



**WPI**



# Water Quality and Quantity

An Interactive Qualifying Project

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## **Abstract**

Cerrito, a small rural poor community in the Chaco region of Paraguay needs sufficient potable water. The team worked with Fundacion Paraguaya, the Junta de Saneamiento, and the Rosarinos Qom community to study the water systems in Cerrito. Relationship development, data collection, and Google Maps, MATLab Mobile and Microsoft Word contributed to deliverable development. The deliverables were digital maps of the water pipelines systems of the Junta de Saneamiento and Rosarinos Qom community. The team created an administrative plan for the Junta de Saneamiento, and maintenance plan for the Rosarinos Qom. It noted the absence of water meters. Recommendations include map continuation for both the Junta de Saneamiento and Qom communities, and review the Junta's water meter progress.

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## **Executive Summary**

Cerrito, a town in the Paraguayan Chaco region has an extensive water system. The team focused on two water systems: the Junta de Saneamiento and Rosarinos Qom. The Junta de Saneamiento is a nonprofit board of elected volunteers. The Rosarinos Qom's water system is a private, independent water system. Both of these systems are fully functional, but still have room for improvement.

Improvements for the Junta de Saneamiento include 2018 Water Team schematic augmentation, and administrative recommendations. Administrative recommendations include the use of work orders. Likewise, improvements for the Rosarinos Qom include a map, and cleaning maintenance recommendations. The map shows the current pipeline and alternative route to avoid eucalyptus trees. The cleaning maintenance recommendations include how to prevent water contamination.

The recommendations made are based on the team's observations. Interviews with water officials on site also led the team to recommendations. Onsite fieldwork with the technicians gave a deeper understanding of the water system. The insight from the technicians allowed the team to better understand the project goals.

This is the second year of this project. Last years 2018 Water team set the foundation for the steps our team took. There are still further steps for future teams to continue to build off our findings.

## Resumen Ejecutivo

Cerrito, un pueblo en la región del Chaco paraguayo tiene un sistema extenso de cañerías para brindar agua potable a la población. Nuestro equipo enfocó en fortalecer dos sistemas de agua potable: el sistema de la Junta de Saneamiento de Cerrito y el sistema de la comunidad Rosarinos Qom. La Junta de Saneamiento de Cerrito es una junta de voluntarios elegidos por la comunidad, y es una organización sin fines de lucro. El sistema de Rosarinos Qom es un sistema de agua potable privado e independiente. Ambos sistemas son completamente funcionales, pero aún tienen oportunidades para mejorar.

Las mejoras que pudimos contribuir para la Junta de Saneamiento incluyeron la actualización e inclusión de mas datos a su mapa de cañerías realizado inicialmente por el equipo de agua conformado por estudiantes de WPI en el año 2018, además de recomendaciones para agilizar la parte administrativa de la Junta. Las recomendaciones administrativas incluyeron la incorporación del uso de órdenes de trabajo para solicitar y registrar reparaciones en el sistema de cañerías. Las mejoras que pudimos contribuir a la comunidad Rosarinos Qom incluyeron un mapa de las cañerías de su sistema de agua potable y recomendaciones para mantener limpia el sistema. El mapa que confeccionamos muestra ambas la cañería actual y un trayecto alternativo para las cañerías para poder desviar el sistema de caños de una futura plantación de árboles de eucaliptos. Las recomendaciones de mantenimiento de limpieza del sistema incluyeron sugerencias de cómo prevenir la contaminación del agua.

Las recomendaciones realizadas se basaron en las observaciones hechas por el equipo, al igual que las entrevistas llevados a cabo con los funcionarios de la Junta de Saneamiento de

Cerrito. El trabajo de campo en situ con los técnicos brindó una comprensión más profunda del sistema de agua para cumplir con los objetivos del proyecto.

Este es el segundo año seguido que estudiantes de WPI colaboran con la comunidad de Cerrito en temas de agua potable. El equipo de estudiantes que trabajó en el 2018 sentó las bases para los pasos que tomó nuestro equipo. Todavía hay pasos adicionales que futuros equipos de estudiantes de WPI puedan tomar para continuar contribuyendo a fortalecer el sistema de agua potable de Cerrito, Chaco.

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# 1 Introduction

Water makes up seventy percent of Earth, yet only 2.5 percent consists of freshwater. Just 1 percent of freshwater can be easily accessible (National Geographic, 2000). As populations grow, access to freshwater becomes a concern. Many developing countries do not have the resources to sustain water usage. Paraguay is one of those countries.

Access to drinkable water in Paraguay is a challenge. Forty percent of Paraguay's population lives in rural regions. In 2015, 870,000 people were reported to be in water crisis (Rodriguez, 2017). Water crisis are caused by inequitable water quality and distribution. Communities in Paraguay have worked to improve the difficulties they encounter.

The team worked with a community in the Chaco Region of Paraguay called Cerrito in Benjamín Aceval. The current team continued development of D-2018 deliverables. The team created pipeline maps, and maintenance plans.

## 2 Background

### 2.1 Importance of water quality and quantity

Access to water is a basic human need. We use water daily to drink, cook, and clean. Adequate consumption of fresh water can have many benefits, such as physical, and mental performance. On the contrary, not consuming the adequate amount leads to counter effects ("Safe Drinking water is Essential", 2007). Therefore, it is important to know the quality and quantity of water available.

The quality of water has major impacts on communities. The Koshland science museum stated, “polluted water isn’t just dirty- it’s deadly.” Poor sanitation can lead to many diseases. These diseases include cholera, typhoid fever, or even cancer from heavy metals can develop. Waterborne diseases cause 1.8 million deaths each year (“Safe Drinking water is Essential”, 2007).

These illnesses do not just affect health but also lead to educational and economic impediments. Illnesses limit economic opportunities such as work. Most communities without clean water tend to be poor. Studies show that poor sanitation can reduce a country’s annual GDP by two to three percent. Work and school absences can have long term effects on family education and economics (“Safe Drinking water is Essential”, 2007).

## **2.2 Latin American Problem**

Latin America is home to one of the Earth’s greatest supplies of fresh drinkable water. These sources include rain water, rivers, desalinated ocean water, and aquifers. Despite large number water sources, a lot of it is not accessible nor safe. Pollution and social inequality contribute to freshwater resources deficiency. Many countries in this region use freshwater sites as if they were dumpsites. Garbage, mining effluent, and industrial and agricultural waste add to the contamination. Abundant supplies of water will have no benefits if contaminated. In this region 30 million people do not have safe potable water in their homes. Only 1 in 6 people have adequate sanitation services (Barlow & Clarke, 2007).

Paraguay has two main sources of water, rivers, and aquifers. Aquifers are the main source in the Chaco region. Aquifers get polluted due to contaminants. Therefore, aquifers

require maintenance to provide drinkable water. So, maintenance of aquifers is important to sustain hygienic standards. (Community Clean Water Access, 2018).

### **2.3 Paraguay's Solution**

Paraguay helped overcome these issues through the sanitation water agency SENASA: *Servicio Nacional de Saneamiento Ambiental*. Paraguay targeted sustainable solutions instead of the simple non effective quick fixes. Long term solutions became beneficial to communities to maintain access to clean water. This new method focuses on the creation of boards. These boards have been trained to operate, maintain, and run the system. The water boards act in concert with rural regions. People on the water board administer and improve water initiatives. (Crespo, 2000).

Paraguay has made improvements on clean water accessibility. Today 94% of the Paraguayan rural population has access to clean water. This is an improvement compared to 51.6% in 2000 (Slawson, 2017).

### **2.4 Water Distribution Cerrito, Paraguay**

Our project was based in a small rural town in Paraguay, Cerrito, in the Chaco region. The collection of the water in Cerrito utilizes aquifers and wells connected to pipes for distribution. The amount of water consumption varies throughout the community. Some people have extensive plumbing such as showers, whereas others use a communal spigot (Community Clean Water Access, 2018).

The two main water distribution methods we focused on are run by boards, and indigenous communities.

#### **2.4.1 Junta de Saneamiento**

Junta de Saneamiento is the largest independent water distribution service in Cerrito with 770 connections (Houben, 2014). Although it is a large distribution source, the Junta de Saneamiento board focuses on sustainability. They accomplish a sustainable solution by training volunteers to maintain the water system.

#### **2.4.2 Indigenous community**

The indigenous community water distribution serves fewer people. The indigenous people in the Cerrito community are the Qom. The Qom community has three tanks compared to six Junta de Saneamiento board tanks.

### **2.5 Project Scope**

Our project has four deliverables. The deliverables are a digitized water map for the Junta, a work order template for the Junta, a Rosarinos Qom pipeline map, and Rosarinos maintenance plan document.

#### **2.5.1 Digitized Water Map**

The first deliverable was a digital version of the water map. This deliverable is an extension of the map completed by the 2018 Water Team. The digital water map shows the pipeline and well locations on a Cerrito overlay. The benefit to a digital map is that it allows for updates to be made. The older map does not allow for this feature. Therefore, a digital version of

the map is an improvement for the Junta. Examples of the maps made last year can be seen in

Figures 1 and 2. This 2019 team's map can be found in Appendix B.

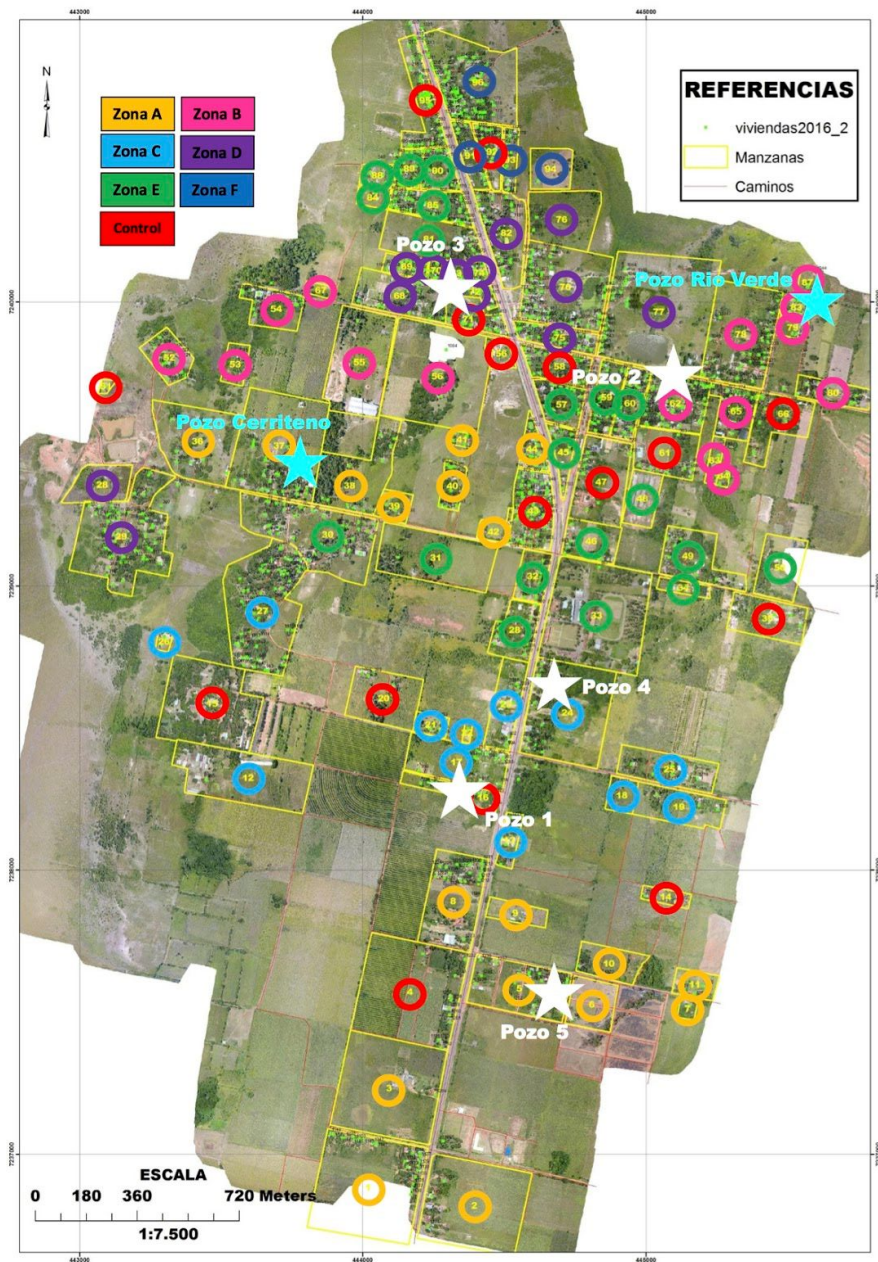


Figure 1: Well Locations in Cerrito (Community Clean Water Access, 2018)



*Figure 2: Community Clean Water Access Pipeline Map of the Junta de Saneamiento (Community Clean Water Access, 2018)*

### 2.5.2 Junta Work Orders

The second deliverable is a work order template for the Junta. The work order includes the location of the job, name, address and telephone number of client, and the date. A work order

allows the Junta to maintain records. Therefore, work orders allow the Junta to gain a better understanding of where their water system needs improvement.

### **2.5.3 Rosarinos Qom Pipeline Map**

The third deliverable is a map for the Rosarinos Qom water system. This map will help the Rosarinos know where their pipes are, show maintenance problem areas, and plan future pipeline systems. Any future system must take into account plans for a eucalyptus plantation. Tree roots destroy pipes.

### **2.5.4 Rosarinos Qom Maintenance Plan**

The fourth deliverable is a water maintenance plan for the Rosarinos Qom. A water maintenance plan identifies preventative measures to ensure potable water. A maintenance plan outlines steps to protect the Rosarinos Qom's water system.

## **3 Methodology**

The methods will be discussed. These include relationship development, data collection, and deliverables.

### **3.1 Relationship Development**

The team established relationships with the community. The community consists of the water board, families, businesses and schools. Interpersonal relations builds trust.

### **3.1.1 Interpersonal Relations**

Good relationships ensure enjoyable and productive work. With good relationships comes humor, friendship and confidence. We need these because we are working cross culturally. We do not want to dominate, demean or annoy members of the community. Rather, we want the community to cooperate with us and enjoy our presence among them. Conversations, terere, and soccer served this goal. Interpersonal relations create a deeper awareness of what people in the area desire (Carmeli, 2009).

### **3.1.2 Spanish and Guarani**

Shared language is the foundation for good conservation building. Spanish and Guarani are the spoken languages in Paraguay. Spanish is the most common language and used in law, business, and day-to-day conversation. Guarani is another Paraguayan language. It has roots in the indigenous people and is used among the working class and in informal conversations. The team communicated in Spanish and learned a little Guarani.

## **3.2 Data Gathering**

This section will explain Wilber Diagrams, MATLAB Mobile and interviews.

### ***3.2.1 Wilber Diagram***

A Wilber diagram provides a framework to better understand why people do what they do. The Wilber diagram includes four reasons for this. (Brown, 2013). The four reasons are intentional, behavioral, cultural, and social systems. These reason were used by the team to



understand why Paraguayans look at water and use it the way they do. Examples of this analysis can be seen in Figure 3.

<u>Interior-Individual</u> Intentional Example: I am happy with my water.	<u>Exterior-Individual</u> Behavior Example: I collect water on my own.
<u>Interior-collective</u> Culture  Example: This is how we always get our water.	<u>Exterior-Collective</u> Social Systems  Example: Our well has pesticides.

*Figure 3: Wilber Diagram (Integral Theory, 2013)*

### **3.2.2 MATLAB Mobile**

MATLab Mobile is an application that assists in data collection. The data was collected from the sensors within the application. These sensors include longitude and latitude. Longitude and latitude determine accurate positions. Accurate positions facilitate the creation of a map.

### **3.2.3 Interviews**

Interviews also provide information that pertains to water quality and usage. The team conducted semi structured interviews. These interviews gained information about the community's water quality, consumption and pipeline locations. The responses were analyzed and the results presented to the community. An example of an interview appears in Appendix A.

### **3.3 Deliverables**

The methods of our schematic maps, a work order template, and maintenance plan will be discussed in this section.

#### ***3.3.1 Schematic map***

The team worked with technicians to locate the pipelines. Using MATlab mobile we pinned longitude and latitude coordinates of pipe locations. The pinned locations were added to google maps and connected with lines to create our schematic. Different layers were added to the map for organizational purposes. The new Junta map was based on last year's map, but is now digitized. The Qom map was made this year. Schematic maps are found in Appendix B.

#### ***3.3.2 Work orders***

Inspiration for the work order came from several templates found online. The Junta's work order template was created on Microsoft Word Appendix C.

#### ***3.3.3 Maintenance plan***

With the guidance of experts and online research our team learned how to prevent root blockages in pipes. Found in Appendix D.

### **3.5 Evaluations**

The success of our deliverables was based on the utilization of the maps, work orders, and maintenance plans.

### **3.6 Timeline**

The team allocated specific tasks to each week of the project. The first week consists of team orientation within the community. Team orientation consists of familiarization with the tank locations. The second week consists of interviews with water officials. The third week was the commencement of the Rosarinos Qom map. The fourth week was the digitization of the water distribution map. The fifth week we focused on the maintenance plans for the Junta and the Rosarinos Qom. The sixth week was for the final paper and presentation preparation. The final week was allocated to the completion of the project.

### **3.7 Ethics**

The team complied with the norms and laws both locally and internationally. All information that was collected was kept confidential and properly disposed of at the end of the project. Permission was given to use the included photos.

## **4 Results**

The team created schematic maps of the water system, and maintenance plans for both the Junta de Saneamiento, and the indigenous Qom community called the Rosarinos.

## **4.1 Junta de Saneamiento**

### **4.1.1 Schematics**

The team created a digital schematic of the pipeline layout in Cerrito. This schematic utilizes a map created by the 2018 IQP Water Team. The schematic shows the street names, tank locations, and pipe connections. Individual maps illustrate each tank and their pipe system. The team combined each map and created one master schematic. The team shared the links of digital map with the Junta de Saneamiento as well with Fernando Pfannl of Fundación Paraguaya. Pictures of the pipeline layouts are found below.

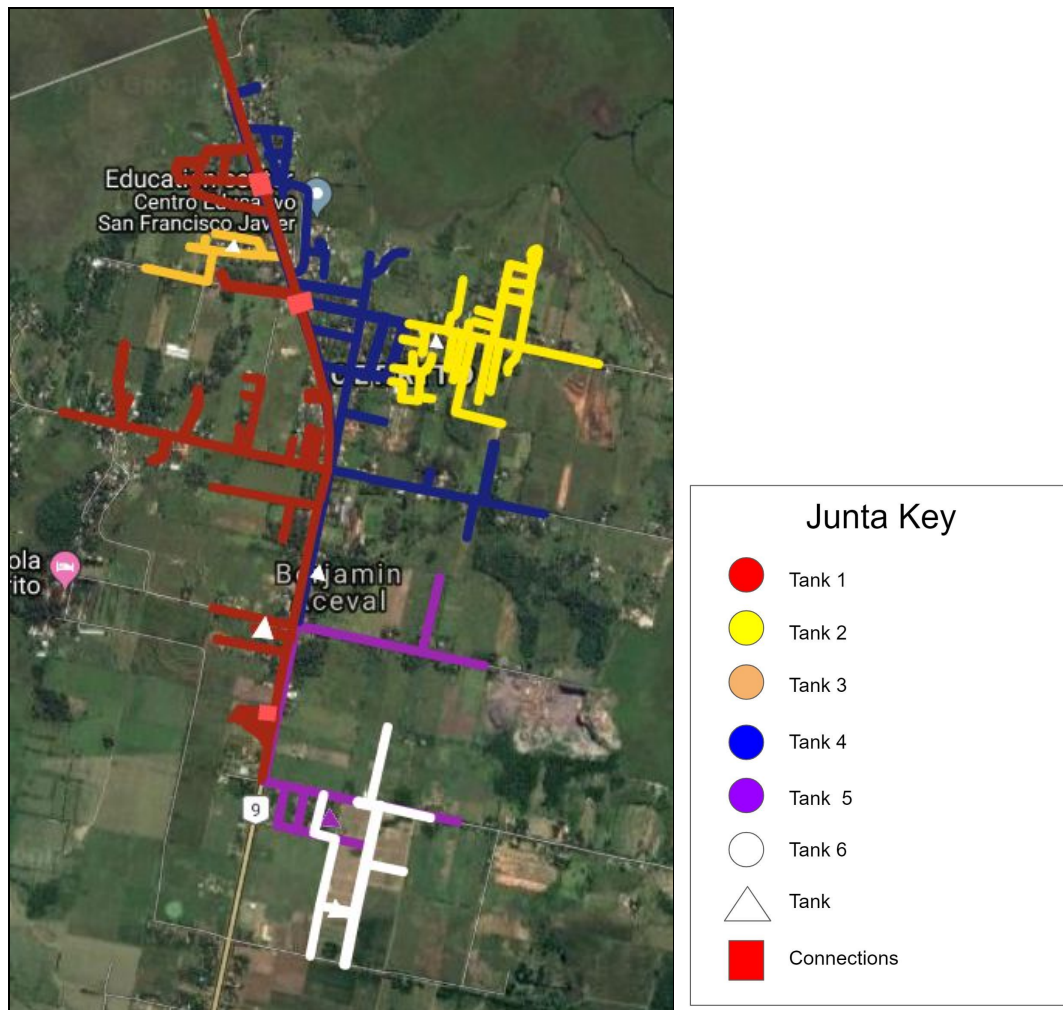


Figure 4: New Schematic of pipelines for the Junta de Saneamiento.

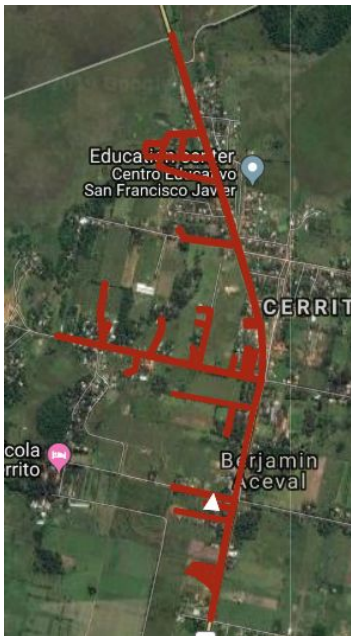


Figure 5: Tank one Schematic of pipelines for the Junta de Saneamiento.



Figure 6: Tank two Schematic of pipelines for the Junta de Saneamiento.

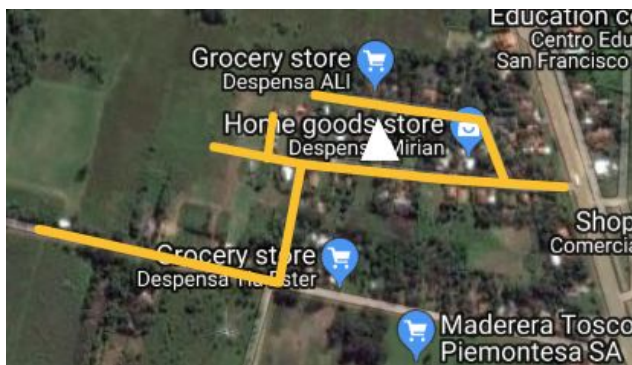


Figure 7: Tank three Schematic of pipelines for the Junta de Saneamiento.

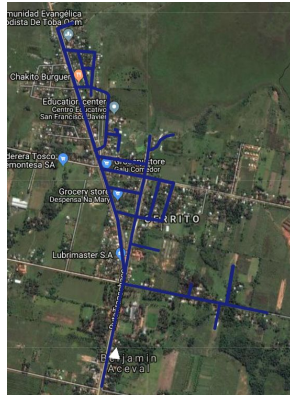


Figure 8: Tank four Schematic of pipelines for the Junta de Saneamiento.

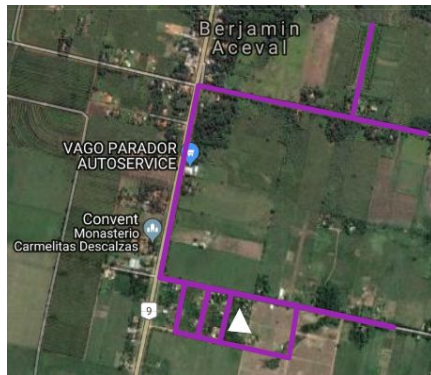


Figure 9: Tank five Schematic of pipelines for the Junta de Saneamiento.



Figure 10: Tank six Schematic of pipelines for the Junta de Saneamiento.

#### **4.1.2 Administrative Maintenance**

The administrative maintenance template presented to the Junta de Saneamiento consists of a work order template. A work order authorizes maintenance or repairs and documents a completed job. A copy of this is found in Appendix D. The work order will help the Junta de Saneamiento keep a record of trouble spots and indicates future actions.

### **4.2 Rosarinos Qom**

The team made recommendations of the water system used by the Rosarinos Qom. These observations include the water schematics and maintenance plan.

#### **4.2.1 Rosarinos Qom Schematics**

The team also created a digital schematic of the Rosarinos Qom pipeline. This schematic shows the location of the pipe, future eucalyptus plantation, locations of water loss, areas of caution, and a proposed pipeline. The team shared the link with Fernando Pfannl for Fundación Paraguaya, and can be seen in Appendix B.

The team created the map because 150 meters of pipe will pass through eucalyptus trees. Relocation of the pipes is necessary to prevent destruction of the current pipe system. The team proposed a pipeline location that will avoid the future eucalyptus



plantation. This proposal will help determine how much pipe is needed for an alternate route.

#### **4.2.2 Rosarinos Water Quality Maintenance Plan**

This maintenance plan recommends ways to attain adequate water pressure and ensure water quality. This maintenance plan includes a guide to blockage prevention, tank check recommendations, and water quality tests. A copy of the plan is found in Appendix D.

## **5 Discussion**

The team's results of the deliverables led to observations of the Junta de Saneamiento, the Rosarinos Qom community, and for future project work.

### **5.1 Junta de Saneamiento**

The results of the team's work with the Junta identified some problems and raised some issues. One problem is the lack of record keeping and the lack of a map that can help analyze water supply.

#### **5.1.1 Work Order Use**

Through an interview with Sra. Nuñez (Secretary of the Junta), the team collected information on how the Junta documents its work and activities. Their documents are well organized. These documents include bylaws, financial records, legal charter and

minutes. They do not include records of water supply maintenance and repair. Sra. Nuñez thought that such records would be helpful. A standard work order consists of sections such as name of the complainant, address, problem, name of repair person, description of work, and date. A work order template was provided to Junta members see Appendix C.

### **5.1.2 Map Update Recommendations**

During field work Sr. Espinola (Junta technician) showed the team the location of new pipelines and a new tank. This appears in Appendix B. With this information a digital map was created. Despite improved accuracy, maps are not often used by the Junta. As a result, the team explained how to read and update them. It also showed how maps can be used to track chronic trouble spots and prioritize their maintenance.

### **5.1.3 Water Meters Continuation**

Water meters in Cerrito are not called water meters. They are called watches. This confused the team for several weeks and left them thinking that there were no water meters. Eventually Sr. Espinola revealed that in a new section town water meters have been installed. This water meter pilot will give the Junta information about water use and reaction of residents. The team encourages this pilot and hopes that water meters will be used by the entire town. A comprehensive metering system can do much to alleviate inequity.

## **5.2 Rosarinos Qom**

The results of the team's work with the Rosarinos Qom identified problems. The first problem is that it is not clear to the Rosarinos' leader whether the eucalyptus plantation is economical. The other problem is the water system lacks sufficient maintenance.

### **5.2.1 Economic Factors on the Eucalyptus Plantation**

One reason why the eucalyptus plantation may not be economical is that its installation will require new water pipe routes. Pipes need to be relocated because eucalyptus tree roots can destroy them. The schematic made by the team showed 835 meters of new pipe that will be needed. This 835 meters of new pipe will avoid the eucalyptus. Up to 350 meters of the current pipeline that pass through the eucalyptus zone can be recovered for the new route. Therefore, only 485 meters of new one-inch pipe may need to be purchased. Sections of this new route will need special attention.

### **5.2.2 Area of Concern**

The map shows this area of concern. The area of concern is a length of pipe that spans 350 meters from the start of the tank. This 350 meters borders the future eucalyptus plantation. Preventative measure must be taken in order to protect the 350 meters of pipe from eucalyptus roots.



### 5.2.3 Preventative Measures

Three preventative measures can be considered. One preventative measure is to protect the pipe during construction. First, one must dig a trench, lay the pipe, cover the pipe in sand, and cover the sand in bricks. This will protect the pipes from vehicles. Another preventative measure is to reinforce the pipe in a protective shell. A protective shell will strengthen the pipe and make it less likely to break to roots. One final preventative measure is to keep the pipe above ground. This will not allow the eucalyptus roots to penetrate the pipe. However, other steps must be taken to protect the pipe from the sun's heat. For example, cloth can be wrapped on the pipe to discourage heat transfer.

### 5.2.4 Water System Maintenance

The Qom know that their water maintenance is not the best. The team thinks that a maintenance plan might help. The maintenance plan suggests more routine checkups.

For example, the tank has not been cleaned since 2016. Part of the problem is the community does not have a ladder. The plan also recommends annual water quality tests.

# Appendix

## Appendix A: Sample Interview Questions

### Interview questions and Surveys

#### For the community members:

- Hello, my name is Kenia. This is Victoria and Michael. My teammates and I are working on a project that addresses water quality and quantity here in Cerrito. Our project focuses on testing the water to make sure there are no contaminants and it's safe to drink. We are also completing a water pipeline map. We appreciate your time please know we don't collect names and you remain anonymous.

What's your name?

How long have you lived here?

Does your family live here?

How large is your family?

How long have you and your family been living here?

- In what ways do you use water?
- How much water do you think you and your family use daily in liters?
- Where do you get your water from?
- How close is a water well to your house?
- Can you describe your water (color, taste, clarity)?
- What do you do if your water isn't clean?

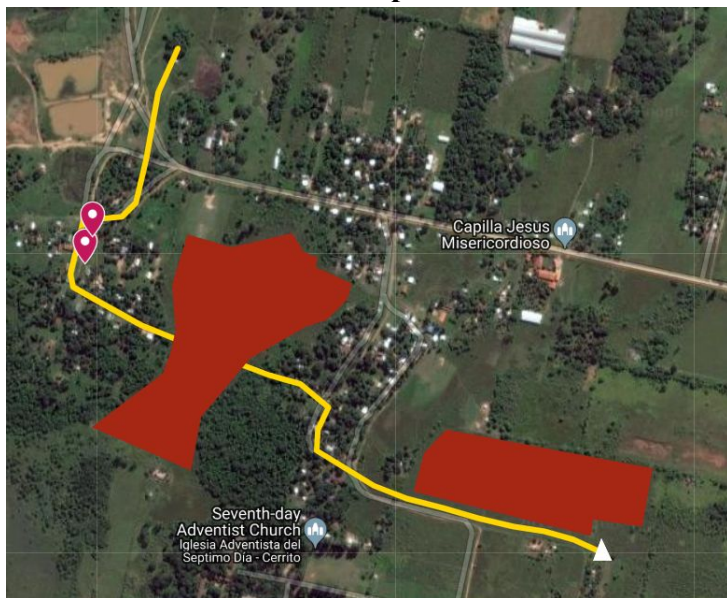
#### For the Water Board:

- Hello, my name is Kenia. This is Victoria and Michael. My teammates and I are working on a project that addresses water quality and quantity here in Cerrito. We appreciate your time please know we don't collect names and you remain anonymous. Our project focuses on testing the water to make sure there are no contaminants and it's safe to drink. We are also completing a water pipeline map.
  - What's your name?
  - How are you?
- We are very happy to work with you, what did you envision us doing when you were told we were coming?
- What does the Junta do?





- How long have you been on the board? Do you like the work?
- Before we start out project, we want to know more about the water in Cerrito.
  - How much water is used in Cerrito?
  - What is the most efficient water source in Cerrito?
  - How often is maintenance performed on the wells?
  - Is there a map of the water system?
  - Who installed the water pipes?
  - What are some common problems faced?

## Appendix B: Pipeline Map

### Current Rosarinos Pipeline Route



**Rosarinos Key**

-  Eucalyptus plantation
-  Current Pipeline
-  Proposed pipeline route
-  Tank

### Proposed Rosarinos Pipeline Map





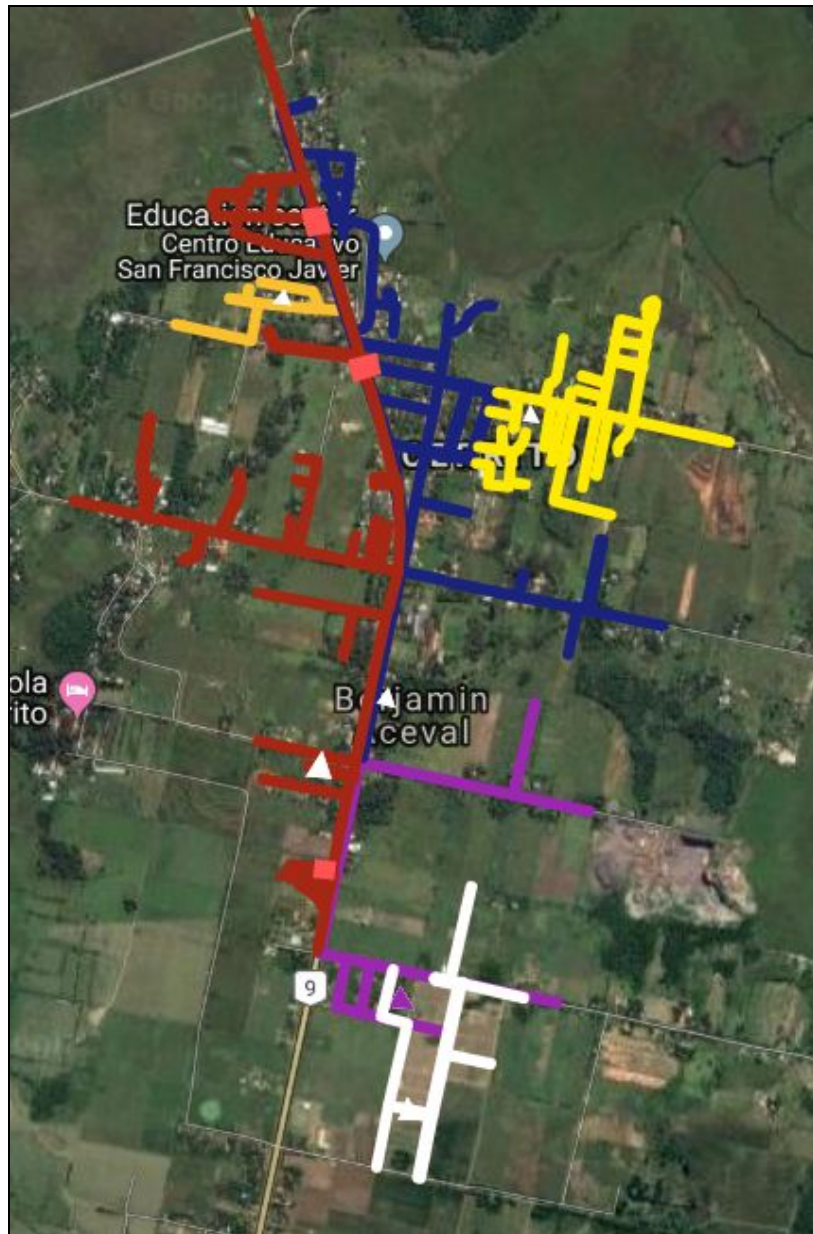
**Rosarino Tank**



**Example of Faulty Pipe with Florentin Gonzalez**



### Junta de Saneamiento





**Junta de Saneamiento Tank 6**



**Junta Water Meter (reloj)**





**Pedro Espinola (Junta Plumber)**



## Appendix C: Junta de Saneamiento Work Order template

# Orden de Trabajo Junta de Saneamiento

Cerrito, Benjamin Aceval

Nombre completo:	Numero de Telefono:	Fecha:
Orden tomada por:		
Direccion:		
Lugar del Trabajo:		

### Descripción de Trabajo

Fecha del trabajo completado:	Trabajo completado por:

## **Appendix D: Rosarinos Maintenance Plan**

### **Rosarinos Maintenance Plan**

#### **Introduction**

This maintenance plan prescribes methods to maintain adequate water pressure and ensure water quality.

#### **Pressure**

Lack of water pressure originates from clogged pipes. These clogs result from grass roots penetrating faulty pipes and junctions. We recommend a focus on preventative measures. These measures include prevention of grass roots and installation of better pipes

Technicians should locate problem areas to prevent grassroots. Problem areas are locations where blockages occur most often.

Installation of better pipes can further prevent blockages and clogs. These pipes are larger in diameter with thicker walls. These measures are long term, sustainable solutions.

#### **Quality**

##### ***Tank check***

Tanks over time can grow algae and potentially harmful bacteria. Biannual cleaning using chlorine should be completed. The tank requires ladder access.

##### ***Water quality test***

Water quality test measure potable water. These test should be completed annually.



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