BLUFFDALE CITY GIS STORMWATER MODEL
Project ID: CEEn-2019CPST-005

by

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A Capstone Project Final Report

Submitted to

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Introduction

Background

In 2019, the City of Bluffdale and J-U-B Engineers came together to sponsor a Brigham Young University Capstone project to improve understanding and documentation of the stormwater system in Bluffdale City. Three BYU students, Jarrad Larsen, Tyler Mecham, and Ben Martineau formed a team, calling themselves J-T-B Engineering, and were assigned by the instructors of BYU's Capstone course to complete the project sponsored by the City and J-U-B. The team and their sponsors decided to limit the scope to a comprehensive study of one of the 24 sub-basins within Bluffdale City, named Bluffdale City Park, and an overview of the Area of Interest will be discussed below.

Objectives

The objectives of the project were to update the existing GIS model of the stormwater infrastructure in the sub-basin, to update two EPA SWMM models of the existing conditions of the sub-basin, and to propose improvements to the system to prevent flooding and high velocities in the pipes.

Schedule Overview

In order to accomplish the objectives of the project, J-T-B Engineering first took several trips to Bluffdale to manually measure storm drain structure and conduit depths and sizes. The team used equipment provided by the City of Bluffdale to shoot GPS points at each of the locations of interest for use in the GIS model. All field work was completed between November 2019 and early March, 2020. Once all of the data was collected, the team built out the existing infrastructure in several GIS shapefiles, coordinating with representatives of the City and J-U-B to answer relevant questions. Throughout the month of March, 2020, the team worked to create EPA SWMM models of the stormwater system's flow capacity, utilizing 10-year and 100-year occurrence storm events. Finally, the team made adjustments to the SWMM models to simulate proposed conditions that adequately convey the runoff of the design storms. This work was completed in early April, 2020. A detailed layout of dates and what was accomplished can be viewed in Appendix B.

Area of Interest

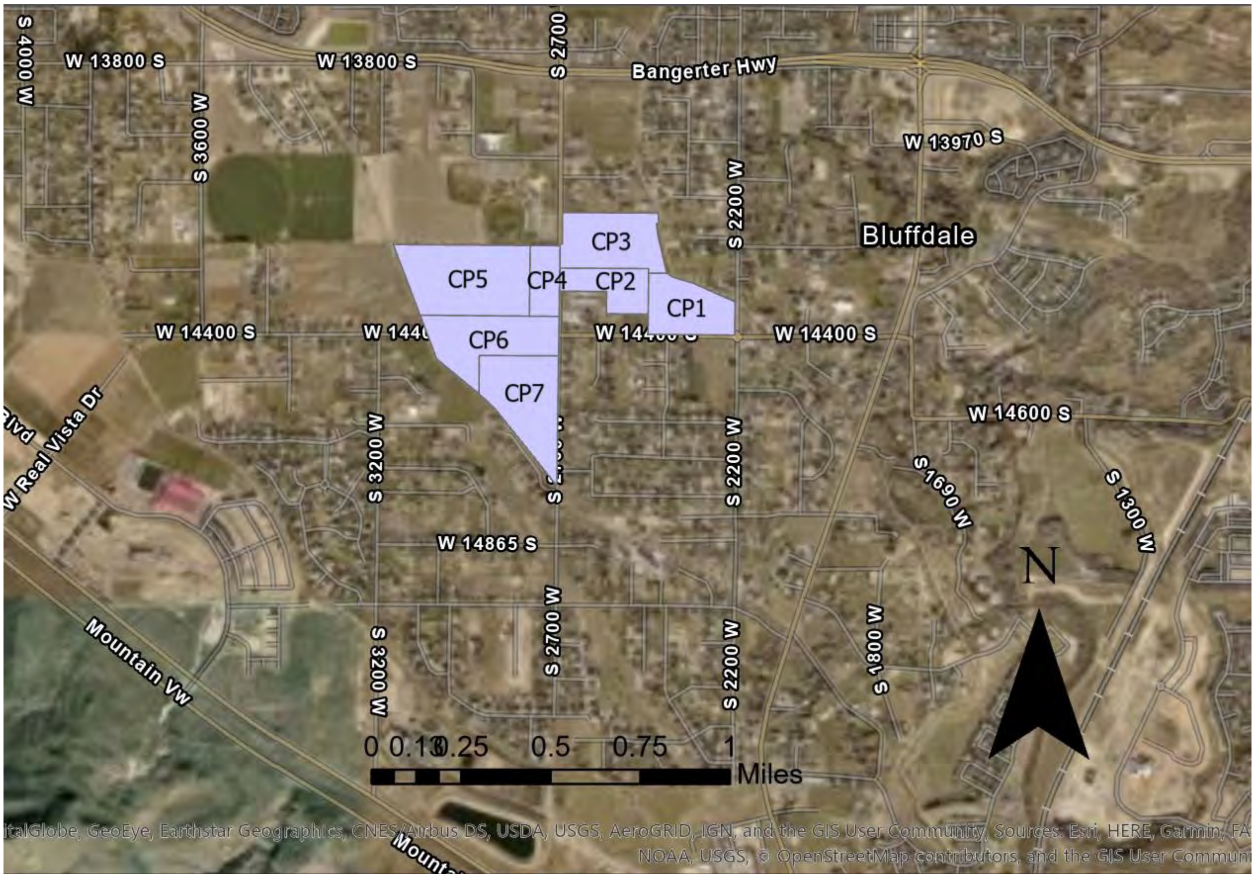


Figure 1: The Bluffdale City Park Watershed in the Context of Bluffdale City

Table 1: Subcatchment Areas

Subcatchment Name	Area (acres)
CP1	21.776
CP2	14.864
CP3	27.764
CP4	10.371
CP5	43.259
CP6	30.393
CP7	32.375

Total Area: 180.802 Acres

The Bluffdale City Park sub-basin as shown above in Figure 1 spans between the Utah Lake Distribution Canal in the south-east, and the Utah and Salt Lake Canal on the north-west. It excludes infrastructure along 14400 S between City Hall and 2700 W because they drain to a different subbasin, but includes the structures and conduit west of 2700 W to the Utah Lake Distribution Canal. Water flows generally from south-east to north-west, where it eventually is detained at the Bluffdale City Park Pond before outfalling into the Utah and Salt Lake Canal. Figures 2 through 4 below shows the sub-basin in greater detail, including the numbering system used to label each box, invert elevations, and pipe diameters and slopes.

Figure 2: Vicinity Map with Conduit, Subcatchments, and Nodes (Node numbers labeled)

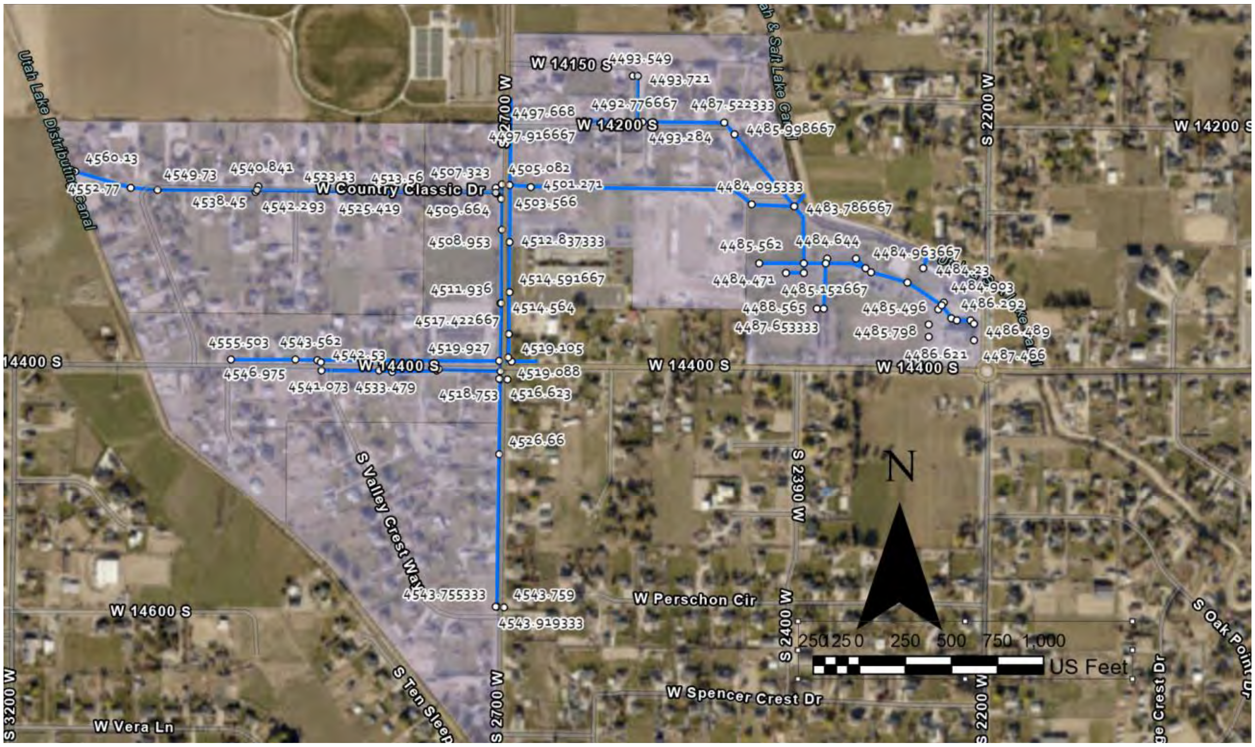


Figure 3: Vicinity Map with Conduit, Subcatchments, and Nodes (Invert Elevations of Boxes Labeled)

Figure 4: Vicinity Map with Conduit, Subcatchments, and Nodes (Diameters of Pipes in Feet Labeled Green, Slope of Pipes labeled White)

Table 2 below summarizes the storm drain pipe lengths by diameter, and Table 3 summarizes the number of storm drain boxes by type.

Table 2: Summary of Pipe in Subbasin by Diameter

Diameter (feet)	Length (feet)
0.8333	2294.041
1	2075.532
1.25	6009.56
1.5	2454.087
2	222.0898
2.5	1318.2

Table 3: Summary of Boxes in Subbasin by Type

Box Type	Amount
Curb Inlet	51
Irrigation	6
Manhole	21

Outline of Report

The remainder of this report covers the work done in greater detail. It is divided into six segments; Data Collection, Pre-Processing, Modeling Approach, Results, Recommendations, and Conclusions, following the chronology of the team's workflow.

Data Collection

Pre-field Work

Before going into the field to collect data, J-T-B Engineering needed to acquire survey equipment and learn how to operate it. In selecting GPS equipment, options were limited to the BYU Civil Engineering (CE EN) Department's TopCon base and rover, and Bluffdale City's Trimble equipment which was reserved for use by the city staff. The team originally elected to use the equipment owned by BYU so team members would be able to gain experience learning to operate it. The initial drawback to using the BYU equipment was that other CE EN students occasionally reserved the TopConn equipment on days the team planned to survey. Before beginning field work, a team member was trained in the basics of how to use the equipment, and provided with written instructions by the office in charge of its maintenance at the university.

DIP Sheet

While in the field, the team measured the storm drain system pipe diameter, depths to flowlines, and box depths. In an early meeting at J-U-B Engineers, the team received a dip sheet template. A dip sheet is an outlined paper used by stormwater and sewer surveyors to record data, and keep things well organized and understandable. It permits the user to keep track of pipe directions, depths, sedimentation, box condition etc. An image of the dip sheet provided by J-U-B is provided in Appendix A for reference. During the first couple of days of data collection, the team focused on filling out DIP sheets. On the third field visit, team members began recording pipe sedimentation on the DIP sheets.

Review Existing Data

Before data collection in the field, J-T-B Engineering reviewed the GIS and SWMM models to understand the mechanics of the system. The team checked what parameters would need to be collected for the models.

Survey

J-T-B began by taking survey points in Bluffdale with minor setbacks setting up the equipment. The team shot data points while completing dip sheets one at a time. During initial post-processing, J-T-B noticed that the surveyed points did not match up with the basemap in GIS. GIS displayed horizontal error in excess of 3 feet in some locations. The error varied inconsistently across the map, eliminating the possibility of a false northing and easting issue. Attempts to correlate the data with control points from the City provided no solution. Further data collection was halted to allow for problem solving, and when no solution was found, it was decided the team would use the City Surveyor's Trimble equipment and resurvey the points.

Field Work

A minimum of two team members at a time traveled to Bluffdale to collect data. The city provided an employee and a vehicle each trip for safety and assistance. Where possible the lids to the manholes and grates were removed for more accurate measurements to be taken. At each location, box invert elevations, flow line invert elevation, pipe location and pipe diameter were noted on a dip sheet. The grates and covers were then mapped with the survey equipment. Field work began in October 2019 and ended in early March 2020.

Pre-Processing

Download Data

The City of Bluffdale provided their existing GIS and SWMM models. The surveyor from the City of Bluffdale extracted the collected data from the Trimble devices and sent it to the team via email as .csv, and .dwg files. The dip sheet data was recorded in the field on paper and manually entered into an excel file, where each row corresponded to a point in the field. Columns represented GPS coordinates, pipe diameters, depths to flowlines, and flowline elevations. A team member downloaded the csv file with coordinates and converted coordinate data to points. These points were used to represent the boxes.

Correlated to GIS

As the data was being added to the GIS map, the J-T-B Engineering compared the existing pipe network with the added points and the DIP sheet data. Flow direction was determined by comparing flowline elevations between boxes and assuring that water flows to the Bluffdale City Park pond. Team members identified adverse slopes when water would flow away from the pond. Amidst the review process, the team determined the inlets on Country Classic Drive are all Low Impact Development (LID). This implies that much of the runoff from this watershed is routed elsewhere as opposed to contributing to flow in stormwater infrastructure. Assumptions regarding how LID affects flow are stated in a later section. The team drew polylines between points to represent conduit in a separate shapefile and added metadata as attributes manually.

Quality Control/Assurance

To Quality Control (QC) the data, team members sorted attribute tables in GIS to look for outliers for each attribute. Attributes in GIS included diameter, slope, Manning's roughness, material, and length for conduit, and coordinates, surface elevation, depth to invert, and invert elevation for the nodes. There were instances where QC work provided indications of points that had been missed in the data collection process, such as zeroes in the diameter attribute of pipes, or pipes whose lengths were larger than expected (around 400 feet). This provided an opportunity to return, search for, and collect any data that had been missed in the field. The team compared surveyed points with the original points provided by the city and found surveyed data to be within a few inches of accuracy.

Modeling Approach

EPA SWMM Limitations

The SWMM program is limited in its ability to model non-urban areas, irrigated cropland, and daily rainfall data. It is also unable to model manhole or inlet loss directly. SWMM typically is able to handle water budget aspects such as irrigation or water supply as well as sediment transport and erosion routines. The team decided the SWMM model developed for Bluffdale would neglect these functions due to lack of necessary data.

The EPA SWMM model is limited primarily in scope. Due to time constraints, and the diminishing value of detail within a model, the SWMM model does not display every pipe, intersection, junction box, and grate nor did it allow for a precise delineation of all subcatchments. The model is also limited in that soil types, Manning's N, and infiltration rates were not specifically analyzed and calculated in fine detail for each individual component of the model. Instead, conditions throughout the watershed were generalized as a whole and applied unilaterally. The model is ultimately limited in the accuracy of prior observations. The model is divided into subcatchments based on the nearest roads and elevation data provided by Bluffdale City to make a representative model of actual conditions. This allows for the model to report overall performance of the system, by accurately modeling the pipes further downstream in the model, with a loss in precision for the smaller upstream pipes. The numerical analysis is also based on numerical assumptions, and is not able to be calibrated with any observed conditions due to a lack of any stormwater system flow data or precipitation data. The results are therefore based on a design storm event.

Model Input

The SWMM model for Bluffdale City Park was previously split into an upper and lower model for both the 10-year and 100-year models. These were combined into a model for the 10-year storm events and a model for the 100-year storm event. This was done to normalize the input of model parameters throughout the watershed and allow for greater ease in modeling. Figure 5 shows a concatenation of the previously existing upper and lower model and Figure 6 shows the newly constructed model.

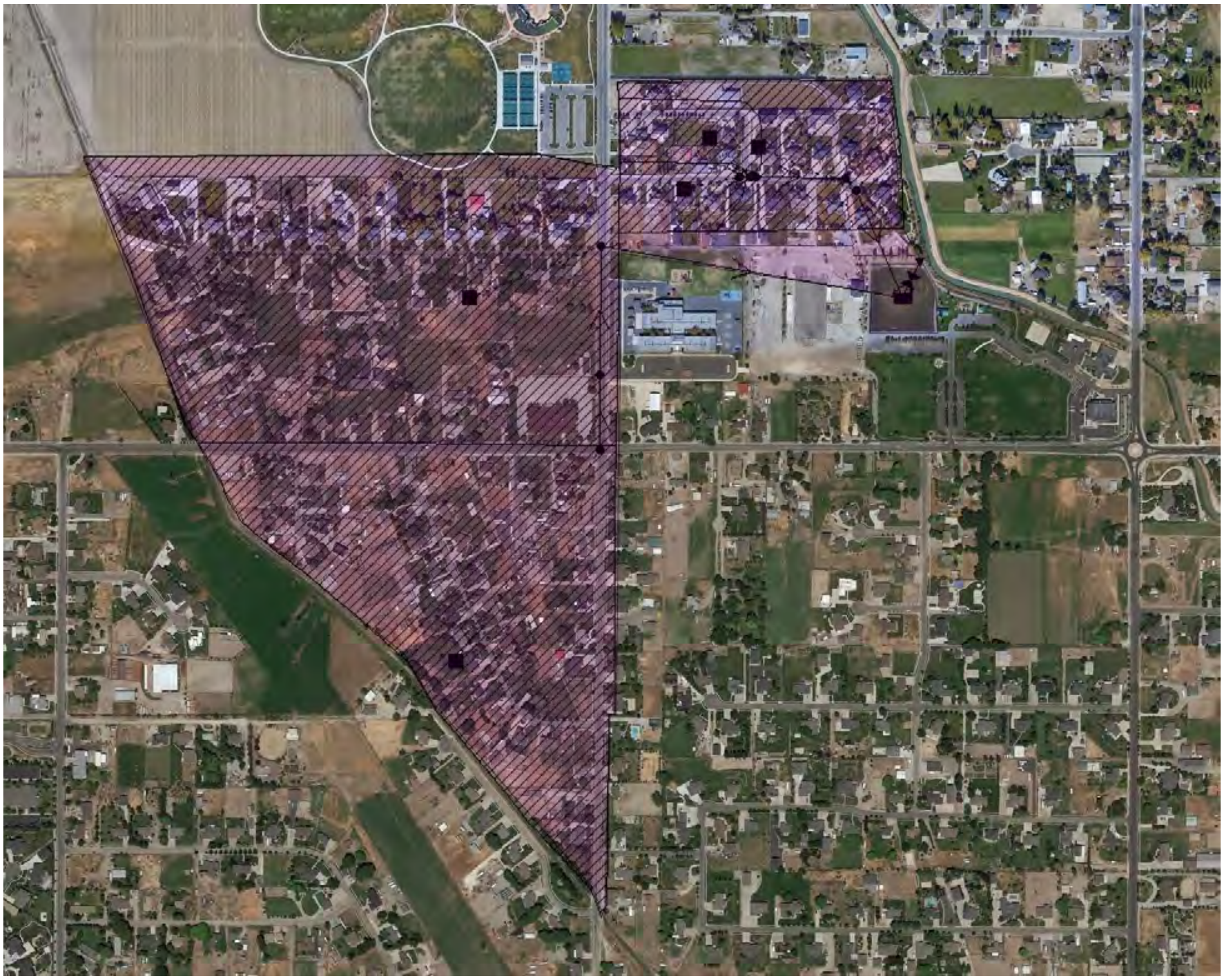


Figure 5: Previous SWMM Model of Bluffdale City Park Watershed

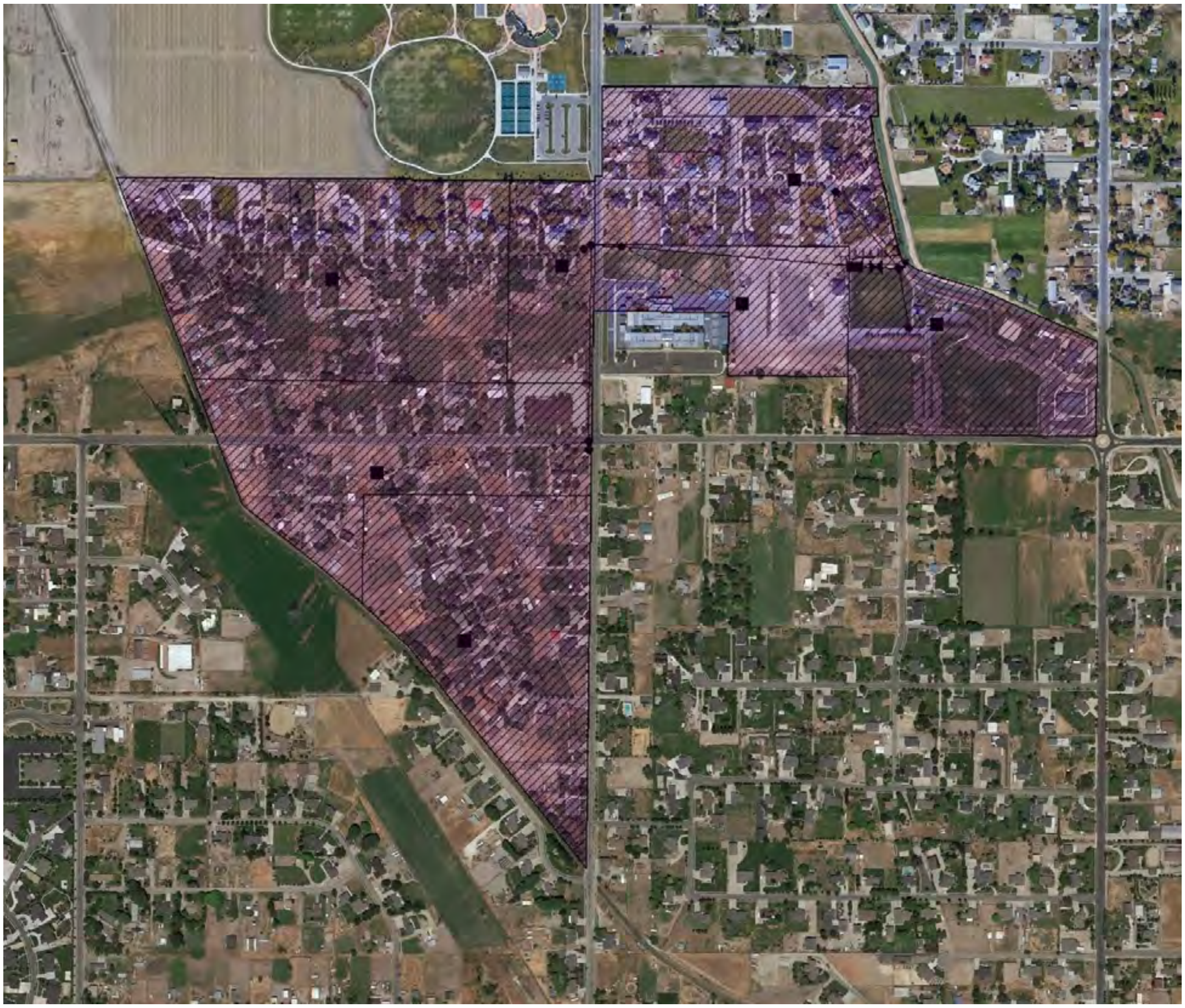


Figure 6: Updated SWMM Model of Bluffdale City Park Watershed

J-T-B Engineering first updated the SWMM model with more detailed polygons delineating the watershed. J-T-B achieved this by outlining city land parcels in CAD and assigned streets and parcels to drain down certain streets in coordination with a city provided DEM.

The georeferenced manholes from J-T-B's survey provide updated locations for subcatchment inlets and their connecting junctions, outlets, as well as the storage pond and outfall. J-T-B used the data compiled from the dip sheets to verify and update link conditions.

The rainfall data in use is from an SCS Type II rainfall curve as obtained from NOAA. This input varies between the 10-year and 100-year storm. The implementation of the SCS rainfall data is one of the main purposes of the project. For the 10-year storm, rainfall volume was 1.68 inches, and for the 100-year storm, the volume was 2.37 inches.

Some points of notice regarding modeling conditions are:

1. The elevation of the detention pond is set at an equal or greater elevation than the pond outlet to allow SWMM to run without error.
    a. Under actual conditions, the lowest elevation of the pond is lower than the pond outlet. This generates an adverse slope error in the model..
2. No ponding occurs at junction boxes in the model
3. Both the slope and Froude numbers are used to determine supercritical flow
4. The force main equation in use is Hazen-Williams
5. A variable step is used in iterations to reach convergence instead of a lengthened step
    a. A variable step allows for the time step to be adjusted from e.g. a 15-minute step to a 14-minute step to allow the model to converge
    b. A lengthened step allows for the period of time steps to be lengthened from e.g. 24 hours to 25 hours to allow the model to converge
6. The model is limited to 8 iterative runs maximum to achieve convergence
7. Zero head tolerance is allowed in the model between iterations
    a. Zero head tolerance specifies that head may not be varied between run iterations to achieve convergence
8. A maximum percent difference of 5% between total system inflow and outflow is allowed
    a. This specifies a maximum percent difference in inflow for the model to be considered in a steady flow period
9. Manning's N values for materials and soils are used in accordance with the EPA-SWMM User's Manual Version 5.1
10. The 24" diameter pipe at the outfall of the watershed acts as an orifice for the pond and outfall

J-T-B Engineering used the same shapefile created in CAD to update the GIS model. The complete index of surveyed manholes, grates, junction boxes, pipes, and inverts supplement the previously existing model with current and updated data. The GIS proposed conditions model reflects the proposed SWMM conditions. In comparing and entering the data into GIS, several points of conflict between data taken and the original model were found The following comments enumerate modeling some discontinuities and decisions made:

1. In the case of discrepancies between pipe diameters, the smaller pipe size is used for a more conservative model
2. Several existing pipes on Country Classic Drive were paved over and are unobservable. It is assumed they connect to the system as shown in the original model
    a. Metadata for pipes along Country Classic are assumed to be the same as in the model provided by the City of Bluffdale
3. The boxes at the southwest and southeast corners of the 2700 W / 14400 S intersection are assumed to be LID.
4. The junctions at the north side of 14400 South between Valley Crest Way and City Park are assumed to all connect in a line.
5. At least one box in City Park drains directly to the pond, as shown in GIS (point 603)
6. A junction box located in City Park was observed to have several inlets that cannot be correlated with existing conditions in the map.

Assumptions

Due to the scope of the project and the nature of SWMM, the model makes several assumptions regarding real world conditions.

1. To make a conservative assumption that the system was already partially saturated, it is assumed throughout the model that there were zero dry days before the storm event took place.
2. Partial inertial dampening is assumed for the watershed
    a. Dampening reduces the terms as flow comes closer to being critical and ignores them when flow is supercritical.
3. It is assumed there was no water depth in junction boxes at the start of the simulation
4. No LID is included in the model because:
    a. To allow for conservative results, it is assumed that all LID existing in the model was flooded at the time of the simulation. This assumption is based on a lack of data regarding the performance and flow capacity of the LID drains.
        i. Therefore, it is further assumed all rainfall falling into subcatchment with LID would run off into the nearest inlet.

Sensitivity Analysis

Several parameters were initially set at default values during the initial model runs. These default parameter values yielded unsatisfactory results, and no safe assumptions could be made. For these parameters, J-T-B Engineering performed a sensitivity analysis to identify reasonable values that would allow for the model to perform as expected.

There was insufficient time to perform infiltration field tests for greater accuracy, therefore a team member performed a sensitivity analysis on the infiltration inputs for each subcatchment. Using Horton's model, there are four inputs to be adjusted; maximum and minimum infiltration rates (in inches/hour), Decay Constant (values between 2 and 7), and Drying Time. Drying Time is not significant for a 24-hour storm event, therefore the default value of 7 days was used. When testing the sensitivity of the Decay Constant, the team found that values between 4 and 7 yield the same infiltration volumes. Changing the Maximum Infiltration rate did little to affect total infiltration. The minimum infiltration rate had the greatest sensitivity. The City of Bluffdale representatives indicated that typically observed values for infiltration were around 40% of total rainfall volume. With that target, the team adjusted minimum infiltration rates until SWMM computed realistic values for infiltration. J-T-B recommends use of a Maximum Infiltration rate of 0.8 in/hr, a minimum rate of 0.1 in/hr, a Decay Constant of 4, and Drying Time of 7 days as inputs for Horton's model infiltration.

Evaporation in EPA SWMM is an input of the Climatology module. There are several ways evaporation can be computed, including through the use of a climate file, temperatures, monthly averages, and a single constant value. For simplicity, and because evaporation is minimal for a 24-hour rainfall event, team members elected to use a single constant value. During a single rainfall event, air is nearly saturated, and therefore will not take on much evaporated water. After performing a sensitivity analysis on the single constant value, J-T-B Engineering recommends an evaporation rate of no greater than 0.05 in/day.

Approach

Upon construction, the SWMM model representing existing conditions ran well and produced accurate results. First, J-T-B Engineering ran the 10-year storm event and sized all network pipes to meet required system flow capacity. The proposed model is constructed from upstream to downstream, upsizing pipes and specifying drop box locations where required for proper model performance.

Following the resizing of the pipes for the 10-year storm, a 100-year storm event was run. The system and detention pond were found to be adequate for both storm events and no further recommendations are made for the 100-year event. See Figure 7.

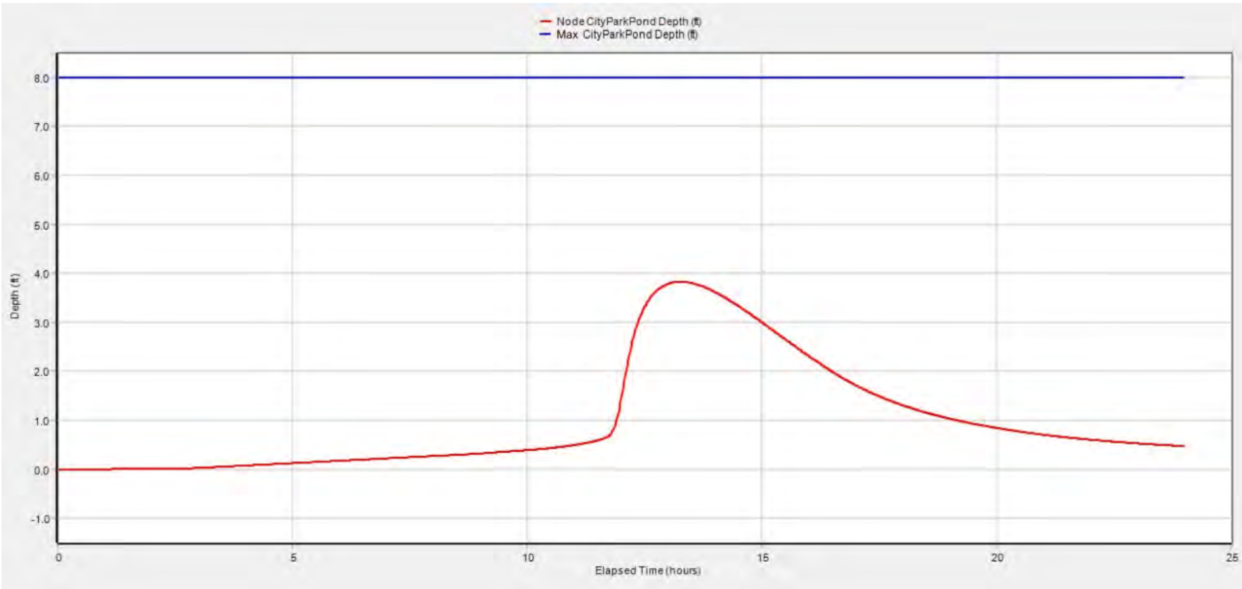


Figure 7: 100-Year Storm Event Storage Pond Capacity and Demand

J-T-B Engineering updated the GIS model as data was collected and post-processed to reflect existing and proposed conditions.

Results

Existing

The SWMM model reflecting existing conditions was found to operate at maximum flow capacity in most pipes during the storm event. The plateau in the curve in Figure 8 shows where maximum flow capacity was reached in the simulation for Link6. These pipes required upsizing to meet flow requirements.

Several pipes were found to have flows in excess of the City specified 15 feet/second. Significant flooding and runoff was also found in the model, due to the pipes meeting flow capacity for a sustained period of time.

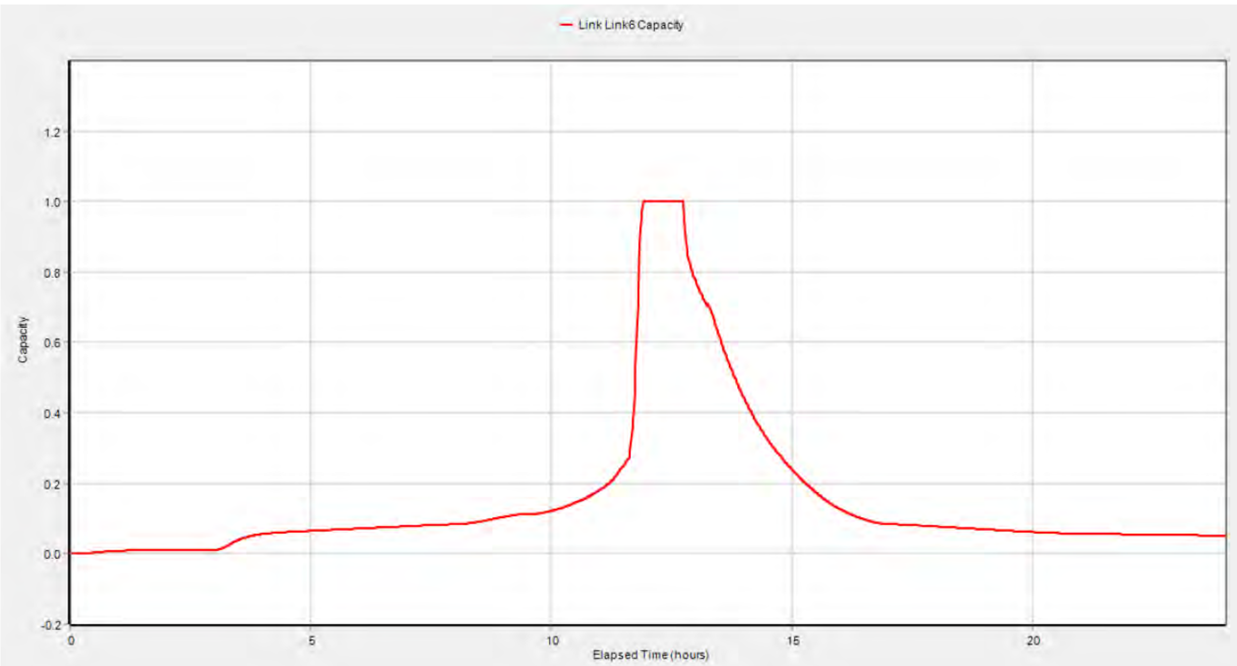


Figure 8: Existing Flow Capacity of Link 6 in the Bluffdale City Park Watershed

Proposed

The pipe velocities were mitigated first. J-T-B Engineering varied Box Junction inlet and outlet offsets, creating drop structures to bring down velocity. Bluffdale specifies a maximum water velocity of 15 feet/second, but where possible, all pipes were resized to be below 10 feet/second. J-T-B then increased pipe diameters to bring all pipes to function just below flow capacity during the 10-year storm event.

The model was rerun after every proposed improvement was implemented in the model until every pipe met flow and velocity requirements. Figure 9 shows the improved flow capacity for Link 6 after improvements.

After the 10-year storm model was optimized, J-T-B carried the proposed conditions over into the 100-year model. The pipes reached flow capacity, as expected in a 100-year storm event, and node flooding was observed only at the pond for the 10-year storm event for 0.36 hours. All nodes had observed flooding, with one node flooding 0.99 hours total as an observed maximum. The observed depth of the pond was sufficient to meet demand for the 100-year event. Runoff and all other output parameters were found to be satisfactory.

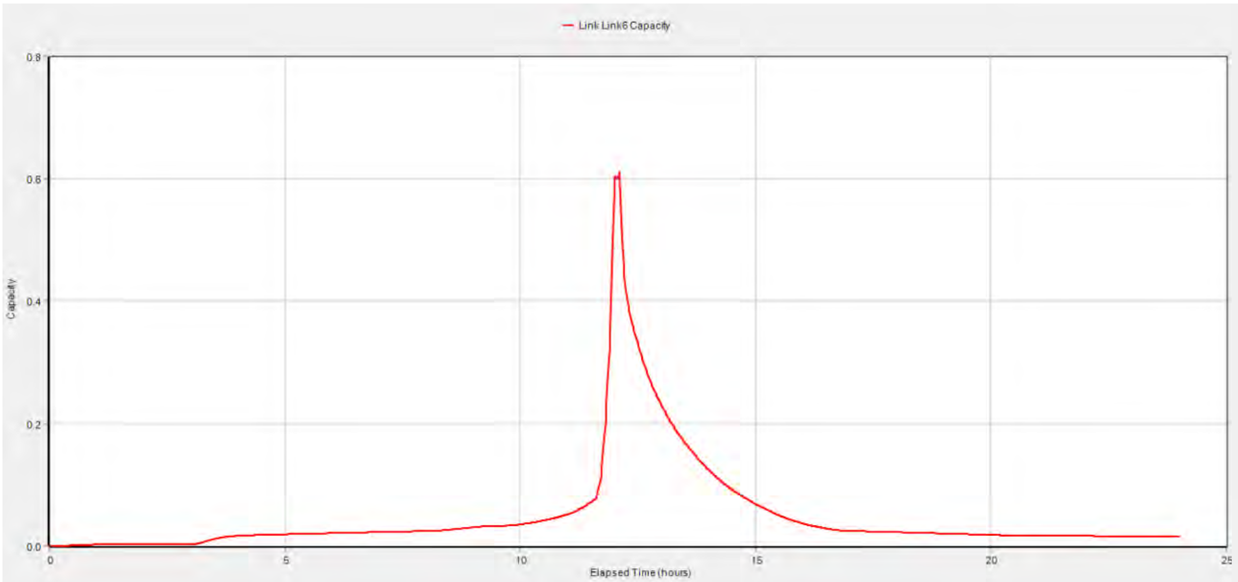


Figure 9: Flow capacity of Link 6 in the Bluffdale City Park Watershed after Proposed Changes

Recommendations

From SWMM Model

The models in EPA SWMM have been described extensively in the Modeling Approach section. It has been shown that conditions in the existing storm drain system are insufficient to convey water from a 10-year rainfall storm event. Conveyance can be increased by increased diameter and change of material. High-velocity flow can be reduced by decreasing the slope of the flowing pipe. The team recommends the pipes in Table 1 below be replaced in order to eliminate flooding and high-velocity flow.

Table 4: Recommendations for Increased Pipe Flow Capacity

SWMM Link Number	Upstream GIS Node #	Downstream GIS Node #	New Diameter (Increase)	Upstream Invert	Downstream Invert	Replacement Length (LF)
0	622	Outfall	N/A	No Change	Decrease 3”	40
1	613	622	36” (+15”)	No Change	No Change	311
2	801	Pond Inlet	36” (+18”)	No Change	No Change	1200
3	638	622	30” (+15”)	No Change	No Change	508
4	104	801	48” (+18”)	No Change	Decrease 55”	158
5	101	104	36” (+21”)	No Change	Decrease 18”	37
6	713	104	36” (+18”)	No Change	Decrease 18”	1012
7	113	713	36” (+18”)	No Change	No Change	42

For reference, Table 2 below describes the physical locations of pipes modeled in SWMM. (See also Figure 2 with node labels)

Table 5: Physical Descriptions of Nodes and Pipes used in SWMM

SWMM Link Number	Physical Description
0	From Pond Outlet (Node 622) to Outfall of Salt Lake Canal
1	From parking lot of Bluffdale City Park (Node 613) to Pond Outlet (Node 622)
2	From entrance to Bluffdale Elementary (Node 801) to Pond Inlet (Node 619)
3	From approx. 2599 West St. (Node 638) to Pond Inlet (Node 619)
4	From corner of Country Classic and 2700 W (Node 104) to entrance to Bluffdale Elementary (Node 801)
5	From one corner of Country Classic and 2700 W (Node 101) to the other Node (104)
6	From corner of 14400 S and 2700 W (Node 713) to corner of Country Classic and 2700 W (Node 104)
7	From one corner of 14400 S and 2700 W (Node 113) to the other (Node 713)

From Data Collection

While post-processing data, the team found several pipes with adverse slopes. A total of four pipes require replacement in order to remedy. Another 6 pipes have accumulated sedimentation that requires cleaning to prevent artificial adverse slopes. These pipes and their recommended actions are tabulated below in Table 3. For reference on location, see Figure 2 in the Introduction section of the report.

Table 6: GIS Data for Pipes with Recommended Actions

Upstream Node	Downstream Node	Upstream Elevation	Downstream Elevation	Height Difference	Recommended Action
220	222	4533.479	4535.264	-1.785	Increase Upstream Invert 3'
1101	1102	4543.759	4543.919	-0.16	Small Adverse Slope, Clean Pipe
1103	1102	4543.755	4543.919	-0.164	Small Adverse Slope, Clean Pipe
906	102	4507.05	4507.573	-0.523	Increase Upstream Invert 1'
633	647	4497.668	4498.083	-0.415	Increase Upstream Invert 1'
644	645	4494.049	4494.054	-0.005	Small Adverse Slope, Clean Pipe
812	811	4487.043	4487.113	-0.07	Small Adverse Slope, Clean Pipe
601	602	4485.91	4486.031	-0.121	Small Adverse Slope, Clean Pipe

612	613	4484.088	4484.38	-0.292	Increase Upstream Invert 0.5'
627	628	4484.471	4484.569	-0.098	Small Adverse Slope, Clean Pipe

Figures 10 and 11 below highlight the recommendations proposed. In Figure 10, J-T-B Engineering recommends changing the slope of the pipes in red. In Figure 11 the team recommends increasing the diameters of the pipes in orange.

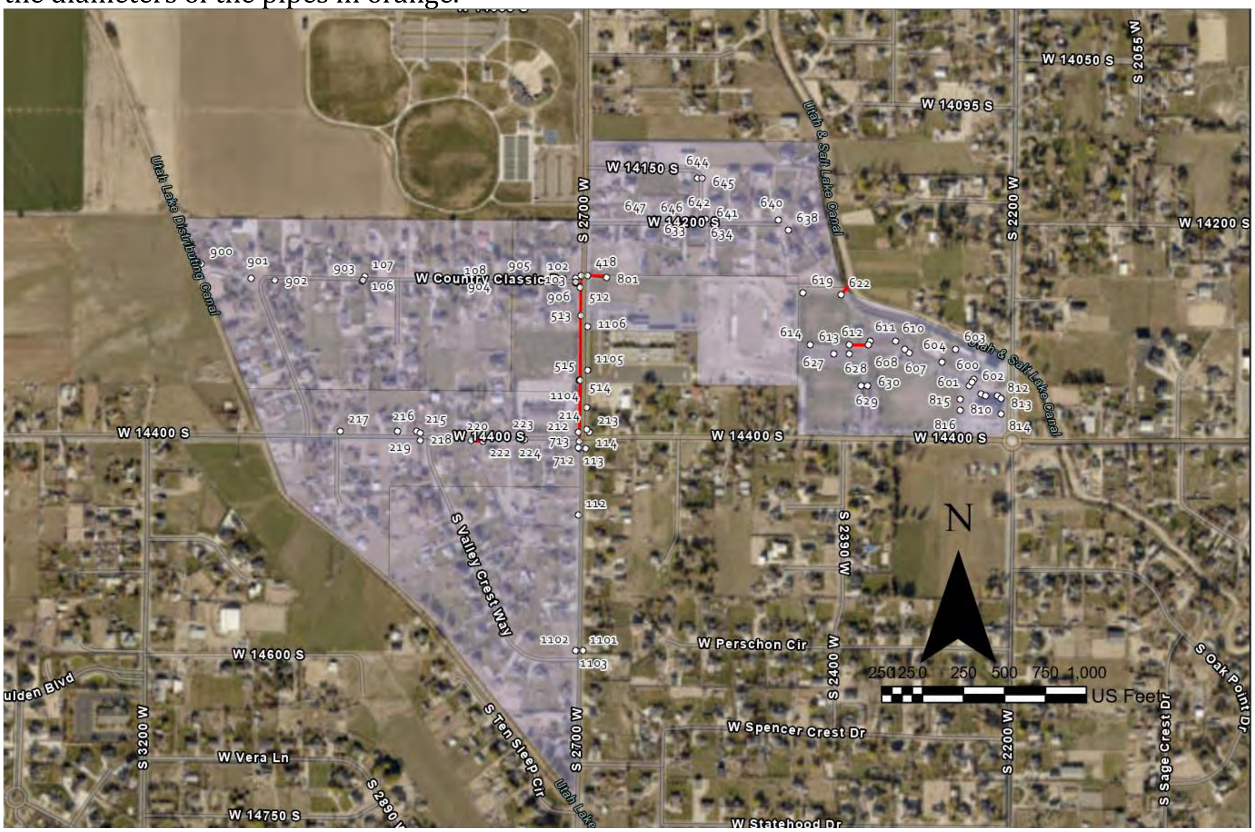


Figure 10: Pipes Recommended to Replace (Change of Slope)

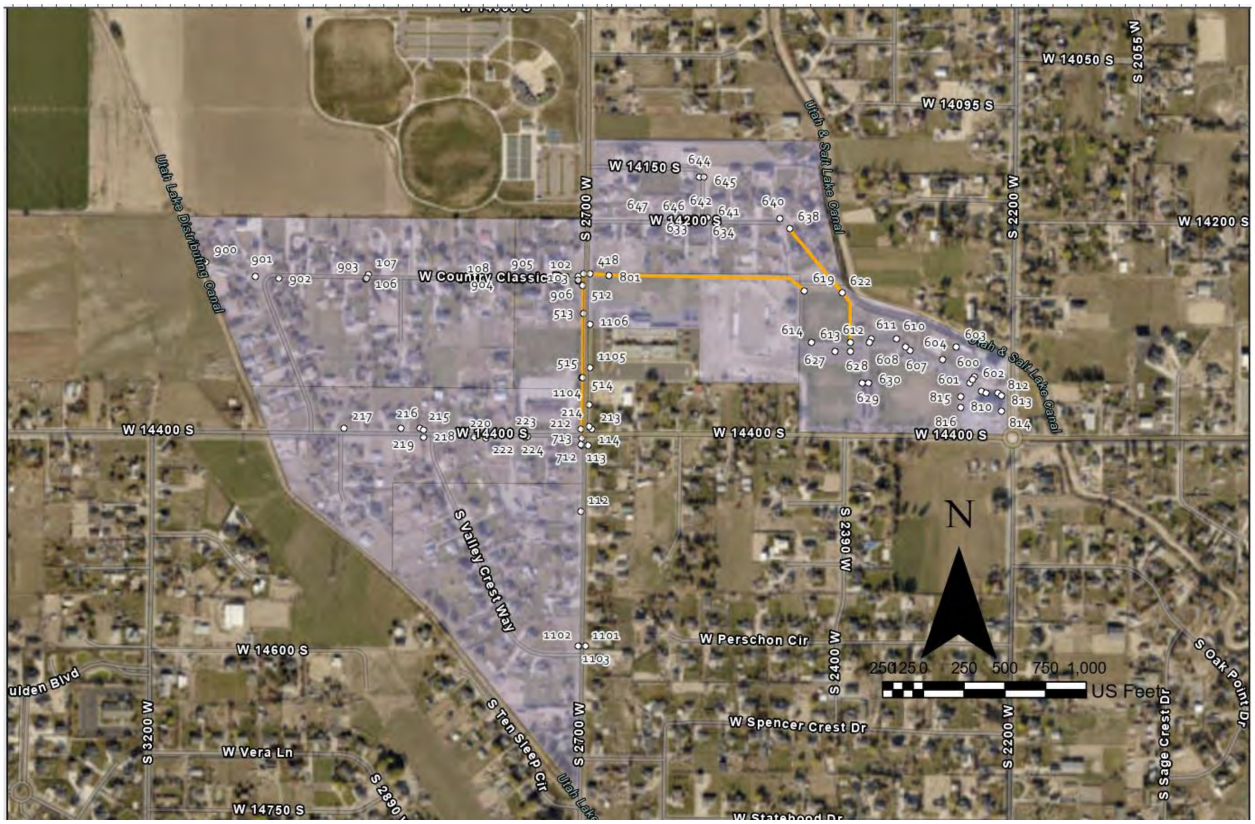


Figure 11: Pipes Recommended to Replace (Change of Diameter)

Conclusions

The infrastructure in the Bluffdale City Park Watershed is aging and has not been properly documented throughout the years. A significant amount of survey and dip sheet recording is recommended for the city of Bluffdale to update all current SWMM models.

The use of LID requires greater attention and documentation. The junction boxes in general could benefit from clearing out. Several pipes are recommended to be upsized to meet design requirements for a 10-year storm. The storage pond is adequate for a 100-year storm. Several adjustments to flow line inverts are recommended to keep velocities at an acceptable level.

We present these updated models and proposed conditions as our recommendations to the city of Bluffdale to prepare for future stormwater system demands.

Lessons Learned

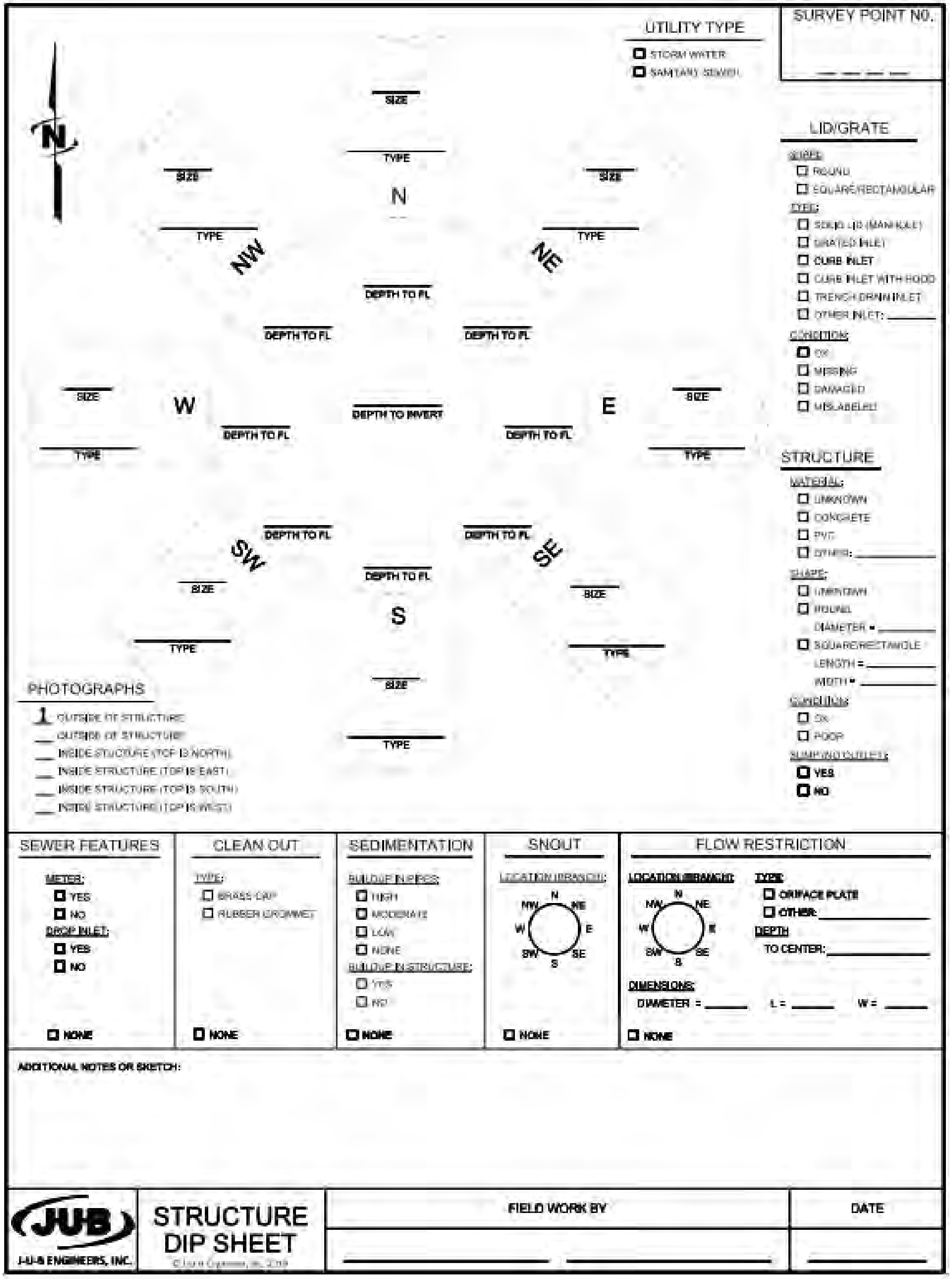
J-T-B Engineering encountered many setbacks as a group that offered many lessons learned. An initial question regarding the scope of the project offered insight on client expectation versus engineer deliverables. Bluffdale initially intended a much larger project, but the scope was lessened, deliverables discussed, methods questioned and time frame adjusted. This all gave good real world experience on projects within an organization and how to manage a project.

The most time consuming challenge was using the survey equipment. Several points were reiterated to the team throughout the weeks of the project.

1. Become very familiar with all hardware and software before beginning the data collection and data processing. This could have prevented all wasted surveying time.
2. Have reliable mentors and experts on hand. This could have resolved any questions in a timely manner,
3. Coordinate dates, times, and plans well with team members and others involved in the project. Much time was lost coordinating efforts between team members.

J-T-B learned the value of keeping an archive of all data, and clearly labeling data. Time was frequently spent redoing a part of the project that had been lost or was not available to all team members. The team also learned the value of inquiring as to how our clients have historically done things, what parameters they use and so on. This allows a team to provide deliverables to the client as expected. Working with J-U-B ENGINEERS and the City of Bluffdale, the team learned that having dependable and responsive coworkers makes working better and delivers a better product. The team you work with is at least as important if not more important than the other aspects of a job.

Appendix A



UTILITY TYPE
☐ STORM WATER
☐ SANITARY SEWER

SURVEY POINT NO.

N

SIZE
TYPE
DEPTH TO FL

NW: SIZE, TYPE, DEPTH TO FL
NE: SIZE, TYPE, DEPTH TO FL
W: SIZE, TYPE, DEPTH TO FL
DEPTH TO INVERT
E: SIZE, TYPE, DEPTH TO FL
SW: SIZE, TYPE, DEPTH TO FL
SE: SIZE, TYPE, DEPTH TO FL
S: SIZE, TYPE, DEPTH TO FL

LID/GRATE
SHAPE:
☐ ROUND
☐ SQUARE/RECTANGULAR
TYPE:
☐ SOLID LID (MANHOLE)
☐ GRATED INLET
☐ CURB INLET
☐ CURB INLET WITH HOOD
☐ TRENCH DRAIN INLET
☐ OTHER INLET: ______
CONDITION:
☐ OK
☐ MISSING
☐ DAMAGED
☐ MISLABELED

STRUCTURE
MATERIAL:
☐ UNKNOWN
☐ CONCRETE
☐ PVC
☐ OTHER: ______
SHAPE:
☐ UNKNOWN
☐ ROUND
DIAMETER = ______
☐ SQUARE/RECTANGLE
LENGTH = ______
WIDTH = ______
CONDITION:
☐ OK
☐ POOR
SUMP (NO OUTLET):
☐ YES
☐ NO

PHOTOGRAPHS
1 OUTSIDE OF STRUCTURE
__ OUTSIDE OF STRUCTURE
__ INSIDE STRUCTURE (TOP IS NORTH)
__ INSIDE STRUCTURE (TOP IS EAST)
__ INSIDE STRUCTURE (TOP IS SOUTH)
__ INSIDE STRUCTURE (TOP IS WEST)

SEWER FEATURES
METER:
☐ YES
☐ NO
DROP INLET:
☐ YES
☐ NO
☐ NONE

CLEAN OUT
TYPE:
☐ BRASS CAP
☐ RUBBER GROMMET
☐ NONE

SEDIMENTATION
BUILDUP IN PIPES:
☐ HIGH
☐ MODERATE
☐ LOW
☐ NONE
BUILDUP IN STRUCTURE:
☐ YES
☐ NO
☐ NONE

SNOUT
LOCATION (BRANCH):
N NE E SE S SW W NW
☐ NONE

FLOW RESTRICTION
LOCATION (BRANCH):
N NE E SE S SW W NW
TYPE:
☐ ORIFICE PLATE
☐ OTHER: ______
DEPTH
TO CENTER: ______
DIMENSIONS:
DIAMETER = ______ L = ______ W = ______
☐ NONE

ADDITIONAL NOTES OR SKETCH:

JUB
J-U-B ENGINEERS, INC.
STRUCTURE DIP SHEET
FIELD WORK BY
DATE

Figure 8: The Dip Sheet Provided by J-U-B Engineers

Appendix B: Schedule

October 2019	7: First meeting at J-U-B Engineers, began working on project, encountered scheduling challenges 15: Meeting with J-U-B Engineers, began negotiating project scope 17: Team meeting began identifying software needed, and began searching for useful equipment for surveying 20: Encountered difficulty in scheduling weather compliant times for data collection in Bluffdale and started looking into EPA-SWMM 31: Meeting with J-U-B Engineers settled on a **consensus for the project scope**
November 2019	11: Data collected from the field was found to deviate intolerably from expected values and calibration has proved difficult, **further collection of data postponed** until a way is found to increase accuracy 14: Meeting at J-U-B Engineers
December2019	12: Meeting at J-U-B Engineers 18: The **30% completion report is turned in** 20: Winter break starts; it is decided to reconvene on the ninth of January
January2020	9: Meeting with J-U-B Engineers 13: Meeting with Professor Hotchkiss 13: **Survey equipment was broken by previous users** causing a delay in data collection 14: Meeting at J-U-B Engineers to address equipment issues 16: Met to review literature on the survey equipment and get it running 22: Meeting with Nicole (a student experienced with the equipment) 27: Team meeting 27: Determined that lack of support and time renders the BYU survey equipment impractical, **Bluffdale allows use of Trimble equipment**
February2020	3: Team meeting 3: Cold and rainy weather make it hard to find times to collect data, more serious study of the EPA-SWMM program begins 10: Team meeting, EPA-SWMM begins to make sense 11: Meeting at J-U-B Engineers 18: Team meeting, data collection is nearly done but there are still points that need to be rechecked and the data has yet to be digitized 24: Team meeting

March 2020	2: Team meeting, **field data collection is essentially finished**, still lack a number of inputs for the EPA-SWMM model 9: Team meeting, time frame is pressing, the learning curve for EPA-SWMM is complicating the process, model shows some discrepancies to be fixed 12: Zoom meeting with J-U-B Engineers 16: Team meeting 19: Zoom meeting with J-U-B Engineers 23: Team meeting, models all but finished with a few important questions arising that need to be understood and answered 26: Team meeting 30: Team meeting (poster), some assumptions of the EPA-SWMM model need to be revisited, **existing EPA-SWMM model complete**
April 2020	1: Team meeting (poster) 2: **Proposed Conditions EPA-SWMM model complete** 6: Team meeting (paper & power point), a few remaining tweaks required for the recommended EPA-SWMM model, **poster complete** 8: Zoom meeting with J-U-B Engineers (paper & power point) 10: **Final PowerPoint and paper complete** 13: **Final presentation with City of Bluffdale Engineering Department**