BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

# Flood Investigation and Solution Evaluation
## Project ID: CEEn_CPST_03

by

**Utah Engineers**
**Jonathan Tshibanda**
**Jevaughn Richardson**
**John Lee**
**Andrew Harline**

**A Capstone Project Final Report**

**Submitted to**

**Michael Clark**
**Spanish Fork City**

**Department of Civil and Construction Engineering**
**Brigham Young University**

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## Executive Summary

**PROJECT TITLE:** Flood Investigation and Solution Evaluation
**PROJECT ID:** CEEn_CPST_003
**PROJECT SPONSOR:** Spanish Fork City
**TEAM NAME:** Utah Engineer

Due to the amount of runoff and high roadway crown, 400 North in Spanish Fork City accumulates water during heavy rainfall. Existing stormwater infrastructure does not remove enough of this water from flooding the roadway and residential property. Spanish Fork has previously used detention tanks to mitigate high runoffs in similar watersheds. Since flooding occurs when the runoff spills over the curb, not all the water needs to be removed to mitigate the flooding.

Using hydrologic models to determine the runoff volume of a storm, runoff is assigned to paths according to natural topology and existing structures. These runoffs accumulate and eventually reach 400 North. Locations for detention tanks were placed along these accumulated flows. It was calculated that 67 percent of the runoff will be caught in the detention tanks.

The first phase involved a preliminary analysis of the existing stormwater systems and infrastructure. The basin and sub-basins were delineated based on contour maps from the Spanish Fork Website and the existing stormwater infrastructure. Runoff coefficients were determined using Hec-22 tables, and rainfall intensity was obtained from the sponsor's recommended values. Our team used a C value of 0.9 based upon the landscape and terrain of the given area. The runoff and volume of water were calculated using the rational method formula contained in HEC-22. The accumulation of volume of water and flow maps were determined for each intersection in the basin. A total volume of 384,700 cubic feet of water was flowing on 400 North.

The second phase of the project involved specifying the required storage capacity and location to reduce flooding. The recommended design was the installation of detention tanks in several park strips along the road as needed. A standard design for detention tanks in Spanish Fork was used to calculate the tank's capacity, which consists of the discharge and tank volume. A six-foot depth by a four-foot width detention tank calculated a volume of 29 cubic feet. The project determined that the existing stormwater infrastructure could not hold the volume of water flowing on 400 North, necessitating the installation of additional detention tanks to prevent flooding. Installation of the two-layered detention tank system would help the stormwater discharge of Spanish Fork by 67%. A three-layered detention tank system can help the discharge by 94%. A two-layered system would cost around 1.2 million dollars, while a three-layered system would cost around 1.8 million dollars.

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# Introduction

## Background:

The project Utah Engineers received was related to the flooding that constantly occurs in certain areas of the city of Spanish Fork. Our assignment was to find a solution to the flooding issue and drainage complications for the crossroads of 400 North and 400 East. During large storm events, the intersection of 400 North and 400 East becomes flooded without proper drainage. The drainage in this area has been primarily irrigation ditches that serve as gutters on the edge of pavement. The ditches get smaller as the system goes downhill while the need for storm drain capacity increases. This results in pooling of water that eventually leads to homes causing property damage and health risks. See figure 1

The project scope is to map a specified area of the city and provide recommended measures to alleviate flooding. To meet these objectives, the project was divided into two phases which consisted of: 1) investigate the stormwater runoff and volume based on existing infrastructure and 2) specify the required storage capacity and location needed to reduce flooding.

Our investigation of the stormwater quantity was based on the modified rational method. The modified rational method is not a standard for calculating volume of runoff. However, for the purpose of this project, where our analysis was limited to about 6 acres of area for sub-basins, our client recommended the use of the modified rational method to estimate the runoff volume. The use of this method has also been approved by our faculty mentor.

Our investigation also included multiple field visits to collect data regarding flow direction and online tools such as the interactive map for Spanish Fork that contains contour data. We also used Google Maps and Google Earth to delineate the area and estimate the total accumulated volume of stormwater on 400 North. We have detailed out two possible options as well as a cost/benefit analysis to assist in choosing the most viable option for the project. Our goal is to reduce the accumulated stormwater volume on 400 North by at least 65 percent.

## Assumptions and Limitations:

Several assumptions had to be made in order to appropriately estimate the volume of water. There are also a few limitations to our project progress. Below is a list of assumptions and limitations:

### Assumptions:

1. We created a model with the assumption that each sub-basin in our analysis had the same C value. The C value is a measure of the distribution between the pervious and impervious area within a basin. It is higher when the basin contains more impervious areas than pervious areas. For this project however, the distribution within different sub-basins was similar enough to assume the same C value based on an average distribution.
2. We assumed that the time of concentration for our sub-basin was less than 5 mins for the maximum runoff calculations. This recommendation for time of concentration was made by our sponsor.
3. We designed for a maximum stormwater volume of 60 mins duration for a 10-year storm. This again was based on recommendations from our client.

4. Additional assumptions regarding runoff, volume calculations and storage capacity are included in the body of the report section.

**Limitations:**

1. The modified rational method constituted the main limitation for this project. Typically, stormwater volume is estimated through the NRSC method instead of the rational method, mainly because, unlike the NRCS method, the modified rational method does not produce a true hydrograph, only an approximation. In addition, it does not account for other factors such as evaporation, temperature, impact of land use changes or other environmental factors.

## Schedule

This timeline highlights the key milestones that our team achieved throughout the project.

- We began the semester by studying and learning about HEC-22 and Dr. Hotchkiss' notes to gain a solid understanding of contours, grading, and hydrology.
- Prototypes of our basins and sub-basins were created using our resources around February 16th.
- We then started team meetings starting from February 28th and began going out to the field on several occasions, including March 3rd, March 8th, and March 25th.
- Throughout the project, we had weekly meetings with Michael and James to update them on our progress and help us get on the right track. James provided us with data from the field on March 15th, which we used to create a flow map of all the intersections by March 27th.
- After analyzing the flow-map, we were able to determine the locations of the basins and sub-basins, which we finished on April 1st.
- Finally, on April 8th we were able to complete the R tank locations and spreadsheet, which helped us identify the best locations for installing underground chambers to manage stormwater runoff in Spanish Fork.

# Design, Analysis & Results

## Preliminary Analysis:

Phase 1 of our project was to investigate the stormwater volume based on tools and maps shown below. We decided to start with a preliminary analysis. The preliminary analysis was based on the current stormwater systems and infrastructure. This analysis was done following the steps below:

1. **Basin and Sub-basin delineation**

Our objective delineating the sub-basin was to find the runoff and volume of water passing each road intersection.

We delineated our basin based on the contour maps provided on the Spanish Fork Website and the existing stormwater infrastructures. The streets 800 East to 400 East currently do not have any stormwater drainage infrastructure other than existing cleaning boxes installed at each intersection. Below is a map of the basin of concern.

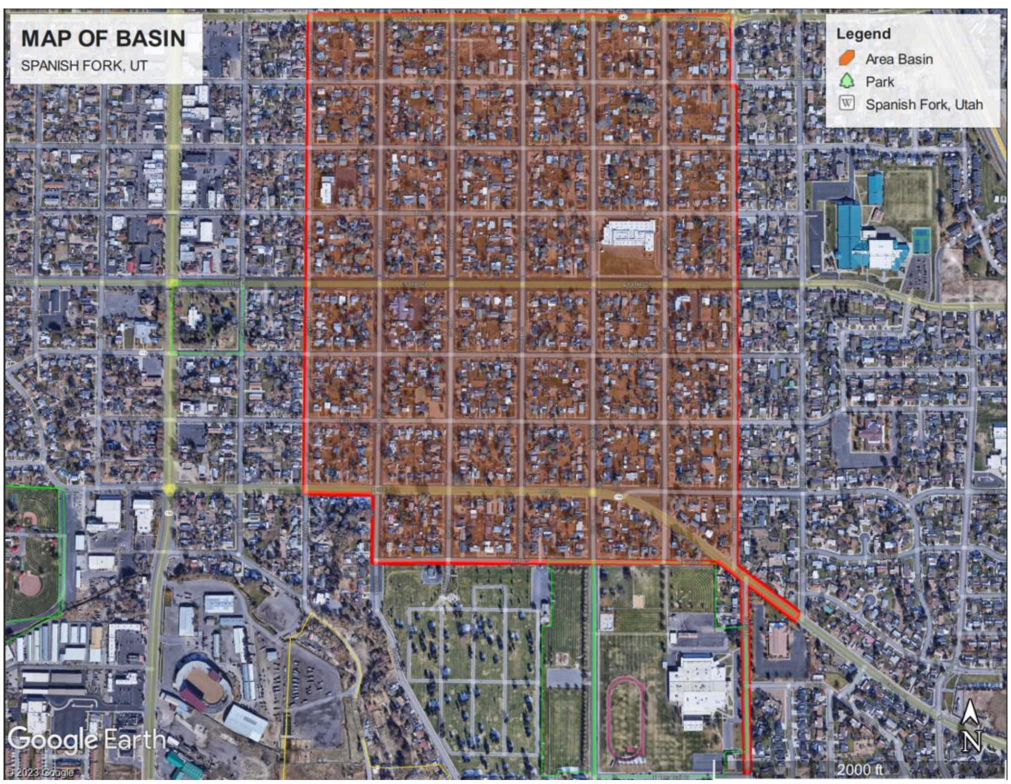


*Figure 1: Spanish Fork, Final Basin Area*

Our sub-basins were determined to be the area covering each block and half of the adjacent streets. Each sub-basin was assumed to be similar with the same C values. Below is an example of a sub-basin for this project. Green is sub-basin A and blue is Sub-basin B:


*Figure 2: Spanish Fork, Sub-Basin Area*

### 2. Runoff coefficient

Using Table 3-1 of Hec-22, we determined that our runoff coefficient for the previous area (Grass, soil, sand) had a C value of 0.18 and every impervious area (driveways, sidewalks, parking lots) had a C value of 0.9.

We calculated our weighted C for the sub-basin as follows:

$$\text{Weighted } C = \Sigma\,(Cx * Ax)/A\_total \qquad \textit{Hec-22 (Equation 3-2)}$$

$$\text{Weighted } C = (\%\text{ pervious area}) * 0.18 + (\%\text{ impervious area}) * 0.9$$

For Sub-basin A, we estimated a distribution as pervious area of 59 percent and the impervious area of 41 percent. The percentages were calculated by using Spanish Fork's GIS tools to determine a total area of impervious surfaces within a standard sub-basin and then compared to the area of a block. Based on these numbers, we estimated the weighted C value to be 0.48.

For Sub-basin B, there is no pervious area, therefore the C value is 0.9.

### 3. Rainfall intensity

We used recommended values from our sponsor for the rainfall intensity. For peak runoff the recommended rainfall intensity was 3.31 in/hours based on a 5 min time of concentration and a 10-year storm.

For maximum volume, we used a rainfall intensity of 0.87in/hour based on a 60 min duration for a 10 year storm.

### 4. Runoff and volume

We used the rational method formula contained in HEC-22 as follows:

$$Q = (CIA) \qquad \text{HEC-22 (Equation 3-1)}$$

Where:
Q = Flow, m3 /s (ft3 /s)
C = Dimensionless runoff coefficient
I = Rainfall intensity, mm/hr (in/hr)
A = Drainage area, hectares, ha (acres)

The volume of water was calculated as follow:

$$V = Q*t$$

Where:
Q = Flow (ft3/s)
t = 3600 second (based on 60 mins duration)

For each sub-basin the volume of water was determined as shown in the tables below Table 1and Table 2 show the calculated volumes for the right and left portion of the intersection respectively.

*Table 1: Sub-Basin A*

| Sub-basin A | | |
|---|---|---|
| Total area | 5.62 | acres |
| Pervious area | 59% | |
| Impervious area | 41% | |
| Pervious C | 0.18 | |
| Impervious C | 0.9 | |
| Weighted C | 0.48 | |
| Runoff | 2.32 | cfs |
| Volume | 8400 | Cubic feet |

*Table 2: Sub-Basin B*

| Sub-basin B | | |
|---|---|---|
| Total area | 0.44 | acres |
| Pervious area | 0% | |
| Impervious area | 100% | |
| Pervious C | 0.18 | |
| Impervious C | 0.9 | |
| Weighted C | 0.9 | |
| Runoff | 0.35 | cfs |
| Volume | 1300 | Cubic feet |

Using this, we calculated the runoff and volume accumulation for each intersection in our basin. This was done with the assumption that each basin had approximately the same C value and the same area.

The table below shows the accumulation of volume of water on 800 East for both left and right flow. Similar tables were also made for 700 East, 600 East, 500 East, and 400 East.

*Table 3: Stormwater Volume of 800 E*

| 800E | L. Flow (Cf) | Split Type L | R. Flow (Cf) | Split Type R | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1252.2 | No split | 8364.4 | No split | 0 | 0 | 0 | 0 |
| 200 S | 2504.3 | No split | 16728.8 | No split | 0 | 0 | 0 | 0 |
| 100 S | 3756.5 | No split | 25093.2 | No split | 0 | 0 | 0 | 0 |
| Center st | 5008.6 | No split | 33457.6 | No split | 0 | 0 | 0 | 0 |
| 100 N | 6260.8 | No split | 41822.0 | No split | 0 | 0 | 0 | 0 |
| 200 N | 7512.9 | No split | 50186.4 | No split | 0 | 0 | 0 | 0 |
| 300 N | 8765.1 | No split | 58550.8 | No split | 0 | 0 | 0 | 0 |
| 400 N | 10017.2 | No split | 66915.2 | No split | 0 | 0 | 0 | 0 |
| flow = | 10017 | flow = | 66915 | | 0 | 0 | 0 | 0 |

Our investigation has also shown that at some intersections, the flow of water changed direction or split such that a certain percentage of water at an intersection either crossed to the other side of the street or flowed straight through the intersection as shown in the image below.

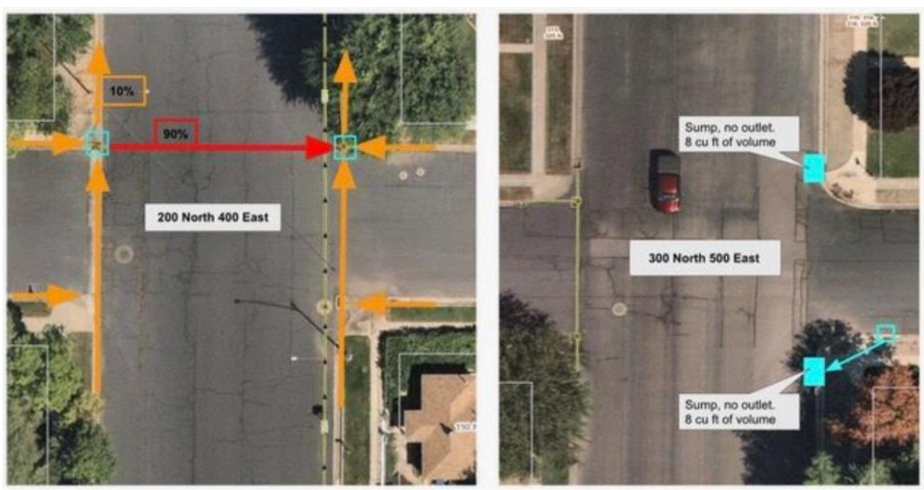


*Figure 3: Flow Map of 200 N 400 E & 300 N 500 E*


*Figure 4: Flow Map of Lots below E Center St*

We had to account for these splits in our analysis in order to know where the water was flowing and what quantity was accumulating at each intersection. Below is an example of the calculated water flow for 800 East based on flow accumulation and flow splits.

*Table 4: Stormwater Flow of 800 E*

| 800E | L. Flow (Cf) | Split Type L | R. Flow (Cf) | Split Type R | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1252.2 | No split | 8364.4 | No split | 1 | 1 | 0 | 0 |
| 200 S | 1502.6 | 60/40 | 16728.8 | No split | 1 | 1 | 0 | 0 |
| 100 S | 16708.8 | 60/40 | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| Center st | 21060.2 | 80/20 | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| 100 N | 22312.4 | No split | 8364.4 | No split | 1 | 1 | 0 | 0 |
| 200 N | 23564.5 | No split | 16728.8 | No split | 1 | 1 | 0 | 0 |
| 300 N | 29945.9 | 60/40 | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| 400 N | 31198.1 | No split | 8364.4 | No split | 1 | 1 | 0 | 0 |
| flow = | 31198 | flow = | 8364 | | 8 | 8 | 16 | 0 |

Similar volume accumulation was done for 700 East, 600 East, 500 East, and 400 East.

We added all the accumulated volumes from all these streets and found a total volume of 384,700 cubic feet of water flowing on 400 North. Even though some areas on 400 North such as the roundabout have inlets that were connected to a detention tank and storm sewers, none of these facilities could hold this amount of water.

## Storage design:

The second stage of our project was to specify the required storage capacity and location needed to reduce flooding. Our sponsor recommended that we analyze detention tanks that can be installed in several park strips along the road as needed. A standard design for detention tanks in Spanish Fork is shown in Figure 7:

Tank capacity:

The tank's capacity consists of discharge and tank volume.

The discharge of the tanks was calculated as follow:

Discharge = Tank discharge width*tank infiltration rate

With tank effective width = 6 ft

Tank infiltration rate = 0.167 in/min (From client)

*Table 5: Stormbrixx Infiltration*

| Stormbrixx infiltration | | |
|---|---|---|
| Infiltration | 0.167 | in/min |
| Effective Width | 6 | ft |
| Discharge | 0.0014 | cfs/ft |

Tank capacity = (Discharge * 60 min * 60 sec/min) + (Tank width * Tank depth)

- For 6ft deep by 4 ft wide tank, the tank capacity is

Tank capacity = (0.0014 * 3600) + (6 * 4)

Tank capacity = 29 cubic feet/ feet

- For 9 ft by 4 ft wide tank, the tank capacity is

Tank capacity = (0.0014 * 3600) + (9 * 4)

Tank capacity = 41 cubic feet/ft

As shown above, every foot of 6 ft deep tank can store 29 cf of water, and every foot of 9 ft deep tank can store 41 cf of water.

## Recommendations

### Detention tank location:

Based on our preliminary analysis and storage capacity calculated above, we recommended tanks locations and depth based on the following requirements from the client:

- All detention tanks are installed on park strips that would be excavated
- Park strip that contains trees or other infrastructure cannot be used for storage

We have included all tank location recommendations in the appendix. Figure 5 is an example of recommended tank locations and length for 4 blocks. See Figure 9 through Figure 11.

To capture the required percentage of the runoff, several detention tanks were placed in the park strips of each street. If the total number of the tanks becomes an issue for the project, locations should be removed from the southeast corner to the northwest of the area. The lengths of each location should be considered to reduce redundancy in labor.

*Figure 5: Detention Tank Locations*

### Tank depth:

We made two separate analyses for different tank depths.

- **For 6ft deep tank**:

  This consists of two layers of R tank as shown on the standard drawing in Figure 7. Below is the analysis made for only 800 East:

*Table 6: R Tanks of 800 E*

| 800E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | | Int. flow L | 0 | | L | R | L | R |
| 300 S | -243.5 | No split | 0.0 | 0/100 | 1 | 1 | 110 | 230 |
| 200 S | -118.1 | 60/40 | 0.0 | 0/100 | 1 | 1 | 280 | 50 |
| 100 S | 548.6 | 60/40 | 0.0 | 0/100 | 1 | 1 | 116 | 180 |
| Center st | 4884.2 | 80/20 | 0.0 | 0/100 | 1 | 1 | 100 | 40 |
| 100 N | 4686.3 | No split | 6914.4 | No split | 1 | 1 | 50 | 50 |
| 200 N | 4778.5 | No split | 8463.8 | No split | 1 | 1 | 40 | 235 |
| 300 N | 11105.3 | 60/40 | 0.0 | 0/100 | 1 | 1 | 60 | 90 |
| 400 N | 12357.4 | No split | 8364.4 | No split | 1 | 1 | 0 | 0 |
| flow = | 12357 | flow = | 8364 | | 8 | 8 | 16 | 1631 |

Similar tables for 700 East, 600 East, 500 East, and 400 East are included in the appendix. Based on the storage capacity of the 6ft deep tank, we calculated that the total water stored or detained in our basin would be 246186 cubic feet or 67% of the initial volume. The required total length of detention tank installed to detain that amount of water is 8834 ft.

*Table 7: Detained Stormwater Percent*

| | | |
|---|---|---|
| Tank Tot. Cap | 256186 | Cf |
| Tank Tot Length | 8834 | ft |
| Volume before | 384662 | cf |
| Volume after | 128476 | cf |
| Percent caught | 67% | |

- **For 9 ft deep tank:**
  This consists of three layers of R tanks. Using these tanks would increase the capacity of tanks but might be more expensive due to excavation. Below is the analysis for 800 East based on 9 ft deep tanks or 3 units.

*Table 8: Three Layers of Detention Tanks*

| 800E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | | Int. flow L | 0 | | L | R | L | R |
| 300 S | -4323.5 | No split | 0.0 | 0/100 | 1 | 1 | 110 | 230 |
| 200 S | -4942.1 | 60/40 | 0.0 | 0/100 | 1 | 1 | 280 | 50 |
| 100 S | -4477.0 | 60/40 | 0.0 | 0/100 | 1 | 1 | 116 | 180 |
| Center st | -480.3 | 80/20 | 0.0 | 0/100 | 1 | 1 | 100 | 40 |
| 100 N | -1278.2 | No split | 6314.4 | No split | 1 | 1 | 50 | 50 |
| 200 N | -1666.0 | No split | 5043.8 | No split | 1 | 1 | 40 | 235 |
| 300 N | 4106.6 | 60/40 | 0.0 | 0/100 | 1 | 1 | 60 | 90 |
| 400 N | 5358.7 | No split | 8364.4 | No split | 1 | 1 | 0 | 0 |
| flow = | 5359 | flow = | 8364 | | 8 | 8 | 16 | 1631 |

Similar tables for 700 East, 600 East, 500 East, and 400 East are included in the appendix. Based on the storage capacity of the 9 feet deep tank, we calculated that the total water stored or detained in our basin would be 362194 cubic feet or 94% of the initial volume. The required total length of detention tank installed to detain that amount of water is 8834 ft.

*Table 9: Three Layer Detention Tank Percentage*

| | | |
|---|---|---|
| Tank Tot. Cap | 362194 | Cf |
| Tank Tot Length | 8834 | ft |
| Volume before | 384662 | cf |
| Volume after | 22468 | cf |
| Percent caught | 94% | |

## Other recommendations:

- **Additional flow direction**

While choosing the tanks locations, we realized that in certain places, there was not enough volume of water while there was a lot of park strip spaces that could be used to install R tanks. To make our design more efficient, we decided to divert some volume of water in those places and specify tanks to reduce the total volume of water. These places include the intersection of 300 S and 200 S with 800 E where the water from the right side should be redirected to the left side that has available tanks space. Additional location includes the intersection between 100 S with 600 E and 500 E where 40 percent of water should be redirected to the left side of the flow.

- **Inlet capacity**

Our design of tank only looked at volume and did not consider runoff. We assumed that the inlet capacity leading to R tanks was able to get the maximum volume of water it was designed for regardless of the discharge rate. In general, inlets are not 100 percent efficient, and can only intersect a certain percentage of water while the water not intercepted is called bypass. With this in mind, we recommend using combination inlets along with the R tanks. According to HEC-22, **Combination inlets** provide the advantages of both curb opening and grate inlets. This combination results in a high capacity inlet which offers the advantages of both grate and curb-opening inlets. Depressing the curb opening would significantly reduce the length of inlet required. Perhaps the most practical inlets or procedure for use where near total interception is necessary are sweeper inlets, increase in grate width.

## Cost Benefit Analysis

The following estimates are not specific due to the large scope of the project and the constant change of construction costs.

**ACO Stormbrixx cost:**

- Taking into account that one module costs roughly $278, we estimated the cost for installing 8834 feet of stormbrixx for both 2 and 3 layers of detention tank versus the benefit as shown in the table below:

*Table 10: Detention Tank Costs*

| Tank depth | Cost | % of water caught |
|---|---|---|
| 2 layers detention tank | $1,227,926.00 | 67% |
| 3 layers detention tank | $1,841,889.00 | 94% |

As shown above, 2 layers or 6 ft are typical and cost less but can only detain 67% of the initial stormwater volume. However, 3 layers of stormbrixx can detain 94% of the initial volume but cost about $700,000 more than the 2 layers.

**ACO StormBrixx installation:**

Total cost estimate per chamber- $60,000-85,000 lump sum

- This cost factors tank configuration, module materials, cavity excavation etc. The cost of each tank fluctuates depending on the size and specification of the unit being installed.
- The cost of these systems may differ from other companies that provide similar detention systems. eg. R-tank, ADS Stormtech etc.

The cost of engineering design layout plans, construction labor, easements and permits for a project of this magnitude varies. The project may be broken up into phases to reduce the large cost to the city.

- If the city decides to sub-contract private sector firms and companies, they will bid for the project with different price ranges in their contracts to complete the engineering and construction scope of the project. This could range from $20,000-$150,000.

## Related Issues

This project will have a great impact on the residents living in the project area in Spanish Fork. The failure of the storm system has plagued the residents for several years by causing flooding onto their properties. The flooding caused by the drainage complications may cause a range of public health issues, including mold, and injuries. The excess water will lead to the flooding of basements, if continuous water damage is prolonged the development of mold could become a major health risk to the home owners. Eliminating the drainage issues will then eliminate any health risks directly connected to the excess water.

Regarding the impact on the safety of individuals and communities in the area, the flooding of the storm system could damage the residents property and homes. The people of Spanish Fork have had to use sand bags to stop water from entering into their homes. Our project's impact will greatly reduce this issue. If families are displaced from their homes, causing more economic hardships due the needed repairs. This can lead to increased levels of stress and mental health issues in affected individuals and communities.

Many of the residents who live in the project area will want to remain in their long term homes, where their families were raised or homes they were born into. Our sponsors grandmother who lives on 400 North where there is major flooding has occurred is one of these individuals. The success of this project will bring great comfort to these individuals as we aim to help them protect their homes. Also, no environment can be truly healthy without the proper management of stormwater this includes planning and implementing measures to control the negative impacts on the environment caused by lack of run-off which led to the flooding.

The storm system’s issues that leads to the flooding cannot be overlooked as it can exacerbate existing social inequalities, particularly for vulnerable residents especially, low-income families, individuals, the elderly, and those with disabilities. The current situation can disproportionately affect these groups, leading to increased levels of financial burden from damage to property. Also, if left unattended, the excess water can have significant environmental impacts. This project focuses on capturing the excess water before it can accumulate and flood these areas. It is key to understand that capturing excess water before it can accumulate. This process involves implementing stormwater management techniques that focus on reducing runoff and increasing infiltration. However, if the intensity of a rainfall event increases more than what the proposed system is intended to store, then mitigation should be in place to protect the environment from excessive damage.

Throughout the project, the focus has been on analyzing the economic impact of the solutions proposed for addressing the storm water issues. Our primary objective is to identify the most sustainable and cost-effective recommendation that is feasible and minimizes the construction timeline. This approach ensures that the residents of the affected area can continue their daily activities without significant disruptions during the implementation of the construction activities. In summary, this project is aimed at addressing the flooding caused by stormwater complications. The successful completion of this project could mitigate the risk of future damage, discomfort, and economic losses caused by the current stormwater system.

## Lessons Learned

Throughout this project, our group faced many challenges. Communication and scheduling our times to meet up to work on certain tasks of the capstone project became quite unorganized. It was not until we had weekly meetings with the city engineers of Spanish Fork, that we had a defined schedule of what was needed and a better scope of this project.

During the learning process of this project, our team was very limited on the knowledge of hydrology. We spent quite a lot of time understanding and reading upon notes from our professors as well as outside research. When working throughout this project, we learned a lot through trial and error.

When starting the flow map, our team needed to understand contours, inlet locations, and splits of the storm water runoff at each intersection. This led to multiple site visits along with receiving data from James Darling. Other than our weekly meetings with the sponsors, we held weekly meetings on the weekends to brainstorm these issues and resolve them to present for the next week.

For calculations, our team needed to find out the total volume of water that was entering the given scope of the project. It was not quite clear why there was so much stormwater until we realized there was another source of stormwater that was leading into the area. After changing the spreadsheet to account for this matter, the city engineers approved the changes.

## Conclusions

Throughout this project, our team used a data-driven approach to design basins and sub-basins in the city of Spanish Fork. Our team utilized a flow chart of the city and a spreadsheet that calculated runoff and discharge, which allowed us to consider various factors that affect the behavior of water in the city, such as the flow of roadways and runoff from housing lots. We were able to consider the unique characteristics of the city, such as its topography, infrastructure, and land use patterns, in our designs.

Our reliance on data as well as our best assumptions or intuition allowed us to create designs that are based on understanding of the behavior of water in the city.

By utilizing a runoff/discharge spreadsheet and a flow map, our team was able to pinpoint optimal locations to install detention tanks in troubled areas. These tools allowed us to identify areas where detention tanks would be most effective in managing flooding and minimizing the impact of stormwater runoff. Through this approach, we were able to provide an additional layer of protection against flooding in the city and improve the overall management of stormwater runoff.

Our team met with the city engineers of Spanish Fork on a weekly basis to provide updates on our progress and get their approval on our work. These meetings were essential to ensure that our designs were well-suited to the needs and priorities of the city. During these check-ins, we were able to provide the city engineers with detailed updates on our progress, including any changes or adjustments we had made to our designs. We were also able to answer any questions they had and address any concerns they raised.

The streets 800 East to 400 East were found to have no stormwater drainage infrastructure, except for existing cleaning boxes at each intersection. The basin was divided into sub-basins, with each sub-basin assumed to have the same C values. Using Hec-22, the runoff coefficient was calculated for each sub-basin, based on the previous and impervious areas. We concluded that a C value of 0.9 would be sufficient based upon the landscape and terrain of the given area.

The rational method formula was used to determine flow, and the volume of water was calculated for each sub-basin. The volume of water accumulating at each intersection was calculated, accounting for splits in flow. The total volume of water flowing on 400 North was found to be 384,700 cubic feet, which exceeded the capacity of the existing stormwater infrastructure. The underground R tank capacity for 6 feet by 4 feet has a volume of 29 cubic feet per foot while the 9 feet by 4 feet has a volume of 41 f cubic feet per foot.

We would recommend the installation of detention tanks on most park strips on most blocks in the problematic area. This allows for about 67 percent of stormwater runoff to be deterred into the detention chambers and will help with the flooding issue of Spanish Fork. This method allows for easy maintenance as well. If maintenance were not as big of an issue, having three layers of detention chambers instead of two would be helpful in deterring stormwater runoff. This would capture 94 percent of stormwater runoff instead of 67 percent.

# Appendix A

# Jong-In (John) Lee

470-338-7436 | krnleekp@gmail.com | Provo, UT | US Citizen

## Education

**Brigham Young University** *Provo, UT*
B.S. Civil Engineering (Senior)
- GPA: 3.58

## Experience

**Civil Science** *Lehi, UT*
Transportation Intern *May 2022 - Present*
- Created removal designs, hydraulic designs, roadway designs, engineer cost estimates using OpenRoads, Microstation, and Microsoft Excel for the projects of Lehi, Provo, and Salt Lake City
- Designed code to help automate engineer cost estimate sheets to improve efficiency and to reduce time and human error for quality checks and finalization
- Calculated and designed corridors, curb slope elevations, terrain elevations, 3D modeling for intersection and driveways, cross sections for roadways, and worked on roundabouts

**FOCUS Engineering** *Midvale, UT*
Site/Civil Intern *March 2021 - August 2021*
- Created site plans, engineer cost estimate designs, and plats for the cities of Lehi, Logan, Eagle Mountain, and Riverton
- Communicated with the Public Works Department and clients to ensure designs were up to proper code and resulted in satisfaction of both party members
- Inspected site construction processes and conversed with contractors for updates on the projects to ensure designs met proper code

**T-O Engineers** *Heber City, UT*
Inspection Intern *May 2020 - February 2021*
- Inspected Hideout, UT for the construction process of seven different residential neighborhoods, as well as, waterlines, sewer lines, conduit lines, wells, and roadways to ensure it followed proper code and design
- Conversed and constructed weekly reports and progress updates to head contractors, Public Works, and the mayor of Hideout, UT
- Designed the new T-O Engineer's office space using AutoCAD and inspected the construction process as well
- Density tested compacted sub-grade, road base, and asphalt with a nuke gauge to ensure proper moisture and compaction were present before paving new road ways

## Skills

| | |
|---|---|
| **Machining** | 3D Printer, Laser Cutter, Welding, Press Brake, Lathe, Drill Press, Band Saw, Miter Saw, Table Saw, Mill, Pneumatics, Hand Tools |
| **Software** | AutoCAD, Autodesk Civil 3D, Adobe PDF, Bluebeam, Revit, ArcGIS, VBA (Excel), C++, JavaScript, HTML, Microsoft Word, Microsoft Excel, Microsoft PowerPoint, Microsoft Outlook, MicroStation, OpenRoads Designer, ProjectWise |
| **Electronics** | Nuke Gauge, GPS surveying meter, Raspberry Pi, Soldering |

## Projects

**Smart Mirror** *Provo, UT*
Personal Project *Sept 2020*
- Utilized a Raspberry Pi 3, monitor, and two-way mirror to display time, calendar, stocks, weather information, and a Reddit news feed using JavaScript

**DIY Go-Kart** *Atlanta, GA*
Personal Project *Aug 2018*
- Constructed a go-kart from recycled materials and broken down vehicle parts, and completed a track with a top speed of 40 mph
- Learned how to weld the frame, as well as repairing and understanding the mechanics of an engine

## Leadership

**Environmental Science** *Provo, UT*
President *Jan 2019 - Present*
- Served as the representative and group leader of the PEPS organization to recruit professors and government officials to the discussion of Utah's pollution issues
- Organized an event in collaboration with BYU and government officials to discuss Utah's air quality and carbon footprints

# Jevaughn A. Richardson

Cell: 385-303-2371 | jevaughn.richardson@gmail.com |Orem, UT

## Skills

- Proficiency in Adobe CAD, Civil 3D, Revit, Bluebeam, Microsoft Office applications
- Proficient in reading and understanding engineering plans and specifications
- Expansive knowledge in construction, site layout, surveying, project management
- Phenomenal problem-solving, analytical, conceptual, and communication skills
- Exceptional ability to prioritize projects and work under pressure to meet client-imposed deadlines

## Education

***Brigham Young University*** Provo, UT

Bachelors of Science in Civil & Construction Engineering (April 2024)

***Knox Community College*** Jamaica W.I.

Associate of Science in Mechanical Engineering (2015 - 2017)

## Work Experience

***Engineering Intern*** **|** Focus Engineering & Survey, LLC. Midvale Utah, 2021 – Present

- Produced Innovative storm drain, sewer, and overall public utility design
- Conducted traffic volume counts, and compiled traffic data to improve design, road safety, and overall efficiency
- Create design deliverables that meet city municipal codes and requirements
- Commercial site and road mass grading and earthworks analysis
- Developed and maintained excellent client relationships
- Survey, map, and layout planned improvements and buildings

***Volunteer Missionary*** **|**The Church of Jesus Christ. London, United Kingdom, 2017 – 2019

- Supervised, directed, and managed a team of 20+ individuals to achieve goals
- Trained groups of volunteers in English, discipline, teaching, and social skills
- Beta-tested efficiency and goal-achieving programs and software

***Engineering Assistant*** **|** Power Services Company Ltd. Jamaica W.I., 2016 – 2017

- Supervised 10+ workers and delegated various project responsibilities to those under my stewardship
- Operated heavy-duty equipment over 8+ hours per day to promptly complete projects and meet client-imposed deadlines

# Jonathan Tshibanda

jonheddy75@gmail.com | 385-208-7189 | 737 600E, Provo, UT 8460

## EDUCATION

**Brigham Young University** Jan 2020
Civil engineering Provo, UT
**Brigham Young University Idaho** Jan 2019 – Dec 2019
Civil Engineering Rexburg, ID
**Cisco Networking Academy**: Jan 2015 – June 2015
IT essentials, Maintenance of computers and introduction to networking Lubumbashi, DRC

## ENGINEERING RELTED EXPERINECE

**Production Engineer** Jan 2021 –Dec 2022
*Acute Engineering* Provo, UT

- Designed wood, concrete and steel for vertical and lateral resistance
- Identifies and solve issues related to the integrity of a structure under load

**Assembly Operator** Aug 2019 – Dec 2019
*Polaris internship* Roseau, MN

- Built and installed control arms on different models of snowmobiles, Atvs and four Runners
- Tested and reworked defective Polaris vehicles in close collaboration with other team members

## SKILLS

- **3D Modeling/Analysis experience:** Associate degree in mechanical design with Solidworks, CAD
- **Coding Experience:** R commander/studio, MATLAB
- **IT maintenance:** Certified with Cisco Networking Academy

## OTHER WORK EXPERIENCE AND SKILLS

**French Tutor** -*BYU French lab* Jan 2020
- Communication and interpersonal skills Provo, UT

**Campus maintenance helper** – *BYU Grounds* July 2020-Aug 2020
- Safety precaution while handling tools and machines, problem solving Provo, UT

**Custodial Helper**- *BYUI Benson Building* Jan 2019- March 2019
- Attention to details and cleaning experience Rexburg, ID

**Church Magazines delivery** – *Church of Jesus-Christ of latter-day saints* Aug 2018 – Dec 2018
- Customer service Lubumbashi, DRC

## VOLUNTEER SERVICE

**Operation Smile** Nov 2014 – Dec 2014
- Served food to children and adult who received facial surgery Lubumbashi, DRC

**Full time volunteer** - *The church of Jesus-Christ of latter-day saints* Aug 2015 – Aug 2017
- Directed over 15 training meetings and conferences for community service and teachings Brazzaville, Congo

# ANDREW HARLINE

◊ 520-870-3521 | ◊ 15andrewh@gmail.com | ◊ Provo, UT

## Education

**Brigham Young University** *Provo, UT*
B.S. Civil Engineering; 3.29 GPA; Dec. 2023 Expected Graduation
Mathematics Minor

## Experience

**Brigham Young University**
Civil Engineering Teaching Assistant *Jan 2021 – CURRENT*
- CEEN 170, computer science and Excel VBA
- Evaluated and graded assignments for 80+ students
- Coached student teams on term projects, held meetings to discuss course concepts
- Coordinate between professor and other TAs concerning class goals and tasks

**Granger Hunter Improvement District**
Engineering Intern *MAY 2022 – AUG 2022*
- Performed inspections for construction according to District specifications.
- Gathered lead and copper for regular EPA test. Analyze data for other Water Quality tasks.
- Oversee construction of capital projects, generate reports, track financing.

**Action Target**
Data Entry Clerk *APR 2021 – AUG 2021*
- Generated reports from market research
- Performed analysis of sales and inventory
- Contacted and responded to clients in addition to making sale orders and invoices per client requests
- Managed spreadsheets containing sales information

**Brigham Young University**
Building and Event Security *SEPT 2017 – JAN 2018*
- Provided security at BYU venues during public events as well as enforced venue policies.
- Patrolled campus to ensure over 30 campus buildings are secure and empty after close.
- Assisted campus police in task as well as assisted students, faulty, and visitors.

## Skills

**Software** ArcGISPro, Revit, AutoCAD Civil 3D, Bluebeam, Microsoft Word, Microsoft Excel, Excel VBA, Python, HTML

## Accomplishments

**American Society of Civil Engineers** Local and National membership

**Concrete Canoe** Compete with other schools in designing and racing a canoe made of concrete

**Eagle Scout**

## Appendix B

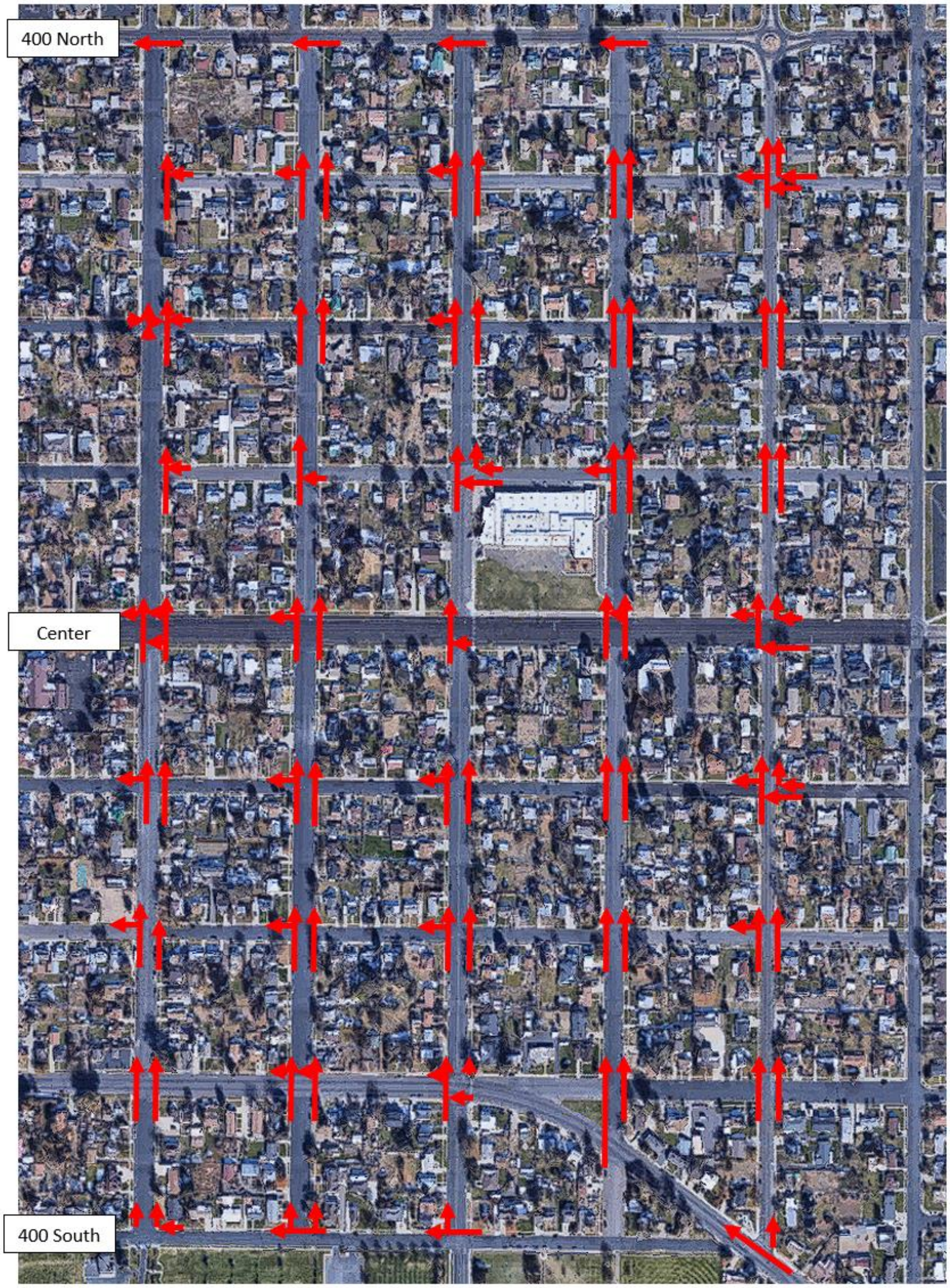


*Figure 6: Flow Map*

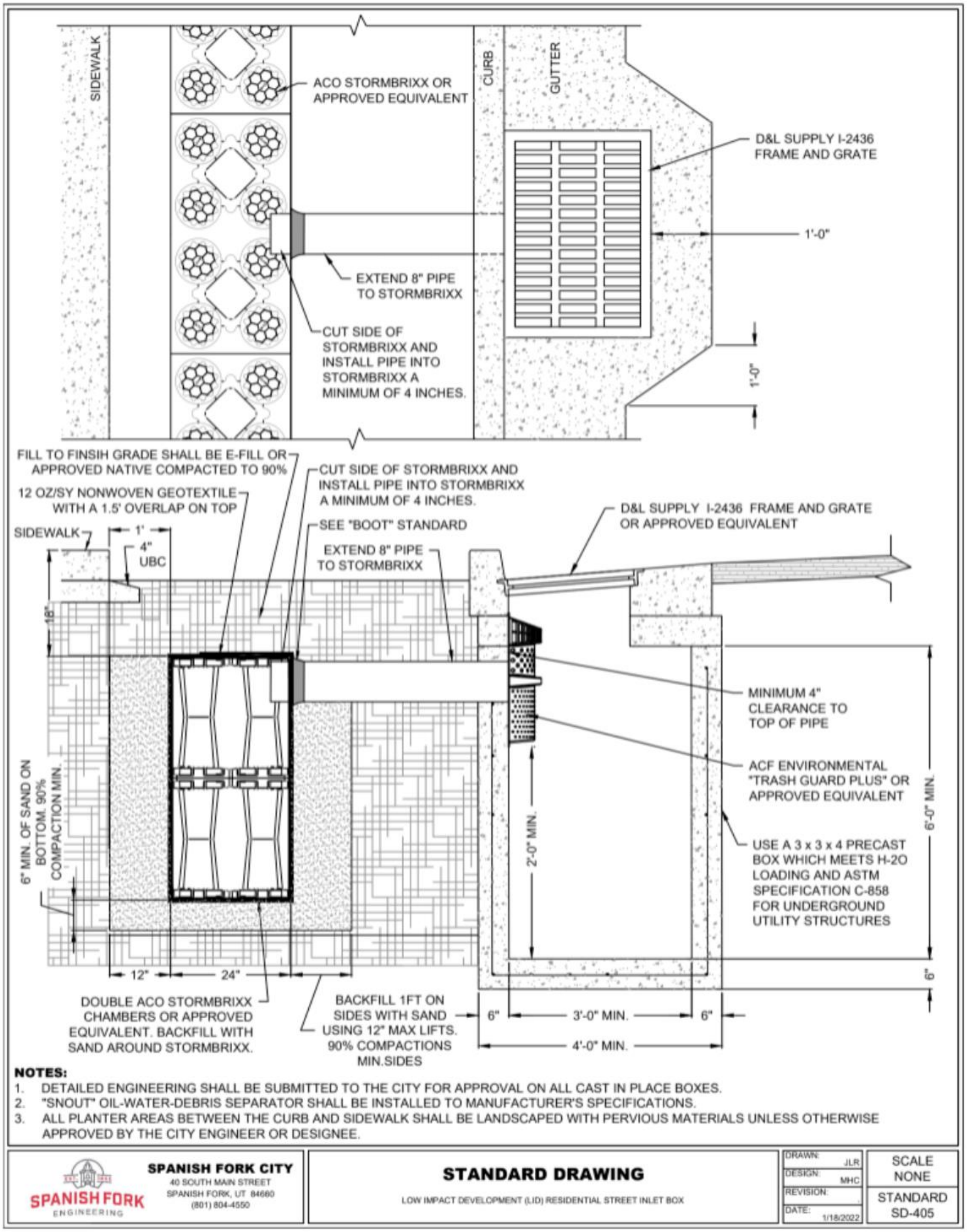


*Figure 7: Stormbrixx Standard Drawing*

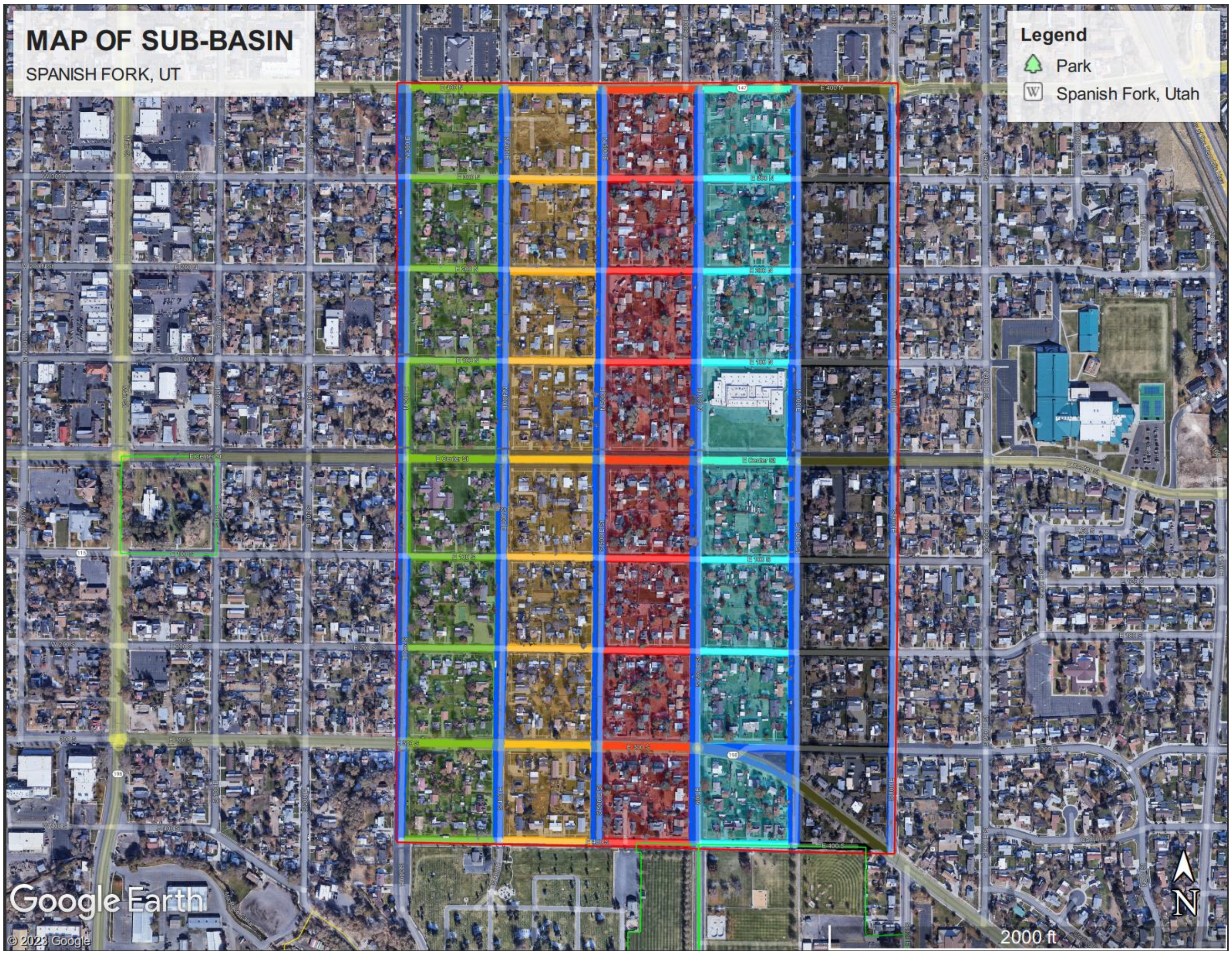

*Figure 8: Sub-Basins*

*EXISTING VOLUME ACCUMULATION*

*Table 11: Stormwater Flow of 700 E*

| 700E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 6252.2 | No split | 8364.39 | No split | 1 | 1 | 0 | 0 |
| 200 S | 7504.3 | No split | 17730.51 | No split | 1 | 1 | 0 | 0 |
| 100 S | 8756.5 | No split | 37234.07 | No split | 1 | 1 | 0 | 0 |
| Center st | 30354.0 | No split | 30518.1 | 60/40 | 1 | 1 | 0 | 0 |
| 100 N | 25284.9 | 80/20 | 38882.5 | No split | 1 | 1 | 0 | 0 |
| 200 N | 26537.1 | No split | 47246.9 | No split | 1 | 1 | 0 | 0 |
| 300 N | 27789.2 | No split | 75575.3 | No split | 1 | 1 | 0 | 0 |
| 400 N | 29041.4 | No split | 83939.6 | No split | 1 | 1 | 0 | 0 |
| flow = | 29041 | flow = | 83940 | | 8 | 8 | 16 | 0 |

*Table 12: Stormwater Flow of 600 E*

| 600E | L. Flow (Cf) | type Split | R. Flow (Cf | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 8769.9 | 60/40 | 0.00 | 0/100 | 1 | 1 | 0 | 0 |
| 200 S | 6013.2 | 60/40 | 8364.39 | No split | 1 | 1 | 0 | 0 |
| 100 S | 4359.2 | 60/40 | 16728.79 | No split | 1 | 1 | 0 | 0 |
| Center st | 30704.6 | No split | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| 100 N | 47751.9 | No split | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| 200 N | 29402.5 | 60/40 | 8364.4 | No split | 1 | 1 | 0 | 0 |
| 300 N | 18392.8 | 60/40 | 16728.8 | No split | 1 | 1 | 0 | 0 |
| 400 N | 19644.9 | No split | 25093.2 | No split | 1 | 1 | 0 | 0 |
| flow = | 19645 | flow = | 25093 | | 8 | 8 | 16 | 0 |

*Table 13: Stormwater Flow of 500 E*

| 500E | L. Flow (Cf) | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 4161.9 | 60/40 | 8526.61 | 60/40 | 1 | 1 | 0 | 0 |
| 200 S | 3248.5 | 60/40 | 20899.83 | No split | 1 | 1 | 0 | 0 |
| 100 S | 2700.4 | 60/40 | 32170.39 | No split | 1 | 1 | 0 | 0 |
| Center st | 2371.5 | 60/40 | 40534.8 | No split | 1 | 1 | 0 | 0 |
| 100 N | 52522.8 | No split | 0.0 | 0/100 | 1 | 1 | 0 | 0 |
| 200 N | 53775.0 | No split | 27966.0 | No split | 1 | 1 | 0 | 0 |
| 300 N | 33016.3 | 60/40 | 48592.3 | No split | 1 | 1 | 0 | 0 |
| 400 N | 34268.4 | No split | 56956.7 | No split | 1 | 1 | 0 | 0 |
| flow = | 34268 | flow = | 56957 | | 8 | 8 | 16 | 0 |

*Table 14: Stormwater Flow of 400 E*

| 400E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1252.2 | No split | 11139.02 | No split | 1 | 1 | 0 | 0 |
| 200 S | 1502.6 | 60/40 | 0.00 | No split | 1 | 1 | 0 | 0 |
| 100 S | 1652.8 | 60/40 | 10164.64 | No split | 1 | 1 | 0 | 0 |
| Center st | 4156.2 | 60/40 | 16088.0 | 80/20 | 1 | 1 | 0 | 0 |
| 100 N | 5408.4 | No split | 24452.4 | No split | 1 | 1 | 0 | 0 |
| 200 N | 6660.5 | No split | 32816.8 | No split | 1 | 1 | 0 | 0 |
| 300 N | 7912.7 | No split | 63192.1 | No split | 1 | 1 | 0 | 0 |
| 400 N | 9164.8 | No split | 71556.5 | No split | 1 | 1 | 0 | 0 |
| flow = | 9165 | flow = | 71556 | | 8 | 8 | 16 | 0 |

*Table 15: 6 ft Tank Stormwater Flow of 700 E*

| 700E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 6252.2 | No split | 6769.39 | No split | 1 | 1 | 0 | 55 |
| 200 S | 3444.3 | No split | 8501.03 | No split | 1 | 1 | 140 | 226 |
| 100 S | 1796.5 | No split | 6907.18 | No split | 1 | 1 | 100 | 356 |
| Center st | 6455.7 | No split | 7285.6 | 60/40 | 1 | 1 | 50 | 150 |
| 100 N | 6166.2 | 80/20 | 9705.0 | No split | 1 | 1 | 0 | 205 |
| 200 N | 6403.4 | No split | 8644.4 | No split | 1 | 1 | 35 | 325 |
| 300 N | 2725.6 | No split | 21077.3 | No split | 1 | 1 | 170 | 115 |
| 400 N | 2237.7 | No split | 25091.7 | No split | 1 | 1 | 60 | 150 |
| flow = | 2238 | flow = | 25092 | | 8 | 8 | 16 | 2137 |

*Table 16: 6 ft Tank Stormwater Flow of 600 E*

| 600E | L. Flow (Cf) | type Split | R. Flow (Cf | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 4907.1 | 60/40 | 0.00 | 0/100 | 1 | 1 | 167 | 55 |
| 200 S | -45.4 | 60/40 | 5174.39 | No split | 1 | 1 | 215 | 110 |
| 100 S | -1197.9 | 60/40 | 5635.07 | 60/40 | 1 | 1 | 240 | 143 |
| Center st | -3781.3 | No split | 0.0 | 0/100 | 1 | 1 | 125 | 490 |
| 100 N | 9061.0 | No split | 0.0 | 0/100 | 1 | 1 | 145 | 0 |
| 200 N | 4795.9 | 60/40 | 6914.4 | No split | 1 | 1 | 80 | 50 |
| 300 N | 2497.8 | 60/40 | 12813.8 | No split | 1 | 1 | 65 | 85 |
| 400 N | 995.0 | No split | 17408.2 | No split | 1 | 1 | 95 | 130 |
| flow = | 995 | flow = | 17408 | | 8 | 8 | 16 | 2195 |

*Table 17: 6 ft Tank Stormwater Flow of 500 E*

| 500E | L. Flow (Cf) | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1421.1 | 60/40 | 2979.49 | 60/40 | 1 | 1 | 30 | 230 |
| 200 S | -658.1 | 60/40 | 7543.59 | No split | 1 | 1 | 130 | 130 |
| 100 S | 67.7 | 60/40 | 6281.62 | 60/40 | 1 | 1 | 161 | 160 |
| Center st | -2079.1 | 60/40 | 7541.0 | No split | 1 | 1 | 165 | 245 |
| 100 N | 11598.5 | No split | 0.0 | 0/100 | 1 | 1 | 50 | 70 |
| 200 N | 11110.6 | No split | 6631.7 | No split | 1 | 1 | 60 | 170 |
| 300 N | 6199.7 | 60/40 | 14196.3 | No split | 1 | 1 | 70 | 85 |
| 400 N | 1651.8 | No split | 19370.7 | No split | 1 | 1 | 200 | 110 |
| flow = | 1652 | flow = | 19371 | | 8 | 8 | 16 | 2066 |

*Table 18: 6 ft Tank Stormwater Flow of 400 E*

| 400E | L. Flow (Cf) | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1252.2 | No split | 4526.79 | No split | 1 | 1 | 0 | 165 |
| 200 S | 1502.6 | 60/40 | 0.00 | No split | 1 | 1 | 0 | 60 |
| 100 S | 1652.8 | 60/40 | 6814.53 | No split | 1 | 1 | 0 | 55 |
| Center st | 2789.1 | 60/40 | 6974.3 | 80/20 | 1 | 1 | 0 | 175 |
| 100 N | 4041.3 | No split | 12003.7 | No split | 1 | 1 | 0 | 115 |
| 200 N | 5293.4 | No split | 17178.1 | No split | 1 | 1 | 0 | 110 |
| 300 N | 6545.6 | No split | 27065.6 | No split | 1 | 1 | 0 | 90 |
| 400 N | 7797.8 | No split | 34415.0 | No split | 1 | 1 | 0 | 35 |
| flow = | 7798 | flow = | 34415 | | 8 | 8 | 16 | 805 |

*Table 19: 9 ft Tank Stormwater Flow of 700 E*

| 700E | L. Flow (Cf) | type Split | R. Flow (Cf) | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 6252.2 | No split | 6109.39 | No split | 1 | 1 | 0 | 55 |
| 200 S | 1764.3 | No split | 1913.03 | No split | 1 | 1 | 140 | 226 |
| 100 S | -1083.5 | No split | -7303.22 | No split | 1 | 1 | 100 | 356 |
| Center st | -3965.0 | No split | -3125.3 | 60/40 | 1 | 1 | 50 | 150 |
| 100 N | -2170.2 | 80/20 | -3165.9 | No split | 1 | 1 | 0 | 205 |
| 200 N | -2353.1 | No split | -8126.6 | No split | 1 | 1 | 35 | 325 |
| 300 N | -8070.9 | No split | -1739.4 | No split | 1 | 1 | 170 | 115 |
| 400 N | -9278.8 | No split | 475.0 | No split | 1 | 1 | 60 | 150 |
| flow = | -9279 | flow = | 475 | | 8 | 8 | 16 | 2137 |

*Table 20: 9 ft Tank Stormwater Flow of 600 E*

| 600E | L. Flow (C | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 5000 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 3308.7 | 60/40 | 0.00 | 0/100 | 1 | 1 | 167 | 55 |
| 200 S | -2552.5 | 60/40 | 3854.39 | No split | 1 | 1 | 215 | 110 |
| 100 S | -5158.8 | 60/40 | 3813.47 | 60/40 | 1 | 1 | 240 | 143 |
| Center st | -16943.8 | No split | 0.0 | 0/100 | 1 | 1 | 125 | 490 |
| 100 N | -5841.4 | No split | 0.0 | 0/100 | 1 | 1 | 145 | 0 |
| 200 N | -4721.6 | 60/40 | 6314.4 | No split | 1 | 1 | 80 | 50 |
| 300 N | -3680.6 | 60/40 | 11193.8 | No split | 1 | 1 | 65 | 85 |
| 400 N | -6323.5 | No split | 14228.2 | No split | 1 | 1 | 95 | 130 |
| flow = | -6323 | flow = | 14228 | | 8 | 8 | 16 | 2195 |

*Table 21: 9 ft Tank Stormwater Flow of 500 E*

| 500E | L. Flow (C | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 286.9 | 60/40 | 684.13 | 60/40 | 1 | 1 | 30 | 230 |
| 200 S | -2274.5 | 60/40 | 2016.87 | No split | 1 | 1 | 130 | 130 |
| 100 S | -4482.3 | 60/40 | 229.24 | 60/40 | 1 | 1 | 161 | 160 |
| Center st | -5997.1 | 60/40 | -1451.4 | No split | 1 | 1 | 165 | 245 |
| 100 N | -2751.9 | No split | 0.0 | 0/100 | 1 | 1 | 50 | 70 |
| 200 N | -3959.8 | No split | -1753.3 | No split | 1 | 1 | 60 | 170 |
| 300 N | -3346.6 | 60/40 | 672.3 | No split | 1 | 1 | 70 | 85 |
| 400 N | -10294.4 | No split | 4526.7 | No split | 1 | 1 | 200 | 110 |
| flow = | -10294 | flow = | 4527 | | 8 | 8 | 16 | 2066 |

*Table 22: 9 ft Tank Stormwater Flow of 400 E*

| 400E | L. Flow (C | type Split | R. Flow (C | Split Type | Amount | Column1 | Tank Len | Column2 |
|---|---|---|---|---|---|---|---|---|
| Int. flow R | 0 | Int. flow L | 0 | | L | R | L | R |
| 300 S | 1252.2 | No split | 1790.69 | No split | 1 | 1 | 0 | 165 |
| 200 S | 1502.6 | 60/40 | 0.00 | No split | 1 | 1 | 0 | 60 |
| 100 S | 1652.8 | 60/40 | 3121.17 | No split | 1 | 1 | 0 | 55 |
| Center st | 1780.5 | 60/40 | 250.0 | 80/20 | 1 | 1 | 0 | 175 |
| 100 N | 3032.6 | No split | 3899.4 | No split | 1 | 1 | 0 | 115 |
| 200 N | 4284.8 | No split | 7753.8 | No split | 1 | 1 | 0 | 110 |
| 300 N | 5537.0 | No split | 10197.1 | No split | 1 | 1 | 0 | 90 |
| 400 N | 6789.1 | No split | 17126.5 | No split | 1 | 1 | 0 | 35 |
| flow = | 6789 | flow = | 17127 | | 8 | 8 | 16 | 805 |


*Figure 9: Tank Locations of 400 N 500 E*


*Figure 10: Tank Locations of 400N 300 E*


*Figure 11: Tank Locations of Center St 300E*


*Figure 12: Tank Locations E center St S 800 E through S 600 E*


*Figure 13: Tank Locations East 300 S 800 E through S 600 E*


*Figure 14: Tank Locations E center St S 500 E through S 200 E*


*Figure 15: Tank Locations East 300 S 500 E through S 200 E*