate of both the quantity and distribution of existing and future flows. The purpose of this chapter is to summarize the results, assumptions, and process of calculating both existing and future wastewater flows.

There are three major components of wastewater flow: domestic wastewater, infiltration, and inflow. Each of these is discussed in detail in this chapter.

DOMESTIC WASTEWATER

Domestic wastewater includes all wastewater produced by system customers, including both residential and commercial customers. There are several methods that can be used to estimate domestic wastewater flow. This study develops domestic wastewater flow projections based on both full time residential population and employment population. The methodology of this study can be summarized as follows:

1. Define the service area.
2. Divide the service area into a number of smaller sub-areas using geographical information system (GIS) mapping.
3. Project residential population for each sub-area based on existing and projected patterns of development.
4. Project employment and other non-residential populations for each sub-area based on existing and projected patterns of development.
5. Adjust projections as required to accommodate areas of special growth consideration including "planned development" zones (PD Zones), Utah Valley University, University Mall Redevelopment, and the Southwest Annexation Area.
6. Estimate the domestic wastewater contribution of each factor (residential and non-residential) based on a statistical analysis of existing levels of development and historic water use in each sub-area.
7. Convert projections of residential and non-residential development to wastewater flow rates based on their historic contributions.

Each step of this process is summarized in the sections below.

STUDY AREA

The study area for this analysis is generally the same as the City's municipal boundary as shown in Figure 3-1 with additional flow inputs from Lindon City (which are conveyed to the City's treatment facility via Geneva Road) and Vineyard City. It is expected that the sewer collection system will continue to expand to provide service to new development within the City, but that services will not extend much beyond the City's current corporate boundaries and the small collection areas in Vineyard and Lindon currently served by the City's collection system. Orem City's collection system will eventually serve all areas in Vineyard south of 400 South.

TRAFFIC ANALYSIS ZONES

Division of the service area into smaller sub-areas is important for two reasons. First, it increases the accuracy of the population and flow projections by examining land use and development patterns at a smaller scale. Second, it yields projections that are distributed spatially across the service area, an important requirement for future modeling efforts.

For this study, sub-areas were defined based on Traffic Analysis Zones (TAZ). A TAZ is the smallest geographic unit used for residential and non-residential population projections developed by the Mountainland Association of Governments (MAG). Non-residential population data includes employees, retail, industrial, and other non-residents. TAZ boundaries are established on an arbitrary basis by MAG for travel demand modeling.

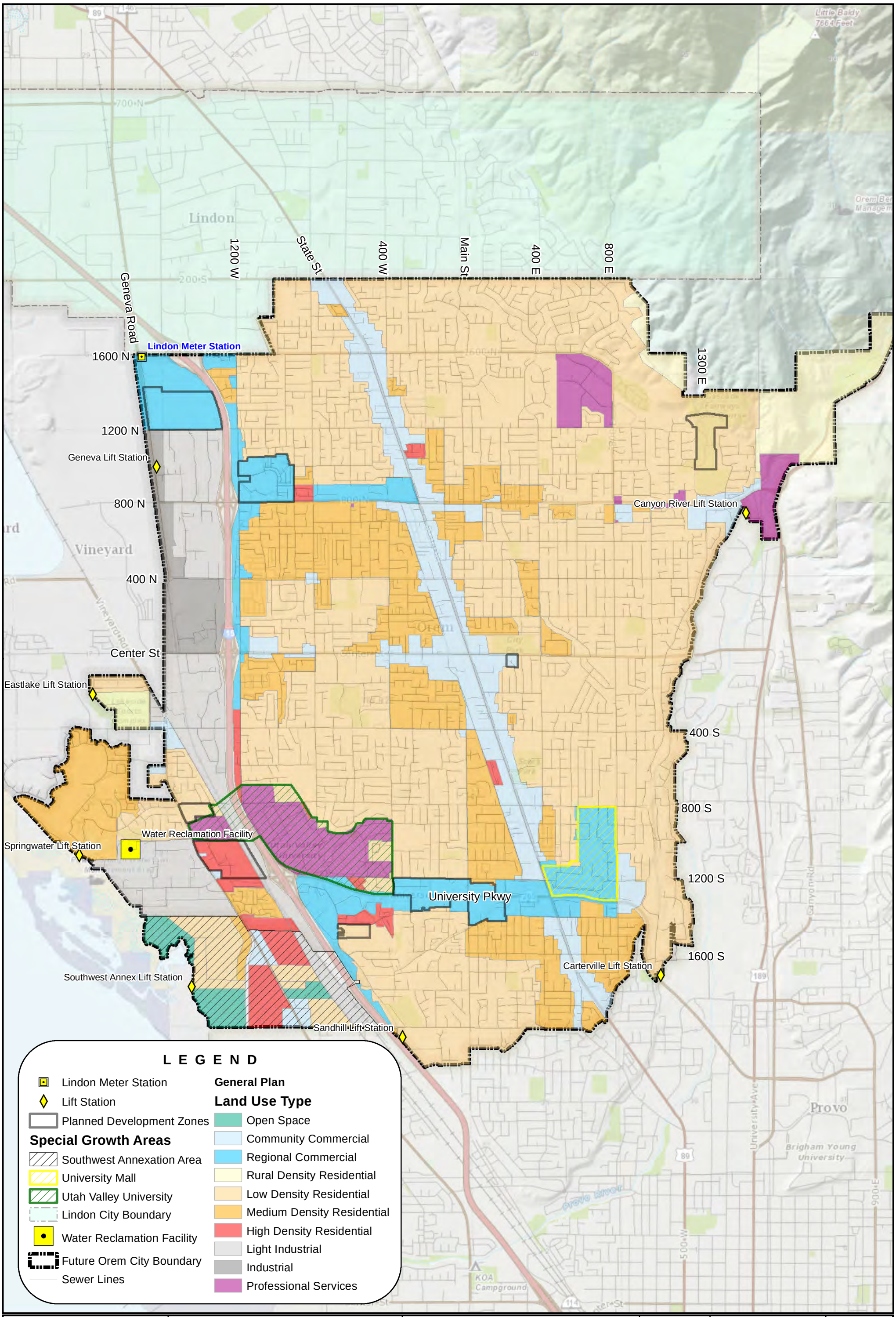
TAZ boundaries were used for this analysis because population projections have already been developed from census data for TAZ areas by MAG. The projections are provided every 5-years starting in 2010 and continuing to 2040. TAZ boundaries were also used because they are small enough to give an adequate distribution of flow across the service area for use in modeling. The TAZ boundaries used in this analysis are shown on Figure 3-2. As can be seen in the figure, TAZ boundaries are not always consistent with the City's service area boundaries. If a TAZ was only partially in the study area boundary, then the percentage inside the boundary was determined. MAG projections were multiplied by this percentage to determine the portion of the TAZ projection within the study area boundary.

OREM CITY RESIDENTIAL AND NON-RESIDENTIAL POPULATIONS

Population projections for the City have been developed using the City's General Plan, population projections from the Governor's Office of Management and Budget (GOMB) and Mountainlands Association of Government. Residential and non-residential projections were developed for two periods: Present to 2040, and 2040 to 2060. The methodology varies slightly for each period.

Projections from Present to 2040

The population projections, from present to 2040, were initially taken from the MAG Population Projection Report, 2011 Baseline. The MAG projections were then adjusted with input from City personnel for the special areas of consideration noted above and for key "planned development" zones (PD Zones). PD Zones are identified separately because of the relatively wide variability in



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OREM CITY
SEWER MASTER PLAN

OREM CITY GENERAL PLAN & SPECIAL GROWTH AREAS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 3-1

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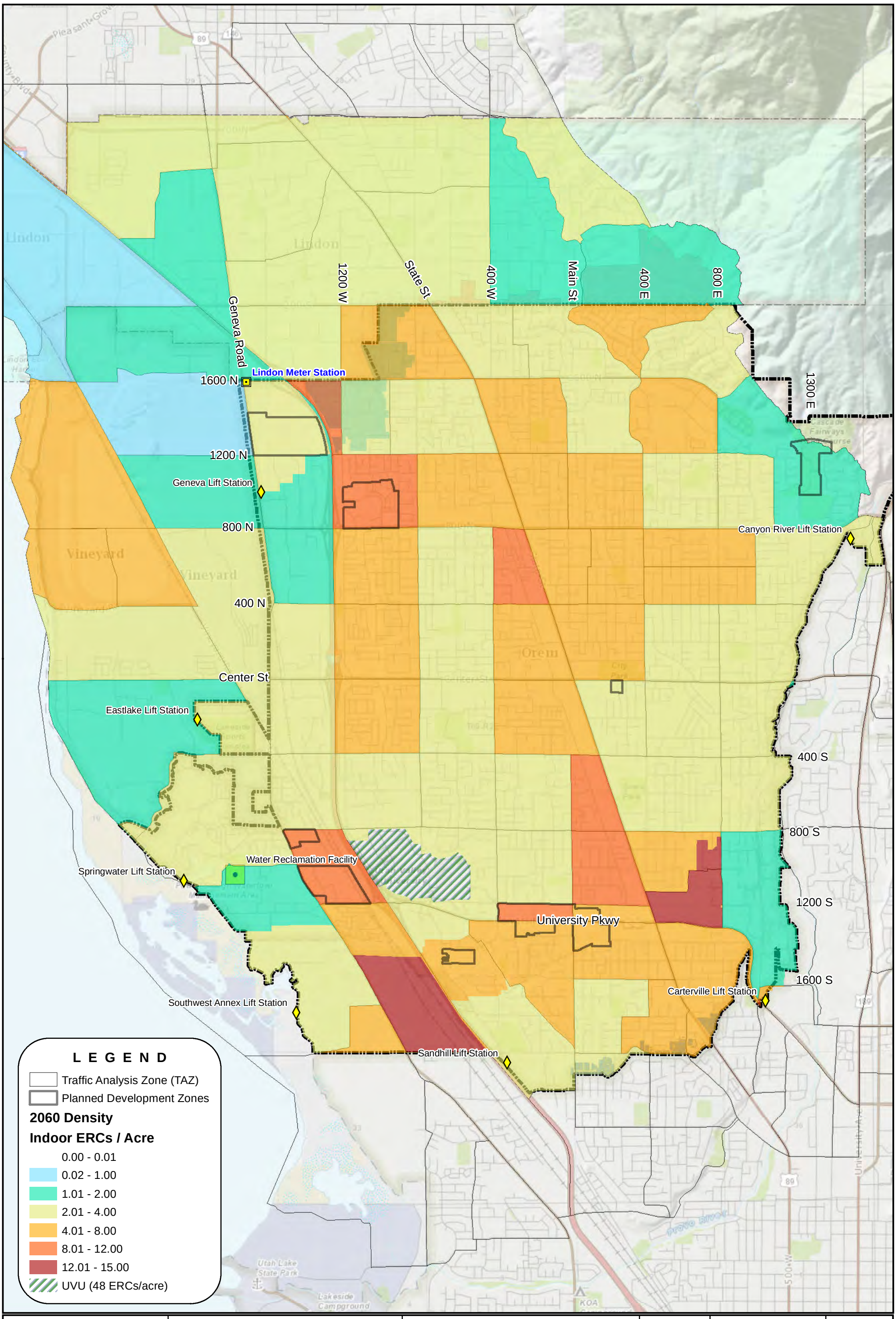

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OREM CITY
SEWER MASTER PLAN

2060 DEVELOPMENT DENSITY
INDOOR ERCS PER ACRE

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 3-2

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types of development that may be incorporated into a PD Zone (including commercial, industrial, mixed use development, student housing). In general, PD Zones are intended to be consistent with the underlying General Plan designation, but may include other development types in the zone in accordance with City and developer interests for the site.

The modified MAG projections were used to estimate where growth will occur in the City. MAG will be updating its projections in the near future, but for the purpose of this study, the distributions used from the 2011 baseline were considered adequate with modifications by City personnel to reflect City estimates. Residential and non-residential populations were treated separately and independently for these projections.

The Southwest Annexation Area was treated somewhat independently for these projections. This area of the City has its own planning documents that have defined buildout wastewater production. An equivalent residential population for this area was developed for this area using the wastewater projections from the August 2015 "Sanitary Sewer Impact Fee Facilities Plan and Impact Fee Analysis" prepared by Lewis Young Robertson and Burningham. This area is shown to be completly built out by the year 2027.

Projections from 2040 to 2060 - Residential

The detailed MAG projections only extend to 2040. Because this does not cover the full planning window of this sewer master plan, growth beyond the year 2040 needed to be examined and incorporated into this study. A buildout estimate of growth was estimated for each area of the City by extrapolating the population from 2040 to 2060 using the final growth rate in the MAG projections for all areas with a positive growth rate (some areas have a negative growth rate associated with declining population). This estimate was compared to the overall GOMB projection for total City population at 2060 and adjustments were made within the special areas of consideration or PD Zones so that the 2060 population distribution matched the 2060 GOMB residential population estimate. Figure 3-2 shows an estimate of equivalent residential connections per acre in 2060 using an average household size of 3.34 persons/household (2008 – 2012 estimate for Orem City).

Projections from 2040 to 2060 – Nonresidential

For non-residential growth, a buildout estimate of growth was estimated by extrapolating from 2040 to 2060 using the final growth rate in the MAG projections for all areas with a positive growth rate. No other adjustments were made for non-residential growth.

Projections for UVU – Nonresidential

Because Utah Valley University (UVU) makes up a significant portion of City-wide wastewater production, and has a significant potential for growth, projections for UVU were treated separately from other nonresidential projections. Based on UVU's current Master Building Plan, the square footage of buildings on the UVU campus is estimated to approximately double to accommodate future student populations in Orem City. As a result, wastewater production for the campus will

also likely double in the future. Projections for UVU assume funding for expansion projects on campus will be uniform through 2060 so that a student population of approximately 53,000 students is reached in 2060. It should be noted that the student population has been used to project wastewater growth for UVU rather than building square footage because an accurate estimate of the existing building square footage was not available during this study. With either approach, the estimated wastewater is anticipated to double within the planning window.

The results of the residential and non-residential projections described above are summarized in Tables 3-1 and 3-2.

Table 3-1
Residential Population Projections

Year	Orem[1] Residential Population	Lindon Residential Population	Vineyard[2] Residential Population	Southwest[3] Annexation Population	Total Residential Population
2010	88,328	10,134	69	0	98,531
2013	91,466	10,595	90	0	102,151
2020	99,227	11,753	223	1,219	112,422
2030	103,321	12,459	526	5.611	121,917
2040	112,288	13,721	727	5,611	132,347
2050	118,900	14,600	788	5,611	139,899
2060	123,600	15,900	806	5,611	145,917

[1]A small portion of the Orem City service area contributes wastewater to Provo City. This area was neglected for Table 3-1.
[2]The estimated service area population from Vineyard City includes all areas in Vineyard south of 400 South and is based on the residential population distribution derived from Mountainland Association of Governments Traffic Analysis Zones.
[3]The residential population indicated for the Southwest Annexation area was calculated based on a build-out flow of 334,646 gpd of wastewater production and the total number of approved ERUs as identified in the area's updated planning documents. For simplicity, all wastewater from the Southwest Annexation Area is being represented as residential.

Table 3-2
Non-Residential Population Projections

Year	Orem[1] Non-Residential Population	Lindon Non-Residential Population	Vineyard[2] Non-Residential Population	Total Non-Residential Population (except UVU)	Total[3] UVU Student Population
2010	130,371	28,225	26	158,622	23,963
2013	135,022	29,509	34	164,565	26,307
2020	146,643	36,584	51	183,278	36,279
2030	155,318	42,121	115	197,554	41,967
2040	161,309	46,158	121	207,588	45,516
2050	164,401	51,487	128	216,016	49,065
2060	167,552	57,431	134	225,117	52,614

[1]A small portion of the Orem City service area contributes wastewater to Provo City. This area was neglected for Table 3-1.
[2]The estimated service area population from Vineyard City includes all areas in Vineyard south of 400 South and is based on the residential population distribution derived from Mountainland Association of Governments Traffic Analysis Zones.
[3]The student population indicated is based on a uniform growth rate through 2060.

DOMESTIC WASTEWATER FLOW PROJECTIONS

The process of using residential and non-residential population data to develop domestic wastewater flow rates was completed by relating the residential and nonresidential indoor water use to wastewater flow rates.

An analysis of indoor water usage for residents, nonresidents, and UVU was developed for Orem City using indoor water meter records. Based on the water meter records, non-residential indoor water use which consists of retail, employment, industrial, and other water uses was equal to approximately 24% of total indoor water use in the City. Based on this data, it was possible to estimate the contribution of wastewater by residential, non-residential, and student populations. Based on the residential and non-residential population data, indoor water meter data, and total influent at the City's wastewater treatment plant, an estimate of per capita domestic wastewater for each user type was developed as summarized in Table 3-3.

Table 3-3
Contribution of Wastewater by User Type

Component	Wastewater Contribution (gpcd)
Residential Population	59.6
Non-Resident Population	11.7
Student Population	31.3

Total domestic wastewater contributions can therefore be estimated by multiplying the projected residential, non-residential, and student populations by their respective per capita wastewater contribution as summarized in Table 3-4.

Table 3-4
Projected Total Domestic Wastewater Flows

Year	Residential Domestic Wastewater Flow (mgd)	Non-Residential Domestic Wastewater Flow (mgd)	UVU Domestic Wastewater Flow (mgd)	Total Domestic Wastewater Flow (mgd)
2013	6.09	1.93	0.83	8.85
2020	6.71	2.14	1.14	9.99
2030	7.27	2.31	1.32	10.90
2040	7.90	2.43	1.43	11.76
2050	8.34	2.53	1.54	12.41
2060	8.70	2.64	1.65	12.99

Water Conservation

It should be noted that the results in the tables above do not include any reduction in future wastewater production associated with conservation. The City currently has a water conservation goal to reduce its per capita water usage (as measured in the year 2000) by 25 percent by the year 2025. A reduction in wastewater flow associated with this projected future conservation was not included for two reasons. First, the projections have been based on recent water use data that already reflects some conservation since the year 2000. Second, the water conservation goal of the City includes consideration of both indoor and outdoor water use. Past history would suggest that the majority of conservation will occur through the reduction of outdoor water use. As a result, the effects of water conservation on indoor water use will likely be relatively small. Because of these two reasons, additional conservation in the future was conservatively ignored for modeling purposes in this study. However, it is possible that, as the City continues to reduce water use through conservation, there may be some effect on indoor water use and domestic sewer flows. This could potentially delay some projected future system deficiencies and associated system improvements. System flow monitoring will be a valuable tool to track changes in domestic sewer production over time and further assess the effects of indoor conservation.

WASTEWATER FLOW DISTRIBUTION

Table 3-4 summarizes total wastewater projections for the City service area as a whole. For hydraulic modeling purposes, these flows must be distributed throughout the service area. For existing conditions, flows were distributed based on winter water use records. The City GIS system includes historic water use records for each meter in the City system. Winter water reads

for each meter were attached to the nearest trunkline manhole in the model to calculate the portion of total domestic wastewater flow associated with each manhole.

To distribute future flows, growth was evaluated by TAZ. The total increase in flow for each TAZ was calculated as described in the sections above. The growth was then distributed to the nearest trunkline manhole within each TAZ. In the case of UVU, increases in flow were assigned to a single manhole because most of the projected expansion will not necessarily require new collection system pipes.

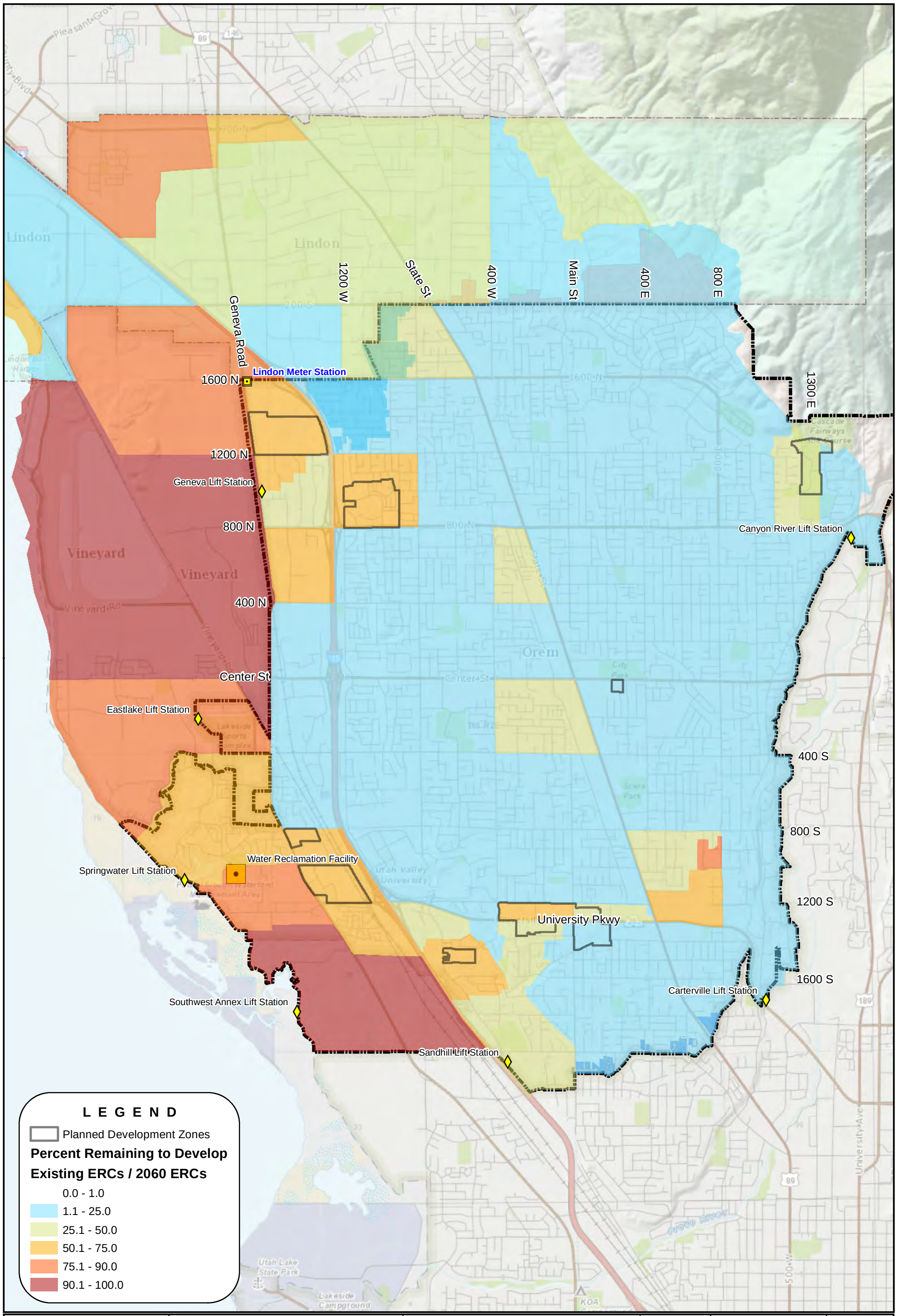
Figures 3-3 shows the potential for growth in Orem based on the estimated percentage of remaining development compared to 2060 in equivalent residential connections.

INFILTRATION

Beyond domestic wastewater contributions, the second component of wastewater flow that must be considered is infiltration. Infiltration is defined as water that enters into the sewer system which is not directly or indirectly related to either domestic wastewater or to a specific storm event. This flow can enter as a result of open pipe joints, cracks in pipes, pipes poorly connected at manholes, leaky lateral connections, roots, etc. Infiltration is generally a function of groundwater levels. Groundwater levels in the service area fluctuate depending on climate and season. Infiltration rates will correspondingly change seasonally but will generally be constant during a single 24-hour period. Temporary increases in the amount of water that enters the system after a storm because of an increase in ground water will be considered as inflow (as discussed in a subsequent section).

Factors that can affect infiltration include pipe age, material, and number and condition of lateral connections. Age can contribute to infiltration in two ways. First, older pipes are more likely to be in poor condition. Cracks, separated joints, and other defects can contribute significantly to increased infiltration. Second, older pipes do not have the benefit of improvements in construction techniques that have occurred over time. Gasketed pipe joints, rubber boots at manholes and laterals, and other improvements have contributed greatly to reducing system infiltration over time.

Infiltration in the collection system was identified primarily through temporary flow monitoring conducted by Orem City personnel over a number of years. Infiltration in the collection system was identified by subtracting domestic flow developed using indoor water use records from the total average flow at flow monitors in the City. To account for seasonal fluctuations in infiltration, the highest average monthly flow over the last 5-years was used as the planning criteria for calibrating the existing condition model. Calibration of the hydraulic model is discussed in further detail in Chapter 4. The total infiltration included in the model for existing conditions is 0.94 mgd. For the City's entire collection system, this equates to approximately 356 gallons per day per inch-diameter mile. For comparison, the American Society of Civil Engineers (ASCE) recommends an allowable infiltration rate for new construction of no more than 500 gpd/in-dia/mile. This would suggest that Orem City has relatively low infiltration for its relative age. This conforms to anecdotal information reported by Orem City personnel and may be the result of the topography and soil characteristics of the Orem bench that result in relatively large depths to ground water. For projecting future infiltration, the existing City-wide infiltration rate (infiltration/domestic flow = 11.7%) was applied to future growth uniformly.



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OREM CITY
SEWER MASTER PLAN

AREAS OF POTENTIAL GROWTH

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 3-3

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Table 3-5 shows projected domestic flows and infiltration through 2060 based on the assumptions above.

Table 3-5
Dry Weather Sewer Flow Rates (mgd)

Year	Projected Domestic Sewer Flows	Estimated Infiltration	Estimated Dry Weather Sewer Flows
2013	8.85	0.94	9.79
2020	9.99	1.10	11.09
2030	10.90	1.42	12.32
2040	11.76	1.51	13.27
2050	12.41	1.57	13.98
2060	12.99	1.63	14.62

INFLOW

The third and final component of wastewater flow that must be considered for wastewater master planning is inflow. Inflow is defined as any water that enters into the sewer system which is directly or indirectly related to a storm event. It can come directly from storm runoff through improper connections to the storm water system, missing or leaky manhole covers, roof drains connected to the system, etc. Storm events can also cause the ground water to raise temporarily, which can cause an increase in flow in the sewer system through the same mechanisms that result in groundwater infiltration during dry weather (cracked pipes, leaky laterals, etc.). Any temporary increase in sewer flow due to raising levels of ground water as a result of snowmelt or rain is considered inflow.

Figure 3-4 shows the flows at the City's wastewater treatment plant 3 days before and after a severe storm event that occurred on September 7, 2013 in Orem City. The storm caused flooding at numerous locations in the City and exceeded the 1 percent probable storm (100-year storm). Resulting inflow at the treatment plant increased flows by at least 150 percent for a short period. It is assumed that many collection system pipes were affected similarly. From this data, it is clear that the City's system does have potential for significant inflow. However, it is not possible to accurately estimate the magnitude and distribution of inflow events for individual pipes without a significant amount of flow monitor and rain gauge data. As a result, inflow has not been included directly in projected flows, but it will be important for the City to include adequate hydraulic capacity in its collection and treatment system to account for inflow events.

WATER RECLAMATION FACILITY CAPACITY

Based on the growth projections through build-out for the Orem City sewer service area, Figure 3-5 summarizes projected flow into the Orem City Water Reclamation Facility. As shown in the figure, average day capacity of the plant is not expected to be exceeded until after 2040. Peak hour sewer flows are more difficult to project because they can be significantly affected by groundwater conditions and inflow events. Based on the best available data, peak hour flows are also not expected to exceed the peak hydraulic capacity of the plant until after 2040. It is recommended

Figure 3-4
Inflow at Wastewater Treatment Plant
for September 7, 2013

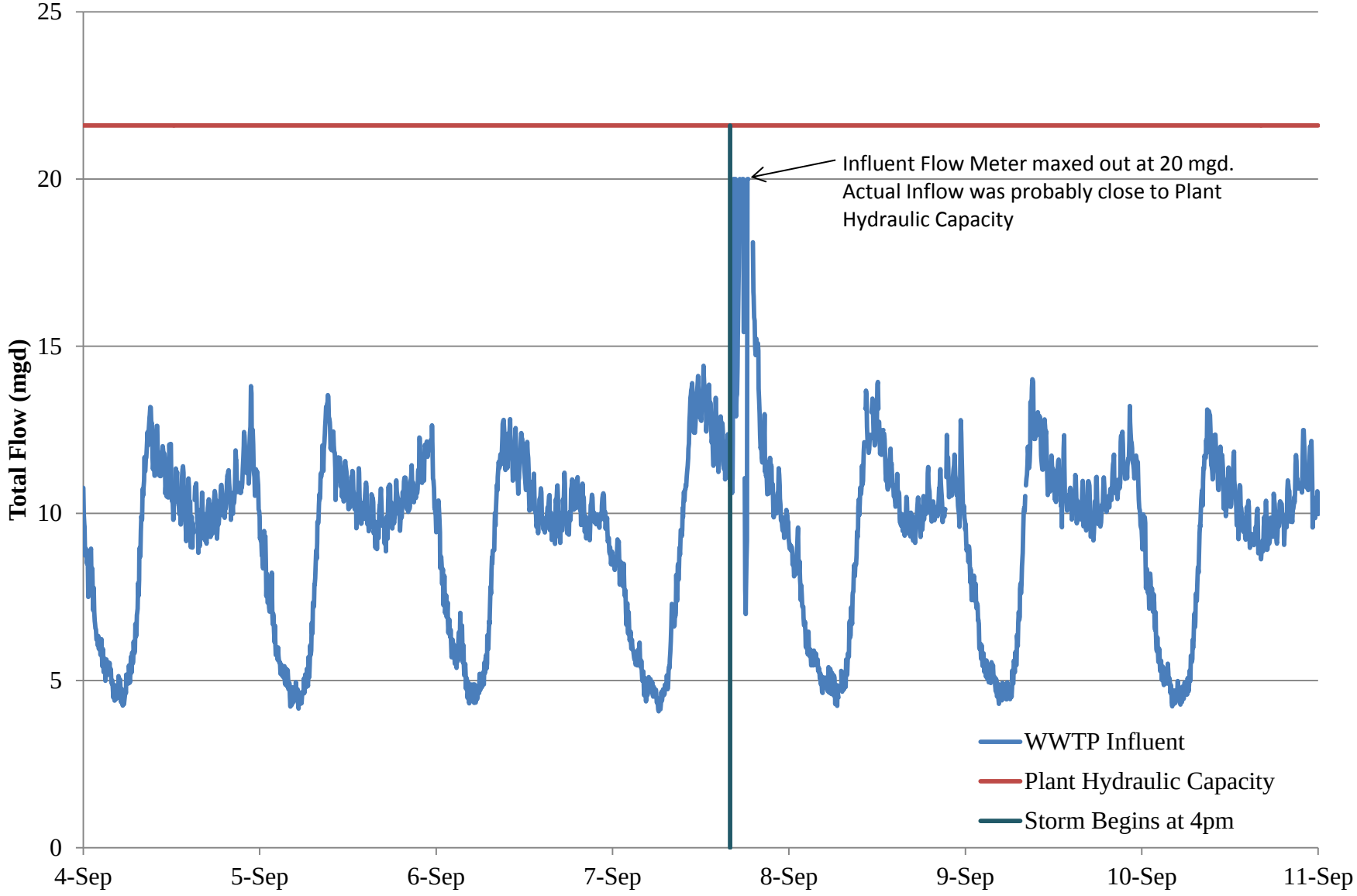
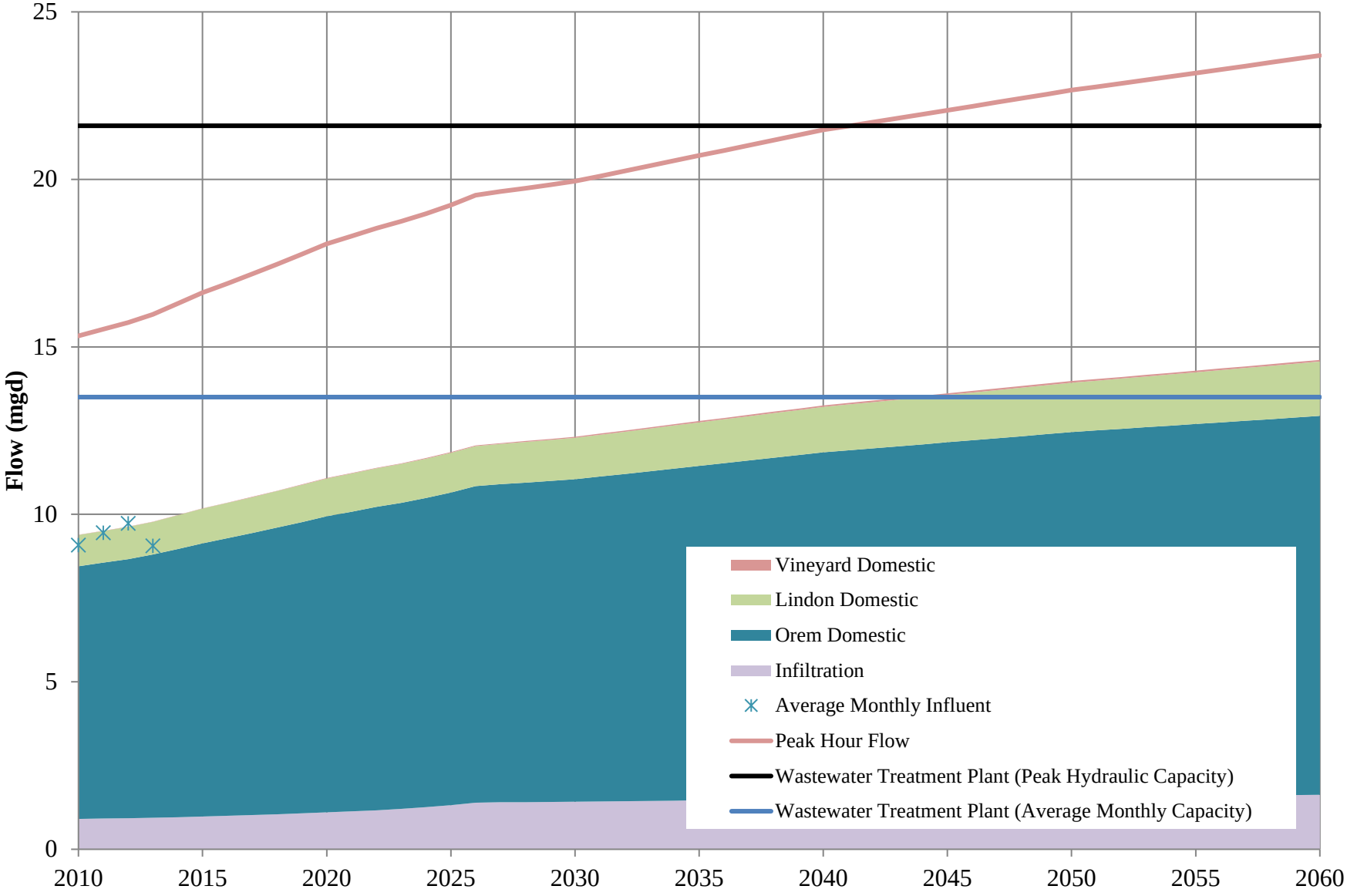


Figure 3-5
Future Wastewater Production to Orem City
Wastewater Treatment Plant



that Orem City continue to monitor and evaluate peak flows relative to plant capacity. However, based on current data, it is not expected that expansion of the plant will be an issue anytime in the near future.

CHAPTER 4
HYDRAULIC MODELING

INTRODUCTION

A critical component in identifying required areas in the Orem City collection system where pipes have capacity deficiencies is the development of a hydraulic computer model. An extended period simulation (EPS) hydraulic model was developed using Innovyze's InfoSWMM software. The purpose of this chapter is to present a summary of the methodology used to develop this model.

GEOMETRIC MODEL DATA

There are two major types of data required to develop a hydraulic model of a sewer system: geometric data and flow data. Geometric data consists of information on the location and size of system facilities including pipes, manholes, and lift stations. It also includes the physical characteristics of the facilities including pipe roughness, invert elevations at manholes, pump settings in lift stations, and a description of any diversions present. This information is generally collected from system inventory data or through direct field measurement. The following sections describe how geometric data was assembled for use in the hydraulic model.

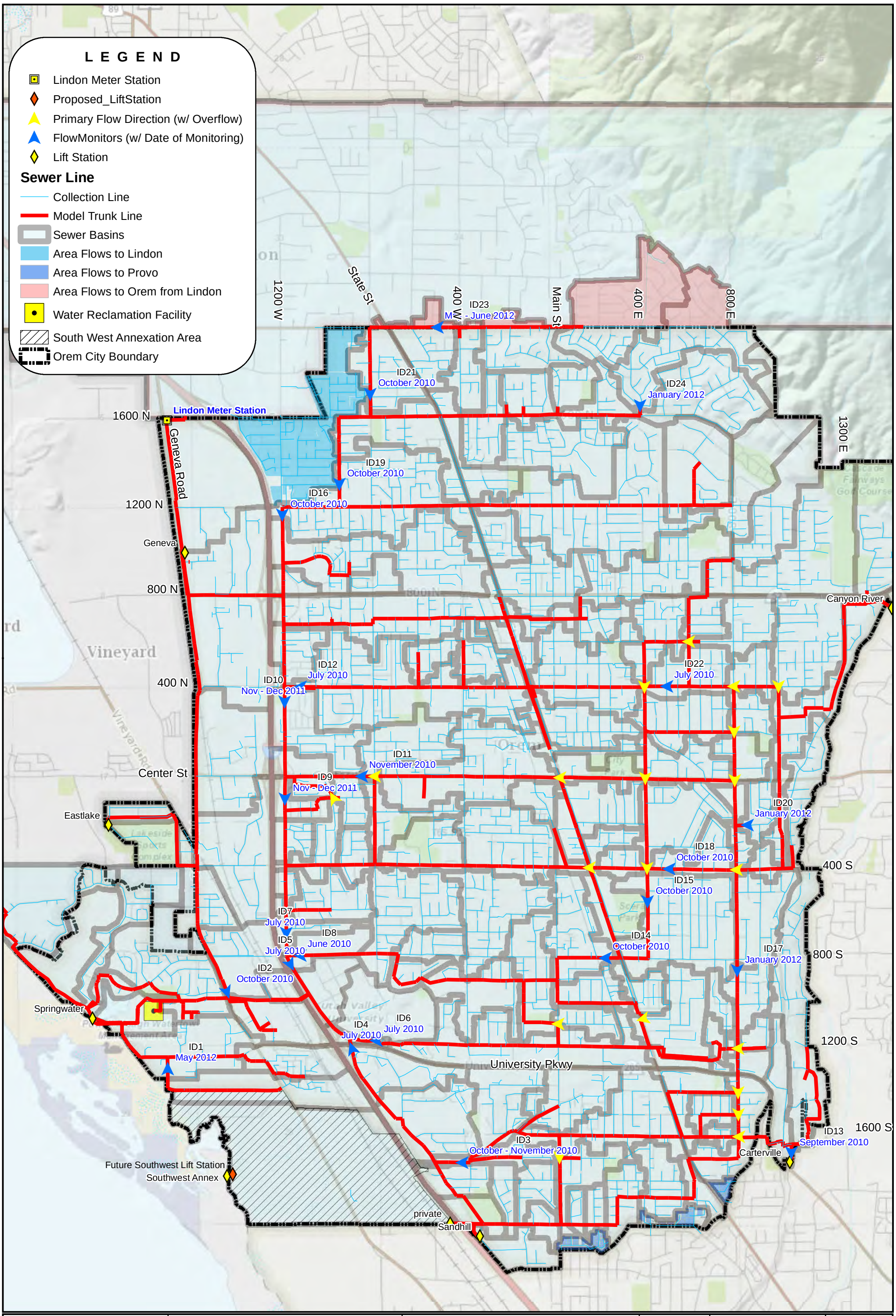
Pipeline and Manhole Locations

Orem City has spent considerable time assembling a GIS inventory of its existing sewer facilities. That database includes information on the location and size of manholes and pipelines in the Orem City collection system. Based on direction from City personnel, pipeline and manhole data was taken directly from the City's GIS database for use in the model. In some areas where manholes did not have reliable invert information, invert elevations were interpolated based on inverts upstream and downstream of areas without information. Areas with interpolated inverts have been documented in the hydraulic model.

Modeled Pipelines

It was not deemed necessary to model all of the sewer pipes in the Orem City sewer system. As smaller pipes are added to the model, the more refined the analysis becomes, but this requires additional time, effort, and expense (including higher annual software maintenance costs for hydraulic modeling). Hence, it is important to consider the required accuracy and available budget when selecting the sewer lines to model.

To optimize the level of effort, it was decided to include in the model all sewer pipes with a diameter of 10 inches or larger and 8-inch pipes serving areas greater than 200 acres as shown in Figure 4-1. As service areas decrease in relative size (less than 200 acres), State minimum slope requirements result in capacities that exceed the potential wastewater production for typical residential densities in Orem City. As a result, modeling pipes that are serving areas smaller than this size will not add any additional meaningful results to the analysis. It is possible that higher density developments may require additional 8-inch pipes to be modeled in the future.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS	OREM CITY SEWER MASTER PLAN	MODEL TRUNK LINES & FLOW MONITORS	NORTH:	SCALE: 0 1,250 2,500 Feet	FIGURE NO. 4-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 4-1 - Trunk Lines.mxd amckinnon 11/7/2014

However, for the purpose of this study, the pipes identified for modeling were considered adequate for assessing potential hydraulic deficiencies. The final selection of sewer lines included in this model was reviewed and approved by Orem City personnel.

Pipe Flow Coefficients

Pipe flow coefficients used throughout the hydraulic model were assigned a Manning's roughness coefficient of 0.013. This is approximately equal to the roughness coefficient of concrete and clay pipe. While there are other materials in the system with lower published roughness coefficients (e.g. PVC), 0.013 was used throughout the system as a conservative approach for estimating pipe capacity. In addition, most collection pipes can develop thin layers of bacteria and solids (a slime layer) that result in relatively uniform roughness coefficients despite varying materials.

Sediment and Debris

Because of the transportable nature of grease and debris in a sewer collection system, it is not possible to identify the exact location and quantity of grease or debris accumulation in the system for any specific point in time. Similarly, the build-up and erosion rates of sediment in sanitary sewer systems are not always well understood. As a result, the detailed modeling of sediment, grease, and debris on a system wide basis is not feasible because of continually changing conditions. Therefore, no sediment was included in the various runs of the hydraulic model. Instead, the design and evaluation criteria for the Orem City collection system is based on "clean" pipes, with an allowance for capacity lost to the accumulation of sediment (see Chapter 5).

It should be noted that the hydraulic modeling software used to simulate the operation of the Orem City wastewater collection system does have the ability to set sediment depth in pipes. Therefore, if the City does collect detailed sediment data for a given section of pipe, the sediment may be added to the model and its effects evaluated. However, it should be emphasized that any sediment levels defined today will change in the future as flow conditions change.

Lift Stations

Orem City has 6 lift stations in its collection system. Where pump curves were available, associated pump performance criteria were input into the model. Pump curves at other locations were estimated based on the required lift and flow capacity of the lift station as reported by City personnel.

Potential Diversion

The City has one diversion in its collection system near UVU and I-15 where flow can be diverted into a parallel sewer main underneath the freeway and railroad tracks. In addition, there are a number of manholes that have two potential flow directions based on the available invert information provided by the City. In all cases, there is a primary flow direction where all flow is conveyed under typical conditions with a potential "overflow" direction primarily used for

flushing lines and system maintenance. Table 4-1 lists the location of these potential diversions along with their primary flow directions which are also shown in Figure 4-1. These potential diversions were identified so that the hydraulic model would correctly simulate the proper flow path for wastewater through the collection system.

Table 4-1
Manholes with Potential Overflow Directions

Manhole ID	Location	Main Flow Direction
17-0171	600 E 600 North (Overflow manhole to the south. All flow goes west).	West
26-0028	400 S 400 East (Overflow manhole to the west. All flow goes south).	South
17-0063	800 E 400 North (Overflow manhole to the south. All flow goes west).	West
17-0072	1000 E 400 North (Overflow manhole to the west. All flow goes south).	South
17-0089	200 N 800 East (Overflow manhole to the west. All flow goes south).	South
19-0086	1000 W 100 South (Overflow manhole to the west. All flow goes northwest).	Northwest
20-0173	800 W Center Street (Overflow manhole to the south. All flow goes west).	West
21-0136	400 E Center Street West (Overflow manhole to the west. All flow goes south).	South
21-0164	Center Street & State Street (Overflow manhole to the south. All flow goes west).	West
26-0154	400 S State Street West (Overflow manhole to the south. All flow goes west).	West
27-0033	800 E 400 South (Overflow manhole to the south. All flow goes west).	West
31-0028	1100 S Main Street (Overflow manhole to the south. All flow goes west).	West
31-0124	1070 S State Street (Overflow manhole to the north. All flow goes west).	West
32-0026	1200 S 800 East (Overflow manhole to the south. All flow goes west).	West
34-0110	1700 S Main Street (This is an overflow manhole to the North. All the flow goes to the south).	South
35-0021	1600 S 800 East (Overflow manhole to the south. All flow goes west).	West
35-0024	1500 S 800 East (Overflow manhole to the west. All flow goes south).	South
35-0026	1400 S 800 East (Overflow manhole to the west. All flow goes south).	South
22-0093	800 E Center St (Overflow manhole to the west. All flow goes south).	South
16-0139	400 North 400 E. (Overflow manhole to the west. All flow goes south).	South

FLOW DATA

Once all required geometric data was collected and a physical model of the system was developed, flow data was obtained to model the system hydraulics. Three types of flow information were required for hydraulic modeling: total magnitude of flow, timing of flow, and distribution of flow across the City service area. Each of these flow characteristics is discussed below.

Total Flow

Flow projections for the Orem City service area were presented in detail in Chapter 3. Total flow for modeling scenarios examined here are summarized in Table 4-2.

Table 4-2
Hydraulic Modeling Scenario Total Daily Flow Volumes (mgd)

Scenario	Existing	2060
Dry Weather Flow/Infiltration	9.79	14.62

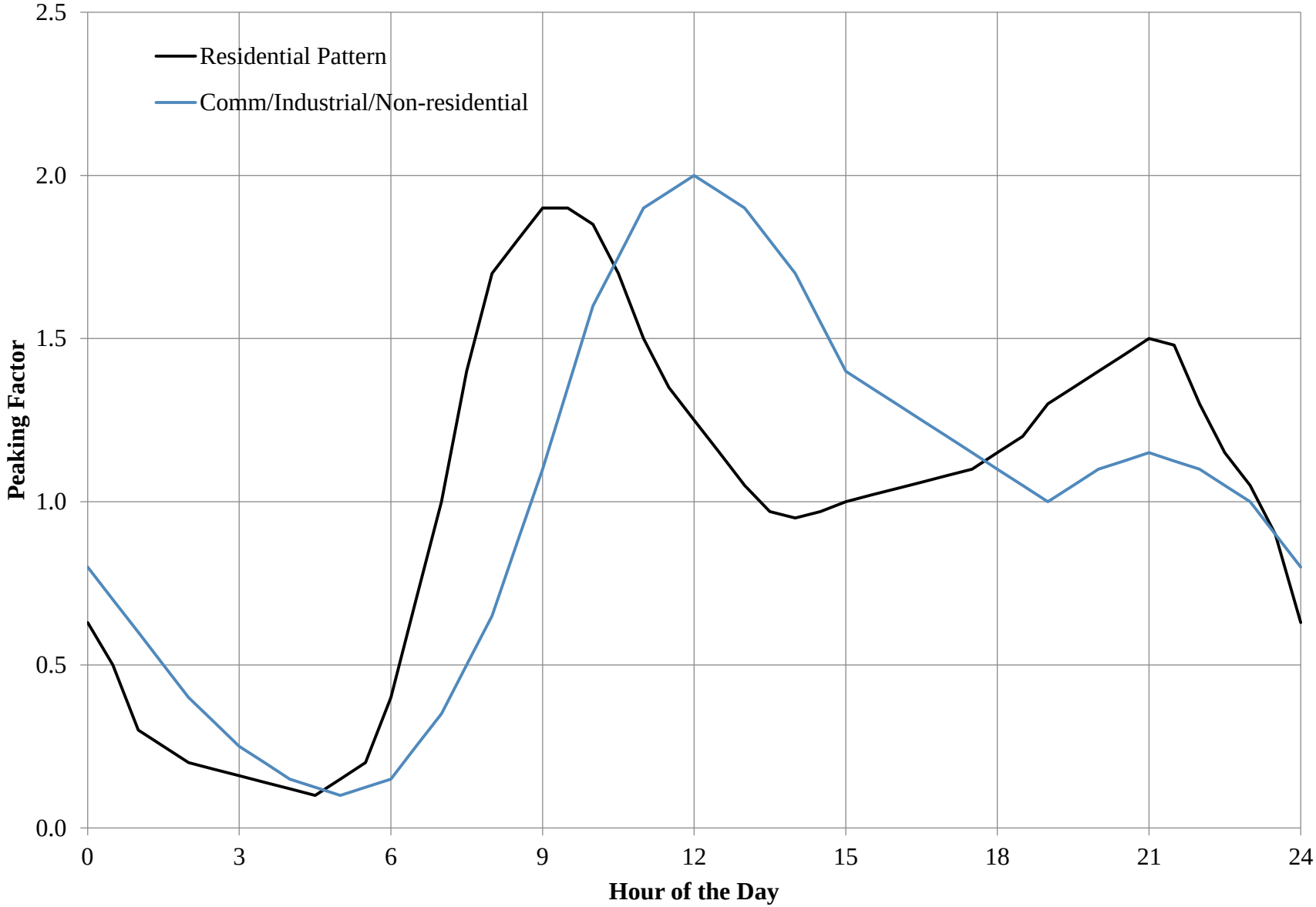
Timing of Flow

It will be noted that the volumes shown in Table 4-2 represent total flow over a 24-hour period. Since sanitary sewer flows vary throughout the day with varying indoor water demands, of much greater importance for the purposes of modeling collection system capacity is the calculation of peak flows that occur during the day. To predict the magnitude and timing of peak flows in the model, it is important to understand how flow varies throughout the day. This is different for each component of wastewater flow.

Domestic Wastewater – The pattern of fluctuating domestic water use is often referred to as a diurnal pattern. These patterns vary depending on the type of user. For example, the typical diurnal pattern for residential weekday wastewater production is shown in Figure 4-2. This figure was developed by dividing measured flows from predominantly residential neighborhoods by each neighborhood's average daily flow, essentially normalizing flow measurements so they can be compared against each other. As can be seen in the figure, peak residential wastewater production typically occurs around 9 a.m. as residents prepare for the work day, with a smaller peak occurring around 9 p.m. as residents clean up and prepare for bed. The average residential pattern shown in Figure 4-2 is the pattern used in the hydraulic model to predict flow for "residential" sewer flows. Figure 4-2 also includes a commercial/industrial diurnal pattern. While industrial flow patterns will largely be dependent on the type of industry, no flow monitoring data was available that could identify a strictly industrial flow pattern in the City. The commercial/industrial pattern shown in Figure 4-2 was developed using flow monitoring on Geneva Road near University Parkway.

Infiltration – As discussed in Chapter 3, infiltration may vary on a seasonal basis but does not generally vary on a daily basis. Thus, it has been assumed that infiltration remains constant throughout the day in the collection system model.

Figure 4-2
Diurnal Patterns in Orem City



Inflow – For this study, inflow has not been modeled directly because of the wide variability in storm events and inflow response possible in the City. For design purposes, Orem City has included a capacity allowance in its design criteria to account for inflow into its collection system.

Table 4-3 shows the peaking factors used for each hour that represent the patterns used in the hydraulic model.

Table 4-3
Hydraulic Model Diurnal Patterns

Hour	Residential	Commercial
0	0.63	0.8
1	0.3	0.6
2	0.2	0.4
3	0.16	0.25
4	0.12	0.15
5	0.15	0.1
6	0.4	0.15
7	1	0.35
8	1.7	0.65
9	1.9	1.1
10	1.85	1.6
11	1.5	1.9
12	1.25	2
13	1.07	1.9
14	0.95	1.7
15	1	1.4
16	1.04	1.3
17	1.08	1.2
18	1.15	1.1
19	1.3	1
20	1.4	1.1
21	1.5	1.15
22	1.3	1.1
23	1.05	1
24	0.63	0.8

Based on the diurnal patterns used above, peak flows simulated in the model are summarized in Table 4-4.

Table 4-4
Hydraulic Modeling Scenario Peak Hour Flows* (mgd)

Scenario	Existing	2060
Dry Weather Flow	17.02	24.92

*Peak hour WWTP inflow from extended period simulation which accounts for attenuation in the collection system.

Distribution of Flow

With flow magnitude and timing estimated, the final step in developing flow data for the model is distributing it spatially across the City:

Domestic Wastewater – Existing domestic sewer flows included in the hydraulic model were distributed based on winter water use data. Winter water meter data collected across the City was assigned to the nearest manhole assuming that the sewer connections from the various water meters would flow to the same manhole. Metered demands which have some inherent inaccuracies with underreporting were factored up to match the estimated domestic production for the City as measured at the City's wastewater treatment plant. Future growth of domestic sewer flow was distributed in the same manner based on growth as projected by TAZ (described in Chapter 3).

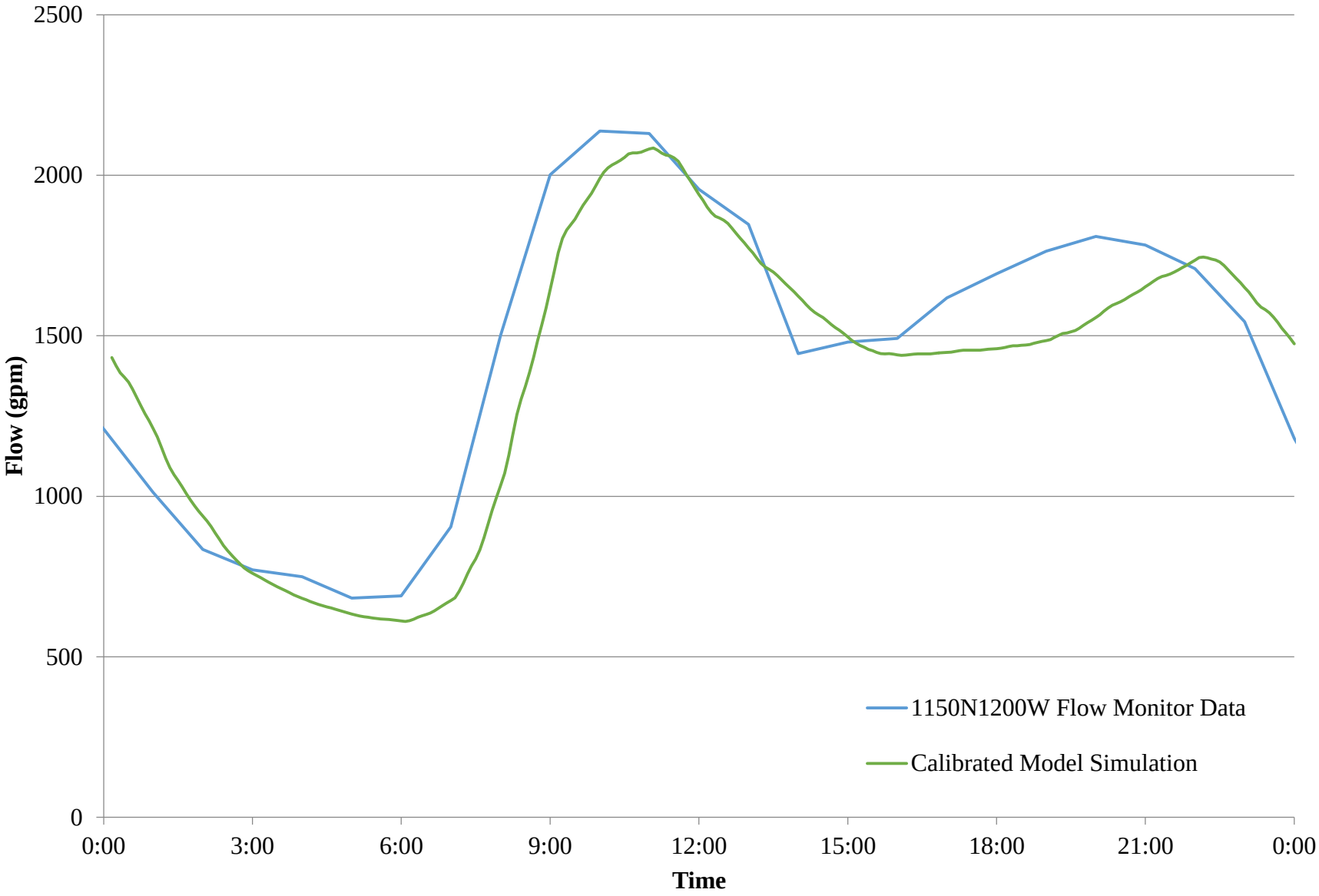
Infiltration – Existing infiltration was distributed using flow monitoring data collected by Orem City. Because infiltration likely varied significantly over the wide range of dates when flow monitoring was collected, each flow monitoring site was compared to treatment plant data for the period of collection and a seasonally adjusted estimate of infiltration was developed for each flow monitoring site. The seasonally adjusted estimate was then distributed into the tributary area for the flow monitor sites.

CALIBRATION

The process of model calibration involves adjusting or modifying certain model parameters in order to better match the actual conditions of the sewer system. Calibration of the model was performed using available historical flow meter data from various locations throughout Orem City. A comparison of model results against the historic flow monitoring results appears to indicate that, in general, the model is reproducing system conditions within a reasonable level of accuracy. However, model adjustments were made where possible in order to better match the historic monitoring results. Final results for one sample flow monitoring location are shown in Figure 4-3. As is the case with all model results of this type, model results produce a slightly smoother curve than the actual flow monitoring results.

It should be understood that the hydraulic model developed for this study relies on the available geometric and flow monitoring data provided by Orem City. As additional pipelines are surveyed or new flow measurement data is collected, the hydraulic model should be updated and recalibrated to reflect the updated conditions. Orem City should continue to update this hydraulic model based on new survey information at least once a year to ensure it reflects current conditions.

Figure 4-3
Simulated Model Results vs Observed Flow at Sample Flow Monitor (ID16)



CHAPTER 5
SYSTEM EVALUATION

With the development and calibration of a hydraulic sewer model, it is possible to simulate sewer system operating conditions for both present and future conditions. The purpose of this chapter is to evaluate hydraulic performance of the collection system and identify potential hydraulic deficiencies.

EVALUATION CRITERIA

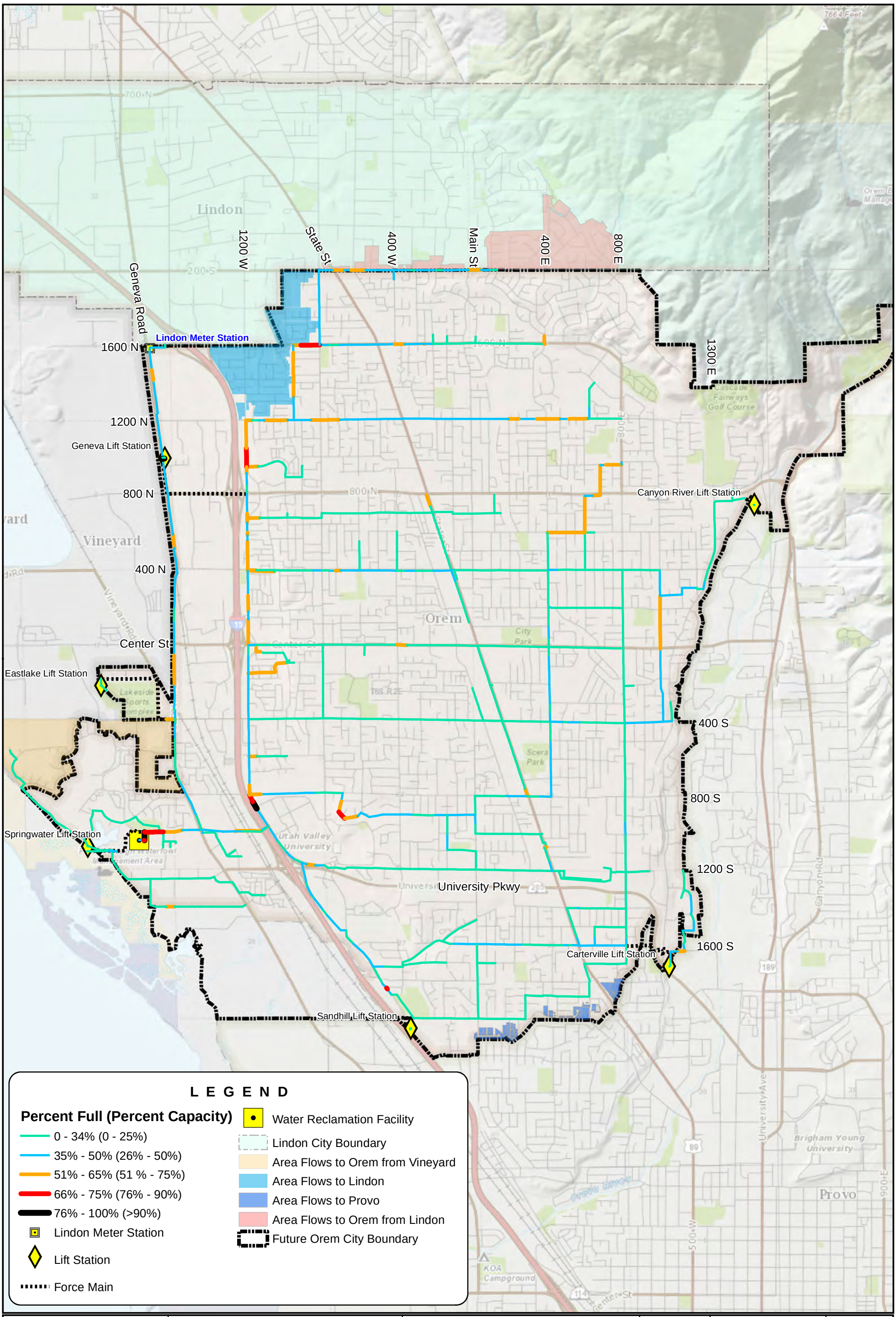
In defining what constitutes a hydraulic deficiency, it is important to consider the assumptions made in estimating sewer flows in the model. As described in Chapters 3 and 4, the sewer flow included in the model is composed of two parts: domestic sewer flow and infiltration. This means that the model represents dry weather conditions only and does not include wastewater flows associated with inflow. Additionally, estimates of domestic wastewater flows and infiltration are based on available historic data. Because these estimates are based on average values and a limited data set, actual flows will fluctuate and may be greater than the model estimates. For example, infiltration during extremely wet years could be more than estimated in the model (e.g. 1983 was a statewide historically wet year that led to high infiltration and flooding in many areas, but this year is outside the historical flow records available at the plant). The criteria established for identifying deficiencies should be sufficiently conservative to account for inflow in the system and occasional domestic and infiltration flows higher than those estimated in the model. The following criteria have been established to identify capacity deficiencies in the system:

- **Pipeline Capacity –** The most important deficiency to eliminate in the sewer system is inadequate capacity. For this master plan, it was decided to define a capacity deficiency as any point where the dry weather peak hour flow in the pipe is greater than 75 percent of the pipe's full flow capacity, which occurs when flow exceeds a depth of approximately 65 percent of the pipe's diameter. The remaining 25 percent of pipe hydraulic capacity was reserved for inflow and/or unaccounted for fluctuations in domestic flow and infiltration. In cases where short segments of relatively flat pipes exist, a maximum allowable depth of 65 percent of pipe diameter is used to define a pipe deficiency. A manning's roughness value of 0.013 was used for all collection pipes to conservatively calculate capacity.

- **Lift Station Capacity –** A lift station capacity deficiency is defined as anytime dry weather peak hour flows exceed 85 percent of the lift station's primary pumping capacity. This criterion is a little less conservative that the capacity criterion for pipeline because all lift stations are required to have at least one backup pump in case of mechanical failure or significant inflow from wet weather events. Lift stations also have storage wet wells that can accommodate higher than expected flows for short durations.

EXISTING SYSTEM ANALYSIS

Figure 5-1 displays the hydraulic capacity of the sewer system under existing peak hour flow conditions. Pipes in the figure are color coded to show the ratio of maximum depth in the pipe to



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OREM CITY
SEWER MASTER PLAN

PEAK FLOW TO CAPACITY FOR EXISTING CONDITIONS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 5-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 5-1 - Existing Capacity.mxd aanderson 10/27/2014

the pipe's full depth. Based on peak flow and pipe capacities alone, there are a few isolated deficiencies scattered throughout the system. These deficiencies are generally due to pipes being laid on a flat slope, which decreases the full flow capacity.

Short sections of flat pipe often do not represent a significant operational or maintenance issue for the system. The results shown in Figure 5-1 represent the maximum flow depth at any point along the length of the pipe. As long as the neighboring pipes have sufficient capacity, the extra depth caused by the flat slope will not result in surcharging problems for the system. Deficiencies observed in the existing system do not appear to pose a significant surcharge risk at this time, but will require monitoring as sewer flows continue to increase. No lift station deficiencies were observed in the existing sewer system.

Carterville Lift Station Infiltration

In general, Orem City has relatively low infiltration rates from groundwater intrusion into sewer collection pipes. The Carterville Lift Station service area appears to be a possible exception to these relatively low infiltration rates. Initial comparisons of metered water use and measured flows through the Carterville Lift Station indicate that a significant portion of flow is attributable to infiltration. Because this amount of infiltration seems unreasonably high, it is possible that there are errors in either the metered water usage for the homes which flow to the lift station or the flow measurement performed on the lift station itself. This considered, it is recommended that the City carry out additional flow monitoring tests both upstream and downstream of the lift station to determine if excessive infiltration is fact an issue that needs to be addressed.

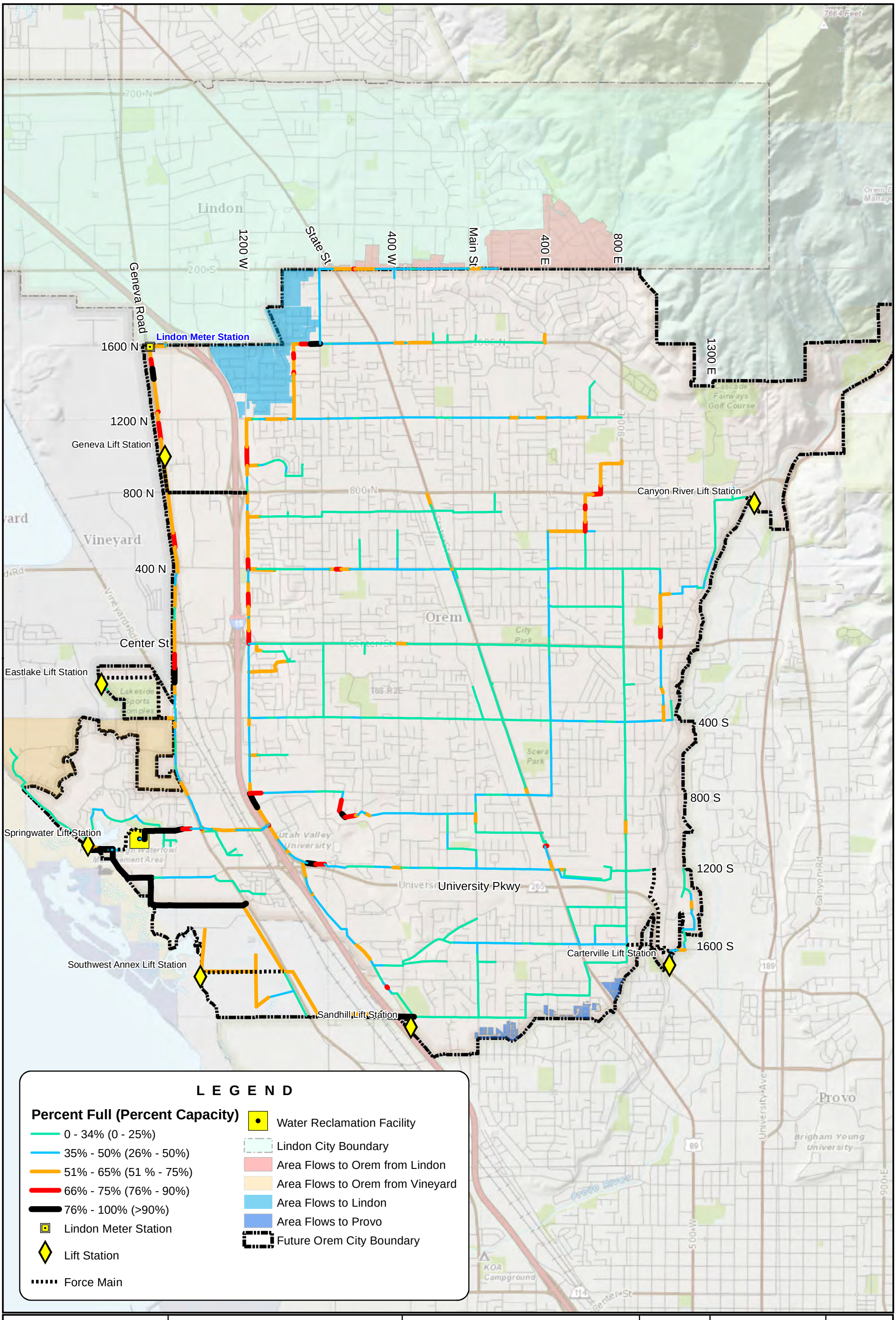
No pipe capacity deficiencies were identified as a result of what has been identified as potentially excessive infiltration at the Carterville Lift Station. However, this represents an area where Orem City could potentially reduce operation and maintenance costs if infiltration is indeed confirmed to exist at the Carterville lift station and can be reduced through sewer line rehabilitation projects.

FUTURE SYSTEM ANALYSIS

Figure 5-2 shows the hydraulic performance as calculated by the hydraulic model for sewer flows at projected conditions in 2060 if no improvements are made to the existing system. These results assume that sewer flows associated with future development will flow to the nearest manhole in the existing system. While the majority of the system under 2060 conditions has ample capacity, some significant deficiencies have been observed in the model results.

Pipeline Deficiencies

As shown in Figure 5-2, model results for the sewer collection system at 2060 show isolated pipeline capacity deficiencies which are mostly a result of pipes laid with shallow slopes. Only some of these simulated deficiencies require an improvement project as discussed below.



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OREM CITY
SEWER MASTER PLAN

PEAK FLOW TO CAPACITY FOR BUILDOUT CONDITIONS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 5-2

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 5-2 - Future Capacity.mxd amckinnon 4/20/2015

1600 North 800 West

Model simulations have indicated that a growth related deficiency will occur in a segment of pipe on 1600 North, downstream of the intersection of 1600 North and 800 West. Based on the current projections and distribution of flows in the model, it is anticipated that this section of pipe will become deficient by approximately the year 2030. This timing is subject to change based on the actual growth patterns in future years.

College Drive/1200 West at 800 South

The section of pipe downstream of the manhole at 1200 West and 800 South is projected to become deficient within the next 6-8 years. GIS data for manhole inverts provided by Orem City indicate an adverse slope in a portion of this deficient pipe. This could be an error in the survey data, and it is recommended that the invert elevations be verified before finalizing any plans for a capital project.

925 South 725 West

Hydraulic model results indicate a potentially deficient section of pipe along 925 South and 725 West. It is estimated that this length of pipe will exceed its available capacity by the year 2030.

Chambery Collection Line

The existing sewer line which conveys wastewater from the Chambery housing development to the Springwater Lift Station is expected to see a significant increase in flow as a result of projected development. Future model results indicate that there will be capacity deficiencies along the entire reach of pipe from Chambery to the Springwater Lift Station. Depending on growth in the area, it is estimated that the available capacity in this pipe will be exceeded within the next 5-10 years.

College Drive near 1200 South

Orem City would like to relocate the outfall of the Carterville Lift Station to 1200 South because of aging infrastructure and concerns about the existing force main's location under University Parkway and between existing homes. As a result of this relocation, a deficiency has been projected at buildout in the pipe along College Drive near University Parkway and I-15. This deficiency appears to be the result of a transition from a steep slope to a flat slope as the 12 inch line runs into the large transmission line near 1-15 and University Parkway. This location will primarily be a concern for surcharging under wet weather conditions.

Lift Station Deficiencies

Table 5-1 summarizes the projected 2060 flow to the lift stations in Orem City.

Table 5-1
Summary of Sewer Lift Stations

Name	Capacity (gpm)	Existing Dry Weather Peak Flow (gpm)	2060 Dry Weather Peak Flow (gpm)*
Carterville Lift Station	500	220	250
Geneva Lift Station	1,987	790	***2,540***
Springwater Lift Station	850	180	***1,320***
Eastlake Lift Station	300	20	70
Canyon River Lift Station	300	2	3
Sandhill Lift Station	300	10	40

*italicized bold text indicates a deficiency.

Geneva Road Lift Station

Primarily due to growth from Lindon City, 2060 model results indicate future deficiencies in the Geneva Lift Station. The lift station at Geneva Road and 800 North is currently equipped with 4 pumps. The pumps include a primary and backup 10 horsepower pump with a capacity of 800 gpm (833 gpm @ 22') that discharges into Geneva Road. When peak flows exceed the capacity of these pumps (such as under wet weather conditions), excess flow can be pumped through a primary and backup 75 horsepower pump with a capacity of 1,190 gpm that discharge to 1200 West. The current combined capacity of Geneva Lift Station is 1,990 gpm. At buildout, peak hour flows are predicted to reach approximately 2,540 gpm, exceeding the current pumping capacity of the lift station. However, the force mains to Geneva Road and 1200 West will have sufficient capacity at buildout. Therefore, it should be possible to achieve the needed capacity at the Geneva Road Lift Station through a relatively inexpensive upgrade to the lift station pumps.

Springwater Lift Station

The Springwater Lift Station has two challenges. First, as a result of projected development, flow routed through the Springwater Lift Station is expected to increase substantially. The primary and backup pump at the Springwater Lift Station are 20 horsepower with a capacity of 850 gpm. With predicted peak hour flows reaching as high as 1,320 gpm, the Springwater Lift Station will require a significant pump upgrade. A second challenge at the lift station is its condition. Orem City personnel have indicated that the lift station and force main are both approaching the end of their service life and need to be replaced in order to meet the needs of existing and future users. As a result, replacement of this lift station will be a high priority for the City.

Orem City Water Reclamation Facility

WRF Inlet

Model results for the sewer system under existing flows indicate capacity issues in a couple of sections of the large inlet pipe to the WRF. These deficiencies currently do not appear to create

the potential for surcharging. However, as can be seen in Figure 5-2, the model simulation results at 2060 suggest that the deficiencies will spread to other connected sections of pipe, extending east from the WRF outfall toward East Shore High School. Building additional capacity through this portion of the system will be required at some point in the future.

Plant Capacity

Growth projections in the Orem City sewer service area are predicted to produce flows into the WRF which could exceed both the average monthly capacity and peak flow capacity of the plant (see Chap. 3, Figure 3-5). However, existing capacity appears to be adequate through at least 2040 and no immediate capacity needs at the plant have been identified. It should be noted that these predictions are based on existing patterns of wastewater flow. It is recommended that the City carry out a more extensive evaluation of plant capacity in the years to come to better identify the timing of any potential expansion improvements at the WRF.

CHAPTER 6
SYSTEM IMPROVEMENTS

The hydraulic model results have identified potential deficiencies in the sewer system under existing and future conditions. This chapter covers system improvements intended to solve deficiencies as the City continues to grow. Once the detailed design of sewer facilities commences, the design capacity of these pipelines or lift stations should be based on projected build-out flows. Improvements are organized in this chapter by type and location of improvement. The priority of each project has been based on the predicted timing of when the improvement will be needed.

COLLECTION SYSTEM CAPACITY IMPROVEMENTS

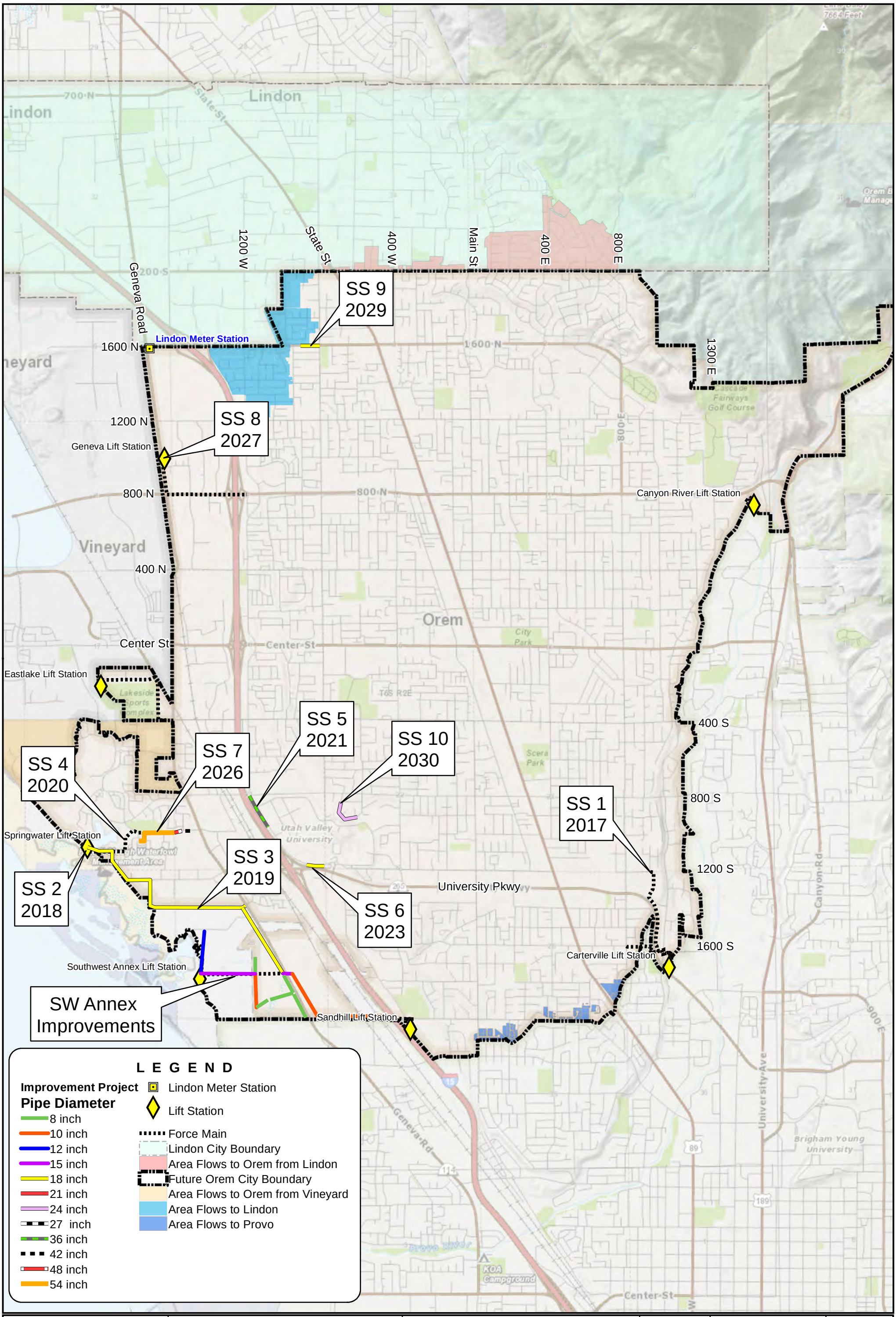
A number of collection system improvements have been identified to resolve hydraulic deficiencies related to existing or projected sewer flows as shown in Figure 6-1. Many of these projects are not needed for many years. All of the projects, regardless of timing, are discussed below and have been shown in the figure.

SS 1. Carterville Force Main Relocation

Although there do not appear to be any pipe capacity deficiencies in the Carterville Lift Station service area as a result of future growth, there are some age related deficiencies that require attention. The current alignment of the Carterville force main goes north out of the lift station then west under University Parkway. The line passes underneath several residential properties and ties into the collection system at 800 East and 1600 South. The line is also relatively old and the City is concerned with the condition of the pipe. In order to avoid potential problems with this line, Orem City has expressed the desire to abandon the existing pipe and relocate it to 925 East 1200 South, running the new line north along the east side of University Parkway and along 1000 East. Another viable outfall location for the force main was evaluated at University Parkway and 800 East. The City will have the option during design to select whichever location best suites the needs of the system.

SS 2. Springwater Lift Station

The Springwater Lift Station is in extremely poor condition and is quickly approaching the end of its useful life. As a result, replacement of the lift station is needed in the very near future. When the lift station is replaced, expansion of the lift station is also needed to accommodate projected future growth. The Springwater Lift Station is currently equipped with primary and backup 20 horsepower, 850 gpm pumps. While this provides more than enough capacity for existing flows, peak hour flows through the lift station are estimated to reach 1,320 gpm in the future. In order to accommodate the increase in flow, it is recommended that the Springwater Lift station be upgraded with 2 larger capacity pumps (1 primary and 1 backup) with a capacity of at least 1,575 gpm. This will allow the lift station to operate at or below 85% capacity at peak hour flows.



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OREM CITY
SEWER MASTER PLAN

FUTURE SYSTEM IMPROVEMENTS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 6-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 6-1 - System Improvements.mxd aanderson 2/17/2016

SS 3. 1400 South, Chambery to Springwater Lift Station

The capacity of the existing 10-inch line which runs along 1400 South will be exceeded as a result of increased flow from new development. In order to convey the total flow for this service area, additional capacity must be provided. Replacing the existing line with a new 18-inch sewer main will provide the necessary capacity through build-out. Orem City GIS data indicates that the existing sewer conduit just upstream of the Springwater Lift Station crosses underneath an existing pond. It is recommended that the City verify the alignment of this section of pipe and analyze the ability to replace it.

SS 4. Springwater Force Main

Model results for build-out sewer flows in Orem City indicate that peak hour flows through the existing 10-inch Springwater force main may exceed the recommended maximum velocity of 7 feet per second at buildout. In a pumped system, high velocities cause excessive head leading to high operating costs and can pose a high risk for transient damage after power failures. In order to reduce peak hour flow velocities while also maintaining minimum velocities through the sewer line, it is recommended to install a new parallel 6-inch force main from the lift station to the outfall near the Water Reclamation Facility.

SS 5. College Drive/1200 West and 800 South

As shown in Figures 5-1 and 5-2, the 550 foot section of pipe on College Drive downstream of the intersection of 1200 West and 800 South is shown as deficient under both existing and future flows. The primary factor contributing to this deficiency is an adverse slope caused by a low point at the manhole invert approximately 275 feet downstream from the manhole at 1200 West and 800 South. It is recommended that the elevation of the inverts along this alignment be resurveyed and checked against the existing Orem City GIS data.

If current model results are accurate, it is recommended that 1,260 feet of 30-inch and 33-inch line be replaced with 36-inch line. However, this pipe should be surveyed and model results updated prior to beginning this capital project.

SS 6. College Drive near 1200 South

As a result of future growth in Orem City, a deficiency is projected under buildout conditions in the 12-inch sewer conduit on College Dr. and 1200 South on the east side of I-15. The recommended improvement for this section of pipe is to replace 820 feet of 12-inch pipe with new 15- or 18-inch pipe. Surcharge concerns at this location will primarily be a concern under wet weather conditions. Because there are no nearby connections, some surcharging at this location may not pose any significant concern. These pipes should be monitored after the first phase of redevelopment at the University Mall to verify that this project is needed. This improvement project is covered in more detail in a technical memorandum regarding development at the University Mall attached as an appendix to this report.

SS 7. 1000 South/Orem Water Reclamation Facility

By 2060, wastewater flow through the pipe on 1000 South leading to the treatment plant will exceed 75 percent of the pipe's hydraulic capacity. The deficient section of pipe starts in the 36-inch section near East Shore High School and continues east to the WRF. One option to eliminate this deficiency is to replace approximately 275 feet of the existing 36-inch pipe with 42-inch pipe, and replace the remaining length of 36-inch/42-inch pipe with a 48-inch/54-inch pipe. Depending on the age and condition of the existing pipe, this option may or may not be cost effective. Another option is to construct a parallel sewer main which would take any flow which exceeds the capacity of the main sewer trunk line.

SS 8. Geneva Lift Station Pump Upgrade

To accommodate build-out flows, particularly from Lindon City, the lift station on Geneva Road at 1000 North will require a capacity upgrade. The Geneva lift station is currently equipped with 4 pumps; a primary and backup 10 horsepower 833 gpm pump and a primary and backup 75 horsepower 1,187 gpm pump. Flow into the lift station up to 833 gpm is routed to Geneva Road through the 10 horsepower pump(s). Any remaining flow is taken by the 75 horsepower pump and sent through a force main to 1200 West. Because the line on 1200 West has more capacity than the line on Geneva Road, it is recommended to upgrade the larger pumps and send the increase in flow due to growth to 1200 West. Upgrading the capacity of the larger pumps from 1,187 gpm to 2,200 gpm would provide sufficient lift station capacity through buildout. It should be noted that the existing lift station building was designed with future expansion in mind. As a result, upsizing of the pumps at this location should be able to be accomplished relatively inexpensively.

SS 9. 1600 North 800 West

At the intersection of 1600 North and 800 West, the existing sewer system consists of a 15-inch pipe on 800 West (north of the intersection) and a 15-inch pipe on 1600 North (east of the intersection) combining into a 15-inch pipe which flows west from the junction. Model results show a capacity deficiency in the section of pipe downstream of the intersection. Replacing 950 feet of 15-inch pipe with new 18-inch pipe would provide the necessary capacity to convey peak hour flows while maintaining surplus capacity for inflow events.

SS 10. 925 South 725 West

A 1,200-foot section of the existing 21-inch pipe along 925 South starting at 725 West is projected to have a capacity deficiency under peak hour build-out flows. Replacing this pipe with a new 24-inch pipe will provide adequate capacity for sewer flows through buildout.

Southwest Annexation Area

One of the largest areas of future growth in Orem is the Southwest Annexation area. It is estimated that the annex will approach full build-out by 2027. In order to convey wastewater flows to the nearby Water Reclamation Facility, Orem City has proposed the installation of

approximately 18,500 feet of new sewer pipe and a new lift station located at the west end of the annex. The main transmission line will run along Geneva Road and tie into the existing sewer system at Geneva Road near Chambery Woods. For reference, these improvements have been shown on Figure 6-1. However, it should be noted that these improvements will all be built and paid for by developers in the area. As a result, none of these projects are included in this master plan.

OTHER COLLECTION SYSTEM IMPROVEMENTS

In addition to the capacity related projects identified in the master plan model, Orem City has compiled a list of additional condition related collection system improvements which are to be constructed within the next 15 years. Table 6-1 contains a summary of these projects.

Table 6-1
Additional Condition Related Collection System Projects

Project Description	Estimated Cost (2014 Dollars)
675 N. 1060 W. to 1200 W. – H2S Concern	$29,500
1720 S. 400 W. to Sand Hill Rd. – H2S Concern	$41,500
Eastwood Street – Replacement Project	$200,000
Westwood Street – Replacement Project	$250,000
Total	**$521,000**

This does not represent a comprehensive list of all condition related system needs, but is intended to highlight the most pressing needs. Additional rehabilitation and replacement needs are discussed in Chapter 7.

WATER RECLAMATION FACILITY IMPROVEMENTS

A comprehensive evaluation of the City's reclamation facility was not included in the scope of this master plan. However, Orem City has identified a series of Water Reclamation Facility improvement projects that they would like to include in the capital facilities plan. Table 6-2 provides a summary of these projects. Among the projects identified is "Struvite Elimination". A technical memorandum documenting issues with Struvite at the reclamation facility along with recommendations is included in Appendix B.

Table 6-2
Orem City Water Reclamation Facility CIP Projects

Project Description	Estimated Cost (2014 Dollars)
Replace headworks bar screens	$400,000
Replace grit washer	$200,000
Third press in solids handling	$500,000
Struvite elimination	$1,600,000
Concrete/membrane existing lagoons	$500,000
Replace back-up generator	$500,000
Replace existing solids presses	$1,000,000
Upgrade/expansion of aeration/grit basin on the headworks facility	$800,000
Sludge disposal options - solar, central county treatment disposal site	$5,000,000
Co-generation technology	$1,000,000
Total	**$11,500,000**

CHAPTER 7
CAPITAL IMPROVEMENT PLAN

Previous chapters of this report have identified improvements to resolve existing deficiencies and to accommodate wastewater flow from future growth. Providing an acceptable level of service requires consistent and continual system monitoring and evaluation, with updates being made when necessary. The purpose of this chapter is to assemble a 10-year capital improvement program to implement the recommended improvements. This will include recommendations regarding levels of funding for system rehabilitation, replacement, and capital improvement projects.

SYSTEM REHABILITATION AND REPLACEMENT

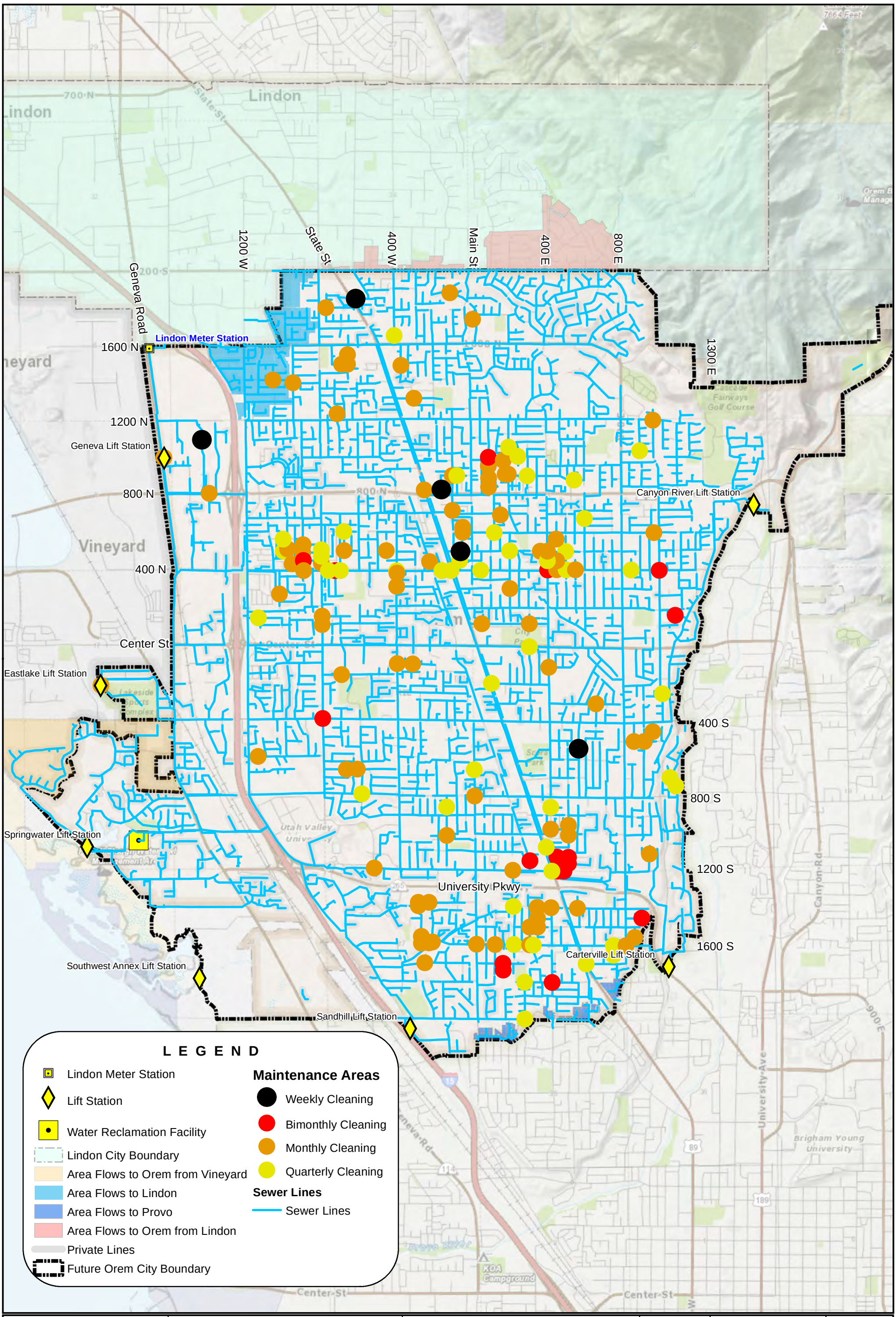
In order to assemble a 10-year capital improvement plan, it is not adequate to consider only capacity related improvements. It is also necessary to budget for the expected rehabilitation and replacement of system components. This section examines known areas of needed rehabilitation and replacement for inclusion in the capital improvement plan. This is not a comprehensive evaluation of existing maintenance procedures or system conditions, nor is it a complete asset management plan. Instead, it is a collection of general observations assembled during the master planning process relative to system rehabilitation and replacement.

Frequent Maintenance Areas

In an effort to improve the condition of the existing sewer system, Orem City has compiled a list of potential projects that could be completed to eliminate problems that require frequent maintenance by City staff (dated 2012). Areas requiring frequent maintenance are shown in Figure 7-1. A complete list of these maintenance projects can be found in Appendix C along with a breakdown of project priorities. Projects contained in the list include:

- Replacing deteriorated pipe
- Lining existing pipe (cast in place pipe)
- Pipe/manhole flushing
- Point repairs (such as at a joint)

A summary of the costs associated with these maintenance projects and the corresponding pay-back period is shown in Table 7-1 below.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS	OREM CITY SEWER MASTER PLAN	FREQUENT MAINTENANCE AREAS	NORTH:	SCALE: 0 1,500 3,000 Feet	FIGURE NO. 7-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 7-1 - Frequent Maintenance.mxd aanderson 2/17/2016

Table 7-1
Estimated Cost of Maintenance Projects & Corresponding

Return on Investment Time Frame	Estimated Cost of Maintenance Projects (2014 dollars)
Less than 10 years	$1,249,000
10 to 20 years	$1,018,000
20 to 40 years	$1,885,000
Greater than 40 years	$1,844,000
Total	**$5,996,000**

The return on investment time frame listed in Table 7-1 was developed by estimating the time and/or materials needed to perform maintenance for each facility requiring frequent maintenance. The annual cost associated with maintenance time and/or materials was then compared with the capital cost of eliminating the problem causing the need for frequent maintenance. The return on investment time frame reflects the number of years required before the capital cost of the improvement is paid back through reduced maintenance costs.

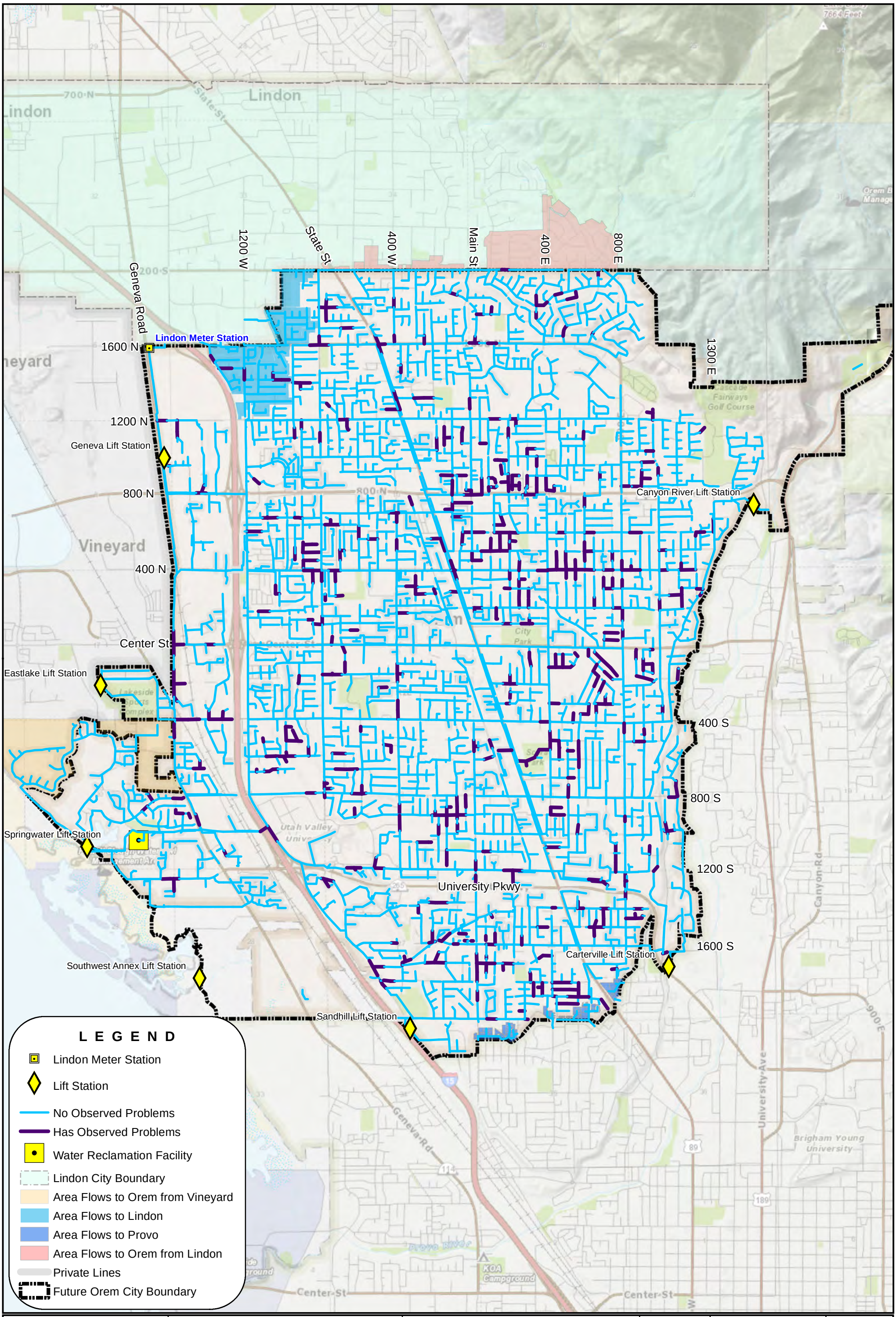
It is recommended that Orem City begin to complete the identified projects to eliminate frequent maintenance areas, starting with those that have the shortest return on investment. Even for those projects that have a longer return on investment, it is recommended that the City consider opportunities to complete some of these projects as opportunities arise. It is important to keep in mind that, as the system ages, these maintenance areas will continue to get worse and new areas will appear. Keeping up with maintenance projects and pipe replacement will help prevent the system from falling into disrepair and will reduce the amount that the City needs to spend in the long run.

Concrete Pipe Assessment and Rehabilitation

One major category of concern relative to sewer system rehabilitation and replacement is the corrosion of existing concrete pipe. Hydrogen sulfide gas in a sewer system can result in the formation of sulfuric acid (H_2SO_4) on pipe and manhole walls. Sulfuric acid can result in severe corrosion of ferrous metals and concrete. The top of a moist concrete pipe is a common area for the formation of sulfuric acid and corresponding corrosion. This is a significant concern for Orem because a large portion of the City's collection system is constructed of concrete pipe.

Orem City diligently inspects pipes on a regular basis to identify rehabilitation needs. Figure 7-2 identifies collection pipes in the City with observed deficiencies such as sulfuric acid related corrosion, breaks or cracks in the line, offset joints, bellies, roots, and infiltration. Some of these observed deficiencies can be eliminated with maintenance, but others require repair and replacement. It is recommended that the City continue to diligently perform preemptive pipe inspections to identify areas where corrosion may be occurring.

Figure 7-3 identifies some areas of the system where H_2S corrosion may be more likely. This is the result of two factors:



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OREM CITY
SEWER MASTER PLAN

SEWER PIPES WITH OBSERVED STRUCTURAL ISSUES

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 7-2

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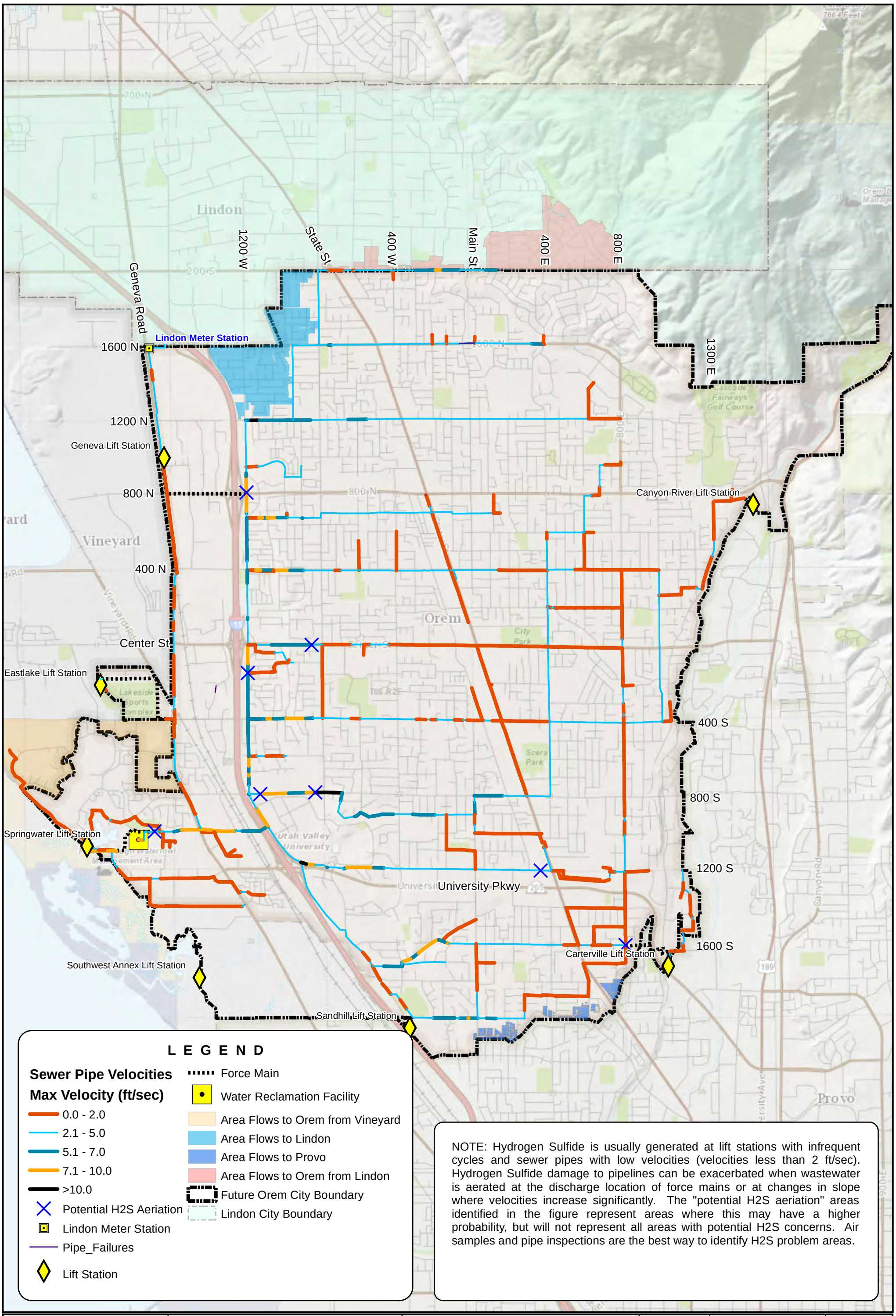

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SEWER MASTER PLAN

PIPES WITH LOW VELOCITIES AND H2S AERATION CONCERN AREAS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 7-3

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 7-3 - H2S Potential Areas.mxd amckinnon 4/21/2015

- ***Hydraulic Conditions*** – H_2S formation is affected by hydraulic conditions in two ways. First, where velocities are low, there is more potential for the accumulation of a slime layer with the bacteria that create H_2S. As a general guideline, pipes with velocities less than 2 ft/sec have a higher probability of developing the anaerobic conditions that generate hydrogen sulfide. Second, where pipes have high velocities, there is a higher probability of aerating the wastewater and releasing the hydrogen sulfide gas that leads to damage of concrete pipe. Figure 7-3 indicates maximum flow velocities in sewer pipes for existing conditions. Of primary concern are those areas where long sections of low velocity flow are followed by a section with high velocity flow (the H_2S forms in the slow sections and is then released in the fast sections). Figure 7-3 identifies a few areas in the City where hydrogen sulfide could potentially be aerated because of significant changes in velocity. However, there are many other factors that can contribute to pipe deterioration including changes of use (e.g. construction of restaurants) and increases or decreases in flow from changing demographics.
- ***Force Main Discharge*** – Other areas of concern for hydrogen sulfide accumulation are at force main discharge locations. Because force mains flow full, very little corrosion will occur through the force main pipe. However, because they full, there is a larger hydrogen sulfide producing slime layer. As the pipes discharge into gravity mains and the flow is aerated, hydrogen sulfide gas can be released.

Where corrosion is observed, it is recommended that aggressive rehabilitation efforts be initiated to protect the pipeline from further damage. If the corrosion has not yet damaged the structural integrity of the pipeline, a cast-in-place pipe (CIPP) rehabilitation can often be done relatively inexpensively to protect the existing concrete and preserve the full design life of the pipe. If the corrosion has progressed to the point that the structural steel in the pipeline is compromised, a more expensive structural rehabilitation or complete replacement of the pipeline will be required.

Because hydrogen sulfide presents a major risk to the City's wastewater infrastructure, it is recommended that condition assessment of the City's existing infrastructure and prioritization of H2S related rehabilitation be an immediate priority. With the initial dollars that become available for this purpose, it is recommended that the City use its own forces and/or contract with outside inspection companies to perform a complete inspection and inventory of the City's existing pipelines. Using the information obtained through this inspection, the City can then develop an asset management plan to prioritize future rehabilitation activities.

System Rehabilitation and Replacement Priorities

Because funding is always limited, it is important to prioritize initial system rehabilitation efforts based on the potential consequence of a pipe not performing as designed. The following criteria may be helpful to Orem City personnel in identifying pipes that are most critical based on their relative importance in the collection system:

- Sewer Flow Rate – Flow rate in a sewer pipe is the single most important indicator of the importance of a pipe. Generally speaking, the higher the flow rate, the larger the area which a pipe serves. Bypass pumping costs, the risk if property damage, environmental and regulatory consequences, the cost of pipe replacement, and problems from sewage up

in the system are all more severe for larger flow rates. In a worst case scenario, if a pipe collapses or becomes blocked and surcharging in the pipeline results in flows backing up into basements and streets, there is a much greater health hazard to the public with a high flow pipe.

- Road Type – It is much more difficult and costly to perform sewer line repairs on streets with dense traffic. Therefore, pipelines located in high traffic areas should be considered more critical than lower traffic areas. For example, the cost of pipe failure along 800 North or State Street would be much greater than an equivalent sized pipe located on a residential street.

- Pipe Depth – The depth of the pipe can have a significant impact on the cost of repairs and rehabilitation of sewer pipe. Extensions on backhoes, very wide trenches, dewatering, etc. make repairs and maintenance much more expensive and time consuming on deeper pipes. Repairing such pipes under an emergency situation would only be that more difficult. For this reason, deep pipelines should be prioritized over shallow pipelines when planning a repair or maintenance schedule.

CAPITAL IMPROVEMENTS BUDGET

Before establishing a 10-year capital improvement plan, it is necessary to determine how much funding will be set aside each year for capital improvements. One of the best ways to identify a recommended level of funding is to consider system service life. As with all utilities, each component of a sewer system has a finite service life. Therefore, it is necessary to continually spend money towards the rehabilitation or replacement of these components. If adequate funds are not set aside for regular system renewal, the collection system will fall into a state of disrepair and be incapable of providing the level of service that Orem City customers expect.

Orem City's sewer collection system is composed of about 1.5 million feet of pipe and over 6,400 manholes. The total cost to replace all of the pipes and lift stations in the Orem collection system would be approximately $380 million based on 2015 construction costs. In reality, it will not be necessary to completely replace the entire system as it ages because of rehabilitation technologies (e.g. slip lining, cast-in-place pipe, etc.). Rehabilitation costs are much lower than replacement costs (20% to 60% depending on pipe diameter). If Orem were able to rehabilitate the entire system rather than replace components, it would drastically reduce the "replacement value" to $90 million. Unfortunately, it is generally not possible to rehabilitate all system components due to either condition or capacity issues. Some pipes are beyond saving with rehabilitation, while others may require upsizing or correction of grade issues; all of these scenarios would require a replacement.

To account for the limitations on rehabilitation, BC&A recommends a renewal budget derived from a combination of rehabilitation and replacement using an approximate design life of 70 years. Table 7-2 shows a comparison of the required annual budget based on replacement, rehabilitation, and the recommended combination of both values.

Table 7-2
Recommended Sewer Collection System Renewal Budget

System Renewal	Annual Budget (2014 Dollars)*
Replacement of all system components	$5,700,000
Rehabilitation of all system components	$1,350,000
50% replacement 50% rehabilitation	**$3,525,000**

*1.5% of complete system "replacement" (ENR=9870) which assumes an average 70 year life cycle for all system components (pipes, pump stations, etc.)

In addition to the collection system, a yearly budget should also be designated for the renewal of the Water Reclamation Facility. The total cost to replace the WRF would be approximately $80 million. Since the WRF incorporates several mechanical and electrical components, a shorter design life (50 years) was assumed. Table 7-3 shows the total recommended capital improvement budget for the sewer collection and treatment system.

Table 7-3
Recommended Total Sewer System Annual Capital Improvement Budget

Component	Value
Collection System	$3,525,000
Water Reclamation Facility	$1,600,000
Total	**$5,125,000**

In addition to system renewal requirements required for maintenance programs, there are also work force needs to operate and maintain facilities. Work force needs are discussed further in a technical memorandum in Appendix D.

10-YEAR CAPITAL IMPROVEMENT PLANS

Based on the City's identified project needs and recommended level of capital investment, BC&A has developed four potential capital improvement scenarios covering the next 10 years. These scenarios are shown in Figures 7-4 through 7-7 and detailed in Table 7-4 through 7-7. The process of developing the several scenarios was as follows

- **Identify the Revenue Available for CIP Based on Current Rates –** Each of the figures show the revenue that is projected to be available for capital improvement projects based on current rates. This represents the revenue the City would have available for capital improvements over the next 10 years if it does not make any changes to its existing rates. It will be noted that this revenue increases gradually over time as additional users join the system.

- **Identify the Recommended CIP Funding Level Based on System Value –** Each of the figures also show the recommended capital improvement project funding level for the wastewater system. This is the level of funding sufficient to perform maintenance related projects and system renewal as discussed previously. This level of funding increases over time to keep up with both system growth and inflation.
- **Develop a Transition Plan between the Current and Recommended Levels of Funding –** From the several figures, it is apparent that the projected revenue associated with existing rates will be woefully inadequate to implement the capital improvement projects needed in the City's wastewater system. At current rates, the City would not be able to keep up with system renewal projects and the level of service in the City's sewer collection and treatment system would begin to decline. Because of the dramatic difference between existing revenue and recommended CIP funding, a budget plan is needed to gradually transition between the two. The several scenarios look at different ways to reach the recommended level of funding:

    - **Scenario 1, 5-year Phase In (Figure 7-4, Table 7-4):** As a starting point, BC&A looked at the immediate needs of the City and identified a transition plan that would address all the most pressing needs while limiting annual rate increases. This resulted in the development of Scenario 1. This scenario includes transitioning to the recommended long-term level of funding over a period of 5 years. This scenario would allow the City to construct all of the recommended projects identified in the planning window and begin to implement additional maintenance and renewal projects.
    - **Scenario 2, 7-year Phase In (Figure 7-5, Table 7-5):** To minimize the required annual increases to the rates, BC&A also looked at slower implementation options. Scenario 2 includes a transition from current to recommended levels of funding over a period of 7 years. While this would reduce rate increases and would allow the City to complete all of its highest priority projects, it would require the City to postpone recommended maintenance and renewal projects. Over time, neglect to these areas will result in a reduced level of service and lead to more frequent and costly emergency repairs. Selection of Scenario 2 over Scenario 1 would result in the delay of $2.5 million in system maintenance improvements.
    - **Scenario 3, 10-year Phase In (Figure 7-6, Table 7-6):** This scenario is similar to Scenario 2, but would transition from current to recommended levels of funding over a period of 10 years. Selection of Scenario 3 over Scenario 1 would result in the delay of $5.9 million in system maintenance improvements.
    - **Scenario 4, Bonding (Figure 7-7, Table 7-7):** The previous three scenarios have looked at funding capital improvements on a pay as you go basis. As an alternative, the City could consider using bond funding as a way to accomplish more of the recommended projects without increasing rates as dramatically up front. Bond funding would also allow some of the costs incurred today to be paid for by future users that will benefit from the improvements. Scenario 4 includes funding all of the same projects as identified in Scenario 1, but uses bond funding to limit rate increases to levels slightly below those identified in Scenario 3. To accomplish this plan, the City would need to take out bonds of $4.5 million and

$7.5 million in 2018 and 2021 respectively. These would be used primarily to pay for collection system projects (e.g. Carterville Force Main Relocation, Springwater Lift Station, etc.) and treatment plant projects (Struvite Elimination, Headworks Replacement, etc.). Normal rate revenue could then be used for system maintenance and renewal.

Tables 7-4 through 7-7 list the improvement projects that could be completed within the next 10-years for Scenarios 1 through 4, respectively. Figures 7-4 through 7-7 show this same information graphically. For comparison purposes, Figure 7-4 includes the total level of funding for all four of the scenarios. System improvement projects have been grouped into the following major budget categories:

- **Collection System Capacity Improvements –** Collection system capacity improvements include projects needed to remedy existing deficiencies in the collection system or to increase capacity to accommodate future growth. Projects included within the next 10-years are those projects with existing deficiencies or deficiencies projected to occur within the next 10-years without improvements. Because these improvements are driven by projected growth, there is little flexibility in when they can be completed.
- **Water Reclamation Facility –** The overall capacity at the City's water reclamation facility (WRF) will be adequate for many years. However, there are a number of components at the WRF that will need to be upgraded or replaced within the next 10-years to continue to provide adequate service for the City. Projects to be included within the next 10-years were identified by City personnel. While there is some flexibility in the timing of these projects, unduly postponing their completion will lead to difficulty meeting treatment standards at the WRF.
- **Maintenance/H2S Related Projects –** Maintenance and H2S related projects include those projects identified above that are associated with frequent maintenance, observed condition issues, or H2S corrosion. There is significant flexibility in when these projects are completed. In the case of the frequent maintenance issues, the City could postpone all these projects indefinitely and just keep performing the maintenance. However, the sooner the projects are completed, the sooner the City will start realizing the savings associated with reduced maintenance costs. In the case of observed condition issues, the City might also postpone the improvements, but this will result in significant future expenditures. As discussed previously, maintenance issues will continue to surface as the system infrastructure ages, and the City will benefit by staying up to date on maintenance.
- **Vehicle (Fleet) Replacement –** City personnel have developed a schedule for vehicle replacement based on approximate use, depreciation, and reliability for maintenance vehicles in the City. Because the City has been behind on its replacement schedule over the last several years, the first two years of the recommended sewer budget include a larger proportion of total capital costs for vehicle replacement as the City replaces some of its vehicles that are already beyond their useful service life. However, these costs should decrease and then remain relatively constant as the City replaces vehicles at more regular intervals in the future.
- **Unplanned System Repairs –** Because the City cannot predict precisely when and where pipe failure may occur in the system, a budget item needs to be included in the

recommended capital fund plan that is dedicated to unplanned repairs. This money will then be available to address repairs to be performed when a deficiency is observed in the system. These likely would include point repairs that appear to be of an urgent nature in the system.

- **System Replacement/Renewal –** After accomplishing all of the specific improvements identified above, any remaining capital improvement budget would be dedicated to system replacement. System replacement costs will include identifying those areas of the City's collection system that appear to be aging and in need of repair or replacement. This budget item will include pipes identified via the City's inspection program that need lining or replacement.
- **SW Annex Improvements –** It will be noted that no costs have been shown in the plan for improvements associated with the Southwest Annex. These projects have been left out of the City's 10-year capital improvement budget because they will be funded and constructed by the annex developers.

Ultimately, selection of an implementation scenario has been left to the City's discretion. All of the scenarios will accomplish the City's most pressing capital improvement projects and will fund the system at the long-term recommended level of funding by the end of the 10-year planning window. Selection of a more or less aggressive implementation plan will ultimately depend on the City's desire to proactively invest in its system versus its tolerance for rate increases. In general, it is recommended that the City implement the transition as quickly as possible since system investment to protect existing assets has been consistently shown to reduce total long-term costs.

Table 7-4
10-Year Capital Improvement Plan – Scenario 1, 5-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$500,000	$500,000	$1,518,214	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$14,786,000	$81,378	$638,416	$953,741	$2,323,666	$1,503,671	$1,898,541	$2,213,316	$2,918,362	$2,226,020	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$48,796,000**	**$2,339,818**	**$3,808,706**	**$4,748,215**	**$5,574,372**	**$6,435,555**	**$6,656,442**	**$6,884,902**	**$7,121,196**	**$7,365,592**	**$7,586,560**

Table 7-5
10-Year Capital Improvement Plan – Scenario 2, 7-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$500,000	$500,000	$1,518,214	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$12,528,000	$81,378	$112,604	$375,818	$1,802,622	$900,000	$1,600,000	$2,213,316	$2,918,362	$2,226,020	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$46,538,000**	**$2,339,818**	**$3,282,893**	**$4,170,292**	**$5,053,328**	**$5,831,885**	**$6,357,901**	**$6,884,902**	**$7,121,196**	**$7,365,592**	**$7,586,560**

Table 7-6
10-Year Capital Improvement Plan – Scenario 3, 10-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$412,604	$500,000	$1,611,624	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$9,770,000	$81,378	$0	$294,364	$1,177,520	$300,000	$1,000,000	$1,600,000	$2,500,000	$2,000,000	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$43,780,000**	**$2,339,818**	**$3,082,893**	**$3,870,292**	**$4,746,738**	**$5,231,885**	**$5,757,901**	**$6,271,586**	**$6,702,834**	**$7,139,571**	**$7,586,560**

Table 7-7
10-Year Capital Improvement Plan – Scenario 4, With Bonding

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000		$962,236								
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000					$413,861					
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000					$942,490					
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000		$212,180								
WRF 4	Third press in solids handling	$500,000					$579,637					
WRF 5	Struvite elimination	$1,600,000		$1,697,440								
WRF 6	Concrete/membrane existing lagoons	$500,000					$579,637					
WRF 7	Replace back-up generator	$500,000					$579,637					
M 1	Frequent maintenance related projects	$5,996,000	$617,588	$1,908,347			$2,085,302			$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000		$58,350								
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000		$63,654								
M 4	Eastwood Street - Replacement Project	$200,000						$238,810				
M 5	Westwood Street - Replacement Project	$250,000							$307,468			
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$518,448	$2,000,000	$2,000,000	$2,987,871	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000
System Replacement	Replace system as needed	$14,786,000	$398,000	$424,785	$956,959	$1,755,980	$850,825	$2,213,805	$2,662,862	$2,654,064	$2,760,746	$3,516,580
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$48,796,000**	**$2,339,818**	**$7,243,497**	**$3,503,661**	**$4,250,862**	**$11,756,043**	**$4,774,233**	**$5,304,597**	**$5,756,898**	**$6,213,169**	**$6,681,504**

Figure 7-4
Recommended Sewer Fund Expenditures, Scenario 1 - 5-year Phase In Plan

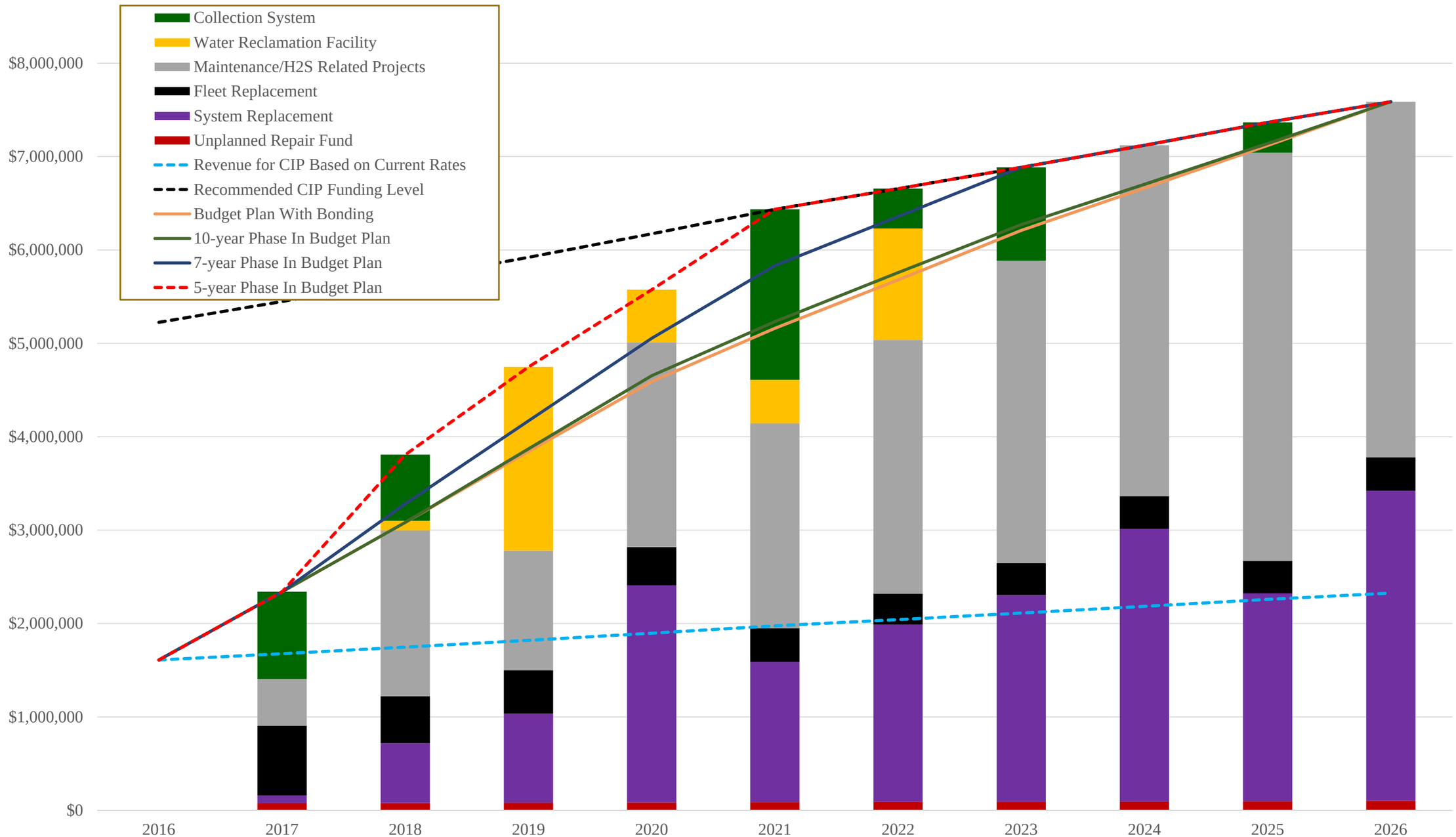


Figure 7-5
Recommended Sewer Fund Expenditures, Scenario 2 - 7-year Phase In Plan

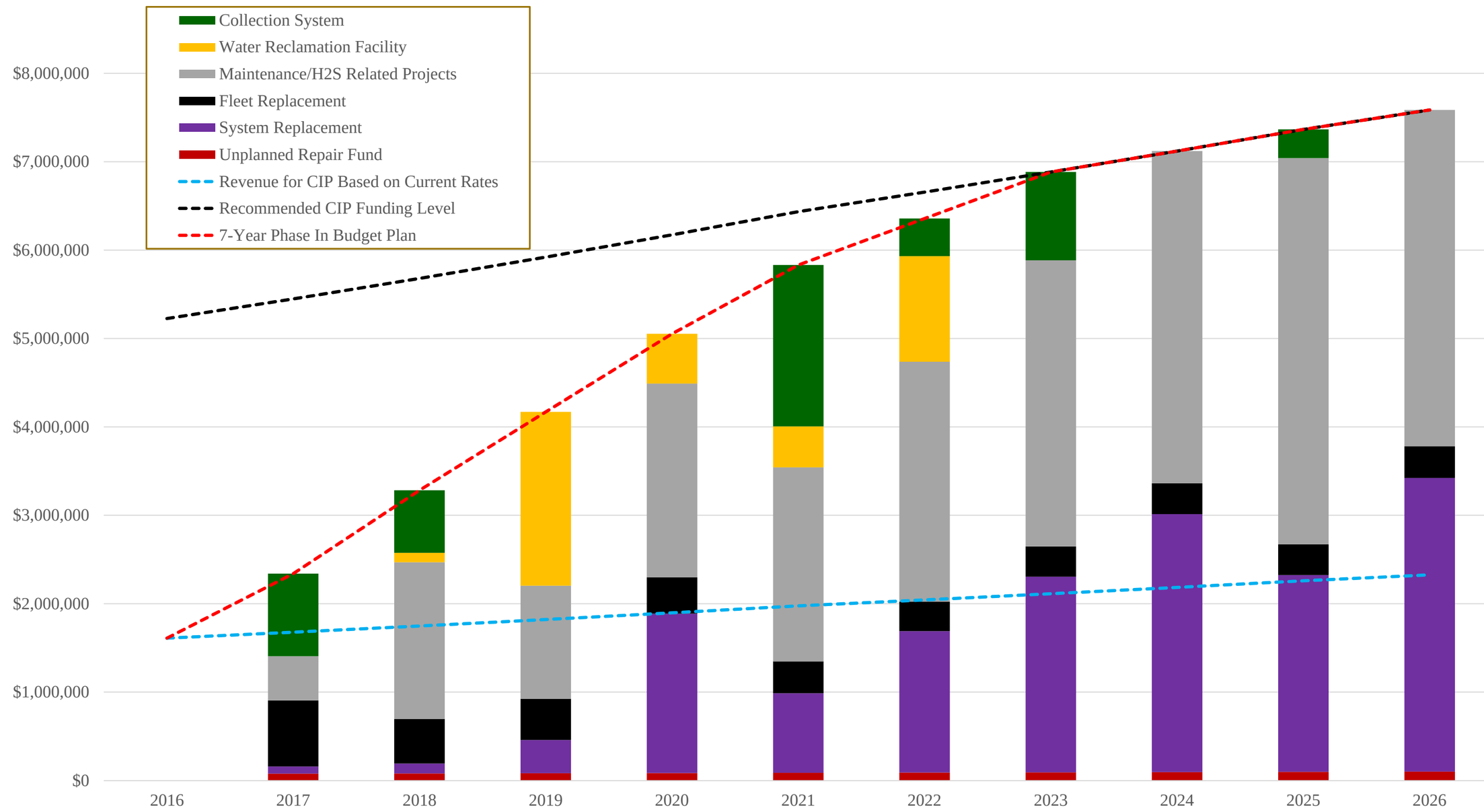


Figure 7-6
Recommended Sewer Fund Expenditures, Scenario 3 - 10-year Phase In Plan

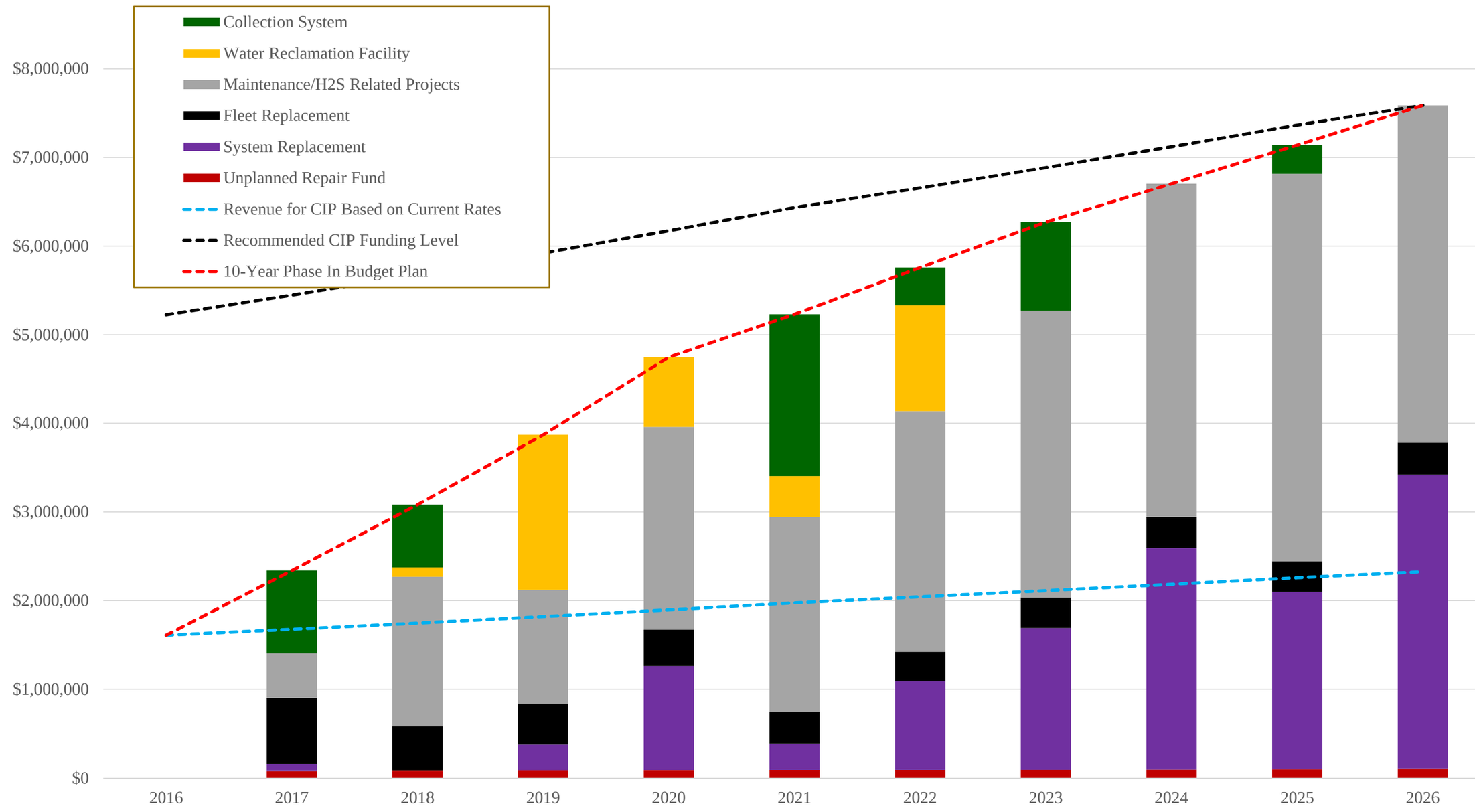
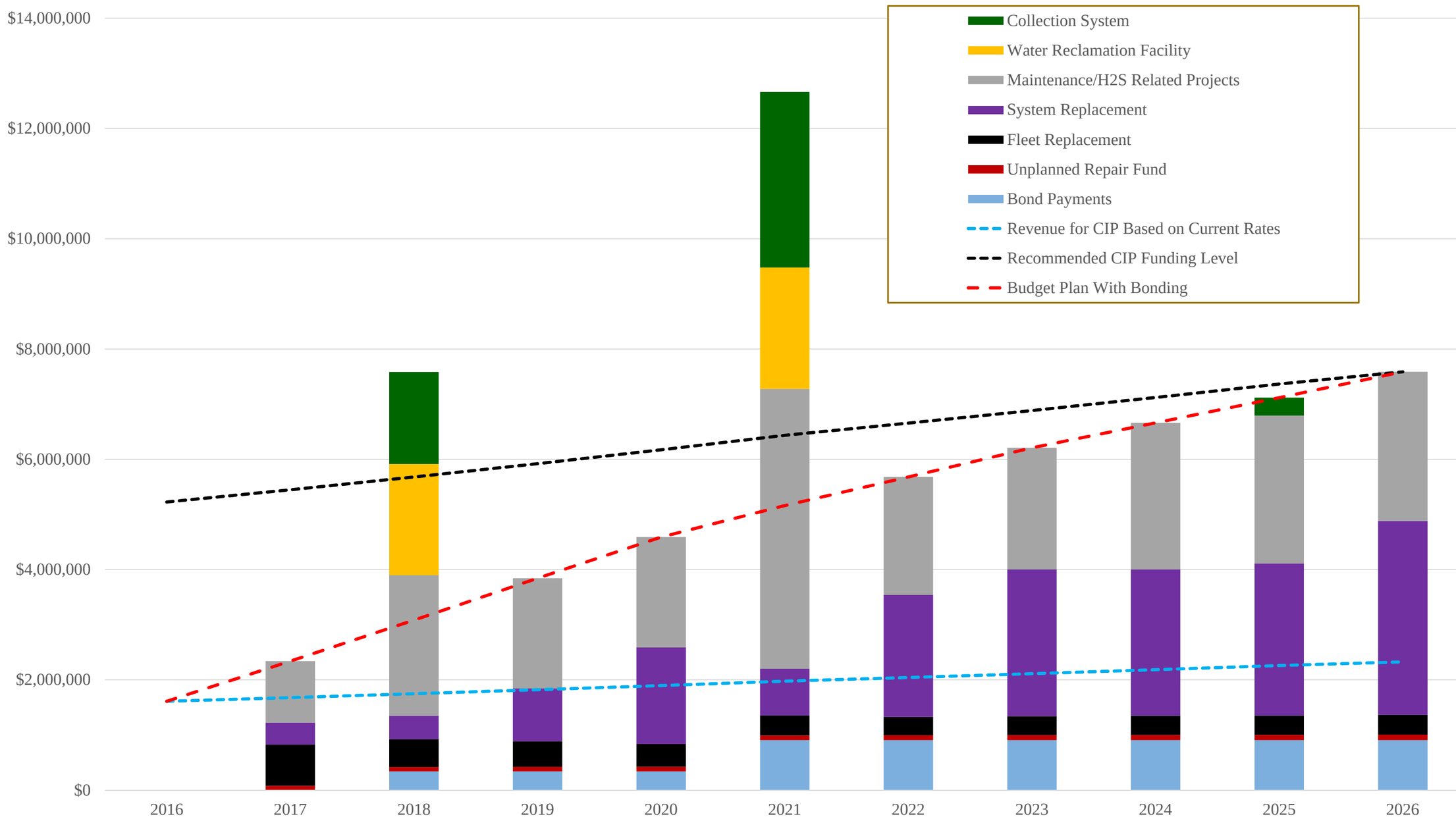


Figure 7-7
Recommended Sewer Fund Expenditures, Scenario 4 - With Bonding



APPENDIX A
LIFT STATION PUMP DATA

4" 5433
MT, W,
WD, CWD
SUBMERSIBLE

1770 RPM

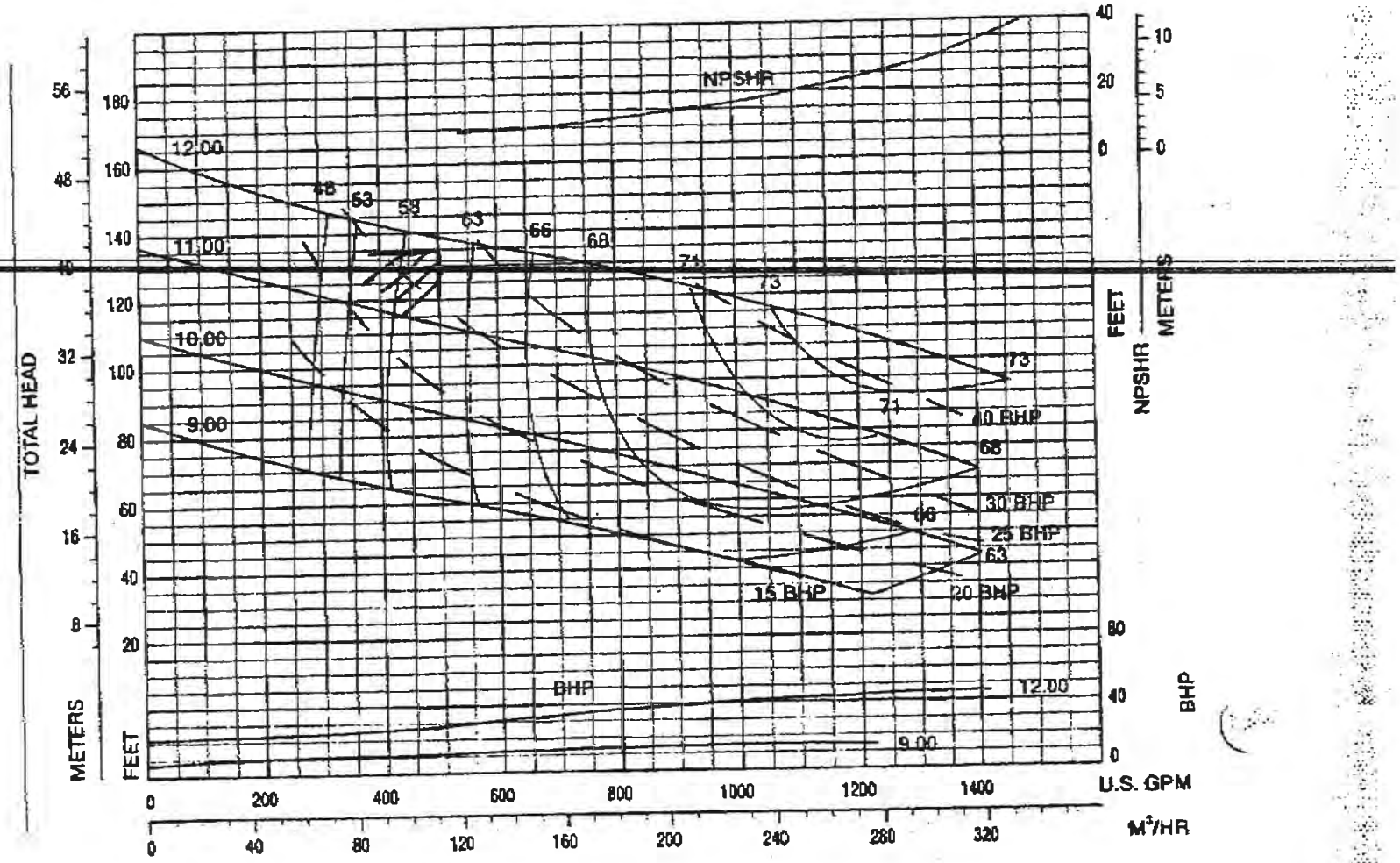
NO. OF VANES
2

SUCTION SIZE
4"
(WD: 4" OR 6")

IMPELLER
T4C1A

INLET AREA
37.50 SQ.IN.

MAX. SPHERE
3"



Fairbanks Morse Pump

8/1/97

500 gpm @ 135' TDH

40 hp Required if TDH could be less than 135'.

Carterville Lift Station

Geneva Lift Station

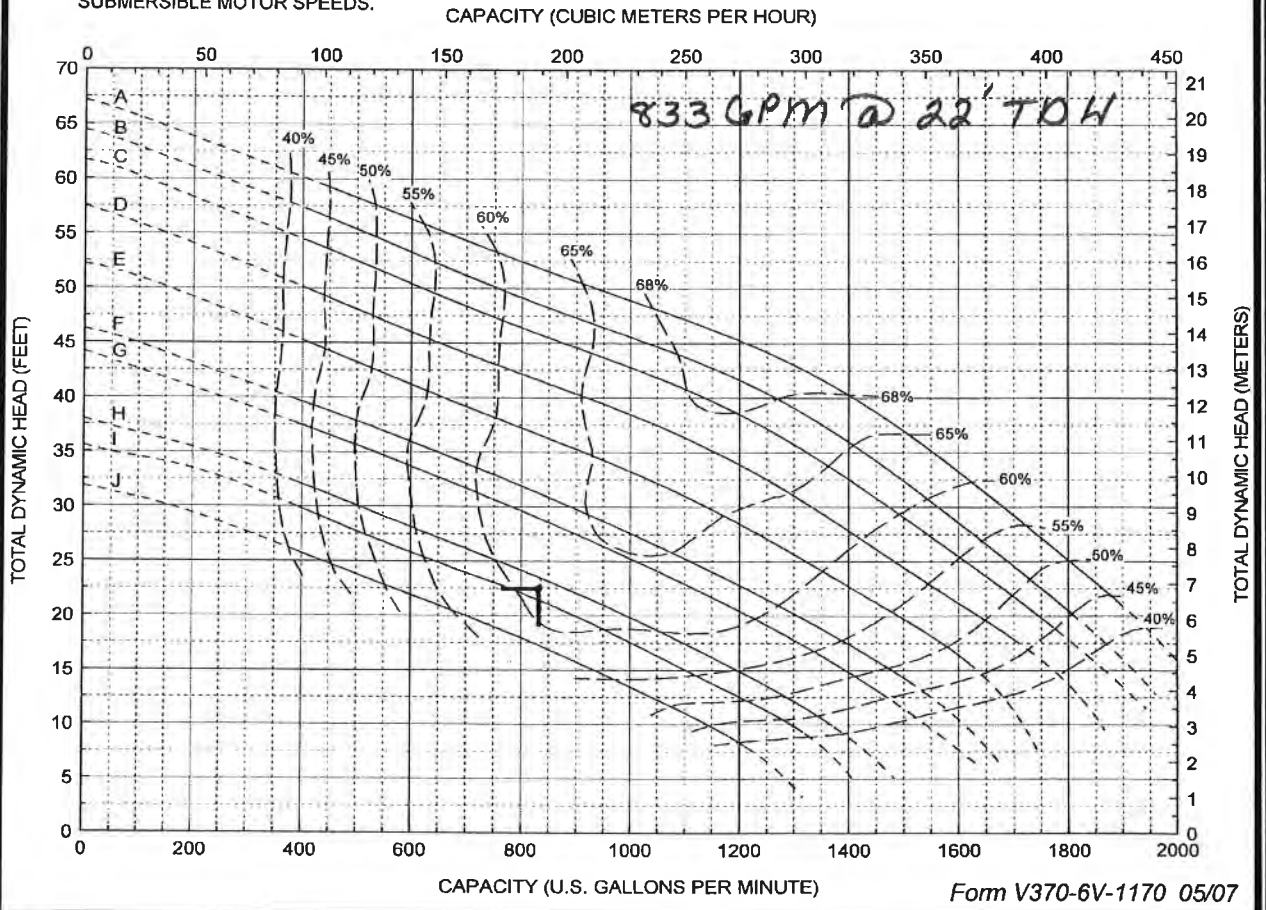
Vaughan E Series Chopper Pump PERFORMANCE CURVE

Models:
HE6U8
PE6U8
SE6U

Back-Pull-Out Casing
4-Blade Impeller
6" Discharge
8" Suction

CURVE	POWER (HP)	SPEED (RPM)	IMPELLER DIAMETER
A	25	1155	11.80" (300 mm)
B	25	1155	11.50" (292 mm)
C	20	1160	11.20" (284 mm)
D	20	1160	10.90" (277 mm)
E	15	1160	10.50" (267 mm)
F	15	1160	10.00" (254 mm)
G	15	1160	9.80" (249 mm)
H	10	1140	9.40" (239 mm)
I	10	1140	9.20" (234 mm)
J	7.5	1150	8.80" (224 mm)

DO NOT OPERATE PUMP IN DOTTED PORTION OF CURVES. CURVES SUBJECT TO CHANGE WITHOUT NOTICE. EFFICIENCIES SHOWN ARE NOMINAL BOWL. GUARANTIED MINIMUM EFFICIENCIES PER H.I. LEVEL B. CURVES ARE BASED ON SUBMERSIBLE MOTOR SPEEDS.



Form V370-6V-1170 05/07

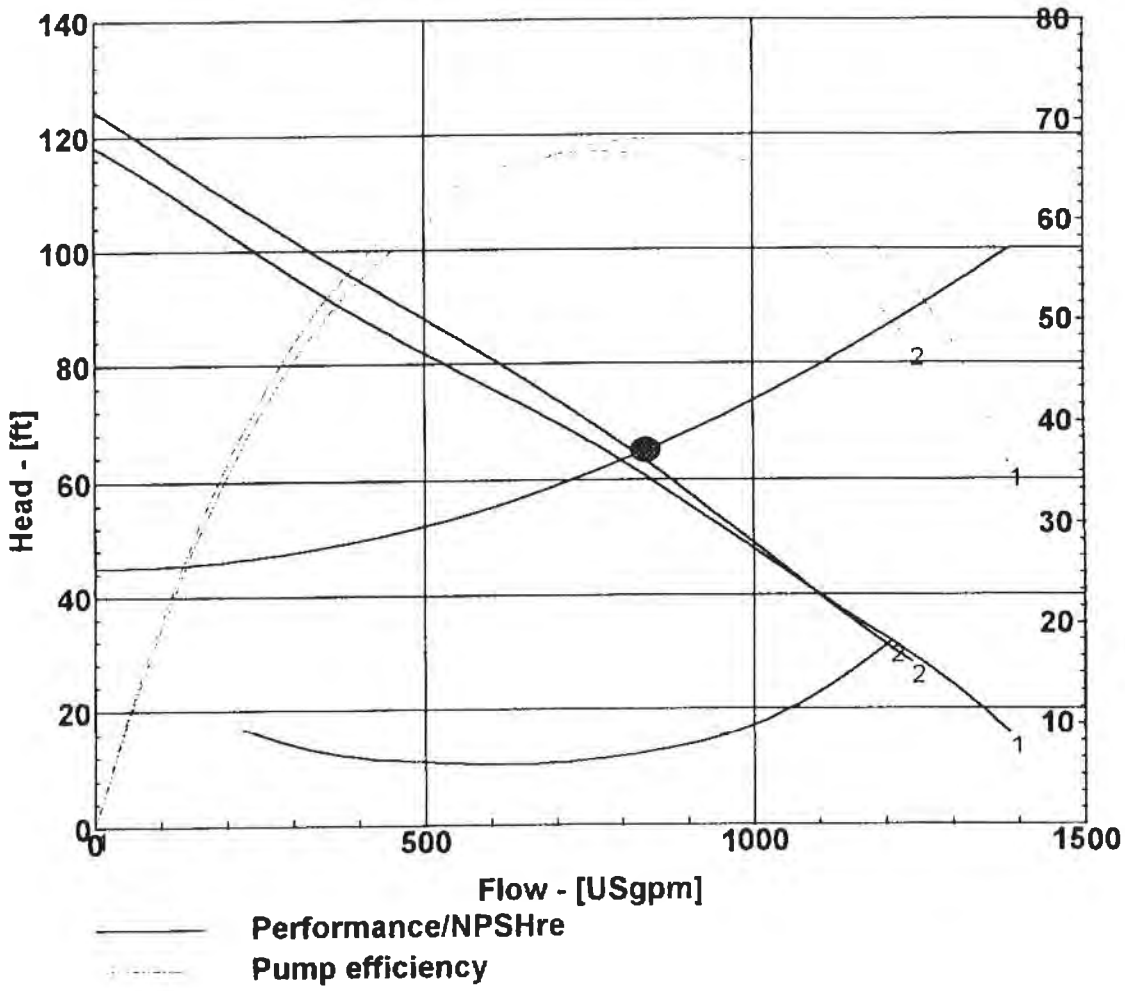
Springwater Lift Station

FLYGT

Duty Analysis - Performance curves

Project: Pump Station Upgrade

Created by:: DAVID L. HUTCHINSON



1. CP 3152 - 63-454-00-5350 20 hp 275 mm
2. CP 3152 - 63-454-00-5360 23 hp 275 mm

APPENDIX B
TECH MEMO:
STRUVITE ANALYSIS AND RECOMMENDATION

Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM-DRAFT

DATE: January 20, 2016

TO: Mr. Lawrence Burton
Plant and Collections Manager
Orem City Municipal Corp
1450 W 550 N
Orem, Utah 84057

FROM: Keith Larson, P.E., Boris Petkovic, P.E.
Bowen, Collins & Associates
154 East 14000 South
Draper, Utah 84020

PROJECT: Orem City Master Plan

SUBJECT: Task 8: Struvite Analysis and Recommendation

INTRODUCTION

As part of the Orem City Sewer Master Plan, City of Orem has requested that Bowen, Collins and Associates (BC&A) evaluate methods to control struvite formation within the City's water reclamation facility (WRF). Struvite formation has been a problem the facility experienced in the past in some of the plant's solids handling processes. The purpose of this memorandum is to provide an overview of existing struvite formation in the WRF's solids handling processing facilities and to provide a general evaluation and recommendations for potential struvite mitigation alternatives.

Struvite (MgNH4P04 ·6H20)—also referred to as magnesium ammonium phosphate (MAP) —is a hard crystalline mineral which is formed by the reaction of magnesium, ammonium and orthophosphate as shown in Equation 1.

$$Mg^{2+} + NH_4^{+} + PO_4^{-3} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O \qquad \text{(Equation 1)}$$

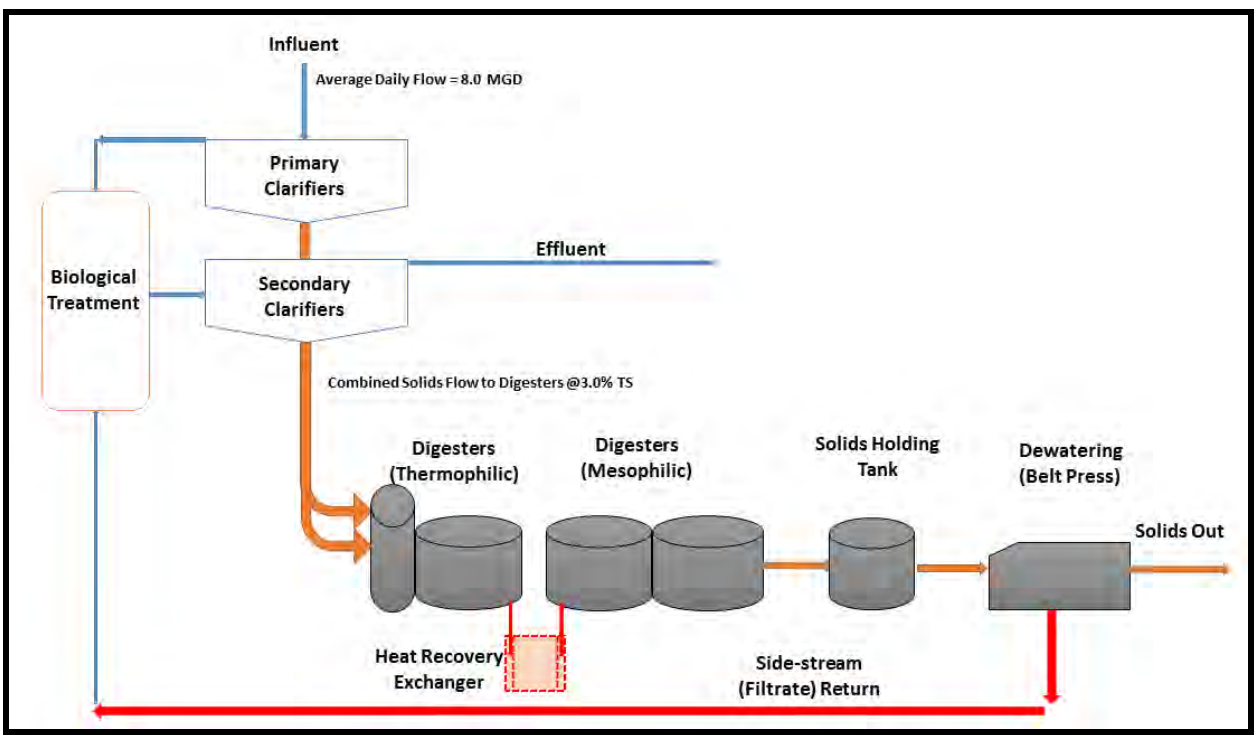
Struvite can precipitate whenever the product of the constituent activities (magnesium, ammonium, and phosphate) exceeds the oversaturation condition. Precipitation then ensues until equilibrium conditions are reached. Conditions affecting struvite solubility include concentrations of the three constituent ions, solution pH, temperature, and ionic strength. The struvite saturation condition, and therefore precipitation can be controlled by altering one or more of these conditions.

Struvite formation has been shown to occur in solids processing facilities (anaerobic digesters, solids processing piping, side stream piping) at a large number of wastewater treatment facilities. Formation of struvite is even more common at wastewater treatment plants that use biological nutrient removal (BNR) for phosphorous removal due to the increased phosphorous concentration in the secondary treatment waste sludge (WAS). Localized formation of struvite has been commonly observed at elbows of piping and suction sides of pipes. The cause for this is the increase in pH resulting from the release of Carbon Dioxide (CO_2). In pipe elbows and pump suction lines, this is due to reduction in pressure that causes release of CO_2 from the solution resulting in an increase of pH in the solution. In the case of side stream, the exposure of sludge to atmospheric conditions causes a portion of CO_2 to be released from the solution increasing the pH.

HISTORICAL OCCURRENCE OF STRUVITE AT THE OREM WRF

Figure 1 presents a simplified process flow diagram of solids processing at the Orem WRF. Orem WRF utilizes a two-phase (thermophilic/mesophilic) anaerobic digestion process for the stabilization of biosolids. The digesters are fed with a mixture of primary solids and Waste Activated Sludge (WAS) from the primary and secondary clarifiers respectively. Following digestion, solids are fed from a sludge holding tank at a rate of 400 gallons per minute (gpm) to the filter belt presses. Typically, solids are dewatered to a solids concentration of 15 percent. Liquid removed during the dewatering process (filtrate) is returned to the headworks building.

Figure 1
Solids Processing Flow Diagram at the Orem WRF (items shown in red indicate historical occurrence of struvite)



Historically, Orem WRF has experienced an accumulation of struvite in the belt press sludge dewatering process building and sludge-to-sludge (heat recovery) heat exchangers for the digesters.

In the dewatering building struvite accumulation was primarily noticeable on the concrete walls and floor directly beneath the belt press equipment. The operations staff has inspected the common area drain and piping to which the belt press equipment discharges. A video of the inspection has been provided and shows that only a slight accumulation occurs in the corners and bends of the pipeline in the form of discoloration. No significant accumulation was visible. In the past, there has been a monthly effort put forth to remove the accumulation that develops in the belt press area.

Accumulation of struvite in the sludge-to-sludge heat exchanger for the digesters has been most troublesome for the operations staff. In order to control the accumulation of struvite deposition, operation staff was forced to shut down the heat exchanger once a month to disassemble and clean. This process typically takes two days to complete with the effort of three personnel. Indication of the need to clean the system has historically been based on observation of pump performance. Reduction in pipe flow capacity was resulting in an increase in pump TDH signaling the accumulation of struvite and the need for cleaning. The amount of struvite that has been collected during these cleaning events is typically less than two cubic feet.

Figure 2
Struvite Accumulation on Heat Exchanger Piping

The operations staff is not aware of any other locations within the plant that may have struvite accumulation forming.

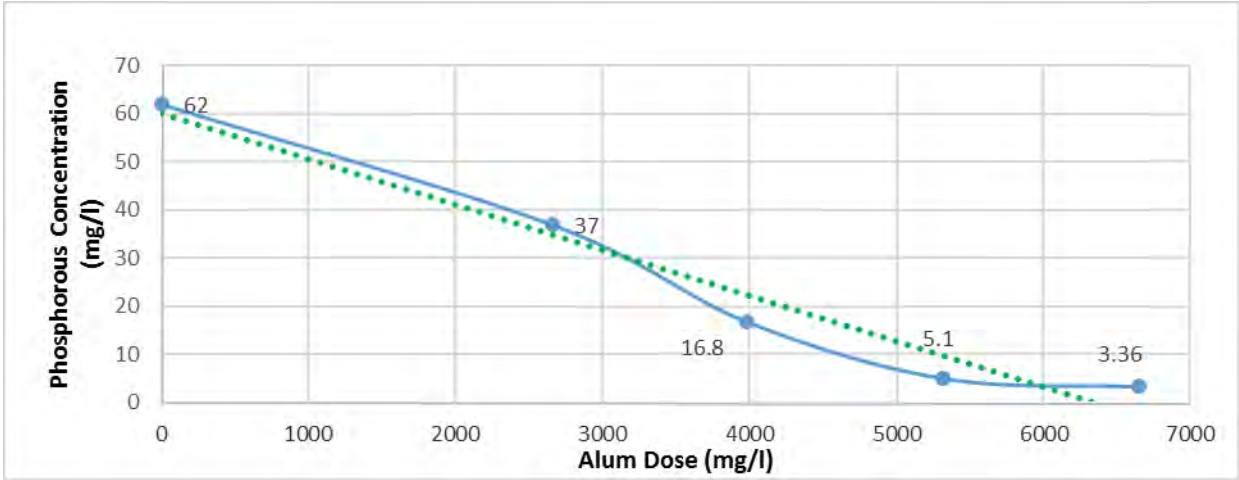
Current Struvite Mitigation Measures

In the last couple of years, Orem WRF staff has been very proactive in their efforts to control the struvite accumulation and has been using chemical addition at the dewatering building and thermophilic digester building. Chemical addition typically targets one of the main struvite components or alters the pH of the solution to prevent formation of struvite. At Orem WRF specifically, Aluminum Sulfate (Alum) addition is used which prevents formation of struvite by binding a portion of PO_4 ions (Equation 2) therefore preventing the saturation conditions to develop.

$$Al^{3+} + H_nPO_4^{\,3-n} \leftrightarrow AlPO_4 + nH^+ \qquad \text{(Equation 2)}$$

Prior to starting chemical addition, Orem WRF staff was assisted by Thatcher Chemical in performing limited bench testing on the sludge to establish a relationship between the Alum dose and the removal of Phosphorus. The developed dosing curve is shown in Figure 3. It is noted that the established curve is merely an approximation due to varying sludge conditions and limited number of samples.

Figure 3
Alum Dose vs. P Concentration Curve (Thatcher Chemical)



Alum dosing systems are installed in the thermophilic digester building and dewatering building in the vicinity of equipment where formation of struvite has been historically observed. According to the staff, the plant currently receives a delivery of approximately 4,000 gallons of Alum per month to control the formation of struvite. Based on the capacity of the existing chemical metering pumps and length of operation the Alum consumption at the two locations is estimated as follows;

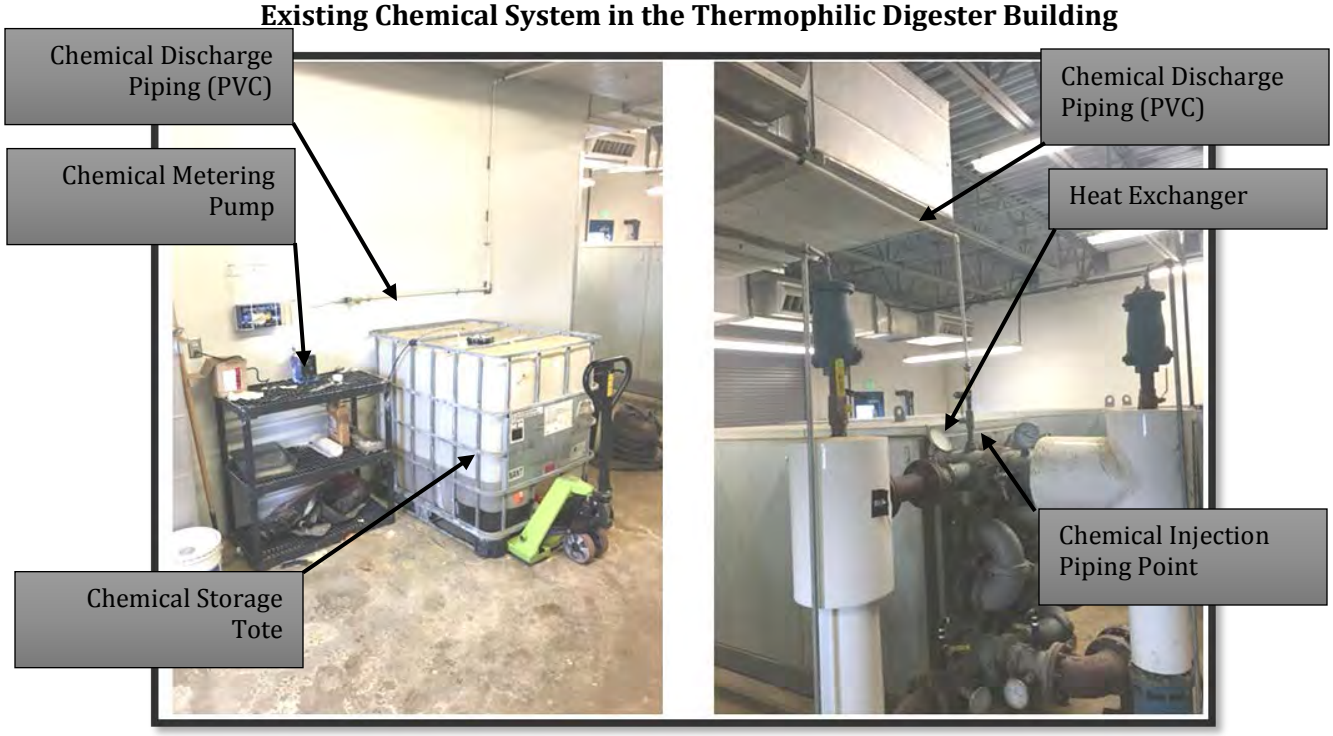
- Thermophilic Digester Building – (Weekly operation=168 hours) X (Existing pump capacity = 1.25 GPH) = 210 gallons per week (900 gallons per month).
- Dewatering Building – (Weekly Operation = 45 hours) X (Existing pump capacity = 10 GPH) = 450 gallons per week (2,000 gallons per Month)

There appears to be a relatively large discrepancy between the amount of Alum delivered to site (4,000 gallons per month) and what the theoretical operational consumption is (2,900 gallons per month). Some of the discrepancy may be attributed to variable length of operation of belt presses ,accidental spillage and leaks, and lack of pump calibration. For the purpose of this evaluation the actual quantity delivered on site is used to develop the operational costs.

Thermophilic Digester Building Chemical Addition System

The chemical addition system installed in the thermophilic digester control building is relatively simple but fully functional. It consists of a metering diaphragm pump with a capacity of 30 gallons per day (GPD), 275-gallon chemical storage tote, two isolation ball valves installed on pump discharge piping and chemical injection point, and PVC discharge piping. At this location, Alum is continuously fed into the sludge piping of the heat recovery heat exchanger. The chemical storage tote is replaced typically on a weekly basis. Notable pulsation of the diaphragm pump suction and discharge was observed during the site visit and also evidence of small alum spills on the floor. No containment for the stored chemical is provided.

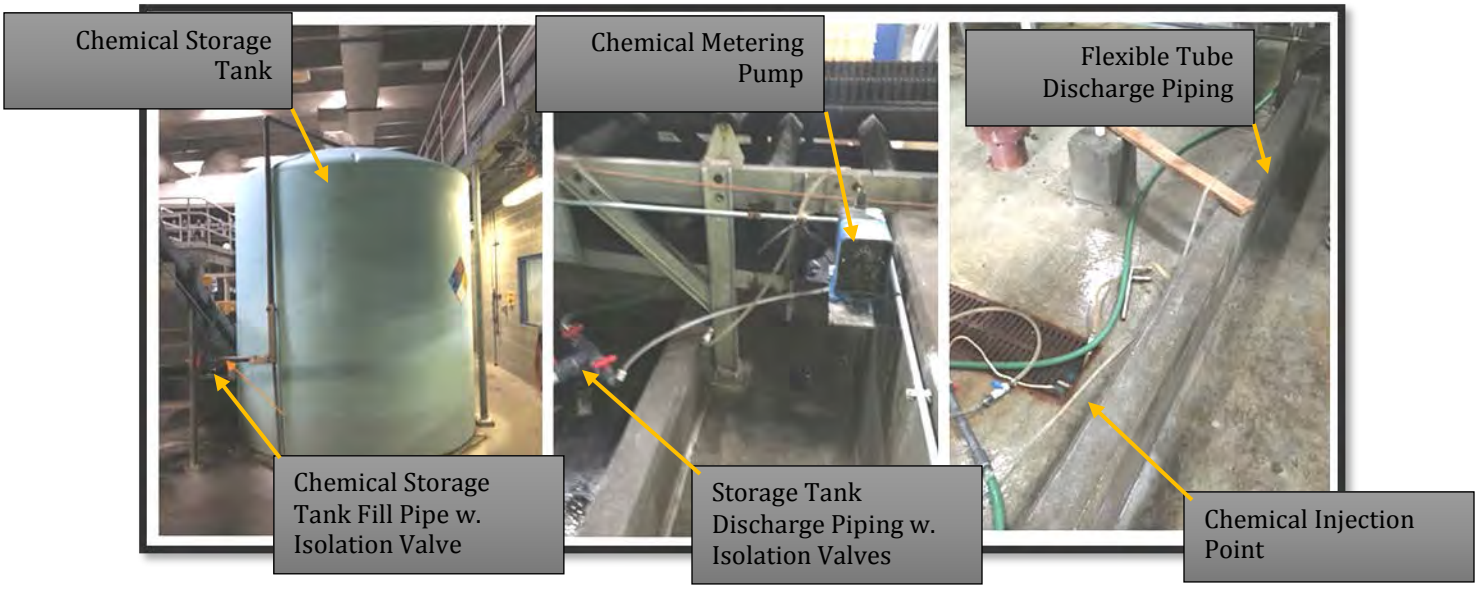
Figure 4
Existing Chemical System in the Thermophilic Digester Building



Dewatering Building Chemical Addition System

Likewise, a simple and functional chemical addition system is found in the dewatering building. It consists of a metering diaphragm pump with a capacity of 240 GPD, 6,000-gallon chemical storage tank, chemical storage tank fill line, two isolation ball valves installed at tank discharge, and flexible tube discharge piping. No containment for the relatively large storage tank is provided. Evidence of prior minor spills is visible on the floor around the tank.

Figure 5
Existing Chemical System in the Dewatering Building



In both locations the injection of Alum at the current dose appears to be effective and has significantly reduced the amount of effort necessary for maintenance. According to the staff, during the annual inspections there was no significant struvite accumulation observed in the heat exchanger and no accumulation was observed in the dewatering building.

Current chemical addition has an associated chemical cost of $4,600 per month. Based on the current operation, the cost per area is $1,400 and $3,200 for the digester and dewatering buildings respectively.

DESCRIPTION OF STRUVITE CONTROL ALTERNATIVES

BC&A, with input from plant personnel, has identified four options for struvite formation control.

- Chemical Addition
- Controlled Struvite Generation
- Sludge/ Sidestream Dilution
- "Do nothing"

The evaluation of alternatives is based on the current plant average daily flows of 8.0 Million Gallons per Day (MGD) and limited plant solids sampling and test data. It is noted that that none of the alternatives guarantee struvite prevention in the entire solids handling system. Consequently, alternatives are evaluated based on the potential to prevent struvite in locations of historic formation in the plant. As a result, the capital costs and operational costs developed during this evaluation may not cover all equipment and actives required to mitigate potential unidentified struvite accumulation throughout the plant's solids handling system.

ALTERNATIVE 1 - Chemical Addition

This alternative assumes that the City will continue with what appears to be a successful practice of Alum addition at the existing locations as a long term solution. If this alternative is implemented, improvements to the current chemical addition system should be made to ensure continuous prevention of struvite formation, to provide operational redundancy, optimize the system (operating cost reduction), and improve operator safety.

Following equipment and operational modifications are identified for this alternative;

Thermophilic Digester Building

Operational Modifications:

Based on the current chemical addition results, current Alum dose appears to be sufficient to prevent struvite accumulation in the heat recovery heat exchanger. The practice of filling the chemical storage totes in the dewatering building and transferring the totes to the digester control building seems to be somewhat labor intensive and provides opportunities for accidental spills. Appropriate training, safety, and spill prevention procedures need to be established to minimize the risks associated with Alum transfer.

Equipment and Layout Modifications:

Chemical dosing pumps - City is currently using a single diaphragm metering pump manufactured

by Pulsafeeder for addition of chemicals to the sludge piping. These are suitable pumps for this application. Following improvements to existing pumping system are recommended:

- **Installation of Automatic Pumps** - The existing pumping system could be improved by installing pumps that allow for automated operation and integration with the SCADA system. Pump integration would allow the staff to remotely monitor and control the pumps.

- **Pump Redundancy** - The current single pump installation does not provide any redundancy. While the redundancy in this particular application is not critical, a redundant pump would provide some operational flexibility.

- **Addition of pump appurtenances** - Typical diaphragm pump installation includes pulsation dampeners and calibration tubes that allow for optimization and also minimize pump maintenance and potential replacement costs.

A simple way of obtaining a pumping system that would include all the improvements listed above is to purchase a pre-assembled pump skid directly from the pump manufacturer like Pulsafeeder.

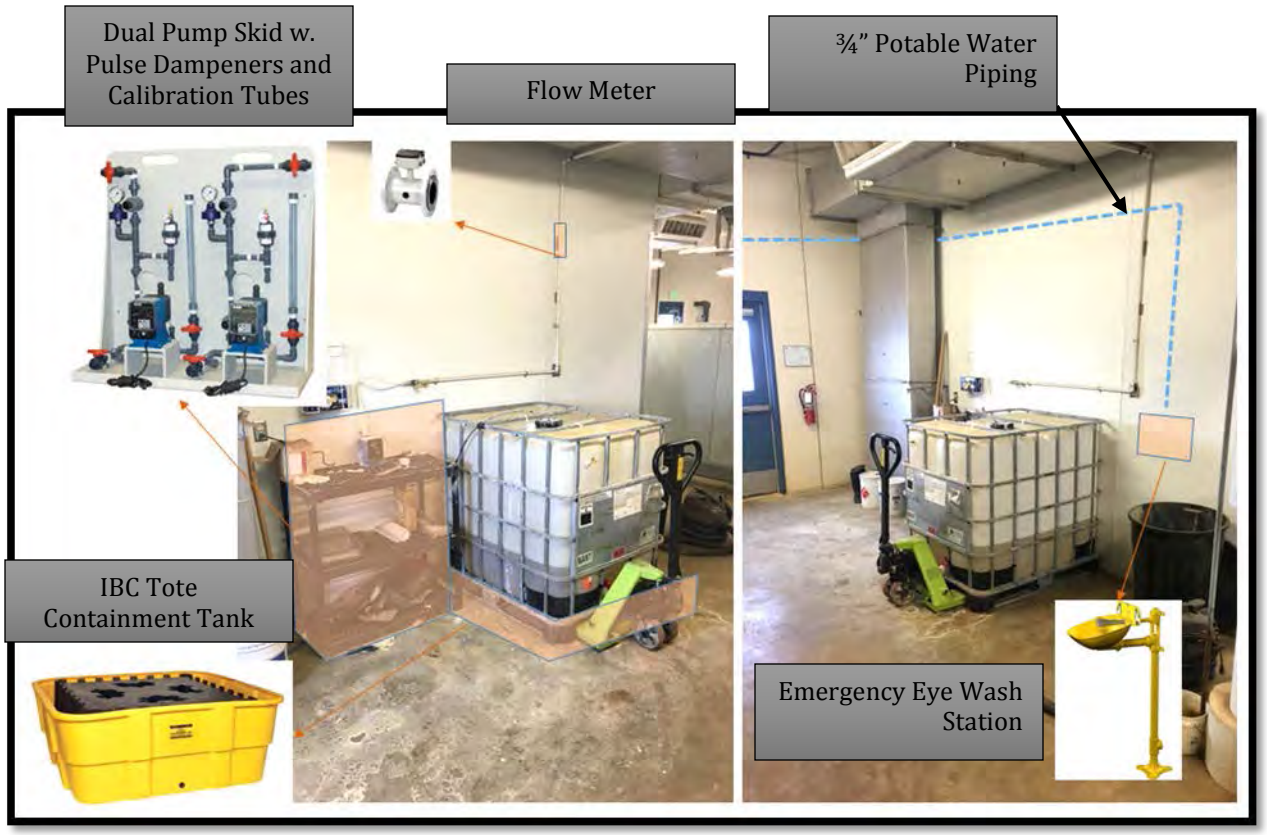
Flow Meter – Installation of a flow meter on the chemical pump discharge line would provide information to staff regarding the chemical rate of flow and quantity of chemical used.

Piping Modifications - Minor piping modifications would be required in order to accommodate the installation of flow meters and other equipment that may be added. Assuming that a skid pumping system is added, minor modifications to existing discharge piping would be required. Schedule 80 PVC piping is commonly used for this application. At this location consideration should be given to use of containment (double wall) piping to avoid potential damage to building wall. A flexible hose connection between the Alum storage tote and the skid suction piping is recommended.

Containment – Liquid-chemical storage areas should include secondary containment for both catastrophic and minor leaks. Containment volume should be a minimum of the largest bulk storage tank volume plus an additional 10 percent. Liquid Alum is a corrosive acid salt and currently Alum is stored in an area which does not provide any containment in case of a spill. A simple polyethylene containment base for the storage tote may be purchased to provide adequate containment of the liquid in case of a spill.

Emergency Eyewash Station – An emergency eyewash station can be installed adjacent to the Alum storage tote to provide for immediate means of treating accidents. Potable water line would need to be extended approximately 50 feet from the northeast corner of the building. Alternatively, a portable eyewash unit that requires no plumbing could be mounted on the wall to avoid the extension of potable water piping.

Figure 6
Potential Improvements to the Existing Chemical Addition System in the Thermophilic Digester Control Building



Dewatering Building

Operational Modifications:

Current Alum dose appears to be sufficient to prevent struvite accumulation in the dewatering building. Potential operational modifications that have been identified are limited to providing system automation, which would allow remote monitoring and control of pumps, and result in reduced operator attendance requirements.

Equipment and Layout Modifications:

Storage tank – The original dewatering building design did not anticipate the need for additional Alum storage space. Although a chemical containment area exists in the building, this space is occupied by Sodium Hydroxide and Polymer Storage tanks. Consequently, plant staff had few options when installing the current Alum storage tank. As a result, some deficiencies are identified;

> **Containment** – No specific secondary containment is provided for this storage tank. Due to the location of a nearby floor drain potential damage caused by minor spills would be limited to a relatively small area. In order to provide the containment volume, most likely a smaller storage tank would need to be installed to allow for the construction of a concrete

containment wall.

Tank Level Indicator and Measurement – A simple reverse level float tank gauge may be installed to allow visual indication of tank level on the exterior of the tank. If a new tank is installed, an ultrasonic level meter may be included that would allow for level measurement and could also be interlocked with an alarm in case of tank leakage.

Seismic Tank Restraints - Typical new chemical storage tank installations in seismic zones include seismic tank restraints. If a new tank is to be installed seismic restraints would be included.

Chemical dosing pumps – Similar to the digester control building, metering diaphragm pumps are used to add the chemicals to the system. Following improvements are identified;

- **Installation of Automatic Pumps** - The current pumping system could be improved by installing pumps that allow for automated operation and integration with the SCADA system to control and monitor the pumps remotely.

- **Pump Redundancy** – The existing installation does not provide any redundancy. While the redundancy in this particular application is not critical, a second, redundant pump would provide some operational flexibility.

- **Addition of pump appurtenances** - Typical diaphragm pump installation includes pulsation dampeners and calibration tubes that allow for optimization and also minimize pump maintenance and potential replacement costs.

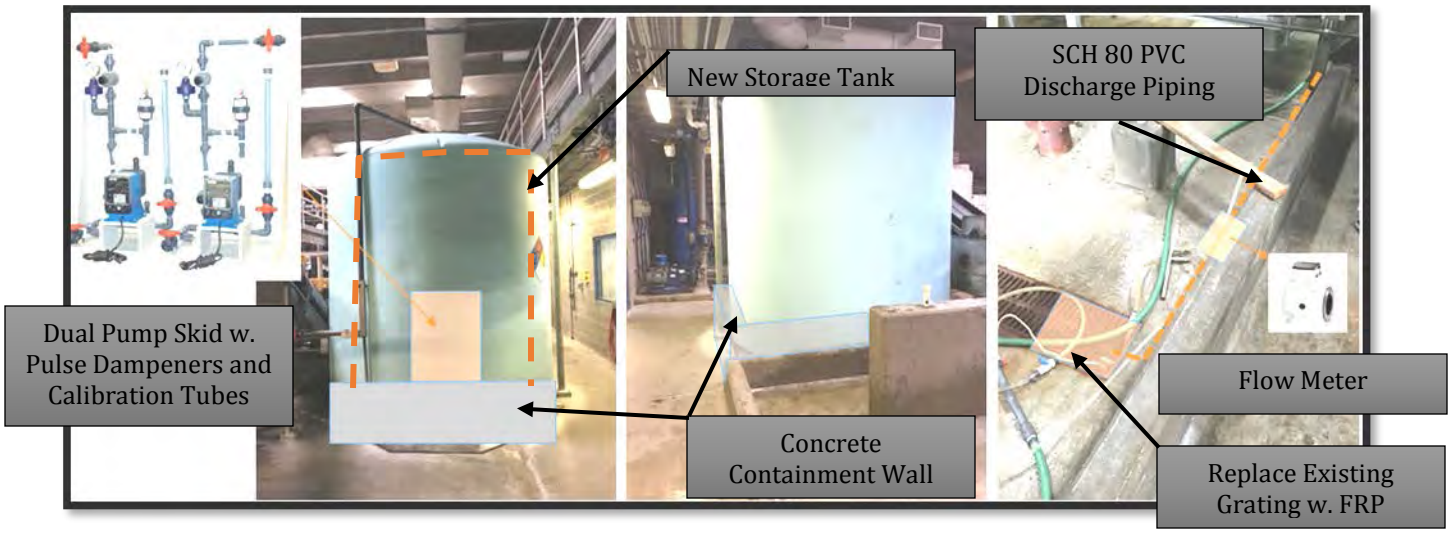
Flow Meter –Installation of a flow meter would provide information to the staff regarding the flow rate and a degree of control.

Piping Modifications – Modifications to existing chemical addition piping would be required in order to accommodate the installation of flow meters and other equipment. At a minimum the flexible hose discharge piping should be replaced with schedule 80 PVC piping that would be routed on the inside of the existing belt press containment wall and adequately supported with fiberglass reinforced plastic (FRP) strut type pipe supports.

Electrical and SCADA Integration – The scope and complexity of electrical work and integration will be dependent on the final selection of equipment. At a minimum the system should allow remote control and monitoring of pumps and allow for automatic operation of chemical addition pumps based on the belt press operation.

Non-Metallic Drain Channel Grating – Consideration should be given to replacing a portion of the existing metal grating at the chemical injection location with FRP grating. This would be a cosmetic improvement and is not critical to the process.

Figure 7
Potential Improvements to the Existing Chemical System in the Thermophilic Digester Control Building



ALTERNATIVE 1 Cost Evaluation

Capital Cost

The capital costs associated with this alternative are estimated at $20,000 and $55,000 for the digester and dewatering buildings respectively. The cost of improvements for the dewatering building includes the installation of a new Alum storage tank and construction of a containment wall. Due to scope and complexity of modifications, for this location the cost of alternative also includes a contractor markup of 10 percent. All costs include a 30 percent contingency. A detailed breakdown of costs is included in Tables 1 and 2 in the Appendix.

Operational Cost

In order to provide a relative cost for the evaluation and comparison with other alternatives, an operational cost associated with chemical and power use, labor costs, and periodical equipment replacement requirements was developed and estimated at $70,200. A detailed breakdown of operational and maintenance costs for this alternative is included in Table 3 in Appendix.

ALTERNATIVE 2 - Controlled Struvite Generation

An alternative method of struvite accumulation prevention is controlled struvite generation. With this approach, rather than preventing struvite from forming in the digesters, digested sludge piping, or dewatering equipment, struvite is preferentially precipitated in a specific location. There are several different technologies currently using this concept for struvite mitigation. The main differences between technologies are generally the location of the reactor, i.e. where the struvite is precipitated in the solids handling process, and the extent of treatment within the reactor. Based on the extent of treatment in the reactor, two different processes are recognized: struvite harvesting and struvite precipitation. In struvite harvesting the final product is a relatively clean, marketable fertilizer. With struvite precipitation approach, the extent of treatment is limited to

controlled precipitation of struvite in the reactor. Following the precipitation, struvite in form of small crystals is retained in the sludge through dewatering and final disposal.

Proposed System Description

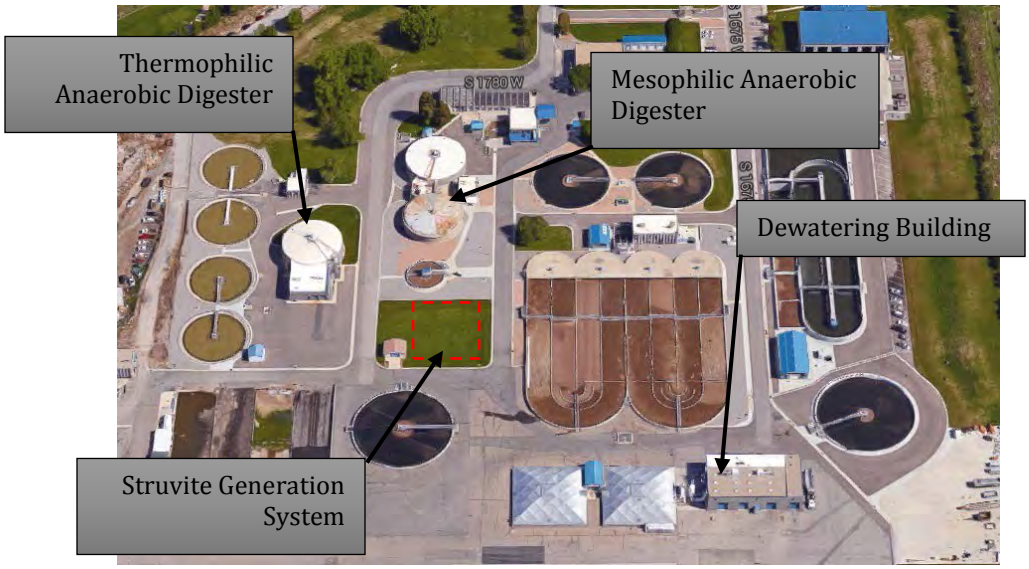
For Orem WRF the proprietary AirPrex technology by CNP was identified as a viable technology for controlled struvite generation. The AirPrex system is a complete sludge optimization and struvite generation system that's installed between anaerobic digestion and sludge dewatering steps. Controlled struvite precipitation is regulated by air stripping in the AirPrex reactor with the addition of a magnesium chloride ($MgCl_2$). This technology is applicable to treatment of digested sludge prior to dewatering and not just the side stream (filtrate). As a result, struvite formation prevention is provided for solids handling processes downstream of the AirPrex system. In addition, CNP claims that due to removal of Phosphorus upstream of dewatering equipment, the AirPrex system would also provide potential benefits in cake dryness improvements (3 to 4 percentage points) and polymer use reduction of 10 to 20 percent.

For the specific application at Orem WRF, the struvite harvesting level of treatment currently does not offer any benefits. Consequently, the analysis of this option is focused on a system that would be limited to struvite precipitation and removal through disposal of sludge.

The size of the AirPrex struvite generation system is determined by the required sludge throughput and the need to maintain continuous operation. Currently, Orem WRF is dewatering 0.76 Million gallons of digested sludge per week. For continuous operation this equates to a design throughput capacity of 75 gpm. In order to maintain the current weekly dewatering regimen, installation of AirPrex system would also require continued operation of the existing solids holding tank.

Potential location for the installation of the AirPrex system at the Orem WRF is identified in Figure 8. This location provides enough space for the installation of required facilities and is in the vicinity of the current dewatering facility sludge feed piping.

Figure 8
Potential Location of Struvite Generation Process



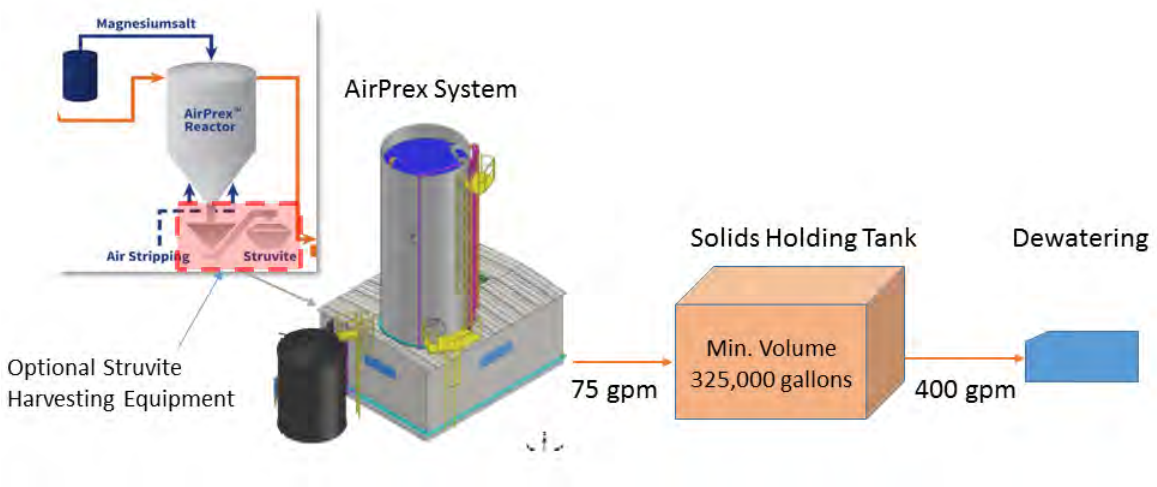
Based on the proposal from CNP, the AirPrex struvite generation system would include the following equipment:

- Reactor Tank by (15-foot diameter by 40 feet high)
- Blower and air distribution system for the reactor
- $MgCl_2$ storage and dosing system
- Defoamer dosing system
- Internal piping for air distribution, chemical supply, and sludge handling
- Chemical dosing and sludge pumps
- Instrumentation and control

In addition to items provided by the system supplier, a CMU or Metal Building to house the blowers, chemical dosing systems, and system pumps would also be required for a successful installation. The building size is estimated based on the information provided by the manufacturers at 40 by 30 feet.

Figures 9 illustrates a typical flow diagram for the installation:

Figure 9
Struvite Generation Process Flow Diagram



In order to harvest the struvite for potential profit, it would be necessary to include additional grit washing and classification equipment as well as solids storage and containment/packaging equipment for the final harvested product.

<u>Capital Costs</u>

The capital costs associated with this option are estimated at $ 2.2 Million. This cost includes a 30 percent contingency and contractor markup of 10 percent. An additional cost of $400,000 would be added for the struvite harvesting equipment. A detailed breakdown of costs is included in Table 4 in the Appendix.

Operational Costs

In addition to the capital cost required to construct the struvite generation facility, the controlled precipitation of struvite would include following operational costs:

Magnesium salt addition (Chemical Cost) - Current AirPrex proposal indicates that for a digested sludge flow of 75 gpm at 3% solids content, 91 gallons per day of $MgCl_2$ at 33% concentration is required. Presently, $MgCl_2$ has a purchase cost of $0.45 per gallon (including freight to the plant). At this rate, the consumption of chemical for struvite precipitation would be approximately $41.0 per day of operation of the AirPrex system. This equates to an annual cost of $15,000 for the chemical.

Electrical costs – The two main electrical costs are associated with the Air Prex system blowers and pumps. An estimated 350 kwH per day will be used for the struvite generation system. At the current cost of $0.08 per kwH the annual cost is $10,500.

Labor costs – It is assumed that 1 hour per day will be required to ensure proper operation of the AirPrex System. This equates to an annual cost of $15,600 assuming a labor rate of $60.00 per hour.

Equipment replacement costs – For the purpose of this evaluation it is assumed that the blowers and pumps will require replacement once during the assumed 20-year useful life. On an annual basis this cost is estimated at $5,000.

No cost savings associated with potential benefits in cake solids content increase and polymer use reduction is assumed.

The total estimated annual operation and maintenance cost for this alternative is estimated at $46,100. Table 5 in Appendix provides a summary of the annual operational cost associated with the AirPrex system.

ALTERNATIVE 3 - Dilution

For Orem WRF this alternative would involve the addition of plant effluent (or utility water) to the sludge stream just upstream of dewatering belt presses or directly into the common filtrate drain. Dilution in the heat recovery heat exchanger loop is not recommended as it would add substantial amounts of liquid to the digesters and result in adverse process conditions and upset the digester heating balance.

Dilution is a proven method for targeted control of formation of struvite which typically targets one or multiple factors that are required for struvite formation. Addition of a diluting liquid typically results in reduction in concentration of constituent's ions, adjustment of pH level or temperature of incoming sludge or sidestream. However, extensive testing is required to determine the required dilution factors due to the specific chemistry of the sludge/sidestream, temperature variations, pH conditions, and chemical properties of diluting liquid itself.

Based on a general review of available data for plants that are implementing this method as a means of struvite mitigation, dilution flows of 0.2 to 1.2 times the sludge or sidestream flow have been needed to prevent struvite formation. For example, Central Valley Water Reclamation Facility (CVWRF) has been successfully applying this approach at their dewatering facility for a couple of years now. In their particular case, addition of a relatively low dilution flow of 30 gpm to the sludge

flow of 160 gpm (factor of 0.2) is required to prevent struvite formation in the belt press. Furthermore, in case of the CVWRF, no increase in polymer use or an increase in the belt press length of operation as a result of the additional flow was observed.

For the purpose of this evaluation, it is assumed that the dilution flow at current conditions for Orem WRF would not exceed 200 gpm (additional 100 gpm per belt press). At this dilution flow rate, if the dilution flow is added directly into sludge piping, the actual flow sent to the belt press would be 300 gpm which is the maximum hydraulic capacity of the belt press and theoretically would not result in longer belt press operating times or additional polymer use. Alternatively, if the dilution water is added to the common filtrate drains directly, there would be no impact to belt press operation.

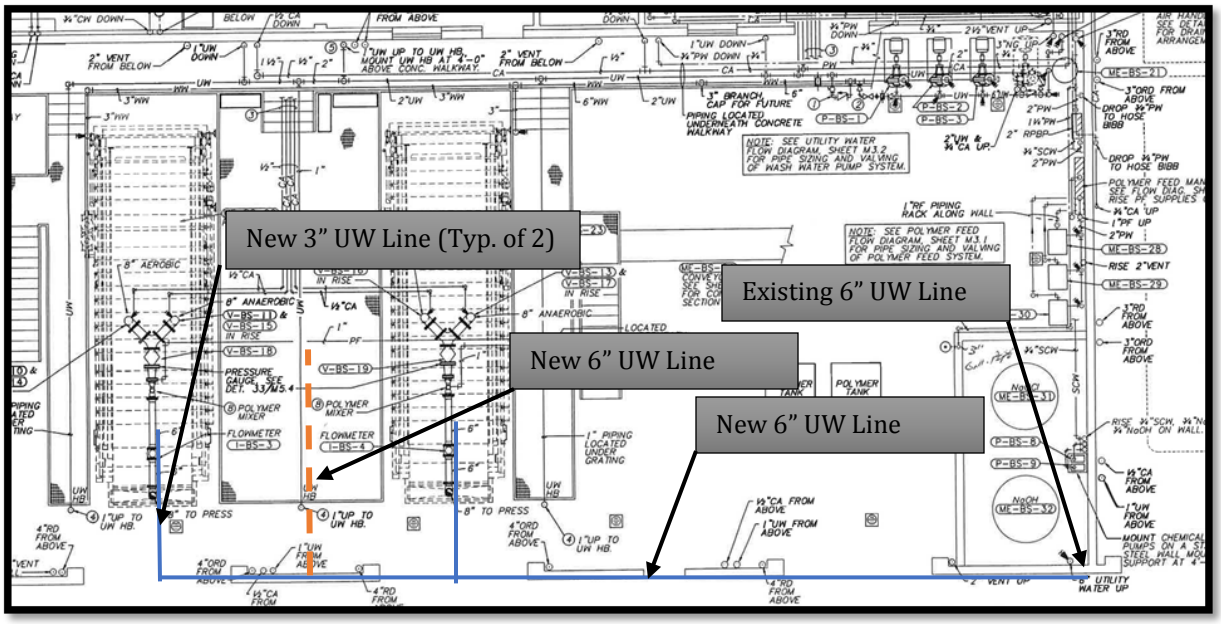
Operational Modifications:

No operational modifications relative to current belt press operations are expected as long as the dilution flow rate is such that the belt press hydraulic capacity is not exceeded or the dilution liquid is added into the common filtrate drain.

Equipment and Layout Modifications:

At low dilution factors the existing 6-inch utility water line providing utility water to the dewatering building is assumed to be adequate to provide additional flows. At a minimum, this line would need to be extended as shown in Figure 10. Also, two new 3-inch lines or a single 6-inch line with flow control, check valves, and flow meters would need to be installed to provide the dilution water to individual belt presses or common filtrate drain respectively. The capacity of existing 12-inch drain piping in the building should be adequate to handle the additional flows and no modifications are anticipated. Potential effect of this new demand on the plant's utility pumps was not evaluated.

Figure 10
Dilution Alternative Piping Modifications



Capital Costs

The capital cost associated with this option is estimated at $31,000 with an assumption that the existing utility pumps can provide the dilution water without any modifications. Capital cost includes the cost of piping upgrades including flow meters, valves, and fittings and a 30% contingency. A detailed breakdown of costs is included in Table 6 in the Appendix.

Operational Costs

As long as the dilution flow rate and sludge feed to the belt press does not exceed the hydraulic capacity of the belt press, the only expected operational cost, would be the fractional increase in the power usage due to the larger demand on the utility water pumps. This cost is estimated at $400 per year. Relative to the current costs of maintaining the wash water system and belt presses no additional maintenance cost would result from implementing this option.

ALTERNATIVE 4 - Do Nothing

A "do nothing" approach would discontinue dosing of alum and allow for the formation of struvite within the system to resume. This would result in an increase in O&M costs to maintain equipment and utilize staff efforts. Additionally, long periods of system downtime would be required.

Operational Modifications

Historically, once a month it has taken operations staff two days to shutdown, disassemble, and clean equipment impacted by struvite accumulation. In order to proceed with this option, the City would need to establish a regular inspection and maintenance schedule and allocate staff for these tasks.

Equipment and Layout Modifications:

With his approach no equipment and layout modifications are required.

Operational Costs

The effort of removing struvite accumulation has historically consumed two days of three operator's work hours which equates to 48 man hours and approximately $2,880 per month. Over a twelve- month period this accounts for up to 576 hours and annual cost of $35,300. This cost also accounts for the necessary disposables such as tools and PPE, and the addition of sodium aluminate to the heat exchangers to aid in the breakup and removal of the struvite formations. This cost does not account for the additional wear and tear of process pumps, equipment, and piping resulting from struvite accumulation and cleaning. This cost also does not account for the potential reduction of maintenance efforts for other plant systems as a result of personnel and resources being allocated to struvite control measures.

DISCUSSION AND ALTERNATIVE EVALUATION SUMMARY

Implementing any of these alternatives for struvite formation control should be done after understanding and recognizing the associated costs and operational implications. Table 1 provides a summary of capital, operation, and life cycle costs for evaluated alternatives.

Table 1
Alternative Evaluation Cost Summary

	Chemical Addition	Controlled Struvite Generation*	Dilution*	"Do Nothing"
Total Capital Cost	**$75,000**	**$2,161,950**	**$53,500**	**$0**
Annual Operation Cost Total	**$70,200**	**$70,500**	**$24,800**	**$35,300**
NPV -20 Years	**$1,120,000**	**$3,211,000**	**$422,500**	**$525,000**

***Includes life cycle costs associated with capital cost and operation costs of chemical addition system in the thermophilic digester building.**

The current practice of chemical addition offers a relatively simple but effective way of struvite control. It provides struvite control at specific areas where formation was historically observed. Another benefit of chemical additional approach is the system simplicity, familiarity of the staff with this system, and the potential complimentary effect on future Phosphorous effluent limits. Biggest disadvantage of the chemical addition alternative is the high cost of chemical. Due to high chemical cost, this alternative has the highest annual operation costs of all evaluated alternatives. The capital costs associated with this alternative are relatively low and if implemented would result in a more efficient operation both from labor and chemical use perspective.

Biggest advantage of the controlled struvite generation alternative is that it would result in prevention of struvite formation in solids handling systems downstream of this process and relatively low annual operation costs. Additionally, there may be operational cost savings that could result from a potential reduction in polymer usage in the dewatering and process efficiencies. Similar to the chemical addition alternative, struvite generation would be beneficial in its ability to effectively remove significant quantities of Phosphorus from the plant through solids disposal. The obvious disadvantage of this alternative is the high capital cost. Another disadvantage of this alternative is that it may have no or limited effect on the struvite accumulation in the existing heat recovery heat exchanger. Consequently, with this alternative the practice of chemical addition or monthly cleaning at the heat recovery heat exchanger would need to be continued.

Dilution alternative is very intriguing as it potentially may prevent struvite accumulation at the belt press with minimum capital and operational costs. The biggest disadvantage for this option is the large degree of uncertainty associated with the required dilution flow rate. Extensive testing is required to establish the appropriate dilution rate and any changes in quality or quantity of sludge being sent to the dewatering belt press may affect the dilution rate. Furthermore, dilution at the belt press would not prevent struvite accumulation at the heat exchanger or any upstream solids handling equipment. Therefore, with this alternative too, the practice of chemical addition or monthly cleaning at the heat recovery heat exchanger would need to be continued. Unlike the chemical addition and struvite generation alternatives, this alternative would provide no benefit in removal of additional quantities of Phosphorous through solids disposal. Finally, with this option approximately 100,000 gallons of already treated water would be returned to the front of the plant.

As shown in the table, the "do nothing" alternative is the lowest in capital cost but has high maintenance costs and very high risks associated with equipment repairs, piping, and valve replacements that should be considered. This approach also increases the potential of struvite

accumulation in other plant systems where maintenance may not be feasible or difficult (for example common filtrate drain piping). Additional accumulations could require emergency replacement of pipes, valves, or other costly plant infrastructure and equipment.

Table 2 provides a summary of general advantages and disadvantages of evaluated alternatives.

Table 2
General Alternative Evaluation Summary

Struvite Mitigation Option	Advantages	Disadvantages
Chemical Addition	• Proven results for struvite control in targeted areas • Common struvite control approach • Relatively simple system and operation • Staff familiarity with the process • Low system maintenance • Positive effect on potential chemical addition for P effluent limits	• High operation cost • Moderate capital cost
Controlled Struvite Generation	• Struvite accumulation prevention in areas downstream of system • Moderate operation costs • Potential increase in cake solids content • Potential for lower polymer consumption • Positive effect on potential chemical addition for P effluent limits	• High Capital Cost • Alum addition at Heat Recovery Heat Exchanger would need to be continued.
Dilution	• No chemical costs • Low capital cost • Potentially low operations cost	• Struvite accumulation prevention is limited to belt press • Alum addition at Heat Recovery Heat Exchanger would need to be continued • Extensive testing required to establish the dilution factor

		• Higher capital and operation costs will result from higher dilution factors • Increase in return flows to the front of the plant • No positive effect on potential chemical addition for P effluent limits
Do Nothing	• No Capital Cost	• Limited Struvite Control • High Labor requirements • High risk of struvite accumulation • Likely increase in equipment, piping, and piping appurtenances replacement frequency • No positive effect on potential chemical addition for P effluent limits

RECOMMENDATIONS

Bowen, Collins and Associates recommends the following actions be taken:

Orem City WRF should continue with the current practice of chemical (Alum) addition and:

- Implement chemical addition system modifications in the thermophilic digester building
- Implement limited chemical addition system upgrades in the dewatering building focusing on the pumping system upgrades and automation. Evaluate current chemical feed rates for alum to determine if a reduction in concentration can be made without formation of struvite in the system
- Consider a future centralized chemical storage and addition structure that would service the dewatering building and also house storage and chemical addition equipment for future effluent polishing
- Continue with regular inspections of areas with high potential for struvite formation and where struvite formation was historically observed
- Continue solids sampling (Total Suspended Solids, Total Phosphorus) for digester solids, dewatered cake and filtrate
- Future designs and pipe replacements should consider use of gradual flow transition fittings (long radius elbows) and the use of smooth walled piping (glass lined DIP, HDPE, etc) to minimize potential of struvite formation.

APPENDIX

ALTERNATIVE 1- Chemical Addition Costs

Table 1
Capital Cost - Thermophilic Digester Building

Item	Quantity	Unit	Unit Cost	Installed Cost
Chemical Addition Piping Modifications	30	LF	$50	$1,500
Flow Meter	1	ea	$2,200	$2,200
New Pump Skid	1	ea	$5,000	$5,000
Containment	1	LS	$1,300	$1,300
Emergency Eyewash	1	LS	$300	$300
Potable Water Extension	50	ea	$30	$1,500
Electrical Modifications/SCADA Integration	30%	-	-	$3,540
			Sub-Total	$15,340
			Contingency (30%)	$4,602
			Total	**$19,942**

Table 2
Capital Cost-Dewatering Building

Item	Quantity	Unit	Unit Cost	Installed Cost
Chemical Addition Piping Modifications	30	LF	$50	$1,500
Removal of Existing Tank and Demo	1	LS	$5,000	$5,000
Containment	4	cy	$1,500	$6,000
FRP Grating	50	sf	$10	$500
New Tank (4,000 gallons)	4000	gallons	$2	$9,000
New Pump Skid	1	ea	$6,000	$6,000
Flow Meter	1	ea	$2,200	$2,200
Instrumentation	1	ea	$2,500	$2,500
Electrical Modifications/SCADA Integration	30%	-	-	$9,810
			Sub-Total	$42,510
			Contractor Markup (10%)	$4,251
			Contingency (30%)	$12,753
			Total	**$55,263**

Table 3
Operation and Maintenance Cost- Chemical (Alum) Addition

Item	Annual Operation Cost (Dewatering Building)	Annual Operation Cost (Digester Building)
Chemical (Alum) Use*	$38,500	$17,000
Power Use	$50	$150
Labor Cost**	$6,250	$6,250
Replacement Cost***	$1,000	$1,000
SUB-TOTAL	$45,800	$24,400
		TOTAL COST = $70,200

*Alum cost of $411 per dry ton.
**Assumes one hour per week for regular maintenance of the system with a labor rate of $60.00/hour.
***Replacement of metering pumps every 5 years.

ALTERNATIVE 2 - Controlled Struvite Generation Costs

Table 4
Capital Cost – Controlled Struvite Generation (AirPrex System)

Item	Quantity	Unit	Unit Cost	Installed Cost
Civil Work	1	LS	$30,000	$30,000
Building (CMU)	1,200	sf	$150	$180,000
AirPrex Equipment	1	LS	$1,000,000	$1,000,000
Equipment Installation	1	LS	$100,000	$100,000
Instrumentation	1	LS	$20,000	$20,000
Electrical/Integration	1	LS	15%	$199,500
			Sub-Total	$1,529,500
			Contractor Markup (10%)	$152,950
			Contingency (30%)	$458,850
			Total	**$2,141,300**

Table 5
Operation and Maintenance Cost- Controlled Struvite Generation

Item	Annual Operation Cost
Chemical ($MgCl_2$) Use	$15,000
Power Use	$10,500
Labor Cost	$15,600
Replacement Cost	$5,000
TOTAL	**$46,100**

ALTERNATIVE 3 – Dilution

Table 6
Capital Cost- Dilution

Item	Quantity	Unit	Unit Cost	Installed Cost
6-inch pipe	100	LF	$50	$5,000
3-inch pipe	75	LF	$25	$1,875
Valves (6 inch)	2	ea	$400	$800
Valves (3 inch)	8	ea	$350	$2,800
Flow Meter	2	ea	$4,700	$9,400
Electrical Modifications/SCADA Integration	20%	-	-	$3,975
			Sub-Total	$23,850
			Contingency (30%)	$7,155
			Total	**$31,005**

Table 7
Operation and Maintenance Cost - Dilution

Item	Annual Operation Cost
Power Use	$400
TOTAL	**$400**

ALTERNATIVE 4 – Do Nothing

Table 8
Operation and Maintenance Cost - "Do Nothing"

Item	Annual Operation Cost
Chemical use	$500
Equipment	$200
Labor Cost	$34,560
TOTAL	**$35,260**

APPENDIX C
ROUTINE MAINTENANCE PROJECTS

Address	Distance, Direction, and Size	Problem, replace or liner.	Pay Off Period (Years)	Total
WELLS FARGO BLDG. 800 N.	Flush manhole	Lat. In m/h needs trough work (in progress).	0.13	$1,500
1450 S 895 EAST	Flush manhole	8" and 2- 4" lat. In m/h trough work allready tried	0.28	$1,500
997 NORTH 75 EAST	Flush	2-laterals into m/h, needs trough work (in progress).	0.28	$1,500
159 NORTH 1080 EAST	Flush manhole	3-laterals in m/h. Trough work ? (in progress)	0.28	$1,500
1100 SOUTH PALISADE	8" Lines	Low flows and off-set joint.	0.28	$1,500
1150 SOUTH 435 EAST	Flush manhole	4" lat. Into m/h. Needs trough work (In progress)	0.37	$1,500
555 WEST 1200 SOUTH	8" Line 376'	1200 s. trunk line blocks 8" line flow. Trough work ?	0.37	$1,500
1150 NORTH 910 EAST	8" Line 325'	Line in good cond. Roots in Lateral, point repair needed	0.37	$1,500
100 NORTH 800 WEST	8" 302'	Line has tree roots, point repairs needed.	0.37	$1,500
320 WEST 100 SOUTH	Flush manhole	4" lat. Into m/h. needs trough work (in progress)	0.56	$1,500
457 SOUTH 950 EAST	Flush manhole	Flush m/h,4" lat. In m/h. Trough work needed.	0.56	$1,500
413 NORTH OREM BLVD.	8" Line	Flush manhole, 8' ties into manhole (low flow)	0.56	$1,500
900 NORTH 70 WEST	6" Lines E-326'/S-689'	East line roots and break (Point repair) South line Lined	0.67	$1,500
450 NORTH 400 EAST	8" Line 237'	This line is in good cond. Found lite roots Trough work	1.11	$1,500
542 SOUTH 560 EAST	Flush manhole	Line Changes from 8" to 6" in manhole	1.37	$16,000
570 NORTH 1016 WEST	Flush manhole	Lateral comes into m/h, flush as needed. Trough work	1.67	$1,500
475 EAST 1140 SOUTH	8" line 148'	Line showing aggregation. "Liner"	2.08	$16,808
1150 SOUTH 500 EAST	8" line 150'	Line showing aggregation. "Liner"	2.09	$16,900
WEST ENTRANCE MACY'S+B52	8" line 275'	Line showing aggregation "Liner"	2.80	$22,650
400 SOUTH 800 WEST	Flush manhole	15"& 8" line into m/h. 15" plugs off 8" flow into m/h.	3.07	$16,560
NORTH ENTRANCE MACY'S	8" line 220'	8" line from north ties into 8" mall line.	3.22	$26,120
400 NORTH 725 WEST	6" line 389'	Multi. breaks, tree roots, prot. Lat. "Liner"	3.25	$26,338
500 NORTH MONT. DR.	8" 246'	Line in fair cond. Has severe bellies "replace"	3.75	$65,842
1800 SOUTH 400 EAST	8" line 679'	Line has several bad bellies. "Replace"	3.82	$41,234
200 NORTH STATE STREET	8" Line 260'	Line has aggregation "Liner'	4.07	$21,960
500 NORTH 360 EAST	8" line W-64'/6" line S-125'	S. line low flow (bellies) W. line agg. Showing "Liner"	4.62	$18,694
693 NORTH ATLANTIS dr.(150e)	6" Line 379'	Line has off-set joints,prot. lateral. "Liner"	4.80	$25,918
420 NORTH 950 WEST	6" Lines S-244'	North line replaced. East line lined. South line "Line"	4.87	$32,848
1500 NORTH 650 WEST	8" Line 215'	Line in good cond. Low flows, poss. Lining	4.91	$19,890
710 NORTH 100 WEST	6" Easement line 400'	Line @ min. grade, liner for flow.	4.96	$26,800
910 NORTH 200 EAST	E-6" W-8"	East line new (Skip Dunn) West line "Liner"	5.01	$20,304
310 NORTH 400 WEST	8" Line 225'	Line has lots of off-set joints. "Liner"	5.02	$20,350
500 NORTH 400 EAST	6" Line 247'	Line showing aggregation "Liner"	5.03	$20,374
300 WEST 1600 SOUTH	8" Line 237'	Line showing wear, has grease in it.	5.16	$20,902
150 NORTH 800 WEST	8" Line 420'	Line in good cond. with off-set joints.	5.43	$29,320
245 WEST 1600 SOUTH	8" Line 275'	Line showing wear, has grease in it.	5.59	$22,650
500 SOUTH 900 EAST	8" Line 300'	Showing severe aggregation. "Liner"	5.88	$23,800
1742 SOUTH 145 EAST FLUSH	Flush manhole	4 lat. Into m/h. Trough work done, flush as needed.	5.93	$16,000
1550 SOUTH 850 EAST	Flush manhole	8", 6", & 4" lat. Into manhole. Flushed as needed.	5.93	$16,000
1830 NORTH 600 WEST	Flush manhole	Trough work done, flush as needed.	5.93	$16,000
1500 NORTH 680 WEST	Flush manhole	3-lat. Into m/h. Trough work done, flush as needed.	5.93	$16,000
500 NORTH 680 WEST	Flush manhole	6" & 8" line in m/h. Flush as needed, trough work ?	5.93	$16,000
270 NORTH 1030 WEST	8" Lines. West line-138'	N & S lines good cond. West line needs "Lining"	6.01	$32,448
320 EAST 1500 SOUTH	8" Line (N,S&E) S-355'	South line needs lining (broken pipe &roots)	6.50	$26,330
500 SOUTH 850 EAST	8" Line 370'	Showing severe aggregation. "Liner"	6.67	$27,020
1600 SOUTH 100 EAST	8" Line 392'	Line has breaks and tree roots. "Liner"	6.92	$28,032
1564 SOUTH 300 WEST DROP MANHOLE	8" Line 600'	Line showing wear, has grease in it.	6.96	$37,600
980 NORTH 188 EAST	6" Lines W-205'/E-100'	Lines in poor condition, holes and breaks "Liner"	7.11	$28,810
1600 SOUTH 280 EAST	8' Line 635'	Line is thinning, severe aggregation "Liner"	7.26	$39,210
165 SOUTH 705 WEST	8" Line 666'	Line has numerous cracks. "Liner"	7.53	$40,636
390 NORTH 400 WEST	6" Line 136'	6" Line and very low flow. "Liner"	8.04	$21,712
1600 SOUTH MAIN	15" Line 656'	Has severe roots, breaks and agg."Liner"	8.65	$46,736
450 NORTH 900 WEST	6" line 283'	Beverly West sub. Project. Lines to be replaced.	8.75	$70,845
400 NORTH 550 EAST	6" Line North / 8" Line South	N. Line pipe missing. S. Line breaks "Liner" both.	8.81	$47,556
400 EAST CENTER	8" Line 378'	15' line coming in from north restricts 8" line from east	8.89	$16,000
400 NORTH 1000 EAST	8" line 297'	Line showing mod. Agg. & bellies "replace"	9.56	$77,419
900 NORTH 100 WEST	8" Line	First 156' Bellies "Replace" Next 181' Agg. "Line"	9.95	$53,738
300 SOUTH - 650 EAST	8" line (E&W) 80' (W)	W. line bellies & aggregation "Replace"	10.43	$28,160
800 NORTH 297 EAST	6" Line 124'	Line from m/h 11-0238 to 11-0205 severe agg. "Liner"	11.27	$15,208
2000 SOUTH 250 EAST	8" Line 103'	Protruding lat./broken pipe/low flow. Work order.	11.85	$16,000
400 NORTH 850 EAST	8" Line 140'	Line has several breaks, unsure of overall cond. of line.	12.18	$16,440
753 SOUTH 1080 EAST	8" Line 170'	Line in fair cond. Few off-set joint and infil. @ Lateral.	13.20	$17,820
1600 SOUTH 235 WEST	8" line 121'	Line has bad bellie "Replace"	13.88	$37,467
480 NORTH 800 WEST	6' Line 400'	6" Easement line. Roots ! It's being treated.	14.89	$26,800
1600 SOUTH 311 EAST	8" Line 237'	Line has small bellies and off-set joints. (Easement)	15.48	$20,902
1400 SOUTH 200 EAST	8" Line 242'	Line showing aggregation "Liner"	15.65	$21,132
1550 NORTH 650 WEST	8" Line 246'	Line in fair cond. Has bellie over 200' "Replace"	16.26	$65,842
1200 NORTH 1000 EAST	8" Line 250'	Line has bad bellies, slow flow. "Replace"	16.48	$66,750
400 NORTH 760 WEST	8" Line 430'	Roots ! It's being treated.	16.54	$29,780
570 NORTH 450 EAST	8" Line 257'	Line has low flow, laid flat. "Replace"	16.87	$68,339
1400 NORTH 950 WEST	8" Line 259'	Line has multiple bellies. "Replace"	16.99	$68,793
800 SOUTH 600 WEST	8" Line 285'	Line in good cond. Needs point repair (work order).	17.12	$23,110
885 NORTH 75 EAST (memo)	6" Lines N-427' E-365'	Line to the north is Lined. Line east needs "Liner"	17.50	$94,475
1880 NORTH 90 WEST	8' Line 270'	Line has lots of bellies "Replace"	17.60	$71,290
875 NORTH 550 EAST	Flush manhole	Lateral comes into m/h, flush as needed.	17.78	$16,000
1600 SOUTH 800 EAST	8" Line 281'	Line has bellies & aggregation "Replace"	18.22	$73,787
1600 SOUTH 200 EAST	8"Line 322'	Line is showing aggregation. "Liner"	18.38	$24,812
850 SOUTH 150 WEST	8" Line 204'	Several small bellies and showing aggregation.	18.80	$25,384
1700 SOUTH 270 WEST	8" Line 267'	Line laid flat w/bellies. "Replace"	18.92	$76,609
947 NORTH 75 EAST	6" Line 315'	Line is in good shape but has multi. breaks, "Liner"	19.19	$77,725
400 NORTH 400 WEST	8" Line 548'	Roots ! It's being treated.	19.56	$35,208
450 NORTH 450 EAST	8" Line 313'	Line has bellies and off-sets "Replace"	20.01	$81,051
500 NORTH 450 WEST	8" Lines N-242' / S-140'	Line North good cond. Line South small bellie & low flow	20.13	$108,714
800 NORTH 1370 WEST	8"Line 319'	Line has bellies and aggregation "Replace"	20.35	$82,413
600 NORTH MONTERY DR.	8" 323'	Line has bellies and cracks "Replace"	20.57	$83,321
400 NORTH 450 EAST	8" Line 325'	Line has bellies and off-sets "Replace"	20.69	$83,775
400 NORTH 160 WEST	12" Line 322'	Line showing severe aggrigation. "Liner"	20.76	$28,032
810 NORTH STATE STREET	6" Lines N-490'/E-89'	N. line, laid flat with bellies "Replace" E. line "Liner"	22.05	$119,088
300 NORTH 200 EAST	8" Line 195'	Line has bellies & breaks "Replace"	22.32	$60,265
526 NORTH 980 WEST	8" Line 357'	Line has bellies and off-sets "Replace"	22.48	$91,039
100 SOUTH 400 WEST	8" Line 364'	Bellies and aggregation "Replace"	22.87	$92,628
1800 NORTH 760 WEST	8" Line 488'	Line has bellies and laid flat "Replace"	23.48	$126,776
1011 SOUTH 150 WEST	8" Line 517'	Severe bellies and aggregation "Replace"	23.59	$127,359
1224 NORTH 710 WEST (crest)	8" Line 382'	Line has 4 severe bellies. "Replace"	23.88	$96,714
1800 SOUTH 250 EAST	8" Line E-214' W-289'	Both lines showing aggregation "Liner"	24.55	$33,138
430 NORTH 800 WEST	6" Line E-415' /8" line N-257'	Line N. bellies and breaks "replace"/ Line E. ?	24.97	$168,544
840 NORTH 75 EAST	6" Lines E-250' N-324'	Line the North, needs "Liner"	25.82	$139,410
400 SOUTH 800 WEST	10" Line 545'	Bellies, 400 S. trunk line slows 800 W. line	26.07	$140,800
1650 SOUTH 740 EAST	8" Line 112'	Line has tree roots. Work order.	26.24	$35,424
1800 SOUTH MAIN	8" Line 339'	Line is showing aggregation "Liner"	28.44	$25,594
800 NORTH 200 EAST	6" Line 617'	Line has bellies & aggregation. "Replace w/8" line.	29.75	$160,655
888 NORTH 275 EAST	6" Lines E-266'/N-16'	East line off-set joints "Replace" South line low flow.	42.57	$76,630
245 SOUTH 1000 EAST	10" Line 203'	Line has bad bellies & roots "Replace"	43.50	$58,720
150 NORTH 1150 WEST	8" Line 232'	Line has several bad bellies. "Replace"	46.42	$62,664
1151 WEST 600 SOUTH	8" Line 339'	Line is in fair cond. A few open joints and laid crooked	55.83	$75,376
1030 NORTH 910 EAST	8" Line 297'	The first 266' lined. The remainder needs to be "replaced"	57.35	$77,419
1000 NORTH 250 EAST	8" Lines N-329'/E-324'	North line good cond. East line severe belly "Replace"	61.89	$83,548
1700 SOUTH STATE/EAST	10 " Line 309'	Line has numerous bellies. "Replace"	62.34	$84,160
1600 SOUTH 740 EAST	8" Line 340'	Line has small bellies, good cond.	64.58	$87,180
850 SOUTH 400 EAST 6" LINE USE TIP ONLY	6" Line 382'	Line has several long bellies. "Replace"	68.24	$92,130
600 NORTH 120 EAST	6" Line 550'	Line has bellies and off-set joints. "Replace" w/8"	77.92	$140,250
500 NORTH 1020 WEST	6" Line 681'	This line has been lined. No further action required.	82.23	$185,017
200 SOUTH STATE / east side	8"/6" Line 413'	Line has crack, aggregation. "Replace"	83.87	$150,967
660 NORTH 600 EAST	8"Lines N-287'/E-289'	E- line good (point repair). N- line agg. & bellies "Replace"	84.86	$152,752
400 NORTH 500 EAST	8" Lines N-323'/S-300'	North line bellies & roots "Replace" South line ok.	87.46	$157,421
400 NORTH 720 WEST	6" Line 1,427'	This line has been lined. No further action required.	91.22	$164,200
1838 SOUTH250 EAST	8" Lines 198' / 155'	Lines good. Lateral in mh's is the problem.	106.81	$96,131
800 SOUTH 200 WEST	8" Line 395'	Line in good cond. Small belly	110.74	$99,665
			Total	**$5,995,657**

APPENDIX D
TECH MEMO:
MAINTENANCE AND MANPOWER

Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

DATE: June 24, 2015

TO: Neal Winterton
Water Resources Division Manager
Orem City Municipal Corp
1450 W 550 N
Orem, Utah 84057

FROM: Keith Larson, P.E.
Bowen, Collins & Associates
154 East 14000 South
Draper, Utah 84020

PROJECT: Orem City Master Plan

SUBJECT: Evaluate Maintenance and Manpower

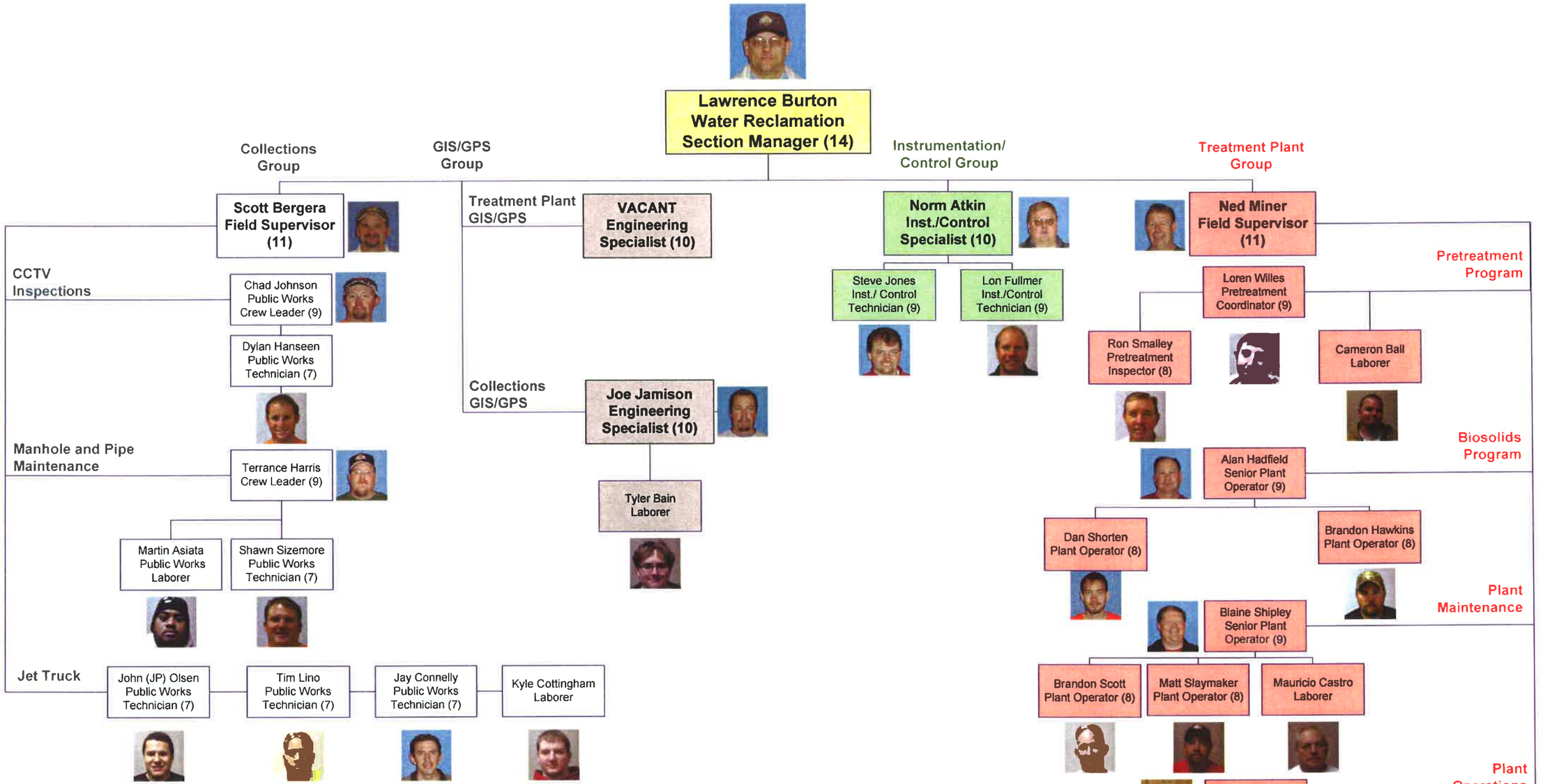
INTRODUCTION

As part of the sanitary sewer master plan, Orem requested that Bowen, Collins and Associates analyze and evaluate the existing maintenance programs and work force needs for Orem City and recommend changes to improve maintenance and how manpower is utilized. BC&A used both subjective interviews with personnel and objective collection of data to analyze and evaluate these aspects of the City's sanitary sewer program. The purpose of this memorandum is to summarize the findings of this evaluation and provide recommendations to eliminate any deficiencies.

EXISTING OREM CITY WATER RECLAMATION SECTION OPERATION AND MAINTENANCE

An organizational chart of the existing personnel in the Orem City Water Reclamation Section is attached. As can be seen in the chart, the section is organized into four groups:

- **Collections –** The collections group operates, maintains, and inspects the City's sewer collection pipelines and manholes. Major tasks include CCTV inspection of sewer pipelines, routine cleaning of sewer pipelines, and repair of damaged pipes and manholes.
- **Treatment –** The treatment group operates and maintains the City's existing water



Water Reclamation Section
Water Resources Division

Updated February 2015

reclamation facility and lift stations located throughout the City. In addition to the daily operation and maintenance of these facilities, this group includes personnel responsible for pretreatment (regulation of discharge for industries within the City) and biosolids management (disposal of treated solids at the end of the treatment process).

- **Instrumentation/Controls –** The instrumentation and controls group is responsible for all electrical instrumentation that meters, monitors, or controls components of the waste water conveyance and treatment process.
- **GIS/GPS –** The GIS and GPS group is responsible for all the gathering, storage, and analysis of data associated with wastewater infrastructure. This includes detailed mapping and modeling of the collection system, and asset management at the water reclamation facility.

Each group is discussed in detail in the following sections. Information regarding the duties and performance of each group has been assembled from interviews with City staff, documents provided by the City, and the City's website.

COLLECTIONS GROUP

The collections group operates, maintains, and inspects the City's sewer collection pipelines and manholes. The group is currently organized into three subgroups: inspection, cleaning, and repair.

Pipeline Inspection

The City's pipeline inspection crew currently has three primary areas of responsibility:

1. **Acceptance of new pipeline installations** – The inspection crew is responsible for inspecting and mapping out all new sewer line installations in the city before they are accepted by the city and the bond is released to the contractor.
2. **Assessing existing pipeline conditions** – When the inspection crew is not inspecting new lines, it is kept busy televising older lines in the system to determine the integrity of the existing lines. The crew identifies problems within the infrastructure and makes recommendations to remedy the problem. This information is updated in the collections data base.
3. **Assisting residents with lateral inspections** – Another service the inspection crew provides for the residents of Orem is inspection of lateral. The inspection truck includes a small camera on a push cable that can inspect homeowners' sewer laterals. While laterals are not the responsibility of the City, this service helps residents identify problems and offer solutions from an unbiased party.

The inspection crew televises approximately 35 to 40 miles of pipe each year to check pipe condition and quality of installation of new pipe. The complete system contains a total of 287 miles of sewer lines. This equates to full inspection of the system once every 7 to 8 years.

Based on the information gathered in association with this evaluation, BC&A would recommend

two actions in association with the existing pipeline inspection activities:

- **Adopt PACP –** It is recommended that the City consider adoption of the Pipeline Assessment and Certification Program (PACP) for all future pipeline condition assessment. PACP is nation standard for pipeline assessment that has two significant benefits. First, it establishes a standard defect severity grading process that allows classification of pipe condition that is consistent, regardless of who is doing the inspection. Second, it allows for the storage of inspection data in a searchable electronic database. These two features facilitate grading of pipelines as part of future asset management decisions. A more comprehensive discussion of PACP is contained in Issue Paper 1 attached to this memorandum.

- **Optimize inspection schedule –**The current practice of the inspection crew is to inspect each pipe on a routine basis (approximately once every 7.5 years). While this is probably adequate for most pipelines, it may not be frequent enough for some of the City's more critical lines, or in areas where corrosion potential is high. For the purposes of prioritizing inspection activities (and resulting maintenance and repair activities), it is recommended that the City establish a process for defining facility criticality. Issue Paper 2 attached to this memorandum discusses criticality in detail. Once criticality is established, it is also recommended that the City develop an improved method for organizing and tracking inspection activities.

Pipeline Cleaning

Orem City's cleaning crew operates multiple jet/vacuum trucks to clean the City sewer lines. The cleaning crew also has specialized equipment for killing and removing tree roots and eliminating grease buildup that occurs in certain areas of the sewer system. Cleaning activities generally fall into one of two categories:

1. **Routine Problem Area Cleaning** – The collection crew has a routine cleaning schedule for pipelines that must be serviced on a weekly, monthly, bi-monthly, quarterly and bi-annual basis to assure good reliable sewer service. Pipelines that fall into this category include areas of the system that have problems with bad hydraulics (resulting in sediment deposition), grease accumulation, tree roots, etc.
2. **General System Cleaning** – Even pipelines that do not have reoccurring problems can benefit from periodic cleaning. As a result, the City has a very proactive cleaning program, with a goal to clean the entire collection system every 3-4 years. The purpose of this program is to grit and debris in the collection system on a regular basis rather than have it build up and cause problems in the collection system or at the treatment plant.

In addition to regular cleaning activities, the pipeline cleaning crew is available 24 hours a day, 7 days a week to respond to sewer emergencies, backups etc. The goal for all responses is to be at the site within 30 minutes of when the call was first received.

Based on the information gathered in association with this evaluation, BC&A would recommend two actions in association with the existing pipeline cleaning activities:

- **Eliminate routine cleaning areas where possible –** As part of the master plan, a detailed analysis of existing routine cleaning areas was completed. From that analysis, several projects were identified to eliminate a number of the routine cleaning areas. Many of the projects are low cost and will be more than offset by reduced maintenance costs within a few years. It is recommended that the City begin to complete those projects, starting with the projects with the quickest payback period. While not all of the routine cleaning areas can be eliminated, a large number can. The amount of maintenance time that can be eliminated through these projects is estimated in Table 1.

Table 1
Routine Cleaning - Annual Hours That Can be Eliminated Through Projects

Frequency of Maintenance	Current Annual Man Hours	Annual Man Hours that can be Eliminated	Man Hours that will Remain
Weekly	182	182	0
Bi-monthly	462	414	48
Monthly	1770	1200	570
Quarterly	366	258	108
Bi-yearly	26	12	14
Total	**2806**	**2066**	**740**

- **Optimize cleaning schedule –**The current practice of the cleaning crew is to provide cleaning for each pipe on a routine basis (approximately once every 3.5 years), regardless of need. Because excessive cleaning can shorten pipe life and consume valuable City resources, BC&A would recommend moving to a cleaning schedule based on need only. To do this, the City will need to develop a method of tracking the results of each cleaning activity in its work order or GIS system. Possible secondary data fields that could be added to accomplish this task include:

Secondary Data Category	Possible Data Entries
Reason for Clean	Routine Cleaning
	Complaint Call or Observed Problem
	Other
Results - Sediment	Little to none
	Less than 5 percent pipe depth
	5-10 percent pipe depth
	10-25 percent pipe depth
	Greater than 25 percent pipe depth
Sediment Type	Fine sediment and sludge only
	Coarse sands and gravels
	Rocks, chunks of concrete, or other large debris
Results - Grease	Little to none observed
	Minor
	Significant
Results - Roots	Little to none observed
	Minor
	Significant
Results – Other Debris	Little to none observed
	Significant other debris observed
Field Assessment	Cleaning not needed – Significant increase in cleaning interval recommended
	Cleaning produced modest results – Small increase in cleaning interval recommended
	Cleaning productive – No change in cleaning interval recommended
	Cleaning overdue – Decrease in cleaning interval recommended

Once the required data collection process is in place, the following actions are recommended:

a. *Continue with Regular Cleaning Schedule for a Period of 3.5 Years.* Because no data is currently available on other pipelines in the system, it is recommended that the City follow its regular, systematic cleaning schedule for a period of 3.5 years, or as long as it takes to clean all the pipe in the system at least once. This will allow the City to develop a baseline of cleaning data.

b. *Develop Future Cleaning Schedule.* After baseline data has been collected, it is recommended that the City review the results and develop a new cleaning schedule

based on need. The goal will be to clean each pipe only when it is needed, instead of simply on a routine basis. For some pipelines this will require more frequent cleaning than is currently occurring, for others, less frequent cleaning will be recommended. Over the years, this cleaning schedule should be revised and improved as additional cleaning data is collected in the system.

Manhole and Pipe Repair

The City's repair crew works to repair and maintain the manholes and sewer pipes throughout the City. The repair crew performs their own sewer line spot repairs, both open trench and trenchless, and repairs damaged hardware, risers and manhole lids. The crew is fully equipped with the equipment and materials necessary to make routine repairs but does not have the manpower or equipment to perform some larger replacement projects.

Staffing for repair crews is often difficult to evaluate because the need for staffing is entirely dependent on how much work an entity wants to do itself versus how much will be contracted to outside providers. With increased staffing levels, the repair crew would certainly be able to do more work in-house and take on larger projects. However, the existing crew appears to be adequate to address the immediate repair needs of the City.

Collections Group Staffing Levels

Trying to compare staffing levels between different sewer providers is complicated because each provider structures its organization a little differently than the next. Providers also tend to have different philosophies regarding how much work to do with its own crews versus how much work to contract to outside providers. This makes direct comparisons between staff levels and positions difficult.

As one method of comparing general staff levels, BC&A completed a comparative analysis of the number of personnel and salary level of the department. Several public agencies along the Wasatch front were used in the comparison. Specific names of the agencies are not included because only rough data was collected. However, this data will allow for some comparison of the staffing level and compensation of the City with other agencies on a general basis. The figures below contain the results of the comparative analysis. Figure 1 looks at raw number of employees (seasonal or temporary employees are not included), Figure 2 looks at average compensation per employee, and Figure 3 looks at total department compensation. Circles represent entities with collections and treatment departments. Squares represent entities with collection systems that are not required to also maintain wastewater treatment facilities.

Figure 1
Total Collection System Employees

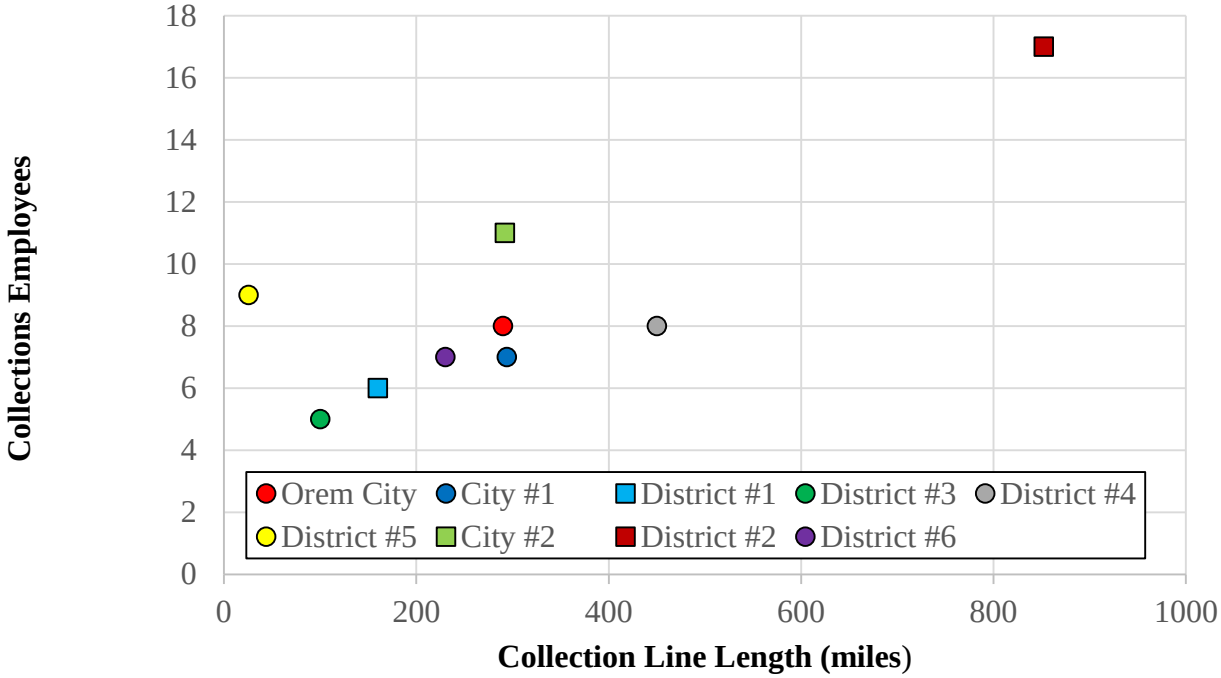


Figure 2
Collections Systems Average Compensation Comparison

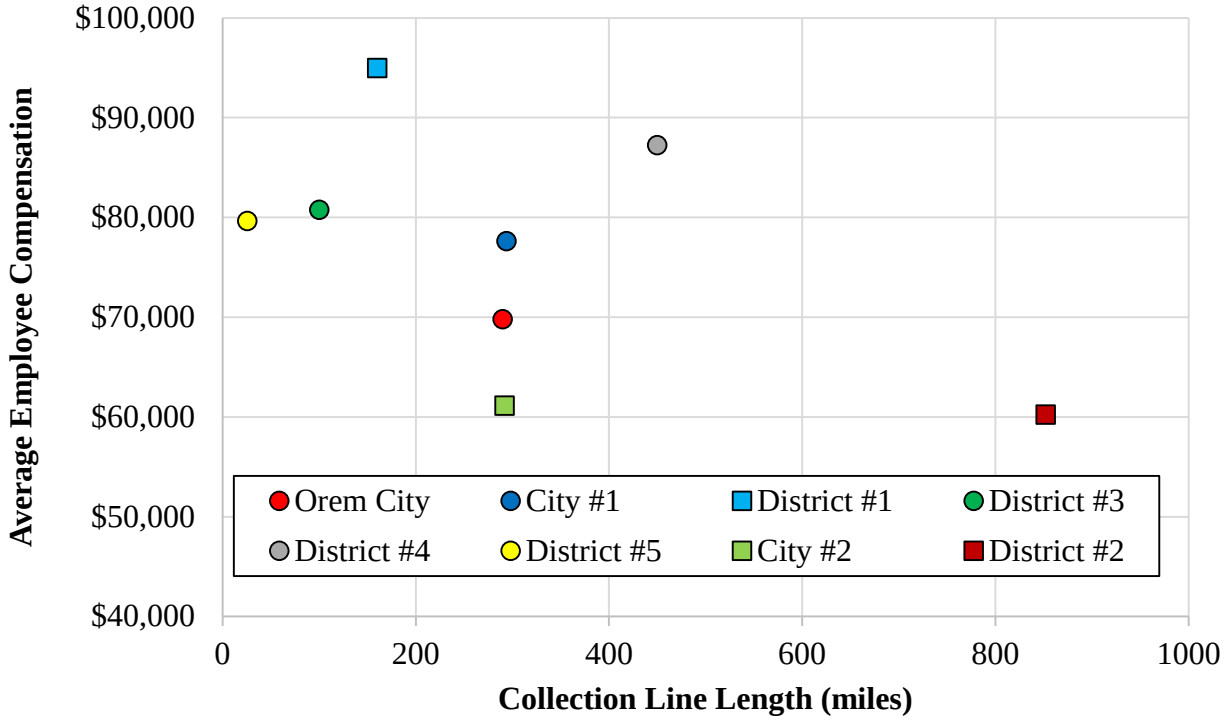
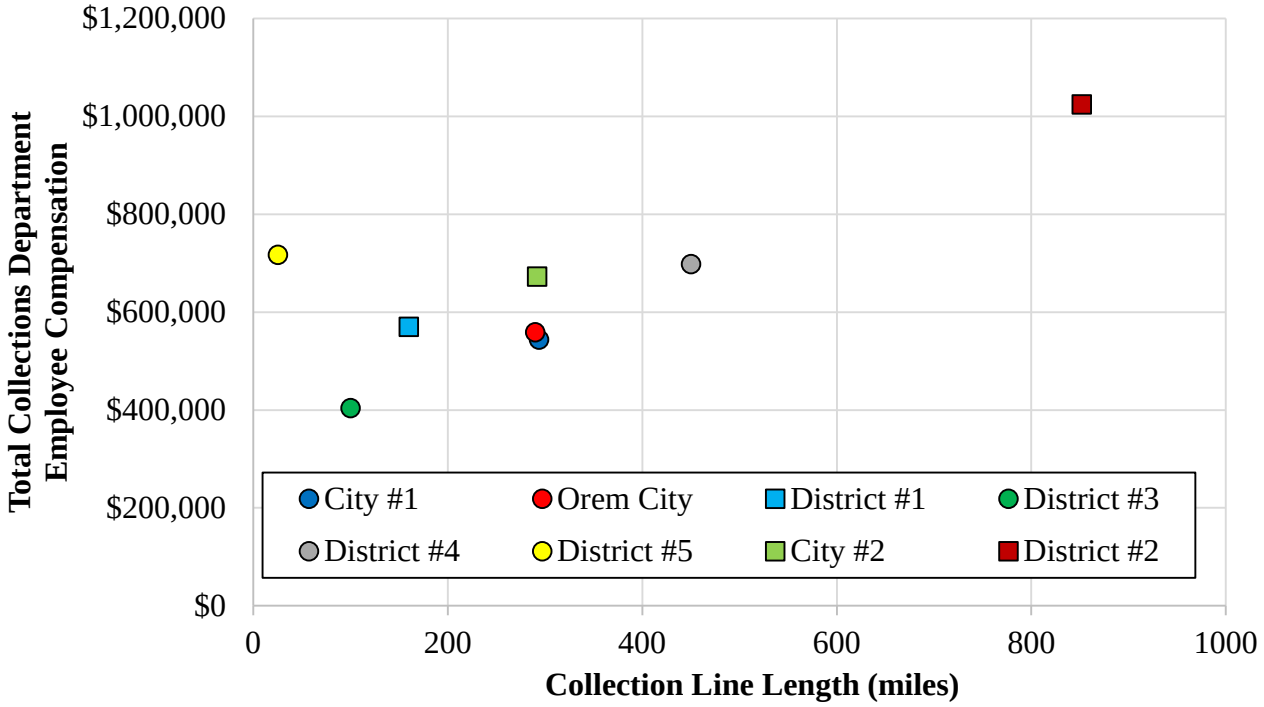


Figure 3
Collections Systems Total Compensation Comparison



A few different observations can be made based on the figures:

- The number of Orem City collection system employees appears to be right in line with the size of its system.
- For the entities surveyed, compensation for Orem City collection system employees appears to be near average. It has the lowest average compensation for an entity operating a wastewater treatment facility, but slightly higher compensation than some entities without a treatment plant.
- Total compensation in Orem City also appears to be approximately in line based on the size of its system. There are some providers with comparably higher compensation, but several other providers with compensation very similar to the City.

Based on all the information available, the collections department appears to be staffed similar to comparable departments along the Wasatch Front. The system appears to be well maintained and no significant shortfalls in staffing were identified. Compensation for collection employees may be slightly below average, but not significantly so.

➢ ***Bottom Line Staffing Recommendation (Collections) – No change***

No changes in the staffing of the collections group are recommended at the current

time. While the percentage of time spent on individual tasks may change per the recommendations contained in this memorandum, the overall level of effort projected for the collections group is consistent with current staffing levels. However, this will change as population and additional collection pipelines are added to the system and the City should continue to look at this issue in future master plans.

TREATMENT GROUP

The treatment group operates and maintains the City's water reclamation facility and lift stations. The group is currently organized into four subgroups: operations, maintenance, pretreatment, and biosolids.

Plant Operations

The operations group covers the water reclamation facility (WRF) and also the wastewater lift stations. Plant operations personnel monitor WRF function and make operational adjustments to account for varying influent conditions. The WRF utilizes an Activated Sludge Biological Nutrient Removal (BNR) treatment process. The BNR process is an extended aeration system that reduces biological loading in the water. The treated water is then disinfected using chlorine prior to discharge. Solids are separated from the wastewater and further processes via a thermophilic anaerobic digestion system. This system is used to further reduce the volume of biosolids produced in the plant and eliminate pathogens. The total treatment process allows water to be separated from the waste as a clean reusable resource and released to environment via Powell Slough and on into Utah Lake.

In recent years, the WRF has undergone several changes, most notably, the addition of the BNR system. This has created some additional responsibilities for operations staff. However, consistent with national trends, the department has leveraged improved technology to maintain staffing levels while absorbing the additional responsibilities. City personnel report that current staff levels have been able to meet the recent addition of new responsibilities for the time being. As the system continues to expand or as new plant functions are added (such as increased treatment for reuse purposes), additional staff will likely be required.

Plant Maintenance

The maintenance group handles all of the work order ticket items for the WRF and 7 system lift stations. This includes 10 motor control centers, 160 pumps throughout the Plant, and many other significant mechanical and electrical components. In total, the plant maintenance crew performs over 4500 preventive maintenance work orders per year. Tasks include the repair, rebuild, and manufacture many custom pieces of equipment for specific applications all around the plant.

Staffing needs in the plant maintenance group will be a function of both the quantity and condition of plant infrastructure. From BC&A's investigations, it appears that some of the equipment

requiring the most maintenance effort is not the oldest equipment but some of the more recent additions to the facility. It appears that some cost driven design decisions during recent plant upgrades may have resulted in long term operational considerations that will result in additional ongoing maintenance.

One example of this is the PVC pipe headers in the aeration piping for the oxidation ditches. Although the equipment has only been in service for a few years, it has already experienced several problems. Based on information taken from interviews, the hot air from the blowers has caused segments of the pipe to become brittle and crack. The resulting air leaks are difficult to deal with and require the operators to reroute plant flow. Significant adjustments like this in plant operation make it a challenge to stay within permit limits. The upgrades have also required additional time from operations personnel as they learn the nuances of the system and how it integrates with the older plant features.

The condition of the lift stations and plant facilities is tracked with a task order system. The task order system helps the personnel keep track of periodic maintenance activities that are needed to keep the facilities in good working condition. The task order system takes the place of manual forms that are used by many municipalities to keep maintenance tracking simple but up to date. The task order system also enables efficient reporting of the status of plant facilities.

Overall, the maintenance group appears to run efficiently but occasionally gets overbooked trying to cover all the recommended maintenance items for the pumps and equipment throughout the plant. As the treatment plant has expanded capacity, there have been no corresponding increases in personnel to accommodate expansion. As a result, the City has had to postpone some maintenance tasks. Proactive inventory management has also been limited, resulting in more expensive reactive inventory management. In addition to these existing issues, the City will be implementing a reclaimed water reuse system in the near future to reduce demands on the culinary water system. The added complexity of treating water to meet secondary water requirements will increase the burden on existing staff. Based on these needs, City personnel have requested increasing staff in the plant maintenance group to better satisfy the needs of continued maintenance with increasing capacity and complexity for the facility.

Pretreatment

The pretreatment group regulates wastewater discharged from the industries within the city. It regulates the types and amounts of pollutants that each industry is allowed to release into the sewer system. By doing this, the pretreatment group protects the treatment plant from excessive amounts of pollutants that can overload its designed treatment capabilities. Activities of the pretreatment group also ensures that no harmful pollutants are discharged that might damage either the collection system, the biological processes of the treatment plant, or the environment. The City pretreatment group currently employs one coordinator, one inspector and on part-time worker.

Efforts of the pretreatment group appear to be successful and operations are running smoothly. Overall, staffing of the pretreatment group appears to be adequate with the possible exception of

increased GIS support which will be discussed subsequently.

Biosolids Management

Each year, the biosolids management group dewaters and arranges for the disposal of approximately 12,500 tons of sludge that are left over after the treatment process. The biosolids are treated to a quality standard set by the Utah State Division of Environmental Quality and one hundred percent of this material is land applied to agricultural areas for fertilizer. It is a high quality soil amendment rich in nutrient value. The current staffing level of the biosolids group appears to be adequate to meet system needs for the foreseeable future.

Treatment Group Staffing Levels

Similar to what was done with the Collections group, BC&A completed a comparative analysis of the number of personnel and salary level of the department. The figures below contain the results of the comparative analysis. Figure 4 looks at raw number of employees (seasonal or temporary employees are not included), Figure 5 looks at average compensation per employee, and Figure 6 looks at total department compensation.

Figure 4
Total Treatment Employees

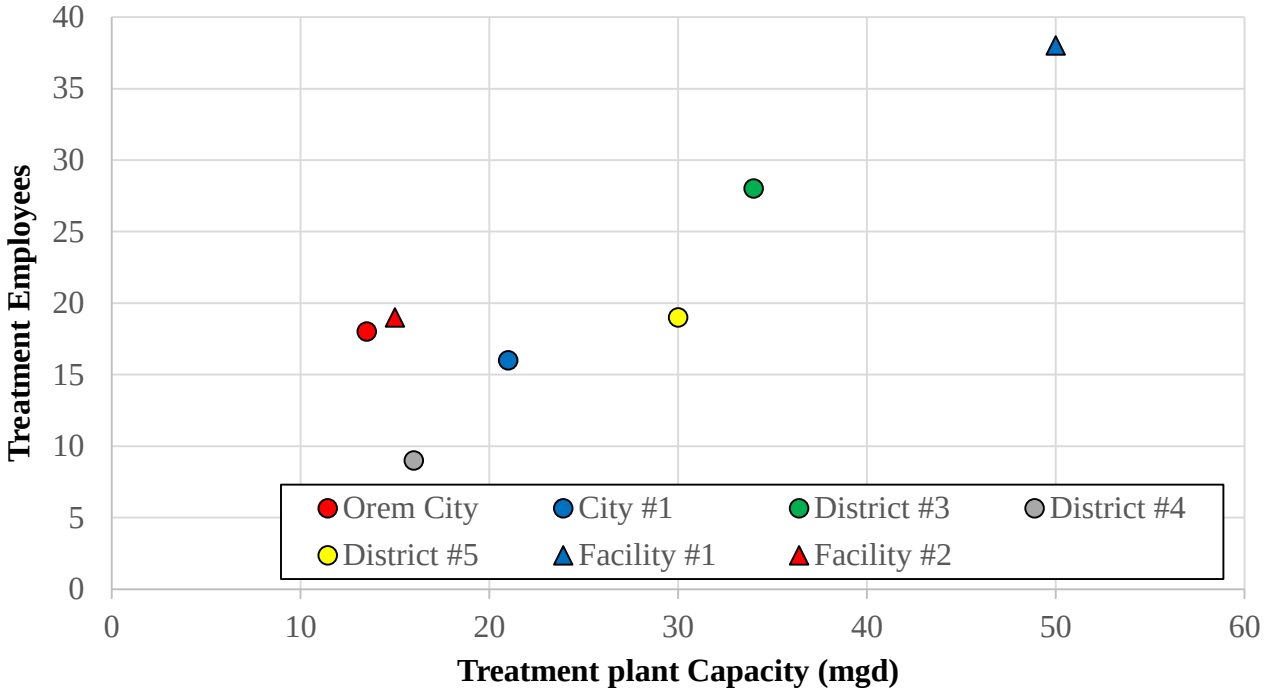


Figure 5
Treatment Entity Average Compensation Comparison

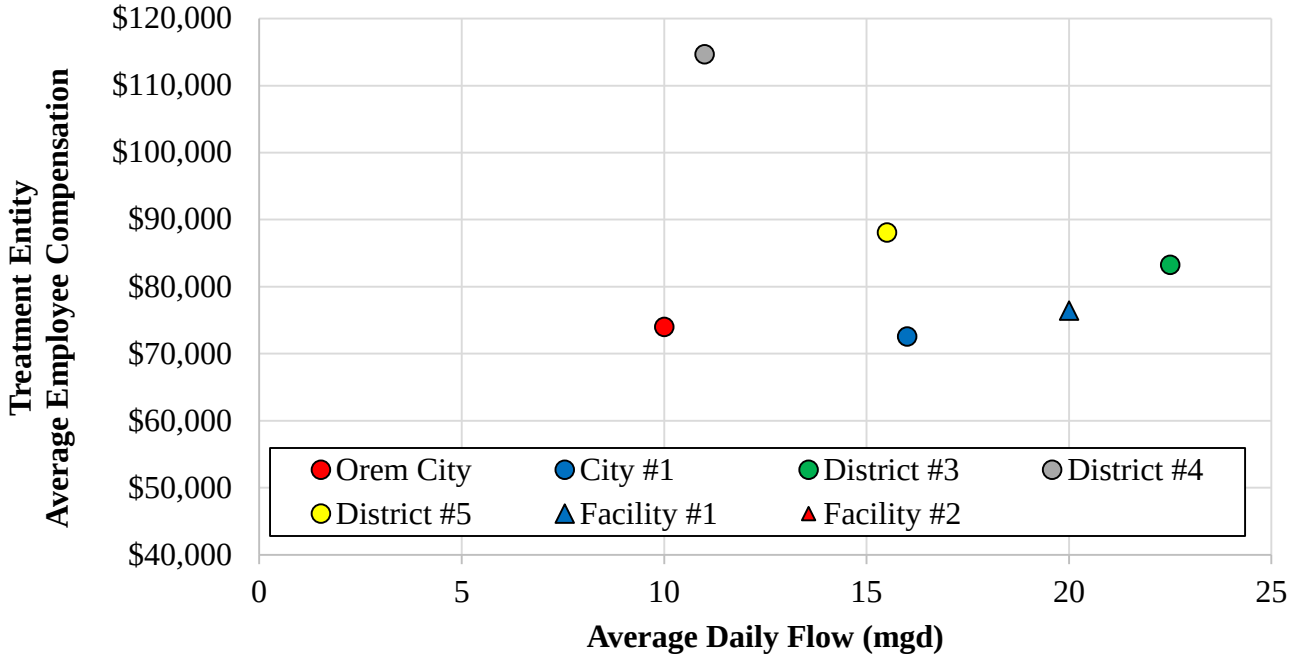
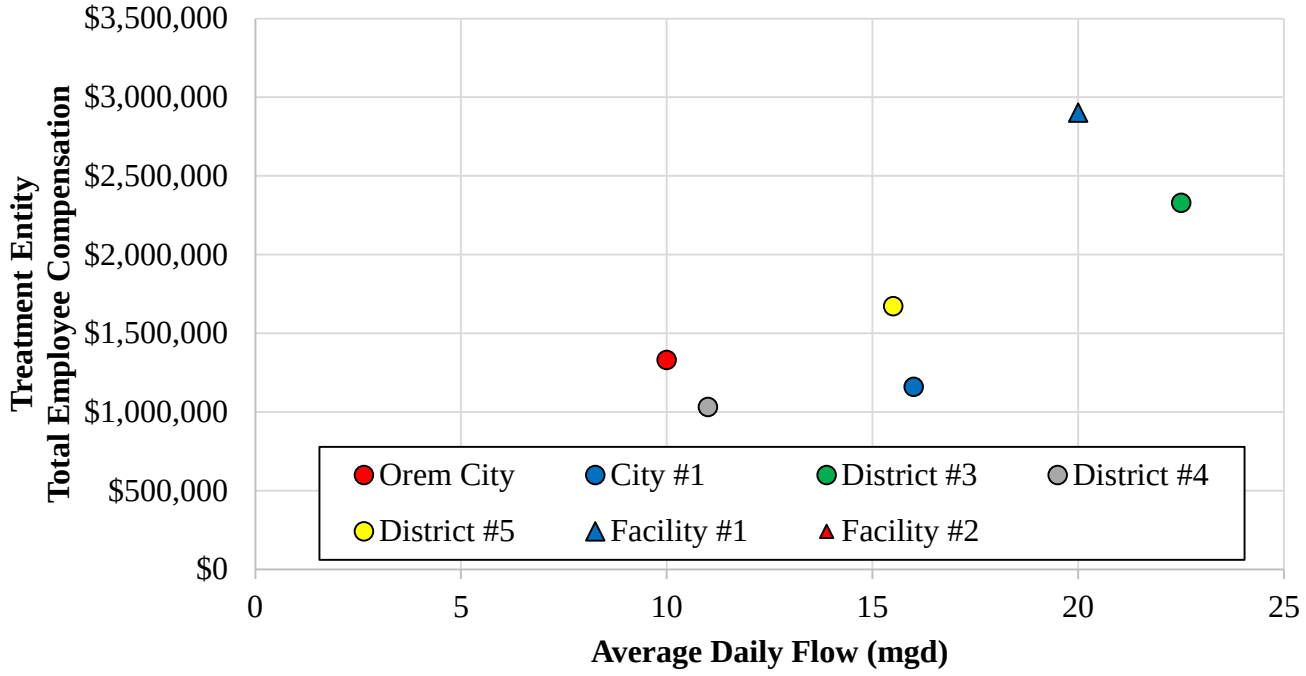


Figure 6
Treatment Entity Total Compensation Comparison



A few different observations can be made based on the figures:

- The number of Orem City treatment system employees appears to be a little higher than average for the size of its system. With this said, treatment plant staffing levels can be difficult to compare because of the different processes and functions that occur at each plant. While plant capacity is indicated in Figure 4 as a reference, this does not account for the relative complexity of operating treatment plant facilities. Issues such as the type of process being used, the age and condition of the plant facilities, whether or not the plant has reuse, number of lift stations, how pretreatment activities are conducted, etc. will all affect how many employees are need to staff a treatment group.
- For the entities surveyed, compensation for Orem City treatment system employees appears to be near average or slightly below average.
- Total compensation in Orem City appears to be approximately in line based on the size of its system.

Based on all the information available, the treatment department appears to be reasonably staffed when compared to similar departments along the Wasatch Front. Staffing levels are slightly higher than other entities of comparable size, but this is likely explained by the significant number of lift stations in the City and relative complexity of the City's treatment process. Compensation for treatment employees may be slightly below average, but not significantly so. The system appears to be well maintained.

With this said, current staffing levels may not be adequate to meet future needs. Of specific concern is the maintenance group. While the maintenance group appears to be run efficiently, it does occasionally gets overbooked trying to cover all the recommended maintenance items for pumps and equipment throughout the plant. Additionally, a major new responsibility is planned to be added in the near future as additional treatment facilities are added to produce reuse water for secondary irrigation.

- ***Bottom Line Staffing Recommendation (Treatment) – 1 Additional Full Time Equivalent (Maintenance Group)***

  It is recommended that the City hold staffing at current levels until the completion of the reuse water system. At that time, it is recommended that the City consider adding one additional full time position to the maintenance group.

  Purpose of proposed new staff: Additional maintenance worker will be responsible for added maintenance load of new reuse treatment system and will increase efforts in maintaining additional equipment added as part of recent treatment plant improvements (65 percent of time). The new position will also help develop and execute an inventory management plan (35 percent of time).

  Consequence of not increasing staff: Because the recommended position is a maintenance position, it may be possible to postpone this additional hire and still

have an operational system for a period of time. However, without additional help, the addition of new duties associated with reuse will result in less time for regularly schedule maintenance activities in the system. This means that many of the important, but not urgent preventative maintenance activities that normally get completed will need to be postponed or skipped for lack of resources. Over time, this will result in premature equipment failure and increased equipment replacement costs.

A second consequence of not filling this position is that inventory management will continue to be based primarily on reactive responses instead of proactive action. While quantifying the costs of this consequence is beyond the scope of this memorandum, it is clear that this will result in higher costs for parts and materials, along with inconvenience and cost associated with inventory delivery delays.

INSTRUMENTATION AND CONTROLS GROUP

Throughout the Orem City collection and treatment system, there is electronic equipment that regulates flow, monitors treatment conditions and stages, turns selected pumps and equipment on and off at predetermined intervals, and sends vital control information to a centralized computer system. This information is then manipulated with control software to allow precise control and information to the operators so that the system can be operated at its peak efficiency. The responsibility for the installation, maintenance, and programming of this equipment falls to the instrumentation and controls group.

The current staffing level of the instrumentation and controls group appears to be adequate to meet existing system needs. However, with technological advances, instrumentation and control has become significantly more sophisticated in recent years. This trend is only expected to accelerate. Because needs can change rapidly in this field, it is recommended that Orem City closely monitor staffing needs in this group over the next several years.

- ***Bottom Line Staffing Recommendation (Instrumentation) – No change***

  No changes in the staffing of the instrumentation group are recommended at the current time, but needs in this group should be monitored closely over the next several years.

GEOGRAPHIC INFORMATION SYSTEM (GIS) GROUP

The Geographic Information System (GIS) and Global Positioning System (GPS) group helps to monitor and map the wastewater treatment and collection system. This is done through the creation and maintenance of a map based database that includes cleaning and work histories, trouble spots, and improvement needs. The database enables staff to keep track of all maintenance and forecast potential upgrades that may be required within the treatment system. This forms the backbone of the City's asset management program.

While this group is currently the smallest group in the department, the activities of the GIS group are essential to the function of the other groups. For the collections crew, the GIS database includes manhole and pipeline data with the physical location, depth, size, material, and condition of each facility. For the treatment crew, similar information is collected and organized relative to treatment plant facilities including pumps and other major pieces of equipment. This information is available to City crews at all times via laptop computers that are equipped in all the maintenance vehicles. The information provided by the GIS group assists City personnel, public, contractors, and independent engineers in designing, repairing, and maintaining the facilities.

According to the City's organization chart, Orem city has a position for a GIS/GPS specialist that has been vacant for some time. Historically, the collections database was maintained by one specialist with the pretreatment and treatment database maintained by a second. As a result, the City has fallen significantly behind on some GIS activities. The City has recently hired an intern to perform some of the basic duties of the missing position, but the intern does not have the skills to fill the full responsibilities of the position.

- ***Bottom Line Staffing Recommendation (GIS) – 1 Additional Full Time Equivalent***

  It is recommended that the City fill the existing vacant GIS position as soon as possible.

  Purpose of proposed new staff: The additional GIS employee will resume the duties associated with the vacant position. This will include focusing on the treatment plant and the pretreatment program which will allow the existing GIS employee to spend more time on his primary focus of the collection system.

  Consequence of not increasing staff: The City has a number of systems where data is stored including: GIS, SCADA, and task order tracking systems. Some of the data storage and use functions that are necessary to operate the facilities could be improved and many agencies have found it to be cost effective to consolidate systems. Annual costs of using multiple software systems to organize and track data can be burdensome. There are a number of possible options the City could evaluate to improve current data storage and operation functions. However, it will not be possible to consolidate and improve systems until a new GIS specialist can be employed to evaluate data collection and storage to improve efficiency.

  Improving GIS performance should be a priority because it helps to organize the time spent by other crews. Activities such as prioritizing inspection, cleaning, and maintenance activities have the potential to save the City thousands of man hours each year. These activities cannot be accomplished without effective data collection and management through GIS. Increasing the staffing in the GIS department is recommended because effectively collecting, maintaining and utilizing data can provide long term cost savings for the City.

CONCLUSIONS AND RECOMMENDATIONS

A number of conclusions and recommendations can be made from the analysis presented in the previous sections:

1. **Fill existing vacancy in the GIS Group –** The City should fill the vacant GIS specialist position as soon as possible. Because GIS is critical to the work flow of all the other groups, the cost of adding a GIS specialist will be largely offset through improved data management, eliminating redundant software systems, and improving work flow.

2. **With the completion of the reuse project, create one new position in the Treatment Group** – Of the entities surveyed for this evaluation, none operate a treatment system to reuse reclaimed water for secondary irrigation. In addition, while the treatment plant capacity has increased in capacity and complexity over the last decade, there have been no corresponding increases in treatment plant personnel. Existing personnel have been able to keep up with most asset management requirements, but increased responsibility may pose risks to exceeding the City's discharge permit if additional personnel are not added to manage facilities. With the completion of the reuse project, it is recommended that the City consider adding one new position to assist with maintenance of the water reclamation facility.

3. **Continue to monitor staffing needs of other groups** – No other increases in staffing have been identified at this time. However, with the addition of the Southwest Annexation area, further development in Vineyard, and overall system growth, the City will want to continue to monitor the effectiveness of existing crews to meet the needs of the system.

4. **Consider changes in work process** – BC&A has provided some recommendations for improvements in the work flow process relative to asset management and maintenance priorities (as summarized previously in this memorandum). Once the existing GIS vacancy is filled, it is recommended that the GIS group look at ways of incorporating these recommendations into the work process to reduce maintenance costs and improve system performance.

5. **Keep an eye on compensation** – The success of a system is is largely determined by its personnel. Since compensation is an important factor to attract and retain personnel to meet the City's long term staffing needs, it is important the that City's compensation package be competetive with neighboring communities. The limited analysis conducted here indicates that Orem City's compensation is about average, but more detailed analysis regarding level of experience and training for each employee to make firm conclusions. It is recommended that the City conitnue to monitor compensation to make sure it is competetively attracting and retaining qualified personnel.

ISSUE PAPER

Issue No: 1

Project: Orem Sewer Master Plan

Date: 19 June 2015

Subject: Pipeline Condition Assessment Data

Attn: Engineering, GIS, O&M, Management

DESCRIPTION OF ISSUE:

The most fundamental component of an asset management program is the development of a program to accurately assess the condition of existing assets. BC&A has reviewed the City's existing condition assessment program for pipelines. Based on this review, we have concluded the City's existing condition assessment program currently produces only limited data that can be used in a meaningful way for asset management. As a result, BC&A would recommend a change of direction in the way pipeline condition assessment data is collected and stored by the City.

ACTION ITEMS:

All – Review the recommended change to PACP condition assessment coding. Make the decision of whether or not to adopt this recommendation.

Management – If the recommended change is adopted, commit the resources necessary to make the change.

GIS –Determine how PACP inspection data will be transferred and stored.

All – Establish a goal for collecting condition assessment data for pipelines in the system

ADDITIONAL DISCUSSION:

PACP condition assessment coding

Existing Condition Assessment Process

Based on interviews with Orem City personnel, the City's current condition assessment program consists of the following process:

1. Pipelines are identified for CCTV inspection in one of three ways:

    a. First, a certain number of pipelines are identified for routine inspection each year. The City crews generally start at one end of the system and systematically work

their way through the entire City. Under this system, all pipes are inspected at an equal frequency.

b. Second, a pipeline inspection can be requested by the City's engineering staff to investigate a specific problem or prepare for an improvement project.

c. Third, after rehabilitation projects or new construction, a pipeline is inspected to verify the quality of the work.

2. CCTV inspection includes capture of video images of each pipeline with comments regarding observations typed manually by inspection staff. There is not a standardized format for these comments and they are currently recorded on the video image only.

3. Once the inspection has been completed, it receives a cursory review from O&M staff. If O&M staff deem the pipeline to have sufficient problems to potentially merit an improvement project it is passed on to engineering for further review. If O&M staff do not identify sufficient problems to merit further consideration, the inspection video is archived.

4. Those videos provided to engineering receive a more detailed review by engineering staff. Those pipelines with problems that require attention are selected and prioritized for future rehabilitation or replacement.

There are two significant problems with the City's existing pipe inspection process:

- **The process is not as useful as it could be.** While it does collect good data for pipelines that will be incorporated into improvement projects, all the inspection information for pipelines not identified for improvement projects is essentially lost. This is for two reasons:

  – The existing process produces video images only. Images are the best resource for design, but are difficult to work with when trying to make long-term asset management decisions for the system as a whole. To be useful for asset management, the condition assessment process must produce a searchable database. A database is required so that queries can be quickly generated that provide condition comparisons between the various assets within the system and comparisons of condition over time for individual assets.

  – The existing process is not standardized. To make decisions regarding which pipelines receive the most attention, the condition assessment performed on one pipeline must be consistent with the condition assessment on any other pipeline. Furthermore, to assess the deterioration of an individual pipeline, the condition assessment performed today must be consistent with the assessment completed on the same pipeline ten years ago.

- **The process is not as efficient as it could be.**

- Without an easily searchable history of past condition, all pipelines must be inspected on an equal frequency. If the City could develop a history of past condition, it could better know which pipelines were exhibiting signs of deterioration and which were relatively stable. This would allow the City to better match the frequency of inspection with the condition of each pipeline, resulting in fewer required inspections over time.

- The City's current practice of documenting problems requires significant typing by inspection staff. Past history with other entities indicates that documenting problems using standardized coding software can decrease the required inspection time for each pipeline.

- Because there is not a good system for storing data, retrieving data in the past has been difficult. Inspection staff indicate that they have had to inspect some pipelines multiple times over a short period because results for past inspections could not be found.

Recommended Condition Assessment Process

Based on the problems identified above, BC&A would recommend a change in the condition assessment process used by the City. We would recommend that Orem City consider adoption of the Pipeline Assessment and Certification Program (PACP) for all future pipeline condition assessment. PACP is recommended for the following reasons:

1. PACP is a standardized method of describing and coding defects and observations that is now used by several hundred other cities in the United States and is based on an international coding system that has been in place for several decades

2. A PACP training and certification program for users is already in place and has resulted in the certification of several thousand individuals since 2002.

3. As part of PACP, a standard database exchange format has been developed that provides a means for exporting and importing TV inspection data from various software vendors and greatly reduce the ability of vendors to maintain a proprietary database.

4. A PACP certification process for CCTV software vendors is in place and almost all current CCTV software vendors in the United States are PACP certified. This generally means that the CCTV software must correctly use the PACP codes and must have the capability to import and export data using the PACP database format.

5. PACP has a standard defect severity grading process that allows a general classification of each pipe segment based on the severity and number of defects. This will facilitate grading of pipelines as part of future asset management decisions.

The alternative to adopting PACP is for the City to develop its own standardized pipe inspection process. This does not seem prudent for two reasons. First, the PACP program is already

developed and ready for use. The cost of developing a new system and maintaining the system would likely be comparable or greater than any cost associated with adopting PACP. Second, PACP is a non-proprietary national standard. That means that equipment and service providers throughout the nation are familiar with the system and can work within it. It also means that any PACP data produced by one provider will be in a format that is recognizable and useable by other PACP providers. If the City were to develop its own standard, any outside provider would need to learn the City's system before it could do work in the City.

Required Resources to Adopt PACP

PACP could be adopted by the City relatively easily, but it will require the commitment of some resources on the part of management. These resources mainly fall into two categories:

- **Coding Software:** The City's existing CCTV inspection trucks currently use proprietary software from CUES to do all CCTV coding. To move to PACP, the City would need to purchase new PACP compatible software. The cost of TV inspection software varies considerably based on the number of licenses and features. Costs can range from $12,000 for a basic single seat license without training and support to $75,000 for multiple seat licenses with advanced features such as GIS integration, software training and support. The National Association of Sewer Service Companies (NASSCO) maintains a list of PACP certified software vendors on their website (www.nassco.org). This list is updated periodically. As the City considers the purchase of PACP software, they should check the current status of proposed PACP software vendors on the NASSCO website. The project team has hands-on experience using some of the PACP certified software and can provide additional input of those systems when the City gets closer to a purchasing decision.

- **Training:** The only other requirement to adopt PACP is that CCTV operators be trained to use PACP coding. This training is what ensures that coding of pipeline observations is consistent from inspection to inspection. PACP training consists of a two day classroom session that discusses the background of condition assessment, rules for using the codes, and a test to evaluate the users knowledge of PACP. PACP training is generally separate from the TV inspection software and the cost of PACP Training is approximately $750 per user plus a daily rate for additional training using the codes in the field.

Data Storage

At the end of a PACP inspection, two major sources of data are produced. The first is a video image of the pipe. The second is an inspection database that is populated with observation codes from the inspection. The City's GIS department will need to develop a system to transfer and store both of these sources of data from the CCTV inspection trucks. BC&A has provided the City with a copy of the PACP database for review by the GIS department. It will be important to store all future data in PACP format so that it is compatible with PACP data from all future service providers.

Establish a Goal for Moving to PACP and Collecting Condition Assessment Data for the System

If the City agrees with the conclusions and recommendations contained in this issue paper, it is further recommended that the City establish a time line for implementing PACP condition assessment of the system. In the future, it is recommended that all inspection activities be prioritized by criticality (see Issue Paper #2). Unfortunately, since no condition assessment data currently exists, it is recommended that initial inspection activities be prioritized by consequence of failure (see Issue Paper #2) with the following goals for completion (times refer to time after adoption and implementation of PACP):

Consequence of Failure Level	Goal for PACP Inspection
1	Within one year
2	Within three years
3 (Concrete pipe & known problems)	Within three years
3 (All other pipe)	Within ten years

The consequence of failure levels referenced above refer to the importance of the pipelines and will be discussed in detail in Issue Paper #2. In brief, Level 1 pipelines represent the most important 5 percent of the system. Level 2 pipelines represent the next most important 10 percent of the system. Level 3 represents all remaining pipelines. To meet this schedule, the City would need to inspect approximately 10 percent of its system each year which is well within the capacity of the existing crew.

It will be noted that Level 3 pipelines have been divided into two categories. City personnel have indicated that they would like to place increased priority on the inspection and assessment of Level C pipelines that fall under either one of two categories: concrete pipe (based on observed corrosion problems with other concrete pipes) and pipes that have had known problems in the past. It is recommended that these pipelines be prioritized like Level 2 pipes.

ISSUE PAPER

Issue No: 2

Project: Orem City Sewer Master Plan

Date: 19 June 2015

Subject: Criticality

Attn: Engineering, GIS, Management

DESCRIPTION OF ISSUE:

Criticality is defined as the combined consideration of the consequence of failure and the probability of failure of an asset. The term criticality is often used interchangeably in asset management with the term risk. This is because criticality is used to compare the risk associated with a given asset relative to the rest of the assets in the system. Criticality is the key component used in decision making for asset management. It is the calculation of criticality that prioritizes the attention and resources of the City as they manage the collection system. The purpose of this issue paper is to discuss the concepts of consequence of failure and probability of failure, and then discuss how to use these concepts in the calculation of criticality for City assets.

ACTION ITEMS:

Engineering, Management – Develop an approach to evaluate consequence of failure

Engineering, Management – Develop an approach to evaluate probability of failure

Engineering, Management – Review and adopt proposed approach to calculate criticality and corresponding decision matrix

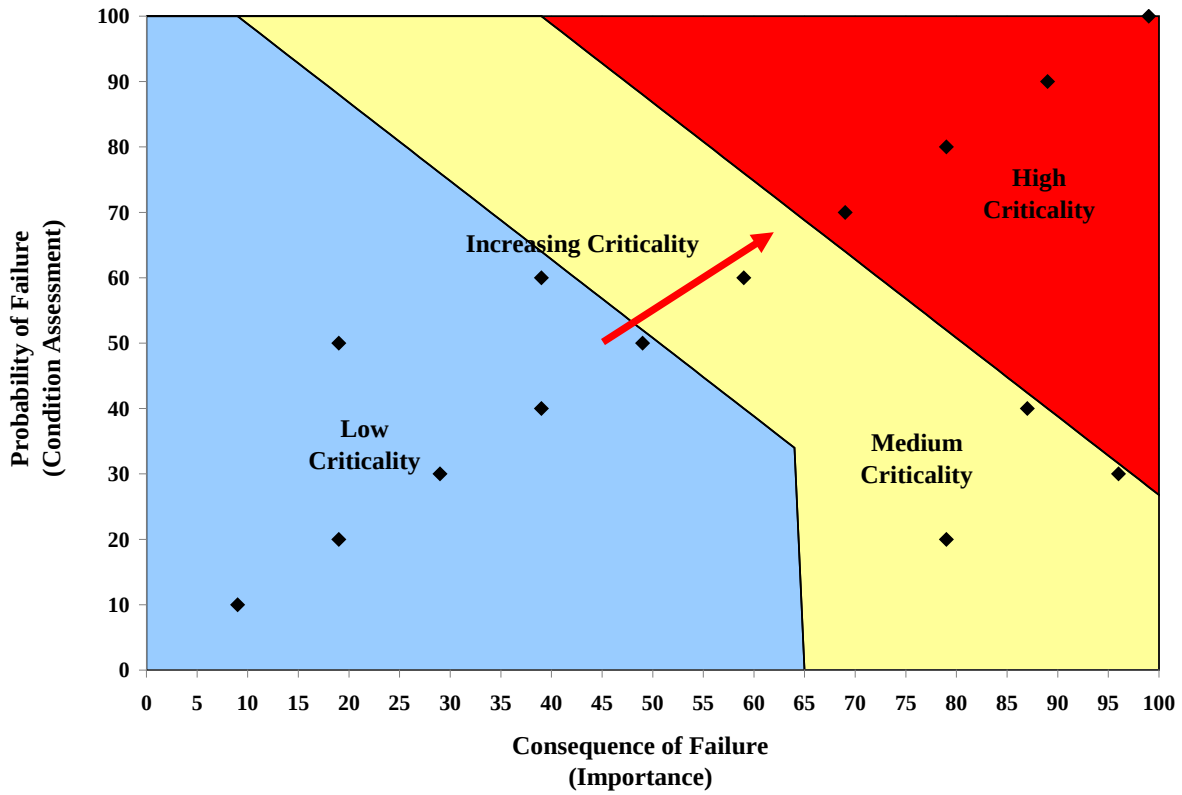
GIS – Calculated criticality and implement into future asset management activities

Engineering, Management – Commit to re-evaluate approach to criticality and improve the evaluation and decision system as additional data becomes available

DISCUSSION OF ISSUES:

Figure 2-1 depicts the theory of criticality. Criticality is the combined consideration of consequence of failure and probability of failure. As shown in Figure 2-1, the greater the probability of failure, and the more important a pipe is, the higher it will be ranked in criticality.

Figure 11-1
Criticality (Risk)



In order to calculate criticality, it is necessary to first evaluate its two individual components. Of these two components, consequence of failure and probability of failure.

Consequence of Failure

Consequence of failure is an estimate of the importance of a pipe based on the impacts that would result if the pipe were to fail. The repercussions of sudden failure can come from public perception, public safety, health concerns, and other factors. The reliability that the pipe adds to the system is also a factor that is considered in rating its consequence of failure. For example, an 8" sewer main that receives the wastewater from 3 houses is obviously not as vital to the reliability and performance of the Orem City sewer system as the 30" pipe on 1200 West that is fed by more than half of the City.

It should be noted that consequence of failure refers to the overall importance of a pipeline ***without consideration*** of its condition. In other words, if there are two pipelines that are identical in every way except that one is in excellent condition and the other is nearing failure, they will still have the same consequence of failure. For asset management purposes, pipeline condition is considered separately as "probability of failure" (to be discussed subsequently). To make wise decisions regarding pipeline maintenance, the City will obviously need to consider both consequence of failure and probability of failure. However, to make sure both issues are

considered and weighed appropriately, these concepts need to be discussed and considered separately first.

Possible Consequence of Failure Rating System

While it is easy to understand the general principle behind consequence of failure, it is much more difficult to implement a rating system to accurately represent consequence of failure. While some consequences are easy to quantify from pipe to pipe (e.g. pipeline replacement costs), most consequences of failure are much more difficult to represent quantitatively (e.g. impacts to health and safety or results of regulatory violations). Instead of trying to quantify each category of consequence, BC&A recommends using a number of easily quantifiable factors to rank the pipes. This ranking gives a relative indication of consequence of failure. Four factors are recommended to estimate the consequence of failure of a sewer pipe: the flow rate in the pipe, the category of road over the pipe, the zoning of the area, and the depth of the pipe.

Sewer Flow Rate

Flow rate in a sewer pipe is the single most important indicator of the importance of a pipe. In most situations, the higher the flow rate, the larger the area that pipe serves. Pipes that have a higher flow rate that do not service a large area still need to have a have a higher consequence of failure rating than pipes with lower flow rates. Bypass pumping cost, the risk of property damage, environmental and regulatory consequences, the cost of pipe replacement, and problems from sewage backing up in the system are all greater for larger flow rates. In a worst case scenario, if a pipe collapses or becomes blocked and the manholes surcharge resulting in wastewater flows in basements and the street, there is a greater health hazard to the public with a larger wastewater flow rate.

One approach is to use the average day flow rate, measured in MGD, as the base rating for the consequence of failure for each pipe. The other three factors that influence the rating can then be used as multipliers to adjust the sewer flow rate to produce a final rating. Table 2-1 contains a list of sample multipliers that could be assigned to each rating factor. This is not necessary a recommendation of final values that should be used by the City, but a starting point for discussion.

Table 2-1
Consequence of Failure Multipliers

Road Class	Multiplier	Zone	Multiplier	Depth	Multiplier
No Road or Residential	1	Open Space/ Industrial	1	0-12	1
Collector	1.2	Residential	1.5	12-20	1.2
Major Arterial	3	Commercial/ Institutional	1.7	20+	1.4
Freeway	10	Downtown	2.0		
Canal X-ing	5				
Rail X-ing	10				

An explanation of each classification and its possible multiplier is included in the following sections.

Road Category

There is a direct connection between the density of traffic and the cost and time associated with maintenance and repairs on sewer pipes. For the purposes of discussion, BC&A grouped streets into four major classifications: interstates, major arterials, collector streets and residential streets.

- ***Interstates*** – Interstates are assigned the highest ranking, because the cost of crossing the freeway is significantly higher than traditional pipe installation methods. The risks to property and potential social disruption impacts that may result if traffic is affected are additional impacts that are considered in this category. The proposed multiplier for the pipes under the freeway was set to be high enough to generally push these pipes into the highest level of consequence of failure. It should be noted, however, that pipes that are in a road that is associated with a freeway underpass would not receive a freeway rating. They would receive the same rating as the road in the underpass.
- ***Major arterials*** – The next classification is the major arterials. They would include State Street and other multi-lane major streets. More disruption would result from traffic control for work on these streets than streets in the other categories. The time and money associated with maintaining the pipes in these streets is fairly high.
- ***Collector Streets*** – The third classification in this category is the collector streets. These streets do not have the volume of traffic that the major arterials have, but still have more traffic than residential streets. Their multiplier is reflective of the traffic volume.
- ***Residential Streets*** – The fourth classification in this category is residential and other small streets. These streets have the smallest volume of traffic and do not add to the criticality ranking of a pipe. Pipes not located in roadways were also included in this classification.

Also included in the road category is consideration of two additional types of crossings, canal and railroad crossings with multipliers as shown in Table 2-1.

Zoning

Zoning is also a factor that impacts the consequence of failure rating. A sewer pipe in an open field will not have as large a consequence of failure as the same sized pipe located downtown or in commercial areas. For this analysis, zoning has been grouped into 4 classifications:

- ***Downtown*** – Pipes in the downtown area are more expensive and time consuming to repair and maintain due to traffic control and general city congestion. If there is an unexpected failure in downtown, there is also a higher probability that the failure will cause property damage. Public health concerns are also higher because of the higher

population density. Therefore, the weighting of the downtown zoning is higher than other areas.

- ***Commercial*** – In commercial areas of the City, the same concerns exist as documented for downtown areas, but to a lesser degree. Therefore, the commercial zoning multiplier is lower than downtown but higher than other zones.
- ***Residential*** – Residential areas do not generally have the same potential for costly impacts as do congested commercial and downtown areas. However, they do have more potential for adverse public health effects than do areas of industrial or open space zoning.
- ***Open Space and Industrial*** – Areas zoned for industrial or open space are assumed to have the least impact from a failed pipe.

Depth of Pipe

The depth of the pipe can have a significant impact on the cost of repairs and rehabilitation of sewer pipe. Extensions on backhoes, very wide trenches, possible dewatering, etc. make repairs and maintenance much more expensive and time consuming on deeper pipes. For the purpose of this analysis, the depth of pipe was grouped into 3 categories:

- ***Less than 12 feet*** – Pipes that are less than 12 feet deep can generally be maintained and repaired using standard construction techniques.
- ***12 to 20 feet*** – Once the depth of a pipeline exceeds 12 feet, repairs and maintenance begin to become more expensive and can be more time consuming. Additional equipment and special construction techniques add to the cost of working on these deep pipes.
- ***Over 20 feet*** – A pipe that is over 20 feet deep will require even more special equipment and construction techniques.

Categories for Consequence of Failure

One a system has been established, the consequence of failure can be calculated for each pipe. To avoid overcomplicating the issue, BC&A has found it prudent to divide facilities into just three consequence of failure categories (Level 1, 2, and 3 ratings). The consequence of failure is relative only to the rest of the system. The top 5 percent of the pipe ratings are identified as Level 1, the most important pipes in the system. The next 10 percent of the pipes have a consequence of failure rating 2. The rest of the pipes are rated Level 3 (remaining 85 percent of the system).

Consequence of Failure for Manholes

The consequence of failure of for manholes is directly related to the consequence of failure of its adjacent pipes. Because the purpose of manholes is to service sewer pipes, each manhole's rating can be set to match its associated sewer pipes' rating. If a manhole touches two or more pipes with different consequence of failure rating levels, the manhole rating can be set to match the highest pipe rating.

Probability of Failure

The second component of criticality is probability of failure. For the purpose of this discussion, failure is limited to consideration of loss of structural integrity. Other failure causes such as natural disasters, vandalism, or damage by contractors are not discussed in this evaluation because there is no way to predict these types of events for individual pipe segment.

Ideally, probability of failure would be defined in terms of an actual probability (i.e. a given segment of pipe has an estimated __% chance of failure in a given year). This would allow for a statistical evaluation of each pipe which would compare the expected cost of continuing without rehabilitation verses the cost of rehabilitation. Unfortunately, estimating the actual probability of failure for a sewer pipe requires an extensive data set on pipe condition and attributes and also extensive information on historic failures that have occurred. The City does not yet have this type of data available. It has been recommended that the City implement improved pipe condition assessment and subsequent tracking of pipe condition over time as part of this master plan effort; however, until this data is collected over the next several years, the City will have to use a less detailed approach to probability of failure.

Given the limited amount of pipe condition data, BC&A would propose initially establishing a structural level of service rating for each pipeline based on PACP scores to define the probability of failure for each pipeline. While this does not assign a specific probability of failure for each pipe, it does give a general indication of the condition of each pipe. In general terms, the lower the level of service rating a pipe has, the higher its probability of failure. Possible probability of failure ratings based on PACP scores are summarized below.

- **Level of Service Grade A –** The PACP structural rating does not exceed 0.35.
- **Level of Service Grade B –** The PACP structural rating falls between 0.35 and 0.5.
- **Level of Service Grade C –** The PACP structural rating falls between 0.5 and 0.65.
- **Level of Service Grade D –** The PACP structural rating falls between 0.65 and 0.8.
- **Level of Service Grade E –** The PACP structural rating falls between 0.8 and 1.0.
- **Level of Service Grade F –** The PACP structural rating exceeds 1.0.

Increasing Probability Of Failure

As additional data for the system becomes available over time, it is recommended that the City revisit probability of failure. It can then be expanded to consider additional factors, potentially including items such as H2S level, pipe age, pipe material, etc. Ultimately, it should be the goal of the City to estimate an actual probability of failure for each pipeline.

Criticality

With probability and consequence of failure defined for each pipe segment, criticality can be calculated. Given the City's current limitations in data, a good place to start would be a criticality matrix as shown in Table 2-2. Instead of using discrete data points for probability of failure and

consequence of failure, this matrix groups this information into basic level of service grades for probability of failure and consequence of failure levels. As additional information is gathered in the future, the matrix can be refined. Criticality in the matrix increases from the lower left corner to the upper right.

Table 2-2
Criticality – Recommended Actions Based on Structural Rating

Structural Level of Service	**Pipe Importance Level 3** Recommended Action	**Pipe Importance Level 2** Recommended Action	**Pipe Importance Level 1** Recommended Action
F	Mid Term Pipe Replacement / Rehabilitation Project	Short Term Pipe Replacement / Rehabilitation	Immediate Pipe Replacement / Rehabilitation
E	Short Term Inspection Schedule	Mid Term Pipe Replacement / Rehabilitation	Short Term Pipe Replacement / Rehabilitation
D	Mid Term Inspection Schedule	Short Term Inspection Schedule	Mid Term Pipe Replacement / Rehabilitation
C	Long Term Inspection Schedule	Mid Term Inspection Schedule	Short Term Inspection Schedule
B	Long Term Inspection Schedule	Mid Term Inspection Schedule	Mid Term Inspection Schedule
A	Long Term Inspection Schedule	Long Term Inspection Schedule	Mid Term Inspection Schedule

Increasing Probability of Failure

Increasing Consequence of Failure

Included in the matrix are recommended actions based on criticality. The intent of the recommended actions is to provide guidelines for the decision making process and focus resources on the assets which are most critical. The recommended actions include both inspection activities and rehabilitation activities. In both cases, the recommended schedule for the time frames listed in the table are as follows:

Immediate	0-1 year
Short Term	1-4 years
Mid Term	4-8 years
Long Term	More than 8 years

It should be noted that this matrix is only a starting point. Two things should be remembered as it is used to help develop future rehabilitation and inspection schedules:

- First, the matrix is not intended as a replacement for engineering judgment. As each pipeline is evaluated, additional issues not covered by the matrix will need to be considered by City personnel when making final rehabilitation and replacement decisions. For example, if a pipe is generally good condition, but has one isolated structural problem, its overall level of service rating may be relatively high. As a result, it may be classified as a low criticality pipeline even though the isolated problem may merit immediate attention. In these cases, it is expected that City personnel will use their judgment to increase the criticality of the pipeline and accelerate resolution of the problem. Despite this limitation, it is believed that using the matrix to augment engineering judgment will enable better asset management than relying on institutional knowledge only.

- Second, the proposed matrix has been developed using limited knowledge and information about the City's system. As additional data is collected, there is significantly more analysis the City will be able to do regarding criticality. Some sewer agencies are using the criticality information and cost data to assign a cost of failure and rating the payback of inspections and other maintenance activities. This type of analysis can provide an agency with the best operation and maintenance returns on limited budget resources. It is recommended that the City review this matrix periodically to review the recommended actions and identify possible improvements to the evaluation procedure. Ultimately, the goal of the City is to adopt best practices and maximize the use of resources in addressing system management needs.

APPENDIX E
TECH MEMO:
UNIVERSITY MALL
DEVELOPMENT EVALUATION

Bowen Collins
& Associates, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

TO: Sam Kelly, Neal Winterton
Orem City
56 North State Street
Orem, Utah 84057

FROM: Andrew McKinnon
Bowen, Collins & Associates
154 East 14000 South
Draper, Utah 84020

DATE: September 15, 2015

SUBJECT: University Mall Development Evaluation

BACKGROUND

Woodbury Corporation has proposed redeveloping the area of the University Mall. The developer has already submitted a detailed road and utility design to the City and it has been reviewed by the Orem City Development Review Committee (DRC). As part of this process, Orem City provided the DRC response dated July 07, 2015 to Bowen, Collins & Associates and has requested that BC&A review development calculations for water, sewer, and storm water to provide feedback regarding the overall impact of the development on the City's water, sewer, and storm water master plans. The purpose of this technical memorandum is to summarize these impacts.

PROPOSED DEVELOPMENT

The concept development of the property is shown in Figure 1. The developer has since developed detailed site and utility plans, but Figure 1 does a good job of summarizing the goals and location of the project.

The developer provided estimates of water and sewer demand for the proposed structures on the site (as detailed subsequently). It is unclear what standard was used for demand estimates. However, based on the demands calculated, estimates appear to be reasonably conservative (and somewhat high in some cases) for peak day and peak instantaneous water demands. Sewer production and peak instantaneous sewer production appear to be somewhat overly conservative.

Fire flow demand was stated to be 2,000 gpm. It is unclear from the DRC response whether the stated fire flow has been reviewed by the City's Fire Marshall or not. It is also unclear from the DRC response what height proposed structures on the site will be. For the purpose of this evaluation, 4,000 gpm

will be used as the required fire flow as a conservative estimate. Required fire flows should be reviewed by the City's Fire Marshall prior to approval.

BUILDOUT MODELING

To determine how the proposed development may affect City master planning for this area under buildout conditions, projected flows for the development were compared to projections in the City's master plans. Table 1 compares projections from the City's master plans to the proposed development.

Table 1
Comparison of Master Plan Requirements to Proposed Development

Critical Planning Flow	Master Plan	Development Projections	Percent Difference
New ERUs proposed as part of University Mall Redevelopment[4]	1,100	3,300	300%
Sewer Peak Instantaneous Production (gpm)[1]	404	1,341	232%
Water Fire Flow (gpm)	3,000	2,000	-33%
Water Peak Day Demand (gpm) [1]	623	1,341	115%
Water Peak Instantaneous Demand (gpm)[2]	1,121	2,414	115%
Sump Infiltration Rate (in/hour)[3]	2	4	100%

[1]Developer provided estimates of peak instantaneous sewer production and peak day demand for the initial phase of the University Mall redevelopment as part of the July 7, 2015 submittal. This included flows of approximately 845.8 gpm for peak instantaneous sewer production and peak day water demand. BC&A used developer provided unit production for similar type development for other parts of the University Mall development to estimate peak instantaneous sewer production and peak day water demand for future phases of the University Mall redevelopment.
[2]Historical flow meter data provided by the City indicates that City wide demands have a peaking factor of 1.8 for peak instantaneous demands compared to peak day demands. BC&A applied a peaking factor of 1.8 to developer provided estimates of peak day demand to calculate the peak instantaneous demand.
[3]The planning infiltration rate for new sumps and detention facilities was 2 inches/hour in the City's master plan if soil information was not available. Observed infiltration rates at several existing detention basins in Orem City were calculated to be approximately 3.3 inches/hour to 4 inches/hour.
[4]The City's estimated indoor water use per equivalent residential connection (gpd) is approximately 200 gpd based on calculations from the City's sewer master plan. Proposed nonresidential and residential development production estimates result in 650,000 gpd of additional sewer production.

Water Modeling

For the purpose of this evaluation, BC&A used a measured City-wide peaking factor of 1.8 for peak instantaneous demand for evaluation purposes. This was applied to developer provided estimate of peak day demand to estimate the impact of water demands on the system. In addition, a fire flow of 4,000 gpm was evaluated for peak day demands because no information was provided on building construction type or heights. Table 2 summarizes the range of pressures and flows available to the development based on the pipe diameters indicated in Figure 2.

Table 2
Available Fire Flow and Pressures For Buildout Conditions

Location[1]	Peak Instantaneous Demand Pressure without Fire Flow[2] (psi)	Peak Day Demand Pressure (static) Before Fire Flow (psi)	Fire-Flow Demand (gpm)	Residual Pressure at Fire Flow (psi)	Available Flow at 20 psi[3] (gpm)
Minimum	67	73	4,000	60	8,000
Maximum	70	77	4,000	73	8,000

[1] – The location for pressures indicated varies, but only refers to available pressures and flows at the main distribution line in front of buildings. Actual pressures at connections to buildings will depend on the size and length of lateral connections. Available pressure and flow at the top of proposed structures will also vary depending on building height.
[2] – Orem City's desired criteria requires at least 50 psi of pressure in the water main during peak instantaneous demand.
[3] – The State of Utah and the Orem City fire marshal require the system to satisfy required fire flow demands with a minimum residual pressure of 20 psi in the main. Note that more than one hydrant or a pumped fire connection would be required to produce the available flow shown.

Based on estimated demands, there is adequate pressure and flow at proposed distribution mains around the building. This is primarily a function of the 16-inch diameter main to the south of the University Mall. Most flow for the development is carried by this pipe. No information regarding building height was provided. Available pressure and flow at the top of structures should be evaluated prior to finalizing pipe diameters.

Sewer Modeling

The developer provided peak instantaneous sewer production numbers for the initial phase of the University Mall redevelopment project (up to 846 gpm). For reference purposes, the DRC Reponse for July 7, 2015 will be referred to as Phase 1 of University Mall redevelopment. Based on the provided values, peak instantaneous production appears to be relatively conservative and was used for evaluation of development sewer collection pipes. BC&A used developer provided peak production estimates to project potential flow from remaining portions of the University Mall redevelopment project. Based on developer provided calculations, peak instantaneous sewer production for the University Mall redevelopment are significantly higher than estimates in the City's sewer master plan. These peak instantaneous flows were simulated in the City's buildout sewer model and resulted in deficiencies along long reaches of the 1200 South sewer trunk line (up to 9,000 feet) as a result of the relatively aggressive projections of production and peaking factors used by the developer's engineer.

Using a recent sewer production study for a sewer district in Salt Lake County, revised sewer production values were estimated by BC&A to assess the potential effects of University Mall redevelopment. A comparison of estimated equivalent residential units for buildings proposed as part of University Mall is listed in Table 3.

Table 3
Proposed Buildings and Associated Equivalent Residential Units (ERUs)

Building	Description	Size (SF/Units)	Developer Projection of ERUs	Revised Master Plan Projection of ERUs
Hotel	Hotel	120	75	36
Office R	Office	30,000	15	8
Retail O	Retail	9,088	5	1
Office AA	Office	100,000	50	25
Office P	Office	208,295	104	52
Retail P	Retail	6,944	3	1
Residential AA	Residential	500	500	400
Office BB	Office	100,000	50	25
Retail BB	Retail	20,000	10	3
Restaurant BB	Restaurant	10,000	50	20
EM11	Shopping Center (Retail/Restaurant)	8,778	9	6
EM9	Shopping Center (Retail/Restaurant)	25,741	26	17
EM5	Shopping Center (Retail/Restaurant)	76,719	77	51
EM5 Office	Office	2,544	1	1
EM3	Shopping Center (Retail/Restaurant)	26,441	26	18
EM2	Shopping Center (Retail/Restaurant)	21,349	21	14
Inflow L (North of Macys)	Residential	41	123	41
Inflow L (North of Macys)	Restaurant	20,000	100	41
Inflow L (North of Macys)	Retail	175,000	88	27
Retail A	Retail	18,000	9	3
Retail C	Retail	6,000	3	1
Ex Macys	Retail	207,537	104	32
Retail Q	Retail	15,000	8	2
Office Q	Office	200,000	100	50
Residential	Residential	125	125	100
Residential	Residential	125	125	100
Residential	Residential	125	125	100
Residential	Residential	125	125	100
Theatre	Retail	66,193	33	10
Residential	Residential	450	450	360
Residential	Residential	578	578	462
EM11	Shopping Center (Retail/Restaurant)	154,762	155	103
Total			**3,272**	**2,273**

Orem City personnel considered the peaking factors used by the developer's engineer to be appropriate for local pipe sizing. However, for the City's sewer trunk line, developer calculations may be overly conservative because the effects of multiple production patterns and attenuation should be considered. For City trunk lines, the revised master plan projections listed in Table 3 will be used to evaluate the capacity of City trunk lines.

Table 4 summarizes flows for the portion of the development evaluated by the developer's engineer along with buildings and required pipe sizes.

Table 4
Peak Production in Sewer Mains for Phase 1
and Required Sewer Main Size

Pad	Developer Estimate of Peak Instantaneous Production at Building (gpm)	Developer Estimate of Peak Instantaneous Production Into Sewer Main (gpm)	Required Pipe Size (in) and Slope
Hotel	41.67	41.67	8" @0.4%
Office R	5.21	46.88	8" @0.4%
Retail O	1.58	48.45	8" @0.4%
Office AA	17.36	65.81	8" @0.4%
Office P	36.16	101.98	8" @0.4%
Retail P	1.21	103.18	8" @0.4%
Theater w/ Expansion	32.39	32.39	8" @0.4%
Aston Court Portion	85.33	117.72	8" @0.4%
Residential AA	277.78	395.50	10" @0.4%
Office BB	17.36	516.04	12" @0.38%
Retail BB	3.47	519.52	12" @0.38%
Restaurant BB	27.78	547.29	12" @0.38%
EM11	3.66	550.95	12" @0.38%
EM9	10.73	561.68	12" @0.38%
EM5	31.97	593.64	12" @0.38%
EM5 Office	0.44	594.08	12" @0.38%
EM3	11.02	605.10	12" @0.38%
EM2	8.90	614.00	12" @0.4%
Inflow L (North of Macys)	68.33	68.33	8" @0.59%
Inflow L (North of Macys)	55.56	123.89	8" @0.59%
Inflow L (North of Macys)	30.38	154.27	8" @0.59%
Retail A	3.13	157.40	8" @0.59%
Retail C	1.04	772.43	12" @0.54%
Ex Macys	36.03	808.46	12" @0.54%
Retail Q	2.60	811.07	12" @0.49%
Office Q	34.72	845.79	15" @0.49%

Based on model results for the system, redevelopment at the University Mall will result in two required projects:

1. **Modification to Developer Improvements –** Flow for pipes with stationing 300+00 to 303+69 (in drawing C3.0) do not consider existing flows in the sewer main that will be collected nor some potential redevelopment elsewhere in the University Mall area. Based

on existing flows and projected growth, the pipes between 300+00 to 303+69 should be 10-inch.

2. **1200 South Pipeline Replacement –** The City's existing sewer trunk line along 1200 South ranges in pipe size from 12-inch to 15-inch with slopes as flat at 0.6% with an average slope of 3%. Based on the existing trunk line size, Project SS6 from the City's sewer master plan will need to be extended by approximately 500 feet as shown in Figure 3.
3. **Future Development Phases –** If possible, it is recommended that future phases of redevelopment direct flow north to 800 South to utilize available capacity in the 800 South sewer main. Local improvements may be needed to accommodate high density growth and future phases of redevelopment could affect the timing of Project SS10 if redevelopment is directed to 800 South.

Storm Water Modeling

The University Mall redevelopment projects lies within an area where sumps are appropriate according to the City's storm water master plan. Sumps should be used to detain and infiltrate all of the 10-year storm event. Based on the soil reports provided by the developer's engineer, it appears that the infiltration rate for the area will be appropriate to use sumps. However, it should be noted that the City's storm water master plan requires that any event above the 10-year storm event must be capable of being conveyed away from private properties without causing any damage. Low points identified for sumps in the developers utility plan should therefore be equipped with overflows as needed to avoid damaging property. For example, the maximum depth for storm water should not exceed 12-inches for areas with vehicles to avoid damaging property. BC&A did not perform a thorough review of the site grading plan, but this should be considered for sumps at low points on the site.

SHORT-TERM MODELING

Because the City's buildout model includes master plan level improvements to accommodate buildout demands, the impact of critical planning flows on existing facilities also needs to be evaluated.

Water Modeling

Projected peak demands for the development were added to the existing scenario in the City's water model. Table 5 summarizes model results.

Table 5
Available Fire Flow and Pressures For Existing Conditions

Location[1]	Peak Instantaneous Demand Pressure without Fire Flow[2] (psi)	Peak Day Demand Pressure (static) Before Fire Flow (psi)	Fire-Flow Demand (gpm)	Residual Pressure at Fire Flow (psi)	Available Flow at 20 psi[3] (gpm)
Minimum	69	75	4,000	61	8,000
Maximum	71	85	4,000	74	8,000

[1] – The location for pressures indicated varies, but only refers to available pressures and flows at the main distribution line in front of buildings. Actual pressures at connections to buildings will depend on the size and length of lateral connections. Available pressure and flow at the top of proposed structures will also vary depending on building height.
[2] – Orem City's desired criteria requires at least 50 psi of pressure in the water main during peak instantaneous demand.
[3] – The State of Utah and the Orem City fire marshal require the system to satisfy required fire flow demands with a minimum residual pressure of 20 psi in the main. Note that more than one hydrant or a pumped fire connection would be required to produce the available flow shown.

As with flows at buildout, it does not appear that proposed redevelopment at the University Mall will result in any water system deficiencies. Again, no information regarding building height was provided. Available pressure and flow at the top of structures should be evaluated prior to finalizing pipe diameters.

Sewer Modeling

Developer estimates of timing indicate that structures in Table 3 may be constructed as early as 2017. Based on flow monitoring conducted in July 2010 and estimated sewer production for 2014, the available capacity of the 1200 South sewer trunk was evaluated to determine how many equivalent residential units may be developed before any sewer trunk line improvements will need to be completed. Table 5 summarizes available ERUs that may be constructed before the improvements along 1200 South must be constructed.

Table 5
Available ERUs for Phases of University Mall Redevelopment

Construction Phasing	Flow (gpm)	ERUs
Available Capacity in 1200 South	585	2,000
Proposed Phase 1 Development*	432	1,556
Existing University Mall Development to be Demolished	24	85
Remaining 1200 South Capacity	177	529

*includes development listed in Table 3 with an estimate of 200gpd/ERU

Based on the number of ERUs proposed as part of Phase 1, it would appear that Phase 1 of the development can be constructed without exceeding the capacity of existing pipes. However, because of the relatively high projections of flow submitted by the developer, it is recommended that the City conduct flow monitoring at 815 West College Drive in the near future to verify available capacity for

existing conditions. It may also be useful to flow monitor at 1200 South 475 East to assess sewer flows as redevelopment occurs.

Redevelopment at the University Mall is not anticipated to affect the timing of Project SS7.

Storm Water Modeling

The proposed development will not affect the timing of any storm drain master plan projects.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be made based on the evaluation performed for this technical memorandum:

- Buildout Modeling – Developer calculations for indoor demands use relatively conservative assumptions. Based on those assumptions, the following conclusions can be made regarding building infrastructure:
    - Water – No changes have been identified to developer proposed pipe sizes based on available data. No data was provided for building heights. Available pressures and flows for buildings will therefore need to be evaluated before approval.
    - Sewer – Approximately 500 ft more sewer main on 1200 South will need to be replaced as a result of University Mall redevelopment as compared to the City's sewer master plan. The additional length could potentially be mitigated by directing more redevelopment flow north to 800 South, but will depend on the timing of growth and available capacity of existing 8-inch mains in 800 South.
    - Storm Water – No changes will be required for the storm water system at buildout.
- Short-Term Modeling – Replacement of the sewer pipeline in 1200 South is not required for Phase 1 of the University Mall redevelopment, but may be required before any subsequent redevelopment phases can proceed. All of the Phase 1 buildings in Table 3 may be completed as early as 2017. All of the University Mall redevelopment is projected to be completed by 2025. As a result, no change in the anticipated timing of SS6 is anticipated as a result of Phase 1.
- Flow Monitoring – It is recommended that the City conduct flow monitoring at 875 West College Drive in the near future to verify existing flows and confirm how much remaining capacity there is in the 1200 South sewer trunk line. This will assist in determining the required timing of Project SS6. Occasional flow monitoring at 1200 South 475 East will help assess the effects of growth on sewer production as a result of redevelopment and will help to assess the accuracy of sewer production projections.

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