Water Demand in Cerro Patacón: Census Team

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Abstract

Unusual weather patterns and the rapid urbanization of Panamá City have stressed Panamá's ability to provide water to citizens. Those most affected are developing communities outside the city, where problems with the water utility IDAAN mean an inconsistent supply of potable water. This project's goal was to assist IDAAN by developing a rationing plan to supply adequate water to each community. We successfully determined the population of each community by compiling and analyzing previously collected demographic information and by gathering new census information. Another IQP team gathered topographical information, and together we developed and presented the rationing plan to stakeholders.

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Table of Contents

List of Figures

Executive Summary

Panama has sufficient water resources to support its population but water shortages remain an issue, particularly in low income communities. The cause of this is twofold: rapid population growth and environmental factors have stressed Panama's water infrastructure, while the organizations tasked with maintaining that infrastructure have lost millions of dollars and are unable to adequately service their customers. The low income communities surrounding the city have the least developed infrastructure, and there is not a consistent supply. The water utility tasked with delivering water knows little about the communities, making progress on new infrastructure slow. Additionally, existing water infrastructure in the communities is often misused or abused, requiring IDAAN to provide human resources to resolve the issue.

Our project, sponsored by Footprint Possibilities, was focused on gathering census data on the 10 communities of Cerro Patacón to better understand the community's' water needs. The data collected were then analyzed to predict current and future water demand by applying a growth factor to the current population. Findings were combined with the topographical findings of our partnering team to develop a water distribution plan that provided a fair, agreed upon amount of water for each community in Cerro Patacón. Both teams established a set of objectives aimed to collect and compile relevant data. We gathered prior census information from local universities and stakeholders and conducted our own censuses for the remaining communities lacking data. Upon completion we will present all findings to the government stakeholders associated with our project to help them better understand the water demand in

each community. We believe this information will allow the stakeholders to install systems that deliver the necessary supply of water to each community.

Our first objective was to gather prior community population and demographic information. Before beginning research on the different communities, the team sought to gather as many existing data as possible to help us best utilize our time on site. We completed this objective through regular conversations with our sponsor Rick Montanari, an interview with a local university, and meetings with the community leaders of Cerro Patacon. Rick Montanari provided us with his collection of past research along with the contact information for the local universities and the community leaders. These existing data allowed us to determine the population of the communities of Kuna Nega, San Francisco, and La Esperanza and focus our efforts on those that had no census information. In order for previous information to be considered valid for our census, we required it to be less than three years old. We believe these results would still be an accurate reflection of the population and that performing a sampling of these large populations would yield less accurate results. Imposing this requirement ensured that our collective data would accurately reflect the Cerro Patacon population.

For the remaining seven communities which did not have prior census work, we conducted a community census to determine the current population. Unfortunately, our team encountered a few obstacles that we needed to overcome before our field work. These obstacles included planning daily transportant, organizing police escorts and the unexpected weather affecting safety and accessibility within the community. This limited our efficiency on site, however our team was effective at handling each one. Once these obstacles were cleared

we conducted census work for each community, which focused on determining the total number of adults and children in each community. Our partnering team focused on gathering topographical data and optimal tank and pipe locations. Both teams made additional observations on each of the individual communities to help differentiate them from one another.

With the complete collection of data, our final objective was to combine our findings and develop a water distribution plan. The analysis was divided into three overlapping areas: population growth, ideal tank locations, and a person's daily water requirement. The team's main focus when analysing the data was to predict the future population growth for years one, two, three, five, and ten based upon of a general 2% growth rate. The other Footprint Possibilities team determined ideal tank placement based off of three main factors: point of elevation, location in community, and available space in the area. Together we established a three stage plan for the water supply that should be provided during emergency, ideal and comfort circumstances. Based on analysis of the data, our teams created a complete final recommendation for the future implementation by government stakeholders.

Our recommendations were organized into two main sections: individual community suggestions, overall community guidelines that should be implemented across Cerro Patacon, and future projects that could be performed in the area. All communities were given a recommendation to prohibit personal connections to the water supply and replace them with community fountains for all residents. We also stress the importance that, in the event of an emergency, the government refrain from cutting off the supply of water to Cerro Patacon for more than one consecutive day. Finally we recommend that all residents are required to

become clients of the local water authority if they desire to have access to this community supply of water. These recommendations are designed to ensure all citizens are provided an adequate supply of water, while also working toward creating a system of responsible water use that is lacking in many communities.

Chapter 1: Introduction

"2015, the hottest year in history." And according to the United Nations, 2016 will only be hotter. Climate change has and will have many effects, and for developing nations around the world, bringing potable water to every citizen is paramount. In 2015, the World Economic Forum rated water as the number one most impactful issue that will affect our future, and the United Nations has declared it a basic human right. Panamá, home to over 3.8 million people, has enough water to provide for all its citizens, yet "significant disparities" remain. Only 70% of the urban population receives continuous access to water, and over 100,000 people require water to be delivered by truck, a costly solution to delivering water to groups of developing communities on the outskirts of the city. Our project takes place in one group of these communities, where water is cutoff for days when it must be prioritized towards the city. Blame falls on problems within the Panamá's water sector, the government organizations tasked with legislation for and delivery of water services. Recent El Niño events, the expansion of the Panamá Canal, and the swelling urban population have stressed the weaknesses in the system, and exacerbated the situation in the communities. To accommodate, the Government of Panamá (GoP) desperately needs to update the existing legislation on water policy and repair aging infrastructure, so that these communities (and the rest of Panamá) can have access to a consistent supply of potable water.

Panamá's water sector consists of several organizations that manage legislation, regulation, and distribution for water. The final and most critical of these is the Instituto de Acueductos y Alcantarillados Nacionales (National Institute of Aqueducts and Sewer or IDAAN)

who provides Water Services and Sanitation (WSS) to customers within 95% of urban Panamá. Years of mismanagement and lax regulation have not been able to keep up with the growing demand for water, as missed tariff collections have accumulated to $104 million in budget deficit. Inefficiencies in IDAAN mean they are unable to keep up maintenance leading to water cuts or weak pressure. When this happens, they prioritize water to the city, and those who've paid their bills. This has the greatest impact on the communities like in Cerro Patacón.

The communities of Cerro Patacón get their namesake from the active landfill directly adjacent. It provides work for many community members, but contributes heavily to a sanitation problem. Each community is unique, with different quality of homes, formality, and road access. For several reasons, IDAAN lacks good information for many of these communities, so there is no established infrastructure to connect to the IDAAN distribution network. Our sponsor, Footprint Possibilities, is a nonprofit organization that aims to help these communities gain better access to potable water and a legal title to the land. They have been working in the communities for years, and have a good understanding of the problems facing each one.

Our project goal is to provide IDAAN with information that they need to asses each community and set up infrastructure to deliver enough water to maintain a consistent supply. To accomplish this goal, we needed to collect information on the population and topography of each community. Two IQP teams worked simultaneously on accomplishing this. Our team gathered population information from sources in Panamá, and conducted a census for each community that needed additional information. The other team focused on topographical data, determining the boundaries and ideal tank locations of each community. Once this information

was gathered, both teams worked together to determine how much water each community would need, and the volume and location of new tanks.

The communities in Cerro Patacón are composed mainly of ten communities. The communities have a total of 7015 people, yet we believe it can grow up to almost 9000 in a decade. This approximation was the result of a simple growth rate formula. As it is stated later on, the communities vary in size significantly. We made the observation that usually the bigger communities were also the oldest; the smallest community is composed of 30 homes while the largest one has 1211. With the census completed, we came up with water demand for the whole area. The water demand is broken to three different options so IDAAN can choose how much water to supply. The options are 20 litres per person, 60 & 80 litres per person, and 100 litres per person.

Through our work with Footprint Possibilities we successfully developed a water rationing plan that will guide IDAAN as they continue to develop infrastructure within the communities. Once completed, the communities will be a step closer to having a reliable supply of water and a dramatically improved livelihood.

Chapter 2: Background

By the time water reaches the communities of Cerro Patacón, it has traveled a journey plagued with challenges. In order to understand why the communities do not receive a reliable supply of water, we must first understand the nature and root of the problem. In this section, we will explore the Panamá water shortage, the organizations that manage the Panamá water sector, and finally the communities themselves. This will allow us to identify where Panamá faces the greatest challenges, and how our project can best address those challenges.

Panamá Canal Watershed

Water for Panamá City and the surrounding area comes from the Panamá Canal Watershed (PCW). This water supplies 95% of Panamá's urban population, along with providing water for the Panamá Canal locks and environmental efforts such as habitat restoration and reforestation (Smithsonian Tropical Research Institute). The PCW was artificially created for the development of the canal between 1904 and 1914. Panamá was charged with maintaining adequate water levels to service the canal and nearby cities. Over the past century, it has morphed and grown, until reaching its latest form in 1999. Realizing the importance of managing the PCW for a developing population, Panamá created the Panamá Canal Authority (ACP) in 1994, tasked with managing the canal and use of water from the PCW. Now the watershed is comprised primarily of the Gatún and Alajuela lakes, both artificially created to expand the watershed. In 2007, the canal expansion broke ground, marking the latest addition to the watershed. It was completed in June 2016 (Canal de Panamá).

2.1 Water Shortage

In February, the ACP reported that the Gatun and Alajuela Lakes were at their lowest level in 103 years (Newsroom Panamá, 2016). The rapid urbanization of the population as well as tourism growth have increased the demand for water. The canal expansion requires millions of gallons of additional water for each ship that passes through. Meanwhile, abnormal weather patterns caused by El Niño further stressed the water supply. It should be noted that in recent months, the water situation has improved and water restrictions are less likely. However, the effects of the drought will continue to be felt and this will not be the last time the watershed levels are at risk. It is crucial that the GoP respond by preparing for future water shortages.

Urbanization

The city of Panamá is a well-developed city; it offers a lot of job opportunities and attractions. The economy has grown an average of 8.07% annually from 2010 to 2016, boosted by the canal expansion (Trading Economics, 2016). In the past decade, hundreds of residential towers have sprung out as the city is ever growing; it has grown so much that journalists have compared it to Singapore, New York and Dubai. Residents who once lived across the country have begun to centralize in Panamá City as economic factors pull them in. The metropolitan area of Panamá holds almost half the population of the entire country, 1.2 million out of 3.7 million according to the 2010 census. This does not account for tourism, a fast growing industry in Panamá; it increased from 1.9 million a year to 2.2 million a year from 2009 to 2012. As people are being attracted into the city, international or national, the need for the more water in the city keeps rising while the water levels for the supply decreases.

Where did that water go?

The weather conditions created by El Niño led to a state of emergency and forced government officials to reallocate water supplies due to the record-breaking drought. Beyond a lack of water for drinking, water shortages affect many other aspects of the country. In one particular case, the drought led to issues with the operation of both the Canal and hydroelectric dams, while also hindering agriculture production. "Lakes Gatun and Alajuela, located within the watershed of the Panamá Canal, are the sources of supply for the Canal's operations, but also provide water for 1.9 million people, or more than 55 percent of the country's population" (Water Crisis in Rain Soaked Panamá, 2015). This water is stretched thin by the development of the canal. However, Panamá is working to provide water for all its citizens. The current government is developing new potable water plants and researching which water bodies could possibly supply water (Sequía Pone En Aprietos Al Canal Y a Panamá Entera, 2016). They hope that this will address many of the issues presented by the development of the third set of locks for the Panamá Canal, and make water more available to those smaller communities around the city.

With a growing population and limited water resources, IDAAN has struggled. In the next section we will see how the problems above are hurting Panamá's water sector.

2.2 Panamá Water Sector

Defined in the Panamanian Water Law in 1997, several government organizations work together to bring generally very good WSS coverage to urban and rural Panamá, particularly when compared to other countries in the region. Unfortunately, this high level of coverage

does not imply consistent water supply, particularly in low income areas. Failures in the setup of the water sector itself mean deep rooted problems across numerous organizations. Truly solving those problems will take hundreds of millions of dollars, and potential restructuring of the water sector. The problems faced by low income communities such as Cerro Patacón stem from these failures by the government, but are primarily connected to IDAAN and their ability to deliver water.

Government Organizations

Managing a supply of water for this growing population are several government organizations. They work together to improve water access in Panamá, and over the years their structures and purposes have changed. The current regulatory framework was defined in 1997, establishing clear roles for various government organizations. The Ministry of Health (MINSA) manages high level operations and future planning, IDAAN, the water utility, provides delivery of water and sanitation services, The National Public Services Authority (ASEP) manages regulation and oversight of projects, and finally the Ministry of Economy and Finance (MEF) handles money matters. Numerous other government organizations and NGOs also have smaller responsibilities. Blame for shortages falls on all these organizations. MINSA has been unable to properly lead the water sector. ASEP barely regulates water in comparison with work it does for electricity and telecommunications. Finally, IDAAN has an operating deficit that leaves them unable to address "operational, maintenance, and investment needs". MEF has provided IDAAN with significant subsidies to cover this, an unsustainable solution.

Figure 1: Panama National Flag

IDAAN

As Panamá has developed and its needs changed, IDAAN has also had to adapt. Founded in 1961, it began with lofty goals and spent large sums of money. IDAAN soon ran out of money, in some ways similar to the position it is in now. In 1982, this was resolved with the first tariff increase in years. However, it was still a weak organization, so the 1997 law restructured IDAAN, giving it "financial and management autonomy" in hopes of resolving previous issues. From here, numerous government projects and millions of dollars have attempted over and over again to resolve challenges. In practice, IDAAN has still not been able to effectively carry out its goal of "providing WSS in an efficient manner".

Figure 2: IDAAN Logo

In 2013, IDAAN had an operating deficit of $31.5 million. Over the past decade, their annual deficit has accumulated to $104 million, of which $79 million is owed by residential consumers (Panamá América, 2016). The reason is simple. Since the tariff increase in 1982, the price of water has not changed from $0.26 per cubic meter of water. Taking inflation into account, water is now technically half the price that it was in 1982. According to ASEP, IDAAN charges a flat $6.40 a month for what is considered a "high minimum" of 30 cubic meters of water. Factoring additional fees brings this total to $7.92 a month. This extremely low cost for a high volume of water provides little incentive to conserve in urban areas. Panamanians use on average around 400L of water per day, on par with the United States but far higher than other countries in the region.

The operation deficit leads to a major problem. Urbanization has surpassed IDAAN's ability to upgrade infrastructure. Without enough money, IDAAN cannot properly maintain or

improve existing water lines. These lines rupture, water is shut off, and service is restored as soon as possible. However, as customers lose faith in IDAAN, they stop paying. Only recently has IDAAN begun cutting off customers who owe large amounts to the utility, in an attempt to reign in the vast quantity of non-paying customers. Unfortunately, many of these non-paying customers are in developing communities, where limited service quality makes it difficult for IDAAN to enforce tariff collection.

IDAAN's financial situation is the primary reason for inconsistencies in service, but it has the greatest impact on smaller, low income communities like Cerro Patacón. When something goes wrong, like a line rupturing, IDAAN must prioritize water distribution to the city, cutting off water to the communities.

2.3 Communities of Cerro Patacón

Just outside Panamá City lies a landfill called Cerro Patacón that has become home for roughly seven thousand people. Cerro Patacón is constantly growing, new communities can pop up in a matter of months and existing communities are constantly expanding. Currently there are 10 communities all at various levels of development, ranging from flimsy shacks made from plywood and whatever wood was readily available, to sturdy concrete homes with porches, decorations and other amenities of a middle class home. These communities also vary in size; from a few hundred people in the smallest communities, to over one thousand in the largest communities. Kuna Nega, the oldest community, predates the landfill and was formed in 1980 by a group of eight Kuna women. Another surge in population occurred in 2007 when a fire in Curundu forced the government to relocate families to a community that became known as La

Paz (Conn). Due to the fact many of these communities are unestablished and not formally recognized, reliable information regarding the founding and current status of the remaining communities is scarce.

The Cerro Patacón area is government land, meaning many of the communities are not recognized by the government and do not have a legal title to live on the land. A formally recognized community has legal access to their property, water supply and other utilities. If a community is not formally recognized they are known as an informal community, with no legal right to the land. Technically, these communities have a limited time to become formalized, otherwise they will be forced to leave. However, many citizens have nowhere else to go and the government has recognized that displacing them is not a practical option. Understanding that people living in the communities need access to water and electricity, the government has allowed certain communities to become formally recognized, thus giving them legal title to the land and legal access to utilities. The government wants to provide a situation where as many people in the community can live comfortably. Due to limited resources, some communities may need to be kicked out, but at present the majority of communities have been formalized or are on the path to being formally recognized.

Communities are also categorized based on whether they are developed or undeveloped. A developed community such as Kuna Nega has typically been around for several years and has concrete housing, paved roads, power and other infrastructure, as well as stores, churches and other nonresidential buildings. A developed community has the resources to last longer into the future. As such developed communities have typically already been formalized

or are on the path to becoming formally recognized. By comparison the less established communities have no such infrastructure and instead are much less organized in their layout.

The variety among communities lends itself to a variety in demographics. Some communities are made up entirely of Indigenous Panamanians called Kunas, while others are an assortment of Panamanian citizens. Each community has a blend of large families and single resident homes. The communities of Kuna Nega, Maser Nega and Kun Kuna Nega are home to an exclusively Kuna population, and are the most homogenous communities. One of the primary reasons Kuna Nega was founded as an alternative to the fast paced city life and a way for the Native Kunas to maintain their heritage for future generations (Espinosa). This solidarity means these communities are typically much more organized. For example, even Maser Nega, a community formed months before we arrived on site already had a community leader and a strong sense of community, all the citizens seemed to know each other. Many more developed communities lacked this connection. For example, in Calle 50 there were many single occupant houses, which means these people were likely using the house to commute to work, while their family lived elsewhere. Employment opportunities are a major motivator for people to move to Cerro Patacón. The landfill offers employment for many residents of Cerro Patacón with minimal commute. The city, home to countless jobs, is also a short drive away. The proximity to such a large amount of employment opportunities, combined with the rent free homes in the informal communities makes it an attractive option for those who desire to move to the city for work, but are unable to afford moving their family with them (Montanari). Some people in Cerro Patacón also simply have multiple homes in different communities in a bid to increase their chances of having a home in a community that will eventually become formalized.

2.4 Water in Cerro Patacón

IDAAN delivers water to the communities of Cerro Patacón two primary ways; water is either piped directly into the communities if a water infrastructure is in place, if not communities have the option to have water delivered by truck. A community's status with the government is the primary factor in how they receive their water. Formally recognized communities have direct connections to IDAAN's water supply through pipes that run along the common walkways of their respective communities. In addition, the communities of Kuna Nega and La Paz are each equipped with large tanks of water to sustain the communities during periods when their access to water is shut off due to a drought. These tanks are typically placed at a high point in each community with a central location, to allow for minimal use of pressure valves. In the event of a water shortage IDAAN will cut off water for several days a week so there is enough water for the city, where people are more likely to pay for water. In this case water can be trucked in so that these people have access to a small amount of water. Informal communities that have set up a water infrastructure also have the option to contact IDAAN and receive water deliveries. However, this method is inefficient and not a lasting solution, as it is expensive to pay for the drivers and the labor to deliver the water (Montanari).

Consistent access to water is not a guarantee for many in Cerro Patacón. Water is a basic necessity of life, so people without it will do anything they can to gain consistent access to it. A major problem in these communities is illegal connections. In particular, the water line that supplies Kuna Nega and San Francisco goes through the communities of Villa Cardenas and La Esperanza, two informal communities. As a result, many people in these communities often illegally tap into the lines to supply the two formal communities, which leads to water

shortages for Kuna Nega and San Francisco. IDAAN has yet to find a reliable solution to this problem, as even if they cut these connections there is no guarantee they will not eventually return (Montanari).

The fear of not having access to water leads many people to horde water. They will fill up a large bucket of water outside their house in an effort to ensure constant access to water. However, this water is susceptible to contamination and will eventually become unsafe to drink. This leads to large amounts of water being wasted in a community where water is already scarce. People will also leave their water systems running even while away so that they can ensure they have access to water when returning home (Montanari) Even in those who use an appropriate amount of water, a lack of infrastructure in many of these communities prevents them from having a reliable method to clean, store, and distribute water (Mejia). In addition, corruption in the governances in many of these communities prevents water from being fairly distributed. Footprint Possibilities has reported numerous instances of high ranking community members installing direct lines to their houses for their personal use. All of these factors contribute to water shortages in Cerro Patacón, and would remain a problem even if the water demand of the community was met.

2.5 Challenges in the Communities

Potable water, a basic necessity of life, is not a guarantee in much of Cerro Patacón, so it can be expected that these communities face numerous challenges. Arguably the biggest of which is gaining formal recognition with the government. Informal communities do not have legal access to water or power and so in many cases these communities create unauthorized

connections to the water and power supplies of formal communities. There have been cases where people in informal communities sell off connections to the main water supply, despite having no right to the water themselves (Montanari). This causes problems for everyone, since the amount of water allocated for a formal community does not account for these additional connections, and so now these communities also have shortages of water. This behavior exhibits a lack of responsibility to others in their community. These people are focusing on day to day survival, instead of the big picture. A major challenge in these communities is instilling this sense of responsibility and trust that everyone will get their fair share. It is difficult to convince people to conserve water when they do not have a reliable source.

Water is not the only resource that is scarce in these communities. Power, living space and other utilities are inadequate in many of these communities. This further contributes to the lack of responsibility in these communities. People focus on how they will live day to day which makes it difficult to plan ahead for their long term needs and how their actions affect the rest of the community.

Another issue that plagues informal communities in particular is communication and organization. Our group ran into numerous obstacles when contacting community leaders in each community, ranging from leaders being preoccupied at our agreed meeting time, to communities lacking leaders entirely. This lack of communication and organization could pose problems for these communities when they eventually try to get formalized. They will not be formalized if they do not have a leader to stand for the community and if they are unorganized the government has no incentive to allow them to stay on the land. The terrain of the land also works against creating a sense of organization in these communities. Much of Cerro Patacón is

filled with hilly terrain, that does not accommodate the installation of roads or organized housing. Instead homes are built in a seemingly random fashion wherever there is empty space, especially in informal communities.

Going to Cerro Patacón the smell brought on by the landfill that surrounds the communities is inescapable. The mountain of trash is visible from every community and its presence permeates into every aspect of daily life. The litter is also a major factor in contaminating the already limited water supply in Cerro Patacón. Living next to a landfill has also seemed to diminish environmental concerns in these communities, as there are several communities in Cerro Patacón where the ground is completely covered in trash. This again speaks to a lack of organization for these informal communities. The more organized informal communities, such as Maser Nega, were devoid of trash, while an unorganized community such as Calle 50 was covered. This seems to indicate this community is less of a community and more a random collection of houses.

2.6 University of Pittsburgh Study

While information about the communities of Cerro Patacón is scarce, Footprint Possibilities has worked with other teams in these communities. Their results and observations help to shed light onto some of the community-specific struggles they faced. The University of Pittsburgh has done previous work in one of the communities in which we will be working in. They gathered topography data along with information on community members and their general lifestyle. Any additional data and observations on the communities is useful because it

gives us an idea of the actual conditions in this area, since the informal nature of many of these communities means that information regarding these communities is limited.

The University of Pittsburgh has worked very closely with Footprint Possibilities over the past few years to develop a water distribution system in the Kuna Nega community. Most of the work done is focused on the technical aspects used in developing a water distribution system. While this project took a different approach than what we will be doing, a lot of their background research and community observations will be useful for us. Based on their research for Kuna Nega we know that the average person in that community requires a minimum of 25 liters each day for water use. This estimate is very low in comparison to the average water consumption per person in the country due to the fact that a majority of citizens in that community do not have running toilets, showers, or washing machines, which significantly decreases their demand for water. This project also brought to our attention that there are also certain needs or reservations made on water by specific groups, such as police and community leaders that need to be accounted for when considering how much water a community needs (Susich et al., 2015).

A second team from the University of Pittsburgh also worked in a very similar capacity to our team on the demographic portion of the water demand study. They worked in the community of La Paz in a similar capacity to the work we will be doing in the other communities of Cerro Patacón. Several of their methods that can be applied to our own study. They contacted community leaders before the start of their project to gauge the scope of the problem. In turn these people would help them conduct the surveys and develop further contacts in each of the communities that would otherwise be unavailable to them. They also

assigned numbers to each of the houses and letters to each of the unmarked streets to help organize their results and develop their survey schedule (Bennett & Berry, 2014).

Several recommendations were developed from their study. The most relevant being to include stakeholders in La Paz with any decision regarding their water supply. They also recommended that residents contact IDAAN and local representatives asking them to act in regards to their current water shortage. It was theorized that Hearing from the local population itself would force IDAAN into action. Encouraging community accountability by asking residents to volunteer in the construction of systems and paying for electricity needed for the pumps were other recommendations developed by the team to increase accountability in the community (Bennett & Berry, 2014).

Chapter 3: Methodology

The goal of our project was to develop a method of determining how much water is needed in the Cerro Patacón communities. The purpose of that determination is to assist IDAAN to better understand and evaluate each community so that they may later install systems to deliver water to each community. To accomplish this, the following objectives were set forth:

1. Gather prior community population information
2. Determine populations of communities for which we could not gather data
3. Develop and present a water distribution plan

To most effectively achieve these objectives, we conducted interviews, performed a community census, and analyzed the population. We conducted interviews with a representative from Universidad Interamericana de Panamá (UIP), held meetings with our sponsor, and had conversations with leaders and members of the various communities. To determine population, we went door to door within the communities, taking a census of the population and making additional observations about the condition of each community. The water demand for each community was determined with the information of the census in combination with the topographical information provided by our partnering team.

3.1 - Gather Prior community population information

Before going to the different communities to determine the water demand in each area, we wanted to gather as much existing data as possible, such as important contacts and other

information related to the communities to help us best utilize our time on site. Having access to past census work performed by UIP and students from the Municipality of Panamá in some of the Cerro Patacón communities allowed us to focus our efforts on those that had no existing information. In order for the information received to be considered valid for our census, we required it to be less than three years old. We believe the census results would still be accurate after this period and that performing a sampling of these populations would yield less accurate results. Having this requirement ensured that our collective data would be as accurate as possible for our recommendations.

Footprint Possibilities has many connections within Panamá City, one of the closest being UIP which has sent many students into Cerro Patacón over the past few years to perform census work on some of the larger more established communities. Two of our members met with Eida Ramos from UIP who provided us with data for Kuna Nega and La Esperanza, two of the largest communities of Cerro Patacón. The data collected for each community focused on the financial status of the community residents but still provided us data on the total number of adults and children in Kuna Nega, as well as the total number of homes in La Esperanza (Ramos). In order to find the total population in La Esperanza, the number of homes was multiplied by an average family size of 2 adults and 4 children that is provided to us by our sponsor Footprint Possibilities. This average family size originates from the past census data they collected since the beginning of their involvement in Cerro Patacón (Montanari). Although we found

Figure 3: Sarah O'Grady meeting with Edia Ramos from UIP

this average to be different than our results for other communities, we were asked by our client to maintain this for our recommendations.

3.2 - Determine Populations of Remaining Communities

For the remaining seven communities, our team performed individual community censuses to determine the current population. The first step to accomplishing this goal was organizing daily transportation between our dormitory in the City of Knowledge and Cerro Patacón. Unfortunately, this seemingly small task proved to be a challenging obstacle for both our team and our partnering Footprint Possibilities team. WPI study abroad policies prohibit students to personally drive themselves in foreign countries. As an alternative solution, it was suggested that our teams invest in daily uber rides or a van service. The uber proved to be an affordable option but after a few visits to the communities we realized that there was an unreliable pick up pattern from Cerro Patacón. The private van service was initially not an option for our teams because it was deemed too expensive, however we eventually found a service that was affordable within the project budget. An additional challenge our teams faced was related to the unpredictable weather patterns Panamá faces during the rainy season. When it rained in Cerro Patacón, we were forced to abandon our work due to unsafe working conditions in the communities. Much of the rough terrain would become slippery, muddy and impossible to explore. Our goal when entering the communities each day was to limit the time spent during the hottest part of the day by beginning work as early as possible. Coupled with the hilly terrain in many of these communities, dehydration and fatigue are real concerns.

Once we safely arrived in Cerro Patacón, our teams would report directly to the police station to meet our daily police escort. The purpose of the police escort was to provide protection and support as we visited each of the communities. The protection they provided was mainly from the wild dogs and other animals that roamed the communities. The support was needed when introducing ourselves to community residents to inform them of our purpose for visiting. Unfortunately, police officers were sometimes limited and we were not authorized to enter the community without one. On a few occasions we were forced to return home because no officers were available on that day due to prior commitments. Having only one officer for some of the larger communities also limited the amount of work we could perform in a day because our teams could not separate to cover more ground.

Our partnering Footprint Possibilities team spent most of their time in the field separate from our team. Although we worked in the same community on a given day, our partnering team was instead tasked with gathering topographical data on each community. This data included determining community boundaries, points of elevation and commonly used pathways or roads. The team used a mobile application called GeoTracker to gather all of the necessary data points needed to complete their project.

Figure 4: GeoTracker Mobile Application

While they collected the topographical data, our team collected our census data. To perform each community census, our team walked together to every home. Community leaders would guide us around the communities to ensure we knew which homes were associated with that area and that all of them were accounted for. A typical conversation with a community

resident consisted of some brief small talk where we introduced ourselves and our purpose of visiting them. From there, we would ask how many adults and children lived in the home and if they had a house number associated with their property. We defined children to be any person under the age of 15 because we believe that this is the age at which personal demand reaches a plateau. In other words, we think that a child's physical development is greatest when under the age of 15. It is important to note that this factor was one established by our team based off of personal opinions. Sometimes, residents in the communities would be hesitant to give us a response but once informed that our work was to improve their accessibility to water, people were generally much more cooperative. In the event that the house was empty, the leader would inform us of the occupants and their ages or we would ask the surrounding neighbors. If the house was unoccupied or abandoned, it would be recorded as such. Fortunately, two members of our team (Ian Taylor and Myles Robinson) speak an adequate amount of Spanish. While they spoke to each representative from each home, our other two team members (Sarah O'Grady and James Whelan) recorded the homes population. Having each pair of two visiting different homes at the same time allowed for our entire team to be more efficient with our time. One thing to note is that the data collected is solely based on the answers provided to us by the community members. It is possible that the information gathered is inaccurate to some degree due to the possibility that residents' responses may not have been entirely truthful.

3.3 - Develop and Present a Water Distribution Plan

In order to develop a water distribution plan from the raw data gathered, our team had to further analyze our data and combine it with our partnering Footprint team to make a complete and accurate recommendation for our sponsor and the relevant stakeholders.

Determine Population Growth

Our main focus when analyzing our data was to predict the future population growth for year one, two, three, five, and ten. There are three distinct but overlapping ways in which populations grow in a community being expansion, densification, and intensification. Expansion of a community refers to its inward, outward or independent growth around the known boundary of the existing settlement. Cerro Patacón is a rapidly expanding community in Panamá and it has become an increasing issue in the fight to provide water to all of its residents. During our time in ID 2050 we were informed that Cerro Patacón was comprised of eight distinct communities but in only four months it has expanded to the ten we see today. Densification is in reference to the population density we observe in every community. Intensification related to the vertical growth in buildings which is not a factor we encountered in Cerro Patacón but it is something to be mindful of going into the future with these communities (Abebe, 22).

In order to determine the exact growth for Cerro Patacón, our team utilized a basic exponential growth equation from the University of Oregon. The equation is Pop(Future) = Pop(Present) * (1+i)n, where Pop(Future) represents the future population, Pop(Present) represents the current population, i represents the growth rate and n represents the number of years into the future to be calculated (Parker). We determined the growth rate based on two

main factors: the current growth rate for Panamá and a general international growth rate for developing nations. The national growth rate for Panamá is currently at 1.6% according to the World Bank's recent study performed in 2015 (Population growth). According to the Population Reference Bureau, there is a 2.4% population growth in the top 50 poorest countries in the world. Although Panamá does not qualify as one of these countries, we believe that the Cerro Patacón communities are representative of the poverty experienced in those countries (Haub). Our team took the average of these two population growths to estimate a future growth of 2% every year.

Identify Ideal Locations for Tank placement

Once our partnering team compiled their data points for each individual community, they were tasked with determining the best placement for each tank. Factors that went into deciding the ideal location included point of elevation, location in community, and available space in the area. Point of elevation is the most crucial factor out of the three because gravity will be controlling the distribution of water around the community and the higher the tank the more efficient the system will be. Having a central location in the community is ideal but not always realistic based off of the surrounding area. Some communities experience an increase in population density around their highest point of elevation limiting the room available to install the large tank necessary to supply the residents. In deciding the ideal location, our team prioritized elevation as an important factor and left the other points up to general consideration.

Understanding Human's Right to Water

In 2010, the United Nations General Assembly clearly recognized each individual's right to water and all of the proper sanitation standards that are essential for this indispensable human right. A human's right to access water is based upon five key facts defined by the World Health Organization (WHO). These five keys include its ability to be sufficient in its supply, safe in its quality, acceptable in its presentation, accessible in its location, and affordable in its price.

> According to the World Health Organization (WHO), between **50 and 100 liters** of water per person per day are needed to ensure that most basic needs are met and few health concerns arise….The water required for each personal or domestic use must be safe, therefore free from micro-organisms, chemical substances and radiological hazards that constitute a threat to a person's health….Water should be of an acceptable colour, odour and taste for each personal or domestic use. [...] All water facilities and services must be **culturally** appropriate and sensitive to **gender, lifecycle** and **privacy** requirements….Everyone has the right to a water and sanitation service that is physically accessible within, or in the immediate vicinity of the household, educational institution, workplace or health institution. According to WHO, the water source has to be within **1,000 metres** of the home and collection time should not exceed **30 minutes…Water, and water facilities and services, must be affordable for all.** (The human right to water and sanitation)

These general guidelines are used throughout the world to insure every citizen has access to an appropriate water supply. Once appropriate water is provided, community residents will use it

for a variety of different purposes ranging from Drinking and cooking to cleaning and sanitation. The WHO has created a hierarchy of water requirements with a complete breakdown of potential areas of water usage ranked by priority seen in figure 5.

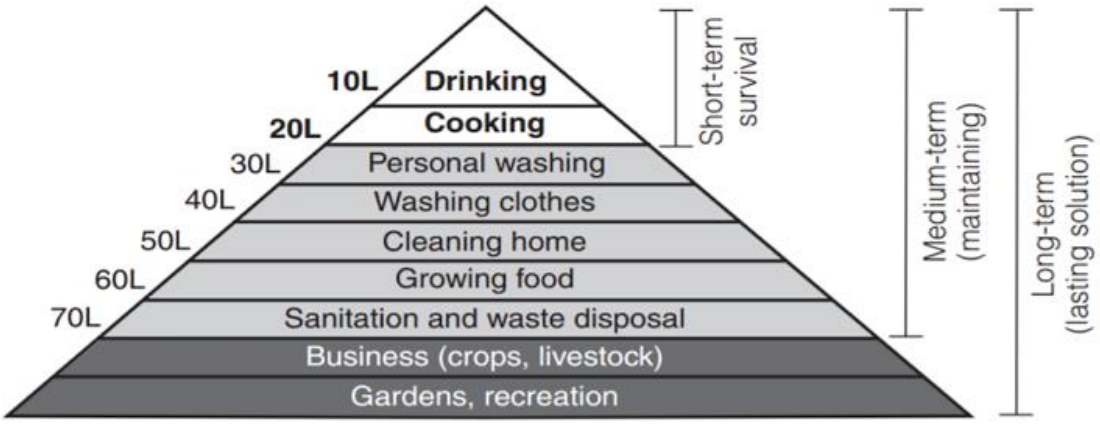

Figure 5: The WHO's Hierarchy of Water Usage

These potential areas of water use are divided into three main sections: short-term survival; medium-term survival; and long-term survival. Short term survival is an emergency supply that strictly limits water use to drinking and cooking purposes only. "Research indicates that 20 liters per capita per day is the minimum quantity of safe water required to realize minimum essential levels for health and hygiene." (Reed) This quantity of 20 liters per resident per day will be considered our Emergency water supply in our final recommendations. The medium-term section adds an additional 50 liters of water per individual to achieve basic sanitation factors such as personal washing and home cleaning to the existing drinking and cooking purposes. We recognize that different individuals have different responsibilities in a home and they might use water in different ways to ensure these proper living conditions. Due to these factors we recommend that our Ideal level, or medium-term, provide 80 liters of water

per adult and 60 liters of water per child per day. The final section outlined in WHO's hierarchy includes any additional areas that could use water. We believe that this final section is crucial in the development of the Cerro Patacón Communities so we suggest a comfort level that provides each resident with 100 liters of water per day. Our full water availability plan for IDAAN is explained below in figure 6.

Figure 6: Our Hierarchy of Water Usage

Present Findings to Government Stakeholders

With our findings in future population, ideal tank locations, and levels of water accessibility, our two teams joined together to create a final recommendation for all government stakeholders associated with this community. The final recommendation includes current populations, predicted populations, physical community size, ideal tank locations, and necessary tank volume needed to support the comfort level of water in the community for their projected 10th year population. We provided a unique recommendation for each community also addressing

those that do not need additional water infrastructure. Additional recommendations were made for future projects and potential improvements to the current system.

Chapter 4: Results

Our team conducted the census for Calle 50, Colinas de La Paz, La Paz, Maser Nega and Villa Cardenas. We gathered relevant data on Kuna Nega, La Esperanza, and San Francisco from past census work provided to us by Footprint Possibilities and local Panamanian universities. The remaining two communities, Genesis and La Bendicion, were given a population estimation based upon google maps and general assumptions. Despite the variety of sources, we believe that the data collected is an appropriate estimation of the current population of Cerro Patacón. The total population in every community was then analyzed to predict future population growth using a 2% growth rate.

Our partnering Footprint Possibilities team gathered data on the boundaries and points of elevation in each community using the mobile application GeoTracker. Together we combined our census and topographical findings to determine the appropriate tank size and location for each community. The complete census tables can be found in Appendix B and the ideal tank placement data can be found in Appendix C.

4.1 Community Breakdown

Below we have provided a community breakdown which includes census data, expected population growth, and topography data. We have organized them based upon how they appear (left to right, top to bottom) on the full community map seen in figure 7. This map is the completed topographical borders for the 10 Cerro Patacón communities established by our partnering Footprint Possibilities team.

Figure 7: Topographical Map of Cerro Patacon

La Esperanza

La Esperanza is a formal community that still fails to obtain legal access to water provided by IDAAN. We believe that people here have personal agreements with IDAAN to obtain their water but the specifics as to where the supply is coming from are unclear. A formal census was performed for La Esperanza by the students of UIP during the summer of 2015 (June, July, and August), from which we were able to gather information on the total number of homes in each of the 5 sectors. In order to determine the total population for this community, we applied an average of 2 adults and 4 children to every home resulting in a total of 448 adults and 896 children. This average was provided to us by our sponsor Footprint Possibilities based

on data gathered in old census work. Our predicted population growth for La Esperanza is seen in figure 8.

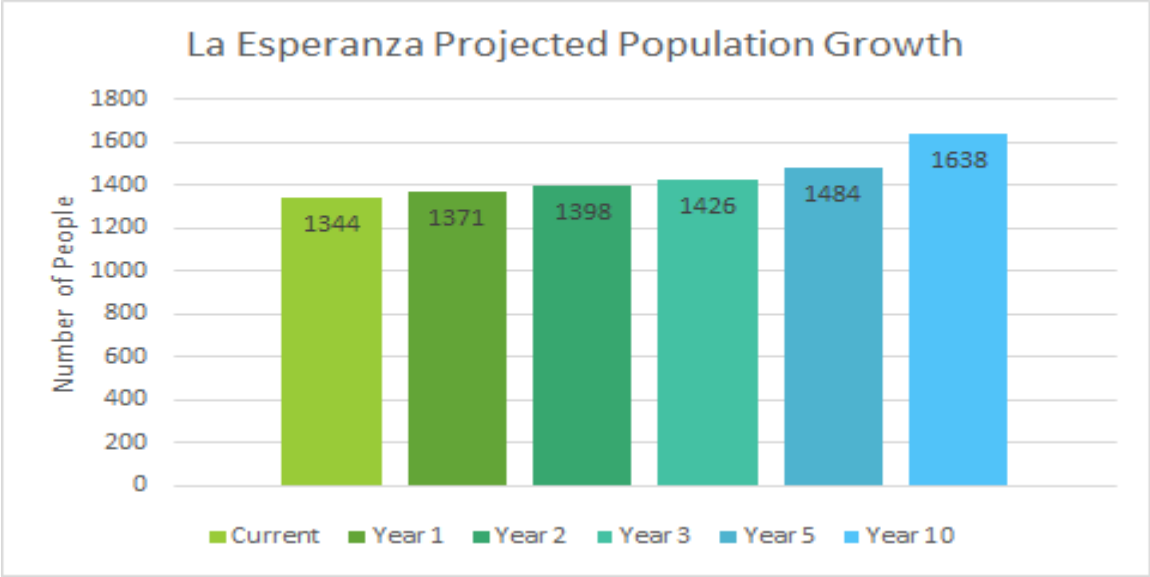

Figure 8: La Esperanza Projected Population Growth

Figure 9 displays a Google Maps view of the community with topographical boundaries outlined in pink, two possible tank locations and main community pathways. The community occupies a total of 20.8 hectares on the other side of the highway away from the main section of communities. Its highest point of elevation, at point 1 on figure 9, is at 420 ft. above sea level with the coordinate point (9.064525, -79.5569). An additional tank location, at point 2, has coordinate points of (9.063559, -79.55591) at an elevation of 348 ft. above sea level. The main pathways through La Esperanza are not vehicle accessible like other formal communities.

Figure 9: Topographical Map of La Esperanza

Villa Cardenas

Villas Cardenas is a small formal community that has access to a regular water supply. The water comes from the main IDAAN pipeline that runs through the community over the bridge toward Kuna Nega. Villa Cardenas is unique in the sense that all of the homes are well constructed and cared for and it is firmly established. The census for Villa Cardenas was performed by our team on September 29th 2016. There is a total of 124 adults and 94 children living in a total of 54 homes making this one of the smallest communities in Cerro Patacón. The average family size for Villa Cardenas is 2 adults and 2 children. Our predicted population growth for La Esperanza is seen in figure 10.

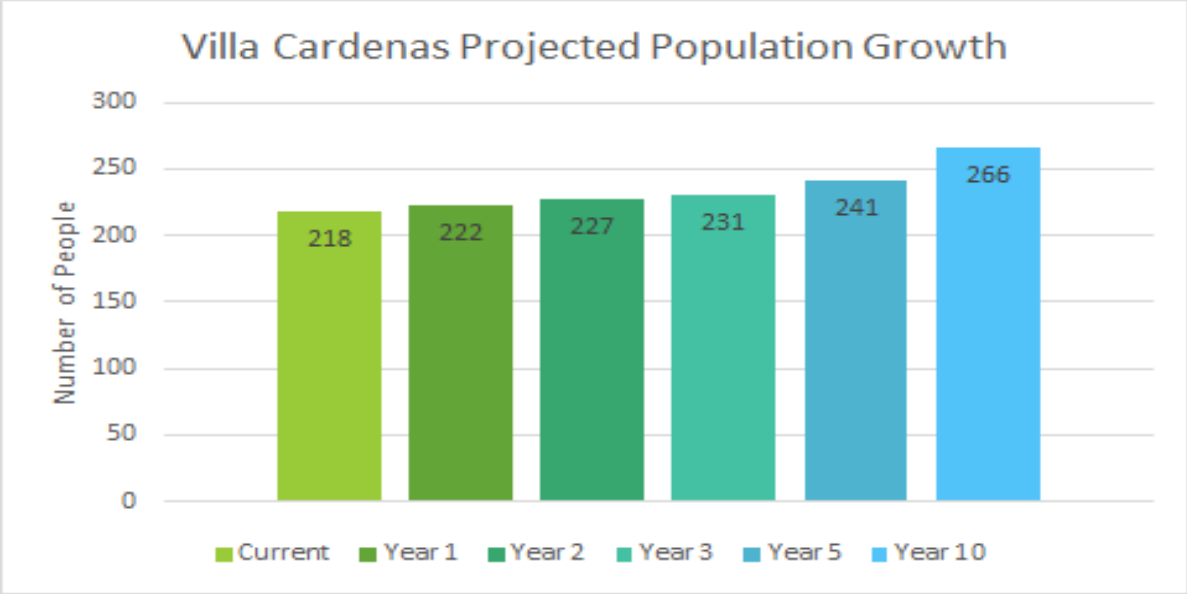

Figure 10: Villa Cardenas Projected Population Growth

Figure 11 displays a Google Maps view of the community with topographical boundaries outlined in dark blue, a potential tank location and two of the main roads outlined in light blue. Villa Cardenas takes up 3.27 hectares on the other side of the highway away next to La Esperanza and Bendición de Dios. The highest point of elevation, at point 1, in Villa Cardenas is located at (9.061016, -79.55441), 361 ft. above sea level. The main pathways in this community are accessible by vehicles and are connected to the main road that borders to the right of the community.

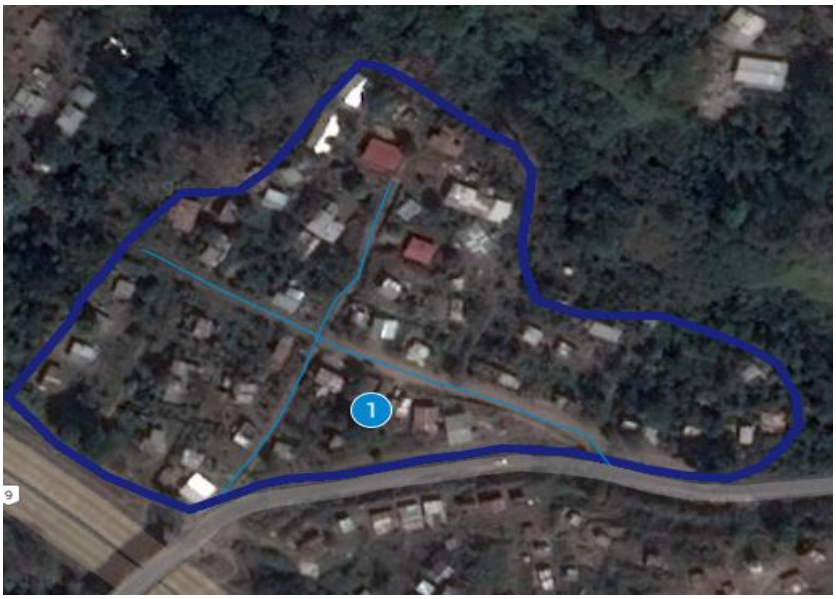

Figure 11: Topographical Map of Villa Cardenas

Bendición de Dios

Bendición de Dios is a large informal community that currently lacks legal access to a regular water supply from IDAAN. We experienced some difficulties gathering information on this community from local community members. Many people were not familiar with this area or its residents. Due to this lack of knowledge, our team opted not to perform census work for Bendición de Dios. In order to determine a current population our team made a few assumptions. First, we assumed that Bendicion de Dios has a similar population density to Villa Cardenas due to its neighboring location and level of establishment. From here we then determined that its size is roughly three times larger than Villa Cardenas according to the Google Maps view of each community. To determine the current population of Bendicion de Dios we multiplied the number of homes by three to get an approximated total of 162 homes. We used the average of 2 adults and 4 children per house provided to us by our sponsor to get

a total of 324 adults and 648 children. Our predicted population growth for Bendicion de Dios is seen in figure 12.

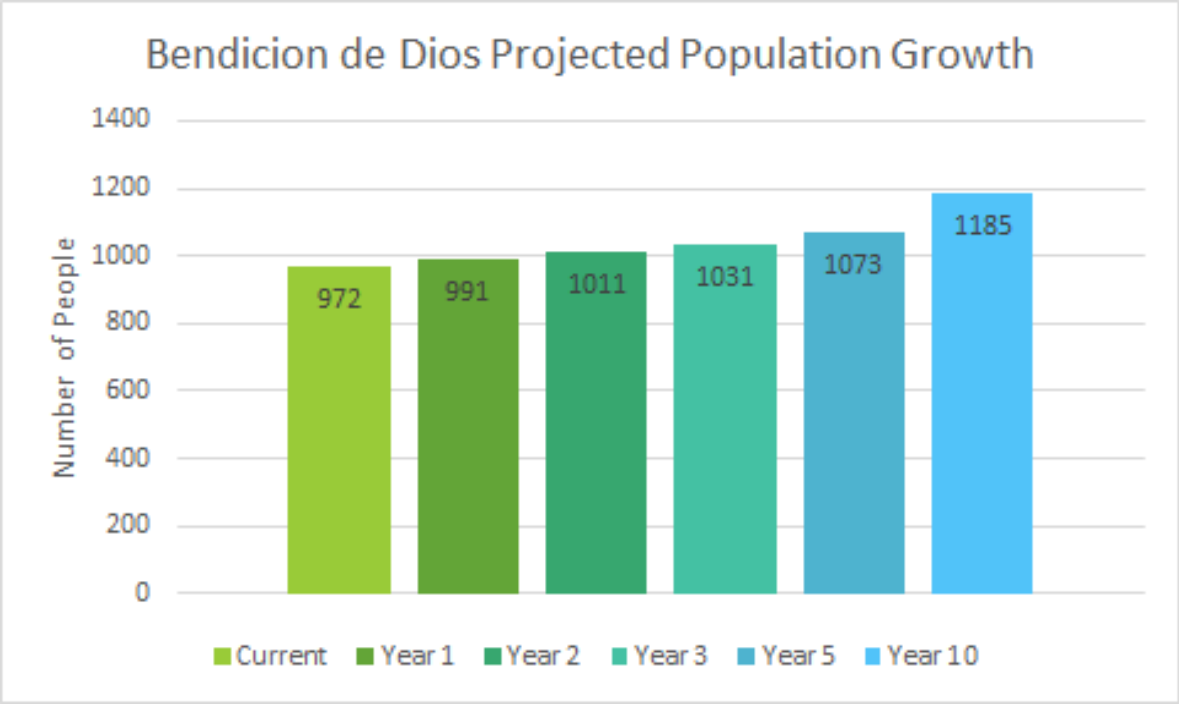

Figure 12: Bendicion de Dios Projected Population Growth

Figure 13 displays a Google Maps view of the community with topographical boundaries outlined in brown. Bendición de Dios takes up 6.21 hectares of land on the other side of the highway next to Villa Cardenas. Due to the lack of knowledge for this area, our teams were unable to gather further topographical data on potential tank locations or main community pathways.

Figure 13: Topographical Map of Bendicion de Dios

Genesis

Genesis is a small formal community that is currently unoccupied due to its lack of water infrastructure. The current absence of residents led our team to make a few assumptions in determining the expected population for the community when it eventually becomes inhabited. By counting the buildings visible in the Google maps view of the community, we determined the number of homes to be 108. From here we applied the average of 2 adults and 4 children to every home giving us a total of 216 adults and 432 children. This average was provided by our sponsor Footprint Possibilities based upon data gathered in past census work. Our predicted population growth for Genesis is seen in figure 14.

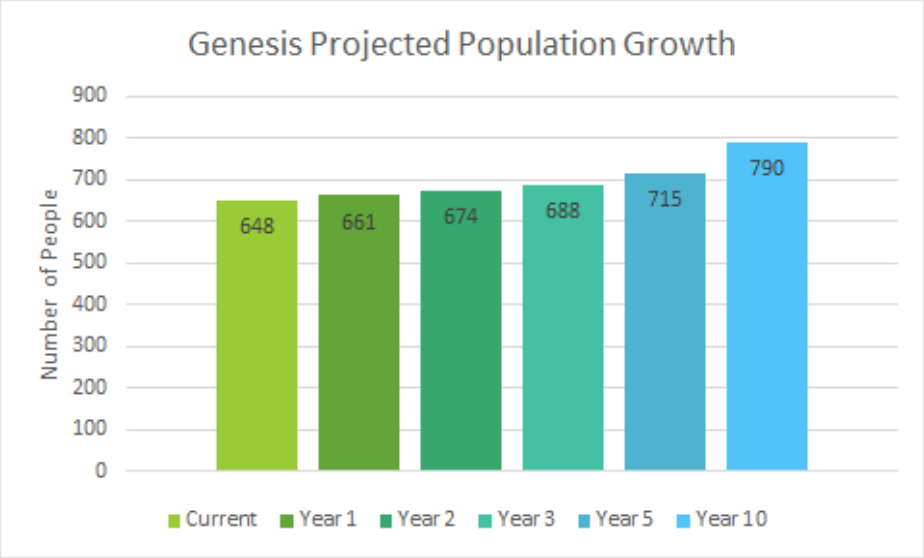

Figure 14: Genesis Projected Population Growth

Figure 15 displays a Google Maps view of Genesis with topographical boundaries outlined in orange, the current tank location and the main roads that run through the community. Genesis takes up 5.57 hectares next to La Paz. The current water storage tank, at point 1, is located at (9.065032, -79.56689), 344 ft. above sea level. It is unclear how much water the tank is capable of storing. The pathways that run through this community are vehicle accessible for future residents.

Figure 15: Topographical Map of Genesis

La Paz

La Paz is one of few formal communities and it is divided into two main sectors; one being the established section of La Paz and the other being the less established section of Kun Kuna Nega. La Paz contained several small businesses, play areas, and churches along the main road heading into the community. A census was performed for this entire community by our WPI Footprint team. We determined that there is a total of 446 adults and 335 children making for an average of 3 adults and 2 children per each of the 174 homes. Our predicted population growth for La Paz is seen in figure 16.

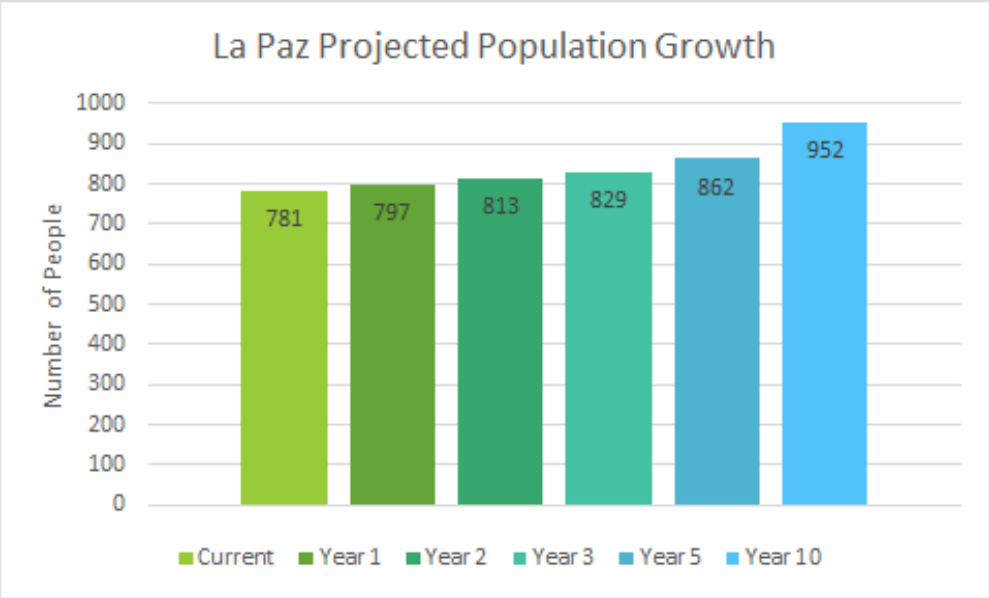

Figure 16: La Paz Projected Population Growth

Figure 17 displays a Google Maps view of La Paz with topographical boundaries outlined in green, the current tank location and a few of the main roads. La Paz takes up a total of 20.8 hectares next to Genesis, Colinas de La Paz and Kuna Nega. There are currently two water storage tanks, at point 1, located at (9.062667, -79.560684). Community leaders informed us that one tank is currently operable and the other is not yet in use. It is unclear how much water these tanks are capable of storing and whether or not it is a sufficient supply for La Paz. The roads in the established section of La Paz are vehicle accessible and organized while the other roads in the Kun Kuna Nega sector have rougher terrain.

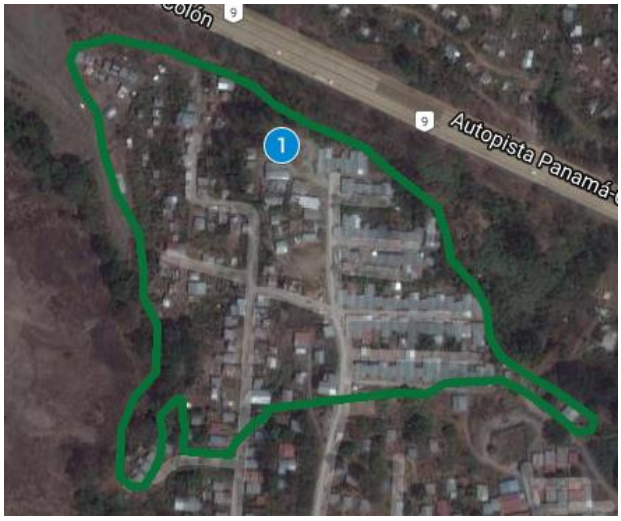

Figure 17: Topographical Map of La Paz

Colinas de La Paz

Data for Colinas de La Paz was obtained by our WPI Footprint Possibilities teams on September 22nd, 2016. Colinas de La Paz is one of the newest communities and is currently informal and unestablished. It currently does not have legal access to a water distribution system or storage tank. There are 69 adults and 56 children filling a total of 30 homes making it the smallest community in Cerro Patacón. The average family size for Colinas de La Paz is 2 adults and 2 children. Our predicted population growth for Colinas de La Paz is seen in figure 18.

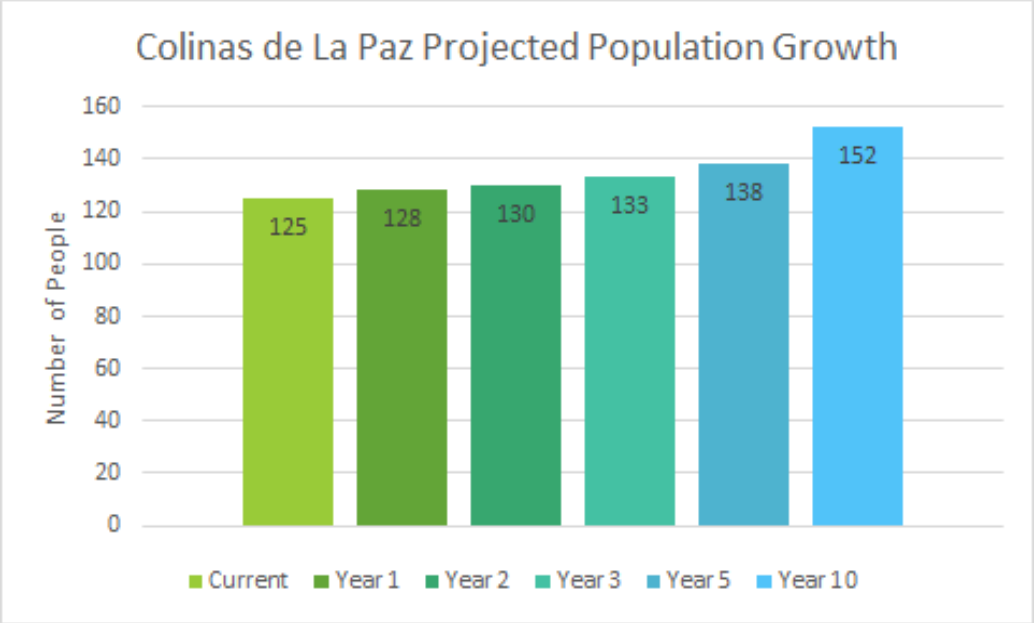

Figure 18: Colinas de La Paz Projected Population Growth

Figure 19 displays a Google Maps view of Colinas de La Paz with topographical boundaries outlined in yellow, two potential tank locations and a main pathway through the community highlighted in light blue. Colinas de La Paz takes up 2.44 hectares of land in between La Paz and Kuna Nega. Its highest point of elevation, at point 1 on figure 19, is at 331 ft. above sea level with the coordinate point (9.055724, -79.561005). An additional tank location, at point 2, has coordinate points of (9.055074, -79.56107) at an elevation of 253 ft. above sea level. Colinas de La Paz is currently one of the most challenging communities to access due to its lack of formal roads and rough terrain.

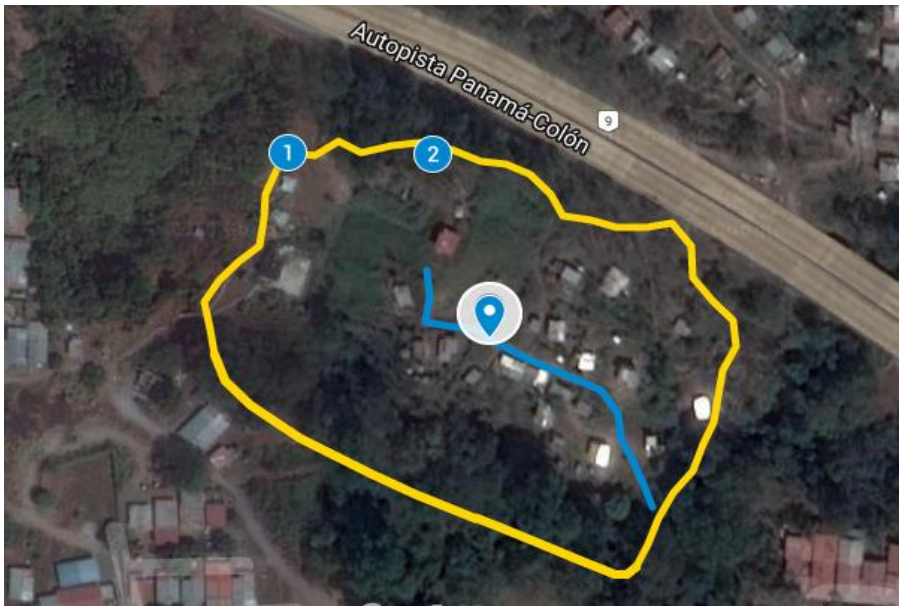

Figure 19: Topographical Map of Colinas de La Paz

Kuna Nega

Kuna Nega is one of the few formal communities in Cerro Patacón and it is the only community to have its own police station which serves 7 of the 10 communities all of which are located on the main side of the highway. It is also comprised of several small businesses, play areas and churches. The community has legal access to water supplied by IDAAN through the main community pipeline and the water storage tanks surrounding the community. The census for Kuna Nega was performed by the students of UIP in October of 2014 and from their data we were able to determine that there is a total of 626 adults and 295 children. Due the large size of the community we were unable to determine the total number of houses. Our predicted population growth for Kuna Nega is seen in figure 20.

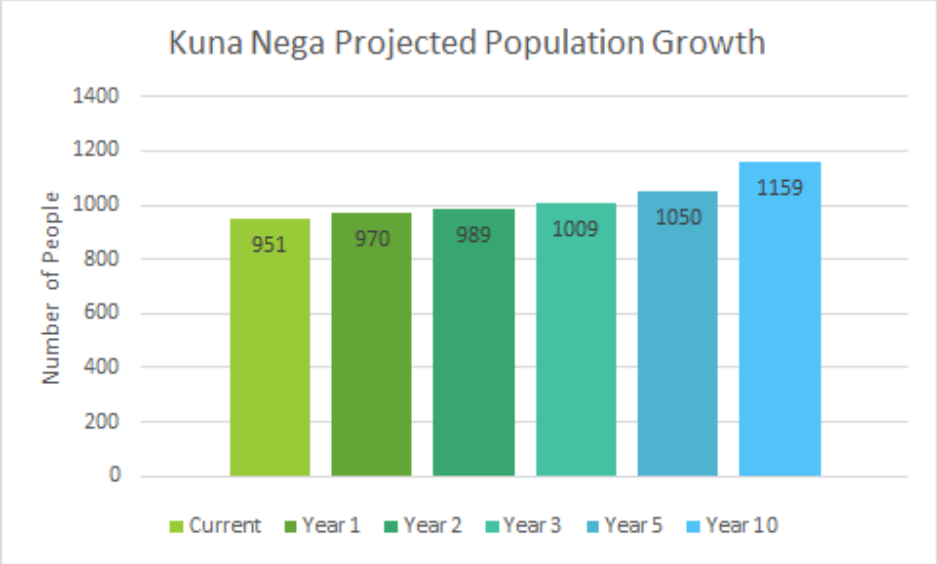

Figure 20: Kuna Nega Projected Population Growth

Figure 21 displays a Google Maps view of Kuna Nega with topographical boundaries outlined in blue and the three current tank locations. Kuna Nega takes up a total of 16.6 hectares in the center of the Cerro Patacón community. The locations of each tank are (9.05798, -79.55679), (9.05831, -79.55644), and (9.06042, -79.56006). The roads throughout Kuna Nega are some of the most commonly used roads throughout Cerro Patacón and the entire community is easily accessible and established.

Figure 21: Topographical Map of Kuna Nega

Maser Nega

Maser Nega is a small informal community that does not have access to a water supply. This community recently separated from Calle 50 making it one of the newest communities in Cerro Patacón. Maser Nega had some of the best community representatives in Cerro Patacón who were extremely helpful to the team as it performed performing census work. The census for Kuna Nega was performed by our WPI Footprint Possibilities team on September 6th of 2016. There is a total of 138 adults and 121 children filling 56 homes. The average family size in Maser Nega is 3 adults and 2 children. Our predicted population growth for Maser Nega is seen in figure 22.

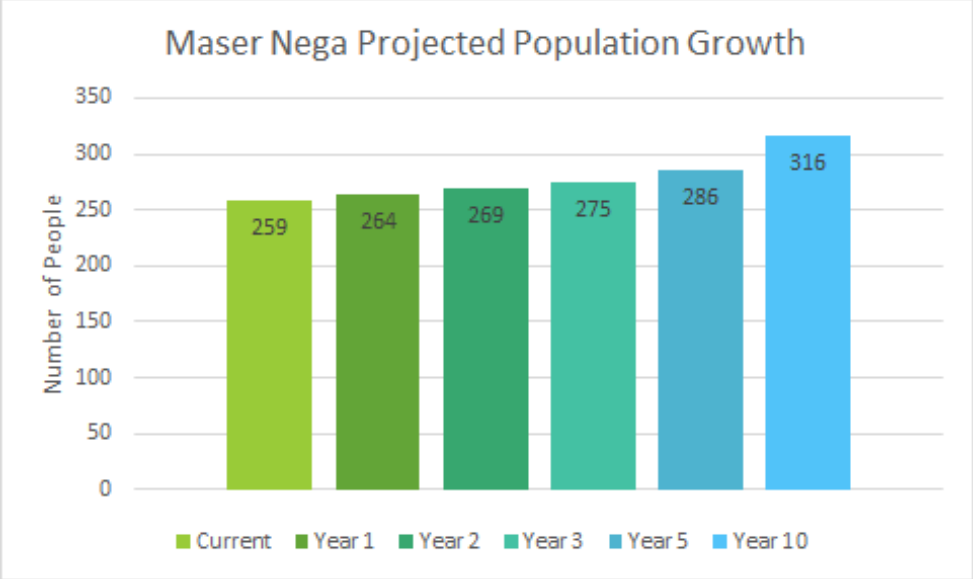

Figure 22: Maser Nega Project Population Growth

Figure 23 displays a Google Maps view of Maser Nega with topographical boundaries outlined in purple, the two potential tank locations and the main pathway through the community highlighted in light blue. Maser Nega takes up a total of 1.61 hectares between

Kuna Nega and Calle 50 surrounded by a stream. The two highest points of elevation are 236 ft. above sea level. One point is at (9.057702, -79.56009), and the other at (9.056604, -79.55934). Maser Nega was one of the most challenging communities to access because of its rough terrain and surrounding stream that separates it from the other communities.

Figure 23: Topographical Map of Maser Nega

Calle 50

Calle 50 is one of the newest communities in Cerro Patacón and is composed of many developing homes containing 1 or 2 residents. Our sponsor informed us that the development of this community is the result of the rapid growth of residents from the formal communities desiring their own tax free property. Calle 50 was ones of the more unkempt and under developed communities we visited in Cerro Patacón. It is currently lacking a legal connection to an IDAAN water distribution network however we did observe an increase in personal water storage containers. Data for Calle 50 was obtained by our WPI Footprint Possibilities team on September 8th, 2016. There are 250 adults and 154 children living in 124 homes making for an average of 2 adults and 1 child per home. We found 11 houses that were currently unoccupied,

which was the most of all 10 communities. Our predicted population growth for Calle 50 is seen in figure 24.

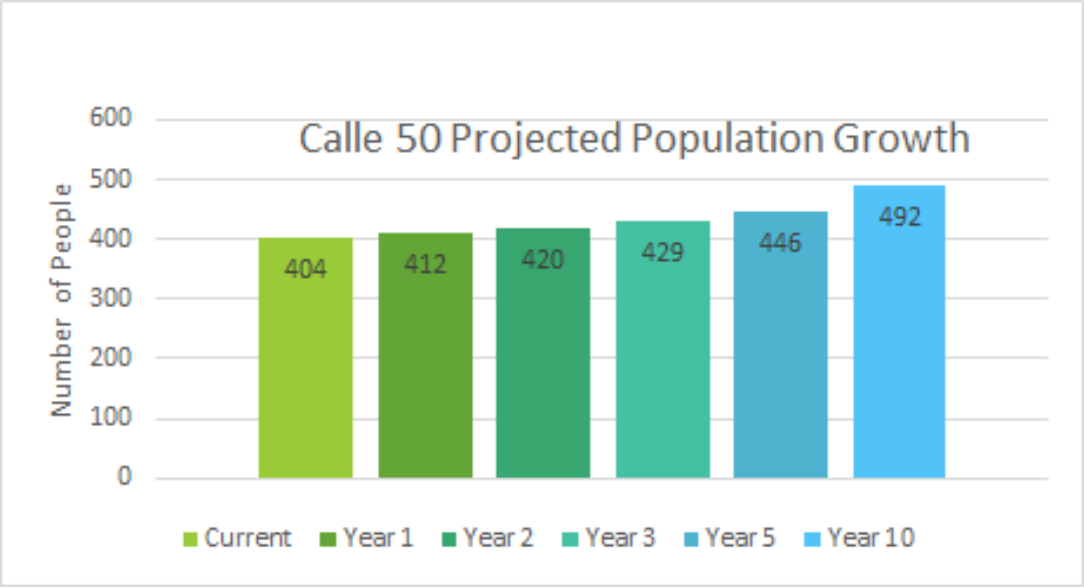

Figure 24: Calle 50 Projected Population Growth

Figure 25 displays a Google Maps view of Calle 50 with topographical boundaries outlined in black, the two potential tank locations and the main pathway through the community highlighted in light blue. Calle 50 takes up a total of 4.65 hectares of land between the main road leading to the rest of the communities and the Cerro Patacón Landfill. Its highest point of elevation, at point 1, is at 359 ft. above sea level with the coordinate point (9.055724, -79.561005). An additional tank location, at point 2, has coordinate points of (9.06355955074, -79.56107) at an elevation of 253 ft. above sea level. The main pathways through Calle 50 are not vehicle accessible but along the main road there are a few short access roads that are mainly used for parking.

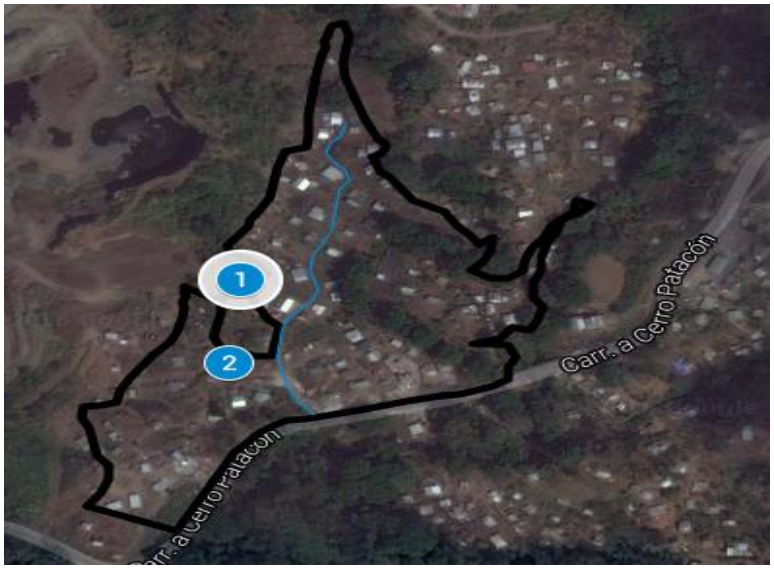

Figure 25: Topographical Map of Calle 50

San Francisco

San Francisco is the largest of the 10 communities and it is made up of 3 main sectors. Within the three main sectors there are small business, play areas and churches for the local residents. This community currently has access to several large water supply tanks that is serviced by IDAAN. Like the other communities, it is unknown how large these tanks are but we are assuming that the tanks in San Francisco are appropriate for the current population. The census work for this community was completed by the students from the Municipality of Panamá in October of 2014. They determined that there was a total of 809 adults and 722 children spread out among 333 homes. The average family size for San Francisco is 3 adults and 2 children. Our predicted population growth for San Francisco is seen in figure 26.

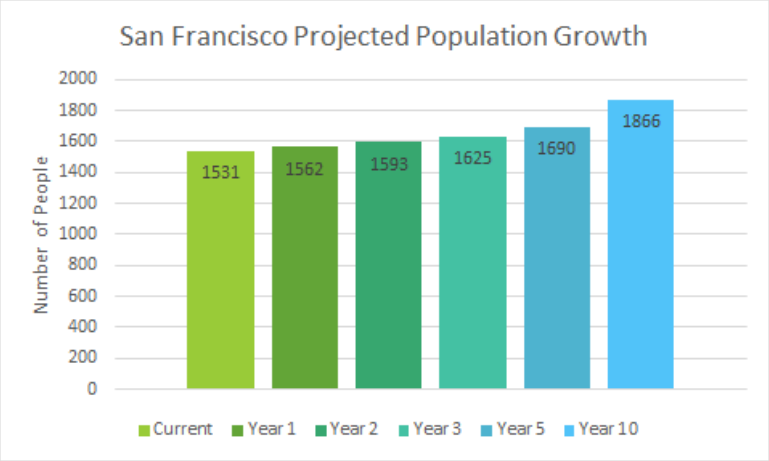

Figure 26: San Francisco Projected Population Growth

Figure 27 displays a Google Maps view of San Francisco with topographical boundaries outlined in orange and the two potential tank locations. San Francisco takes up a total of 49.2 hectares along the right side of the community. The two tank locations are (9.05877, -79.55421) and (9.05700, -79.55471).

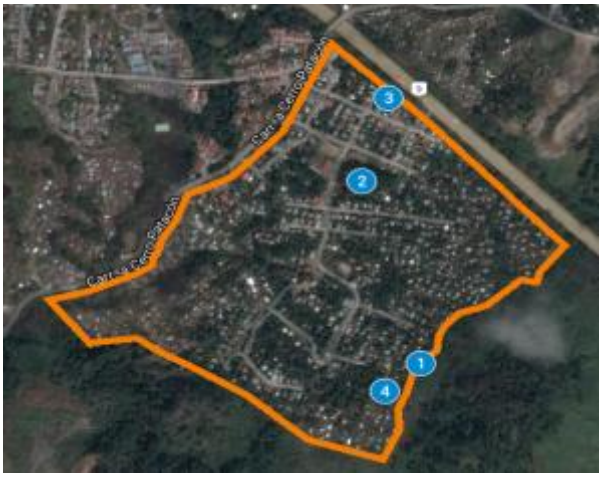

Figure 27: Topographical Map of San Francisco

4.2 General Cerro Patacón Information

Once the census data was compiled in one complete table, our team used the growth equation mentioned in the methodology section to calculate the expected population for year one, year two, year three, year five and year ten as seen in Appendix B.

Figure 28 provides a visual breakdown of each individual communities' growth over the next 10 years in relation to one another. Figure 29 provides the collective Cerro Patacón population growth over the next 10 years.

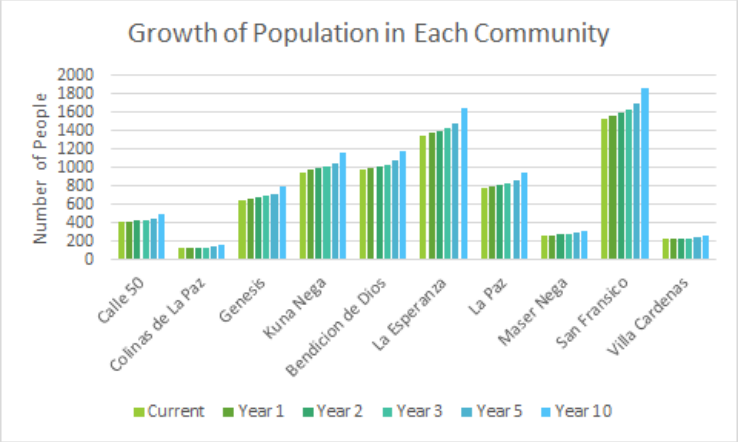

Figure 28: Growth of Population in Each Community

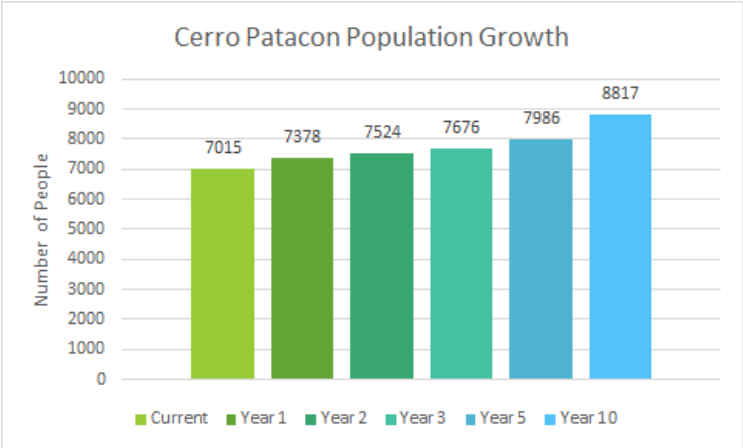

Figure 29: Cerro Patacon Population Growth

Chapter 5: Discussion

Both our team and our partnering Footprint Possibilities team joined together to develop a water distribution plan for each individual community that determines the optimal size and location for tanks in each community. We have also compiled a list of future projects that we believe to be necessary for the continued growth of the Cerro Patacón community.

5.1 - Community Recommendations

In future development of water storage and distribution infrastructure in the Cerro Patacón communities we suggest that each community receive access to their own system. We choose to recommend individual community plans due to the unique nature of each community. The distribution infrastructure in each community should be restricted to communal fountains in densely populated areas and all personal connections should be eliminated. Each of these fountains should be equipped with a meter to keep track of the water being collected. Having individual storage tanks with community fountains and meters allows for government stakeholders to gather a better understanding as to where the water is going and how it is being used within each community. We also recommend that all residents of Cerro Patacón be required to become clients of IDAAN if they desire to have access to the community supply of water.

The desired amount of water needed for each stage of our water availability plan is discussed in the Methodology section of this report. Here we will be referring to each stage as comfort, ideal, and emergency supplies. All tank sizes should be able to hold the ideal quantity

of water needed for the expected population size 10 years from now. Figure 30 presents the water Cerro Patacón needs to supply the entire community at each stage of our plan. Below we provide another community breakdown emphasizing the individual recommendations for the community.

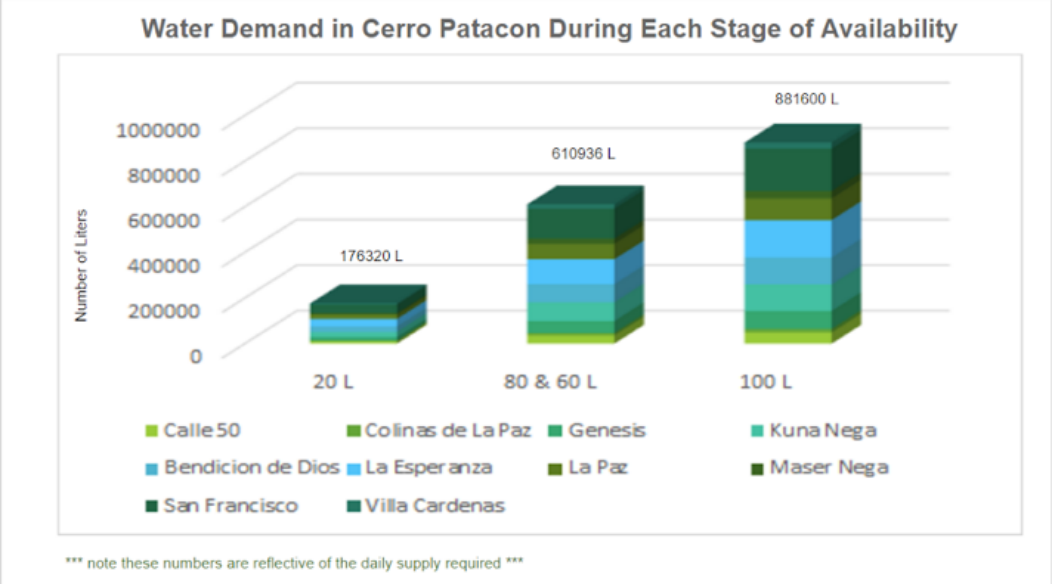

Figure 30: Water Demand in Cerro Patacon During Each Stage of Availability

La Esperanza

Figure 31: View of La Esperanza

Based on of the projected population of 1638 people in 2026 we determined the ideal daily supply of water to be 163,800 L, the comfort daily supply of water to be 109222 L, and the emergency daily supply of water to be 32760 L. The highest point of elevation in La Esperanza is also a very central location in the community making it the ideal storage tank location with the coordinate point (9.064525, -79.5569) at 420 ft. above sea level.

Villa Cardenas

Figure 32: Standard Home in Villa Cardenas

Based off of the projected population of 266 people in 2026 we determined the ideal daily supply of water to be 26600 L, the comfort daily supply of water to be 18968L and the emergency daily supply of water to be 5320 L. Its highest point of elevation is at 361 ft. above sea level with a coordinate location of (9.061016, -79.55441) making it the ideal tank location. Although Villa Cardenas currently has access to water, we still suggest that a storage tank be installed to ensure a supply during emergency periods.

Bendición de Dios

Figure 33: View of Bendicion de Dios

Based off of the projected population of 1185 people in 2026 we determined the ideal daily supply of water to be 118500 L, the comfort daily supply of water to be 78991 L, and the emergency daily supply of water to be 23700 L. No ideal points of elevation were gathered for this community but we suggest that appropriate topographical and census data is collected in the near future.

Genesis

Figure 34: Main Road in Genesis

Based off of the projected population of 790 people in 2026, we determined the ideal daily supply of water to be 79000 L, the comfort daily supply of water to be 52660 L and the emergency daily supply of water to be 15800 L. Genesis currently has a small water tank located at (9.065032, -79.56689), 344 ft. above sea level. We are unsure of the volume of this existing tank but we suggest that an additional tank should be added to hold all of the necessary water needed for this community.

La Paz

Figure 35: View of La Paz and the Cerro Patacon Landfill

Based off the projected population in 2026, we determined the ideal daily supply of water to be 95200 L, the comfort daily supply of water to be 67996 L and the emergency daily supply of water to be 19040 L. La Paz currently has a large tank located at (9.062667, -79.560684). We are unaware of how much water this tank can hold but we assume that it is sufficient for the future demand of La Paz. We do recommend that individual taps be disconnected from the current distribution system and for the water to be instead accessed through community fountains.

Colinas de La Paz

Figure 36: View of Colinas de La Paz

Based off the projected population in 2026, we determined the ideal daily supply of water to be 15200 L, the comfort daily supply of water to be 18968 L and the emergency daily supply of water to be 3040 L. Colinas de La Paz's highest point of elevation is 331 ft. above sea level at (9.061659, -79.558174) making it the ideal location for the water storage tank.

Kuna Nega

Figure 37: View of a Standard Home in Kuna Nega

Based off of the projected population for 2026, we determined the ideal daily supply of water to be 115900 L, the comfort daily supply to be 82623 L and the emergency daily supply of water to be 23180 L. Thanks to the current pipeline system and the four existing storage tanks, there is no need to implement a new system for this community. We do recommend that individual taps be disconnected from the current distribution system and for the water to instead be accessed through community fountains.

Maser Nega

Figure 38: View of Main Road in Maser Nega

Based off of the projected population for 2026 we determined the ideal daily supply of water to be 31600 L, the comfort daily supply to be 22308 L and the emergency daily supply of water to be 6320 L. Maser Nega's two

highest points of elevation are both at 236 ft. above sea level. We determined that the ideal location for the tank would be at (9.056604, -79.55934) due to its central location in the community.

Calle 50

Based off of the current population we determined the ideal daily supply of water to be 49200 L, the comfort daily supply of water to be 35643 L, and the emergency daily supply of water to be 9840 L. Calle 50's highest point of elevation is 259 ft. above sea level with coordinates of (9.055724, -79.561005) with a relatively central location making it the ideal tank location.

Figure 39: Children gathering in Calle 50

San Francisco

Based off of the projected population for 2026 we determined the ideal daily supply of water to be 186600 L, the comfort daily supply to be 131700 L and the emergency daily supply of water to be 37320 L. The size of the storage tanks currently implemented are unknown to us but we believe them to be sufficient in holding the adequate amount of water for San Francisco. We do recommend that individual taps be disconnected from the current distribution system and for the water to instead be accessed through community fountains.

Figure 40: View of San Francisco

5.2 - Future Project Work in Cerro Patacón

In the event that WPI or another university decides to partner with Footprint Possibilities in the future we have recommended to major projects below that could be split into smaller tasks if necessary. We believe that one of the main issues experienced, at the community level, is the misuse and abuse of the current system.

The projects we recommend focus on developing a sense of personal accountability with water usage and educating community members on ways to conserve water.

Encourage a sense of personal accountability

Many people that we have worked with throughout this project have mentioned that one of the major obstacles this community faces is their lack of accountability when it comes to access to water. Most of the residents in these communities do not currently pay for their water supply which causes them to misuse and abuse the system. Cutting personal lines and moving toward a fountain system is a step in the right direction, but does not change attitudes toward accountability. We suggest that a future project focus on finding ways to implement a system that encourages each citizen to hold themselves and their neighbors accountable for their water usage. This should also include implementing a system with IDAAN directly to ensure everyone is paying for the water the receive. We do acknowledge that this is a large undertaking and it will take time to become accepted but we believe it is necessary for improvement of Cerro Patacón.

Educate citizens on water conservation techniques

One major issue we observed during our time in Cerro Patacón was water misuse and abuse. Many residents were in possession of their own personal water storage tanks that were being contaminated by their exposure to the air. If people continue wasting water, then many of the problems regarding the water shortage in Cerro Patacón will persist even with our proposed rationing plan. Every citizen should be informed and educated on proper water usage and storage techniques to optimize their supply. This topic is closely related to creating a system of accountability, as citizens who hold themselves and their neighbors accountable for water use will conserve more water. We recommend that a future team focusing on accountability also work to educate citizens on common ways water is wasted and good water conservation practices.

Chapter 6: Summary

Panamá as a country has the resources to ensure consistent access to water for all citizens. However numerous bureaucratic failures have led to shortages for low income communities such as Cerro Patacón. IDAAN has been operating under a deficit due to undercharging for water and not collecting payment from clients who refused to pay. This deficit has limited IDAAN's ability to address issues regarding the operation and maintenance of its systems, as well as various investment needs. The organization is also unable to update its infrastructure to account for the urbanization that is increasing population and water demand in Panamá City. These shortages have their greatest impact in low income communities such as Cerro Patacón. When IDAAN has a water shortage from a drought, or broken pipe they are forced to redirect water to the city, leaving marginalized communities without access to water for multiple days at a time

A lack of information and communication is another major factor for the water shortage in Cerro Patacón, particularly for the informal communities. IDAAN will provide water, even to communities that are considered informal, so long as they set up a water infrastructure and provide information regarding their water demand. However, in many communities' census information was not available, or was not shared with IDAAN or any relevant stakeholders who could help provide citizens with water. Relevant topographical information, such as optimal tank and pipe locations had also not been performed or shared in many of these communities

Working closely with IDAAN, Footprint Possibilities, our partnering Topographical team and other relevant stakeholders we developed a water rationing plan to give IDAAN the

information needed to provide water for all the Cerro Patacón communities. Our team conducted a census survey to determine the total population and total water demand of Cerro Patacón. We developed three plans for water supply, an emergency plan which provides 20 liters. This is the absolute minimum and only accounts for drinking and cooking needs. The ideal plan provides 80 liters per adult and 60 per child. This account for additional uses, such as showering, washing clothes and gardening. Finally, our comfort plan provides 100 liters, enough that people in Cerro Patacón would have an excess supply of water. Our census information was then combined with the topographical team's data to determine the total water demand of Cerro Patacón under each plan, as well as optimal tank and pipe locations. By providing IDAAN and the relevant stakeholders with all the information needed to deliver water to Cerro Patacón our team is confident that water will be provided to every citizen in Cerro Patacón.

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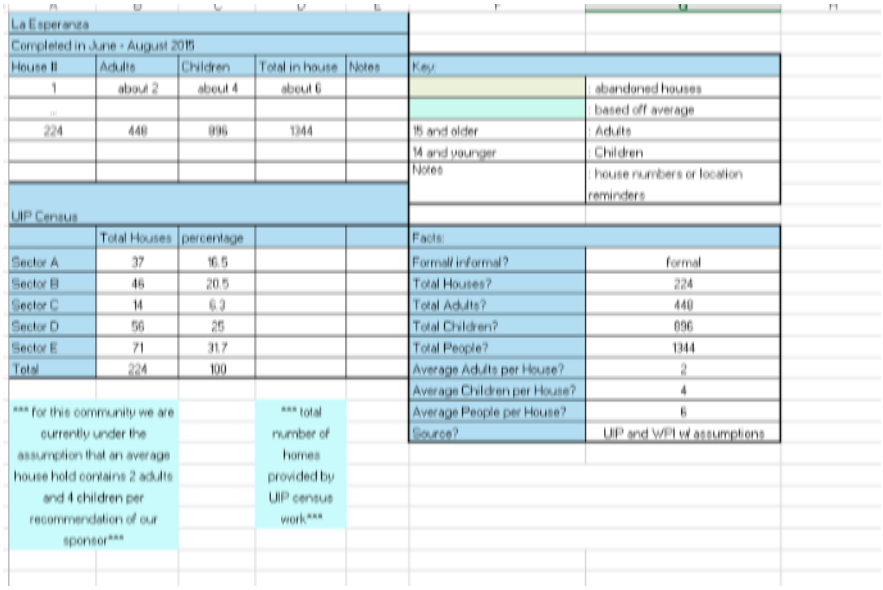
Appendicies

Appendix A - Sponsor Description- Footprint Possibilities

Footprint possibilities is the Panama division of Engineers without Borders that is currently working to provide water and other amenities to the people of Cerro Patacon. The company was founded by Rick Montanari and his wife. Rick is an American expat from St. Petersburg, Florida, who has been heavily involved in quality assurance for the construction of the new canal locks. Valmy Guerrero is his second in command. As a resident of Cerro Patacon he is involved with most of the fieldwork done in the communities, as well as establishing contacts within the community for the organization.

The company was founded in 2008 with the stated mission of organizing and seeking funding for the local community of Cerro Patacon. The organization's stated goal is to enhance general health and provide increased educational and cultural opportunities through their technical knowledge, funding and infrastructure improvement. Their primary focus is water provision, and that is where the majority of their work has been completed. The organization has successfully installed two backup water tanks in the communities of Kuna Nega and La Paz. These tanks help their communities maintain access to water even when IDAAN cuts off the water supply to these communities. The organization relies on volunteers in the communities and has frequent events focused on maintaining or improving the water infrastructure that is currently in place. They also support various construction projects and educational opportunities within the community.

Appendix B – Census Data



La Esperanza

Completed in June - August 2015

House #	Adults	Children	Total in house	Notes
1	about 2	about 4	about 6	
...				
224	448	896	1344	

Key:	
	abandoned houses
	based off average
15 and older	Adults
14 and younger	Children
Notes	house numbers or location reminders

UIP Census

	Total Houses	percentage		
Sector A	37	16.5		
Sector B	46	20.5		
Sector C	14	6.3		
Sector D	56	25		
Sector E	71	31.7		
Total	224	100		

Facts:	
Formal/informal?	formal
Total Houses?	224
Total Adults?	448
Total Children?	896
Total People?	1344
Average Adults per House?	2
Average Children per House?	4
Average People per House?	6
Source?	UIP and WPI w/ assumptions

*** for this community we are currently under the assumption that an average house hold contains 2 adults and 4 children per recommendation of our sponsor***

*** total number of homes provided by UIP census work***

Villa Cardenas

Completed on 9/29/16

House #	Adults	Children	Total in house	Notes
1	2	3	5	
2	1	2	3	
3	4	4	8	
4	4	2	6	
5	5	2	7	
6	3	1	4	
7	4	0	4	
8	4	4	8	
9	1	0	1	
10	2	1	3	
11	2	1	3	
12	2	3	5	
13	3	5	8	
14	3	2	5	
15	2	2	4	
16	1	1	2	
17	2	2	4	
18	2	2	4	
19	2	0	2	
20	2	3	5	
21	0	0	0	
22	2	3	5	
23	4	1	5	
24	2	3	5	
25	4	1	5	
26	2	3	5	
27	2	1	3	
28	2	2	4	
29	2	2	4	
30	2	0	2	
31	2	0	2	
32	2	0	2	
33	2	2	4	
34	2	3	5	
35	2	0	2	
36	1	1	2	
37	2	3	5	
38	2	4	6	
39	1	1	2	
40	2	3	5	
41	2	3	5	
42	2	1	3	
43	2	1	3	
44	4	2	6	
45	2	2	4	
46	0	0	0	
47	4	3	7	
48	2	1	3	
49	4	3	7	
50	2	1	3	
51	4	3	7	
52	3	1	4	
53	2	0	2	
54	0	0	0	
Total:	81	61	142	
Average:	2.38235294	1.79411765	4.176470588	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

Facts:	
Formal/ informal?	formal
Total Houses?	54
Total Adults?	124
Total Children?	94
Total People?	218
Average Adults per H	2.3
Average Children per	1.74
Average People per H	4.04
Source?	WPI

Observations
*Seemed very established
*Acsess to water, and electricity
* homes very nice like La Paz

La Bendicion

Completed with assumptions

House #	Adults	Children	Total in house	Notes
1	about 2	about 4	about 6	
...				
162				
Total	324	648	972	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

community we are currently under the assumption that an average house hold contains 2 adults and 4 children per recommendation of our sponsor***

*** we are assuming that the population dencity of this community is similar to neigboring Villa Cardenas but we are aproximating that it is 3 times the size***

Facts:	
Formal/ informal?	formal
Total Houses?	162
Total Adults?	324
Total Children?	648
Total People?	972
Average Adults per House?	2
Average Children per House?	4
Average People per House?	6
Source?	WPI w/ assumptions

Genesis

Completed with assumptions

House #	Adults	Children	Total in house	Notes
1	about 2	about 4	about 6	
...				
108				
Total	216	432	648	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

*** for this community we are currently under the assumption that an average house hold contains 2 adults and 4 children per recommendation of our sponsor***

Facts:	
Formal/ informal?	Formal
Total Houses?	108
Total Adults?	216
Total Children?	432
Total People	648
Average Adults per House?	2
Average Children per House?	4
Average People per House?	6
Source?	WPI w/ assumptions

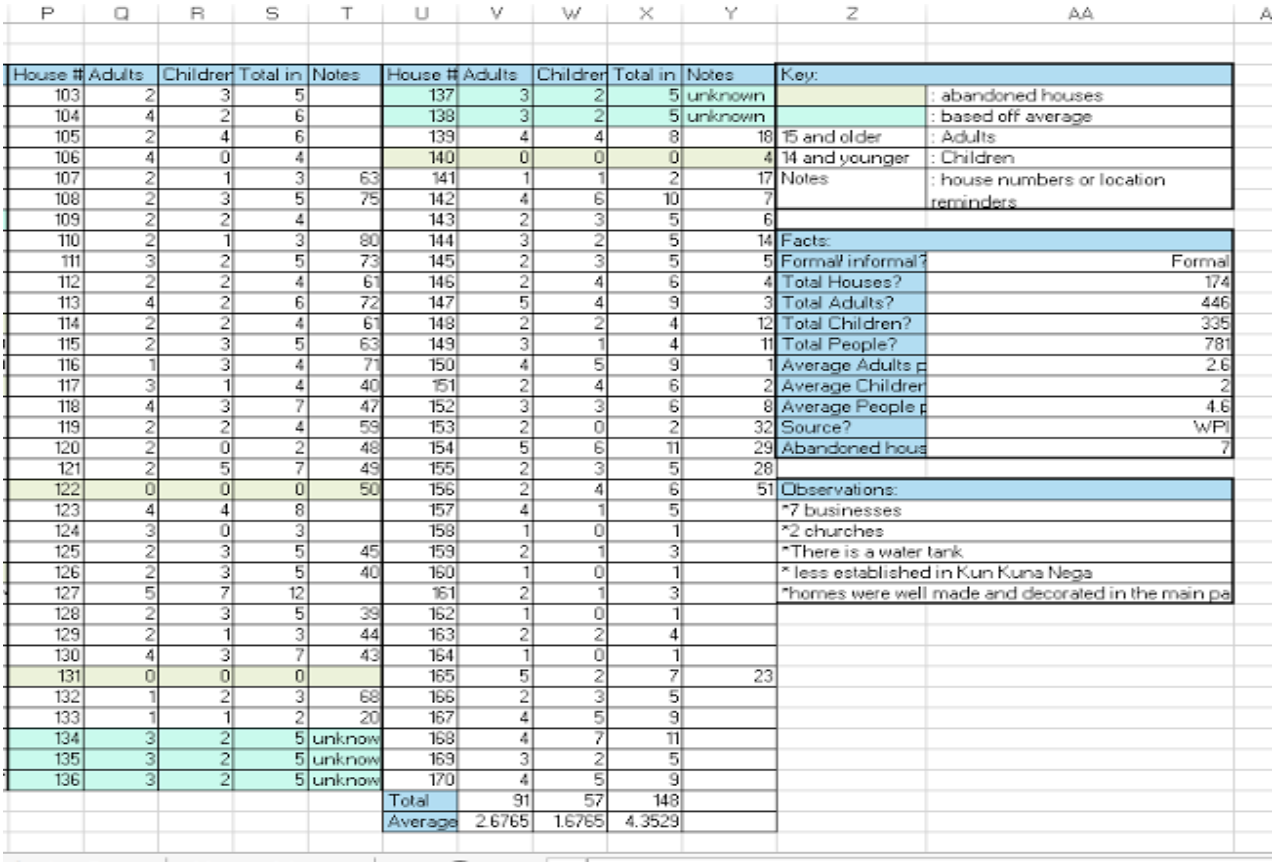
*** we determined 108 homes by counting them on the google map provided to us by Footprint Possibilities***

Observations:
*empty because there is no water

La Paz (including Kun Kuna Nega)

Completed on 9/14/16 - 9/22/16 - 10/4/16

House #	Adults	Children	Total in hou	Notes	House #	Adults	Childr	Total in	Notes	House #	Adults	Children	Total in	Notes
1	2	0	2		35	3	3	6		69	2	1	3	
2	2	0	2		36	3	0	3		70	3	3	6	
3	5	1	6		37	4	3	7		71	6	0	6	
4	3	1	4		38	4	2	6		72	3	3	6	
5	4	3	7		39	4	0	4		73	5	3	8	
6	3	0	3		40	2	0	2		74	2	1	3	
7	3	4	7		41	2	3	5		75	3	2	5	
8	3	4	7		42	2	0	2		76	4	2	6	
9	4	1	5		43	6	12	18		77	8	2	10	
10	2	2	4		44	2	1	3		78	3	2	5	
11	3	1	4		45	1	0	1		79	5	2	7	
12	4	0	4		46	2	0	2		80	0	0	0	
13	3	1	4		47	2	2	4		81	3	3	6	69
14	3	0	3		48	2	3	5		82	4	1	5	70
15	1	1	2		49	2	4	6		83	0	0	0	
16	5	2	7		50	3	2	5		84	2	0	2	
17	2	2	4		51	6	0	6		85	2	0	2	
18	1	0	1		52	3	1	4		86	2	3	5	
19	2	6	8		53	3	0	3		87	3	3	6	
20	3	0	3		54	3	3	6		88	2	1	3	
21	0	0	0		55	2	4	6		89	2	1	3	
22	4	4	8		56	2	0	2		90	2	0	2	
23	2	5	7		57	2	4	6		91	2	2	4	
24	2	1	3		58	3	6	9		92	0	0	0	
25	3	3	6		59	3	4	7		93	2	0	2	<- start of Kun Kuna N
26	3	1	4		60	2	3	5		94	2	1	3	
27	3	1	4		61	2	2	4		95	2	2	4	
28	3	4	7		62	2	0	2		96	2	2	4	
29	3	0	3		63	5	0	5		97	1	0	1	
30	1	2	3		64	1	1	2		98	1	1	2	
31	1	0	1		65	2	0	2		99	2	3	5	
32	4	4	8		66	4	0	4		100	2	2	4	
33	2	2	4		67	4	1	5		101	2	1	3	
34	2	1	3		68	4	4	8		102	2	1	3	77



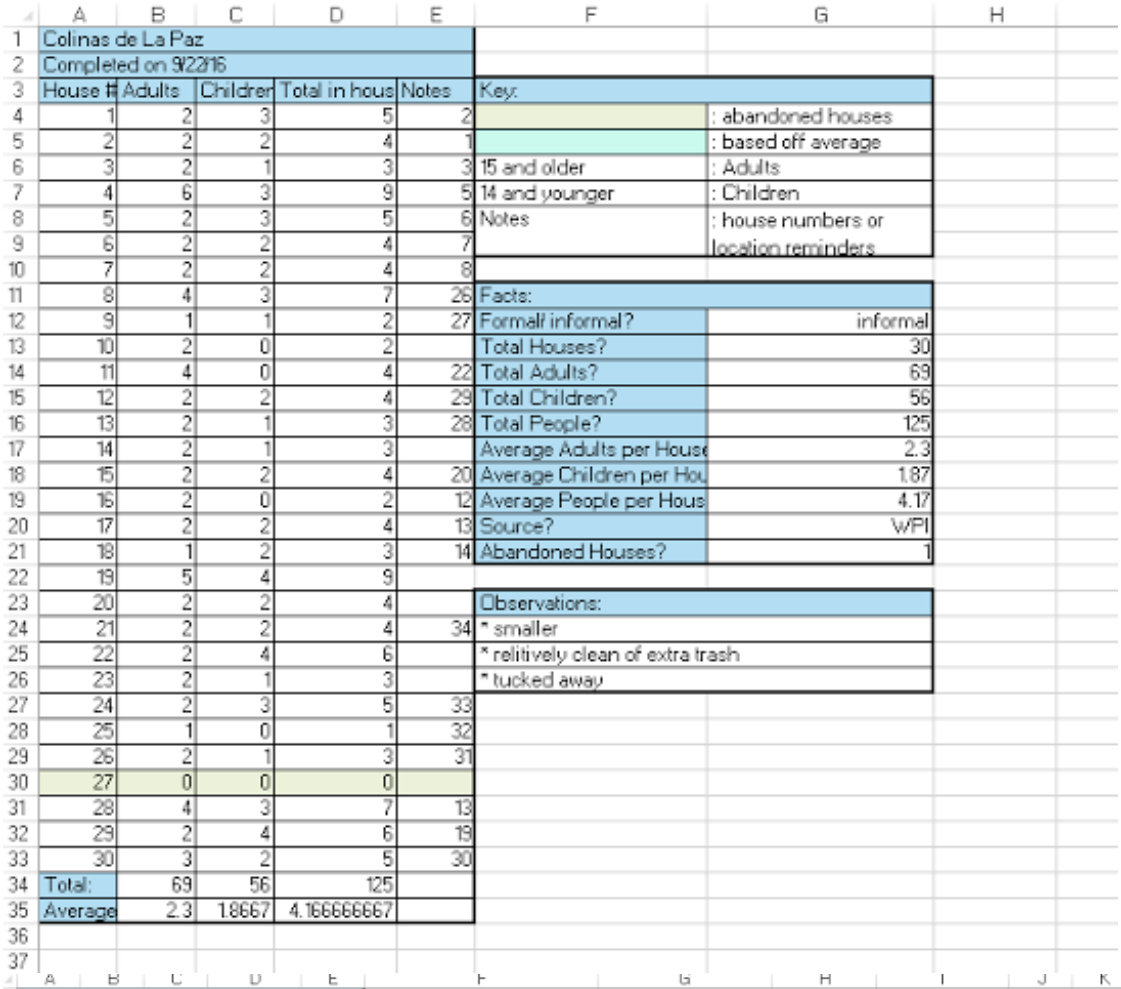
House #	Adults	Children	Total in	Notes
103	2	3	5	
104	4	2	6	
105	2	4	6	
106	4	0	4	
107	2	1	3	63
108	2	3	5	75
109	2	2	4	
110	2	1	3	80
111	3	2	5	73
112	2	2	4	61
113	4	2	6	72
114	2	2	4	61
115	2	3	5	63
116	1	3	4	71
117	3	1	4	40
118	4	3	7	47
119	2	2	4	59
120	2	0	2	48
121	2	5	7	49
122	0	0	0	50
123	4	4	8	
124	3	0	3	
125	2	3	5	45
126	2	3	5	40
127	5	7	12	
128	2	3	5	39
129	2	1	3	44
130	4	3	7	43
131	0	0	0	
132	1	2	3	68
133	1	1	2	20
134	3	2	5	unknow
135	3	2	5	unknow
136	3	2	5	unknow

House #	Adults	Children	Total in	Notes
137	3	2	5	unknown
138	3	2	5	unknown
139	4	4	8	18
140	0	0	0	4
141	1	1	2	17
142	4	6	10	7
143	2	3	5	6
144	3	2	5	14
145	2	3	5	5
146	2	4	6	4
147	5	4	9	3
148	2	2	4	12
149	3	1	4	11
150	4	5	9	1
151	2	4	6	2
152	3	3	6	8
153	2	0	2	32
154	5	6	11	29
155	2	3	5	28
156	2	4	6	51
157	4	1	5	
158	1	0	1	
159	2	1	3	
160	1	0	1	
161	2	1	3	
162	1	0	1	
163	2	2	4	
164	1	0	1	
165	5	2	7	23
166	2	3	5	
167	4	5	9	
168	4	7	11	
169	3	2	5	
170	4	5	9	
Total	91	57	148	
Average	2.6765	1.6765	4.3529	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

Facts:	
Formal/ informal?	Formal
Total Houses?	174
Total Adults?	446
Total Children?	335
Total People?	781
Average Adults p	2.6
Average Children	2
Average People p	4.6
Source?	WPI
Abandoned hous	7

Observations:
*7 businesses
*2 churches
*There is a water tank
* less established in Kun Kuna Nega
*homes were well made and decorated in the main pa



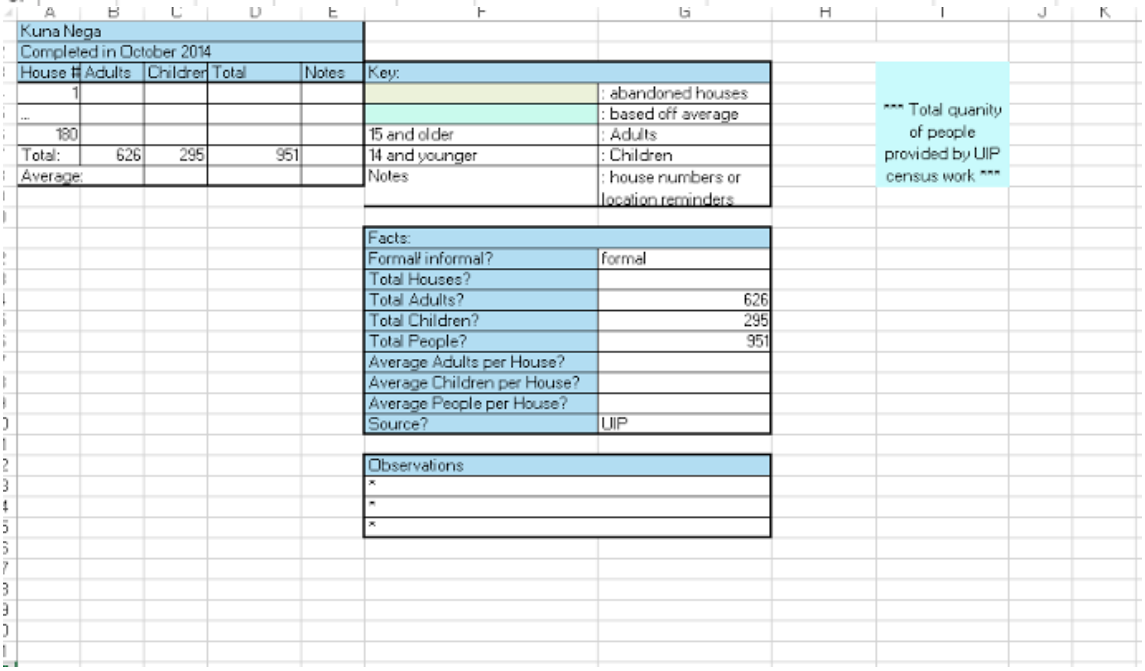
Colinas de La Paz
Completed on 9/22/16

House #	Adults	Children	Total in hous	Notes
1	2	3	5	2
2	2	2	4	1
3	2	1	3	3
4	6	3	9	5
5	2	3	5	6
6	2	2	4	7
7	2	2	4	8
8	4	3	7	26
9	1	1	2	27
10	2	0	2	
11	4	0	4	22
12	2	2	4	29
13	2	1	3	28
14	2	1	3	
15	2	2	4	20
16	2	0	2	12
17	2	2	4	13
18	1	2	3	14
19	5	4	9	
20	2	2	4	
21	2	2	4	34
22	2	4	6	
23	2	1	3	
24	2	3	5	33
25	1	0	1	32
26	2	1	3	31
27	0	0	0	
28	4	3	7	13
29	2	4	6	19
30	3	2	5	30
Total:	69	56	125	
Average	2.3	1.8667	4.166666667	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

Facts:	
Formal/ informal?	informal
Total Houses?	30
Total Adults?	69
Total Children?	56
Total People?	125
Average Adults per House	2.3
Average Children per Hou	1.87
Average People per Hous	4.17
Source?	WPI
Abandoned Houses?	1

Observations:
* smaller
* relitively clean of extra trash
* tucked away



Kuna Nega
Completed in October 2014

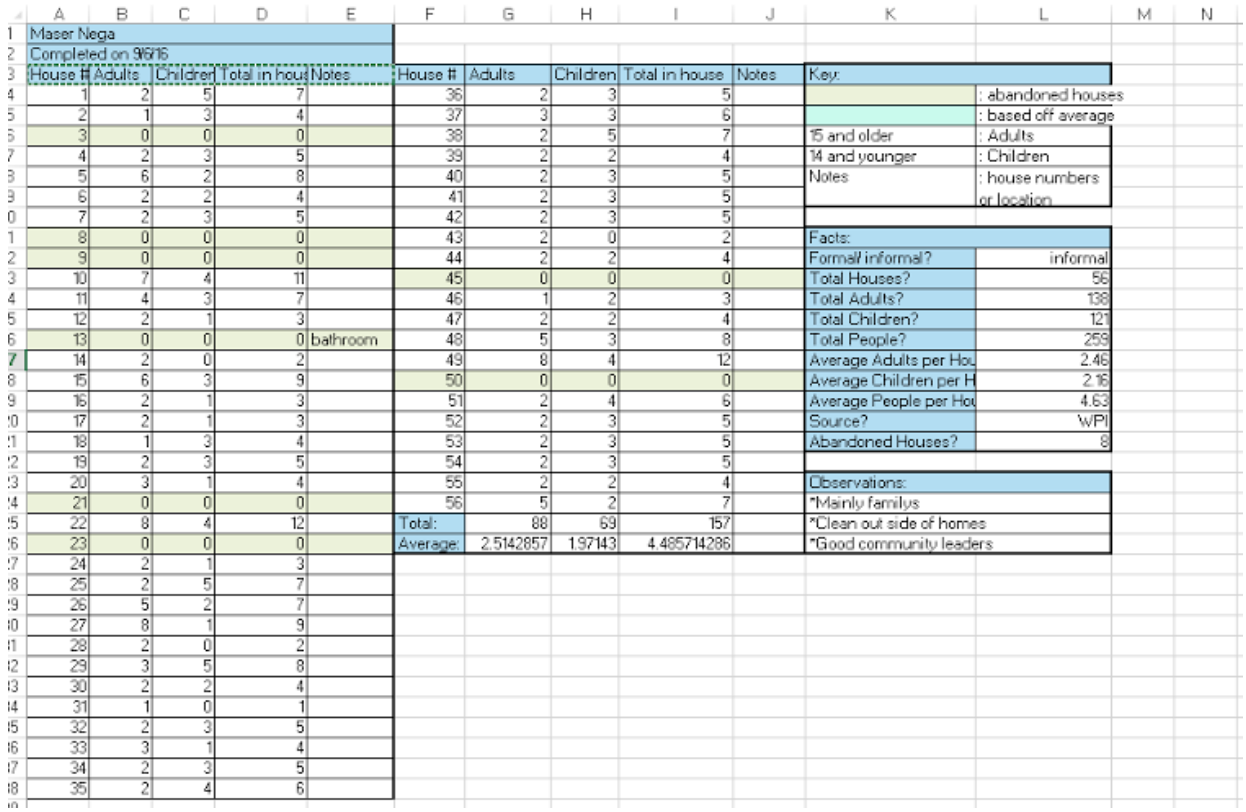
House #	Adults	Children	Total	Notes
1				
...				
180				
Total:	626	295	951	
Average:				

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

*** Total quanity of people provided by UIP census work ***

Facts:	
Formal/ informal?	formal
Total Houses?	
Total Adults?	626
Total Children?	295
Total People?	951
Average Adults per House?	
Average Children per House?	
Average People per House?	
Source?	UIP

Observations
*
*
*



Maser Nega
Completed on 9/6/16

House #	Adults	Children	Total in house	Notes
1	2	5	7	
2	1	3	4	
3	0	0	0	
4	2	3	5	
5	6	2	8	
6	2	2	4	
7	2	3	5	
8	0	0	0	
9	0	0	0	
10	7	4	11	
11	4	3	7	
12	2	1	3	
13	0	0	0	bathroom
14	2	0	2	
15	6	3	9	
16	2	1	3	
17	2	1	3	
18	1	3	4	
19	2	3	5	
20	3	1	4	
21	0	0	0	
22	8	4	12	
23	0	0	0	
24	2	1	3	
25	2	5	7	
26	5	2	7	
27	8	1	9	
28	2	0	2	
29	3	5	8	
30	2	2	4	
31	1	0	1	
32	2	3	5	
33	3	1	4	
34	2	3	5	
35	2	4	6	
36	2	3	5	
37	3	3	6	
38	2	5	7	
39	2	2	4	
40	2	3	5	
41	2	3	5	
42	2	3	5	
43	2	0	2	
44	2	2	4	
45	0	0	0	
46	1	2	3	
47	2	2	4	
48	5	3	8	
49	8	4	12	
50	0	0	0	
51	2	4	6	
52	2	3	5	
53	2	3	5	
54	2	3	5	
55	2	2	4	
56	5	2	7	
Total:	88	69	157	
Average:	2.5142857	1.97143	4.485714286	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location

Facts:	
Formal/ informal?	informal
Total Houses?	56
Total Adults?	138
Total Children?	121
Total People?	259
Average Adults per Hou	2.46
Average Children per H	2.16
Average People per Hou	4.63
Source?	WPI
Abandoned Houses?	8

Observations:
*Mainly familys
*Clean out side of homes
*Good community leaders

Calle 50

Completed on 9/8/16

House #	Adults	Children	Total in house	Notes
1	2	1	3	
2	2	0	2	
3	2	1	3	
4	2	0	2	
5	0	0	0	
6	1	0	1	
7	2	0	2	
8	4	1	5	
9	2	1	3	
10	0	0	0	
11	0	0	0	
12	1	0	1	
13	0	0	0	workshop
14	2	1	3	
15	3	4	7	
16	0	0	0	
17	2	1	3	
18	3	0	3	
19	1	4	5	
20	1	1	2	
21	2	2	4	
22	0	0	0	
23	2	0	2	
24	2	4	6	
25	4	1	5	
26	1	0	1	
27	2	0	2	
28	1	0	1	
29	1	0	1	
30	2	0	2	
31	1	0	1	49
32	1	0	1	50
33	2	0	2	51
34	1	0	1	
35	1	0	1	
36	1	0	1	new
37	1	0	1	
38	0	0	0	
39	2	0	2	19
40	6	0	6	18
41	1	0	1	
42	2	0	2	57
43	2	4	6	59
44	2	2	4	58
45	2	0	2	62
46	2	1	3	69
47	2	2	4	63
48	4	1	5	64
49	0	0	0	66
50	2	1	3	68
51	2	1	3	67
52	2	2	4	70
53	3	1	4	71
54	2	4	6	72
55	2	1	3	60
56	1	0	1	55
57	2	1	3	61
58	1	0	1	78
59	2	3	5	
60	2	0	2	75
61	4	0	4	76
62	2	2	4	
63	2	3	5	64
64	3	0	3	74
65	2	2	4	83
66	2	3	5	84
67	5	2	7	85
68	0	0	0	86
69	2	0	2	87
70	2	1	3	88
71	0	0	0	
72	2	4	6	92
73	2	2	4	93
74	2	0	2	95
75	2	3	5	94
76	3	2	5	89
77	3	0	3	130
78	1	3	4	131
79	8	1	9	128
80	2	0	2	127
81	2	1	3	126
82	2	0	2	96
83	2	0	2	97
84	2	3	5	99
85	6	4	10	100
86	2	4	6	125
87	2	1	3	126
88	2	2	4	120
89	4	3	7	122
90	2	2	4	123
91	3	2	5	121
92	4	2	6	118
93	2	0	2	119
94	2	0	2	117
95	2	1	3	116
96	1	2	3	115
97	3	2	5	101
98	3	1	4	103
99	2	2	4	106
100	4	0	4	105
101	2	0	2	107
102	0	0	0	
103	0	0	0	
104	1	4	5	109
105	1	3	4	
106	2	1	3	111
107	2	2	4	110
108	2	3	5	112
109	2	4	6	131
110	2	2	4	
111	2	3	5	
112	3	0	3	133
113	1	2	3	134
114	1	2	3	
115	2	0	2	135
116	3	3	6	136
117	2	3	5	140
118	4	4	8	138
119	3	1	4	143
120	4	1	5	142
121	3	4	7	141
122	2	2	4	137
123	2	2	4	
124	2	2	4	145
Totals:	52	22	74	
Average	1.5294	0.6471	2.176470588	

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

Facts:	
Formal/ informal?	informal
Total Houses?	124
Total Adults?	250
Total Children?	154
Total People?	404
Average Adults per House?	2.02
Average Children per House?	1.24
Average People per House	3.26
Source?	WPI
Abandoned houses	11

Observations:
*Many people stored water in large tanks
*Lots of trash surrounding homes
*Many people were away at work
*Community leaders were confused and out of touch

San Fransico

Completed on 10/2014

Sector 1 + 2			
House #	number of people in a hou	total membe	Notes
Sector 1 + 2			
1..12	1	12	
13..37	2	50	
38..75	3	114	
76..128	4	212	
129..173	5	225	
174..211	6	228	
212..228	7	119	
229..237	8	72	
238..246	9	81	
247	12	12	
Total:	565	558	1123
Average:	2.3	2.3	4.5

Sector 3			
House #	Adults	Children	Total
248	3	2	5
249	3	6	9
250	4	0	4
251	1	7	8
252	3	0	3
253	2	6	8
254	2	0	2
255	2	4	6
256	3	0	3
257	3	0	3
258	7	3	10
259	2	0	2
260	2	0	2
261	3	2	5
262	6	0	6
263	2	2	4
264	1	2	3
265	2	8	10

House #	Adults	Children	Total				
266	1	0	1		298	2	1	3
267	2	2	4		299	2	4	6
268	4	7	11		300	3	3	6
269	6	2	8		301	3	5	8
270	4	0	4		302	2	2	4
271	3	1	4		303	2	1	3
272	2	5	7		304	2	3	5
273	2	0	2		305	4	0	4
274	3	0	3	doesn't	306	2	1	3
275	3	0	3	say if	307	3	3	6
276	4	0	4	there was	308	1	3	4
277	9	0	9	kids	309	2	2	4
278	5	3	8		310	1	2	3
279	6	1	7		311	1	2	3
280	4	0	4		312	1	2	3
281	3	3	6		313	1	2	3
282	5	0	5		314	2	2	4
283	3	0	3		315	4	2	6
284	3	1	4		316	3	3	6
285	4	0	4		317	2	2	4
286	4	0	4		318	4	0	4
287	2	2	4		319	2	3	5
288	4	0	4		320	3	2	5
289	2	1	3		321	2	2	4
290	2	3	5		322	2	3	5
291	3	3	6		323	2	3	5
292	2	2	4		324	2	1	3
293	2	1	3		325	2	1	3
294	3	2	5		326	4	1	5
295	3	6	9		327	3	3	6
296	3	7	10		328	2	0	2
297	2	0	2		329	2	3	5

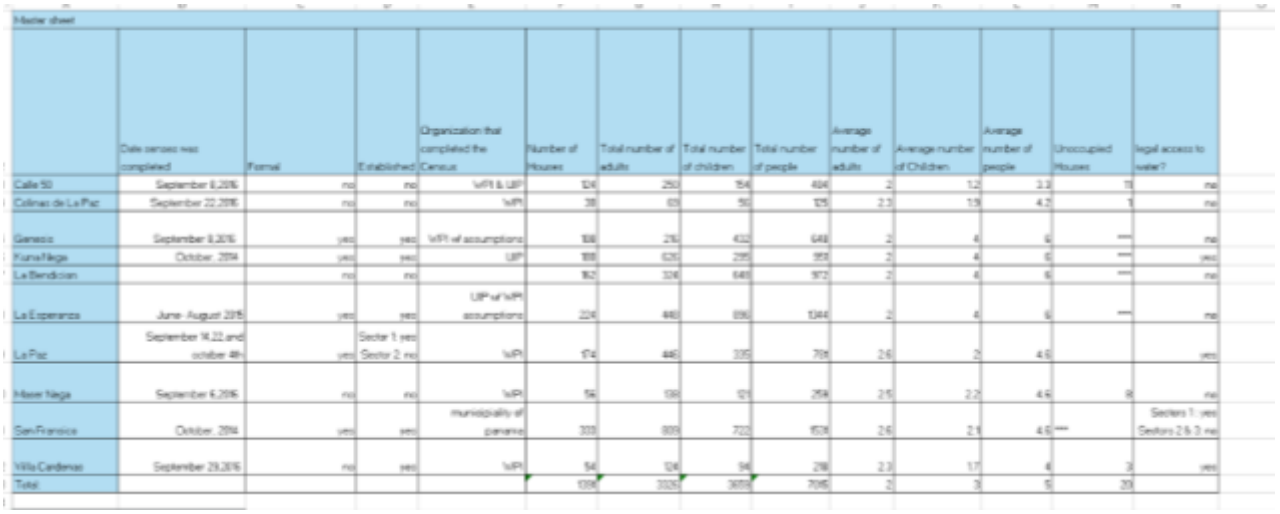
House #	Adults	Children	Total
330	4	0	4
331	3	0	3
332	2	1	3
333	3	2	5
Total:	51	42	93
Average	2.8333	2.3333	5.1667

Key:	
	: abandoned houses
	: based off average
15 and older	: Adults
14 and younger	: Children
Notes	: house numbers or location reminders

*** this census tell us that 558 of the 1123 residents are children***

Facts:	Sector 1 + 2	Sector 3	Total
Formal/ informal?	formal	informal	
Total Houses?	247	59	333
Total Adults?	565	244	809
Total Children?	558	164	722
Total People?	1123	408	1531
Average Adults per House?	2.3	2.8	2.55
Average Children per House?	2.3	1.9	2.1
Average People per House?	4.5	4.7	4.6
Source?	municipiality of panama		

Observations
*
*
*



Master sheet

	Date census was completed	Formal	Established	Organization that completed the Census	Number of Houses	Total number of adults	Total number of children	Total number of people	Average number of adults	Average number of Children	Average number of people	Unoccupied Houses	legal access to water?
Calle 50	September 8,2016	no	no	WPI & UIP	124	250	154	404	2	1.2	3.3	11	no
Colinas de La Paz	September 22,2016	no	no	WPI	38	63	50	125	2.3	1.9	4.2	1	no
Genesis	September 8,2016	yes	yes	WPI +/- assumptions	198	276	432	648	2	4	6	---	no
Kuna Nega	October, 2014	yes	yes	UIP	188	626	295	951	2	4	6	---	yes
La Bendicion		no	no		162	324	648	972	2	4	6	---	no
La Esperanza	June- August 2015	yes	yes	UIP +/ WPI assumptions	224	448	896	1344	2	4	6	---	no
La Paz	September 14,22,and october 4th	yes	Sector 1 yes Sector 2 no	WPI	174	446	335	781	2.6	2	4.6		yes
Maser Nega	September 6,2016	no	no	WPI	56	136	121	259	2.5	2.2	4.4	8	no
San Fransico	October, 2014	yes	yes	municipality of panama	333	809	722	1531	2.6	2.1	4.6	---	Sectors 1 yes Sectors 2 & 3 no
Villa Cardenas	September 29,2016	no	yes	WPI	94	124	94	218	2.3	1.7	4	3	yes
Total					1394	3326	3653	7015	2	3	5	28	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		Population								water demand after 10 years						
2		Current	Year 1	Year 2	Year 3	Year 5	Year 10			20 L	80 & 60 L	100 L				
3	Calle 50	404	412	420	429	446	492		Calle 50	9840	35643	49200				
4	Colinas de La Paz	125	128	130	133	138	152		Colinas de	3040	10825	15200				
5	Genesis	648	661	674	688	715	790		Genesis	15800	52660	79000				
6	Kuna Nega	951	970	989	1009	1050	1159		Kuna Nega	23180	82623	115900				
7	La Bendicion	972	991	1011	1031	1073	1185		La Bendici	23700	78991	118500				
8	La Esperanza	1344	1371	1398	1426	1484	1638		La Esperar	32760	109222	163800				
9	La Paz	781	797	813	829	862	952		La Paz	19040	67996	95200				
10	Maser Nega	259	264	269	275	286	316		Maser Neg	6320	22308	31600				
11	San Fransico	1531	1562	1593	1625	1690	1866		San Fransi	37320	131700	186600				
12	Villa Cardenas	218	222	227	231	241	266		Villa Carde	5320	18968	26600				
13	Total	7015	7378	7525	7676	7986	8817									
14																
15	Equation used	Popfuture= Poppresent*x(1+i)^n														
16																
17	Popfuture	future population														
18	Poppresent	present population														
19	i	growth rate = 2%														
20	n	number of years														
21																
22																

Appendix C – Topographical Data

	Size (Ha.)	Highest Point
Calle 50	4.65	Coords: 9.055724, -79.561005 Elevation: 259 ft
Colinas de La Paz	2.44	Coords: 9.061659, -79.558174 Elevation: 331 ft
Genesis	5.57	Coords: 9.065042, -79.56689 Elevation: 344 ft
Kuna Nega	16.6	(9.05798, -79.55679), (9.05831, -79.55644), and (9.06042, -79.56006)
Bendicion de Dios	6.21	***
La Esperanza	20.8	Coords: 9.064525, -79.5569 Elevation: 420 ft
La Paz	7.23	9.062667, -79.560684
Maser Nega	1.61	Coords: 9.056604, -79.55934 Elevation: 236 ft
San Francisco	49.2	(9.05877, -79.55421) and (9.05700,-79.55471)
Villa Cardenas	3.27	Coords: 9.061016, -79.55441 Elevation: 361 ft