FLOODPAIN MAPPING AND FLOOD IMPACTS IN THE DOMINICAN REPUBLIC
PROJECT ID: CEEN_2018CPST-DR-004

by

The Flood Stoppers
Jared Lillywhite
Wade Roberts
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A Capstone Project 30% Completion Report

Submitted to

Fidel Perez
INDRHI

Department of Civil and Environmental Engineering
Brigham Young University

December 10, 2018

Executive Summary

PROJECT TITLE: FLOOD MAPPING
PROJECT ID: CEEn_2018CPST_004
PROJECT SPONSOR: INDRHI
TEAM NAME: The Flood Stoppers

The main idea of this project is to ultimately generate damage curve outputs for areas and watersheds selected by Fidel Perez in the Dominican Republic that can give an idea of how expensive a varying flood might be in those areas. The steps for developing these curves include first, to explore the utility of the HAND procedures currently developed by Corey Krewson, second, to compile population density and infrastructure layers in the selected areas to assess impact in terms of human life and potential damage costs, and lastly, to explore the use of satellite imagery that can be used with model data to validate and also as a means of near-real time flood monitoring. This information could then be used to give to government officials in the Dominican Republic in helping them locate different areas they need to allocate resources and funding to developing and improving flood prevention infrastructure. Important milestones and their corresponding dates are as follows:

- Basic App Functionality – Jan 25th
- 100% App Completion – March 22nd
- Final Presentation – March 11th

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Introduction

The main purpose of this project is to explore and monitor flooding in certain regions of the Dominican Republic in order to provide tools to raise awareness of the socioeconomic impact that the floods have in the country. This project will explore the utility of the HAND procedures currently in development and will help compile population density and infrastructure layers to assess the impact and damages costs. Moreover, the project will explore the use of satellite imagery together with model data to validate and monitor real-time floods.

To accomplish the goal mentioned, the team will develop an app which will facilitate and enable the tracking of floods data. Additionally, the group will provide progress reports and a PowerPoint presentation to present the results. Main accomplishments up to this point include meeting with a representative from the project sponsor, defining the scope of work, and this report. Some of the main milestones of the next semester include the trip to the Dominican Republic on January 25th and submission of the final report and presentation on April 11th.

Schedule

Our schedule is a bit unorganized at the 30% mark in our project. The reason for this is that we are uncertain what will need to be done after we go to the Dominican Republic. Once we are able to visit the people of the Dominican Republic and get a better Idea of what we want from our web application, we feel that we will better be able to make a detailed plan to create a tool that will benefit them.

Week	Milestones
10/08/18-10/12/18	● Submit our statement of work. ● Meet with Corey Krewson and discuss his current progress with the app, as well as how we might be able to build on it to include the impacts of flooding in the Dominican Republic. ● Start to build a specification manual of what we want to have to app accomplish, and how we are going to do that.
10/15/18-10/19/18	● Submit our regular status report 2. ● Research more specific details on the open source software and data we will need to build our application. ● **Wade and Dan**: Research server we can use to store the data that we are provided. ● **Jared and Seth**: Research open source GIS software that we can use to do spatial analysis. ● Meet to discuss progress on 10/15 at 2pm.
10/22/18-10/26/18	● Submit our regular status report 3. ● Continue to research more into open source software and how we can implement it into our app. ● Meet to discuss progress on 10/22 at 2pm.
10/29/18-11/02/18	● Finish spec and start to run testing on what we have found. ● Submit our regular status report 4.
11/05/18-11/09/18	● Meet with sponsor? ● Submit our regular status report 5.
11/12/18-11/16/18	● Continue to build a working model of our GIS model that we will use to perform analysis. ● Submit our regular status report 6.
11/19/18-11/23/18	● Continue to build a working model of our GIS model that we will use to perform analysis. ● Submit our regular status report 7.
11/26/18-11/30/18	● Continue to build a working model of our GIS model that we will use to perform analysis. ● Submit our regular status report 8.
12/03/18-12/07/18	● Continue to build a working model of our GIS model that we will use to perform analysis.
12/10/18-12/14/18	● Submit our 30% completion report.
12/31/18-01/04/19	● Christmas Break

01/07/19-01/11/19	● Gather and Organize all of our Data, meet with professors to verify that our plans are valid. ● Set up local development environments for Corey's app.
01/14/19-01/18/19	● Start working on the basis of our app potentially work on some functionality that we can demonstrate in the DR (If time). ● Make a presentation for the DR?
01/21/19-01/25/19	● Go to the Dominican Republic.
01/28/19-02/01/19	● Work on App ○ Start adding our flood damage curves to the app with visuals. ● Start adding MODIS data to an archive to view flood extent for past floods.
02/04/19-02/08/19	● Work on App ○ Continue with adding flood damage curves and linking them with forecasts ● Continue archiving MODIS data for validation of our flood extent maps historically.
02/11/19-03/15/19	● To be determined based on our circumstances and what we are struggling with.
03/18/19-03/22/19	● 100% App Completion
03/25/19-03/29/19	● Debug app and test user interface.
04/01/19-04/05/19	● Prepare for Final Presentation
04/08/19-04/12/19	● Final Presentation

Assumptions & Limitations

Many of the assumptions and limitations for this project revolve around the distance gap between Utah and the Dominican Republic. It is being assumed that anything generated from ArcGIS, satellite imagery, population densities shapefiles, elevation data, locations of buildings, and any other information regarding the Dominican Republic is accurate and appropriate for the scope of this project.

The damage curve selected to pattern the damage curves for areas in the Dominican Republic is the damage curve already existing for South Africa. It is being assumed that real time damage curves for the Dominican Republic would match that of one generated in South Africa.

A limitation of this project's scope is limited information and resources. Generating a damage curve specific to the Dominican Republic requires extensive input from multiple teams of government employees who have access to all sorts of real-time, ever changing data such as population density, location and cost of buildings, cost of reconstruction, specific zoning densities (i.e. agricultural, commercial, subdivision), and actual environment parameters.

Design, Analysis & Results

This section contains a summary of the design, analysis, and results that have been completed up to this point in the project. Specifically, this section covers the current state of the web application, our efforts to collect satellite imagery, and our research into depth-damage curves.

Existing Application

The design of our web application will be built off of the existing Flood Extent application as built by Corey Krewson. The current state of this application is shown below in Figures 1 and 2. The application shows a time series of forecasted flood extent maps for every stream reach in the Dominican Republic.

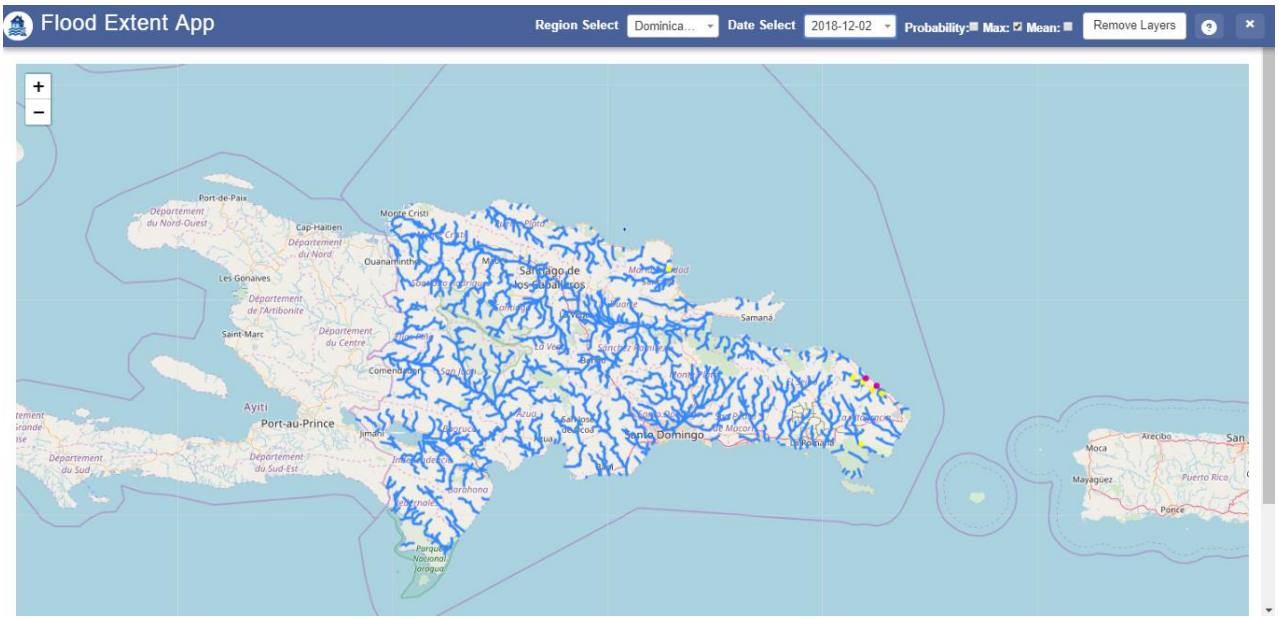

Figure 1 Existing Flood Extent Application Regional View

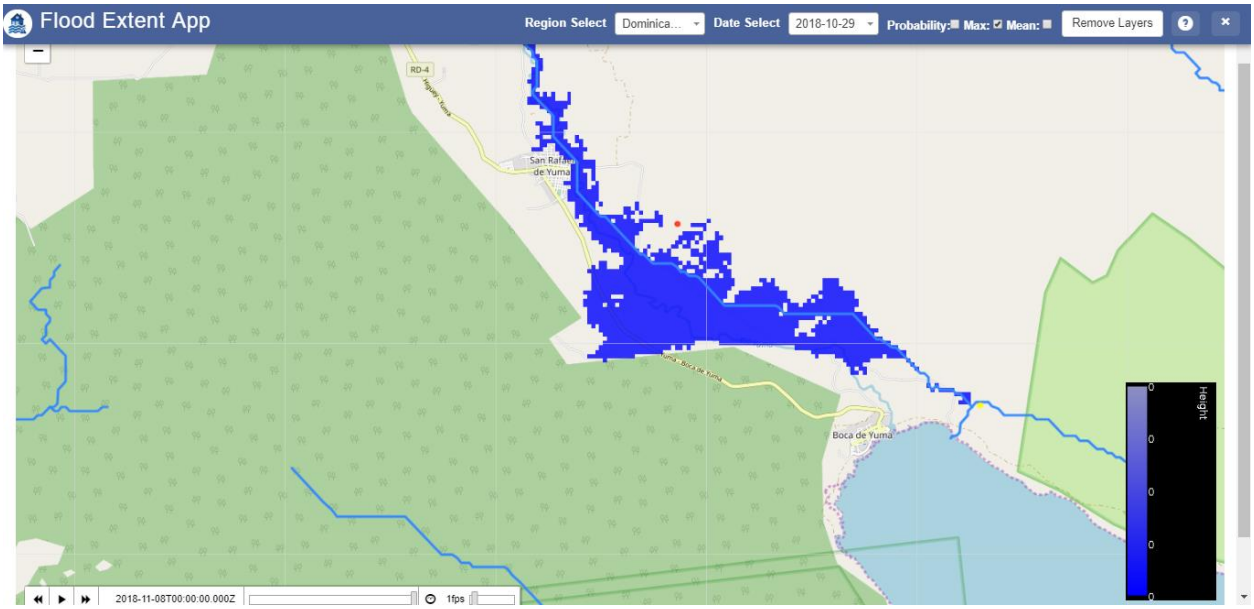

Figure 2 Existing Flood Extent Application – Flood Extent

We will be adding functionality to this application to show the economic impact of floods based on the extent of the flooding and the appropriate flood-damage curve for the area.

Historical Floodplain Mapping Validation

To begin the process of validating our HAND floodplain extent maps, we plan on gathering MODIS time series data to observe satellite floodplain data and compare it to our DEM generated HAND flood map. MODIS data has been used in other studies to observe floodplain extent. We currently have an archive of historical floods in the Dominican Republic provided by the Dartmouth Flood Observatory, and we plan to gather MODIS time series data that corresponds to the floods that they have archived. If we have enough time next semester, we also hope to be able to start to do a basic analysis of how well our HAND technique performs historically based on the ECMWF model routed with RAPID.

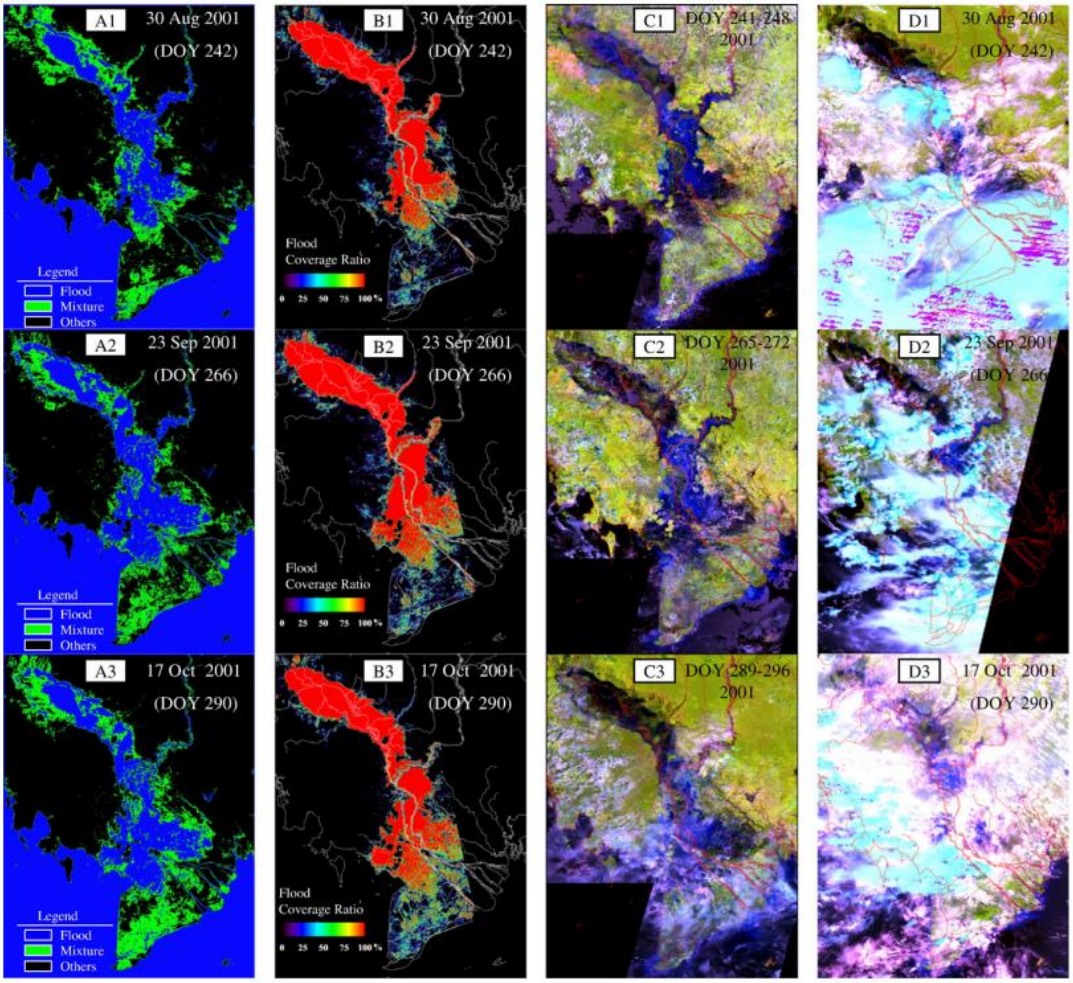

Figure 3. MODIS Data from a Study of South Asia

Depth-Damage Curves

In order to estimate the damage caused by the floods, it will be added to the application depth-damage curves to measure the damage. Depth-damage curves denotes the flood damage that would occur at specific water depths per asset or per land-use class. In order to create such a curve for the Dominican Republic, much information, which is out of the scope for this project, would be required.

Therefore, in order to estimate the damage, it will be used depth-damage curves created by The Joint Research Centre (JRC) for countries with similar climate characteristics as the Dominican Republic. The JRC is the European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. It is expected that by using a different country curve it will be possible to obtain a general idea of the monetary cost of flood damages.

The curves chosen for application in this project are those defined by the JRC for the countries of Brazil and St-Maarten which were considered the parameters to create the curve for South and Central America.

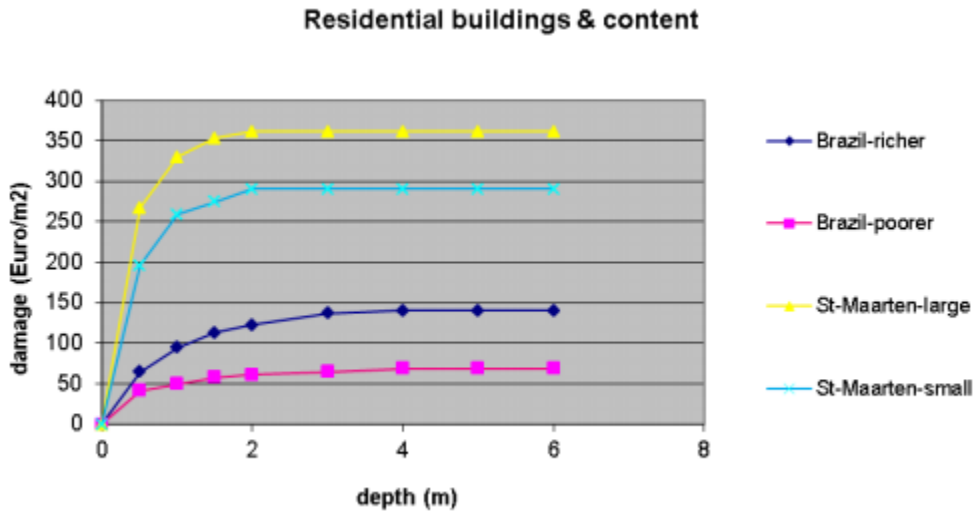

Figure 4 Damage per square meter for South America - residential buildings.

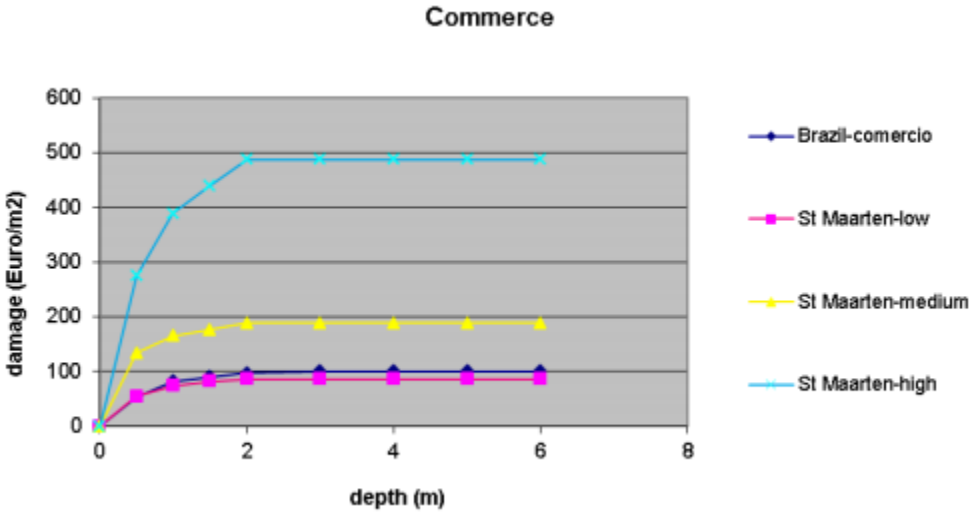

Figure 5 Damage per square meter for South America - commerce.

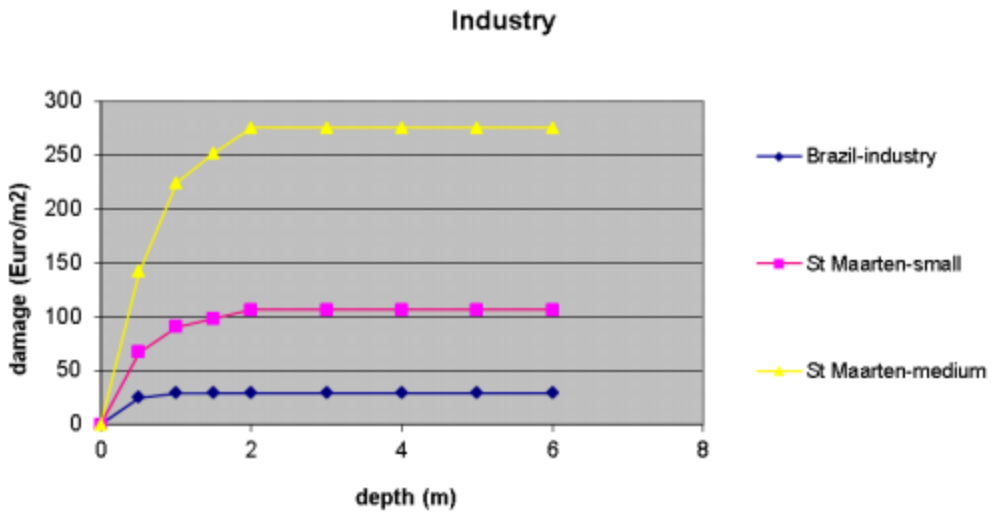

Figure 6 Damage per square meter for South America - industry.

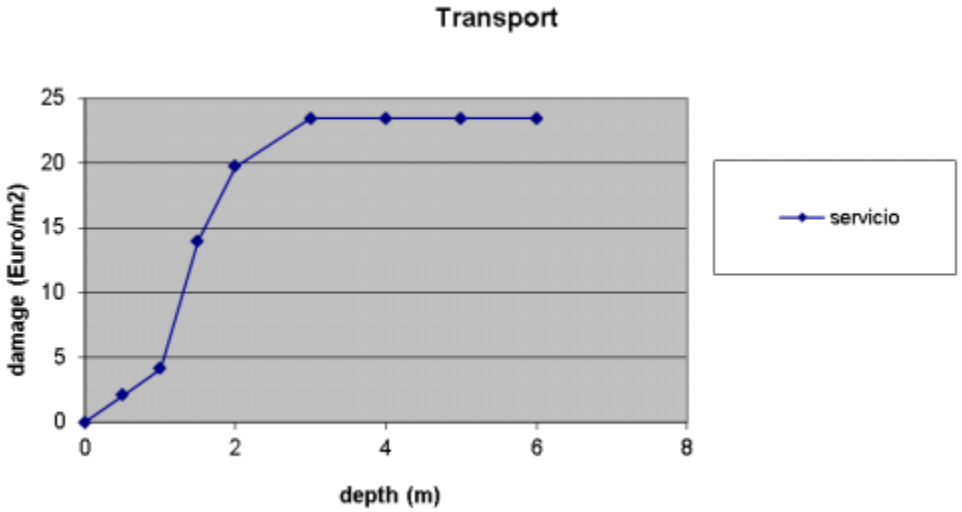

Figure 7 Damage per square meter for South America - transport.

Lessons Learned

This semester our group was able to gain valuable knowledge from our experiences in CE EN 471A. We were able to hear from a variety of speakers and learn more about how to succeed in Civil Engineering. We were able to learn more about the process of generating flood maps using the HAND methodology. We were able to learn about a software package called HAZUS and its usefulness in approximating the cost of natural disasters in the United States. We learned about the Dartmouth Flood Observatory and the archive of historical floods that they have compiled. We learned about MODIS time series data and its use in looking at the surface water in historical floods.

All these lessons have helped us to become more prepared as we go into the next semester to complete our capstone project. We feel confident that we will be able to overcome challenges and achieve the goals that we have set.

Conclusions

At this point in the project, we have concluded that the creation of a flood-damage curve for every region in the Dominican Republic is infeasible in the terms of our project. We came to this conclusion by meeting with the project sponsor and researching flood-damage curve creation methods. The data required for the creation of an accurate flood-damage curve is extensive, and the computational techniques required are beyond the time allotted for this project. We have concluded that the use of a damage-curve from a similar country will be a more appropriate approach to the development of our web-application.

Throughout the remainder of the project, we will be looking to make conclusions regarding the most effective flood-damage curve for use in specified areas of the Dominican Republic. We will also look to make conclusions regarding the validity of the flood extent maps produced through the HAND procedure.

Recommendations

In order to obtain more accurate and reliable data of flood impact in the DR, it would be required the development of a depth damage curve specific to the country. Our recommendation is to encourage the agencies at the DR to develop a Depth-Damage curve for the country in order to improve the accuracy of the application developed in this project.

Appendix A

Seth Barrus

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OBJECTIVE: Obtain a full-time job in the Civil Engineering industry by Spring 2019

EDUCATION

Brigham Young University *Anticipated April 2019*
Provo, UT

- B.S. Degree – Civil Engineering
- GPA: 3.15
- Vice President of the BYU ASCE Student Chapter for 2018

RELEVANT COURSEWORK

- CE En 433 – Hydraulic Engineering
- CE En 531 – Hydrological Modeling
- CE En 551 – Water Facility Treatment Design

WORK EXPERIENCE

South Valley Sewer District *May 2017-August 2017, May 2018-Present*
Engineering Intern Bluffdale, UT

- Reviewed over 400 construction plans which included drafting, revising, and sending redline letters asking the design engineer to meet the District's regulations
- Surveyed using GPS instruments and integrated the points to the District's ArcMap site using GIS
- Prepared about 150 bond documents to be paid by contractors before they could begin construction
- Inspected sewer pipe on a $50 million project being constructed in Herriman
- Wrote a VBA code determining the number of sewer laterals needing to be connected to the mainline and how much more flow would be coming to the treatment plant
- Prepared 150 legal easement documents utilizing AutoCAD in determining the location of the easement

BYU Broadcasting *May 2012-April 2013, May 2015-May 2018*
Student Engineer Provo, UT

- Facilitated signal flow for nationally televised events reaching about 65 million homes
- Communicated with outside vendors ordering supplies needed for projects
- Learned to make tough, "in the moment" decisions in solving a problem

VOLUNTEER EXPERIENCE

Provo High School *November 2015-March 2018*
9th Grade Boys' Basketball Coach Provo, UT

- Spent the last three seasons coaching a team of 13 high schoolers how to work together as a team and perform to the best of their ability on and off the court
- Coordinated with parents and boosters on receiving thousands of dollars of funding for the basketball program

OTHER INFORMATION

- Member of the BYU Student Chapter of ASCE since Fall 2012
- Achieved language proficiency certificate for Indonesian
- Received First Aid and CPR Training certification
- Hobbies include rock climbing, skim boarding, working on my car, and playing piano

Dan Costa

Civil and Environmental Engineer Student

Education

Aug 2019 **Bachelor of Civil and Environmental Engineering**
Brigham Young University, Provo - UT

- GPA: 3.57/4.0
- Passed the Fundamentals of Engineering Exam (FE)
- Research Assistant, Marriot Business School (2017-2018)

Experience

May 2018 – Sep 2018 **Civil Engineering Intern**
Freeport-McMoRan, Morenci - AZ (Fortune 500 Company)

- Designed and implemented safety changes according to AASHTO Standards to an intersection located inside the Morenci Mine
- Managed a $1.2M USD parking lot and retention pond project together with a Sr. Engineer
- Coordinated with 4 different groups of contractors and 6 different company departments to perform tasks in assigned projects
- Presented an overview of two projects to 100+ employees including managers and supervisors of the company
- Created a budget and Gantt Chart for project construction

May 2017 – Sep 2017 **Civil Engineering Intern**
Earthtec Engineering, Lindon - UT

- Performed air, slump, density, and compaction tests of concrete, soils, and asphalt for 30+ different residential, public and commercial projects
- Received certification on: Nuke Gauge Safety, Concrete Technician I, and Work Place Safety.
- Communicated with contractors and clients to optimize meetings with clients and contractors
- Traveled to 20+ locations in the state of Utah using a company vehicle to collect data and perform tests

Apr 2014 – Dec 2015 **Drafter/Designer**
Grupo Torquatos, São Paulo - Brazil

- Drafted 20+ commercial projects using Autocad2D and designed partitioning walls according to architect's specifications
- Discussed plans during weekly meetings with engineers and architects to improve projects
- Communicated with clients and contractors to clarify projects and resolve concerns

Extra-Curricular Activities

Jan 2017 – May 2018 **Member of the Engineering and Technology Leadership Council (ETLC), BYU**
- Trained student club leaders to promote engineering and networking opportunities for 300+ students throughout all disciplines in the college of engineering.

Sep 2018 – Today **Member of the American Society of Civil Engineer Leadership (ASCE), BYU Chapter**
- Provided networking and service opportunities for 100+ students in the Civil Engineering program at BYU

Personal Info

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Springville, UT, 84663

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E-mail
danilo.dacosta52@gmail.com

Linkedin
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Software

AutoCAD 2D	Excellent
Microsoft Office	Excellent
Revit	Very Good
AutoCAD CIVIL 3D	Good
Microsoft Project	Good

Languages

Portuguese	Fluent
Spanish	Advanced
Mandarin	Intermediate

Interests

Team Work Environment

Challenging Tasks

Leadership Opportunities

Relocation if Necessary

Opportunities to Learn

Jared C. Lillywhite

1563 S 450 E, Orem, Utah 84058
(801)309-5124 jaredclillywhite@gmail.com

EDUCATION

BS, Civil and Environmental Engineering Aug 2015- Dec 2019

Brigham Young University, Provo, Utah

- 3.89 GPA
- Institute of Transportation Engineers- Activities Coordinator
- Heritage Scholarship Award Recipient

PROFESSIONAL EXPERIENCE

Transportation Inspector May 2018- Present

AECOM, Salt Lake City, Utah

- Completed WAQTC Transportation Technician Qualification Program, receiving a 100% score on the Sampling, Reduction, and Density Testing Technician certification exam.
- Quickly became familiar with UDOT 2017 Standard Drawings and Specifications to ensure quality of construction for UDOT projects.
- Inspected and approved bid items for payment on various projects worth over $10 million.

Hydroinformatics Research Assistant August 2017 – May 2018

Brigham Young University, Provo, UT

- Attended and assisted in presentation at 2017 GEO Plenary in Washington, D.C.
- Developed time-saving methods for formatting streamflow data for use in statistical analysis.
- Used Spanish language skills to obtain data and share test results with water managers in Latin America
- Produced visual presentations documenting work in the Dominican Republic using ESRI software

Intern / Field Technician May 2017 – August 2017

Earthtec Engineering, Lindon, Utah

- Created thorough and detailed reports documenting soil and asphalt density tests throughout Utah.
- Received praise from supervisors for positive feedback of job performance from contractors in the field
- Became Nuclear Moisture-Density Gauge Certified

RELEVANT COURSEWORK

Geometric Design of Highways

- Currently enrolled, creating a preliminary re-design of a local intersection using AutoCAD Civil 3D.

Urban Transportation Planning

- Currently enrolled, researching the impact of shared mobility on congestion and public transit. Developing travel demand forecasting skills using Cube software.

Geospatial Software Development

- Developed a fully functioning web application to calculate the ideal route for a new bike trail between two user-selected endpoints, given user-selected parameters. Gained skills in HTML, JavaScript, CSS, and Python.

SKILLS

- Geographic Information Systems (ArcMap, ArcGISPro)
- Spanish Proficiency
- Computer Programming: VBA, Python, HTML, JavaScript, CSS
- UDOT SRDTT, CTT, and Crash Cushion Certifications
- Moderately experienced with AutoCAD Civil 3D

Wade Roberts

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SKILLS/ACHIEVEMENTS/ABILITIES

- Skilled with Python and Matlab with the ability to learn new computer programs quickly
- Highly skilled with GIS programs such as ArcGIS Pro
- Skilled with *CAD programs* such as SolidWorks, with an associates certification with SolidWorks
- One year of experience developing environmental web applications on the Django Stack
- Worked on projects with *NASA* to develop tools that allow executives in developing countries to make decisions regarding flooding

PROJECTS/RESEARCH

NASA/SERVIR Aug 2017 - Present
Research Assistant Provo, UT

- Collaborate with others as well as work individually to create web apps that provide state-of-the-art, satellite-based Earth monitoring data, geospatial information, and tools to help improve environmental decision-making among developing nations

University of Arkansas May 2017 – July 2017
Research Assistant Fayetteville, AR

- Coordinated with PhD graduate students to conduct computational material science simulations at the nanoscale using a high performance computing center.
- Refined technical reading and writing skills through researching literature and writing a final report that is expected to lead to a publication.

EDUCATION

Bachelor of Science: Civil Engineering Apr 2019
Brigham Young University Provo, UT

- GPA 3.95, GPA in Major 4.00
- Actively involved member of BYU ASCE student chapter

Associate of Science Apr 2017
Southern Utah University Cedar City, UT

- GPA 3.99
- Dean's List (Four Semesters)
- President's Scholarship Recipient

PUBLICATIONS/PRESENTATIONS

iEMSS 2018 Conference June 2018
Fort Collins, CO

- Presented on my work with Python package *Hydrostats* and its usefulness in environmental modeling.

VOLUNTEER EXPERIENCE

Organization Feb 2014-Jan 2016
LDS Missionary New Delhi, India

- Attained leadership skills while personally leading up to 25 other full time service missionaries