RIVERTON RE-PURPOSING SEWER TRUNK LINE TO GROUND WATER SUB-DRAIN
Project ID: CEEn_2018CPST_011

by

BKAT Engineering
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A Capstone Project 30% Completion Report

Submitted to

Trace Robinson
Riverton City

Department of Civil and Environmental Engineering
Brigham Young University

December 10, 2018

Executive Summary

PROJECT TITLE: Riverton Re-purposing Sewer Trunk Line to Groundwater Sub-drain
PROJECT ID: CEEn_2018CPST_011
PROJECT SPONSOR: Riverton City
TEAM NAME: BKAT Engineering

Project Requirements

The scope of this project is to recommend a solution to drain groundwater and stabilize the hillside next to Lovers Lane in Riverton, UT. This task may require the repurposing an existing sewer line in the hill for carrying water out of the hill. To make a final recommendation, several options are to be analyzed and compared. In this report, three possible solutions are proposed. For the final report, one recommendation will be made after thorough analysis considering cost, benefits, feasibility, and longevity.

Tasks

In order to complete this project several tasks will still need to be completed. The team will need to contact different companies in order to get an idea of the cost for each of the options. The team will then need to run a benefit to cost analysis on each option, A general drainage system for the hillside will need to be designed, based on the best solution. Further design and illustration may be needed. The overall results will need to be complied in order to report final results and recommendations.

Project Objectives

The objective of this project is to produce the best solution to the excessive water content in the hillside. There are three different solutions to this problem all of which are discussed in detail. These three options vary in their cost, effectiveness, and longevity.

Schedule Timeline

This project began on September 17, 2018 when the team met together and received the documents indicating the project needs. The team then proceed to research and gain knowledge on the project. After gathering the necessary data, the team then submitted a Statement of Work for the project. Since that submission, the team has met with Trace Robinson, of Riverton City (Client of the Project). The team has visited the project sight on multiple occasions, to examine the existing drainage system, take photos and basic measurements. Furthermore, the team has

contacted the canal company who owns the canal adjacent to the hillside. After this, the team then discussed three viable solutions.

In the next few months the team will analyze the cost for each possible solution. The benefits will be analyzed, along with the feasibility of each option. After the analysis of each possible solution is completed, the options will be compared and discussed as a team. After a complete comparison is made for each option, the team can begin to finalize a final recommendation. The team is planning to have a final recommendation by March 29, 2019. To accomplish this, the final cost estimates for each of the recommendations are to be completed by March 18, 2019. The final report, including the analysis for each option and final recommendation, will be completed and submitted to the client by April 4, 2019. Presentation on the project will be prepared for any time following April 4, 2019.

Future Deliverables

- A final report discussing all the drainage options considered, and a final recommendation to the city of Riverton.
- 3 possible design concepts with estimated costs, effectiveness, and longevity.
- Summary of analysis done by the team
- A poster reflecting a summary of the project, and recommendation to be presented to various entities.
- A PowerPoint presentation summarizing the work and analysis coming to a final recommendation for Riverton City.
- Any other additional reports as proposed and agreed upon between BKAT Engineering and Riverton City.

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Introduction

Overview

The scope of this project is to create a solution to minimize the amount of excessive groundwater in the hillside in order to stabilize the hill. In this report three different concepts are presented which will successfully decrease the water content in the hill:

1. Lining of the canal on the top of the hill in order to decrease water seepage,
2. Install an entirely new drainage system and connect it to the abandoned sewer line
3. To clean out the existing sewage line and connect it to the abandoned sewer line.

Each of the three options have unique benefits and costs. Each option could be considered to help reduce excessive groundwater from the hillside. Because of this, each one will be analyzed and ranked in the coming months.

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Assumptions

- Roughness (n-values) assumed from visual interpretation of the canal.
- Canal's Dimensions were assumed to be constant throughout.
- Flow rate is assumed to be a constant flow of the average flow rate as measured by the South Jordan Canal Company.
- Seepage from the canal is assumed to be a significantly large number.
- The lengths of the different sections of the canal was also assumed from basic measurements on Google Maps.

Expectations

It is expected that by April 4, 2019, the team will have produced an analysis for all three options. It is also expected that the team will produce a final recommendation based on these results, including a general layout/design for the recommendation. The final recommendation should decrease the water content of the hill in order to stabilize the hill for future.

Requirements

The results of this project should decrease the water content of the hillside next to Lovers Lane in Riverton, UT. Decreasing the water content will in turn stabilize the hill in order to make the area below the hillside buildable.

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Assumptions & Limitations

In calculations for the canal, many factors are assumed. All n values are estimated for the different wetted perimeter surfaces of the canal. Standard practice when using the manning's equation involves estimating the n value based on attributes of the canal, such as vegetation and type of surface. As seen in Figure 1, the canal has various lining materials and levels of vegetation. However, the majority of the canal is unlined, as seen in Figure 1.

Figure 1. Unlined Section of Canal

The n values for each applicable section of canal are estimated based on the lining and vegetation at the canal. The n values used for the canal are listed in Table 1.

Table 1. Roughness (N) Values for Canal

Section	Canal Bottom	Bottom Condition	Min	Normal	Max
1	Earth Winding and Sluggish	Stony Bottom and Weedy Banks	0.025	0.035	0.04
2	Concrete	Finished, with Gravel Bottom	0.015	0.017	0.02
3	Channels Not Maintained, Weeds and Brush Uncut	Clean Bottom, Brush on Sides	0.015	0.017	0.02

Dimensions of the canal are assumed to be constant throughout. Perfect analysis would also involve calculation with varying flow rates depending on the season. Calculations with flow rate are based on a range of average values measured by the South Jordan Canal company. Total length of the canal will also be approximated. Calculations with all of these assumptions may result in values differing from the actual.

Obtaining an accurate calculation of the total amount of canal seepage is difficult because long-term seepage has been occurring for an extended period of time. Thus, canal seepage will be estimated to a reasonable value. Calculation of slump is also not feasible due the difficulty in modeling the area but can be estimated by visiting the site. Slump estimations will be applied throughout the canal evenly. We are limited primarily to estimations for calculations of seepage and slump, which may have an effect on the results of our plans. Despite this, future values of seepage and prevention of future slump are our main focus and the result of plans pursued will become evident by observations as they are implemented.

Existing Conditions

The hillside for the project runs adjacent to Lover's lane in Riverton, Utah. This hillside has previously been tested by geotechnical engineering firm AGEC. In the report by AGEC, dated June 21,2015, it was reported that the steepest section of the hill is about 2.6:1 as indicated in Table 2. Furthermore, it was determined that the hill's stability was marginal. This indicates the hill has high potential for movement, and possible mitigations should be investigated.

Table 2. Slope Results for Hillside

Profile	Height of Slope (with respect to Lovers Lane			Slope (horizontal : vertical)	
	Above	Below	Total	Steepest	Overall
A	40	35	75	1.4:1	5.3:1
C	45	26	71	2.6:1	2.5:1
D	32	32	64	2.0:1	3.2:1

In addition to strength testing, AGEC tested the hill for depth to groundwater. It was found that the depth to groundwater was shorter than other nearby areas. This indicates the possible influence of seepage water from the adjacent canal. In addition, previous studies collected soil sample from the hill and performed a sieve analysis. This analysis reported that the soil is mostly made up a silty sand. Results are tabulated in Table 3 (next page).

Table 3. Sieve Analysis Gradation Results

Sieve Designation	Sieve Opening Size (mm)	Percent Passing (%)	Project Specifications (%)
5"	127	100	-
3"	76.2	100	-
1 1/2"	38.1	100	-
3/4"	19.1	89	-
3/8"	9.52	64	-
#4	4.76	46	-
#8	2.38	37	-
#16	1.19	29	-
#30	0.59	23	-
#50	0.297	18	-
#100	0.149	14	-
#200	0.074	10	-
GRAVEL	SAND	SILT & CLAY	
54%	36%	10%	

Design, Analysis & Results

Previously, geotechnical analysis has determined that the hillside at Lover's Lane stability is marginal, suggesting a need for more stability. Based on site visits, soil properties, and location, it was determined that the seepage from the canal is the main issue for the hillside. Existing drains in the hill are continually draining water, but many of these pipes are clogged or deteriorated. The soil in the hillside consists of mostly silty sand, which provides low stability strength. Altering the slope is not in the plans for the city at this time. Based on this information, the team's purpose was to propose a solution for the instability in the hill caused by the excess of groundwater. At this point in the project, this report includes three possible solutions. Each scenario will receive a preliminary design and analysis, but only the option chose as a recommendation will receive more in-depth design and analysis, in later reports.

The first option is to address the source of the water seepage, with the South Jordan Canal. This scenario includes lining the South Jordan Canal with an impermeable membrane and/or concrete to prevent water seepage during the irrigation season. Figure 2 illustrates on approximate cross section of the canal. This option may be a bit complicated due to the fact the Canal is not owned by the City of Riverton. The canal is owned by The South Jordan Canal Company. Therefore, any project involving lining the canal could only be possible depending on the coordination of Riverton City and South Jordan Canal Company., and the willingness to work together of each. Based on initial analysis, this may be the most effective means to stabilize the hillside. Lowering the seepage rate from the canal will increase the stability of the hill significantly.

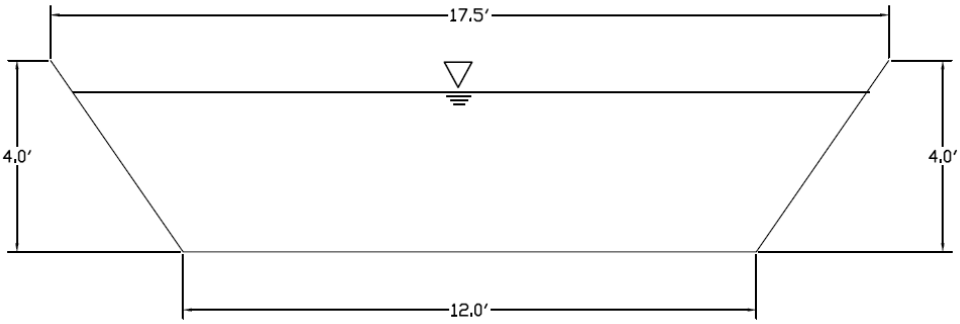

Figure 2. Typical Cross Section of Canal

The second option is to install a completely new drainage system in the hillside and connect it to the existing abandoned sewer pipe. This may include removal of the old draining

system, installing wet wells, perforated pipe, and horizontal drains to drain the moisture in the hill. This option is effective in removing the water from the hill and transporting it away from the site. But it does have the potential to become very expensive. Also, maintenance may become an issue in the future, as roots, leaves, and sediment infiltrate the system. Furthermore, there may be a concern that excavating and installing the drains may trigger movement in the hillside.

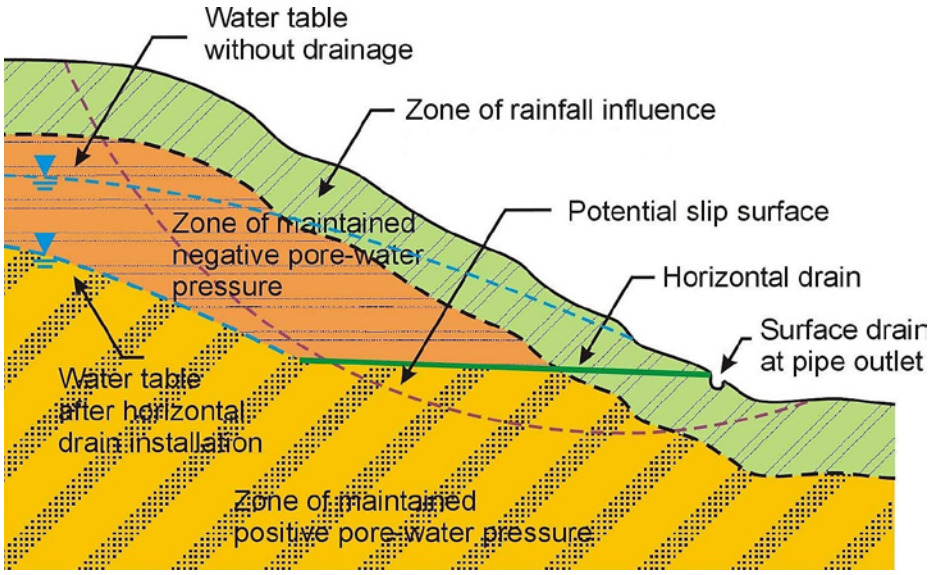

Figure 3. Theoretical Effect of Horizontal Drains

The third option is to clean out the existing drainage system and connect it to the abandoned sewer pipe in the hill. This takes advantage of the previously installed drainage system, optimizes it, and transports the moisture out of the area. Issues may include the deterioration of the drainage pipes and wells, the ability to connect old deteriorated pipes to a reinforced concrete pipe (RCP), and future maintenance costs. Figure 4 depicts some the standpipes and drainage system in the hill currently.

Figure 4. Existing Standpipes in Hill

Lessons Learned

As a team, there are things that we have learned quickly during this project. This section is describe challenges, and obstacles students had to overcome so far in the project. Communication is one of the most difficult challenges. Getting in touch and waiting to hear back from every part of the project has taken a while for several reasons. We have learned to continue to be persistent and find the most effective mode of communication for each case.

Technical requirements for some of the modeling, such as seepage, is beyond the experience of any of the students on the team. Therefore, discussions were made with various professors to understand the effects and estimation of the seepage from the canal. Furthermore, understanding the site has required multiple visits, rereading multiple documents, reviewing mapping imagery, and reviewing team photographs. This process has enabled student to truly understand the need, and possible solutions for this project.

Conclusions

Based upon our visual findings and research of past studies listed above, one conclusion became abundantly clear. Water in the hillside needs to be removed. Our initial hypothesis is that the main source of that water is the canal itself, as there has not been nearly as much seepage once the canal was shutoff. We also observed that many of the large sloughs in the hillside were began directly below the bottom of the canal. Furthermore, the wetness of the hill decreased significantly after the canal was shut off. However, there is still evidence of a groundwater problem even without water in the canal.

Another conclusion that was also formed based upon our site visits and further research of drill holes and maps is that the soil is conducive to sliding. This seems to be especially true under wet conditions. This was visually evident in our site visits by the sloughing that we witnessed in the hillside. Many of the soils we witnessed were very silty or sandy, with very fine particulates and not many aggregates.

Based on everything the team has completed so far, the team came up with three possible solutions. These solutions vary in cost, effectiveness, designs, benefits, and longevity. Each option will be analyzed and compared over the coming months. After considering the previously mentioned criteria, the options will be ranked. A final recommendation will be submitted shortly after.

Recommendations

We have two main purposes to accomplish. The first, is to eliminate as much of the groundwater as possible. To do this, seepage must be minimized. Secondly, mitigation of the remaining groundwater by way of diversions and drains.

Several means of accomplishing these goals have been considered, such as:

- Working with the South Jordan Canal Company to line the canal, whether by rubber liner, concrete, or similar materials.
- Install additional new vertical and horizontal drains to mitigate additional groundwater.
- Simply recondition existing drain lines to better handle groundwater seepage by cleaning them and making repairs.
- Utilize and existing abandoned sanitary sewer line within the hillside to diver groundwater collected by drains.
- Reinforce the hillside by berming it up with additional engineered fills and aggregates.

The final recommendation will be submitted after thoroughly analysis of the three solutions proposed in previous sections.

Appendix A – Student Resumes

ALEX FISHER

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ANF.BYU@GMAIL.COM

407-607-2398

OBJECTIVE

Seeking an engineering position where I can apply and enhance my technical and engineering skills, carrying out my work efficiently and professionally.

EDUCATION

AP Scholar Graduate

Apopka High School **2007 - 2011**

B.S. Degree in Civil Engineering

Brigham Young University **2012 - 2019**

EXPERIENCE

DRAFTING INSTRUCTOR **2018 - 2019**

Brigham Young University

- Taught and developed course curriculum for an entry level CAD drafting class. Developed assignments and tests for students.

TEACHING ASSISTANT **2017 - 2018**

Brigham Young University

- Acted as an aide to students in learning drafting programs like AutoCAD and Revit. Reviewed and graded assignments and work.

SPECIAL EVENTS TECHNICIAN **2015 - 2017**

Brigham Young University

- Worked independently or in small groups to setup and facilitate various activities and events. Instructed other employees in the proper procedure and use of equipment.

VOLUNTEER **2012 - 2014**

The Church of Jesus Christ of Latter-Day Saints

- Spent 2-years as a church volunteer in Wisconsin providing service for the community, leading and instructing other groups of volunteers and aiding outreach goals. Minimal Supervision working 60+ hour weeks.

SKILLS

Languages

- English & Spanish

Programming Languages

- VBA, C++, Python, HTML

Engineering Skills

- Some experience Surveying
- Some experience with various soil tests

Software Proficiency

- CAD: AutoCAD, Revit and Catia
- ArcGIS software
- MS office programs: Word, Excel, PowerPoint, OneNote

Bryce C. Terry

5927 Genoa Lane, Stansbury Park, UT 84074
435-243-0411 | bryce.terry@live.com

EDUCATION

Brigham Young University Provo, UT

Bachelor of Science in Civil Engineering June 2019

- BYU GPA 3.3/4.00
- Passed FE Exam, August 2018
- ITE and ASCE member

EXPERIENCE

Herriman City Herriman, UT

Engineering Intern December 2016-Current

- Assist City Engineer in preparing for meetings, attend meetings with City Engineer, assist Project Engineer with managing capital improvement projects.
- Create and design construction drawings in AutoCAD Civil 3D for storm drain installation project, form striping plans, and design roadways/corridors.
- Prepare and submit applications for various state and county permits.
- Review traffic impact studies, plan solutions and respond to traffic concerns from citizens.

Jeffrey B. Terry Stansbury Park, UT

Assistant Manager of Business April 2013 - May 2014, May – Sept 2016

- Oversaw researching, examining and listing items for sale online.
- Led in marketing items and making items more likely to sell
- Ran the business while owner was absent or on vacation.

VOLUNTEER SERVICE

The Church of Jesus Christ of Latter-Day Saints Orlando, FL

Full-time Missionary, Zone Leader, District Leader May 2014 - 2016

- Learned and became proficient in Haitian Creole.
- Led a group of 10-12 missionaries, conducted weekly training meetings, followed up on goals, and conducted weekly progress report discussions with the Mission President and fellow missionaries.
- Helped the Mission President implement goals, ideas, and cultures to improve effectiveness of missionaries within the zone.

SKILLS AND INTERESTS

- Experience in using engineering software such as AutoCAD Civil 3D, Esri ArcMap and ArcGIS Pro, HCS, Synchro, HEC-HMS, Bluebeam Revu, and Microsoft Office Suite.
- Captain of both soccer and basketball teams in high school
- Earned Eagle Scout Award at age 14.

KRISTI GARATE

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kristi.garate@gmail.com

EDUCATION

CIVIL ENGINEERING BS, BRIGHAM YOUNG UNIVERSITY **(PROVO, UT)**
AUGUST 2014 - DECEMBER 2019

- 3.0 GPa
- Emphasis: Structural
- Senior Capstone:
  - Worked with Riverton City to Repurpose Sewer Line
- Relevant Courses taken:
  - Structural Analysis
  - Elementary Soil Mechanics
  - Hydraulic Engineering
  - Reinforced Concrete Design

HIGH SCHOOL GRADUATE, EDWARD C. REED HIGH SCHOOL **(SPARKS,NV)**
AUGUST 2010 - JUNE 2014

- 4.0 GPa
- School Athletics: Tennis & Skiing
- Leadership: Judicial Board
- Other Activities: Musicals and Show Choir

EXPERIENCE

ACCOUNTING CLERK, FAST GLASS INC **(SPARKS, NV & OREM, UT)**
AUGUST 2009 – CURRENT

- Transferred Inventory
- Supplied Warranties
- Balanced Books
- Processed Lien Releases
- Filed/Faxed/Emailed/Called

NIGHT CUSTODIAN, MISSIONARY TRAINING CENTER **(PROVO, UT)**
AUGUST 2014 – APRIL 2016

- Trained 30+ Employees
- Worked as Secondary Supervisor
- Required to Troubleshoot Problems
- Coordinated with 15 other Employees
- Reviewed the Work of others

SKILLS

- Able to perform Civil Engineering analysis tests
- Can effectively use excel
- Able to learn quickly
- Experience with surveying equipment
- Experience with AutoCad and REVIT
- Experience with SAP2000
- Effectively able to work with others
- Visual Basic (VBA) capable

TANNER HALES

Provo, Utah | 801-791-3512 | tannerhales1994@gmail.com |

EDUCATION

• B.S. Civil and Environmental Engineering • April 2020 • Brigham Young University

• High School Diploma • May 2013 • Morgan High School

WORK EXPERIENCE

Project Engineer Intern • WW Clyde & Co. • May 2018-Current

Field engineer intern position, assigned to Bangerter 4-Interchanges Joint Venture Project project, responsible for carrying out and managing daily construction tasks, both in the field, as well as office tasks.

- Responsibilities included:
  - Managing and tracking production of up to 4 crews of approximately 5-6 laborers and craftsmen by coordinating with superintendents, and foremen. This included planning and scheduling work, tracking timecards, ordering supplies and materials, conducting on-screen and in-field quantity take-offs, and tracking production.
  - Providing cost analysis reports for all crews operating within the joint venture project on a daily basis using HeavyJob and Excel.

Equipment Operator • Center Point Construction • May 2007- September 2017 (Summer Position)

Site development and excavation position responsible for carrying out and managing tasks such as; setting elevations, laying out and excavating footings for buildings, laying utilities, constructing rock walls, landscaping, demolition, and site preparation for projects often in excess of 50,000 square feet in size.

- Responsibilities included:
  - Managing often high-pressure site development and excavation projects at locations such as data centers, oil refineries, distribution warehouses, and large-scale concrete tilt-up buildings, while overseeing crews of 5+ additional laborers, and coordinating project logistics with other subcontractors on a tight budget and timeline.
  - Utilizing various types of surveying equipment to conduct field measurements and material take-offs.
  - Safely operating and maintaining fleets of vehicles and heavy equipment including (among others) large excavators, front-end and skid loaders, dump trucks , and telescoping forklifts.
  - Maintaining various daily and weekly reports pertinent to projects such as daily vehicle inspection reports, daily labor reports, project status updates, SWPP inspection reports, and daily safety meeting records.

Site Development Lead (Part-Time) • Brigham Young University • September 2017-Current

Site Development position responsible for carrying out and managing tasks, mainly in the area of landscaping, under the direction of Project Manager. These projects mainly consisted of removing old landscaping, including sod, trees, shrubbery, sidewalks, curbs, and drains, to install new landscaping.

- Responsibilities included:
  - Overseeing crews of 2-5 other laborers and operators to perform tasks.
  - Safely operating and maintaining various types of equipment and vehicles such as small excavators, front end and skid-steer loaders, forklifts, and Class A CDL dump trucks.

ADDITIONAL SKILLS, EXPERIENCE, AND ACKNOWLEDGEMENTS

- OSHA 10 Certified as of July 2017
- Eagle Scout as of December 2010
- August 2015-Present: Member of American Society of Civil Engineers
- July 2013-July 2015: Served as a full-time proselyting missionary for The Church of Jesus Christ of Latter-Day Saints