RESERVOIR SITE EVALUATION AND DAM SITE SELECTION
Project ID: CEEn_CPST_001

by

Active Engineering
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A Capstone Project Final Report

Submitted to

Harold Mitchell
Parowan Irrigation Company

Department of Civil and Construction Engineering
Brigham Young University

3/18/2023

Executive Summary

PROJECT TITLE: RESERVOIR SITE EVALUATION AND DAM SITE SELECTION
PROJECT ID: CEEn_CPST_01
PROJECT SPONSOR: Parowan Irrigation Company
TEAM NAME: Active Engineering

The goal of this project was to determine the site for a new reservoir near Parowan, Utah. A potential site for the reservoir was chosen and then surveyed. The survey data was processed to create an accurate topographic map from drone LiDAR data. Several other maps and models of potential dam designs were created along with their volumetric capacities and final elevations. It was also requested to tie in two section corners or quarter corners to the models to show a more accurate location for the proposed reservoir. These have been included in the final map drawings. All of these tasks were to be completed between September 2022 and April 2023. The final product is contained in this report and published as a poster.

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Introduction

Overview

- Create potential dam and reservoir designs for Parowan Irrigation Company
- Provide a volumetric analysis of the proposed reservoir and dam
- Provide final height of dam

Tasks

- Perform fieldwork
- Interpret data
- Make maps in Civil 3D with data
- Create tables containing height of dam and storage capacity

Schedule

- Field work to be completed by 10/22/2022
- Complete analysis and designs of new reservoir by 2/24/2023
- Complete draft report for project by 4/10/2023
- Submit final draft of report by 4/17/2023
- Present project by 4/17/2023

Assumptions

- Lidar models were created without interruptions to data
- Rovers were completely vertical when surveying
- Minor changes to landscape with data point reduction
- Civil 3D calculations were correct
- Sensors on drone were standardized and accurate

Expectations

- Topographic maps with storage capacity for each dam scenario
- Storage curve of height vs capacity
- Writeup of drone procedures

Requirements

- Provide designs for new reservoirs with expected volume capacities
- Tie-in points to model with quarter corner and section corner connected in model
- Provide height of dam

Schedule

Due to time sensitive aspects of this project, it was imperative that a specific schedule was set and followed. With this project being located in Parowan Canyon, fieldwork was found to be the most time sensitive aspect of the project due to the canyon's unpredictable weather conditions. The proposed project schedule was as follows:

- Drone training and test flight to be completed by October 15th.
- All field work to be completed by October 22nd.
- Data to be backed up and stored in a reliable location by October 23rd.
- 3D model to be created from drone flights by February 6th.
- Calculations and estimates to be completed by February 28th.
- Report to be written by March 30th.
- Poster to be completed by April 5th.
- Final PowerPoint to be completed by April 17th.

Assumptions & Limitations

As with any project, there are a few assumptions that were made. Since the LiDAR data had to be modified to remove all trees, it was assumed that doing so didn't disrupt the landscape drastically. When reviewing the new point cloud without trees, it was determined that the landscape did not have any major issues introduced due to the point reduction. When thinning out the point cloud it was assumed that the points that were kept were close enough to the actual landscape that it wouldn't provide any issues to the storage capacity. When trying to get the LiDAR point cloud into Civil 3D, it had to go through several other software programs to convert it into a proper file type. It was assumed that by doing this the point cloud was not dramatically distorted. When surveying the ground truth points, section corner, and quarter corner it was assumed the GPS rovers were completely vertical and accurate.

Design, Analysis & Results

The following is a summary of the design process that was used to create the topographical maps and models that are included in this report:

Design Process

- Fly and map terrain with LiDAR camera attached to DJI Matrice Drone
- Process data using DJI Terra to create a .LAS file
- Import .LAS file into Cloud Compare and delete vegetation from model
- Export project into Autodesk Recap to convert into compatible file format from Civil 3D (.RCP, .RCS)
- Import .RCP file into Civil 3D to create point cloud
- Create surface using point cloud in Civil 3D
- Use surface to create topographic terrain map
- Create multiple models and determine height of dam and total volume of reservoir.

For more details on the design process listed above, click the following links that were written for this report:

(1) Lidar processing using DJI Terra
(2) Merging multiple .LAS files on Cloud compare
(3) Vegetation Removal Instructions
(4) Downsizing point cloud for easier use in civil 3d
(5) Importing .las file into civil 3d

Design Results

Three different dam scenarios were created for the reservoir. The first Alternative was to place a dam in the optimal location but keep it low enough that the existing road would be unaffected. A topographic map for alternative 1 is shown in Figure 1 and a storage curve for Alternative 1 can be seen in Figure 2. The second alternative was to place a dam further downstream and aimed for the maximum capacity A topographic map for alternative 2 is shown in Figure 3 and a storage curve for Alternative 2 can be seen in Figure 4. The third alternative was to place a dam in the same location as the first alternative, but to build it as high as reasonably possible, which would require a

relocation of the existing road. A topographic map for alternative 3 is shown in Figure 5 and a storage curve for Alternative 3 can be seen in Figure 6. A comparison of the maximum storage for each alternative can be seen in Table 1.

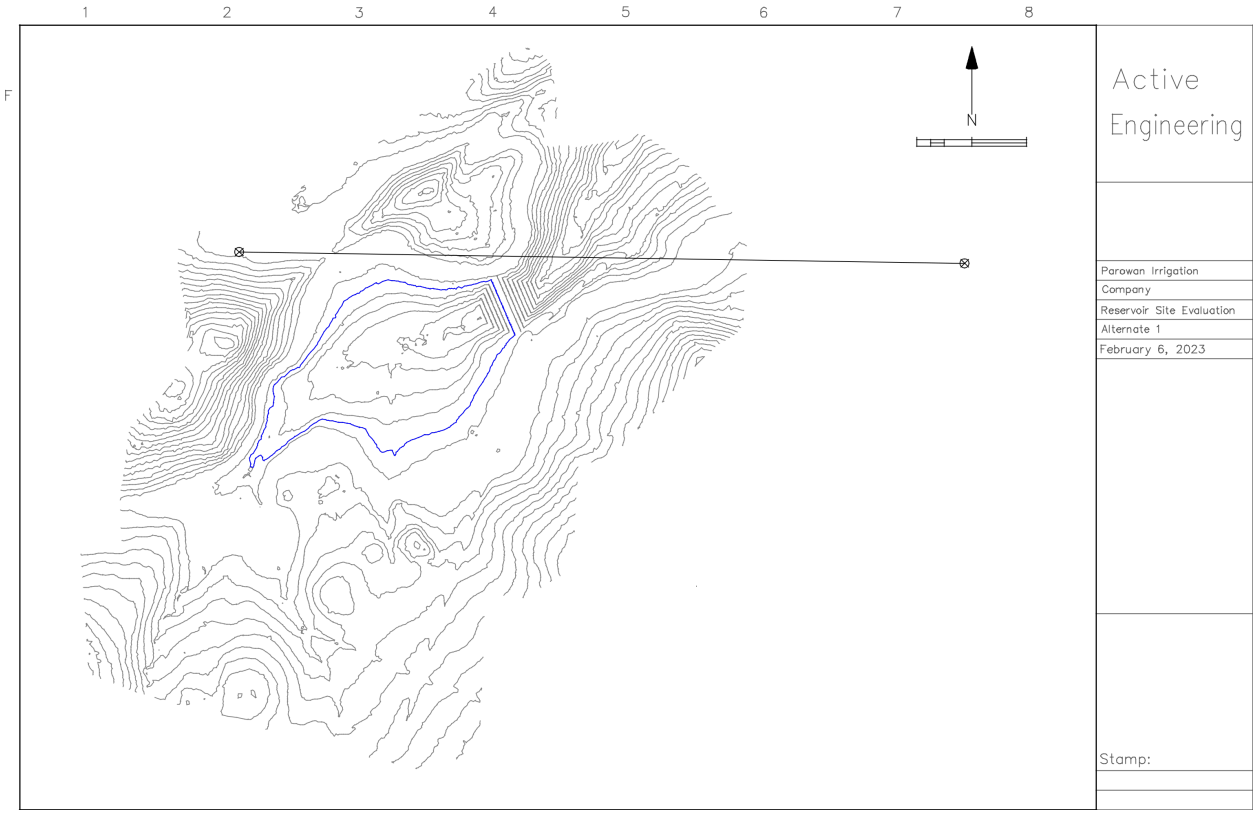

Figure 1: Topographic Map of Alternative 1

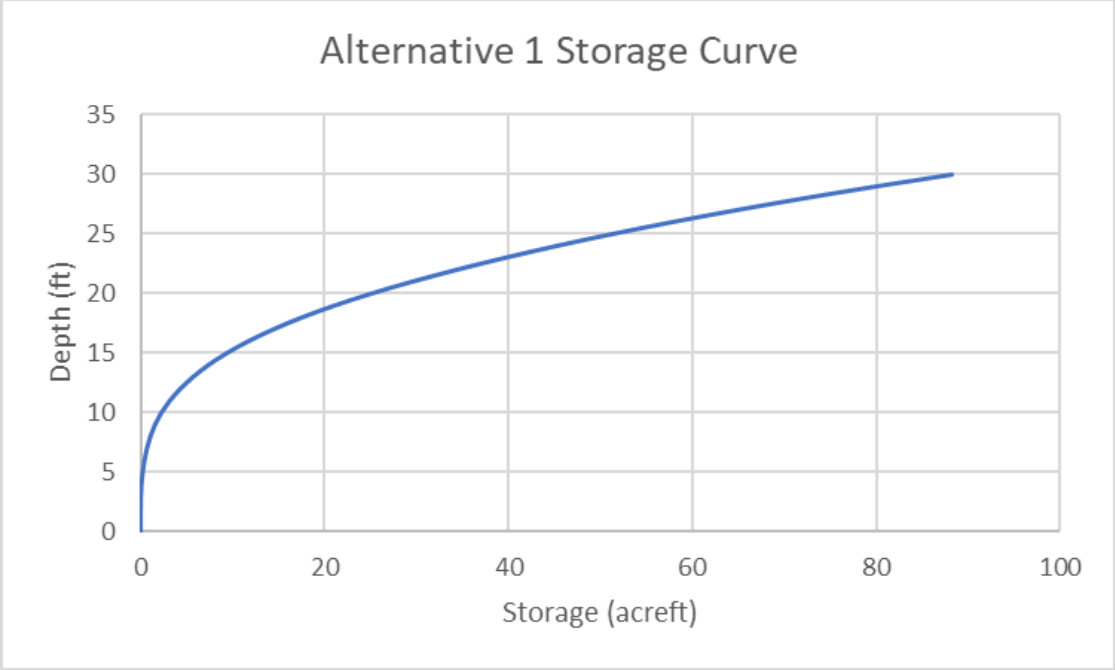

Figure 2: Storage Curve for Alternative 1

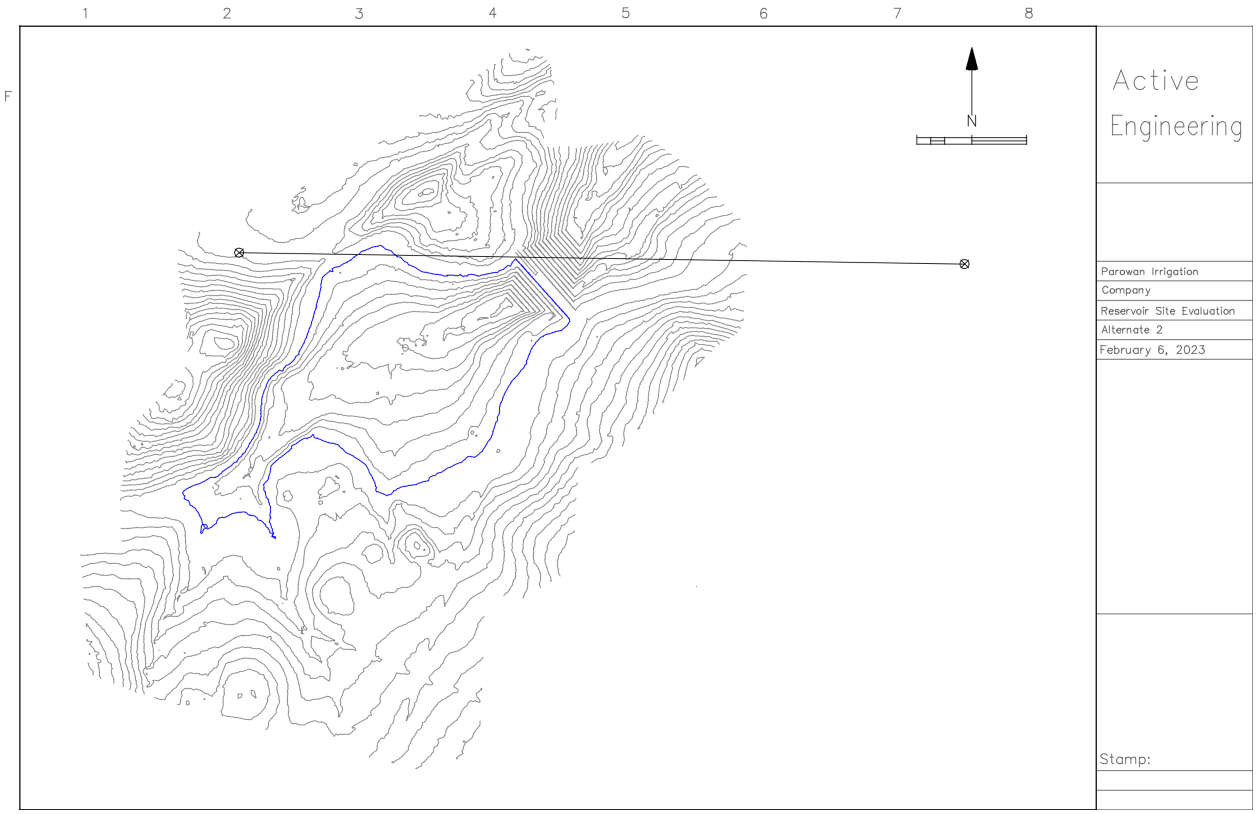

Figure 3: Topographic Map of Alternative 2

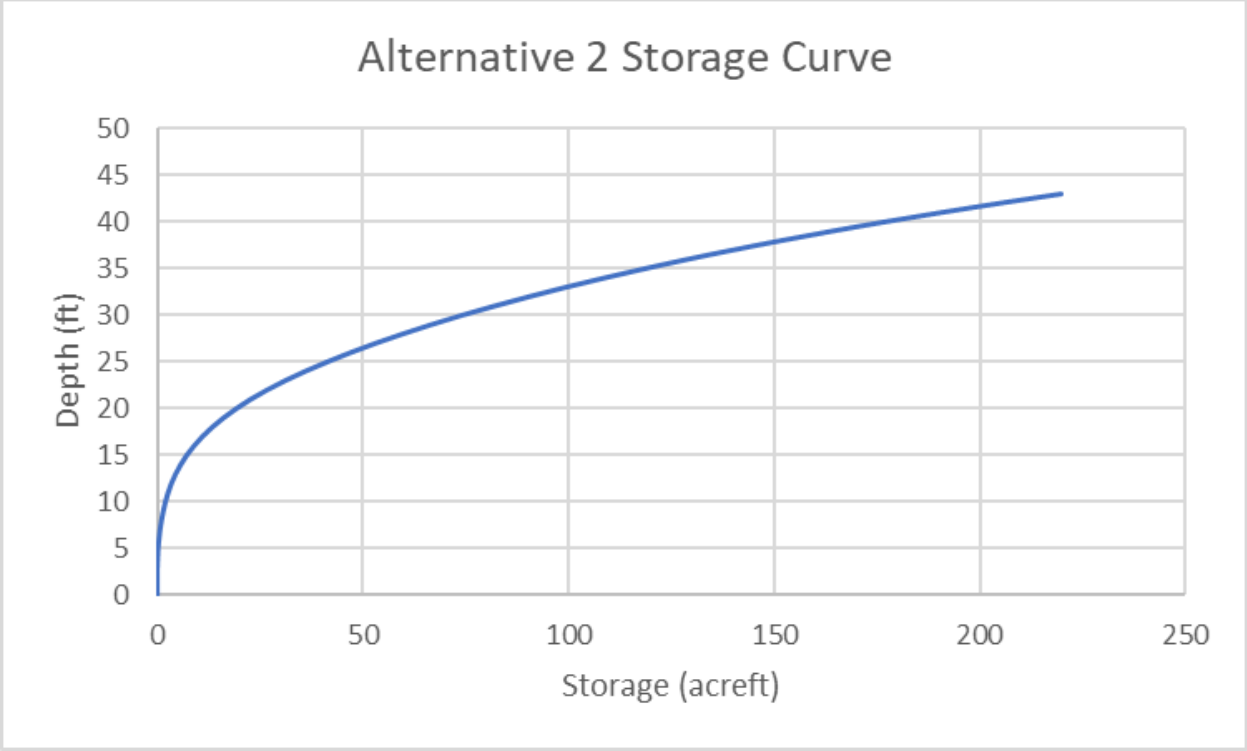

Figure 4: Storage Curve for Alternative 2

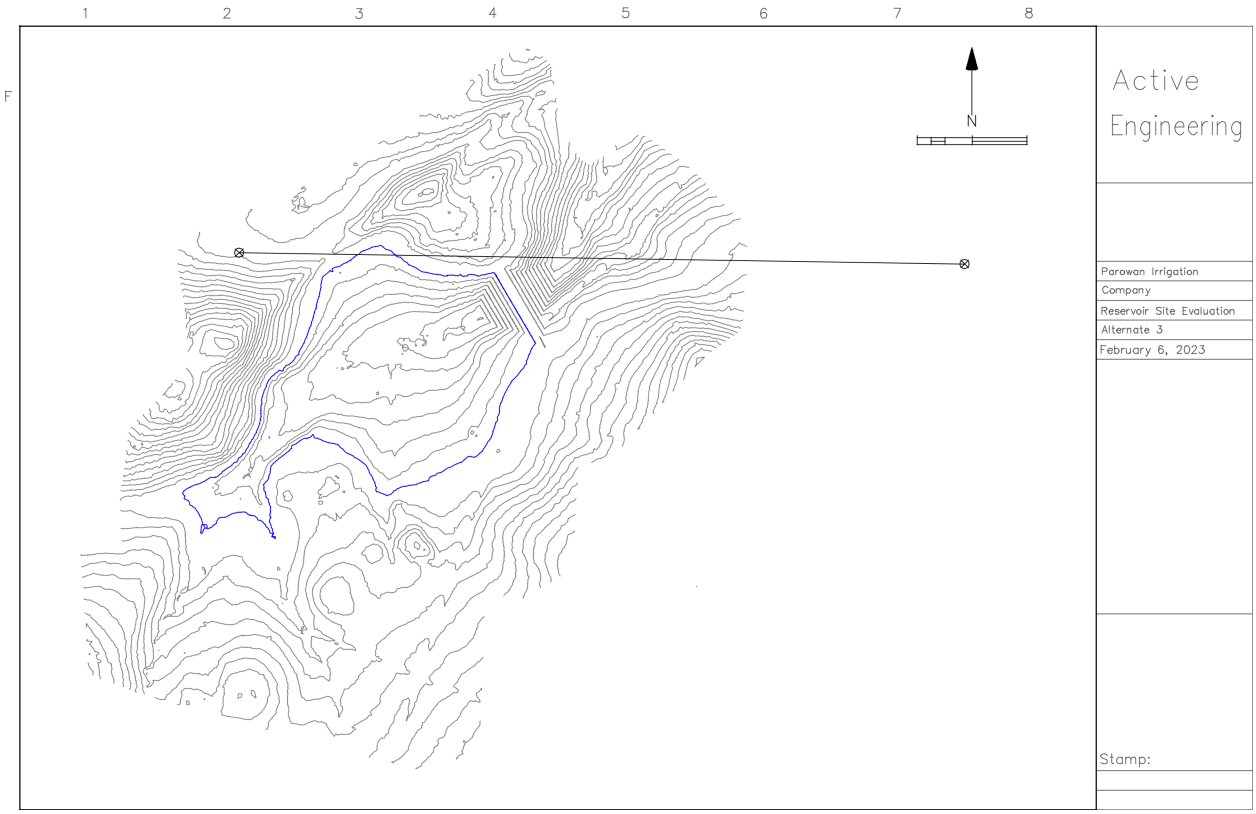

Figure 5: Topographic Map of Alternative 3

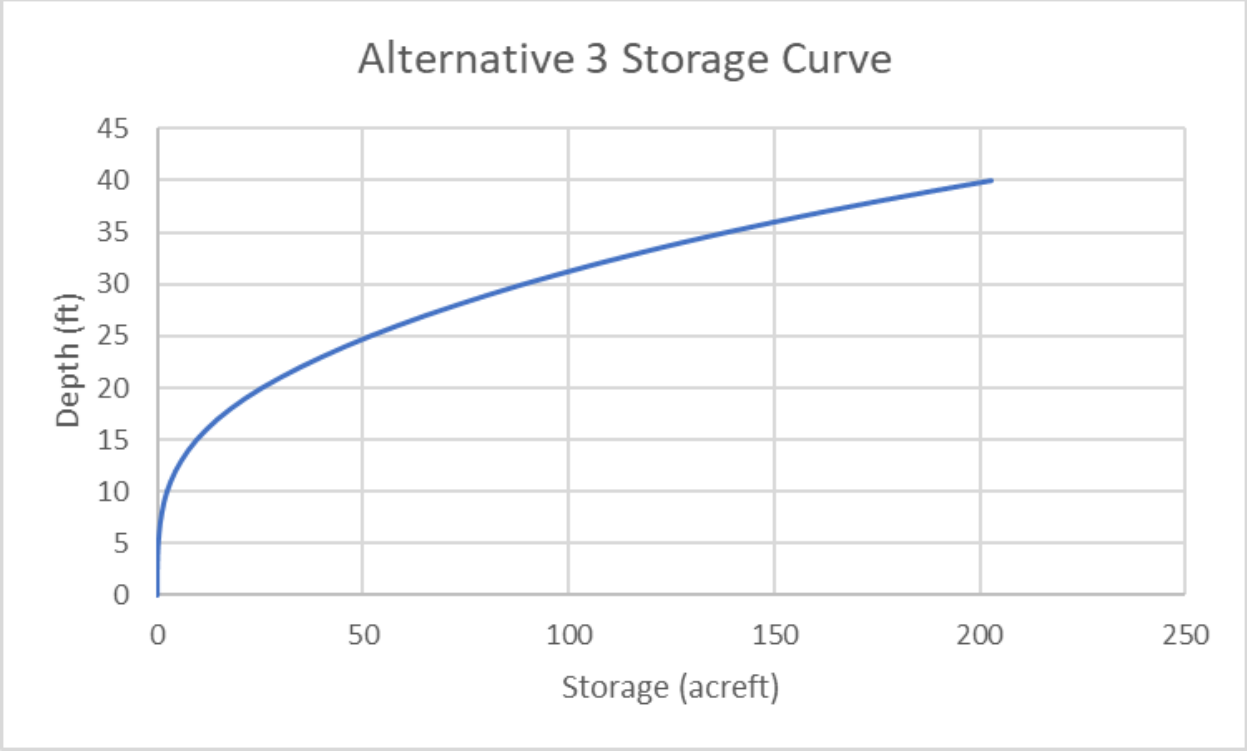

Figure 6: Storage Curve for Alternative 3

Table 1: Maximum Storage Comparison

Alternative	Storage (Acre-ft)
Alternative 1	88
Alternative 2	220
Alternative 3	203

Related Issues

The following are issues that must be considered when constructing a new earthen dam and reservoir:

Public Health and Safety

The first concern in the construction of any new dam is public health and safety. The construction process can be dangerous, and there is a risk of accidents or damage during the building phase. Furthermore, the dam itself may pose a risk of collapse, which could lead to the release of large amounts of water and cause damage to the city of Parowan which lies at the mouth of the canyon. It is essential that proper safety measures are in place to minimize the risk to workers and surrounding populations.

Social Factors

The construction of the dam may also impact the local community, including those that rely on aquifers and wells for irrigation. Since the city of Parowan and the surrounding valley houses are mostly farmers, it is important that these residents be considered in the discussion of the construction of a new dam and reservoir. Wells and aquifers could dry up with the installation of this new dam and therefore would potentially affect the livelihoods of the farmers that rely on the water for irrigation.

Environmental Factors

The construction of a new dam also has environmental impacts, including the alteration of the natural flora and fauna that reside in the valley. It is important to minimize the impact on the environment and to implement measures to protect the local ecosystem. The introduction of heavy construction vehicles could impact the existing road in a negative way. Since the original road was not designed to have such heavy traffic, it may need to be replaced or rehabilitated once the dam construction is over.

Economic Factors

The construction of a new dam could also affect the livelihood of farmers that rely on natural wells and aquifers. Storing water in the designed reservoir would keep water from naturally draining into the ground which could harm the amount of irrigable water that is available. This could have long-lasting effects that would need to be analyzed prior to approval. Constructing a new reservoir may also potentially add a new location that could attract fishermen. If the reservoir has enough water stored in it, fishing may be a way to bring more people to Parowan. Hunting might also be increased as animals would potentially be attracted to the reservoir.

Lessons Learned

The ability to overcome challenges encountered during the project highlights the value and importance of adaptability, resourcefulness, and perseverance in the face of unexpected obstacles. Overcoming these challenges required each member to leverage collective knowledge, research skills, and creativity to identify solutions that were not immediately apparent.

Several technical challenges with the equipment that were encountered, included non-functional drones, GPS units, and difficulties in interpreting and exporting drone data. The main solution was to leverage online resources, such as YouTube videos and electronic manuals, to learn how to set up the equipment and how to use different programs to analyze and visualize the data collected in the field.

Another set of challenges related to limited access to necessary equipment, such as school computers and lab facilities. To overcome these obstacles, key cards were obtained and programs were purchased and downloaded onto a single computer. This allowed access to the drone data that had been collected.

Limited time due to conflicting schedules and midterms were other challenges that were encountered. To overcome these difficulties, an online schedule was created with tasks assigned to each group member. This ensured that even without official group meetings, members would be able to complete the necessary tasks to further the progress of the overall project.

Challenges were also faced that related to the computer models, including difficulty in removing trees and shrubs in the 3D model, difficulty in reading data points and glitching of the computer model itself. To remove trees and shrubs, different modes and programs were researched and implemented. As for the data points, it was decided that manually importing them would be the best solution. This allowed for section corners to be easily visualized. Map data was then saved to multiple locations to avoid accidental deletion.

Importing the 3D model into a website that would allow for access via QR code was one of the final challenges that was faced. After researching different apps and sites, one was found that would allow the model to be uploaded and accessed. A QR code was then created and is included on the final project poster.

Conclusions

After performing the analysis Active Engineering concludes that the most optimal alternative would be the third alternative. This alternative provides the greatest amount of storage capacity, while requiring the lowest amount of fill material. This alternative will add 203 acre feet of additional storage capacity, which would increase the total storage capacity of the watershed by approximately 40%.

Recommendations

Active Engineering recommends that the Parowan Irrigation Company perform further geotechnical and structural analysis at the proposed site using a professional and licensed engineer. Soil surveys were not completed during the course of this project and would therefore need further analysis performed. Due to the scope of this project, the dam was also not structurally designed and would therefore need further analysis. Other recommendations include further analysis of the roadway that leads up to the site which would be under stress due to the required materials being transported via trucks.

Active Engineering recommends that the Parowan Irrigation Company board reach out to all farmers in the area that may potentially be affected by the construction of the new dam. It is also recommended that surveys be sent out to the community within Parowan to gain data on the public's perception of the proposed dam and reservoir. Active Engineering recommends that the Parowan Irrigation Company reach out to the U.S. Forest Service as well to coordinate efforts with them so as to minimize damage to the surrounding environment and ecosystems.

Appendix A

Ean Price
(360) 255-3918 · ebprice7@gmail.com · linkedin.com/in/ean-price

EDUCATION

Brigham Young University Apr 2023
Bachelor of Science: Civil Engineering, Emphasis in Structural Engineering – **GPA: 3.53** Provo, UT
- Timber Design, Structural Steel Design, Reinforced Concrete Design, BIM Modeling, Hydraulics

PROJECTS

Parowan Canyon Dam Proposal Oct 2022 - Apr 2023
Team Lead Parowan, UT
- Managed a team of four senior level civil engineering students in funded research project
- Piloted DJI Drones to design a new reservoir and dam capable of holding 218 ac-ft of water
- Utilized Civil 3D and DJI Terra to create a point cloud from acquired LIDAR data
- Developed comprehensive documentation for BYU describing how to operate DJI Drones and accompanying LIDAR cameras

EXPERIENCE

Acute Engineering Jan 2022-Present
Student Production Engineer Provo, UT
- Structurally design custom homes, production homes, and light commercial construction in a consistently timely manner as part of a client-based team
- Structurally design light framed wood structures including framing layouts, shear walls, foundations, retaining walls, cantilevered columns, and steel moment frames
- Create custom structural details for unusual architectural features
- Review submittals for accuracy and write-up addendums for Building Officials

Edge the Service Company Apr 2021-Aug 2021
Route Coordinator Chicago, IL
- Solicited door to door using sales tactics and techniques to push pest control servicing and to expand customer base throughout the greater Chicago region
- Applied negotiation skills and worked to streamline servicing to allow for operations to continuously produce new customers
- Generated $72,000 in revenue

City of Saratoga Springs May 2020-Aug 2020
Engineering Intern Saratoga Springs, UT
- Collaborated in writing documents necessary for city regulations including updating the city's water conservation plan
- Shadowed construction inspectors while monitoring and marking the locations of utility lines throughout construction sites
- Applied GIS to locate and track utility, sewer, and water systems throughout the city

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-Day Saints Aug 2017-Feb 2018
Representative Fukuoka, Japan
- Communicated in Japanese with locals and taught an average of 10 individuals and groups each week on how to enrich their lives through personal application and study
- Led a weekly English learning course with an average of 12 individuals
- Orchestrated various typhoon and storm cleanup projects with local congregations and residents

SKILLS

- Proficient in AutoCAD, Python, Revit, VBA and Navisworks

Holten Flinders

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Profile

Senior at BYU in Civil Engineering. Active in ASCE since freshman year. Gained the ability to work hard and communicate effectively with others through internships and coursework. Time management skills are a forte especially when supervision is minimal. An innate desire to solve problems efficiently and learn all that is possible. Enthusiastic and looking forward to the field of Civil Engineering.

Education

Brigham Young University — September 2017 - April 2023
BS, Civil Engineering — Provo, UT

- GPA: 3.81/4.0
- Member of Tau Beta Pi Engineering Honors Society
- ASCE freshman liaison
- ASCE sophomore liaison
- Relevant Classwork: Advanced Writing and Oral Communication, Fluid Flow Theory, Advanced Hydraulics and Fluid Flow Theory, Soil Properties, Foundation Design, GIS

Relevant Engineering Experience

RB&G Engineering — April 2022 - August 2022
Geotechnical Engineering Internship — Provo, UT

- Wrote technical reports for clients
- Reviewed results and paperwork for each project
- Communicated with supervisors about project details in high-stress environments
- Maintained high levels of attention to detail when inspecting projects

Connect Engineering — April 2021 - August 2021
Materials Technician — Idaho Falls, Idaho

- Reviewed lab results for presentation to clients
- Navigated difficult situations and solved problems with contractors
- Utilized knowledge from school in understanding and preventing problems
- Gained field knowledge about different project types including roads, buildings, and airports

Brigham Young University Idaho — January 2021 - April 2021
Calculus Teaching Assistant/ Course Developer — Rexburg, Idaho

- Led and designed projects and homework for students
- Coordinated with professor to make sure projects and deadlines were met each week
- Evaluated and implemented best practices to innovatively teach students about calculus
- Published material for students each week
- Proofread the professor's material before being published to the class

The Church of Jesus Christ of Latter-Day Saints — June 2018 - June 2020
Full-Time Volunteer Serving Underprivileged Population — Salt Lake City, UT

- District leader who led and organized multiple areas with numerous volunteers
- Enhanced communication skills to collaborate with others
- Increased ability to adapt to any situation including conflict resolution
- Adapted to different cultures by increasing social awareness
- Developed time management skills by planning daily, weekly, and monthly activities

Taylor T. Mann
Student of Civil Engineering
438 Venado Dr. Santa Barbara CA, 93111 (805)-637-8120 taylortmann@gmail.com

SKILLS

Finish carpentry, drywall, window installation, heavy equipment operator, Drone Pilot-FAA Certified, mechanic, project scheduling and estimating, Bilingual.

EXPERIENCE

Okland Construction Company
September 2018- December 2018, Tempe AZ - *ICT CAD Technician*

- Project startup creating 3D Models for collaboration
- Clash detection for Banner Healthcare, MIHS Healthcare, and D4 Rec Center.
- Helped with Creighton University project win by creating 3D Logistic Plan for the interview
- Create topo maps, site surveys, and point clouds with a Drone
- Trained with the Mattaport and Faro scanner to create As-Builts and quality control inspections.

Mann Construction, Santa Barbara CA - *Skilled Laborer/ Carpenter*

June 2013- September 2014, April 2018 - August 2018

- I contributed to the completion of custom homes with estimated project values of $2 - 3.5 Million, and full house remodels estimated at $800,000 - $1.5 Million
- Participated in and oversaw grading, foundation, framing, and finish carpentry work
- Created material lists, and light estimating

PT Morgan Enterprises, Mesa AZ - *Carpenter*

July 2017 - September 2017

- I contributed to home remodel projects estimated between $50K-$80K
- Finished carpentry, door and window installation, cabinetry, and drywall
- Coordinated work with subcontractors
- Created material lists and minor estimating

BYUI CM & design department, Rexburg Idaho - *Course Lab Assistant*

September 2018

- Help tutor students using the 3D design Revit

EDUCATION

BYU - *Civil and Environmental Engineering*

Estimated graduation in the Winter of 2023

Accomplishments

I am an Eagle Scout. The scouting program taught me life skills that earned me a great appreciation and respect for the outdoors. I served for 2 years as a Representative of the Church of Jesus Christ of Latter-day Saints in the Central American country of Panama. I learned how to cooperate with different cultures and people. I have also taken my studies very seriously and have achieved a 3.6 GPA.

LYLE PRINCE

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ldprince414@gmail.com

To learn and develop engineering skills, and to improve quality of life through Civil Engineering.

WORK EXPERIENCE

MAY 2021 – PRESENT

ENGINEERING INTERN, JONES AND DEMILLE ENGINEERING

Design and format plans for various civil engineering jobs. Produce projects in five different states ranging from large scale solar farms to small subdivisions to meet client demands.

APRIL 2022 – PRESENT

RESEARCH ASSISTANT, BRIGHAM YOUNG UNIVERSITY

Research current developments in Building Information Models and their applications to increasing the accuracy of structural models.

JANUARY 2022 – APRIL 2022

TEACHING ASSISTANT, BRIGHAM YOUNG UNIVERSITY

Presented a fluids lab once a week and assisted in grading papers. Instructed students about concepts related to fluid mechanics to increase their understanding.

EDUCATION

APRIL 2023

WORKING TOWARDS BACHELOR OF ENGINEERING, BRIGHAM YOUNG UNIVERSITY

- Current GPA: 3.96
- Currently Studying Civil Engineering

SKILLS

- Experience with AutoCAD and REVIT.
- Experience with VBA Code in Excel.
- Fluent in Spanish
- A good sense of humor

ACTIVITIES

2018-2020

SERVED A MISSION FOR THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS

Served as missionary in Lima, Peru to help people both temporally and spiritually.

2018

REGIONAL STERLING SCHOLAR MATHEMATICS

Won Regional Sterling Scholar in Mathematics for outstanding academics, citizenship, and leadership.

2016

EAGLE SCOUT

I earned my Eagle Scout in 2016. For my project, I replaced all the street signs in New Harmony, Utah. After completing my eagle, I earned six additional eagle palms.