# SF COLLABORATION
# PROJECT ID: CCE_CPST_01

**by**

**BuiLD Engineering**
**Dillon Muirbrook**
**Lorenzo Eusebi-Diehr**
**Bryson Price**

**A Capstone Project Final Report**

**Submitted to**

**Josie Paxton**
**City of Spanish Fork, UT**

**Department of Civil and Construction Engineering**
**Brigham Young University**

**April 11, 2022**

# Executive Summary

| | |
|---|---|
| **PROJECT TITLE:** | SF COLLABORATION |
| **PROJECT ID:** | CCE_CPST_01 |
| **PROJECT SPONSOR:** | Spanish Fork City |
| **TEAM NAME:** | BuiLD Engineering |

Spanish Fork City wanted to categorize water meters into types/categories based on the drinking water usage of the people/entities they meter. The categories should help in identifying atypical usage for individual meters for a specified subtype (land use: residential, commercial, industrial, agricultural, school/park and government/municipal, zone type, property/parcel size, etc.). The classification of meters required an understanding of water usage/metering and experience with GIS. The city wanted to run simple queries with the organized data and display the results in an Esri dashboard.

# Table of Contents

# List of Figures

# List of Tables

# Introduction

This project categorized water meters into types/categories based on the lot type/zone as metered by the city. This data was then aggregated and incorporated into a GIS database. The database supports an interactive GIS dashboard that can be used to track water use trends by lot type and/or time period.

# Schedule

This project consisted of multiple stages of work.

First, BuiLD Engineering, hereafter known as “the team” received the raw metering data from the City of Spanish Fork, hereafter known as “the city.” A meeting between the team and the city was necessary to identify the desired categories the data should be separated into. As part of that meeting, a determination was made about the way the dashboard should be configured. As a final step for this phase, the data was categorized and prepared for future manipulation.

Second, an investigation into the feasibility of establishing a statistical baseline for each category was carried out.

Third, using the data from phase 1, the team created a dashboard to represent the data in a visual, interactive, and readable way. This dashboard is the final deliverable.

This is a week-by-week schedule for 2022 that documents the project progress.

Jan. 3-7

- Meeting to discuss items mentioned in phase 1

Jan. 10-14

- Categorize the data

Jan. 18-21

- Categorize the data

Jan. 24-28

- Categorize the data

Jan. 31-Feb. 4

- Clearly document the categories
- Review categorized date with the city

Feb. 7-11

- Investigate statistical baseline feasibility

Feb. 14-18

- Investigate statistical baseline feasibility

Feb. 22-25

- Qualify the data

Feb. 28-Mar. 4

- Qualify the data

Mar. 7-11

- Review best practices for dashboard creation

Mar. 14-17

- Create the dashboard

Mar. 21-25

- Create the dashboard
- Meet with the city to revise the dashboard appearance/utility

Mar. 28-Apr. 1

- Create the dashboard

Apr. 11-15

- Present the dashboard to the city

# Assumptions & Limitations

| Assumption | Limitation |
|---|---|
| Usage within one address category is uniform | • Category averages and standard deviations would not be representative.<br>• Example: estate house on a large lot is in the same residential category as an apartment complex. These two water uses, would not be comparable. |
| In data reduction, reasons for data deletion were subject to bias | • Clearly defined procedures for address deletion was never defined due to extreme variability in reasons for exclusion. |
| Data is categorized monthly | • Meters take date on the 20$^{th}$ of every month. This means the monthly data displayed in the dashboard represents a slight offset. This same problem occurs on an annual data. |

*Table 1: Assumptions and Limitations*

# Design, Analysis & Results

Stage 1:

An initial meeting provided the team with a basic understanding of the project requirements and details. The city requested we consider several factors for the classification of drinking water consumption, with the overarching goal of utilizing a dashboard to identify high-consuming users. We were asked to design a system that would take into account address type, parcel size, and even zoning type. It was intended that the dashboard be capable of performing queries on underlying data and display a real-time report of high users based on predefined criteria. All of these features were expected to be interactive.

| Address Type |
|---|
| Residential |
| Commercial |
| Industrial |
| Landlord/Multi-Unit |
| School District |
| City Facility |
| HOA |

*Table 2: Address type criteria used*

As the project was in its early stages, and the team (with the city) gained a better understanding of the state of the available data and the capacities of the Esri online dashboard system, it became apparent that a slight change in scope would be required, as both the creation of the dashboard and the statistical analysis of the data combined to be too much work for one capstone project. Accordingly, the team refocused on the communicated higher priority: the interactive dashboard. The design for this dashboard was constrained heavily by the data available, but the team decided to fully utilize the limited analysis functions supported by the Esri system and process the data accordingly.

Stage 2:

In this stage, an investigation into the possibility of having a statistical baseline was carried out. Multiple options were examined including, a separate spreadsheet system, calculations prior to data input, and native calculations withing the dashboard. Given the city's desire to use a GIS dashboard to display the data and the time constraints, statistical analysis was deemed out of scope for this project. A GIS dashboard does not perform many calculations, so this program is not a viable option to calculate statistics nor atypical usage.

Once this limitation had been verified, the team began reducing the vast amount of raw data for the express purpose of utilizing the basic analysis functions available on the dashboard. This included spending many hours analyzing individual data points that had not joined correctly with the city's address database, usually due to a discrepancy in the address text field. As the join did not support a near-match, and there was no general rule as to why the match wasn't made, it was necessary to consider as many of them as possible to potentially alter our input usage data values in order to bring it in harmony with the addresses database (thereby allowing further joins to match more data points). However, because of the magnitude of this endeavor (and the lack of a clear reason or reconcilable difference for most no-matches), some 10k-15k data points (of the 45k+) were removed from consideration. It is assumed that these data points did not follow a related pattern, and so removing them is assumed to have no skewing effect on the analysis.

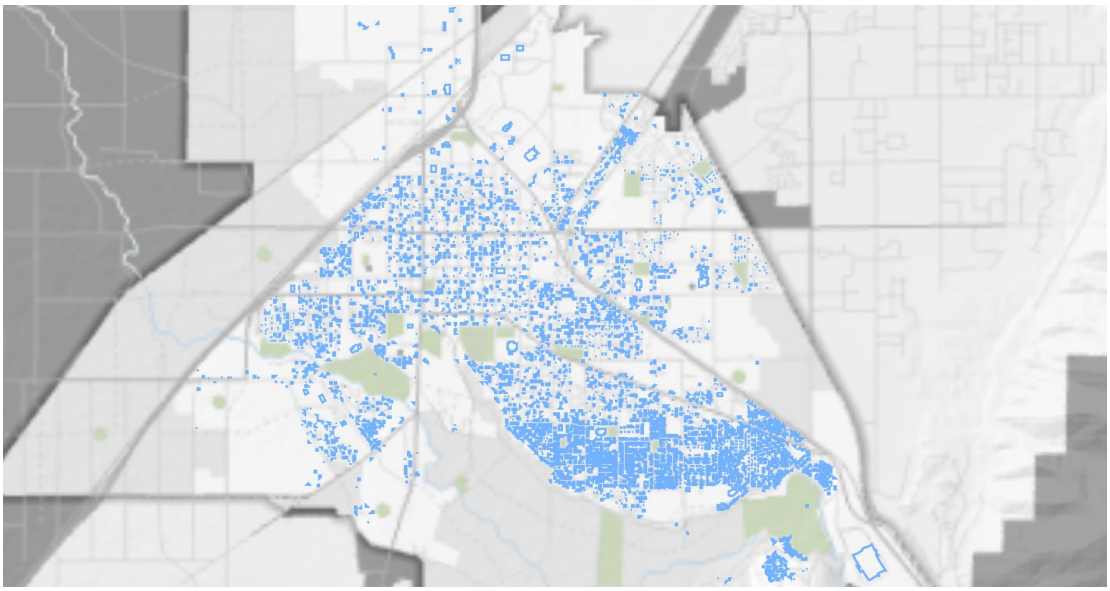

*Figure 1: Map showing extend of discrete data points analyzed*

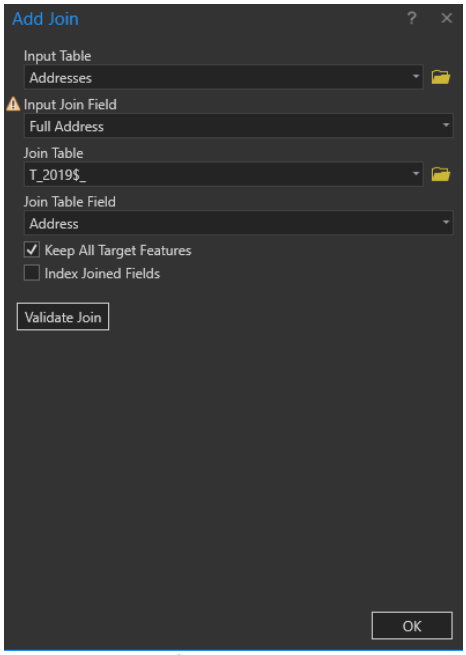


*Figure 2: Setup of Join operation in ArcGIS Pro*

Stage 3:

When the data were finally reduced and the no-match points removed, the data were compiled back into a server-based feature class (all in one feature class, differentiated by a year field). With the data ready to go, the team began the development of the dashboard.

Although severely limited in its application and functionality, Esri's online dashboard building system is extremely user friendly. Nonetheless, the team spent numerous hours simply getting up to speed on the nomenclature and backend process of the dashboard. While no script or code was necessary, a firm understanding of the interrelated elements and how the dashboard logic processed changes was critical. Several elements were tested on the dashboard, and functionality was pushed to its limit as the team attempted to accomplish more of the initial goals. Several draft versions were developed and edited by the team, and after several iterations a draft was presented to interested parties at the city for input and revision.

Following that feedback, the team was able to refine the dashboard, polish its presentation, and include every feature requested by the city that was possible to include. Once these finishing touches were applied, the city was presented with one more final

draft which was subsequently approved. The dashboard is currently online and operational for internal use by Spanish Fork City.

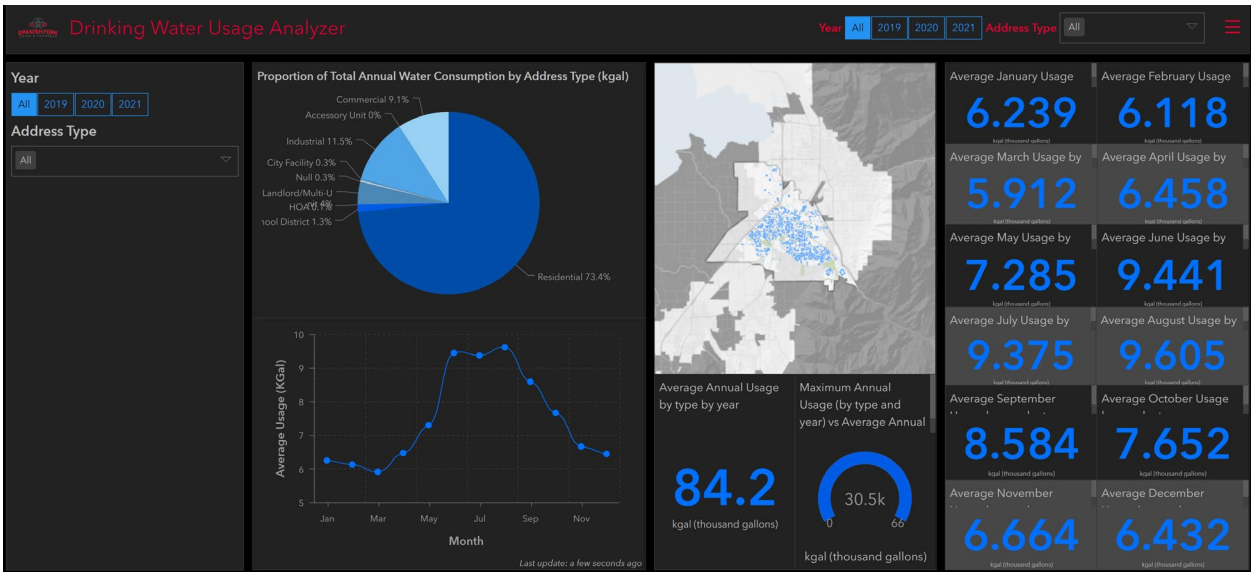


*Figure 3: Image of an early draft of the dashboard*

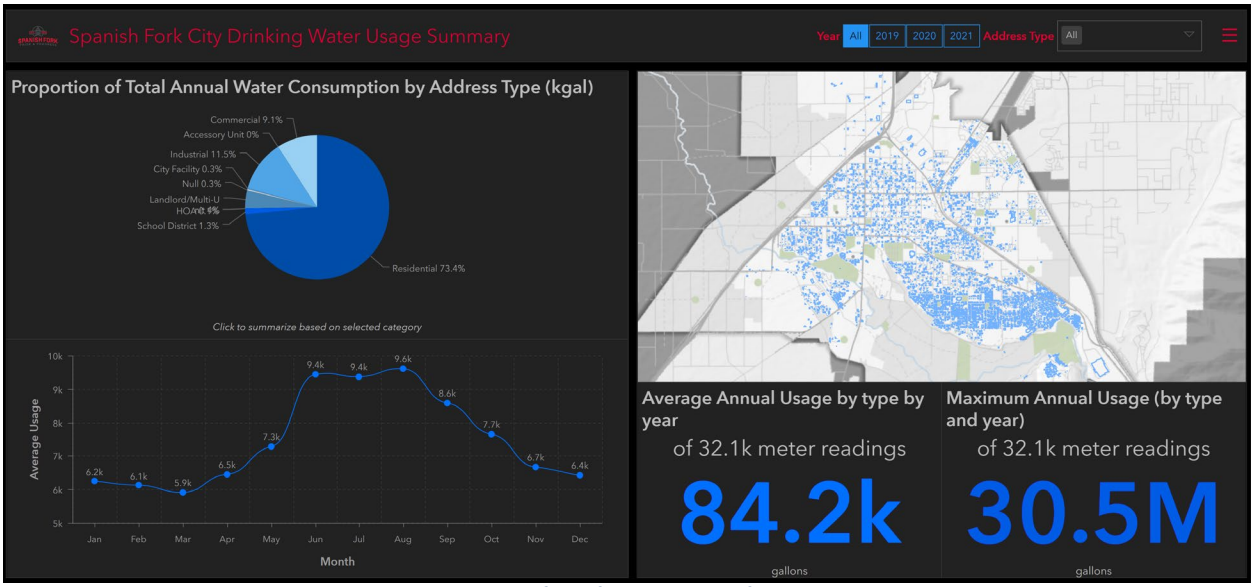


*Figure 4: Image of the final version of the dashboard*

# Related Issues

Like any project, technical factors were a large consideration. In addition, a good project considers extraneous factors. Below is a list of other factors considered.

- Public health
  - By minimizing water leaks, areas that should be dry can stay that way. This decreases the amount of habitat in which mold and water borne pathogens can grow. This decreases the chances of the city's population having related health problems. This also helps the city to track possible infiltration due to leaks that may contain contaminated water. This protects the aquifer for future use and maintains sustainability.
  - By better understanding consumption patterns, the city is more capable of providing consistent, pressurized water to end users. This will help the city's population have continual access to clean water – a necessity for good health.
- Safety
  - Water leak detection helps public safety by curbing the possibility of property damage due to excessive saturation, soil degradation, erosion, and creation of an environment in which pathogens can prosper.
- Welfare
  - The dashboard easily summarizes the data. This makes it easy for city officials and employees to quickly check the current water use situation.
- Social factors
  - This dashboard creates an easy way to track water usage, and demographics can be included in that analysis. This can help city officials and employees maintain equitable water access for every citizen, business, and visitors.
- Environmental factors
  - Tracking water consumption helps the city understand water resource use. This helps city officials and employees maintain sustainable water use. This protects the environment by not overusing local water sources.
  - The city can use consumption data to plan and execute conservation efforts by targeting specific demographics and/or parameters. After instituting the plan, the city also has a way to track the plan's effectiveness.

- Economic factors
  - With the capability of tracking water use, the city can look for ways to use less water. This will translate to economic benefits by using the water treatment plant less, save end users money, and spend less time addressing problems.

# Lessons Learned

| Challenge Encountered | Team Approaches and Resolutions | Lessons Learned |
|---|---|---|
| Initially, mobilizing a team with three varying schedules was difficult. | We maintained an open line of communications and let one another see our calendars. | While coordinating schedules can be difficult, with proper planning and communication it is easily done. |
| Planned times schedules often may not be followed. As the project progressed, unforeseen challenges arose. | Investing extra time and effort to addressing those solutions, as a team, was critical. | Any project will have bumps in the road. Addressing those challenges as a team is the best way to move forward. |
| A previously planned solution may not be adequate. Sorting through the data was harder than expected. | We came up with a new way to address the massive amount of data in the project. Originally, we thought the data would be cleaner, so going through it by hand would not be hard. However, that was not the case, so we automated the process through VBA code. | Sometimes, a new solution to a known problem is the best way to keep the project moving. We should always be willing to examine our current practices or ideas and improve them. A paradigm shift is not a bad thing. |
| Some projects are very open-ended. | At first, we were not sure how to start the project nor what the end goal was. As we talked more with the city, we learned what they wanted. Then, we could learn the technical aspects of what needed to be done. | In a project, take care of the people first. If we make sure we know who we are working for and what they want, guiding our technical skills and learning is easier. This helps projects be more efficient and satisfactory to the client. |
| Throughout a project, more information may be necessary. | After getting the data, we realized we needed to know more about what the final product should look like, so we scheduled another meeting with the city. | It is not a bad thing to check in with a client while working on a project. This helps the client feel more involved in the process and decreases lost company time. |

*Table 3: Challenges, Solutions, and Lessons*

# Conclusions

The results from this project have shown us the average water usage for many different address types. Even with the assumptions we made in order to create the dashboard, specifically making all buildings that fell into an address category uniform, we were able to see general trends of increased water use in the summer months. An overall percentage comparing all the different address categories can be observed through our dashboard with residential by far having the most usage. The project pulled together the water usage data provided to us and simplified it into a readable format upon which further analysis can be done by the city of Spanish Fork.

# Recommendations

This project provides an excellent baseline understanding of the city's general water situation. Furthermore, it was determined what would be required for a more comprehensive analysis tool. Outside of using this dashboard internally as presently constructed, if the city chooses to pursue development of analysis tools capable of performing the queries they expressed, the following is recommended:

- All statistical analysis should be done outside of an ArcGIS Pro or Esri dashboard environment. Accordingly, the process for creating and updating these data will require use of several programs and processes.
    - It is recommended that a project addresses the creation of template spreadsheets capable of performing the statistical analysis and summarizing such features as the top 10 users for a given selection, after accounting for/removing outliers (requiring disparate analysis)
    - For these purposes, it is recommended that Microsoft Excel be utilized for its capacity to run analysis script. VBA script backing operative buttons or other functional interactive elements is recommended to make the process of updating data sets possible for a single user in relatively little time
- Once the data analysis methods have been established, it is recommended that a system be devised in which the static usage data (tabular) can be joined to geospatial data (city Address database).
    - To avoid the problems this capstone team had, this system will need to formalize a process and criteria for removing non-matches and/or adjusting them to work
    - These data will then need to be incorporated to server-based features classes, grouped insofar as it is possible (discrete feature classes cannot be processed by a dashboard
- Finally, a new dashboard (or several) will need to be developed to incorporate these various analyses.

# Appendix A

Each team member's resume is included hereafter.

## APPENDIX A

**Dillon Muirbrook**
(801) 368-2668 · dmuirbro@outlook.com · linkedin.com/in/dillon-muirbrook

### EXPERIENCE

**Spanish Fork City** — Jun 2019-Present
*Engineering Intern* — Spanish Fork, UT

- Develop innovative solutions and designs for traffic management
- Lead teams on 20+ diverse projects, requiring exemplary interpersonal and technical skills
- Conduct 30+ traffic studies and write detailed reports, including recommendations
- Utilize advanced software to create, run, and analyze system models
- Provide technical support for a wide variety of applications/positions

**Seraphim Aerial Imaging, LLC** — Sep 2019-Present
*Managing Partner, Chief Pilot* — Provo, UT

- Oversee internal operations and provide primary contact for clients
- Communicate and network with clients/client companies to coordinate job specifications
- Pilot 50+ drone missions and process 1000+ images and videos

**Spanish Fork City** — Feb 2017-Jul 2017
*Administrative Intern* — Spanish Fork, UT

- Handled professional correspondence with engineers and firms
- Created 50+ employee documents and numerous data analysis forms

**NSFM Pizza (Domino's)** — Jun 2015-May 2017
*Manager* — Spanish Fork, UT

- Led a team of more than 10 employees amid great instability and change to achieve noteworthy production and quality benchmarks
- Directed inventory management for dozens of products and controlled cash flow

### EDUCATION

**Brigham Young University** — Apr 2023
Bachelor of Science: Civil Engineering, Emphasis in Transportation Engineering — Provo, UT
*Minor in Mathematics*

- GPA 3.60
- Recipient of Academic Scholarship each Semester thus far
- Member, BYU Chapter of ASCE; Member, BYU Chapter of ITE
- Courses taken in all Civil Engineering disciplines, with emphasis on Transportation
- Proficient in Virtual Basic, working knowledge of Python, experience with HTML

### SKILLS & ABILITIES

- Excellent familiarity with Esri ArcGIS Pro, working knowledge of Autodesk AutoCAD/Revit
- Extensive expertise with office productivity software (Microsoft Office and G Suite)
- Commercial sUAS (Drone) Pilot, licensed under Part 107
- Proficiency with Pix4D Photogrammetry Software
- Effective communicator
- Fluent in professional Spanish
- Quick learner

### VOLUNTEER EXPERIENCE

**The Church of Jesus Christ of Latter-Day Saints** — Jul 2017-Jun 2019
*Missionary (Church Representative)* — Tabasco, Mexico

- Led large groups of peers to set and achieve ambitious goals
- Handled finances for an organization comprised of more than 150 individuals
- Participated in planning and execution of large events and logistical coordination

**BYU ENGINEERING**
**Civil & Construction Engineering**

**CAPSTONE**

# LORENZO EUSEBI-DIEHR

## SKILLS

- Genuine
- Dependable
- Detail oriented
- Conflict resolution
- Great customer service

## PROFFESSIONAL SUMMARY

My experience with customer service and having served a two-year mission have allowed me to develop people skills and a strong work ethic. Through my service as a missionary I also learned the importance of time management, conflict resolution, and dedication.

## EXPERIENCE

**Engineer's Assistant | Keith Tucker Consulting Engineer | Jun 2015-Jun 2017, Jul 2019-Sept 2019**

Helping complete manometer tests, examining data received from tests, facilitating customer interactions, and going over plans and files.

**Full-Time Representative | LDS Church | Jul 2017-Jul 2019**

Daily contacting, individual teaching, and assistance with people from around the world while collaborating with a teaching companion.

**Sales Associate | Cougar Tech | Sept 2019-April 2020**

Assisting customer's technological needs, processing orders, selling a wide range of technology, and creating customer relations.

**Customer Service Rep| Home Depot Online| June 2020-June 2021**

Answering calls, placing orders, resolving order mishaps, and creating customer relations

## EDUCATION

**Civil Engineering | Full-time Student | BYU**

GPA 3.65

Initiated in 2016 and currently studying



Lorenzo.eusebi1@gmail.com

7145526259


## VOLUNTEER WORK AND LEADERSHIP

**I served a two-year mission in Italy, Milan where I was able to perform many services such as teach English, working in soup kitchens, and helping communities in many different cities in anyway possible.**

# Bryson L. Price

*Phone: (541) 430-2019 | Email: pricebryson@gmail.com* | www.linkedin.com/in/bryson-p

## EDUCATION

**BS: Civil and Environmental Engineering** — December 2022
*Brigham Young University* — Provo, UT

- GPA 3.90
- Full Tuition Scholarship
- Spanish Language Certificate
- American Society of Civil Engineers (ASCE)
- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- Relevant Courses: AutoCAD, Geomatics/ArcGIS, Structural and Materials Analysis, MS Excel VBA Coding, Sustainable Infrastructure, Global Leadership, Intro to Transportation, Geology, Fluid Dynamics

## WORK EXPERIENCE

**Engineering Intern** — September 2021-Present
*HCF Corporation* — Sandy, UT

- Created and processed Civil 3D details for 4 projects
- Optimized parking lot parking with 45 stalls

**Capital Needs and Utilities Analyst** — April 2020-December 2021
*Brigham Young University Physical Facilities* — Provo, UT

- Trained 2 new employees
- Managed database representing an inventory worth $1+ billion
- Operated utilities office with a $24 million annual budget
- Created process to cut annual costs by $100,000

**Project Management Intern** — July 2020-August 2020
*Core Physical Therapy* — Green, OR

- Created WBS with 6 major deliverables
- Supervised 5 laborers

**Resident Assistant** — August 2019-April 2020
*Brigham Young University Residence Life* — Provo, UT

- Mentored approximately 40 students
- Referred residents to relevant campus resources

**Student and Character Development Intern** — March 2016-March 2017
*Oregon FFA Association* — State of Oregon

- Wrote comprehensive curriculum for workshops tailored to audiences of 2-50 students
- Testified to Oregon Congress on behalf of 2 bills

**Owner and Founder** — September 2012-August 2017
*Mojo Mowing* — Oakland, OR

- Compiled and managed financial information for 15 clients
- Demonstrated monthly profitability over 5 years
- Scheduled maintenance on 10 pieces of equipment

## VOLUNTEER EXPERIENCE

**Traffic Research Volunteer** — January 2020, February 2021
*Brigham Young University – College of Civil Engineering* — Provo, UT

- Calculated pedestrian and vehicle traffic in an intersection over time

**Full-time Volunteer Representative** — September 2017-August 2019
*Church of Jesus Christ of Latter-Day Saints* — Quetzaltenango, Guatemala

- Coordinated daily service efforts for teams of 2-150 people

**Eagle Scout, Project – DreamCenter Homeless Shelter** — October 2013
*Boy Scouts of America* — Roseburg, OR

- Created daily schedules for a 17-person team
- Constructed portable handicap ramp and covered area