PRESSURE ZONES ANALYSIS FOR JUB ENGINEERS

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EXECUTIVE SUMMARY

The Pressure Zones Analysis by MaRS Engineers presents the findings and recommendations of a study of possible sites for a future culinary water tank. J-U-B Engineers commissioned the study to the BYU Capstone committee to evaluate potential sites for a culinary storage tank and the effect on existing pressure zones.

The design standards were set by J-U-B Engineers in their report to Lindon city, "Lindon City: 2015 Culinary Water System Master Plan and Capital Facilities Plan." The total max day demand anticipated for the city by the year 2024 is 3,138 gpm with an average day demand of 1,687 gpm (peaking factor set as 1.86). Focus areas for the new culinary tank were land owned by Lindon city and the expansion of the existing 0.5 million gallon (MG) tank to a 1.38 MG. A map including all tested locations is found in the Appendices.

Repeated analysis led to the discovery of a water loop between the three main tanks, which significantly reduced their ability to supply the lower zones. It is recommended that the connection of the 18" drain pipe (from the 0.5 MG and 1.0 MG tanks) to the main water line on center street at 700 E be moved to 400 E. The success of every location is dependent on this extension and its cost, about $460,000, is included in the cost estimate of each successfully tested location. The following table summarizes the successful tests, with a tank located at Sumac Hollow as the recommended location.

Table 1: Successful Tests

TESTS						
Test Locations	**Provide Zones**	**Status**	**Initial Cost**	**Yearly Cost**	**Supplemental Notes**	**Tested Designs**
1) Sumac Hollow	1, 2, 3	Pass	$ 2,282,000	$ 137,900	Inefficient at Low Demands	2
2) Expansion of Tank	1, 2, 3, 4	Pass	$ 2,556,000	$ 137,200	Inefficient at Low Demands	2
3) Oak Canyon J. High	1	Pass	$ 4,414,000	$ 132,800	Inefficient at Low Demands	2
4) City Center Park	1	Pass	$ 4,346,000	$ 138,100	Requires High Water Tower	4

A tank located at Sumac Hollow was found to be surprisingly effective. The location is in an undeveloped area and would have minimum environmental issues. It would require 1200 ft. of 18" pipe to connect it to a main line. As shown in Table 1, the initial cost is over $250,000 less than the second recommended design. The yearly cost is a few hundred dollars more; however, it would take well over the life span of Lindon's water system before the yearly cost exceeds the initial savings. As such, the new tank at Sumac Hollow is the recommended model.

CULINARY WATER SYSTEM UPGRADE PLAN

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INTRODUCTION

Purpose

This document is intended to present MaRS engineers' recommended plan for the location of a new culinary tank in Lindon city. It discusses the City's current culinary water system, as well as the advantages and disadvantages of different plausible locations for the new tank. The conclusions are based on available land, immediate costs, future costs, and the use of a computer model EPA Net, with system input data provided by J-U-B Engineering.

Scope

This report discusses the water model used for analysis, the analysis approach, and summarizes the results and costs associated with each tank location option. Background

Lindon’s culinary water originates from four wells spread throughout the city, with an additional amount from a mountain spring. This water is stored in four culinary tanks in three locations within the city. An analysis by J-U-B of the city's future culinary needs recommends a minimum of 0.88 million gallons (MG) of additional storage by the year 2024.

In J-U-B's report to the city, "Lindon City: 2015 Culinary Water System Master Plan and Capital Facilities Plan", their recommendation for providing this additional storage was to upsize the 0.5 MG tank to a 1.38 MG tank. J-U-B commissioned this study to examine other possible locations for storage that would reduce energy loss in the culinary system while not negatively affecting the pressure zones. The analysis model provided by J-U-B contained all the wells and water demands anticipated by the year 2024. The main purpose of MaRS Engineers was to use the provided model to assess and analyze possible locations for a future tank and its effect on the current pressure zones.

Objectives

The objectives of the analysis are listed below:

1. Obtain information for possible locations for a new culinary tank.
2. Model the locations in EPA Net with at-buildout parameters.
3. Adjust the new system as needed to meet standards of pressure and flow.
4. Estimate cost of the new systems.
5. Rate each system based on their cost and feasibility.
6. Make recommendations for the most viable option.

APPROACH

Existing Conditions

A map of the culinary water system of Lindon in 2015 is provided in the Appendices. The system currently has six pressure zones, four wells and four culinary tanks. The wells provide the bulk of the water for Lindon apart from a spring that feeds into the Canberra tank.

The data used to perform analysis was provided by J-U-B. Their data was based on 2014's calendar year actual water use data and locations, as well as the used tank and well supervisory control and data acquisition (SCADA) data for their evaluations. J-U-B analyzed the existing culinary system with this data and a complete description of their process can be found in their report "Lindon City: 2015 Culinary Water System Master Plan and Capital Facilities Plan" to the city.

Levels of Service

Demand

The total max day demand anticipated for Lindon in 2024 is 3,138 gpm, with an average day demand of 1,687 gpm and daily peaking factor of 1.86.

Pressure

As per discussion with J-U-B, the required pressure for the city for average days is between 50 psi and 150 psi. However, the minimum value may be waived based on certain conditions consistent with the Utah Administrative Code Section 309-105-09, Minimum Water Pressure requirements. The levels of service required for analysis are listed here:

a. Minimum of 20 psi with fire flow during peak day demand
b. Minimum of 30 psi during peak instantaneous demand
c. Minimum of 40 psi during peak day demand

Storage

Code requires that fire suppression storage no less than 120,000 be available unless a local fire authority decides otherwise. Based on the expertise of the local fire authority for Lindon, the amount of fire suppression storage should equal 4,500 gpm for 3 hours, which accumulates to 810,000 gallons.

Due to communication between J-U-B and the Lindon City staff, other emergency storage should be provided for 12 hours of average day demand, which amounts to 782,000 gallons.

Fire flow

While maintaining 20 psi system-wide during fire flow, the system must also provide the following minimum requirements:

a. 1,000 gpm per minute in temporary and permanent dead end lines in residential zones
b. 1,500 gpm in residential zones
c. 2,000 gpm in commercial and industrial zones

Tank Locations

A focus for MaRS was to find locations that would 1) reduce energy loss in the system by providing storage at a lower elevation and 2) reduce the need for PRV's. A working model of any of these locations would result in long-term savings for Lindon city.

To save Lindon city the expense of purchasing new property, the first models focused on placing tanks in parks. The elevation of each location was determined through the webpage Free Map Tools – Elevation Finder. These elevations were compared with the ones in J-U-B's model and verified to be accurate.

The existing PRV's reduce the pressure in the system to about 80 psi. Using a simple conversion of pressure (psi) to head (ft.), with 80 psi as our pressure standard, we determined that a tank needed to be elevated at least 185 ft. above its connection to the main lines directly below a PRV. Figures A 1 in Appendix A shows a contour map of Lindon city and A 2 shows the approximate line above which a tank must be located to gain enough head. The line is located at an elevation 185 ft. above the last pressure zone, which locates most of the tested locations in pressure Zone 4. Parks low in elevation (throughout Zone 1) were avoided since they cannot create enough head to be beneficial without a pump or water tower.

After most of the available locations in Zone 4 were tested, we decided be creative and try to make locations in Zone 2 work, despite their need for pumps or water towers. A brief overview of these tests is mentioned in the section "Other Preliminary Tests."

Modeling

A model in EPANET was provided by J-U-B of Lindon's culinary water distribution. It included some of the future improvements (such as upgrading well #3 to 1900 gpm) to the existing system and was fit to analyze the future needs of Lindon city at the time of buildout. The model had the peak daily factor set as 1.86. This factor was used as per their instruction with the assumption it would not significantly change after buildout.

The models analyzed are modified versions of the original J-U-B model. Each copy embodies a different location and all changes necessary to make the culinary system operable. Efforts were initially concentrated on areas other than J-U-B's recommendation to the city of expanding the 0.5 MG tank. However, this area was also tested to compare it with other options.

The success of a model depended on its ability to meet the levels of service mentioned above for the 1.86 peak factor. To ensure the system would work indefinitely, locations were tested at a minimum of 200 hours to receive clear signs of sustainability.

FUTURE CULINARY WATER SYSTEM AT BUILDOUT OPTIONS

Overview

A review of the tested models and their associated costs are found in the following sections. The models are placed in the order of options found most favorable for Lindon.

Repeated trial and error in analysis led to the discovery of a loop in the water path of a few main lines. The existing 0.5 MG and 1.0 MG tanks empty into a pipeline used to refill the 2 MG tank and supply the upper zone. The water then descends down to refill the 0.5 MG and 1.0 MG tanks. This means the 0.5 and 1.0 MG tanks are not actually fulfilling their purpose in providing for the lower zones but are kept in a loop of providing water for the upper zones and being refilled by the 2 MG tank. To resolve this issue, we found it was necessary to extend the connection point of the 0.5 MG and 1.0 MG tanks on Center street from 700 E and 400 E. This provided an access point where the water wouldn't be immediately transferred back up to the upper zones. Because of the necessity of this extension to make any model work, it is included in and recommended for each model. This cost is also included in each model as it was necessary for the success of every tank as recorded in Table 2.

Table 2: Total Completed Tests

TESTS						
Test Locations	**Provide Zones**	**Status**	**Initial Cost**	**Yearly Cost**	**Supplemental Notes**	**Tested Designs**
1) Sumac Hollow	1, 2, 3	Pass	$ 2,282,000	$ 137,900	Inefficient at Low Demands	2
2) Expansion of Tank	1, 2, 3, 4	Pass	$ 2,556,000	$ 137,200	Inefficient at Low Demands	2
3) Oak Canyon J. High	1	Pass	$ 4,414,000	$ 132,800	Inefficient at Low Demands	2
4) City Center Park	1	Pass	$ 4,346,000	$ 138,100	Requires High Water Tower	4
Murdock Canal Trail Head	1	Fail	N/A	N/A	Pump Failure - Neg Pressure	4
Squaw Hollow Park	1, 2	Fail	N/A	N/A	Pump Failure - Neg Pressure	2
Pioneer Park	1	Fail	N/A	N/A	Insufficient Head	1
Hollow Park	1	Fail	N/A	N/A	Pump Failure - Neg Pressure	4
Fryer Park	1	Fail	N/A	N/A	Feeds N. Area - Pump Failure	2

Energy (operating) costs were also calculated for each model that tested successfully. Due to the archaic nature of the modeling system, the only energy costs tabulated are for pumps, whereas PRV's and other monitoring systems are not included. Energy costs were based on the averages for commercial use energy found on Rocky Mountain Power's webpage and another webpage known as Electricity Local that adjusts the cost per city.

Field Near Sumac Hollow

Because of its low upfront cost, the field near Sumac Hollow is our first recommended location for a new tank. The field is a little over 23 acres but about a 1/3 of an acre would be required. The tank would connect to the existing 18” pipe that drains the 1.0 MG and 0.5 MG tanks. A single pipeline would be used to both fill and empty the new tank. The new tank would be approximately 109 ft. in diameter and 15 ft. in height. Figure 1 shows the model used for this design.

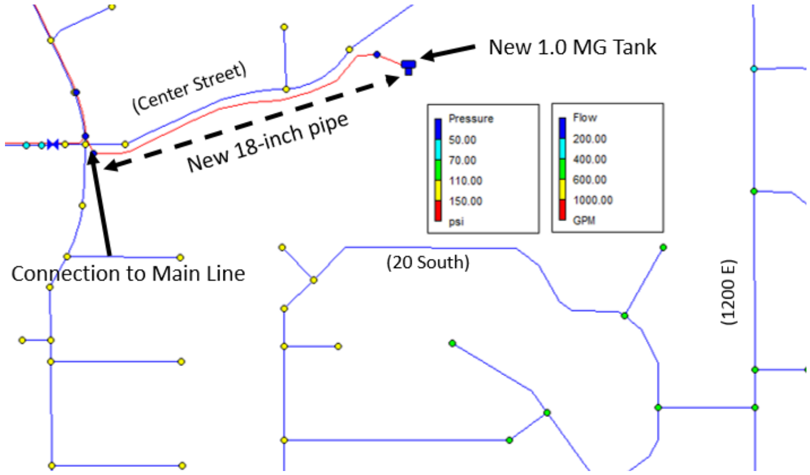

Figure 1 – Field Near Sumac Hollow Model

The main advantage of this option is its cost. Because the tank is only a million gallons, it would be cheaper than upgrading another tank to an even larger size. The connection point to a main line is relatively close and allows for less new pipe and cheaper installation than other locations. The anticipated cost of this tank is $2,282,000, which includes: the new tank, the pipe to connect it to the main line, and the extended line from 700 E to 400 E as mentioned previously. The total cost of the 23.3 acres, found through a parcel map of Lindon online, was found to be $701,100, which implies each acre is worth about $30,000. The tank is anticipated to only occupy 1/3 of an acre, which implies the cost of the acquired land would be only $9,000.

Another advantage of this tank is that it provides more storage redundancy for Lindon. If the 0.5 MG and 1.0 MG tanks were ever to go offline the new 1.0 MG tank would be conveniently linked to the same line and could cover the same zones.

Some potential disadvantages with this tank are its slightly higher energy costs and eventual maintenance costs. In order to minimize energy loss, the tank would need to be excavated 10-15ft to bring its energy cost to approximately $137,900 a year. If the tank was not excavated the energy cost would be about $30,000 more each year.

0.5 MG Expansion

The 0.5 MG tank expansion focuses on expanding the 0.5 MG tank to a 1.38 MG tank. The existing 0.5 MG tank is in a park on 835 E near 300 N, next to a 1.0 MG tank. These tanks receive their water from several wells and empty into the 18" main line along Center street at about 400 E. Contents from this tank are pumped up to the 2.0 MG tank as needed to supply the Canberra zone. The new tank would be approximately 128 ft. in diameter and 15 ft. in height. Figure 2 shows the model used for this design.

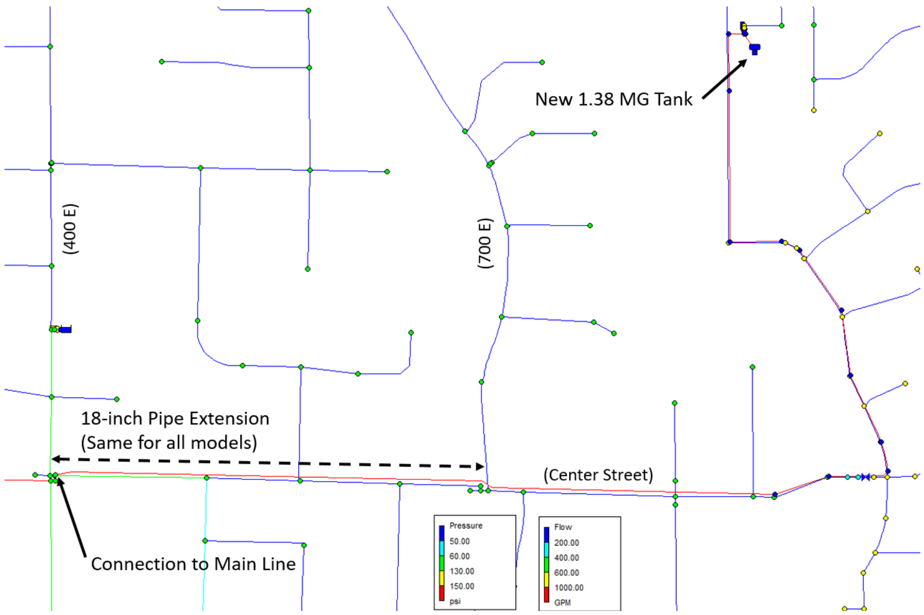

Figure 2 – 0.5 MG Expansion Model

The advantages of this option are the cost and simplicity of it. The land is already owned by Lindon and there is enough space available for the expansion – see the appendices for the approximate size of the new tank in comparison to the existing. There is also no need for major modifications to the existing culinary system and only a 3-block extension of the 18" pipe is required. This results in less interference with the public's day-to-day activities from less construction. The cost is relatively cheap compared to extensive piping and land acquirement required for a new tank in a new area.

This tank would cost more than the Sumac Hollow design because it requires the removal of an existing tank and would have a larger tank (1.38 MG) installed. This tank would cost about $270,000 more than the Sumac Hollow design, which is why it is not our first recommended option.

Oak Canyon Junior High Field

This tested location is the soccer field of Oak Canyon Junior High. The tank itself would not be taking the place of a soccer field; rather it would be between a field and the road 2000 N. The expected cost of this tank is $4,414,000, which includes the tank and the extension of the 18" pipe mentioned before. It would be buried as to not interfere with any school activities and would not overlap with any of the soccer fields.

The tank would be 109 ft. in diameter and 15 ft. tall giving it a total capacity of 1.0 MG that is fed directly from the Central Park pump. However, it would require about 15,010 ft. of 12" pipe, which would bring up the cost significantly. Figure 3 shows the model used for this design.

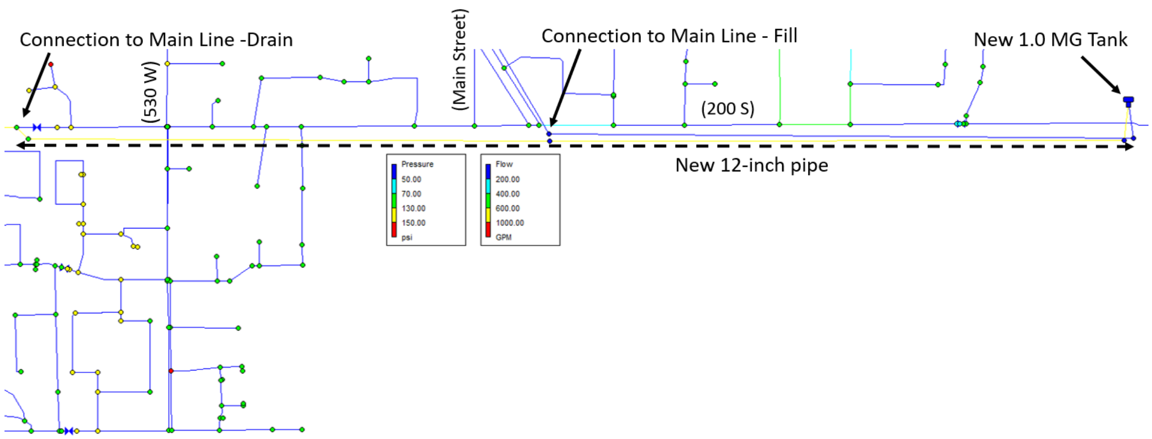

Figure 3 – Oak Canyon Junior High Field Model

This tank offers only few advantages, one being that much of the property in that area is unused and could be utilized for the city. Another slight advantage is that this tank is expected to reduce facility costs as compared to the other options by a few thousand dollars a year.

However, because it would take up school property and would require a lot of new piping it is not a recommended location. The land is currently owned by the school district and it is likely that this land would be difficult to purchase.

City Center Park Tower

A tower located in City Center Park, in Zone 1, was considered to reduce extensive pipe layout. The tower would be located on the SE side of the park and just NE of the water park. The tank would be 30 ft. in height with a 50 ft. diameter, while the tower itself is 100 ft. high. Even with the initial cost of the tower this design was predicted to be over $130,000 cheaper than the tank at Oak Canyon Junior High. However, the yearly cost would be greater than the expanded tank. Figure 4 shows the model used for this design.

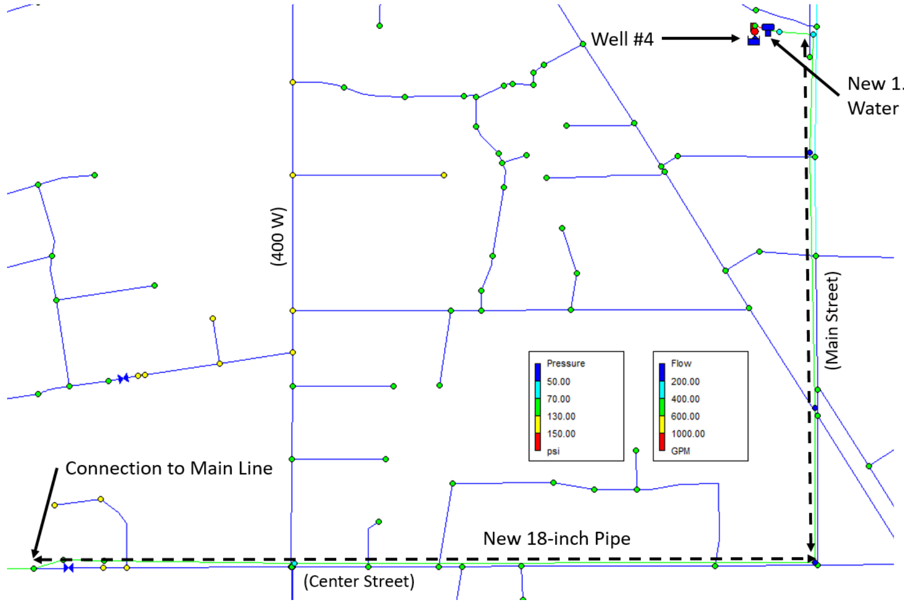

Figure 4 – City Center Park Tower Model

An advantage this tank could offer would be its proximity to well #4, which directly feeds into the tower. This would greatly reduce the need for new piping compared to other tank locations. Another advantage is that the initial buildout cost is $68,000 cheaper than the Oak Canyon Jr. High tank, as well as the land is used for the well and is located in park and no new land acquirement would be needed.

However, it should be noted that the tower would be visually unappealing to the residents and the water park nearby due to its height and visual obstruction. This would create public opposition that could hamper the building of the tower. The tower is also much more expensive initially than other recommended locations.

Other Preliminary Tests

The appendices contain a map of all locations with a tested model. No other models have met the required levels of service. The current models all have the same or similar problems, which are summarized below:

1. The 2 MG tank drains quicker than it can be filled, which results in negative pressures in the Canberra pressure zone
2. A lack of elevation usually requires a pipeline that must either extend past the existing PRVs an extensive distance or a pump must be installed to increase its pressure sufficiently
3. Well #4 adds considerable pressure to the lower zone, causing it to exceed the limit of 150 psi static pressure

To resolve these issues, MaRS has attempted adding a pump for each prospective tank to assist their ability to contribute to the zones, but this usually results in higher pressures or prove ineffective in filling the upper tank. However, the pressure issues of the middle zone would remain.

Test Failures in Northern Lindon

There are a significant number of parks and other locations in the Northern part of Lindon that are desirable locations but failed. Each of these locations fed into the upper regions of Zone 1 causing well #3 to fail due to lack of head. This is caused by well #3 which feeds into the northern part of Zone 1, causing a higher flow in that region.

Various tests were concluded to be improbable if they fed into the northern region of Zone 1. As such, tests were performed to resolve the issue by adding additional pipelines to drain into the lower southern regions of Zone 1. However, this caused a significant increase in cost and the tests at these locations were halted due to the inflation of initial cost.

Wells Feeding Directly to a Tank

It was determined early on that the culinary water system in Lindon is relatively inefficient as the wells pump past several PRVs to reach the northern water tanks. To resolve this issue, each well was tested by diverting its feed directly to a new tank at various locations. This was also done to well #3 in hopes that the flows would not conflict. However, it was concluded that well #4 is the only one that can have its flow diverted directly to a new tank and not amplify the drainage of the upper water tanks.

CONCLUSION AND RECOMMENDATIONS

The recommended location for a storage tank is the development near Sumac Hollow. This was determined by the cost comparisons of the successful tank locations as shown in Table 3.

Table 3: Recommended Tank Designs

TESTS						
Test Locations	**Provide Zones**	**Status**	**Initial Cost**	**Yearly Cost**	**Supplemental Notes**	**Tested Designs**
1) Sumac Hollow	1, 2, 3	Pass	$ 2,282,000	$ 137,900	Inefficient at Low Demands	2
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3) Oak Canyon J. High	1	Pass	$ 4,414,000	$ 132,800	Inefficient at Low Demands	2
4) City Center Park	1	Pass	$ 4,346,000	$ 138,100	Requires High Water Tower	4

The Sumac Hollow design does not require any pumps and allows Lindon to fulfill their water need without significant new construction. Because this tank would share a pipeline with the 0.5 MG and 1.0 MG tanks there is increased redundancy to supply the lower zones. If the above tanks ever became offline, the new tank would be able to cover the zones below until the upper tanks became online. The pump above would be able to deliver water to the upper zones because it is on the same line as the other two tanks. The tank would also be in a convenient location where future growth is expected and could be planned for in the development. If desired, the tank has the ability to be buried in the ground so as not to be publicly visible and increase its energy efficiency. The estimated cost is $ 2,282,000, which includes the new tank installment and the extension of the 18" pipeline.

The extension of the 18” pipeline from 700 E to 400 E is highly recommended because it was critical to the success of every model, and would eliminate future problems for Lindon city. This extension alone provided the following solutions to issues we had with the model:

1. Provides more head for the 0.5 MG and 1.0 MG tanks to supply the lower zones, even during times of high pressure
2. Reduces the use for Well #4, which over pressurizes the system if left on too long
3. Reduces all other pump use because the tanks are being utilized
4. Enables the 2.0 MG tank to be refilled instead of only drain
5. The model does not fail due to negative pressures

The cost of the extension itself adds about $460,000 to every suggested design but is considered in every case a necessary component of the design. This estimate may be conservative however, and further exploration into the matter may reveal a cheaper cost for an equally quality system. Unfortunately, any savings in energy would not be sufficient to make up for the initial cost.

LESSONS LEARNED

Many lessons were learned through this capstone experience about team projects. One lesson is of the reality of different skill sets among the team members. One member had some experience with piping and water structures and was able to figure out the EPANet program at a very fast rate. When other team members struggled with their model for several hours, this individual was able to figure out the problem in minutes. Another team member was good at writing and research and excelled when it came to compiling and editing reports. We found that it was useful to utilize these skillsets by having each team member manage a portion of the project. These team members were in charge of reviewing the final product related to their skillset and spent most of their time in those areas most applicable to them. This allowed the quality of the project to increase and shorted the amount of time needed. However, each team member was given the opportunity to contribute to every aspect of the project to ensure everyone experienced something new.

We also re-learned the importance of communicating within a team. One difficulty we had was ensuring all team members were on the same page about some facet of the project. It was not uncommon for one team member to learn something new but not share the information with everyone else. Some team members had difficulty in just communicating in general; they didn't forewarn they weren't going to be at meetings, didn't respond to texts or calls, and sometimes took weeks until they finally explained what they had accomplished on their tasks. From these experiences we learned the importance of communicating as progress of the project depends heavily on this ability.

For two of the three team members a project involving water was something entirely new. One team member was enrolled in their first water class when the project was assigned in October, and another was currently taking a hydraulics class. This created a great learning opportunity for all the team members as we learned and taught each other how the system works. Additionally each member learned how to utilize EPA Net in modeling water systems and was able to contribute to the project.

APPENDIX A

MAP

Figure A 1 – Preliminary Contour Map of Lindon with Pipes, Tanks, and Wells

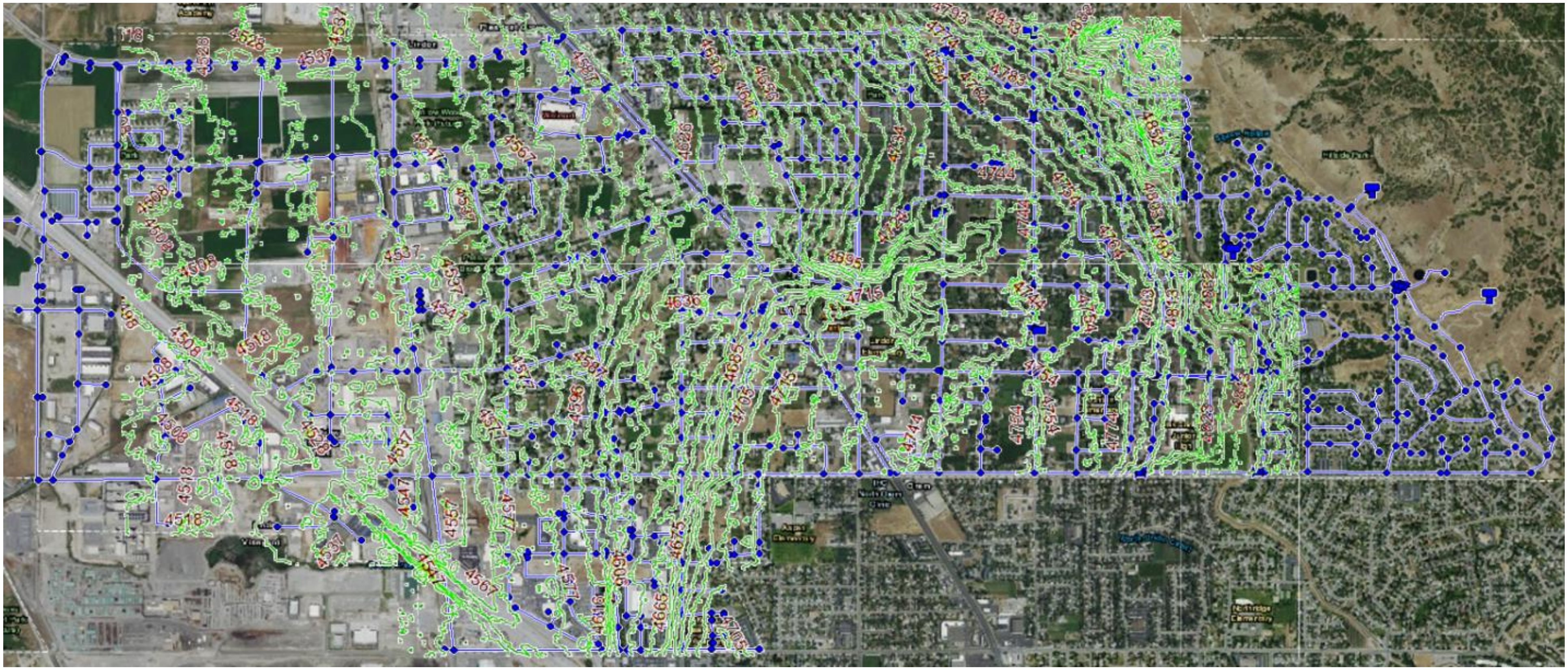


Figure A 2 - Preliminary Tested Locations

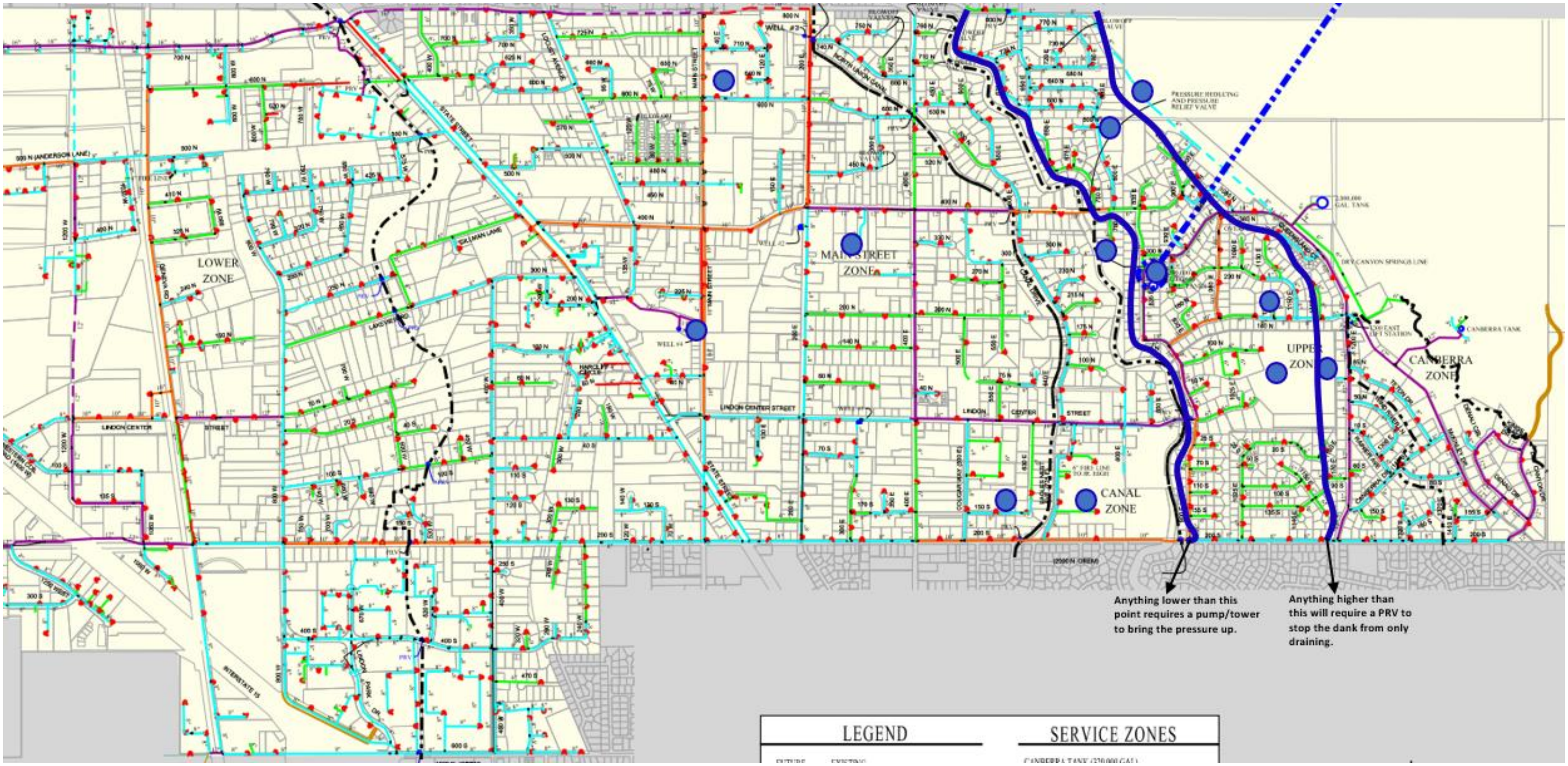


Figure A 3 – Existing and Future Expansion of 0.5 MG Tank (Relative Sizes)

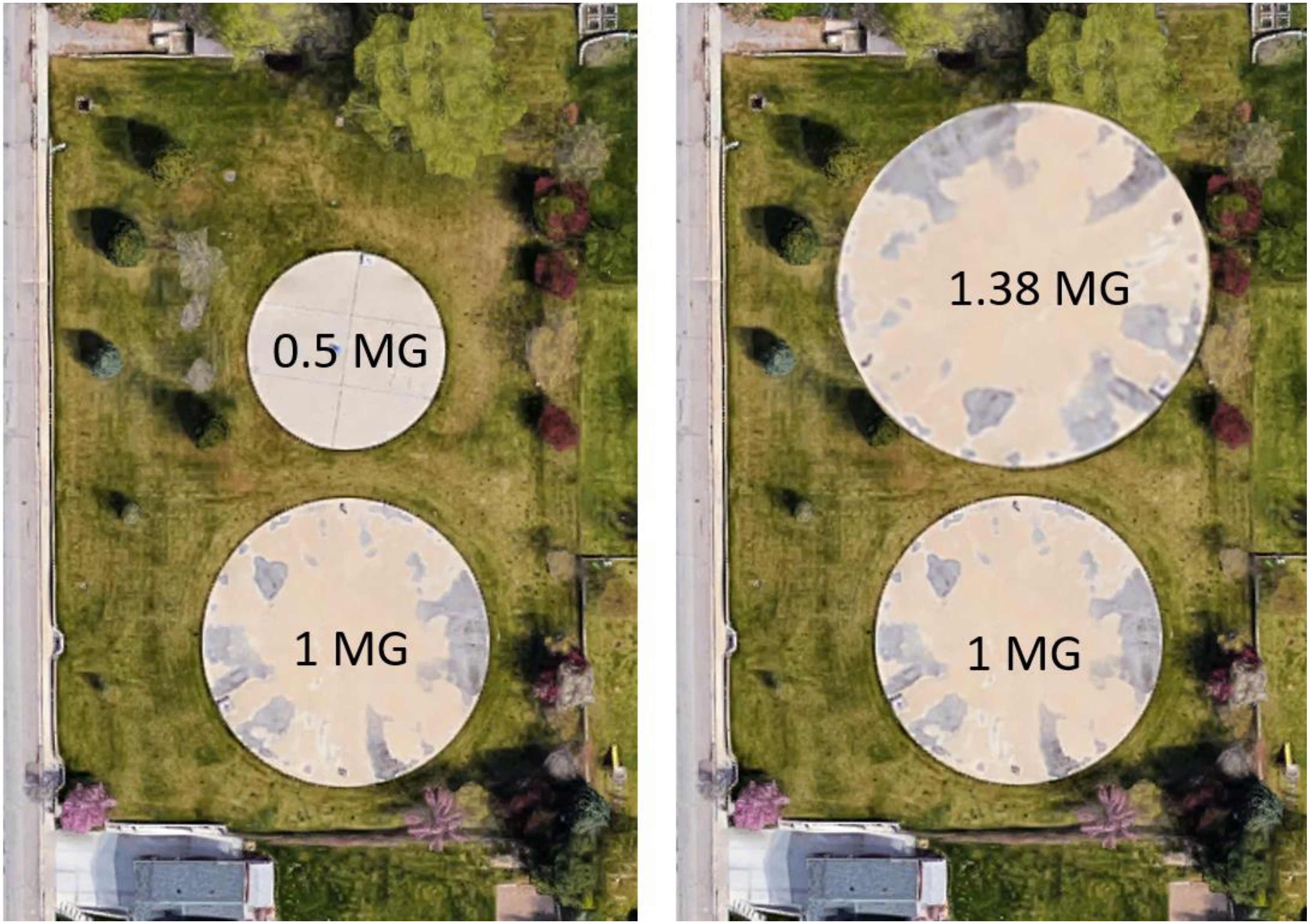


Figure A 4 – Flow Loop Discovered between the 2 MG and 0.5 and 1.0 MG tanks.

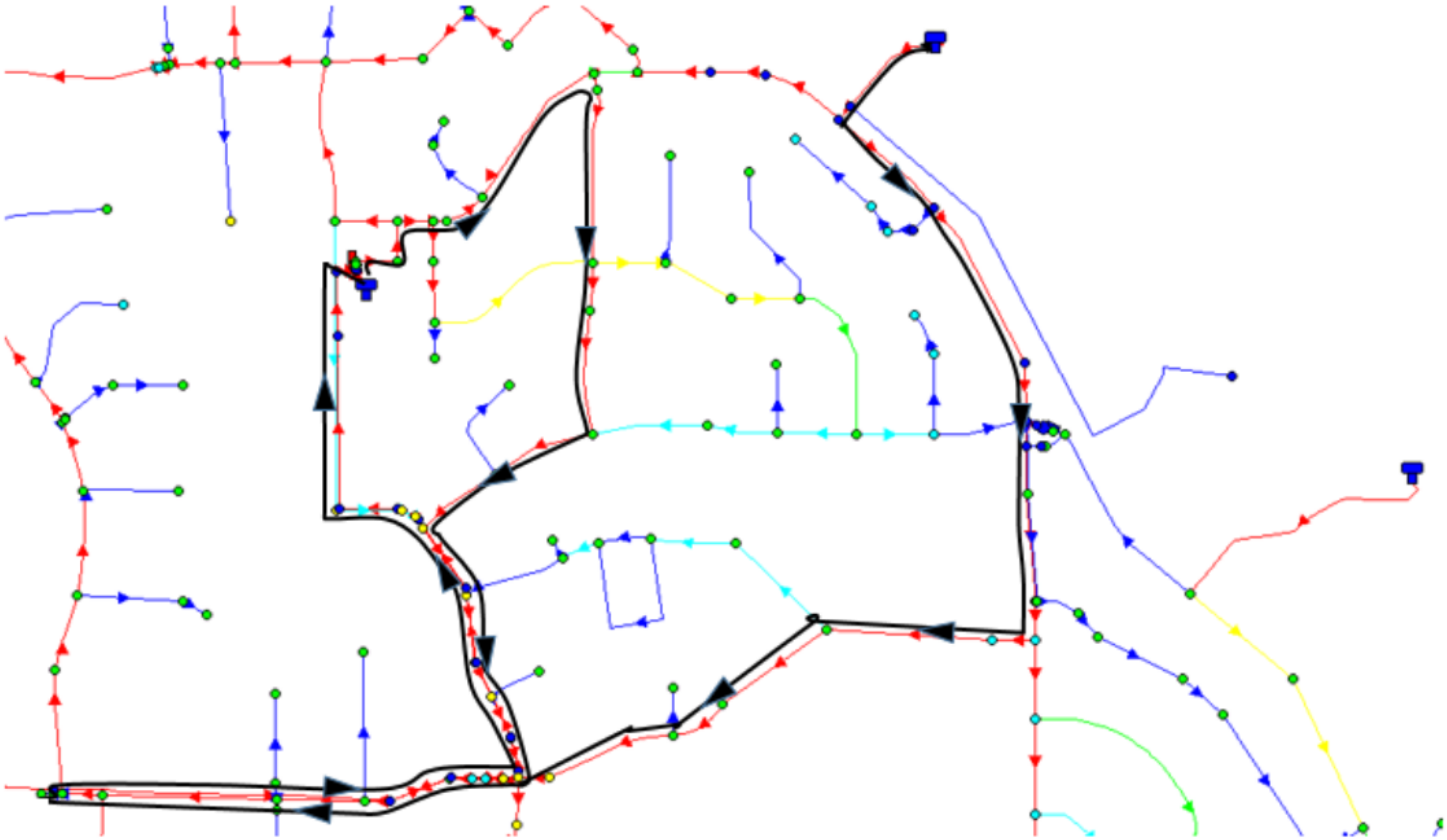
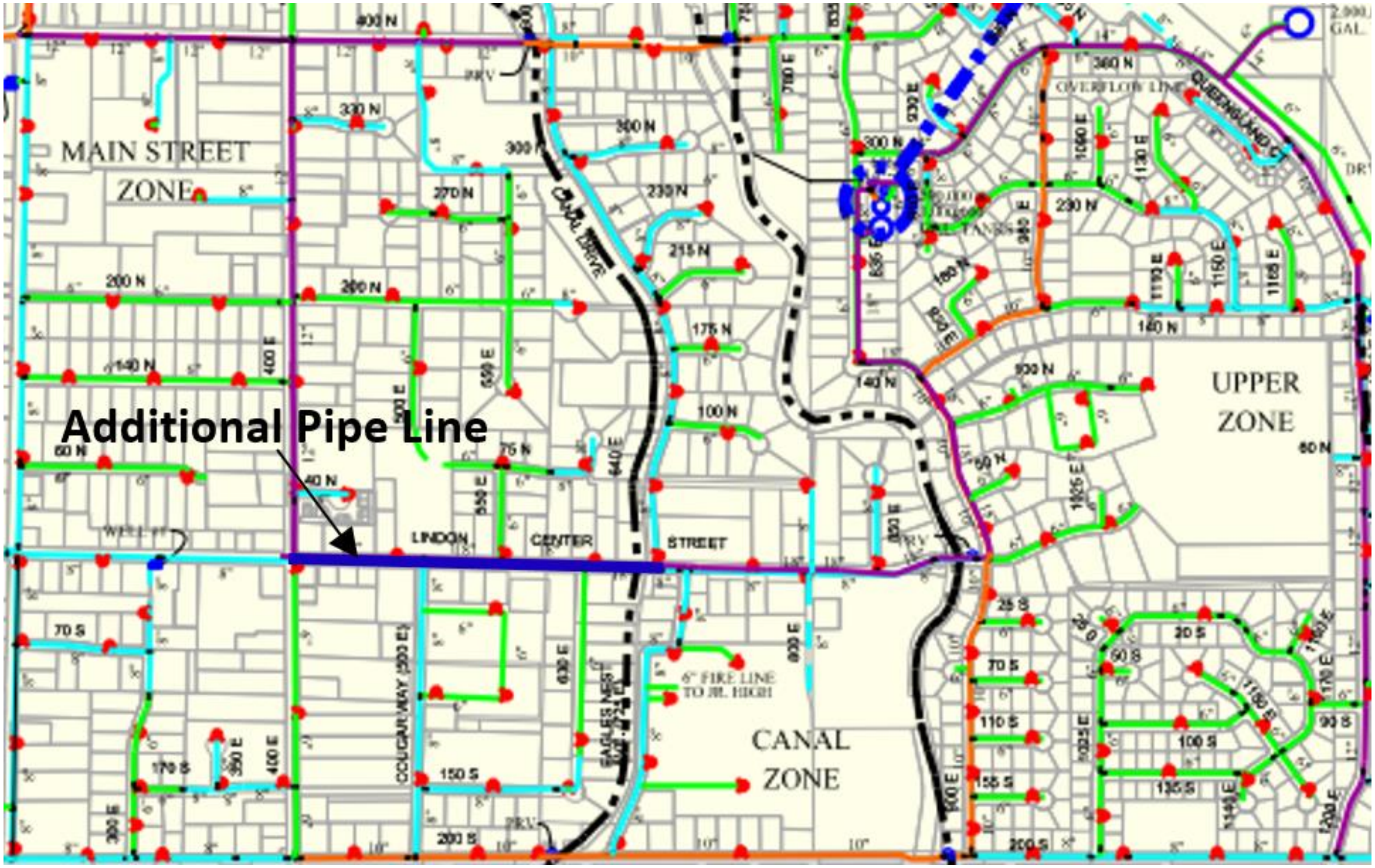


Figure A 5 - Additional Pipe Line Installment



APPENDIX B

Opinion of Projected Costs

In order to closely reflect previous cost estimates, costs were based on estimates provided and established by J-U-B for their projects. Some values were slightly modified to reflect inflation that occurred since their 2015 estimates and other preferences. Lot specific values were determined based on J-U-B estimates, interpolation, and research of current construction costs. J-U-B's opinion of 25% total costs for preliminary engineering, construction engineering, materials testing, construction inspection, administrative, legal, and bonding was used without modification.

Table B 1 – Miscellaneous Costs Used for Project Cost Analysis and Interpolation

Item	Unit	Amount
Remove existing pump and motor	lot	$ 5,000
Video inspection of well	lot	$ 2,000
Brush and bail well casing and perforations	hour	$ 250
Test pump well (24 hours test)	lot	$ 15,000
Re-install existing pump and motor	lot	$ 5,000
1900 gpm pump and 300 hp motor	lot	$ 125,000
300 hp variable frequency drive	lot	$ 20,000
650 gpm pump and 100 hp motor	lot	$ 75,000
100 hp variable frequency drive	lot	$ 10,000
Chlorination equipment and appurtenances	lot	$ 40,000
Drinking Water Source Protection Plan update	lot	$ 10,000
Preliminary evaluation report and drinking water source protection	lot	$ 75,000
Well drilling 16" casing	lot	$ 500,000
Well house	lot	$ 250,000
Mechanical piping, fittings, valves, meter	lot	$ 50,000
Electrical service entrance improvements and capacity upgrades	lot	$ 125,000
Mechanical piping, fittings, valves, flow meter and appurtenances	lot	$ 75,000
Telemetry and SCADA equipment	lot	$ 65,000
Land acquisition	acre	$ 100,000
Earthwork (cut)	C.Y.	$ 11
Earthwork (fill)	C.Y.	$ 10
Remove and dispose of existing tank	lot	$ 55,000
New tank (1.38 MG)	each	$ 1,300,000
Kilowatt hr	hr	$ 0.0803
Asphalt repair	L.F.	$ 35
Other Fees: Engineering, Legal Administrative, Finance	25% of total costs	

Table B 2 – Costs Used for Estimated Pipe Installation

Item	Unit	Unit Price
8" Water main	L.F.	$ 59
10" Water main	L.F.	$ 69
12" Water main	L.F.	$ 82
14" Water main	L.F.	$ 101
18" Water main	L.F.	$ 148
8" Gate valve	each	$ 1,500
10" Gate valve	each	$ 2,500
12" Butterfly valve	each	$ 3,000
14" Butterfly valve	each	$ 4,000
18" Butterfly valve	each	$ 6,500
8" Bend/Reducer	each	$ 500
10" Bend/Reducer	each	$ 650
12" Bend/Reducer	each	$ 800
14" Bend/Reducer	each	$ 1,000
18" Bend/Reducer	each	$ 1,600
10" Cross	each	$ 1,500
12" Cross	each	$ 1,800
14" Cross	each	$ 2,200
18" Cross	each	$ 3,200
Culinary line bedding material	L.F.	$ 2
Culinary line backfill material	L.F.	$ 16

Table B 3 – Estimated Cost for the 0.5 MG Tank Expansion

Item Description	Quantity	Unit	Unit Price	Amount
Earthwork (cut)	13200	C.Y.	$ 11	$ 145,200
Earthwork (fill)	6600	C.Y.	$ 10	$ 66,000
Remove and dispose of existing 0.5 MG tank	1	LS	$ 55,000	$ 55,000
1.38 MG tank	1	each	$ 1,300,000	$ 1,300,000
Piping, fittings, valves, meters, etc.	1	each	$ 55,000	$ 55,000
Telemetry/Control/Monitoring	1	each	$ 55,000	$ 55,000
18" Extension to 400 E				
Earthwork (cut)	1055	C.Y.	$ 11	$ 11,605
Earthwork (fill)	880	C.Y.	$ 10	$ 8,800
18-inch Main Line	1900	L.F.	$ 148	$ 281,200
Asphalt repair	1900	L.F.	$ 35	$ 66,500
Other Fees: Engineering, Legal Administrative, Finance 25%				$ 511,076
			Total Cost	**$ 2,556,000**

Table B 4 – Estimated Operation Costs for Expansion

Pump	Kw-hr/Mgal	Average Kwatts	Peak Kwatts	Cost/Day
147P (Well #2)	817.54	9.53	10.21	$ 18.37
161P (Well #3)	638.16	65.04	72.34	$ 121.72
170P (1200 E Lift Station)	749.82	16.53	16.54	$ 5.91
189P (835 E Lift Station)	1316.3	63.95	64.27	$ 116.81
767 (Well #4)	1141.5	106.61	107.1	$ 3.06
829 (Well #1)	751.17	20.56	21.13	$ 39.62
New Buildout	775.01	36.59	37.14	$ 70.52
			Day Total	**$ 376.01**
			Year Total	**$ 137,243.65**

Table B 5 – Estimated Cost for the Sumac Hollow Tank

Item Description	Quantity	Unit	Unit Price	Amount
Earthwork (cut)	9500	C.Y.	$ 11	$ 104,500
Earthwork (fill)	100	C.Y.	$ 10	$ 1,000
1 MG Tank	1	each	$ 1,000,000	$ 1,000,000
Piping, fittings, valves, meters, etc.	1	each	$ 55,000	$ 55,000
Telemetry/Control/Monitoring	1	each	$ 55,000	$ 55,000
Land acquisition	0.3	acre	$ 30,000	$ 9,000
Pipe From Tank to Corner of Center Street and 900 E				
Earthwork (cut)	667	C.Y.	$ 11	$ 7,333
Earthwork (fill)	560	C.Y.	$ 10	$ 5,600
18-inch pipe	1200	L.F.	$ 148	$ 177,600
Asphalt repair	1200	L.F.	$ 35	$ 42,000
18" Extension to 400 E				
Earthwork (cut)	1055	C.Y.	$ 11	$ 11,605
Earthwork (fill)	880	C.Y.	$ 10	$ 8,800
18-inch Main Line	1900	L.F.	$ 148	$ 281,200
Asphalt repair	1900	L.F.	$ 35	$ 66,500
Other Fees: Engineering, Legal Administrative, Finance 25%				$ 456,285
			Total Cost	**$ 2,282,000**

Table B 6 – Estimated Operation Costs for Sumac Hollow

Pump	Kw-hr/Mgal	Average Kwatts	Peak Kwatts	Cost/Day
147P (Well #2)	829.26	9.31	10.17	$ 15.39
161P (Well #3)	650.23	63.37	72.29	$ 18.84
170P (1200 E Lift Station)	749.21	16.53	16.54	$ 5.93
189P (835 E Lift Station)	1311.44	63.85	64.24	$ 114.00
767 (Well #4)	951.61	107.13	112.3	$ 123.08
829 (Well #1)	767.51	20.3	21.1	$ 30.08
New Buildout	782.4	36.53	37.15	$ 70.40
			Day Total	**$ 377.72**
			Year Total	**$ 137,867.80**

Table B 7 – Estimated Cost for the Oak Canyon Junior High Tank

Item Description	Quantity	Unit	Unit Price	Amount
Earthwork (cut)	9500	C.Y.	$ 11	$ 104,500
Earthwork (fill)	100	C.Y.	$ 10	$ 1,000
1 MG Tank	1	each	$ 1,000,000	$ 1,000,000
Piping, fittings, valves, meters, etc.	1	each	$ 55,000	$ 55,000
Telemetry/Control/Monitoring	1	each	$ 55,000	$ 55,000
Land acquisition	0.3	acre	$ 100,000	$ 30,000
Pipe Extension to 530 West				
Earthwork (cut)	8339	C.Y.	$ 11	$ 91,729
Earthwork (fill)	6950	C.Y.	$ 10	$ 69,500
12-inch pipe	15010	L.F.	$ 82	$ 1,230,820
Asphalt repair	15010	L.F.	$ 35	$ 525,350
18" Extension to 400 E				
Earthwork (cut)	1055	C.Y.	$ 11	$ 11,605
Earthwork (fill)	880	C.Y.	$ 10	$ 8,800
18-inch Main Line	1900	L.F.	$ 148	$ 281,200
Asphalt repair	1900	L.F.	$ 35	$ 66,500
Other Fees: Engineering, Legal Administrative, Finance 25%				$ 882,751
			Total Cost	**$ 4,414,000**

Table B 8 – Estimated Operation Cost for the Oak Canyon Junior High Tank

Pump	Kw-hr/Mgal	Average Kwatts	Peak Kwatts	Cost/Day
147P (Well #2)	814.67	9.58	10.21	$ 18.46
161P (Well #3)	639.07	65.24	72.3	$ 115.82
170P (1200 E Lift Station)	752.94	16.53	16.54	$ 5.97
189P (835 E Lift Station)	1318.19	63.98	64.25	$ 113.31
767 (Well #4)	0	0	0	$ -
829 (Well #1)	748.88	20.61	21.13	$ 39.72
New Buildout	772.53	36.59	37.14	$ 70.51
			Day Total	**$ 363.79**
			Year Total	**$ 132,783.35**

Table B 9 - Estimated Cost for the Water Tower in Lindon City Park

Item Description	Quantity	Unit	Unit Price	Amount
Earthwork (cut)	1000	C.Y.	$ 11	$ 11,000
Earthwork (fill)	100	C.Y.	$ 10	$ 1,000
1 MG Water Tower	1	each	$ 1,600,000	$ 1,600,000
Piping, fittings, valves, meters, etc.	1	each	$ 80,000	$ 80,000
Telemetry/Control/Monitoring	1	each	$ 55,000	$ 55,000
Land acquisition	0.4	acre	$ 100,000	$ 40,000
Pipe From Lindon City Park to 530 West				
Earthwork (cut)	3789	C.Y.	$ 11	$ 41,678
Earthwork (fill)	3160	C.Y.	$ 10	$ 31,600
18-inch pipe	6820	L.F.	$ 148	$ 1,009,360
Asphalt repair	6820	L.F.	$ 35	$ 238,700
18" Extension to 400 E				
Earthwork (cut)	1055	C.Y.	$ 11	$ 11,605
Earthwork (fill)	880	C.Y.	$ 10	$ 8,800
18-inch Main Line	1900	L.F.	$ 148	$ 281,200
Asphalt repair	1900	L.F.	$ 35	$ 66,500
Other Fees: Engineering, Legal Administrative, Finance 25%				$ 869,111
			Total Cost	**$ 4,346,000**

Table B 10 - Estimated Operation Cost for the Water Tower in Lindon City Park

Pump	Kw-hr/Mgal	Average Kwatts	Peak Kwatts	Cost/Day
147P (Well #2)	809.73	9.66	10.2	$ 18.63
161P (Well #3)	663.17	62.56	71.49	$ 57.49
170P (1200 E Lift Station)	772.99	16.51	16.54	$ 6.20
189P (835 E Lift Station)	1294.8	63.53	64.12	$ 116.44
767 (Well #4)	699.5	57.43	87.65	$ 69.38
829 (Well #1)	753.23	20.62	21.1	$ 39.73
New Buildout	739.52	36.62	37.14	$ 70.57
			Day Total	**$ 378.44**
			Year Total	**$ 138,130.60**