SPRINGVILLE IRRIGATION CANAL BREACH MITIGATION
PROJECT ID: CEEN_2018CPST_012

by

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Executive Summary

PROJECT TITLE: SPRINGVILLE IRRIGATION CANAL MITIGATION
PROJECT ID: CEEn_2018CPST_012
PROJECT SPONSOR: City of Springville
TEAM NAME: Centilium Engineering

The irrigation canal leading from the Wayne Bartholomew Family Park in Springville, Utah, has experienced a breach subsequent loss of water. The canal spans approximately 2,000 feet with an adjacent paved walking-trail and residential dwellings. The Springville City and Springville Irrigation Company operate and maintain the canal that is currently shut off with very little water remaining in the canal.

Centilium Engineering Capstone (CEC) was selected by the City of Springville to analyze and model solutions to mitigate the breach. CEC was also asked to evaluate options to alter the current configuration of water flow from Strawberry Reservoir into the Bartholomew Family Park Pond.

Each of the proposed designs have been evaluated according to cost, social and environmental impact, ease of construction, aesthetics, maintenance, and liability. Proposed solutions are divided into two categories: those involving mitigating the breach, and those for improving circulation within the pond.

CEC received a recommended deadline of mid-March from the City of Springville for completion of the analysis. Project Deliverables include a final report, slideshow, and formal presentation for the City of Springville's engineers on April 8, 2019. The presentation will discuss CEC's recommended solutions.

Approximate costs of examined alternatives range from approximately $200K to $1.7M. Cost of materials and construction vary according to each solution. Some solutions span the entire 2,000-foot length of the canal while other span approximately 300 feet.

The recommended solutions are piping the entire ditch, or to install a French drain to mitigate the breach. CEC also recommends installing a pipe to divert a portion of the Strawberry water to enter the pond at the location of the "New Creek" in order to improve water quality. These solutions were chosen because they solve the problem of the canal breaching the retaining wall. The French drain is recommended because it is the cheapest option and easy to install as it only spans 300 feet. The pipe is suggested because it prevents the possibility of the canal overtopping. The option to improve water quality was chosen because it is the least expensive.

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Introduction

The origins of this project date back to 2010 when the Rivers subdivision was constructed. Several homes were built on parcels along the irrigation canal. During the construction process, the Springville Irrigation Company insisted that the canal be piped to reduce liability should the canal breach and flow downhill through the new subdivision.

The decision was brought before the City Council, and the vote to keep the canal open was made in order to preserve the natural beauty of the area. Features such as the open water source and existing walking-trail running parallel to the irrigation canal were important to preserve. In some locations, trees on either side of the canal transpire up to 100 gallons of canal water per day per tree. One of the deciding factors behind keeping the canal an open water source was to maintain the water source for the trees. It is not known if there is another water source located along the canal, such as a spring, and CEC assumes that the trees would die if the water source from the canal were to be stopped.

Eventually, homes were constructed on parcels located directly downhill (south) of the open canal. In some cases, the homebuilder cut into the hillside just below the trail and open canal, installing rockery walls to hold back the hillside. In these locations, the elevations of the homes are below the elevation of the canal.

In 2018, the canal breached along the properties that undercut portions of the canal. One particular portion of the breach reportedly had water shooting out of the side of the canal like a faucet, while other locations simply leaked. The water quickly pooled in the backyards below the breached areas, posing an immediate risk of damage to the adjacent homes.

In addition to the problems with the breach, the city has found that water in the retention pond at Wayne Bartholomew Family park is not circulating well. The main source of water from Strawberry Reservoir enters the pond close to the outlet for the canal and short-cuts directly to the outlet rather than traveling throughout the entire pond. CEC was asked to investigate possible solutions to cause the water to circulate more before exiting the pond. It is anticipated that this would improve water quality within the pond.

The City of Springville has tasked CEC with creating and evaluating possible solutions to mitigate the breach along the irrigation canal and improve water circulation the Wayne Bartholomew Family Park pond.

To accomplish this, CEC has created, analyzed and evaluated several solutions for both problems. Data and samples have been collected and analyzed to further aide CEC in evaluations of possible causes behind the breach. CEC obtained measurements of the dimensions of the canal. Water flow was then analyzed at various flow rates. Several analyses were done to establish the potential risk of installing each solution to ensure the solution did not magnify the problem or cause new ones to occur. One of the larger problems CEC analyzed was the possibility of the canal overtopping and flooding the houses south of the canal.

In the following sections of this report, CEC will propose several solutions that have been designed to mitigate current breaching of the canal and prevent further breaching in the same locations. Several solutions will also be proposed that should increase water circulation within the pond. Each of these solutions have been cost analyzed based on both financial factors and other factors such as social impact.

Assumptions & Limitations

One of the challenges CEC faced during investigation was an unknown water depth. This information was needed to analyze the fluid flow through the soil. In order to solve this problem, measurements of the canal were obtained and the flow through the canal was analyzed using Hydraulic Toolbox. During this step, several assumptions were made. First, it was assumed that the irrigation canal experiences continuous flow. This allowed CEC to use Manning's equation. In turn, the slope of the canal was assumed to be continuous and was calculated using approximately 50% of the length of the canal. CEC also assumed that the smallest cross sections of the canal would control the flow and height of water in the canal.

While creating flow nets, the critical section was defined as the location where the retaining wall was highest and the distance from the canal to the rear wall of the house was the shortest. The flow nets were created using values received from Hydraulic Toolbox for hydraulic head at critical flow, approximately 30 cfs. From the gradation analysis performed, the soil was determined to be Sandy CLAY. Using correlations from NRCS, CEC assumed he hydraulic permeability coefficient, K, to be 0.142 ft/day or 0.5 micrometers/second.

For the flow net design, CEC assumed the soil to be isotropic in nature, and that the soil is homogeneous to a depth of approximately 20 feet below the surface. CEC also assumed that a sheet pile or cut off wall could easily be installed within five feet of the retaining wall without disturbing the structural integrity of the wall. Later, we learned the soil would not hold the wall while solutions were installed so the distance was moved to approximately 10 feet. The length of the back yard was assumed to be 25 feet, a value which was measured using ArcGIS Pro. Additionally, basement depth was assumed to be eight feet below ground level. As a result, CEC found that the height of a certain solutions would need to be approximately 6.5 feet below the surface. With the new distance from the wall, CEC assumed that the height of the solutions would only need to be 3.5 to 4 feet.

CEC also assumed that the two homes closest to the junction with retaining walls were the only houses with an elevation difference that could permit breaching to occur through the retaining wall. For the other homes, it was assumed that a breach would be unlikely to occur. Additionally, CEC assumed that driving sheet piles approximately 25 feet from existing structures would not damage foundations. This assumption is based on the proximity of a new well in Springville that did not damage structures within a close proximity of the project.

Limitations that CEC experienced are as follows. The main limitations found during the project are those caused by not being professional engineers. CEC is made up of students who do not have not experience with in-depth engineering work. Therefore, before any suggested solutions are implemented, a licensed engineer is required to analyze any results CEC finds.

Other limitations that CEC experienced include public opinion, cost, property boundaries, space, and hydrologic uncertainty. Any solution that is presented is subject to public opinion. Along with this, CEC has been informed that the aesthetic qualities of an open water source are desirable to citizens in the area. These opinions have been taken into account in some of the project designs but ignored in others to find high quality solutions. Cost is the main concern on this project. Many of the current project designs are expensive and may not be feasible. Additionally, the canal passes through two privately owned parcels, with the majority of the easement located between other privately-owned parcels. This could increase costs as well as limit physical space to implement proposed solutions. Due to the abundance of springs in the area, there is a possibility that a natural spring may be contributing to the canal breach, causing the problem to be more difficult to resolve than anticipated.

Design, Analysis & Results

Design Process:

To create and evaluate design options, CEC first visited Ditch #1 in September 2018, and obtained canal dimensions and soil samples at several different locations along the length of the canal. A simple soil sample analysis was performed to determine the mechanism of breach within the canal walls. The results indicated that the fine-grained soil had been washed away in the area around the breach location. Next, CEC used the canal dimensions to model fluid flow in the canal and determine the water depth. This information provided hydraulic head values. These values were used to create flow net models which were essential in evaluating potential solutions. Finally, after several flow nets were created to determine optimal placement and depth of different rehabilitation options, cross sections of the designs were created. Cost estimates and feasibility rankings were generated for each solution using different weighting methods that sought to evaluate each design based on economic, social and environmental criteria.

Soil Analysis:

Two soil samples were obtained, and tests were performed by CEC in the Brigham Young University laboratory. The first soil sample was taken from the site of the breach and the second from upstream in the canal to assess whether the breached soil was significantly different in composition. The soil was sampled eight inches below the surface from the bank of the canal and was taken with a square-nosed shovel to minimize bias in sampling.

The soil went through an Atterberg limits test and a full gradation was performed using ASTM standard sieves. Based on the discovered difference in fines content between the soil at the breach location and the upstream soil, CEC determined that the fines in the area where the breach occurred have been washed away. In fact, there were twice as many fines present in the upstream soil compared with the soil near the breach. The soil at the breach site was then classified as a Clayey SAND using the USCS soil classification system. However, considering that the fines near the banks have been washed away, CEC concluded that the soil near the breach at greater depths would likely be a Sandy CLAY, much like the upstream soil sample.

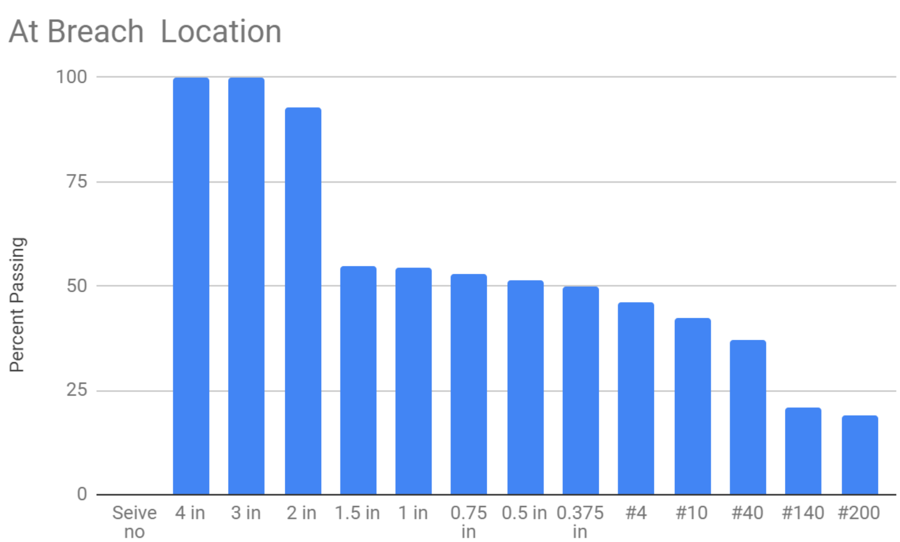


Figure 1: Soil gradation at breach location

Fluid Flow Analysis:

To calculate the water depth within the canal at the design flow rate of 20 cfs, the canal was assumed to have continuous flow. This assumption allowed for a fluid flow analysis to be completed using a hydraulic toolbox, a software which uses Manning's equation to calculate flow rate or flow height within a channel. Due to the inconsistency of canal bank conditions, several Manning's coefficients and canal cross sections were analyzed using the minimum specified design flow rate of 20 cfs to produce the maximum water depth. The data generated included Manning's coefficients and results can be seen in Tables 3 and 6 located in Appendix C.

A worst-case scenario was analyzed using a typical cross-section of the canal with a height of 3 feet, and widths of 12 feet and 4 feet. The specified minimum flow rate of 20 cfs was increased to 30 cfs. A typical cross section with 30 cfs yields a maximum water depth of approximately 1.6 feet. This was calculated using a Manning's coefficient for earth channels made of stone or cobbles. The returned depth of 1.6 feet was used as a design parameter and was assumed to be a maximum depth throughout the length of the canal.

The generated results indicated that there would be little risk of overtopping events during normal operation of the canal. The worst-case fluid flow analysis results are depicted below in Figure 2.

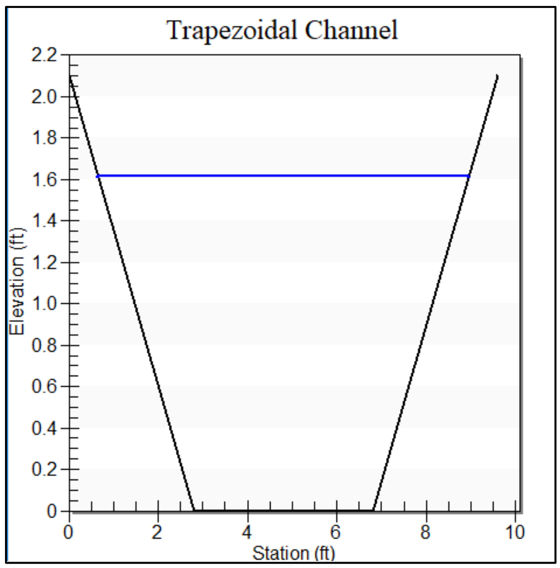


Figure 2: Fluid flow analysis results for governing water depth using the Manning's coefficient for earth channel with stone and cobbles and a flowrate of 30 cfs

Flow Net Analysis:

CEC created several flow nets to aid in analysis. Each of the flow nets were created using GMS 10.4.2, using the previously mentioned assumptions. The flow nets were designed using a section of the canal with the highest elevation difference between the canal and adjacent homes. The distance between the canal embankment and home was also minimized. This was considered the critical case for flow net calculations. The flow nets were created using hydraulic head values from the worst-case scenario conditions of 30 cfs water flow. CEC considered several placements for sheet pile and cut-off walls and created a computer modeled flow net for each. The flow nets included in this report were considered best options due to non-turbulent flow. Turbulent flow would increase the risk of soil failure due to piping. Figures 3 and 4 are examples of a flow net calculating using a cut-off wall and sheet pile, respectively.

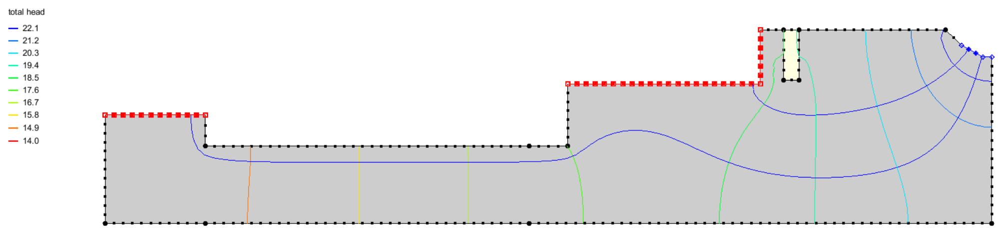


Figure 3: Flow net calculated using cut off wall options

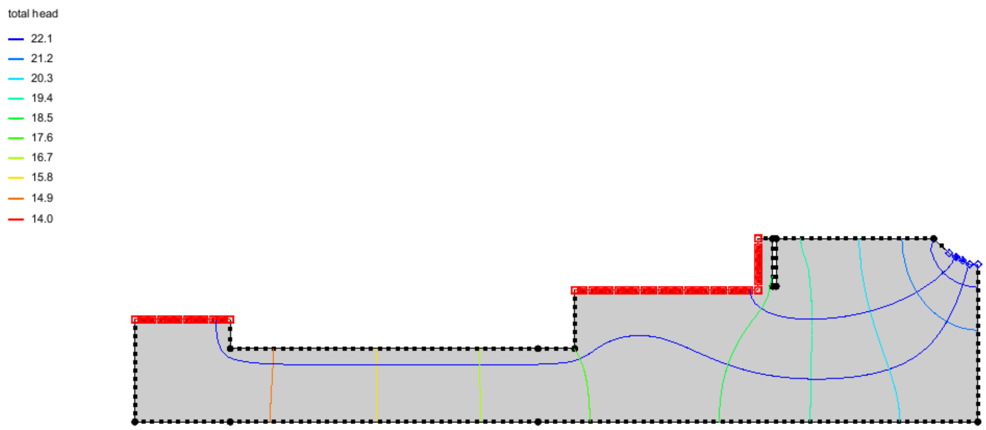


Figure 4: Flow net calculated using sheet pile option

High Risk Low Probability Event Analysis

To provide a more complete analysis, CEC evaluated low probability high risk events. The highest risk (outside of accidental death) was found to be flooding damage to the surrounding homes due to the canal obstruction. Using FEMA's estimated flood loss potential tables, CEC calculated the cost per inch of water in the average home along the canal. Using an average basement size of 1000 square feet (typical for the surrounding homes). CEC then calculated the height of water that would accumulate in 5 homes due to the worst-case flood scenario of complete canal obstruction located at the canal midpoint with peak flow. Figure 5 shows the cost of the worst-case flood scenario versus the response time. CEC found that, even if the canal were shut off immediately, there would still be enough excess water in the canal to overtop and cause over $100,000 in damage. One extreme flooding event could cost as much as piping the entire canal.

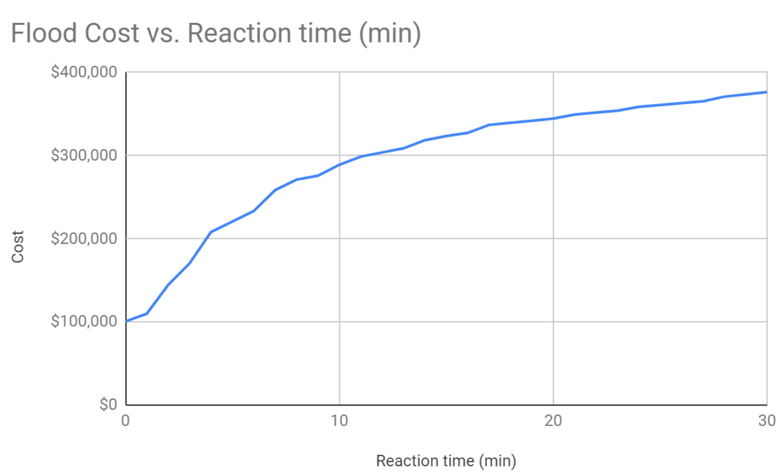


Figure 5: Potential flood cost versus canal shut off reaction time

Design:

All designs were created using the following criteria:

- 25-30 feet between the rockery wall and back of home
- Average basement depth of 8 feet
- 30 cfs critical flow in the ditch

Drains behind Retaining Wall:

A perforated pipe will be placed approximately 5-6.5 feet below ground surface. Gravel will be backfilled above the drain. The French drain will redirect water from the canal to the storm drain in the road. Installing drains directly behind the rockery walls will cost an estimated $210 K.

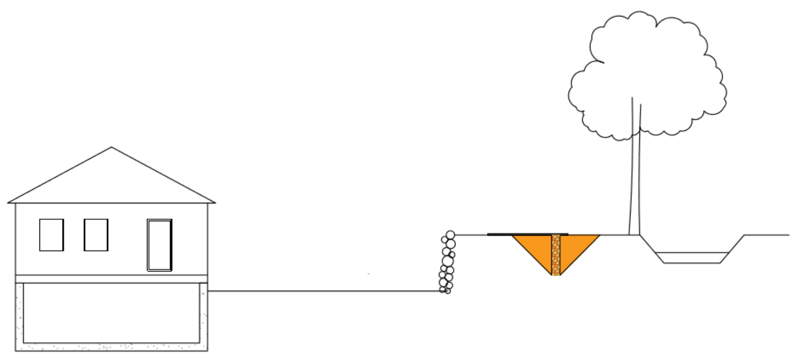


Figure 6: Drains behind retaining wall cross section

Reline Ditch:

The canal will either be relined with clay, cobble, or geomembranes to prevent/water seepage from the canal. This would be among the most affordable options with an estimated cost of $426 K for the concrete liner, and $220 K for the geomembrane liner. Relining the ditch would have minimal negative environmental impact and would not negatively impact the trees along the canal. The canal would remain uncovered, however. The geomembrane liner also has a very short design life. The concrete liner would last longer but would still require significant maintenance.

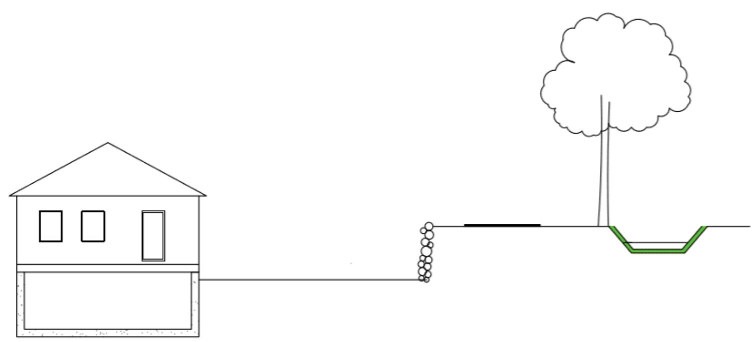


Figure 7: Cross section for relining ditch option

Sheet Pile:

The lots with large retraining walls which are most susceptible to breach, a sheet pile could be driven between the canal and the retaining walls. These sheet piles would form an impermeable barrier which would prevent the canal from breaching the retaining wall. This option is estimated to cost $225 K. After more information about the soil was obtained, it was determined that a sheet pile would not be feasible due to the size of the large rocks within the soil. This option is not recommended.

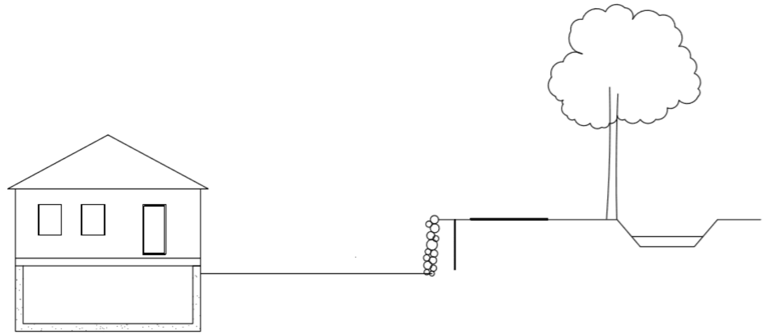


Figure 8: Cross section of sheet pile option

Pipe Entire Ditch:

The entire length of the canal would be piped to prevent water seepage. The estimated cost is $760 K. Piping the canal would stop any breaches from occurring and minimize liability. There is a risk that there is an unknown spring in the area and if that is the case it could still cause a breach if the canal were only piped. This approach would also deprive the trees along the canal of water and most likely kill them.

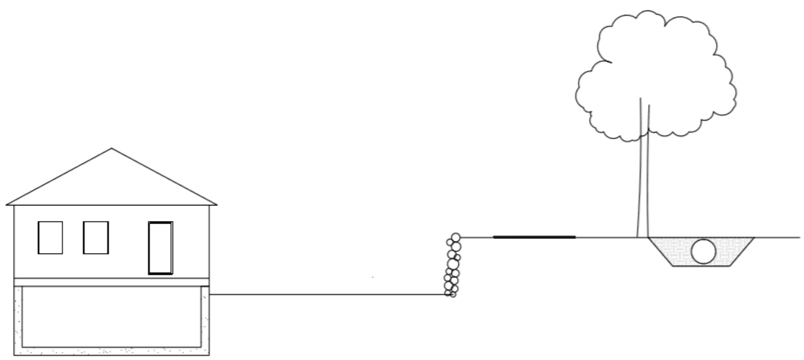


Figure 9: Cross section of piping the ditch

Pipe Ditch behind Last Two Houses:

This option would pipe the segment the canal where houses were built with large retaining walls. Piping part of the ditch would be cheaper than piping the entire canal with an estimated cost of $250 K but would not protect against hydrostatic pressure from possible springs in the area. This option also keeps most of the canal exposed.

Cut off Wall:

Another means of mitigating the breach would be to dig out a section of the embankment and replace it with compacted clay fill. This section of extremely low permeability would prevent water from breaching the wall, instead driving it deeper into the ground. This option has an estimated cost of $525 K.

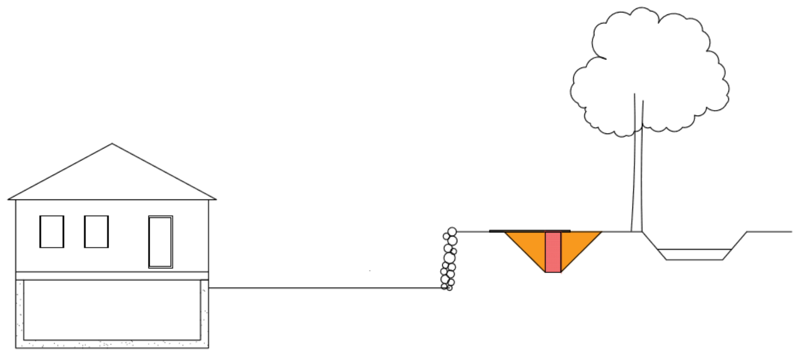


Figure 10: Cross section of cut off wall

Cut-off Wall Plus Long Strawberry:

Similar to the proposed cut off wall solution, this option includes filling a segment of the space between the ditch and the canal with clay. There would be an impermeable clay pipe, with Strawberry water flowing through it, back to the retention pond. This would help increase water circulation. This option is estimated to cost $1.7 M.

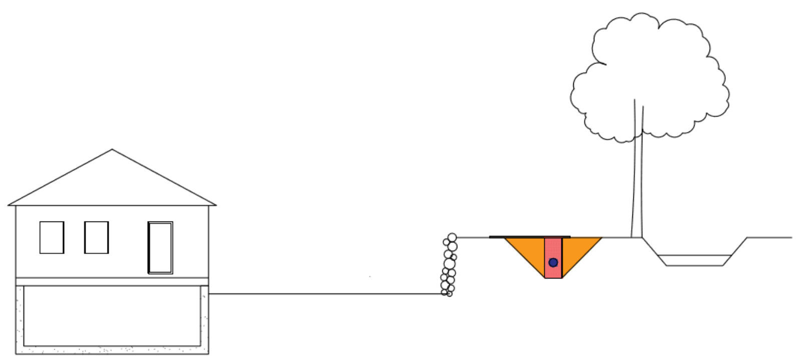


Figure 11: Cross section of cut off wall with long strawberry included

Cut-off Wall Plus Long Strawberry and Pipe Entire Ditch:

This option is similar to the cut off wall option with Strawberry water running through it. There would be a second pipe within the cut off wall running the canal water parallel to the Strawberry water. In this option some water could be allowed to continue to flow through the canal to allow for the survival of the surrounding trees. This option is estimated to cost $1.75 M.

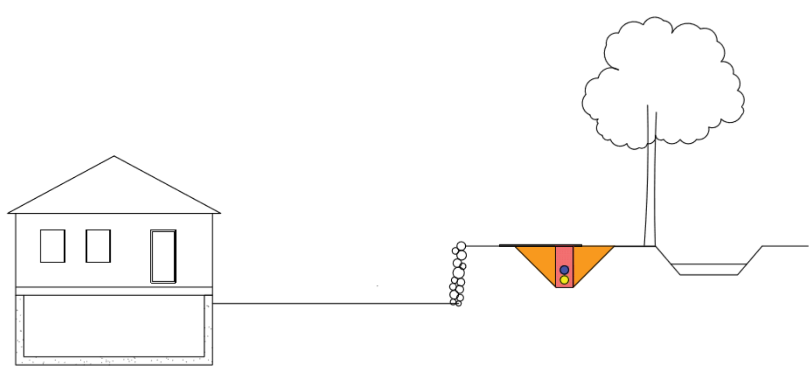


Figure 12: Cross section of cut off wall with long strawberry and piped canal

Short Strawberry:

To increase the quality of the pond water, the Strawberry water inlet could be moved to another location to give the water enough time to thoroughly mix. This option brings the inlet from where strawberry is currently entering the pond and redirects the flow to enter at the new creek and mix into the pond, increasing water quality. This option is estimated to cost $340 K.

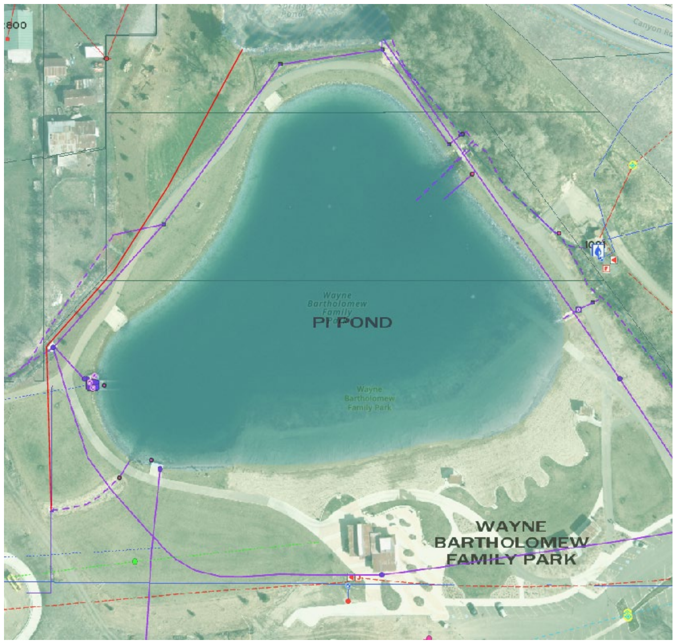


Figure 13: Plan view of short strawberry option

Medium Strawberry:

Another option for the Strawberry water is to bring the inlet from the location where it is currently flowing into the pond and bring it around to the NE side of the pond. This option is estimated to cost $460 K.

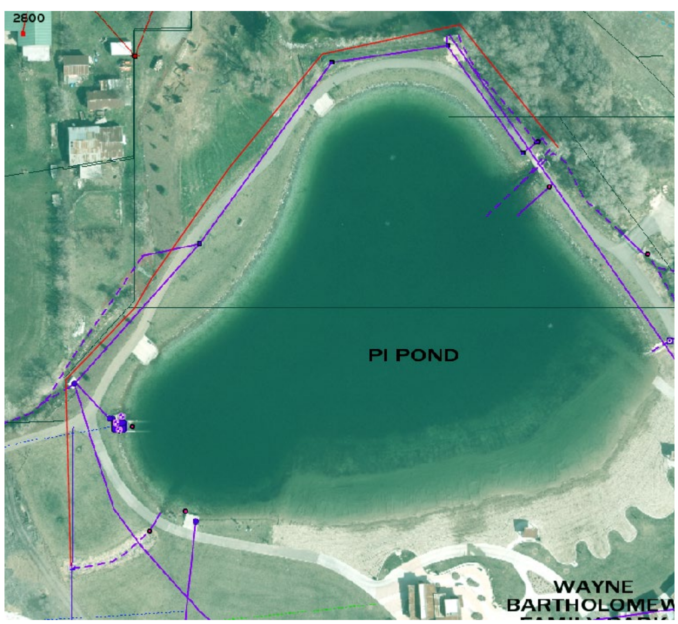


Figure 14: Plan view of medium strawberry

Long Strawberry:

Another option proposed is to bring the Strawberry water in from the junction at the lower end of the canal back up to the east side of the pond. This option is estimated to cost $1.16 M.

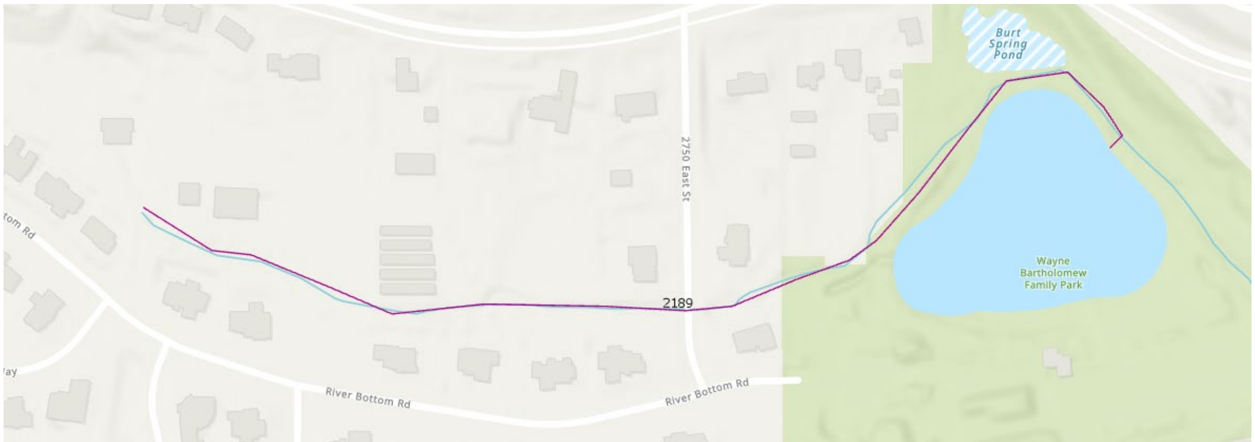


Figure 15: Plan view of long strawberry

Table 1 lists generated cost estimates for each design option listed above.

Table 1: Cost Estimates

Project Options	Cost Estimates
Drains behind Retaining Wall	$210,000.00
Reline Ditch Concrete	$426,000.00
Reline Ditch Geomembrane	$220,000.00
Sheet Pile	$225,000.00
Cut-off Wall	$522,000.00
Pipe Ditch behind Last Two Houses	$248,000.00
Pipe Entire Ditch	$760,000.00
Cut-off Wall Plus Long Strawberry	$1,702,000.00
Cut-off Wall Plus Long Strawberry and Entire Ditch Piped	$1,750,000.00
Short Strawberry	$337,000.00
Medium Strawberry	$458,000.00
Long Strawberry	$1,160,000.00

Table of Feasibility:

To assess which options were more optimal than others, a ranking system was constructed. The categories assessed included cost, social impact, environmental impact, speed of implementation, aesthetic appeal, potential for liability, and maintenance costs. Each solution was given a number between 1 and 5 to indicate feasibility for each category. If a solution performed well in the category, then it was given a 1 and if it did not perform well, it was given a 5. Each solution was then given a total ranking with weights that took multiple perspectives into account.

The idealized perspective of cost to the City showed results as follows: 0.4 for cost, 0.05 for social impact, 0.1 for environmental impact, 0.15 for speed of implementation, 0.05 for aesthetic, 0.15 for liability, and 0.1 for maintenance. From the perspective of the City with respect to liability, the weights are as follows: 0.3 for cost, 0.05 for social impact, 0.15 for environmental impact, 0.05 for speed of implementation, 0.05 for aesthetic, 0.2 for liability, and 0.2 for maintenance. From the perspective of homeowners in the area, the weights are as follows: 0.2 for cost, 0.2 for social impact, 0.15 for environmental impact, 0.15 for speed of implementation, 0.15 for aesthetic, 0.05 for liability, and 0.1 for maintenance. From the perspective of the environmentalists, the weights are as follows: 0.1 for cost, 0.2 for social impact, 0.3 for environmental impact, 0.1 for speed of implementation, 0.2 for aesthetic, 0.05 for liability, and 0.05 for maintenance.

Table 2 lists the feasibility final scores of each of the design option listed above.

Table 2: Final Scores for Table of Feasibility

Project Option	Cost	Liability	Social Impact	Environmental Impact
Reline Ditch (Geomembrane)	2.40	2.85	2.05	1.90
Reline Ditch (Concrete)	3.40	3.65	2.95	3.05
Pipe the Entire Ditch	3.65	3.45	4.25	4.50
Pipe Ditch behind Last Two Houses	2.35	2.45	2.30	2.30
Sheet Pile	2.10	2.05	1.90	1.75
Cut-off Wall	3.15	2.95	3.00	3.15
Cut-off Wall Plus Strawberry	3.70	3.40	3.25	2.85
Cut-off Wall Plus Strawberry and Piped Ditch	3.95	3.50	3.55	3.35
Drains Behind Retaining Wall	1.90	1.90	2.10	1.90
Long Strawberry	3.40	2.90	3.00	2.40
Medium Strawberry	1.90	1.90	2.10	1.90
Short Strawberry	1.35	1.55	1.75	1.70

Lessons Learned

Defining the scope of the project was a difficult challenge for CEC to overcome. This was a large project and a potentially infinite number of solutions could be considered. The members of CEC learned to be discerning and only evaluated solutions that seemed viable and efficient.

Time management was critical in this project as in any project. As mentioned previously the team had to learn how to evaluate what endeavors were worth the time needed. The decision to estimate hydraulic conductivity based on gathered results was made because further testing was time prohibitive. This decision allowed CEC to create a concise, but full analysis of all proposed options. Additionally, CEC experienced challenges managing fulltime school work, part time employment and the challenges involved in this capstone project. Time management skills were therefore invaluable to CEC. CEC often met on weekends and in the evening to accomplish all assigned tasks.

Creating cost estimates was far more difficult than anticipated, stretching the ability of the members of CEC. CEC was initially forced to learn how to be detail oriented and consider every aspect of the construction project. Critical thinking was also needed to find and evaluate reliable sources for unit material costs, labor costs, rental fees, and restoration costs.

Developing good communication practices was a great asset to CEC as our schedules rarely lined up to work together. Communicating as a team to ensure that every avenue of failure was considered, and every solution was well evaluated was a challenge. The team initially struggled to efficiently share engineering calculations and data collected with other team members through various computer programs. Professional communication skills were developed as the team updated and sought feedback from the City and other professionals.

Conclusions

The canal breach will become a recurring problem if a solution is not implemented. Through soil analysis, the failure was determined to have been caused by piping through the canal bank and retaining wall. This piping was likely caused by a tree root that stretched from the canal to the wall. From the analysis of the soil, it is likely that the soil is a Sandy CLAY, with a permeability of approximately 0.5 micrometers per second. Through fluid flow analysis, CEC determined that the critical or highest possible hydraulic head for the design flow was roughly one and one half (1.5) feet. CEC also determined through groundwater modeling that turbulent flow through the soil and heaving of the soil embankment are highly unlikely. The problems that needed to be addressed in the designs were a way to prevent water from reaching the retaining walls, which would then flood the properties below the canal.

Recommendations

Based on the feasibility results, CEC recommends either placing a French drain behind the retaining walls at the critical section of the canal or to pipe the entire canal. The drain is the cheapest option, while installing pipe would minimize future liability and eliminate unforeseen problems. CEC recommends the implementation of either of these options to mitigate the breaching of the canal. Additionally, CEC recommends using the short strawberry option to increase water quality in Bartholomew Pond. This option is the cheapest alternative and will be easiest to maintain.

Appendix A: Resumes

REED **REIMSCHUSSEL**

495 East Center, Pleasant Grove, Utah, 84062 · (801)616-6583
Reimschusseler912@gmail.com

EDUCATION

2012-PRESENT

DEGREE IN PROGRESS , BRIGHAM YOUNG UNIVERSITY

Area of Study: Civil Engineering- 113.5 Credit Hours Completed
Relevant Courses may include: Engineering Mechanics-Statics; Engineering Mechanics: Dynamics; Elementary Linear Algebra; Calculus of Several Variables, Elementary Differential equations, Engineering Drafting w/ CAD applications; Mechanics of Materials; CE EN 270 Computer Methods, Hydraulics and Fluid Flow Theory, Structural Analysis, Elementary Soil Mechanics.

MAY 2012

HIGH SCHOOL DIPOLMA, PLEASANT GROVE HIGH SCHOOL

EXPERIENCE

AUGUST 2017 – PRESENT

RESEARCH ASSITANT, DR. KEVIN FRANKE

Assistant in the Next Generation Liquefaction project, data entry and management in generating a liquefaction potential curve for Davis, Weber and Salt Lake counties. General assistance in data entry, management and analysis.

APRIL 2018 – AUGUST 2018

FIELD TECHNICIAN, RB&G ENGINEERING

Duties: Quality assurance and Quality Control testing and field testing. Conducted concrete testing both on site and compressive strength tests. Soils testing such as gradations and proctor testing.

APRIL 2017 – AUGUST 2017

BUILDING SECURITY OFFICER, BRIGHAM YOUNG UNIVERSITY

Duties: Building Security Checks, Writing Building Security Reports, and Patron Surveillance

SKILLS

- Proficient with Microsoft Excel and Visual Basic
- Have conducted many Proctor tests and gradations.
- Familiar with AutoCAD and Revit
- Construction Experience
- Experience Driving Forklifts and Box Trucks

Delila Lasson

669 E 800 N S304 | Provo, Ut | (615)992-4776 | lila@lassons.net

LinkedIn Profile: https://www.linkedin.com/in/delila-lila-lasson-92b652123/

OBJECTIVE

I am seeking a promising career as a Civil Engineer position providing me the opportunity to apply and enhance my current Engineering skills while, contributing constructively towards the growth of the company.

SUMMARY

I will be completing my bachelor's degree in civil engineering from Brigham Young University in April 2019. I have been working on building the Next Generation Liquefaction database since I began my junior year in the program. I am also working with Intermountain GeoEnvironmental Services to test and verify building site preparation and suitability for their clients.

EDUCATION

Bachelors, Civil Engineering, Brigham Young University, Provo, UT, anticipated graduation April 2019

- Active participant in: Women in Engineering BYU chapter and American Society of Civil Engineers BYU chapter
- Pursuing an emphasis in Geotechnical Engineering

WORK EXPERIENCE

Engineer Intern, Intermountain GeoEnvironmental Services Inc., 12429 S. 300 E., Ste. 100, Draper, Utah, 8/2018-present

- Performed excavation observations to verify if the site was suitable to build on
- Digitized raw field data for various SPT test holes

Earthquake Research Assistant, Brigham Young University, Provo, UT, 09/2017-present

- Reached out to various Geotechnical firms to gather data
- Processed raw earthquake damage data for the 2011 Tohoku, Japan earthquake for Dr. Jonathan Stewart (UCLA) to be placed in the Next Generation Liquefaction database
- Coordinated with another university to accomplish tasks relevant to the Next Generation Liquefaction database and other projects

OTHER EXPERIENCE

Volunteer Representative, The Church of Jesus Christ of Latter-day Saints, Billings, Montana, June/2013 – December/2014

- Provided training for 5 volunteer representatives as they began their volunteer work
- Developed leadership, teaching, interpersonal, and communication skills
- Provided any service to those in need. Spent approximately 5 hours a week performing service the entire 18 months totaling 390 service hours
- Provided training for 3 of my leaders

SKILLS

Computer

- Familiar with Microsoft office programs
- Familiar with ArcGIS programs such as ArcMap
- Familiar with AutoCAD and Revit
- Quick learner when it comes to computer programs

Max Barnes

www.linkedin.com/in/mbarnes7
(801) 361-0910 · barnesmaxmax@gmail.com

EDUCATION

Brigham Young University — Apr 2020
B.S. Civil and Environmental Engineering — Provo, Utah
Minor in Scandinavian Studies – Swedish Emphasis

- 3.39/4.00 GPA
- Phi Eta Sigma National Scholarship, Loftur Bjarnason Scholarship – (*Merit Based*)

Relevant Coursework

- Fluids, Soils, Mechanics of Materials, Statics, Dynamics, Transportation, Advanced GIS, Engineering of Materials and Structural Analysis (enrolled Winter 2019)

Technical Skills

- Geosystems – ArcMap, ArcGIS Pro, Total Station
- Autodesk/CAD Apps – Fusion 360, AutoCAD 2018, AutoCAD Civil 3D 2018, Revit Design

ENGINEERING EXPERIENCE

City of St. George Public Works — Jul 2018 – Present
Intern — St. George, Utah

- Draft site plans for future development using AutoCAD, allowing continuous growth to City services
- Calculate 1600+ equivalent residential unit drainage values regaining $100,000+ of annual revenue
- Create geospatial database using ArcGIS Pro to track permeable surface area, aiding in updating billing rates
- Streamline processes for maintaining and archiving drawings and other records saving 2 hours weekly

Springville Canal Breach Mitigation Senior Capstone Experience — Sep 2018-Apr 2019
Team Lead — Springville, Utah

- Researched and designed 5+ solutions to prevent further leakage from 100-year-old irrigation canal

American Society of Civil Engineers Rocky Mountain Region (ASCE) — Apr 2018
Pre-Design Team Member — Provo, Utah

- Coordinated design and building of system which delivered water to multiple locations for competition
- Competed in regional Pre-Design competition taking 2nd place out of 20 teams

OTHER EXPERIENCE

Missionary Training Center of the Church of Jesus Christ of Latter-day Saints — Dec 2017 – Present
Shuttle/Bus Driver — Provo, Utah

- Assist 20+ patrons/day to safely board and exit vehicle during transport in the greater Salt Lake City area
- Identify methods to improve safety while loading and unloading patrons from large 12-passenger vans

SERVICE

Phi Eta Sigma Honor Society — Apr 2017 – Present
President — Provo, Utah

- Plan and execute monthly club activities designed to encourage participation in club and community activities
- Guide efforts to increase attendance at activities from 60-80+ using principles of 4DX

The Church of Jesus Christ of Latter-day Saints — Aug 2013 – Aug 2015
Volunteer — Stockholm, Sweden

- Provided 100+ hours of community service over a 24-month period in various non-profit organizations and community events in the Stockholm and greater Copenhagen areas
- Increased effectiveness of volunteers by conducting 70+ personalized one-on-one 24-hour trainings designed to uplift, motivate and inspire missionaries to attain goals in a 12-month period
- Led, conducted and planned 6+ monthly training meetings for a team of 10+ volunteers, designed to accomplish group goals, and increase effectivity

Meghann Morgan

www.linkedin.com/in/meghann-morgan
meghannmorgan16@gmail.com
(208) 703-6836

Education

Brigham Young University – Provo, Utah — December 2019

- Civil Engineering Major
- GPA: 3.82

Relevant Classwork

- Fluid Dynamics — Winter 2018
- Elementary Soil Mechanics — Winter 2018
- Technical Communication — Summer 2018
- Structural Analysis — Fall 2018
- Metals, Woods, and Composites — Fall 2018
- Concrete, Masonry, and Asphalt — Fall 2018
- Transportation Engineering — Fall 2018

Skills

- Relevant Software: Revit, AutoCAD, Microsoft Excel (advanced)
- Programing Languages: VBA
- Foreign Languages: Spanish

Professional Experience

College of Civil and Environmental Engineering – Provo, Utah — September 2018-Present
Fluid Dynamics Lab Teaching Assistant

- Lead and prepare student lab experiences

BYU Math Lab – Provo, Utah — August 2017-August 2018
Upper Division Math Tutor

- Helped students understand concepts for linear algebra, differential equations, and multivariable calculus

BYU Physical Facilities – Provo, Utah
Groundskeeper — May 2016-August 2017

- Beautified and landscaped in a team

Custodian — November 2015 -April 2016

- Cleaned, organized, and disinfected assigned areas in a team

J. Weil Foodservice: Office Executive Secretary – Boise, Idaho — June 2012-January 2014

- *Accounts Receivable* – processed customer payments and managed customer accounts
- *Accounts Payable* – reviewed and processed vender invoices and prepared invoices for payment
- *Customer Service* –responded promptly to customer inquiries and complaints
- *Receptionist* – answered phone, screened and directed calls, took and relayed messages, received customer payment, organized office area, sorted and filed invoices

Volunteer Experience

Habitat for Humanity – Provo, Utah — November 4, 2017
Volunteer

Utah Community Academy of Science, UCAS – Orem, Utah — March 4, 2016
Balsawood Bridge Competition

Geneva Elementary School – Provo, Utah — 8 October 2015, 3 February 2016, 4 February 2016
Spanish Translator

- Translated during parent teacher conferences for Spanish speaking parents and teachers

Appendix B: Correspondence

Wayne Lee wlee@byu.edu via gmail.com — Wed, Sep 19, 12:09 PM
to Reed, Max, Lila, me, Rollin

All,

Attached is the PowerPoint (converted to pdf) Presentation referred to by the project description. I am sending the pdf because the PPT is about 6 times larger in file size and BYU may not handle it well.

This is a great project that involves all aspect of a real world project including technical (engineering), politics (government, residents, etc.), and some challenges that may require engineers to think outside the box.

It would be best if I can sit down with you all to describe/explain/clarify some of the background information not intuitively obvious in the Presentation file, as this was presented by the Director of Public Work to the City Council and Mayor of Springville. Both presenter and audience are intimately familiar with Springville so a lot of the explanations and details are omitted in the presentation. I suggest that we meet and discuss this before the kick-off meeting next Monday so that you can go into the kick-off knowing the background information for this project.

Please let me know when would be good for us to meet, if you all so desired.

Thanks,

Dr. Lee

Wayne Y. Lee, Ph.D., P.E. (AZ & WA)
Director, Capstone Program
Department of Civil & Environmental Engineering
Brigham Young University
Provo, UT 84602
Landline: (520) 647-9861
Cell: (520) 300-6706
E-Mail: WLee@byu.edu

Meeting Minutes with Dr. Lee:

Information about project that will be useful to know

- The canal, trail, and trees predate all of the homes that have been built in the area
- The homeowners often complain about how many people use the walking trail even though they knew there was a trail when they purchased their homes
- Leakage developed along the trail about a year ago. The irrigation company (who owns the canal) came forward and said that they wanted to pipe the canal because they were liable for damages caused by the leak. The city and residents said no, and now the city is liable for damages. If we pipe the canal, all of the trees die unless other provisions are made.
- There is concern about the pond to the north which is being fed from multiple places--the water quality is bad in drought years like this year because of algae. The pond directly feeds the canal. On a good year, the canal could overtop the dike and flood homes which were built at a lower elevation near the canal. We need to figure out how to be sure the pond always has adequate water for good water quality.
- One solution is to pipe water into the pond (strawberry could be a good source)
- Is there a compromise on the problem of pedestrians
- Main issues are the water quality an the major flooding
- The city and public haven't liked any of the proposed solutions which is why they asked us to solve this for them.
- They hope that our different perspective will help solve the problem in a better way--we see things that they don't see
- There are a few requirements:
    - It must be economical--keeping costs down. Must be cheap solution
    - There must be solutions that please many people, project needs to make sense--appeal to their logic
    - be able to do it quickly--they want to have quality water
    - Is there a combination of solutions that could work
- This is a different project because we are dealing with people, the government, and the irrigation company
- Springville wants to do it right so that they don't' have the liability problem in the future
- We won't be able to please everybody

- What if the leak isn't actually from the canal??? Because of this, We don't know if any of the proposed solutions will actually fix the problem
- There will be A LOT OF OPPOSITION FROM EVERYONE about choosing the piping solution
- At the end of the year, they want US to go and present our findings to all the big important people from the city of springville
- The strawberry water issue is big
- Option 4 has a lot of negatives--try and find the positives in the problem, but also list reasons why it is a bad idea
- Solution 3 build a wall, doesn't' solve overtopping problem--build a short wall to prevent overtopping
- The best water source is strawberry. Get that water source into the pond so it will flow down
- If they are worried about the trees dying, they could install irrigation so that the trees don't die. Make it an appealing area rather than covering the pipe with concrete--turn the negatives into positives--keep in mind that we don't actually know where the leak is coming from

Advice from Dr. Lee about how to work with clients:

- Never give them one option. Always provide 2 or more options--we have these options what do you think? They will ask which one we recommend, and we need to provide reasons to backup the option that we recommend, always lead them to ask you questions so you can tell them what you know they need to know. If we get them to ask us questions that we already know the answer to, everyone will feel smart. Them for asking us questions and us for being able to answer the questions we go there mto ask. Minimize the random questions.
- If you can turn a negative into a positive people will love you. Be able to turn failure into an opportunity, or anything else at that matter--continually negotiate projects as you work on projects
- Don't be afraid to share ideas--focus on being open not defensive. Turn everything into an opportunity. If you are creative you can always find projects--in 15 years down the road we can be a hot commodity on the market. The difference between average and outstanding is that the person who is outstanding pays attention and comes up with solutions for the customer--help the customer win
- Modifying their ideas is perfectly acceptable
- Justify all the reasons why something isn't a good idea

Questions for capstone

1. Can we pipe strawberry water before it reaches pump system so that it doesn't have to pump upstream?
2. What's the change in elevation from the pump station to the pond
3. Natural spring water - is piping feasible? Will it fix the problem?
4. Irrigating for trees after piping canal?
5. Min depth needed in pond to ensure water quality
6. Lining temporarily
7. Build small retaining wall on side of canal to prevent flooding.

Max Barnes <barnesmaxmax@gmail.com> Mon, Sep 24, 5:33 PM
to bhaslam, me, Reed, Lila

Byron,

Here is a copy of the template for the Scope (Statement of Work) form that we are going to fill in and return to the City for approval before October 8th. Please let us know if there is anything specific that needs to be included in this form from your side.

We are going to meet Dr. Hotchkiss at the Wayne Bartholemew Family Park parking lot at 5 pm on Friday, September 28. Please come if you are able.

Thanks,
Max Barnes
Centilium Engineering Capstone

Byron Haslam <Bhaslam@springville.org> Tue, Sep 25, 10:58 AM
to Max, me, Reed, Lila

Centilium Engineering Capstone Team,

I have talked over the project with Brad Stapley. I wanted to give you some follow up information for your scope you are working on. First, Brad would like you to keep piping the strawberry Water to the east of pond as an option. He feels like it would be good to have you continue looking at this option. Second, we wanted to let you know that we have talked with the irrigation company and it has been decided that the stream needs to carry a minimum of 20 cfs. Lastly, we do not have any time sensitive deadlines. Let me know if you have any other questions.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org
springville ENGINEERING

Max Barnes <barnesmaxmax@gmail.com> Mon, Oct 1, 10:34 AM
to bhaslam, me, Reed, Lila

Byron,

After our site visit last Friday, we have several questions:

1. Which houses did the breach occur at?
2. Dr. Hotchkiss mentioned a meeting on Tuesday, October 9 at 6:30 am about water in Springville. Could two representatives from our capstone group attend?
3. We are thinking about wading the canal to get a better feel for its current condition. Do you know who we would need to talk with to get permission to do that?
4. We also thought about trying to talk briefly with the homeowners along the canal. Would that be a problem?
5. Do you know what the current flow rate in the canal is? It was very slow, however, there was some flow. What water source is currently feeding the canal?
6. Do you know how we can get the bury depths for the utilities under E 1100 S as well as the dirt intersection where the canal disappears (the dirt road possibly going into Goldberry farms near the horse enclosure)?

Thanks,
Max Barnes
Centilium Engineering Capstone

Byron Haslam <Bhaslam@springville.org> Mon, Oct 1, 4:24 PM
to Max, me, Reed, Lila

Max,

Please see my response below in BLUE.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org
springville ENGINEERING

Byron,

After our site visit last Friday, we have several questions:

1. Which houses did the breach occur at? The Breach happened at 2611 E 1100 S.
2. Dr. Hotchkiss mentioned a meeting on Tuesday, October 9 at 6:30 am about water in Springville. Could two representatives from our capstone group attend? If you would like to you can attend the meeting you can. They will not be discussing Ditch #1 but you could see if they will discuss it since you are there.
3. We are thinking about wading the canal to get a better feel for its current condition. Do you know who we would need to talk with to get permission to do that? The ditch is currently dry so you can walk it if you would like.
4. We also thought about trying to talk briefly with the homeowners along the canal. Would that be a problem? The City prefers that you not talk to the residents on your own. People may be frustrated about the ditch and we do not want them to take it out on you. If you think this would be critical to your project, we can look into the city doing a public meeting where you attend. That way the City is running it.
5. Do you know what the current flow rate in the canal is? It was very slow, however, there was some flow. What water source is currently feeding the canal? The water feeding the canal is Hobble Creek. The agreement with the Irrigation Company is to be able to flow 20 cfs.
6. Do you know how we can get the bury depths for the utilities under E 1100 S as well as the dirt intersection where the canal disappears (the dirt road possibly going into Goldberry farms near the horse enclosure)? I have attached some survey points. Also, Our online GIS has depths on Sewer.

1332	7223380.607	1622514.195	4782.271	EOC
1333	7223308.752	1622507.812	4777.887	IRRIG BOX
1334	7223306.954	1622531.177	4778.599	EOA
1335	7223272.779	1622628.305	4779.9	EOA
1336	7223278.462	1622629.577	4780.412	EOA
1337	7223269.232	1622625.173	4778.044	NG
1338	7223266.491	1622625.478	4774.64	NG
1339	7223237.246	1622803.003	4782.573	EOA
1340	7223231.904	1622800.656	4782.278	EOA
1341	7223225.298	1622798.041	4782.006	NG
1342	7223222.594	1622796.282	4776.843	NG
1343	7223221.685	1622800.6	4781.552	NG
1344	7223189.651	1623606.083	4783.907	IRRIG DTICH FL
1345	7223190.052	1623611.25	4783.856	IRRIG DTICH FL
1347	7223191.876	1623540.948	4783.817	IRRIG DTICH FL
1348	7223309.61	1623921.435	4785.684	IRRIG DTICH FL
1349	7223312.216	1623925.903	4792.089	IRRIG MANHOLE
1350	7223309.574	1623921.76	4785.616	IRRIG PIPE 48 FL

Max Barnes <barnesmaxmax@gmail.com> Mon, Oct 15, 10:46 AM
to bhaslam, me, Lila, Reed

Byron,

We have spent some time looking at a solution for moving the Strawberry water to encourage better circulation and increased water quality in the pond. We have come up with a few ideas, but need some information about the water.

1. What is the maximum amount of water in cfs taken from strawberry?
2. What is the average flow in cfs taken from strawberry?
3. Does the City of Springville or the Springville Irrigation Company have geotechnical reports about the area where the breach occured? If so, we would like access to these reports so that we can better evaluate possible problems and solutions
4. If these geotechnical reports are not available, could we take a soil sample in the area? We would provide fill dirt for the area where the sample is taken from
5. We noticed that the park has permitted parking stalls. We are curious to see if we could get 1-2 parking passes for the parking lot for use during this project

Thanks,
Max Barnes
Centilium Engineering Capstone

Byron Haslam <Bhaslam@springville.org> Mon, Oct 15, 2:13 PM
to Max, me, Lila, Reed

See below.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org
springville ENGINEERING

Byron,

We have spent some time looking at a solution for moving the Strawberry water to encourage better circulation and increased water quality in the pond. We have come up with a few ideas, but need some information about the water.

1. What is the maximum amount of water in cfs taken from strawberry? I do not know the max cfs from strawberry. Currently it comes down a 30" pipe. Jeff's thought was to tie a 24" pipe to the strawberry outlet structure and push as much water as we could back to the Bartholomew pond.
2. What is the average flow in cfs taken from strawberry? See above.
3. Does the City of Springville or the Springville Irrigation Company have geotechnical reports about the area where the breach occured? If so, we would like access to these reports so that we can better evaluate possible problems and solutions We do not have a geotechnical report for that area but you can go take a sample if you would like to.
4. If these geotechnical reports are not available, could we take a soil sample in the area? We would provide fill dirt for the area where the sample is taken from See above.
5. We noticed that the park has permitted parking stalls. We are curious to see if we could get 1-2 parking passes for the parking lot for use during this project. Let me reach out to our building and grounds to see if they can get us permit.

Max Barnes <barnesmaxmax@gmail.com> Fri, Nov 2, 12:58 PM
to Rollin, me, Lila, Reed

Dr. Hotchkiss,

We appreciate your attendance at our meeting this afternoon. The information and knowledge you share with us is always welcome and very much appreciated.

Attached you will find the most current version of our Statement of Work. Please look over this and feel free to provide any feedback you have.

We did have a one follow up question from our conversation. If we know the flow, cross-section, and canal elevations, can we determine the interface elevation at each cross-section at the known flow?

Respectfully,
Max Barnes

Max Barnes <barnesmaxmax@gmail.com> Thu, Nov 1, 12:44 PM
to bhaslam, me, Reed, Lila

Byron,

Attached you will find our drafted SOW. Please take a few minutes to look over the document. We would appreciate any feedback the City has, as well as any additional information or changes that need to be made.

You can click here to view our most recent progress reports. Were currently working with the soil samples we gathered, and are going to begin further analysis for the project.

Thanks,
Max Barnes
Centilium Engineering Capstone

Byron Haslam <Bhaslam@springville.org> Nov 1, 2018, 1:14 PM
to Max, me, Reed, Lila

Max,

I have a few thoughts looking over the SOW. I would describe more of the work you will be doing in the introduction. Give maybe a paragraph to the introduction saying you have been selected by Springville City to look at options of fixing the ditch and aa option of piping Strawberry water back to the Bartholomew pond. Also, the City Surveyor might have elevations to go along with your GIS Map elevations. Lastly, when you get doing estimates, it might be a good idea to use the total cost estimates from Brad's presentation to double check yourselves.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org

springville ENGINEERING

Max Barnes Nov 5, 2018, 10:18 AM
to Bhaslam, me, Reed, Lila

Byron,

Attached you will find an updated version of our SOW. Do you happen to have the contact information for the city surveyor and the city arborist (or a local arborist)?

Would you like us to continue contacting just you, or should we begin including Brad Stapley?

Thanks,
Max Barnes
Centilium Engineering Capstone

Waterboard Council Meeting Minutes:
Water Meeting Questions:

Q. How valuable is the plant life around the canal? We understand that it is important, however we are concerned that one of our solutions may cause some loss to plant life along the canal, mainly the trees along the south side of the canal.

A. Very important to the people who live there, the people who pay for the water don't carea about the tree. It comes bac to dollars. Who is going to pay for it

Decided not to pipe it originally because of the older hertigage trees. People might not choose to wawter it. And the trees "could" die

Q. How can we mitigate use of the canal during construction and in the future? Especially privately used sections.

A. We should have access and rights, that is something that we don't need to worry about, there are no water rights for animal use, so manure man has to deal with it.

Q. At the junction where the canal ends, where does the water go? Where can we get elevations and pipe capacities? Are there plans for the junction?

A. There won't be any issues with the junction, we don't need to worry about it

Q. What purpose does the irrigation pipe running under 1100 S/River Bottom Rd currently serve? Logistically, is there a possibility of running a second irrigation pipe under 1100 S/River Bottom Rd to connect to the junction, bypassing the canal?

A. Expensive, 36 inch PI pipe that runs both directions (some of them like this idea), they talked a lot about springs or leakage causing water in the canal right now, then talked more about the trees. Didn't throw the idea out it's just going to be more expensive

Q. We want to get your thoughts, ideas, and concerns about finding a solution to cause more water circulation in the pond. Options that we have come up with thus far include:
a. Water feature (similar to lazy river near city library in St. George, Utah, or that of City Creek Mall in Salt Lake City)
b. Underwater wall
c. Piping a small portion of strawberry water to other end of pond
A. There is a pipe that goes along where we thought to put the river, open box under concrete that would have to be changed. PI pipe makes a left hand turn when the water demand is high and doesn't go into the pond--valving issue. Be imaginative

Contact Information

1. Albert Harmer--Springville Irrigation, (801) 310-2344
2. Marlin Boyer--Springville Irrigation, (801) 361-8075
3. Patti Anderson--Springville Irrigation Front Desk, (801) 491-2985
4. Shawn Barker --Springville City Water, (801) 420-0421, sbarker@springville.org

Max Barnes <barnesmaxmax@gmail.com> Mon, Dec 10, 2018, 4:12 PM
to bstapley, bhaslam, me, Lila, Reed

Brad and Byron,

Please find a copy of the 30% completion report attached.

Respectfully,
Max Barnes
Centilium Engineering Capstone

Max Barnes <barnesmaxmax@gmail.com> Mon, Dec 10, 2018, 4:12 PM
to Rollin, Reed, me, Lila

Dr. Hotchkiss,

Please find a copy of the 30% completion report attached.

Respectfully,
Max Barnes
Centilium Engineering Capstone

Rollin Hotchkiss <rhh@byu.edu>
to Max, Reed, me, Lila
Mon, Dec 10, 2018, 7:47 PM

Max:

Very good job! I like the template approach Dr. Lee had set up.

Two comments: you visited the Water Board, not the waterboard. Big difference!

The particle size distributions are Very interesting. Have the fines been washed out at the breach location?

Rollin
Sent from my iPhone

Lila Lasson <Lila@lassons.net>
to Max, Reed, me
Mon, Jan 14, 9:25 AM

Mouth of canal
Center
Height 5 feet
Distance 102.9 ft
Height 10.093ft

Bridge

Center
Height 5 feet
Distance 35.1
Height10.028
Side
Distance 27.2
Height 7.230

West of bridge
Center
Height 10.354
Distance 46.6
Side
Distance 29.2
Height 6.027

Behind rude ladies house
Center
Distance 33.0
Height 10.055
Angle 14
Center
Distance 68.7
Height 9.798
Angle 11.9
Side
Height 5.945
Distance 30.1
Angle 58.5

Mouth of canal west side
Center 1and
Height 11.017
Distance 59.0
Angle 199
Center 2
Distance 76.9
Height 11.143
Angle 201
Center 3
Distance 93.3
Height 10.949
Angle 198.5
Side
Distance 124.6
Height 8.33
Angle 196

West side of fence
Center
Distance 71.5
Height 4.401
Angle 134
Side
Height 2.89
Distance 47.1
Angle 140

West of gazebo house
Center
Distance 69.5
Height 5.532
Angle 321.5

House West of gazebo house
Center
Distance 121.5
Height 5.046
Angle 331

Backshoot
Center
Distance 71.3
Height 4.138
Angle 140.5

Center of property west of gazebo
Center
Distance 58.2
Height 5.047
Angle 329
Side
Distance 59.4
Height 3.007
Angle 322bi

End of canal
Center
Distance 32.5
Height 8.424
Angle 237.5

Dr. Hotchkiss,

This is late notice, but we were hoping to be able to meet with you this evening directly after 472 at 5 pm. If this time doesn't work, we are able to meet as a group at 5 or 5:30 pm on Thursday this week as well.

Please let us know.

Thanks,
Max Barnes
Centilium Engineering Capstone

Max Barnes
to crandallfarms, me, Reed, Lila
Thu, Jan 24, 5:20 PM

Calvin,

We met a few months ago at the Springville Water Meeting. I am one of the students from BYU working to find solutions to the leaking that is happening in Ditch #1. My team and I have come up with several questions and concerns about the canal and its history that we wanted to discuss with you. I was hoping that there was a day next week, possibly on Tuesday or Thursday between 11:30 and 2 that we could meet for lunch.

I'm not very familiar with restaurants in Springville, are there any that you would recommend? I'm thinking something like Cafe Rio or Chili's. I'll come prepared with a short list of questions.

Also, we are trying to find contact information for the Ditch Rider with Springville Irrigation Company, I believe his name is Tom Stettser. Do you know how to get in contact with him?

Thanks,
Max Barnes
Centilium Engineering Capstone

Max Barnes
to JPenrod, me, Reed, Lila

Thu, Jan 24, 3:25 PM

Mr. Penrod,

I am a member of an engineering capstone group at BYU working on a solution to stop the leaking of Ditch #1 near the Bartholomew Family Park. We have come across several legal questions regarding possible solutions to the problem that you might be able to help us answer.

One question specifically addresses an assumption that we are able to fix the presumed leak in the ditch when in reality the leaking comes from another source such as a natural spring. A few other types of questions we have are regarding noise, construction, and possible loss of vegetation (cottonwood trees that currently grow along the canal). I can go over these questions at greater depth with you during our meeting.

I wanted to see if there was a time we could meet next week for about 30 minutes to discuss some of the potential legal issues. I am available Wednesday-Friday after 3:30. Alternatively, I could potentially meet on Tuesday or Thursday before 9:30. Or, if there is a time that works better for you, please let me know.

Thanks,
Max Barnes
Centilium Engineering Capstone

John Penrod <JPenrod@springville.org>
to Max, me, Reed, Lila

Fri, Jan 25, 8:53 AM

Max,

Thanks for the email. I am available this coming Wednesday any time after 3:30. Let me know what works for you.

Thanks -

JOHN PENROD
City Attorney
jpenrod@springville.org
801.489.2703
springville.org

springville LEGAL

From: Byron Haslam
Sent: Tuesday, February 05, 2019 12:11 PM
To: Shawn Barker
Cc: Jake Nostrom
Subject: Pipe Size

Shawn or Jake,

The Capstone group from BYU wants to know the size of the pipe dumping the strawberry into the PI pond? Do you know what flow it carries?

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org

springville ENGINEERING

From: Jake Nostrom
Sent: Tuesday, February 5, 2019 1:35 PM
To: Byron Haslam <Bhaslam@springville.org>; Shawn Barker <sbarker@springville.org>
Subject: RE: Pipe Size

CUP supply's us Strawberry water through a 24"meter which ties directly into our 36" transmission line. The most we have ran is 20 CFS during a test.

JAKE NOSTROM
Field Supervisor
janostrom@springville.org
801.491.7818
springville.org

springville WATER

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801.491.7863
springville.org

springville ENGINEERING

Byron Haslam <Bhaslam@springville.org>
to Bradley, Max, Lila, me, Reed
Tue, Feb 5, 12:12 PM (12 days ago)

Max,

Attached is the Bid Schedule we talk about. I will let you know the City council date.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801 491 7863
springville.org
springville ENGINEERING

SECTION 00310

BID SCHEDULE

PROJECT IDENTIFICATION

Name: 1150 NORTH STORM DRAIN

Submitted to: Springville City
110 South Main
Springville City, Utah 84663

RELATED SECTIONS

Section 01025: Measurement and Payment

SCHEDULES TO BE ADDED TO THE AGREEMENT

This Bid Schedule contains the schedule of values which will be incorporated into the Agreement (Section 00500) by reference.

BID SCHEUDLE

Approach To Work and Constraints
The following shall be considered in preparing the Bid Schedule:
1150 North must remain open to traffic with a minimum of one lane of traffic in each direction at all times. Access to all adjacent streets will need to be provided at all time during the project.
Night work will be allowed (if requested), but not required.
Cost of mobilization is limited to no greater than 5% of the cost of construction.
Schedule of Values

ITEM	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL AMOUNT

1	Mobilization	1	LS		$
2	Traffic control	1	LS		$
3	Remove and Dispose of Existing Storm Drain Pipe	662	LF		$
4	Remove and Dispose of Existing Drainage Structure	5	EA		$
5	Remove and Dispose of Existing Pavement	15500	SF		$
6	Remove and Dispose of Existing Concrete Flatwork	200	SF		$
7	Remove and Dispose of Existing Concrete Cross Gutter	150	SF		$
8	Remove and Dispose of Existing Concrete Curb and Gutter	110	LF		$
9	15 Inch RCP	450	LF		$
10	18 Inch RCP	132	LF		$
11	24 Inch RCP	980	LF		$
12	6” Water Main Loop	2	EA		$
13	Plug Existing Storm Drain Pipe	1	EA		$
14	Remove and Replace Sewer Lateral	1	EA		$
15	Furnish and Install 5’ Storm Drain Manhole	5	EA		$
16	Furnish and Install Storm Drain Combo Box	3	EA		$
17	Furnish and Install Dual Storm Drain Inlet Box(APWA Plan 315.2)	1	EA		$
18	Furnish and Install Storm Drain Inlet Box	2	EA		$
19	4” Asphalt	15500	SF		$
20	Adjust Existing Manhole to New Finished Grade	3	EA		$
21	6” Concrete Flatwork (includes associated roadbase)	200	SF		$
22	Concrete Cross Gutter (includes associated roadbase)	150	SF		$
23	24" Concrete Curb and Gutter (includes associated roadbase)	50	LF		$

24	30" Concrete Curb and Gutter (includes associated roadbase)	60	LF		$
25	Landscaping/ Landscaping Restoration	220	SF		$
BID TOTAL					$

BIDDER'S ACKNOWLEDGEMENT

The BIDDER acknowledges to the OWNER that the BID provided herein includes total cost required to build a fully functioning project including all work, materials, appurtenances, accessories, and related items as outlined within these specifications and shown in the drawings.

COMPANY: ______________________________

Signed: ______________________________

Title:

Date: ______________________________

Email: ______________________________

Phone #: ______________________________

- END OF SECTION –

Byron Haslam <Bhaslam@springville.org>   Feb 5, 2019, 12:22 PM (12 days ago)
to Max, Bradley, Lila, me, Reed

Max,

You are on the City Council Agenda to give your presentation on March 12th at 5:30.

Thank you,

BYRON HASLAM P.E.
Staff Engineer
bhaslam@springville.org
801 491 7863
springville.org

springville ENGINEERING

From: **Byron Haslam** <Bhaslam@springville.org>
Date: Wed, Feb 27, 2019 at 11:15 AM
Subject: RE: Cost Analysis
To: Max Barnes <barnesmaxmax@gmail.com>

Max,

I would increase the labor cost some. I would round it off to the nearest dollar also, probably $50

Thank you,

engineering_emailsig_bhaslam_V1

Appendix C: Data Analysis and Design

Data collection

Table 3: Canal Measurements

Locations	Top Width	Bottom Width	Notes	Min Depth	Max Depth	30 cfs depth min	30 cfs depth max
Closest to Pond	27	12		0.473	0.698		
Bridge (Choke Point)	7	7	Height:3	0.716	1.106		
2811 E			Couldn't get into canal				
Culvert	12	4	D=3	0.895	1.298	1.124	1.616
2745 E (East)	27	16	Some Vegetation	0.403	0.599		
2745 E (Center)		16	Some Vegetation	0.413	0.622		
2745 E (West)	18	11	Some Vegetation	0.507	0.755		
2727 E			Not a lot of vegetation, Couldn't get into canal.				
2709 E	16.5	11.5	Height: 3	0.497	0.743		
2677 E (East)	14	7	1 side vertical 1 side angled, Pics on Reeds phone 1-7	0.668	0.991		
2677 E (West)	11	12	Choke Point	0.496	0.752		
2653 E	14	8	Sample 1 (Bag)	0.617	1.124		
2611 E			Breach, Sample 2 (Bucket)				
2577 E			Pics on Meghann phone				

Table 4: Additional Canal Measurements

Length of Canal (ft)	1502
Perimeter of Canal (ft)	28
Area of Canal (ft^2)	81
Partical Canal (ft)	285

Table 5: Springville City Ditch 1 Survey Data

1332	7223380.607	1622514.195	4782.271	EOC			40.1500328	-111.5640461
1333	7223308.752	1622507.812	4777.887	IRRIG BOX			40.1498355	-111.5640687
1334	7223306.954	1622531.177	4778.599	EOA			40.1498306	-111.5639852
1335	7223272.779	1622628.305	4779.9	EOA			40.149737	-111.5636376
1336	7223278.462	1622629.577	4780.412	EOA			40.1497526	-111.5636331
1337	7223269.232	1622625.173	4778.044	NG			40.1497272	-111.5636488
1338	7223266.491	1622625.478	4774.64	NG			40.1497197	-111.5636477
1339	7223237.246	1622803.003	4782.573	EOA			40.1496398	-111.5630125
1340	7223231.904	1622800.656	4782.278	EOA			40.1496251	-111.5630209
1341	7223225.298	1622798.041	4782.006	NG			40.149607	-111.5630302
1342	7223222.594	1622796.282	4776.843	NG			40.1495995	-111.5630365
1343	7223221.685	1622800.6	4781.552	NG			40.149597	-111.5630211
1344	7223189.651	1623606.083	4783.907	IRRIG DTICH FL			40.1495106	-111.5601394
1345	7223190.052	1623611.25	4783.856	IRRIG DTICH FL			40.1495117	-111.5601209
1347	7223191.876	1623540.948	4783.817	IRRIG DTICH FL			40.1495166	-111.5603724
1348	7223309.61	1623921.435	4785.684	IRRIG DTICH FL			40.1498405	-111.5590115
1349	7223312.216	1623925.903	4792.089	IRRIG MANHOLE			40.1498477	-111.5589955
1350	7223309.574	1623921.76	4785.616	IRRIG PIPE 48 FL			40.1498404	-111.5590104

Soil Analysis

-3/4	wet + pan	1389						
	dry + pan	1254.5						
	pan	347.9						
	total dry	906.6						
	mositure content	14.83564968	Seive no	Diameter inches	wet weight	dry weight	% weight retaine	% Passing
+3/4	wet + pan	1374	4 in	4	0	0	0	100
	dry + pan	1346	3 in	3	0	0	0	100
	pan	254.9	2 in	2	1895.2	1847.781896	7.367551538	92.63244846
	total dry	1091.1	1.5 in	1.5	9743.7	9499.911599	37.87843601	54.75401246
	mositure content	2.566217579	1 in	1	135.5	132.1097757	0.5267535001	54.22725896
			0.75 in	0.75	346.7	338.0255294	1.347789214	52.87946974
Total wet weight of sample		27350.8	0.5 in	0.5		106.1	1.336971904	51.54249784
Total dry weight of sample		25079.9996	0.375 in	0.375		126.2	1.590253104	49.95224474
-3/4 wet		15229.7	#4	0.187		290.3	3.658086181	46.29415855
-3/4 dry		13262.1708	#10	0.0787		313.8	3.954210967	42.33994759
+3/4 wet		12121.1	#40	0.0165		406.9	5.12736916	37.21257843
+3/4 dry		11817.8288	#140	0.0041		1291.3	16.27174194	20.94083649
			#200	0.0029		152	1.915360315	19.02547617
						2686.6		

Wash	Wet+ Pan	6153				
	pan	1334				
	total dry	4196.432043				
atterberg lilmits	bop					
Ken	10	26.1	24	15.9	0.2592592593	
Santa Maria	14	29	27	16.7	0.1941747573	
Eddie/ helam	25	39.3	36.8	25.6	0.2232142857	
#5 eddie		18.3	17.4	12.7	0.1914893617	0.1707446809
boomerang		20.3	19.7	15.7	0.15	PL=17
	can					LL=22
snake 1	19	16.1				PI=5
Snake 2	27.7	25.1				
rogue	27.6	16.2	https://structx.com/Soil_Properties_007.html			
DSM3	31.4	15.9	k=	5*10^-9 to 1*10^-6 m/s		
titanic	25.9	15.2				
MI	25.6	16	https://www.nrcs.	0.42-1.41	micrometers per second	

Fluid Flow Analysis

Table 6: Manning's Coefficients

Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035

How to perform mannings equation: https://www.lmnoeng.com/Channels/trapezoid.php

Assumed height of canal = 3 ft and assumed channel flow = 20 cfs

- What is the elevation change?
  - East Elevation: 4785.685
  - Mid Elevation: 4783.817
  - Distance: 400 ft

Slope = 0.00467

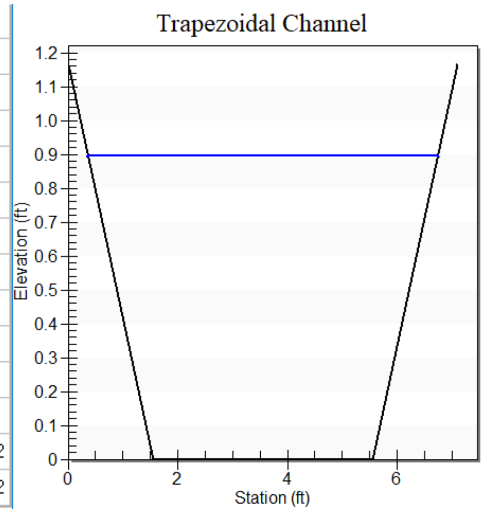
Worst Case: Culvert

Top - 12 Bottom - 4

Z1 & Z2 = 1.3333

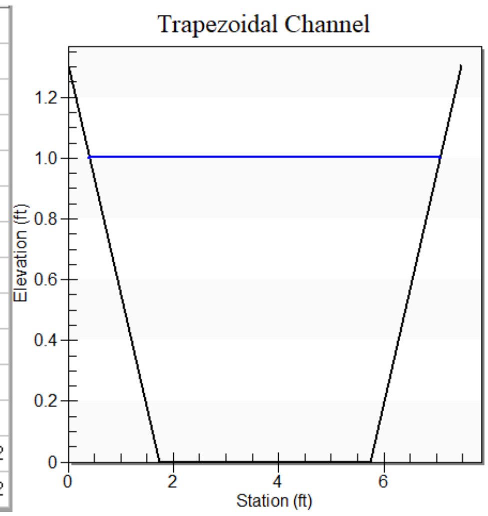
Results with smooth earth

Flow	20.000	cfs
Depth	0.895	ft
Area of Flow	4.650	sq ft
Wetted Perimeter	6.984	ft
Hydraulic Radius	0.666	ft
Average Velocity	4.301	fps
Top Width (T)	6.387	ft
Froude Number	0.888	
Critical Depth	0.833	ft
Critical Velocity	4.696	fps
Critical Slope	0.006...	ft/ft
Critical Top Width	6.222	ft
Max Shear Stress	0.261	lb/ft^2
Avg Shear Stress	0.194	lb/ft^2



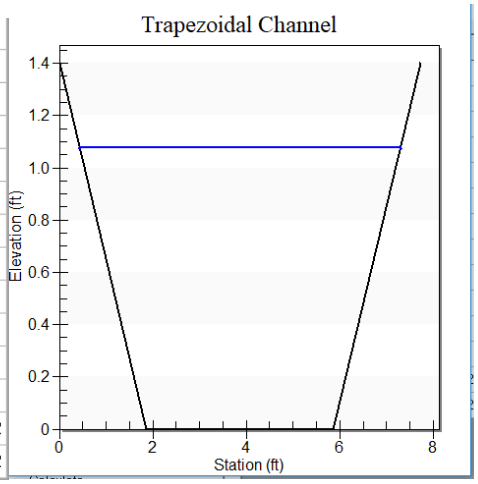
Results with clean earth channel

Flow	20.000	cfs
Depth	1.003	ft
Area of Flow	5.352	sq ft
Wetted Perimeter	7.342	ft
Hydraulic Radius	0.729	ft
Average Velocity	3.737	fps
Top Width (T)	6.674	ft
Froude Number	0.735	
Critical Depth	0.833	ft
Critical Velocity	4.698	fps
Critical Slope	0.008...	ft/ft
Critical Top Width	6.221	ft
Max Shear Stress	0.292	lb/ft^2
Avg Shear Stress	0.212	lb/ft^2



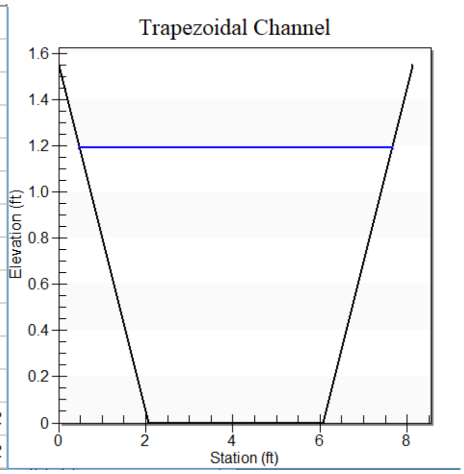
Results with gravelly earth channel

Flow	20.000	cfs
Depth	1.077	ft
Area of Flow	5.854	sq ft
Wetted Perimeter	7.589	ft
Hydraulic Radius	0.771	ft
Average Velocity	3.417	fps
Top Width (T)	6.871	ft
Froude Number	0.652	
Critical Depth	0.834	ft
Critical Velocity	4.694	fps
Critical Slope	0.011...	ft/ft
Critical Top Width	6.222	ft
Max Shear Stress	0.314	lb/ft^2
Avg Shear Stress	0.225	lb/ft^2



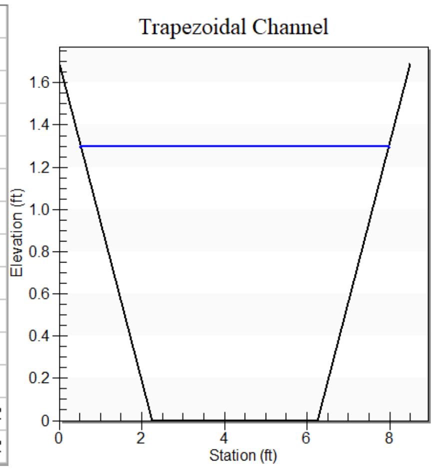
Results weedy earth channel

Flow	20.000	cfs
Depth	1.192	ft
Area of Flow	6.660	sq ft
Wetted Perimeter	7.972	ft
Hydraulic Radius	0.835	ft
Average Velocity	3.003	fps
Top Width (T)	7.177	ft
Froude Number	0.549	
Critical Depth	0.834	ft
Critical Velocity	4.693	fps
Critical Slope	0.016...	ft/ft
Critical Top Width	6.223	ft
Max Shear Stress	0.347	lb/ft^2
Avg Shear Stress	0.243	lb/ft^2



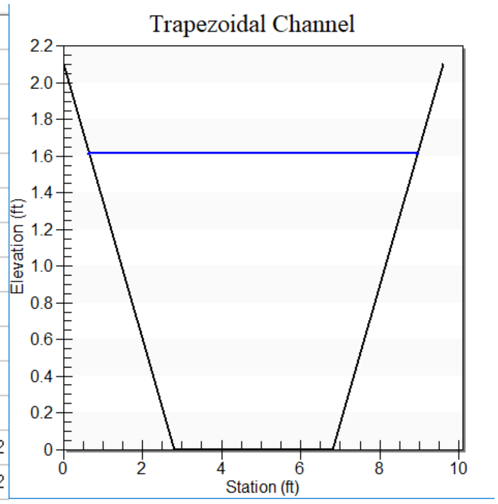
Results stony, cobbles earth channel

Flow	20.000	cfs
Depth	1.298	ft
Area of Flow	7.436	sq ft
Wetted Perimeter	8.325	ft
Hydraulic Radius	0.893	ft
Average Velocity	2.690	fps
Top Width (T)	7.460	ft
Froude Number	0.475	
Critical Depth	0.834	ft
Critical Velocity	4.694	fps
Critical Slope	0.022...	ft/ft
Critical Top Width	6.222	ft
Max Shear Stress	0.378	lb/ft^2
Avg Shear Stress	0.260	lb/ft^2



Results 30 cfs stony, cobbles earth channel

Flow	30.000	cfs
Depth	1.616	ft
Area of Flow	9.946	sq ft
Wetted Perimeter	9.387	ft
Hydraulic Radius	1.060	ft
Average Velocity	3.016	fps
Top Width (T)	8.309	ft
Froude Number	0.486	
Critical Depth	1.063	ft
Critical Velocity	5.208	fps
Critical Slope	0.021...	ft/ft
Critical Top Width	6.835	ft
Max Shear Stress	0.471	lb/ft^2
Avg Shear Stress	0.309	lb/ft^2



Flow Net Analysis

Cost Analysis

Table 7: Costs of Materials and Labor

Cost to move dirt per yard	$100.00	Cubic yard
Cost to Transport Dirt	$15	Cubic yard
Cost of Sheet pile	$50.00	sq ft
Cost of Labor/Construction	$43.31	per hour per person
Cost Concrete lining	$5.50	sq ft
Cost Geomembrane liner	$1.38	sq ft
Cost of HDPE pipe (12in)	$25	linear feet
Cost HDPE pip (36in) per foot	$41.85	
Cost Cubic foot of compacted clay fill		
36 in concrete pipe + labor per foot	$80.60	
HDPE Pipe labor per foot	$18.50	
Cost of fill dirt per cb yard	$15.00	
Cost of dredging per cb yard	$20	
Perferated Pipe (3 in)	$1.28	
Pipe Sock (3in)	$0.23	
gravel per cb yd	$23	
Cost of pipe layer per hr	$150.00	

Table 8: Cost Analysis

Cost Analysis of Options													
Reline Ditch		Pipe the Ditch		Pipe Part of the Ditch		Cut off wall		Cut off Wall + Strawberry		Cut off wall +strawberry+pipe ditch		Drain behind	
Geomembrane liner	$58,037.28	Pipe	$62,858.70	Pipe	$11,927.25	Compacted Clay Fill	$20,861.11	Compacted Clay Fill	$20,861.11	Compacted Clay Fill	$20,861.11	Gravel	$1,578.06
Concrete liner	$231,308.00	Compacted Fill	$61,694.65	Compacted Fill	$12,825.00	Excavation	$166,888.89	Strawberry	$1,157,177	Strawberry	$1,157,177	Perferated pipe	$364.80
Dredging canal	$9,298	Labor	$504,000.00	Labor	$168,000.00	Labor	$145,521.60	Labor	$138,592.00	Labor	$138,592.00	Pipe Sock	$65.55
Labor Liner	$109,141.20	Restoration	$4,500.00	Dredge	$9,298	Concrete Core	$52,570.00	Concrete Core	$52,570.00	Pipe	$37,550	Excavation	$31,666.67
Restoration	$4,500.00			Restoration	$4,500.00	Restoration	$48,514.00	Restoration	$48,514.00	Concrete Core	$52,570.00	Labor	$42,000.00
										Restoration	$48,514.00	Restoration	$72,771.00
												strom drain connection exc.	$14,444.44
												Strom drain conn. pipe	$166.40
												Connection to storm drain	$10,000
Total Geomembrane	$180,976.66	**Total**	$633,053.35	**Total**	$206,550.43	**Total**	$434,355.60	**Total**	$1,417,714.44	**Total**	$1,455,264.44	**Total**	$173,056.92
Total Concrete	$354,247.38	**% Error Total**	$759,664.02	**% Error Total**	$247,860.52	**% Error Total**	$521,226.72	**% Error Total**	$1,701,257.33	**% Error Total**	$1,746,317.33	% Error Total	$207,668.30
% Error Total concrete	$425,096.86	**Rounded**	$760,000.00	**Rounded**	$248,000.00	**Rounded**	$522,000.00	**Rounded**	$1,702,000.00	**Rounded**	$1,750,000.00	Rounded	$210,000.00
% Error Total Geomembrane	$217,172.00												
Rounded Concrete	$426,000.00												
Rounded Geomembrane	$220,000.00												

Short Strawberry		Med Strawberry		Long Strawberry	
Pipe	$11,250	Pipe	$20,275	Pipe	$54,600
Excavation	$10,000.00	Excavation	$18,022.22	Excavation	$182,044.44
Labor	$252,000.00	Labor	$336,000.00	Labor	$672,000.00
Restoration	$7,156.00	Restoration	$7,156.00	Restoration	$55,670.00
Total	$280,406	**Total**	$381,453	**Total**	$964,314
% Error Total	$336,487	% Error Total	$457,744	**% Error Total**	$1,157,177
Rounded	$337,000.00	Rounded	$458,000.00	**Rounded**	$1,160,000.00

Feasibility

Table 9: Table of Feasibility

	Feasability								Cost	Liability	Social Impact	Environmental impact		
Options	**Cost**	**Cost Rank**	**Social Impact**	**Environmental Impact**	**Speed of Implementation**	**Aesthetic**	**Liability**	**Maintanance required**	**Final Score**	**Final Score**	**Final Score**	**Final Score**		
1	$215,000.00	1	1	2	3	1	5	5	2.40	2.85	2.05	1.90	Reline Ditch	** Geomembrane
2	$420,000.00	3	1	4	3	3	5	4	3.40	3.65	2.95	3.05	Reline Ditch	**Concrete
3	$755,000.00	4	5	5	4	5	1	3	3.65	3.45	4.25	4.50	Pipe the entire ditch	
4	$445,000.00	3	3	2	2	2	4	2	2.75	2.75	2.50	2.40	Pipe ditch behind last two houses	
5	$225,000.00	2	3	1	2	1	4	1	2.10	2.05	1.90	1.75	Sheet pile behind walls	
6	$275,000.00	2	3	4	4	2	4	1	2.75	2.65	2.80	3.05	Cut-off wall	
7	$1,405,000.00	4	3	2	5	2	4	3	3.70	3.40	3.25	2.85	Cut-off wall Plus long strawberry	
8	$1,450,000.00	5	1	3	5	5	2	3	3.95	3.50	3.55	3.35	Cut-off wall Plus long strawberry and ditch entire canal	
9	$62,000.00	1	2	2	1	1	4	4	1.90	2.40	1.80	1.80	Drains behind Retaining wall	
A	$1,025,000.00	5	3	1	4	2	1	3	3.40	2.90	3.00	2.40	Long Strawberry	
B	$450,000.00	2	3	1	2	2	1	3	1.90	1.90	2.10	1.90	Medium Strawberry	
C	$330,000.00	1	3	1	1	2	1	3	1.35	1.55	1.75	1.70	Short Strawberry	
	^#		^Scale	^Scale	^#	^Scale	^Scale		1.90	2.05	1.80	1.75		
				1= ideal		**Lower score is best			1.35	1.55	1.75	1.70		
				5= not ideal										

Weights for fin:	Cost	Liablity	Social Impact	Environmental impact
Cost	0.4	0.3	0.2	0.1
Social Impact	0.05	0.05	0.2	0.2
Environmental	0.1	0.15	0.15	0.3
Speed of Imple	0.15	0.05	0.15	0.1
Aesthetic	0.05	0.05	0.15	0.2
Liability	0.15	0.2	0.05	0.05
Maintenance	0.1	0.2	0.1	0.05
	1			1