SEWER SYSTEM CONSOLIDATION
PROJECT ID: CEEN_2018CPST_009

by

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A Capstone Project Final Report

Submitted to

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Department of Civil and Environmental Engineering
Brigham Young University

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Executive Summary

PROJECT TITLE: SEWER SYSTEM CONSOLIDATION
PROJECT ID: CEEn_2018CPST_009
PROJECT SPONSOR: Coleman Engineering
TEAM NAME: Invictus

The Castle City Mobile Home Park, in Newcastle, CA, currently uses treatment ponds to treat their own sewage; however, the lifetime of these ponds are coming to an end and they will need to be replaced in the near future. The sponsor, Coleman Engineering, asked Team Invictus to analyze two alternatives for connecting the mobile home park's sewage collection system to existing sewer lines in the surrounding city of Newcastle. Two options have been provided by Coleman Engineering; the first option would consist of boring under the highway (I-80) and connecting to the Kentucky Greens line, and the second option would follow the highway and Newcastle Road to connect to an existing sewer line near the intersection at Newcastle Road and Indian Hill Road. Because the scope of the project falls under the jurisdiction of the South Placer Municipal Utility District (SPMUD), the project limits are defined by their specifications. Due to the lack of provided flow data, these specifications as well as other SPMUD guidelines were used to estimate the existing flows in both the Kentucky Greens force main and the mobile home park wastewater line. Analyses of the flow capacity of the proposed options were performed using WaterCAD in order to determine whether or not the designs will allow resultant pipe velocities and pressures to meet SPMUD standards. In addition to the WaterCAD model, a cost analysis was performed for each sewer line to determine the most economical option. Throughout this process, the team learned the importance of breaking assignments down to their most basic tasks, keeping presentations simple, using time effectively, learning how to take criticism, and communication skills. From the results of modeling and performing a cost analysis, Team Invictus concluded that Option 2 would cost approximately $400,000 less than Option 1 and recommended that more accurate data be acquired before implementing Option 2.

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Introduction

The sewage treatment ponds for the Castle City Mobile Home Park have reached their life expectancy and will need to be replaced; advisably by connecting a sewer line to the South Placer Municipal Utilities District. To determine the ideal location for the new sewer line, models for each option have been performed using WaterCAD by Bentley. Cost analysis of each option were also performed to provide the ideal location and cost of the proposed sewer line.

Description of options:
Option 1: Option 1 starts at the treatment pond and makes its way around the mobile home park to I-80. It runs along I-80 for approximately 250 feet before turning and crossing beneath the interstate. It then runs northwest about 300 feet where it connects to a gravity line in the Kentucky Greens area. Option 1 ends here, but a second option (Option 1b) exists from needing to upgrade the existing gravity line, Kentucky Greens lift station, and/or the Kentucky Greens force main.

Option 2: Option 2 starts at the treatment pond, also makes its way around the mobile home park and to I-80. It follows I-80 for approximately 800 feet before cutting through the north end of the mobile home park and then following Newcastle Road north until it connects to the existing Newcastle 8" sewer line near the Denny's at Newcastle Road and Indian Hill Road.

Schedule

Date	Days	Time	Task
Every Week during Semester	M	4:00-6:00 pm	Status Report and Group Time Log
Every Week during Semester	W or F	1:00-2:00 pm	Team Meetings
12 October 2018	F	3:00-5:00 pm	Meeting with Sponsor (Chad Coleman)
7 December 2018	F		30% Completion Report
1 February 2019	F	1:00-2:30 pm	Meeting with Sponsor (Chad Coleman)
11 April 2019	Th	11:00 am	2-Minute Presentation in ASCE Seminar
11 April 2019	Th	12:00 pm	Poster Display
12 April 2019	F	11:00 am -12:00 pm	Full Presentation to Sponsor
15 April 2019	M		Final Report

Assumptions & Limitations

- Existing topography
  - GIS data for the Newcastle area was requested repeatedly from the South Placer Municipality, however our Capstone Team was never able to receive the necessary elevation data. In order to know sufficient details of the Newcastle elevation, data was found using the available online outlets. Through these acquisitions data, proposed line elevations were estimated.
- Detail of elevation data
  - Due to the nature of data acquisition being limited by the available elevation data online, team Invictus assumed the elevations acquired to be accurate. Addition assumptions were made my team Invictus based off of Google map elevation data, to predict the proposed slopes for the sewer line options.
- Budget
  - No budget was given in the scope of the project, thus Team Invictus assumed that the viability for implementation of one of the proposed sewer lines would be based on the cost analysis performed. However, if a budget were proposed for the project, team Invictus made better judgements on material use; one example being materials to be used for the piping. No recommendation was given for the pipe material so PVC pipe was selected.
- Unknown location of existing utilities
  - It is assumed that regardless of the existing location of utilities, the model will be accurate. It is assumed that existing utilities were installed with hindsight for new or additional utilities would be installed. Team Invictus is limited with this knowledge as no data was ever received from the South Placer Municipal Utilities District after our requests.
- South Placer Municipal Utilities District Codes and Specifications
  - The South Placer Municipal Utilities District codes and specifications were obtained from the districts web page entitled "Developer Resources - Specifications and Ordinances". From the written codes and specifications Team Invictus assumed the size of the additional lift stations that would be required to meet the new sewer line.
- Existing flows of the blue line
  - It was assumed that all of the new sewer lines for the Castle City Mobile Home Park will lead to the 8 inch diameter gravity line (which starts near Denny's and flows to the location near the abandoned treatment site). From this the number of resident feeding into each of the existing sewer lines was estimated using the SPMUD minimum flow assumptions. These estimated flows were combined in accordance with the flow direction (these assumptions are true assuming team Invictus is unable to obtain actual flow data from the SPMUD. Using these calculations sizing for proposed and existing pipe sections were established.
- Existing condition of Kentucky Greens lift station (kind of)
  - No data could obtained from the South Placer Municipal Utilities District to determine the current condition of the Kentucky Greens lift station. It is assumed that the Kentucky Greens lift stations is in good condition as not reports of inadequacy was found online. Additionally, it was assumed the Kentucky Greens

lift station was built to SPMUD codes and specifications as to the minimal sizing of the lift stations; pertaining to lift station well sizing, well construction (cement dimensions), and pump sizing. Current flow was estimated based on number of residential units and estimated residence in each home. The sizing for the existing Kentucky Greens dimensions were estimated from original construction plans and the new estimated flows were used in estimating the cost, sizing, and function of the proposed improvements to the Kentucky Greens lift stations.

- No future development in plan
  - Assumed that no other development will be built near the Castle City Mobile Home Park that would use the proposed sewer lines. This was assumed based off of available developable land. If this is true then the proposed sewer lines will not need to be designed to be larger than what will be required from the Mobile Home Park. Team Invictus is limited with the uncertainty of future development in the surrounding area.
- Force mains need to have 3 feet of cover, gravity lines need to have about 5 feet of cover
  - South Placer Municipal Utility District specifications and ordinances require that force main be covered by a minimum of 3 feet of cover and 5 feet of cover for gravity lines. Acquired elevations were adjusted to meet these standards.
- Design for the peak hour flow
  - Based on the codes and specifications on the South Placer Municipality website (Section 3 - Design, page 3-1), the max flow for the Castle City Mobile Home Park was assumed to be 100 gallons per day (0.069 gpm) per resident. Using the assumed 100 gallon per minute and the 200 units in the Castle City Mobile Home Park, assuming 4 residence in each unit, 80,000 gallons per day (56 gallons per minute) was assured for Peak Flow Data. This data was used for the modeling and design of each of the proposed alternatives. Existing flow data for in-place sewer lines was estimated similarly.
- Inflow & Infiltration (I&I) combined with peak hour flow is sufficient to meet South Placer Municipal Utility Districts flow ranges of 2 - 6 feet per second (I&I data based on KG information)
  - I&I data was requested from South Placer Municipal Utility District, however no data was ever received. We was assumed that the Kentucky Greens sewer lines were designed for Peak Flow and I&I flow rates. By estimating the flows based on the existing pipe size and the velocity range from 2 ft/s to 6 ft/s based (Section 3 - Design, page 3-1).

Design, Analysis & Results

This section is organized into three parts describing the following: data acquisition, Water CAD analysis, and cost analysis.

Data Acquisition

Coordinates and Elevations: The outline for the two options were provided in a PDF map. A digital elevation raster (also known as a DEM file) was downloaded from the United States Geological Survey website and then loaded in to ESRI's ArcGIS Pro software. ArcGIS Pro was used to obtain the XY coordinates of the corners of the map, as well as the elevations for the junctions in the pipe options. These were then transferred to the WaterCAD models.

Existing Pipe Flows: The mobile home park, the city of Newcastle, and the South Placer Municipal Utility District (SPMUD) were all unable to provide us with flow data. Existing pipe flows were estimated according to the details outlined in the Assumptions & Limitations section of this report.

Condition of Existing Kentucky Greens Lift Station: Eric Nielsen, our contact at SPMUD, was able to give us feedback about the feasibility of pumping wastewater from another 200 homes through the existing pump at the Kentucky Greens lift station pump. Although he was unable to provide supporting data, his gut reaction was that it would be incapable of servicing such an increase in wastewater volume. This information led the team to rule out Option 1a, meaning that Option 1 would no longer be split into two parts; it would simply include putting a lift station in at the treatment ponds, pumping the wastewater through new pipe to the existing gravity line and to the Kentucky Greens lift station, and finally pumped up the Kentucky Greens force main to the connection with the city 8" line.

Pump parameters: With some help from Cody Tom, an engineer-in-training at Coleman Engineering, an example spreadsheet (titled "Calcs LS - Brentwood Mertage.xlsx") was modified to calculate the total static head needed to be overcome by each pump. These calculations included sizing the lift station's height as well as the elevation change in the force main profile. The calculation spreadsheets are attached in the appendix.

WaterCAD model

Analysis method: The PDF map was converted to a TIF file format and uploaded into WaterCAD as a basemap using the coordinates of the corners as found from the overlay map in ArcGIS Pro. Pipe, junctions, and pumps were then outlined with the help of the background image. Option 1 was modeled in two segments. WaterCAD does not have the capabilities of correctly modeling gravity-fed pipes, so just the uphill (force main) portions of Option 1 were modeled. Option 2 had a few dips in the profiles, but because they were relatively short and shallow, they were included in the modeling of the Option 2 force main. The modeled sections are highlighted in Figure 1 and the profiles of the three sections are shown in Figure 2, Figure 3, and Figure 4.

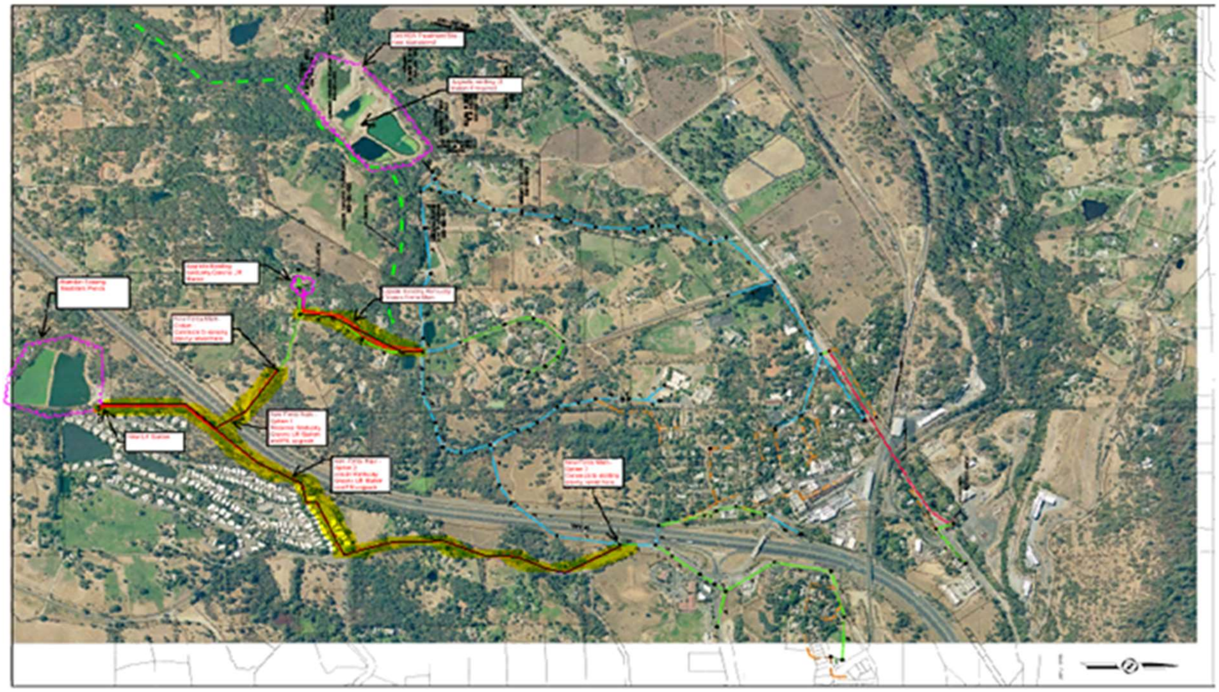

Figure 1: Sponsor-provided PDF map with sections to model.

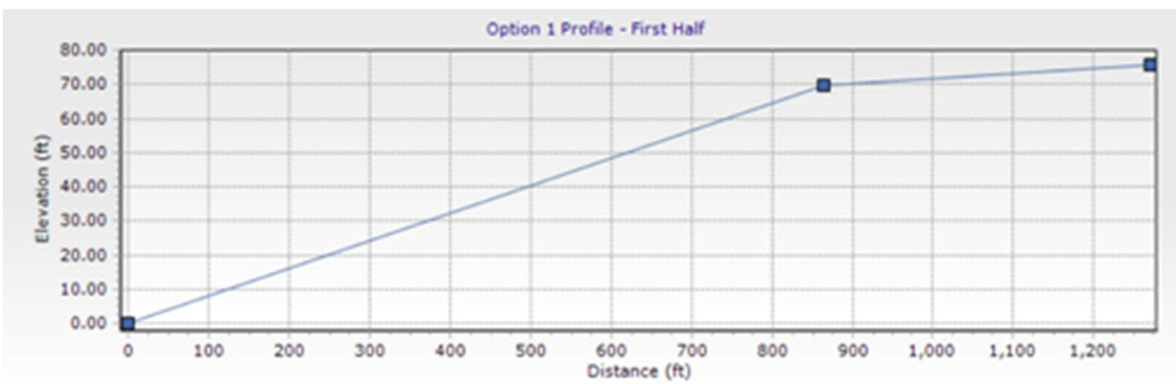

Figure 2: Profile of the first force main in Option 1.

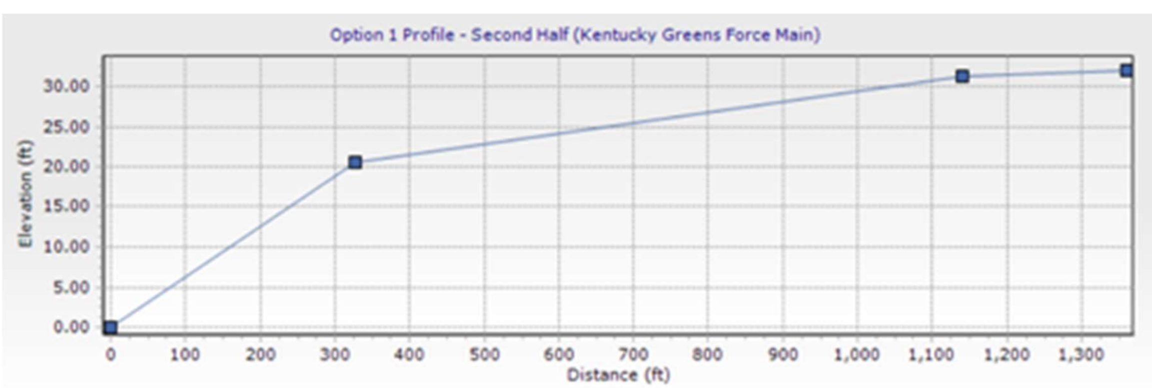

Figure 3: Profile of the Kentucky Greens force main (the second force main in Option 1).

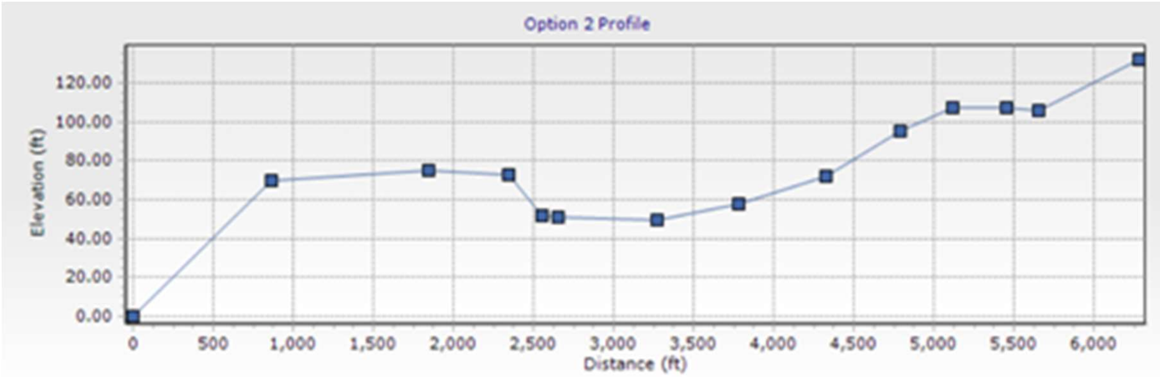

Figure 4: Profile of the entire Option 2 layout.

Each pump had to also be modeled in WaterCAD. The design head and flow for each pump can be seen in Figure 5, Figure 6, and Figure 7. The design flows represent the peak flow expected to travel through the pump.

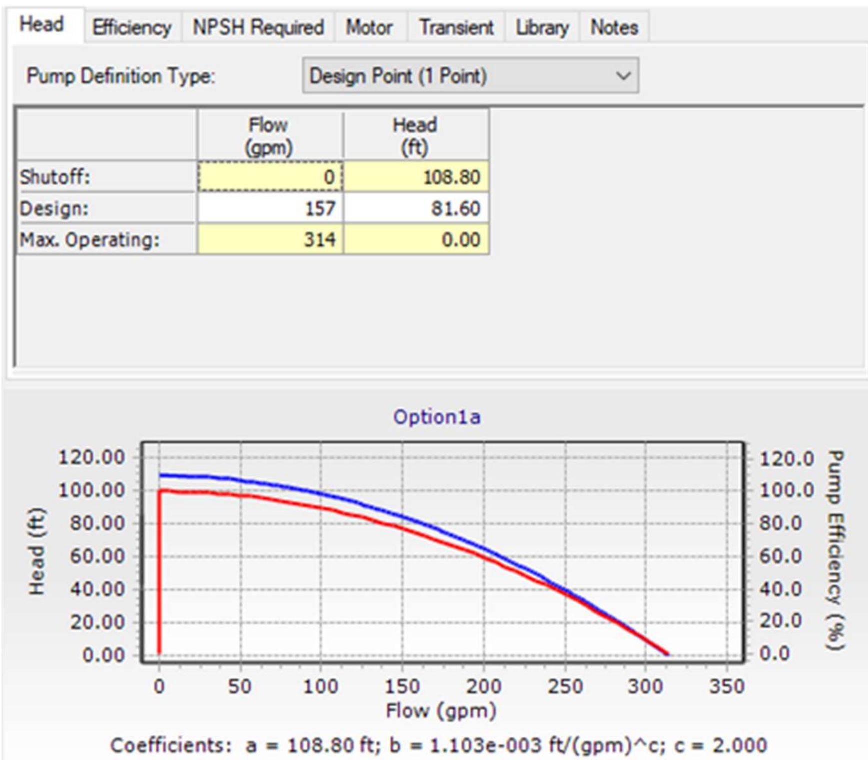

Figure 5: Pump parameters for Option 1's lift station at the treatment ponds.

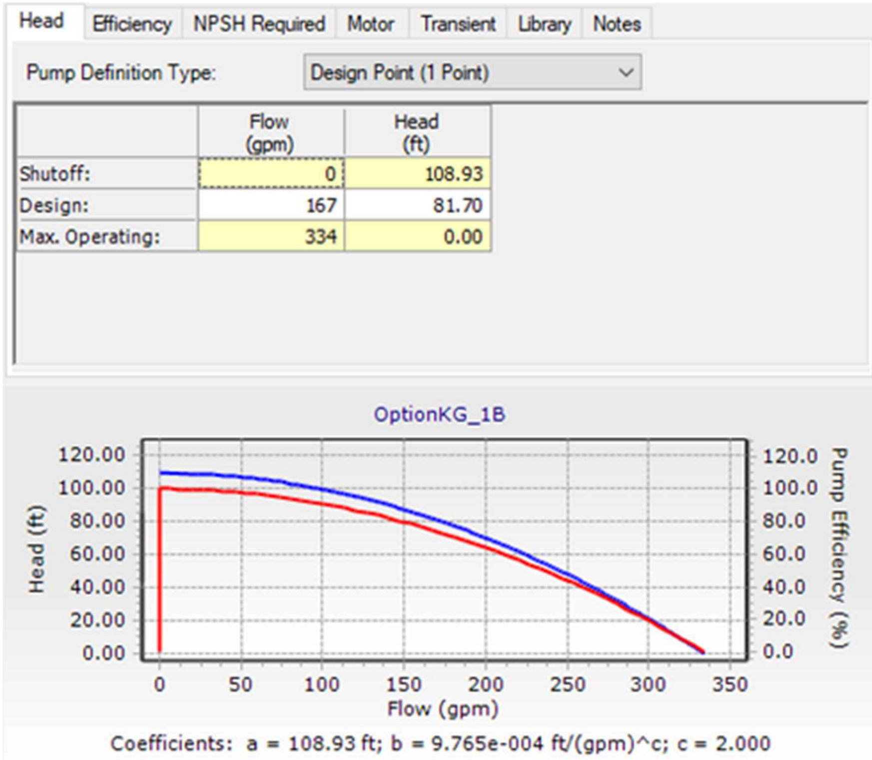

Figure 6: Pump parameters for the Kentucky Greens lift station.

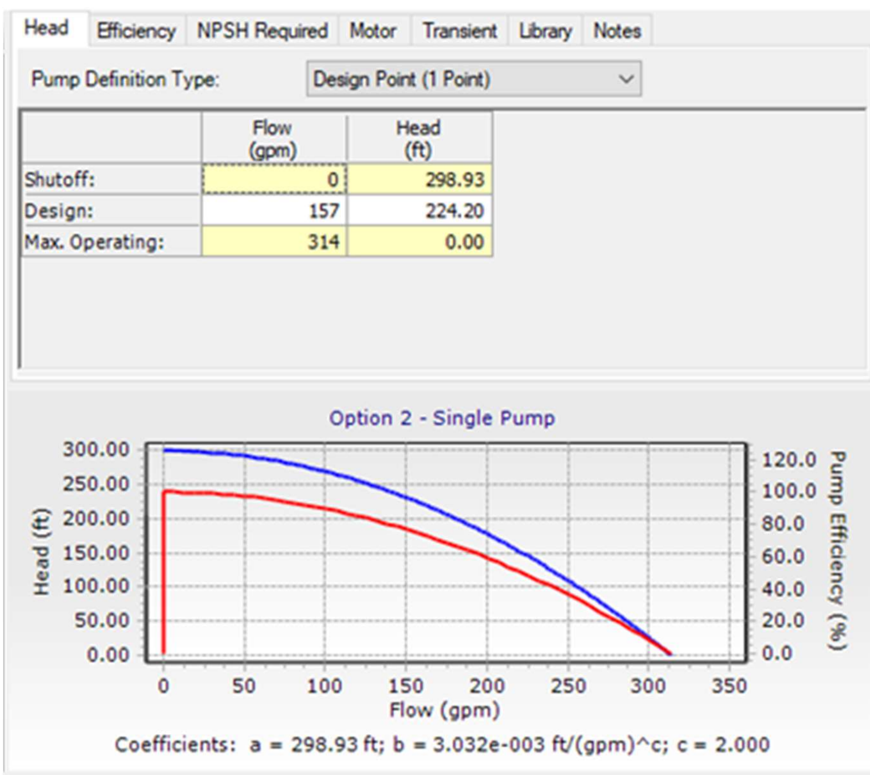

Figure 7: Pump parameters for Option 2's lift station at the treatment ponds.

Results: One of the goals of the WaterCAD model was to make sure that the resultant pressures and velocities in the pipes would meet SPMUD standards. If they didn't, the pumps, pipe diameters, or alignments would need to be changed. With the previously shown pump parameters, all of the models produced pressures and velocities within the constraints (no negative pressures and velocities between 2 and 6 feet per second). The results of the WaterCAD analysis are given in Table 1, Table 2, Table 3, and Table 4. For simplicity, the results of both force mains in Option 1 are combined (although the models were ran as separate entities).

Table 1: Resultant Pressures in Option 1

Label	Elevation (ft)	Pressure (psi)	Hydraulic Grade (ft)
J1.01	69.90	4	80.11
J1.02	20.60	7	37.25
J1.03	31.20	1	33.12

Table 2: Resultant Velocities in Option 1

Label	Velocity (ft/s)	Flow (gpm)	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C
P1.01	3.55	139	865	PMP1A	J1.01	4.0	PVC	150.0
P1.02	3.55	139	406	J1.01	T1A	4.0	PVC	150.0
P1.03	3.08	271	328	PMP1B	J1.02	6.0	PVC	150.0
P1.04	3.08	271	813	J1.02	J1.03	6.0	PVC	150.0
P1.05	3.08	271	220	J1.03	T1B	6.0	PVC	150.0

Table 3: Resultant Pressures in Option 2

Label	Elevation (ft)	Pressure (psi)	Hydraulic Grade (ft)
J2.01	70.00	60	208.62
J2.02	75.00	52	194.71
J2.03	73.00	50	187.65
J2.04	51.40	58	184.69
J2.05	51.10	57	183.26
J2.06	49.70	54	174.61
J2.07	57.50	48	167.33
J2.08	72.20	38	159.61
J2.09	94.90	25	153.11
J2.10	107.00	18	148.47
J2.11	107.50	16	143.65
J2.12	106.00	15	140.88

Table 4: Resultant Velocities in Option 2

Label	Velocity (ft/s)	Flow (gpm)	Length (Scaled) (ft)	Start Node	Stop Node	Diameter (in)	Material	Hazen-Williams C
P2.01	4.15	162	865	PMP2	J2.01	4.0	PVC	150.0
P2.02	4.15	162	983	J2.01	J2.02	4.0	PVC	150.0
P2.03	4.15	162	500	J2.02	J2.03	4.0	PVC	150.0
P2.04	4.15	162	209	J2.03	J2.04	4.0	PVC	150.0
P2.05	4.15	162	101	J2.04	J2.05	4.0	PVC	150.0
P2.06	4.15	162	612	J2.05	J2.06	4.0	PVC	150.0
P2.07	4.15	162	514	J2.06	J2.07	4.0	PVC	150.0
P2.08	4.15	162	546	J2.07	J2.08	4.0	PVC	150.0
P2.09	4.15	162	460	J2.08	J2.09	4.0	PVC	150.0
P2.10	4.15	162	327	J2.09	J2.10	4.0	PVC	150.0
P2.11	4.15	162	341	J2.10	J2.11	4.0	PVC	150.0
P2.12	4.15	162	196	J2.11	J2.12	4.0	PVC	150.0
P2.13	4.15	162	628	J2.12	T2	4.0	PVC	150.0

Cost Analysis

A cost analysis spreadsheet was created with reference to examples provided by the project sponsor. In developing the cost analysis, it is important to remember that it is a preliminary report, and costs given are estimates and subject to change. The estimates given are conservative in their values, and the actual cost of each line item may be lower than the estimate once a final design is selected, and the appropriate bidding and vendors have been selected. The spreadsheets used are attached in the appendix.

The cost analysis tried to use representative data to the best of its ability, but many assumptions had to be made in regards to the sizing and quantities of specific line items. The team was unable to acquire a copy of "Heavy Construction Costs with RS Means Data," as the cost was outside of the team's budget and coordination in obtaining a copy for the department was not met. In light of this, the estimates given try to follow construction practice trends and costs.

In comparing the different options available to Newcastle and the SPMUD, it is important to focus on the differences between the line items for each item. The main differences for each option are:

- Option 1
  - Upgrade of the Kentucky Greens Pump
  - Double the Pumps needed
  - Boring under I-80
- Option 2
  - Longer section of pipe needed
  - Avoid boring under I-80

The cost analysis determined that the most expensive line item for Option 1 would be the costs associated with boring under I-80. It was estimated that the cost of boring would cost $1,500/linear-foot, and using a conservative estimate of boring for 200 feet, the cost came to $300,000. The second most expensive line item would be the cost of installing new PVC Pipe.

Option 1 uses two different sizes of pipe, but due to the large quantities needed it is expected that they can be bought and installed with minimal overhead cost factors. The combined costs of the pipe comes out to $188,000. The next line item in terms of the costs for Option 1 involves the installation of four new pumps. Two pumps will need to be installed at the new lift station, and two new pumps will be required at Kentucky Greens. Two pumps at each location are required, and although only one pump will be active and operating, a backup is necessary and mandated by city code for periods of maintenance. The cost of each pump includes the necessary motors and fittings for the pump to function, and were estimated at #30,000/pump. Final sizing is yet to be determined, but a conservative 5-horsepower pump was used. A model that fits this criteria is the Flygt N-Technology Model N 3085 Pump from Xylem.

From Option 2, the single most expensive line item is the length of pipe to be installed. This came out to an estimated $252,000. With only two pumps needed, the cost for pumps comes to $60,000. Option 2 would be the recommended action from Team Invictus, not only due to it being more economical, but also due avoiding boring under I-80. Construction under this major roadway could raise social and environmental concerns that were outside the scope of the cost analysis.

Two statements to emphasize are that since this cost analysis was performed in the early stages of planning and development, the contingency percentage used may need to be increased. As design reaches more finite and final phases, the costs of each line item can become more accurate, and the contingency will change to reflect this. It is also worth mentioning that the cost of additional pipe from Option 2 ($64,000) is nearly equal to the cost of additional pumps needed in Option 1 ($60,000).

Lessons Learned

As Team Invictus we have worked together to accomplish the design for our Capstone project, yet each step of this process has stretched our team and taught us valuable lessons. As university students we have been taught the basic principles of Civil Engineering. This project was an opportunity for us to apply these principles as well as the skills that will aid us in becoming successful engineers. Lessons learned by our team include, but are not limited to: developing a guiding plan early on in the project, keeping presentations simple, spending time effectively on the tasks for the project, maintaining a healthy exchange of feedback amongst team members, knowing how to effectively use phone calls in the professional sphere, and double-checking our work.

Our sponsor shared the wisdom of organizing a detailed plan of completion for any project in the early stages of development. Simply put, when a team receives an assignment, it is to their interest that that assignment promptly be broken down into the most basic tasks with deadlines to accomplish each. Some groups may make the mistake of operating without a clear plan and end up falling victim to a last-minute time crunch because of any tasks that prove to be time-demanding. In the future as the members of our team go on into the professional sphere, our lesson of breaking down assignments will help us to be prepared for any tasks that may demand more time than expected.

Keeping presentations simple becomes vitally important as college students graduate into the professional sphere of the world. While dull, complicated presentations have the power to mislead professionals toward undesired outcomes, the right presentations with simple messages and figures have the power to guide professionals toward the successful completion of life-changing projects. In light of this level of effect, we developed simplified custom presentations best-suited for our sponsor and for any investigators interested in our project.

This semester, our team began to keep track of the time we spent on individual project tasks each week. Our goal for each week was 8 hours per week. Over the weeks, our success for meeting this goal varied. We began to explore methods for accomplishing our goal. Though our goal called for as many hours as possible, we also learned to use time productively. As our team graduates into the professional sphere, knowing how to spend time effectively will help us to become competent civil engineers.

Every professional team needs to understand the importance of offering and receiving feedback. Our team was fortunate enough to learn from the book *Where's the Gift?* (by Nigel and Michael-John Bristow) in which we learned that any feedback - no matter how it may be delivered - is truly a gift. Feedback provides an individual the opportunity to recognize a weakness and improve oneself. At first our team struggled to apply this wisdom, but in the end our ability to share and apply feedback became a strength that helped each of our members to become better and contribute to the success of the project.

Communications skills took on a whole new meaning as our team sought to obtain data from various agencies. Our initial method of communication was via email; however, we found this form of communication to be ineffective. As we tried different approaches, we found the most effective method to be phone calls. Once we applied this tactic, we received prompt feedback from the different agencies. We acknowledge that different forms of communication are preferred by different generations; this may have been why phone calls brought quicker results. Knowing the most appropriate ways to communicate with other professionals in our careers will save us valuable time and energy in the future.

Our sponsor directed us to also understand the importance of reviewing the figures and tables applied to the presentation. Upon further inspection of the graphs and charts produced by the WaterCAD models and cost analysis, our team discovered that at least one of the graphs had a slight incongruity with elevation data. Through this experience we learned the value of thoroughly reviewing data at the completion of a project.

Conclusions

The Castle City Mobile Home Park sewer treatment needs will be best met by using the second option (the option which runs parallel to I-80 as found in the analysis of this project) as outlined in the finding by Team Invictus. Analyses of the flow capacity of the proposed options were performed using WaterCAD in order to determine whether or not the designs will allow resultant pipe velocities and pressures to meet SPMUD standards. From this analysis, the resultant pipe velocities and pressures were within SPMUD standards, with pipe sizing ranging from 4 to 6 inch PVC pipe, and the lift station sized at 6-ft diameter and 8-ft depth. In addition to the WaterCAD model, a cost analysis was performed for each sewer line to determine the most economical option. Option 2 was found to be more economical, mainly due to avoiding any boring costs associated with I-80. From the results of modeling and performing a cost analysis, Team Invictus concluded that Option 2 would cost approximately $400,000 less than Option 1 and recommended that more accurate data be acquired before implementing Option 2. From this project, Team Invictus has learned how to perform analysis in WaterCAD and also how to prepare a preliminary cost analysis.

Recommendations

In further evaluation of the proposed project, Team Invictus recommends:

- Record and/or obtain updated flow measurements
  - From the mobile home park
  - For existing city lines
  - Obtain I&I data from these flow measurements
- Assuming updated flow data does not significantly alter the results, implement Option 2

Because this design is in its early stages, communication with all involved stakeholders (especially the city of Newcastle) should be established as soon as possible to ensure the proposed design is in line with the stakeholders' future development.

Appendix

Pump Calculation Spreadsheets – Option 1

Coleman Engineering
1358 Blue Oaks Blvd., Suite 200
Roseville, CA 95678
916.791.1188

Project: Delta Shores West SLS
Project #: MSAE19-001
Author: CJT
Date: 2/21/2019

Wet Well Sizing:
157 GPM Submersible Pump
124.5 TDH (feet)

Reference Materials
Handbook of Environmental Engineering Calculations, Lee & Lin, McGraw-Hill 1999

Design Criteria	*Value*	*Units*	*Comments*
Average Daily Flow, Qd	*14*	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Peaking Factor, PF	*4.03*		Calculated as Peak Hour Flow / Average Daily Flow
Peak Hour Flow, Qh	56	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
I&I Flow	101	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Pump Design Flow per Pump, Qp	**157**	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Minimum Pump Run Time, Tr	*1*	min	Typical Value, to minimize cycling
Minimum Wet-Well Volume, Vm	157	gal	Vm = Qp * Tr **(Round Up to Nearest Integer)**
Pump Starts/Hour, Max	**12**	**starts**	**Divided by 2 pumps for individual pump starts, verify with selected pump during design**
Pump Cycle Time, T	5.0	min	T = 60 min / hr x Max Pump Starts/Hour
Wet-Well Volume for Cycle Time, V(T)	64	gal	V(T) = T x $(1/(Qp-Qd) + 1/Qd)^{-1}$ **(Round Up to Nearest Integer)**
Wet-Well Volume for Qp = Qh, V(Qh)	196	gal	V(Qh) = T x Qh / 4 **(Round Up to Nearest Integer)**
Maximum Cycling Time, Tm	***30***	**min**	**From Reference Material, typical value used to limit the volume of the Wet Well.**
Wet-Well Design Volume, Max, Vmx	**417**	**gal**	**Maximum allowable Wet Well Design Volume to minimize retention (cycle) times. Vmx = Tm x Qd (Rounc**
Wet-Well Storage Volume, V	***196***	gal	V = max of Vm, V(T) & V(Qh) and must be < Vmx
Diameter of Wet-Well	**6.0**	FT	Copied from Delta Shores Phase 1 SLS
Required Storage Depth for V, Dv	1.02	FT	Dv = V / π / r^2 x 1.10 SF for Conical Btm of Wet-Well. Min of 0.5 ft
Gravity Line Invert Elev @ Wet-Well	***(3.33)***	**FT**	**Calculated based on MSA plan set 'Delta Shores West - Street 13 & Street 14 STA 21+00.00 to end' Sheet 37**
Pump + Motor Height	38.00	**IN**	**Estimated to be Flygt NP 3153 HT 3~ 465, or similar (not used in calculations unless water cover over motor is required)**
Pump + Motor Height	3.2	**FT**	**Calculated**
Minimum Water Level Over Pump	11.00	**IN**	**Minimum water level from WW floor for running conditions (NP 3153 HT 3~465)**
Required Pump Submergence	1.92	**FT**	**Min. Liquid Level + 12 inch Safety Factor for Level Control Variation, verify with actual pump during design**
Freeboard to Lag Pump "ON"	0.50	FT	Design Value
Freeboard From High Alarm Level to Gravity Line I.E.	**0.50**	FT	Design Value
TOC Base Elevation of Wet-Well	***(7.77)***	FT	Gravity Invert Elev - Submergence - Storage - Total Freeboard
Lift Station RIM Elevation	**0.00**	FT	**Based on MSA plan set 'Delta Shores West - Street 13 & Street 14 STA 21+00.00 to end' Sheet 37**
Total Depth of Wet-Well	***7.77***	FT	L.S. RIM Elev - TOC Base Elev of Wet-Well
Pump Min. Water Elevation	***(6.85)***	FT	Minimum water level for pump running conditions referenced from TOC base
All Pumps "OFF" Elevation	***(5.85)***	FT	TOC Base + Required Pump Submergence
Lead Pump "ON" Elevation	***(4.83)***	FT	All Pumps OFF + Required Storage Depth
Lag Pump "ON" Elevation	***(4.33)***	FT	Lead Pump "ON" Elev + Freeboard to Lag Pump "ON"
High Level Freeboard	0.50	FT	Design Value (High Level set 6" above "Lag Pump ON Elev.")
Alarm - High Level Elevation	***(3.83)***	FT	Lag Pump "On" Elev + High Level Freeboard
Low Level Freeboard	0.50	FT	Design Value (Low Level set 6" below "All Pumps OFF Elev.")
Alarm - Low Level Elevation	***(6.35)***	FT	All Pumps OFF - Low Level Freeboard
Discharge Piping Invert Elevation	(3.00)	**FT**	
Pump Discharge Riser Pipe Length	***3.35***	FT	Estimated based on Discharge Pipe I.E. - Alarm Low Level Elevation

Static Lift	*Value*	*Units*	*Comments*
High Point in Force Main Elevation	75.80	FT	Calculated high point in FM at LS assuming FG + pipe elevation + pipe dia.
Pumps "OFF" Elevation	(5.85)	FT	Repeated from above
Total Static LIft	81.6	FT	High Point Elev - Pumps "OFF" Elevation

Friction Losses	*Value*	*Units*	*Comments*
Length of Force Main	3,000	FT	Based on MSA Delta Shores Improvement Plans - Utility Files
Hazen-Williams Roughness Coeff.	150		Assumed C-Value for new PVC
Inside Diameter of Force Main	4.0	IN	PVC with 6" ID
Velocity in Force Main	4.0	FT/SEC	Velocity is calculated per pump, not valid if both pumps are operating
Lift Station Minor Losses	2.7	FT	Estimated Minor Losses for Lift Station, 45˚ bends, and 90˚ bends.
Head Losses from Friction	42.8	FT	Using Force Main Length, Design Flow, Diameter, & Hazen-Williams Coefficient shown above
Total Dynamic Head	***124.5***	FT	Total Static Lift and Head Losses from Friction

Motor Horsepower	*Value*	*Units*	*Comments*
Assumed pump efficiency	67%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Assumed motor efficiency	88%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Calculated Total Efficiency	59%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Horsepower	8.4	hp	Calculated

Pump Calculations Spreadsheet – Option 2

COLEMAN ENGINEERING
Coleman Engineering
1358 Blue Oaks Blvd., Suite 200
Roseville, CA 95678
916.791.1188

Project: Delta Shores West SLS
Project #: MSAE19-001
Author: CJT
Date: 2/21/2019

Wet Well Sizing:
157 GPM Submersible Pump
224.5 TDH (feet)

Reference Materials
Handbook of Environmental Engineering Calculations, Lee & Lin, McGraw-Hill 1999

Design Criteria	*Value*	*Units*	*Comments*
Average Daily Flow, Qd	*14*	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Peaking Factor, PF	*4.03*		Calculated as Peak Hour Flow / Average Daily Flow
Peak Hour Flow, Qh	56	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
I&I Flow	101	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Pump Design Flow per Pump, Qp	**157**	gpm	Given per MSA Exhibit "F" Phase 3 Sewer Flow Summary Table - Node W5
Minimum Pump Run Time, Tr	*1*	min	Typical Value, to minimize cycling
Minimum Wet-Well Volume, Vm	157	gal	Vm = Qp * Tr **(Round Up to Nearest Integer)**
Pump Starts/Hour, Max	**12**	**starts**	**Divided by 2 pumps for individual pump starts, verify with selected pump during design**
Pump Cycle Time, T	5.0	min	T = 60 min / hr x Max Pump Starts/Hour
Wet-Well Volume for Cycle Time, V(T)	64	gal	$V(T) = T \times (1/(Qp-Qd) + 1/Qd)^{-1}$ **(Round Up to Nearest Integer)**
Wet-Well Volume for Qp = Qh, V(Qh)	196	gal	V(Qh) = T x Qh / 4 **(Round Up to Nearest Integer)**
Maximum Cycling Time, Tm	***30***	**min**	**From Reference Material, typical value used to limit the volume of the Wet Well.**
Wet-Well Design Volume, Max, Vmx	**417**	**gal**	**Maximum allowable Wet Well Design Volume to minimize retention (cycle) times. Vmx = Tm x Qd (Round**
Wet-Well Storage Volume, V	***196***	gal	V = max of Vm, V(T) & V(Qh) and must be < Vmx
Diameter of Wet-Well	**6.0**	FT	Copied from Delta Shores Phase 1 SLS
Required Storage Depth for V, Dv	1.02	FT	$Dv = V / \pi / r^2$ x 1.10 SF for Conical Btm of Wet-Well. Min of 0.5 ft
Gravity Line Invert Elev @ Wet-Well	***(3.33)***	**FT**	**Calculated based on MSA plan set 'Delta Shores West - Street 13 & Street 14 STA 21+00.00 to end' Sheet 37**
Pump + Motor Height	38.00	**IN**	**Estimated to be Flygt NP 3153 HT 3~ 465, or similar (not used in calculations unless water cover over motor is required)**
Pump + Motor Height	3.2	**FT**	**Calculated**
Minimum Water Level Over Pump	11.00	**IN**	**Minimum water level from WW floor for running conditions (NP 3153 HT 3~465)**
Required Pump Submergence	1.92	**FT**	**Min. Liquid Level + 12 inch Safety Factor for Level Control Variation, verify with actual pump during design**
Freeboard to Lag Pump "ON"	0.50	FT	Design Value
Freeboard From High Alarm Level to Gravity Line I.E.	**0.50**	FT	Design Value
TOC Base Elevation of Wet-Well	***(7.77)***	FT	Gravity Invert Elev - Submergence - Storage - Total Freeboard
Lift Station RIM Elevation	**0.00**	FT	**Based on MSA plan set 'Delta Shores West - Street 13 & Street 14 STA 21+00.00 to end' Sheet 37**
Total Depth of Wet-Well	***7.77***	FT	L.S. RIM Elev - TOC Base Elev of Wet-Well
Pump Min. Water Elevation	***(6.85)***	FT	Minimum water level for pump running conditions referenced from TOC base
All Pumps "OFF" Elevation	***(5.85)***	FT	TOC Base + Required Pump Submergence
Lead Pump "ON" Elevation	***(4.83)***	FT	All Pumps OFF + Required Storage Depth
Lag Pump "ON" Elevation	***(4.33)***	FT	Lead Pump "ON" Elev + Freeboard to Lag Pump "ON"
High Level Freeboard	0.50	FT	Design Value (High Level set 6" above "Lag Pump ON Elev.")
Alarm - High Level Elevation	***(3.83)***	FT	Lag Pump "On" Elev + High Level Freeboard
Low Level Freeboard	0.50	FT	Design Value (Low Level set 6" below "All Pumps OFF Elev.")
Alarm - Low Level Elevation	***(6.35)***	FT	All Pumps OFF - Low Level Freeboard
Discharge Piping Invert Elevation	(3.00)	**FT**	
Pump Discharge Riser Pipe Length	***3.35***	FT	Estimated based on Discharge Pipe I.E. - Alarm Low Level Elevation

Static Lift	*Value*	*Units*	*Comments*
High Point in Force Main Elevation	132.35	FT	Calculated high point in FM at LS assuming FG + pipe elevation + pipe dia.
Pumps "OFF" Elevation	(5.85)	FT	Repeated from above
Total Static LIft	138.2	FT	High Point Elev - Pumps "OFF" Elevation

Friction Losses	*Value*	*Units*	*Comments*
Length of Force Main	6,250	FT	Based on MSA Delta Shores Improvement Plans - Utility Files
Hazen-Williams Roughness Coeff.	150		Assumed C-Value for new PVC
Inside Diameter of Force Main	4.0	IN	PVC with 6" ID
Velocity in Force Main	4.0	FT/SEC	Velocity is calculated per pump, not valid if both pumps are operating
Lift Station Minor Losses	2.7	FT	Estimated Minor Losses for Lift Station, 45˚ bends, and 90˚ bends.
Head Losses from Friction	86.3	FT	Using Force Main Length, Design Flow, Diameter, & Hazen-Williams Coefficient shown above
Total Dynamic Head	***224.5***	FT	Total Static Lift and Head Losses from Friction

Motor Horsepower	*Value*	*Units*	*Comments*
Assumed pump efficiency	67%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Assumed motor efficiency	88%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Calculated Total Efficiency	59%	%	Provided on Flygt NP 3153 HT 3~ 465 Data Sheet
Horsepower	15.1	hp	Calculated

Opinions of Probable Cost – Option 1

No.	Item	Quantity	Unit	Unit Cost	Cost
1	Mobilization / Demobilization	10%	LS	$ -	$ 108,000.00
2	Sheeting, Shoring, and Bracing	5%	LS	$ -	$ 52,000.00
3	SWPPP and Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
4	Excavation	1	LS	$ 5,000.00	$ 5,000.00
5	Dewatering	1	LS	$ 5,000.00	$ 5,000.00
6	Pre-Cast Concrete Wet Well (6-ft dia x 8-ft depth)	1	LS	$ 15,000.00	$ 15,000.00
7	Wet Well Lid and Access Hatch with Safety Grate	3	EA	$ 8,000.00	$ 24,000.00
8	Lift Station Valve Vault (6-ft L, 4-ft W, 6-ft D)	1	LS	$ 15,000.00	$ 15,000.00
9	Reinforced Concrete Footings / Equipment Slabs	10	CY	$ 1,000.00	$ 10,000.00
10	Yard Piping	1	LS	$ 10,000.00	$ 10,000.00
11	Sewer Pumps, Motors, and Accessories	4	EA	$ 30,000.00	$ 120,000.00
12	Pump Station Valves	20	EA	$ 2,000.00	$ 40,000.00
13	Inlet and Outlet Manholes	23	EA	$ 2,400.00	$ 55,000.00
14	PVC SDR Pipe 4-in dia (includes installation and backfill)	2200	LF	$ 40.00	$ 88,000.00
15	PVC SDR Pipe 6-in dia (includes installation and backfill)	2000	LF	$ 50.00	$ 100,000.00
16	Bore and Jack under I-80	200	LF	$ 1,500.00	$ 300,000.00
17	Site Improvements (fencing/wall, gate, pavement pad, shade cover, etc.)	1	LS	$ 60,000.00	$ 60,000.00
18	Generator and Automatic Transfer Switch	1	LS	$ 50,000.00	$ 50,000.00
19	Site Electrical, Controls, Instrumentation, and SCADA	1	LS	$ 120,000.00	$ 120,000.00
				SUB-TOTAL ESTIMATED COST =	$ 1,182,000.00
		15%		FINAL CONTINGENCY =	$ 177,000.00
					$ 1,400,000.00

Opinions of Probable Cost – Option 2

No.	Item	Quantity	Unit	Unit Cost	Cost
1	Mobilization / Demobilization	10%	LS	$ -	$ 79,000.00
2	Sheeting, Shoring, and Bracing	5%	LS	$ -	$ 38,000.00
3	SWPPP and Erosion Control	1	LS	$ 5,000.00	$ 5,000.00
4	Excavation	1	LS	$ 5,000.00	$ 5,000.00
5	Dewatering	1	LS	$ 5,000.00	$ 5,000.00
6	Pre-Cast Concrete Wet Well (6-ft dia x 8-ft depth)	1	LS	$ 15,000.00	$ 15,000.00
7	Wet Well Lid and Access Hatch with Safety Grate	3	EA	$ 8,000.00	$ 24,000.00
8	Lift Station Valve Vault (6-ft L, 4-ft W, 6-ft D)	1	LS	$ 15,000.00	$ 15,000.00
9	Reinforced Concrete Footings / Equipment Slabs	10	CY	$ 1,000.00	$ 10,000.00
10	Yard Piping	1	LS	$ 10,000.00	$ 10,000.00
11	Sewer Pumps, Motors, and Accessories	2	EA	$ 30,000.00	$ 60,000.00
12	Pump Station Valves	20	EA	$ 2,000.00	$ 40,000.00
13	Inlet and Outlet Manholes	32	EA	$ 2,400.00	$ 77,000.00
14	PVC SDR Pipe 4-in dia (includes installation and backfill)	6300	LF	$ 40.00	$ 252,000.00
15	Site Improvements (fencing/wall, gate, pavement pad, shade cover, etc.)	1	LS	$ 60,000.00	$ 60,000.00
16	Generator and Automatic Transfer Switch	1	LS	$ 50,000.00	$ 50,000.00
17	Site Electrical, Controls, Instrumentation, and SCADA	1	LS	$ 120,000.00	$ 120,000.00
				SUB-TOTAL ESTIMATED COST =	$ 865,000.00
		15%		FINAL CONTINGENCY =	$ 130,000.00
					$ 1,000,000.00

John Henry Jensen

2960 Chippewa Way, Provo, UT 84604 | 385.421.1901 | jensen.h.john@gmail.com

Objective

· Eager to learn more and gain valuable experience in Civil Engineering

Education

BACHELOR OF SCIENCE | ANTICIPATED APRIL 2019 | BRIGHAM YOUNG UNIVERSITY

· Major: Civil and Environmental Engineering

· Minor: Mathematics

· Related coursework: Reinforced Concrete Design, Fluid Mechanics, Structural Steel Design, Auto CAD, Introduction to Earthquake Engineering, Concrete Mixture Design, Soil Mechanics and Structural Analysis

· Special interests: Structural, Transportation and Geo-Technical Civil Engineering

Skills & Abilities

CREATIVE

· Used Excel to develop inventory tracking spreadsheet for a small local business

· Created spreadsheet to predict outcome of NCAA March Madness Bracket based on the outcome of every tournament since 1975 using VBA (Visual Basic for Applications)

PROBLEM-SOLVING

· Investigated problems with decreased BYU Engineering student attendance at Devotionals and increased attendance by 400%

· Performed Cost Analysis for Sewer System Consolidation Project for Senior Capstone at BYU

COMMUNICATION

· Developed effective communication and presentation skills as a missionary for The Church of Jesus Christ of Latter-day Saints in Chile through community service and teaching daily, which included weekly English lessons and tutoring in Mathematics

Experience

ENGINEERING INTERN | SUNRISE ENGINEERING INC. | WASHINGTON, UTAH

· Wrote Master Plans for both Secondary Irrigation Water and Transportation

· Surveyed under the direction of Project Engineers' at job-site locations

STUDENT EMPLOYEE | BYU GROUNDS

· Performed daily tasks in landscaping and maintenance

· Promoted to student lead position after one year of work

· Supervised tasks for 6-10 students and oversaw completion

TRAFFIC COUNTER | UNIVERSITY OF UTAH

· Assisted in a University Research Study for a comprehensive parking study in Orem, UT

Jordan M. Kersey

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267-625-3530
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LinkedIn URL: www.linkedin.com/in/jordan-michael-kersey

EDUCATION

B.S. in Civil Engineering — **April 2019**
Brigham Young University — *Provo, UT*

- Elected as Secretary in the student chapter of the American Society of Civil Engineers (ASCE)
- Skills: ArcGIS Pro, Microsoft Office
- GPA: 3.17

WORK EXPERIENCE

BYU Civil Engineering — **Sept. 2018-Dec. 2018**
Statics Teaching Assistant — *Provo, UT*

- Mentored & taught 50+ students daily in basic Statics & Physics concepts
- Corrected & provided constructive feedback for 50+ homework sheets bi-weekly
- Collaborated with faculty & other TA’s weekly on facilitating class

Aptive Environmental — **May 2017-Aug. 2018**
Pest Control Applicant — *Livermore, CA; Trooper, PA*

- Operated & performed safety inspections on company vehicle and equipment for 200+ business days
- Negotiated with 1600+ clients in English, Spanish, and Chinese

BYU Sprinkler Shop — **July 2016-Apr. 2018**
Sprinkler Technician — *Provo, UT*

- Renovated 10+ irrigation systems weekly through digging, removal and installation of PVC pipe
- Participated in a variety of weekly team projects that included pipes, controllers, and wires

BYU Physical Facilities — **Aug. 2015-Jun. 2016**
Custodian — *Provo, UT*

- Learned to be self-driven and work independently on weeklong projects
- Actively identified problems and utilized available solutions to resolve them

Dreamscapes, Lawn Care Specialists — **Apr. 2012-Aug. 2015**
Maintenance Technician — *Dixon, CA*

- Analyzed and performed improvements needed for 100+ lawns to become beautiful landscapes
- Maintained & operated 4 large machines daily

VOLUNTEER EXPERIENCE

Coleman Engineering — **Sept. 2018-Apr. 2019**
Capstone Team Member — *Provo, UT*

- Compared three options for replacing an old wastewater system in Newcastle, CA
- Researched and constructed cost analysis spreadsheets for three project options
- Collaborated on a team to compile presentations, reports, and cost analysis sheets

Lifey App — **Sept. 2018-Dec. 2018**
On-Campus Intern — *Provo, UT*

- Expanded the usage of a new educational video-help app to 1000+ users

Church of Jesus Christ of Latter-Day Saints — **Oct. 2012-Oct. 2014**
Full-Time Representative — *Managua, Nicaragua*

- Oversaw online purchases, postal services, and delivery routes for 170+ members of the organization
- Organized an essential storage facility that held 1000+ items of significance

CL

Christian Lundskog

linkedin.com/in/christian-lundskog 435-671-7294 middleskogs@gmail.com

Education

Brigham Young University
B.S. of Civil and Environmental Engineering
Anticipated Graduation: *December 2019*
Current Member of BYU ASCE Student Chapter
Capstone Project to Consolidate two Sewer Systems
GPA: 3.27

Utah Valley University
Received Generals Associates in 2015
GPA: 3.59

Experience

Teachers Assistant – *Soil Mechanics* **January 2019 - Current**
Provo, Utah
- Assist 48 students in understanding and applying challenging soil mechanics concepts
- Oversee a weekly soils laboratory exercise for a group of 8 students
- Coordinate with fellow teacher assistants daily to discuss effective teaching methods and tasks to be completed

Berg Engineering – *Civil Engineering Intern* **May 2018 – August 2018**
Midway, Utah
- Prepared concept designs for clients seeking preliminary subdivision property plans
- Compiled site plans for clients to be submitted to city and contractors for construction
- Updated engineering plans to match installed utilities for city records asbuilts plans

Stein Eriksen Lodge (5 Star Hotel) – *Grounds Tech* **May 2017- August 2017**
Park City, Utah
- Interacted with hotel guests, assisting them to navigate the property
- Maintained grounds and landscaping of flowerbeds, grass, watering systems, etc.
- Translator and leader for Spanish speaking team members

Vinyl Fence Installation – Client Contracted **September 2016**
Heber City, Utah
- Independently planned and implemented installation of vinyl fence

Vivint Solar – CAD Technician **June 2014 - January 2016**
Provo, Utah
- Mass produced custom roof top solar array designs in a timely manner
- Verified design quality for fellow designers to ensure quality designs for customers
- Collaborated with Sales Representatives on an individual basis to meet customer expectations

Skills

- Fluent in Spanish
- Proficient in computer aided drafting (Autodesk CAD)
- Proficient in Photoshop, Microsoft Word, Excel, Publisher, and PowerPoint
- Experienced in basic residential construction and landscaping (roof layout, framing, grounds maintenance)

Volunteer Service

Church Mission, Neuquén Argentina BSA Eagle Scout BYU ASCE Officer - Historian

Camille Lunt

480-643-9330 lunt.camille@gmail.com 725 N 800 E #11 Provo UT 84606

EDUCATION

Pursuing BS in Civil Engineering, Brigham Young University ***Anticipated Graduation: December 2019***

- Cumulative GPA of 3.99
- Member of ASCE, ITE, and AREMA BYU student chapters
- Relevant coursework: geometric design of highways, basics of transportation engineering, VBA
- Successfully qualified for and retained a university academic scholarship for 3 years in a row

INTERNSHIP

Traffic Safety Intern, Arizona Department of Transportation ***May 2018 - August 2018***

- Analyzed 2 large data sets to assess the effectiveness of ITS implementations
    - Presented findings to upper-level management
    - Created a nearly-automated process to update travel time analyses with new data
    - Wrote informal instruction manual on how to repeat analysis of speed feedback sign data
- Performed a variety of crash analyses including:
    - Statewide highway pedestrian crash review
    - Holiday weekend interstate travel crash analysis
    - Disabled highway vehicles crash review
- Performed a Road Safety Assessment (RSA) with a team
- Improved time required to create crash summary reports from 60 minutes to 10 minutes by writing macros

RESEARCH

Intersection Safety Research Assistant, Grant G. Schultz Ph.D., P.E., PTOE ***September 2017 - present***

- Performs virtual site visits and analyzes crash data to complete reports for 60 identified hotspot segments
- Analyzes over 200 Utah state road junctions via Google Earth to improve an intersection safety analysis model
- Prepares ideas for the next section of research: a segment safety analysis model
- Coordinates with fellow research students on a weekly basis

LEADERSHIP EXPERIENCE

Treasurer, ASCE BYU student chapter ***January 2018 - present***

- Oversees income and outcome of club funds
- Participates in planning events for the club

Field Trip Coordinator Assistant, ASCE BYU student chapter ***September 2014 - April 2015***

- Contacted professional engineers via email and phone calls to ask to tour their firms
- Coordinated transportation and times to visit and reported the organized tour information to my department

New Student Orientation Leader, Brigham Young University ***August 2015 and August 2018***

- Led 30 new BYU students for 2 days in their orientation to the university
- Gave tours, answered questions, and counseled students on study habits
- Encouraged the students throughout the semesters that followed

Religious Volunteer in Taiwan, The Church of Jesus Christ of Latter-day Saints ***April 2016 - August 2017***

- Trained 2 new volunteers one-on-one for extended periods of time
- Taught weekly English class
- Learned 2,000 Chinese characters with no formal training, could comfortably communicate with natives

SKILLS

- Visual Basic for Application (Excel VBA)
- ArcGIS
- Microsoft Office; Adobe PDF
- Some familiarity with Civil 3D and Microstation
- Mandarin Chinese: conversationally fluent, intermediate Chinese reading and writing