Wastewater Assessment and Management at La Escuela Agrícola San Francisco de Asís

Interactive Qualifying Project

Sponsoring Agency: Fundación Paraguaya

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Abstract

La Escuela Agrícola San Francisco en Cerrito had several challenges with wastewater that they needed assistance on. These challenges involved a failing leach field, a lack of documentation regarding the system and its compliance, and a lack of understanding by students at the school of water usage and treatment. The objective of this team was to assist in providing deliverables to solve these challenges at the school. The following report is a description of the teams research, methods, results, and recommendations related to solving those challenges. To fulfill these goals, the team conducted extensive research, performed semi-structured interviews with experienced locals, and synthesized that information into solutions and recommendations. As a result, this project produced a comprehensive map and descriptive guidebook of the system, an environmental compliance report of the system, a leach field revitalization plan, and a wastewater educational unit for students at the school. In addition to these deliverables, the team provided some overarching recommendations about wastewater management and sustainability at La Escuela Agrícola.

Acknowledgements

This Interactive Qualifying Project would not have been possible without the continuous support and assistance from several individuals.

We would like to give a major thanks to the administration, faculty, and staff at La Escuela Agrícola de San Francisco. Specifically, we would like to thank Director Hugo Florentín, who helped us understand the expansion of the school and its buildings. We would like to thank Lic. Roberto Giménez for his assistance in completing the Environment Compliance Review. We would especially like to thank Professor Virgilio Borges for his continuous efforts to help us understand and improve the wastewater system of the school.

We would like to thank Benson Colella for his insight into La Escuela Agrícola San Francisco, previous Paraguay projects, and the IQP process throughout our time on this project.

We would also like to thank Engineer José Luis Salomón for his continuous support on understanding the history of the school's wastewater as well as his insight on project deliverables.

Lastly, we would like to thank Dr. Robert Traver and Professor Dorothy Wolf for their continuous guidance, feedback, and support on all aspects of our project.

Together this team has made an immense amount of progress improving the Wastewater System at La Escuela Agrícola, and we cannot thank you all enough.

Sincerely,
Juan Arreloa
Jacob Borges
Rebecca Dawley
Gregory Kaleshian

Executive Summary

During the spring of 2020, the wastewater management and assessment team sought to explore varying aspects of wastewater treatment along with ways to get the community involved. The objectives for the project mainly focused around increasing understanding of the system for all and seeking potential improvements. With the help of Professor Viriglio Borges and Engineer José Luis Salomón, we were able to successfully accomplish our goals. Detailed maps and guides of the wastewater system, a leach field revival plan, an educational unit, and an environmental compliance review were the physical outcomes. Generally, our project emphasized the importance of upkeep to a system to ensure longevity, effectiveness, and prevention from the disaster that can be septic failure.

Following the completion of this project, our team compiled a series of recommendations for both future IQP projects and the decision makers of La Escuela Agrícola. To begin, the wastewater guidebook could be expanded to include additional pertinent information such as water flow calculations and financial considerations. As the school continues to grow, increasing the capacity of the wastewater treatment system is crucial, thus making it our second recommendation. Next, the campus should be persistent with overall maintenance, including an evaluation of what's going down their drains. Finally, we hope that decision makers create a long term plan for the system and include wastewater treatment in future budgets.

There are five key deliverables that were completed in collaboration with experienced locals from this project. A detailed map of the campus' varying wastewater treatment systems served as the basis for the rest of our products. Developed from the map was a guide that describes details of specific buildings as well as a design of canals to fix the problems of the

green filter. We created an educational unit consisting of three lesson plans on wastewater and its treatment for the students of Prof. Virgilio Borges. Finally, our group analyzed the environmental compliance of the school in accordance with Paraguayan laws. Each of these deliverables had different objectives and target audiences.

The methods of all the created products were similar. Initially, possible ideas were introduced to us and we were challenged to make them a reality. After producing a draft of each product, we received feedback during regular meetings with people in Paraguay. This was a continuous cycle until the final product was satisfactory.

Authorship

The entirety of this paper was written and edited by the wastewater assessment and management team as a whole. Each individual contributed a fair amount of their personal writing to get general ideas down, and the final product was a collaborative effort amongst the team. Together, we performed extensive research on Paraguay, La Escuela Agrícola, and wastewater systems. We also met with experienced locals in Paraguay and worked with them to understand our project and develop its deliverables. From this research, we developed our introduction, background, methodologies, results, discussion, and recommendations for our project in order to meet our combined objectives.

Juan Arreola

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1. Introduction

Paraguay is a country located near the center of South America, landlocked by its neighbours Brazil, Argentina, and Bolivia (Central Intelligence Agency (CIA) 2018). The country is predominantly rural, with 53.8% of the land being used for agricultural purposes (CIA, 2018). In these rural areas, poverty is a serious concern for many individuals considering that a third of the population lives below the poverty line (Dirección General de Estadística, Encuestas y Censos, 2018). A wide range of organizations and programs have been created to combat this economic challenge. One such organization, La Fundación Paraguaya, dedicates itself to eliminating poverty in Paraguay. Significant resources have been targeted for the rural community of Cerrito outside of the capital city, Asunción (Fundación Paraguaya, 2018).

In Cerrito, La Fundación Paraguaya has focused on turning individuals in the community into "agricultural entrepreneurs". One of the most effective ways of going about that process is through a self-sustaining school called La Escuela Agrícola San Francisco (Fundación Paraguaya, 2018). At the school, students are taught practical skills while yielding agricultural products to support the school's operation. The curriculum at La Escuela Agrícola emphasizes agricultural practices, critical thinking, problem solving, and hospitality (Fundación Paraguaya, 2018).

La Escuela Agrícola has a unique infrastructure designed to fit its demands. A wastewater treatment system is one of many factors to be aligned with the school's operational requirements. Despite several improvements and efforts from previous projects teams, the system still requires updates to fit the school's sustainability goals. Previous groups have put immense effort into a leach field, constructed out of what used to be a pool (Colella, B., Fischer, Z., & Hernandez, V., 2019) and this project attempts to further their efforts and also develop new objectives.

The objectives for the project were to map the current wastewater system, revive the failing leach field, develop a guidebook describing the school's wastewater, develop a lesson plan for students, and create an environmental compliance review. The final report below will outline the background research conducted to understand these deliverables. It will also include the methodologies used to complete them, final results, and further discussions and recommendations.

2. Background

2.1 Introduction

The intent of this project at La Escuela Agrícola in Cerrito, Paraguay was to improve the sustainability and knowledge of the wastewater system. Supporting the school's long established goals of being environmentally and economically self sustainable exemplifies the project goals (Fundación Paraguaya, 2018). This project explored feasible solutions to wastewater treatment and assessment, especially in terms of leach fields, environmental compliance, and community involvement. As a result of multidisciplinary research and collaboration with experienced locals, the team identified areas of improvement regarding the wastewater system and developed deliverables to obtain those improvements..

The main deliverables of this project were a comprehensive map of the system, a guidebook describing the system, an environmental compliance report, a revival plan for the leach field, and a lesson plan for students to better understand wastewater. The following sections review geographical area, organizations, as well as septic system operation and management to provide a general background of the work completed in the project.

2.2 La Fundación Paraguaya and La Escuela Agrícola

La Fundación Paraguaya is a global organization focused on innovative yet feasible solutions to poverty in communities worldwide (Fundación Paraguaya, 2018). They have fourteen "hubs" around the world where dedicated teams work to eliminate poverty in the surrounding communities.

Paraguay remains the central hub of the Foundation's development of innovative poverty solutions. Within the rural town of Cerrito, the pathway to overcoming poverty focuses on providing educational opportunities for local youth to become "rural entrepreneurs" (Fundación Paraguaya, 2018). La Escuela Agrícola, a self-sustaining agricultural school, is continuously providing this service to the people of Cerrito and surrounding communities. The school offers extensive opportunities for students. These activities require significant infrastructure to be successful. A focal point of Fundación Paraguaya's initiatives at the school is the wastewater system (Colella, B., Fischer, Z., & Hernandez, V., 2019). The wastewater system of La Escuela Agrícola services the entirety of the campus. Wastewater systems of this complexity present unique challenges that are either economical, technical, or managerial in nature. Accomplishing the end goals of this project will require a complete understanding of the system and its innerworkings. (Rodda et al., 2010).

2.3 Wastewater Systems

2.3.1 General Background

Wastewater systems of various types are used to treat wastewater and repurpose it into groundwater. Generally, water can be categorized into three main types: freshwater, greywater, and blackwater (Brain et al., 2015). Freshwater is water that is safe for human and animal consumption. Wastewater that does not contain solid waste is categorized as greywater. Greywater is able to be consumed by humans and animals, however it does pose some risk to humans due to lack of purification (Utaberta et al., 2015). Finally, blackwater is the most contaminated water type that contains harmful pathogens from humans and animals. Many systems direct grey and blackwater out of buildings through pipeline networks until reaching the septic tank.

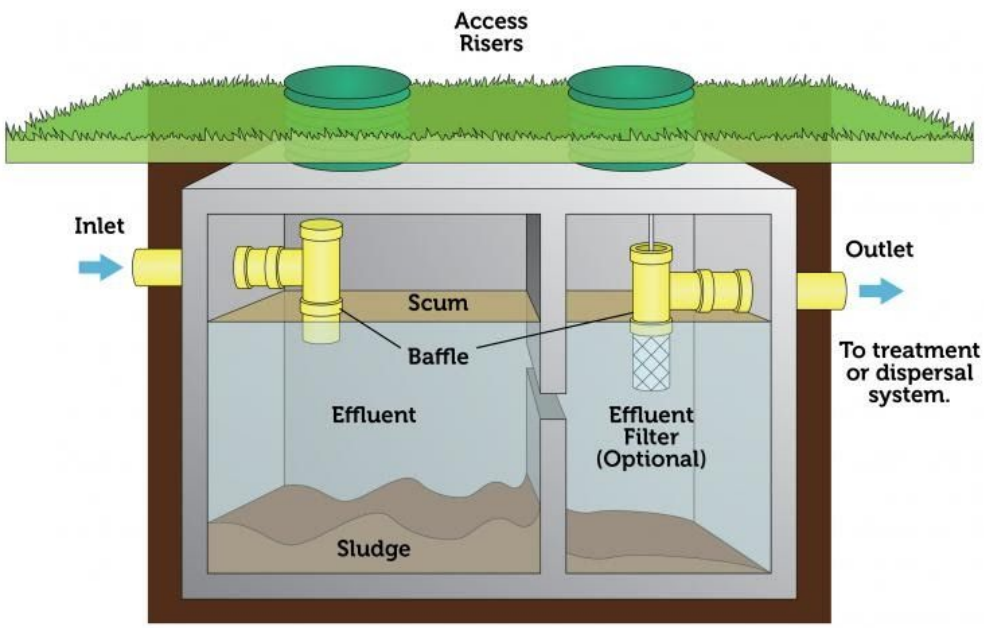

Figure 1: Diagram of a traditional septic tank (Environmental Protection Agency (EPA), 2018)

A common design of a septic tank can be seen in Figure 1. The process of treatment begins with separation by densities of incoming discharge. Scum, effluent, and sludge are the three main components of wastewater and are separated over time. The scum level consists of oils and cleaning fluids and floats on the surface. Effluent is the contaminated water that continues through the treatment process. Sludge is any solid waste that sinks to the bottom of the tank. Effluent then moves into a separate chamber, where treatment is continued, until it returns to the natural groundwater (EPA, 2018). A leach field, also known as a drainage field, is often the second stage of decontamination. Here, the water runs through parallel pipes that are supported by layers of gravel and sand. The perforated pipes allow for a steady rate of water dispersion over a large area to minimize the risk of flooding or creating a single pool of wastewater. As water travels through the sand and gravel, microbes within the soil decompose the pathogens within it. The final treated product flows downstream back into the natural waterways to be recycled. The movement of natural water through underground topography is an important consideration for the design of an effective treatment of wastewater (Ingram, 2000).

Due to its rural setting, La Escuela Agrícola requires a decentralized network of water treatment systems. A sample of a similar system can be seen in Figure 2. Each aspect of the network tailors to specific demands of the campus and its facilities. Overall, it is cost efficient and somewhat environmentally friendly. The benefits of a decentralized system coincide with the school's sustainability goals.

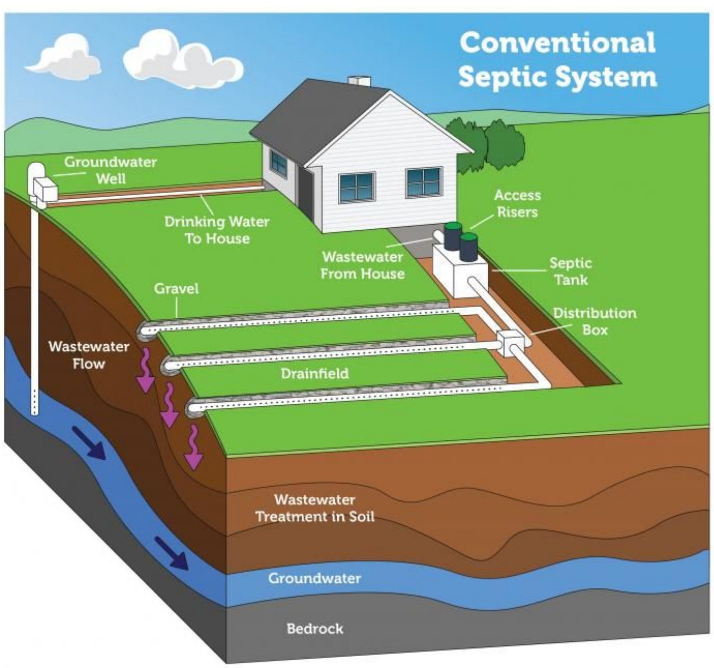

Figure 2: Diagram of a decentralized septic system (EPA, 2018)

2.3.2 Importance of Maintenance Plans

With such limited resources, it is extremely important for the school to keep its system well maintained and functioning efficiently to effectively process wastewater. Failure to do so can cause a backup of untreated water, causing damage to the campus as well as groundwater contamination risks. (Aldarondo et al., 2017). Management plans play a key role in ensuring the system operates properly and reduces risk to the surrounding environment and community.

2.3.3 Management and Maintenance Plans

Providing easy-to-read, simple instructions encourages those responsible to take better care of their systems. This technique is frequently used throughout the United States for a variety of decentralized systems. Knowledge of the impact of septic systems failure inspires people to make it their responsibility to help their community and the environment.

2.4 Wastewater at La Escuela Agrícola

To achieve the project goals, it was critical for the team to become knowledgeable of wastewater at the school in terms of the system itself and what the people there know about wastewater. The primary sources for this information were Eng. José Luis Salomón, Prof. Dorothy Wolf, and Prof. Borges. Eng. Salomón is an engineer who was once the director of the school and knows the history of the system. Prof. Wolf works for Fundación Paraguaya, is an advisor for WPI projects, and has extensive experience with the school and its community. Prof. Borges is the school's manager of maintenance. He knows more about the wastewater system than anyone else, which was critical for our project.

On campus, there are three ways water is treated. The most common is through septic tanks and cesspools. These structures separate solids from liquids and allow for effluent to be released for further treatment or into the soil. The second type of system is a leach field, based on an American design described in section 2.4.1. In some cases, the wastewater from certain buildings exits straight into the ground without any treatment. Understanding these systems on campus was a critical step in being able to effectively deliver the objectives of this project.

3. Methodology

The goal of the methodology section is to explain how the team gathered the information required to complete the target deliverables. Each deliverable had unique methodologies related to its content. However, the overarching format of executing our deliverables was very similar. First, we gathered as much information as we could about each subject from past reports and outside research. Next, we prepared questions for further discussion with our advisors and sponsors. At this point, we began a cycle of meeting with the experienced locals, compiling information through informal interviews, framing the problem, drafting solutions, and reviewing the drafts. This cycle of drafting and review was critical in providing the desired deliverables. The following sections describe our approaches to completing wastewater maps and guides, leach field troubleshooting, lesson plans, and an environmental compliance analysis.

3.1 Mapping the System

The comprehensive map of the wastewater system at La Escuela Agrícola required three development stages: updating previous maps, verifying and editing with advisors, and polishing the maps for clarity and consistency. Mapping of the school’s wastewater system was integral in understanding the complexities and different aspects of the system. The map of the system developed in 2016, shown in Figure 3, lacked crucial up to date information.

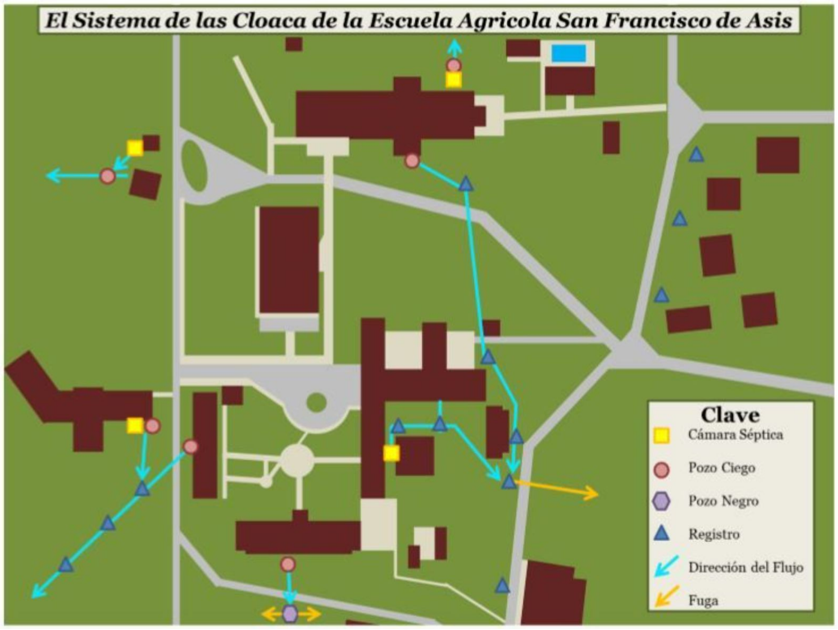

Figure 3: Wastewater Treatment at La Escuela Agrícola, as of May 2016 (Colella et al., *2019)*

The team set out to consult multiple sources to create updated versions of this map. During weekly meetings with our sponsors and advisors, the map was updated using PowerPoint. Every week, new information would be given to us, mostly from Professor Borges who knew the most about the system and the campus. Another source of information was this year's Paraguay Erosion IQP team, who developed similar maps for their project. Anytime their group made updates to their maps, they informed us. Using each other as resources was very effective in saving time and effort in our mapping projects. Having editable maps in the hands of multiple people ensured that we had the most updated information possible. This map was not only key for the team's understanding of the system, it also became an important part of our other deliverables.

3.2 Leach Field Revitalization

To develop a leach field revival plan, our group conducted extensive research along with informal interviews to brainstorm solutions. Prior to this seven week term, our group performed significant research on leach fields, their upkeep, and resolving potential problems. Since the system at the school is an American inspired leach field, this information was readily accessible. From initial discussions with Benson Colella and Dr. Traver, we knew the leach field had become flooded (Colella & Traver, personal communication, February, 2020). We had weekly meetings with our advisors and sponsors through Zoom calls to gain a deeper understanding of possible causes. Through semi-structured interview questions, the team gathered as much information as possible about the leach field's surrounding areas.

Prof. Borges informed us that the leach field and the area around it were constantly saturated with groundwater. Based on this evidence, our group co-created a plan with Prof. Borges and our advisors to use canals to move excess groundwater around the leach field. After hypothesizing the canal plan, proper methods to verify the validity of the plan were required. To accomplish this, the team used applications like Google Earth and elevation profiling features to ensure water would properly flow in the proposed plan.

3.3 Lesson Plan Development

Creating a lesson plan required seeking inspiration online, discussing with Prof. Borges the information he wanted to cover, using an organized template format, and constant revisions. To get an idea of what other educators have done when teaching about wastewater, our group sought out online resources. These resources provided a foundation for the activities designed to fit the goals of this deliverable. Prof. Borges discussed with us a general outline of what topics he would like to cover in this educational unit. To ensure clarity, the format of our lesson plans was loosely based on those of Madeline Hunter, a well known American educator. With feedback from Eng. Salomón, Prof. Wolf, and Prof. Borges the educational unit was frequently updated to reflect appropriate language choices and activities for the Paraguayan students.

3.4 Wastewater Guide Book Development

The development of the wastewater guide book consisted of researching treatment information, interviewing advisors about campus specifics, and gathering pictures. The team started by researching general information about wastewater systems. We collected background information including how varying aspects of a system work and the risks of a mismanaged system. Next, semi-structured interviews were conducted by the team. Prof. Borges, Prof. Wolf, and Eng. Salomón shared their thoughts on what information would be helpful in a wastewater guidebook. We also worked with our advisors on designing an easy to understand format for the guidebook. Finally, pictures of septic treatment sites at each building were taken by Prof. Borges and placed in the guidebook.

3.5 Environmental Compliance Analysis

An analysis of the school's compliance with environmental laws was produced from exploring site specific details and researching Paraguayan law. Prof. Wolf raised concerns that the constant changes to the system would cause it to be in violation of Paraguay's environmental regulations. To investigate these concerns, we needed to collect as much information about the school's wastewater treatment system as possible. The system map helped identify all the wastewater systems built at the school over the years. From the map, we proceeded to identify a list of legal risk areas that the school needs to be aware of. For example, the close proximity of the leach field to the wetlands raised the issue of the leach field's impact on wild areas. We therefore decided to investigate environmental preservation laws. After identifying these risk areas, we proceeded to find and examine as many relevant laws and regulations that apply to the school as possible.

Prof. Wolf and Hugo Florentín had sourced a previous environmental audit conducted in 2018 that reviewed the school's wastewater system and agricultural operations. This environmental audit established the legal compliance of the system as it stood in 2018. This allowed us to concentrate our efforts on analyzing the additions to the school's wastewater system since that point. These additions were in the form of new septic tanks that were paired with existing cesspools as well as a potential cheese factory. With the map, audit, and regulations, we were able to cross reference every aspect of the school's wastewater system and ensure that no part infringed upon Paraguayan law.

4. Results

There are five key deliverables that the group completed in conjunction with experienced locals. The primary deliverable of these was a comprehensive map of the wastewater system. The secondary deliverables, which were developed using information gathered from the map, were a leach field revitalization plan, a wastewater lesson plan, a wastewater guidebook, and a compliance report of the system. Each of these deliverables had different goals and target audiences as are described in the following sections.

4.1 System Maps

This map is a diagram of the school campus and wastewater system. Information gathered from meetings and collaboration with other teams allowed us to create this map. The map was a key part in all of our deliverables and helps staff, teachers, students, and visitors to understand the wastewater system at a glance.

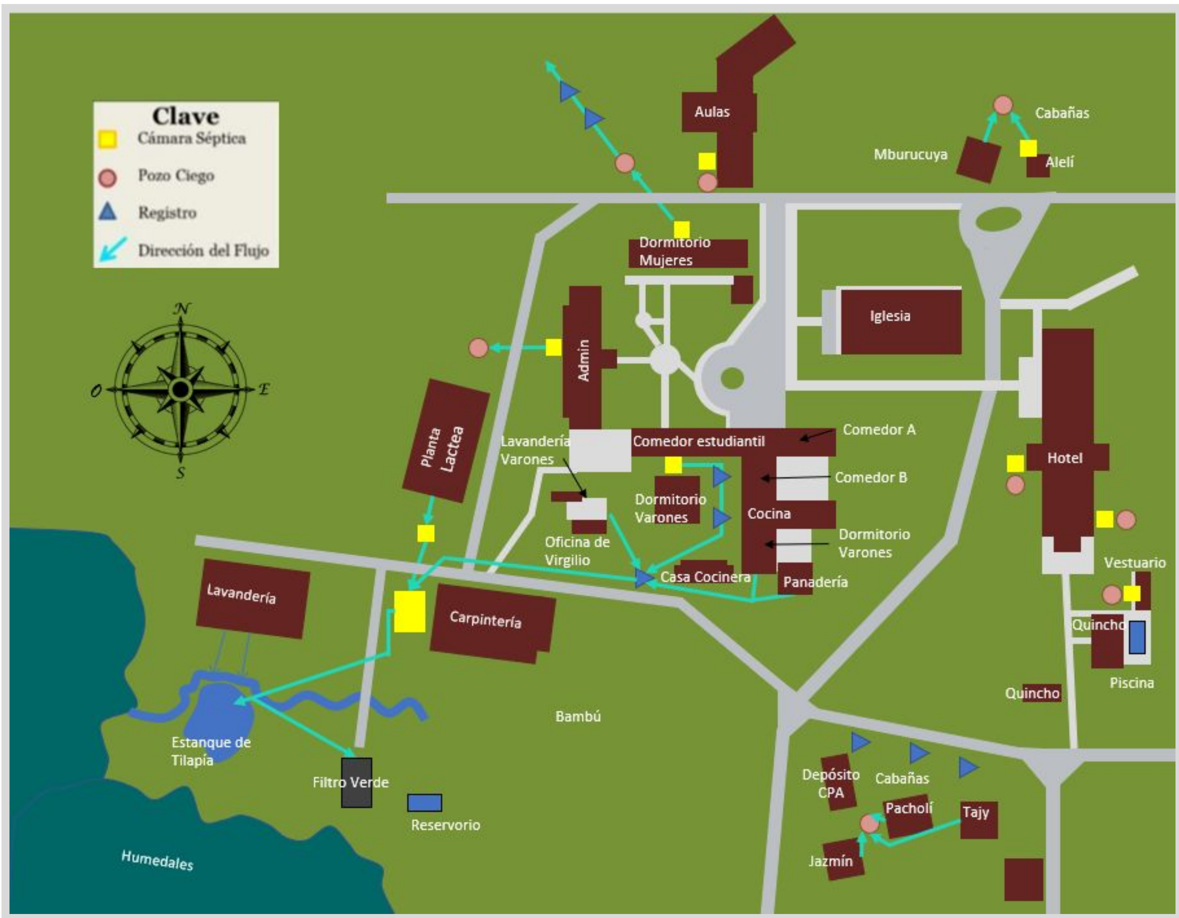

Figure 4: Map of the wastewater system at La Escuela Agrícola

The map in Figure 4 displays the entirety of the wastewater system at the school. Septic tanks, cesspools, and pipelines are all marked and labeled in the legend. The simplicity of this map makes it easy for anyone to understand the wastewater system of the school.

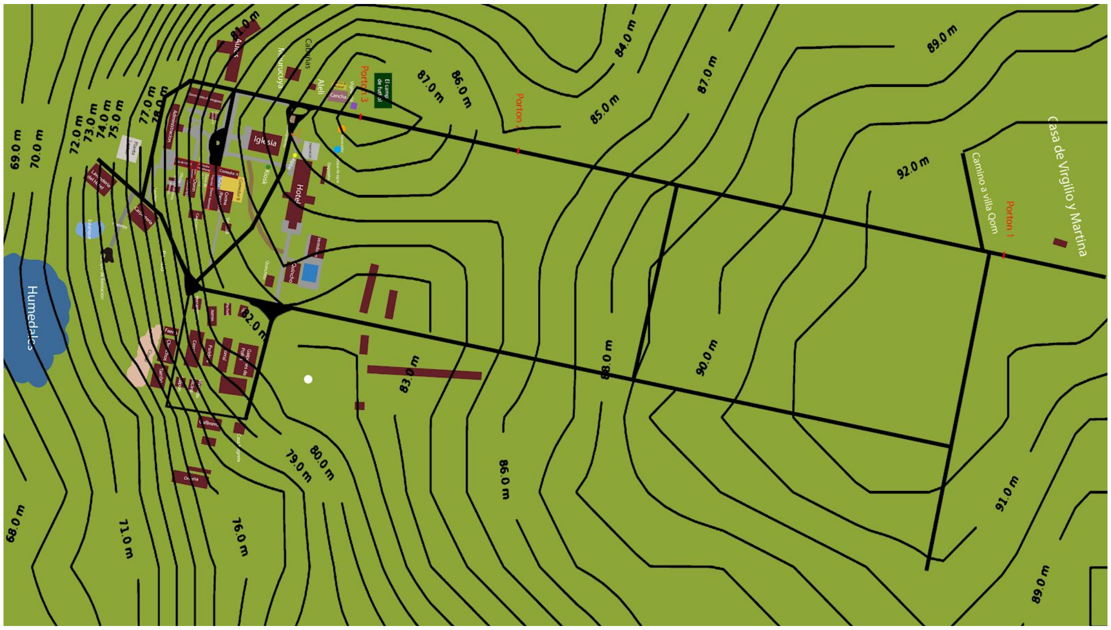

Figure 5: Elevation map of La Escuela Agrícola and surrounding area

The map in Figure 5 was a collaborative effort with the wastewater and erosion teams. The map displays the elevation profile of the campus and surrounding area. Teams used Google Earth and topographical maps to determine the elevation overlay. This map aided our team in understanding how the groundwater flows. This information helped in our plan to reestablish the leach field.

4.2 Leach Field Revival Plan

The goal of the leach field revitalization deliverable was to create diagrams of the trenches as well as an elevation profile to understand water flow. Through our methodology of research and semi-structured interviews, the team was able to co-create a map detailing the plan. That plan involves cleaning, deepening, and expanding a series of canals around the leach field. A detailed version of the map and canals can be seen below in Figure 6.

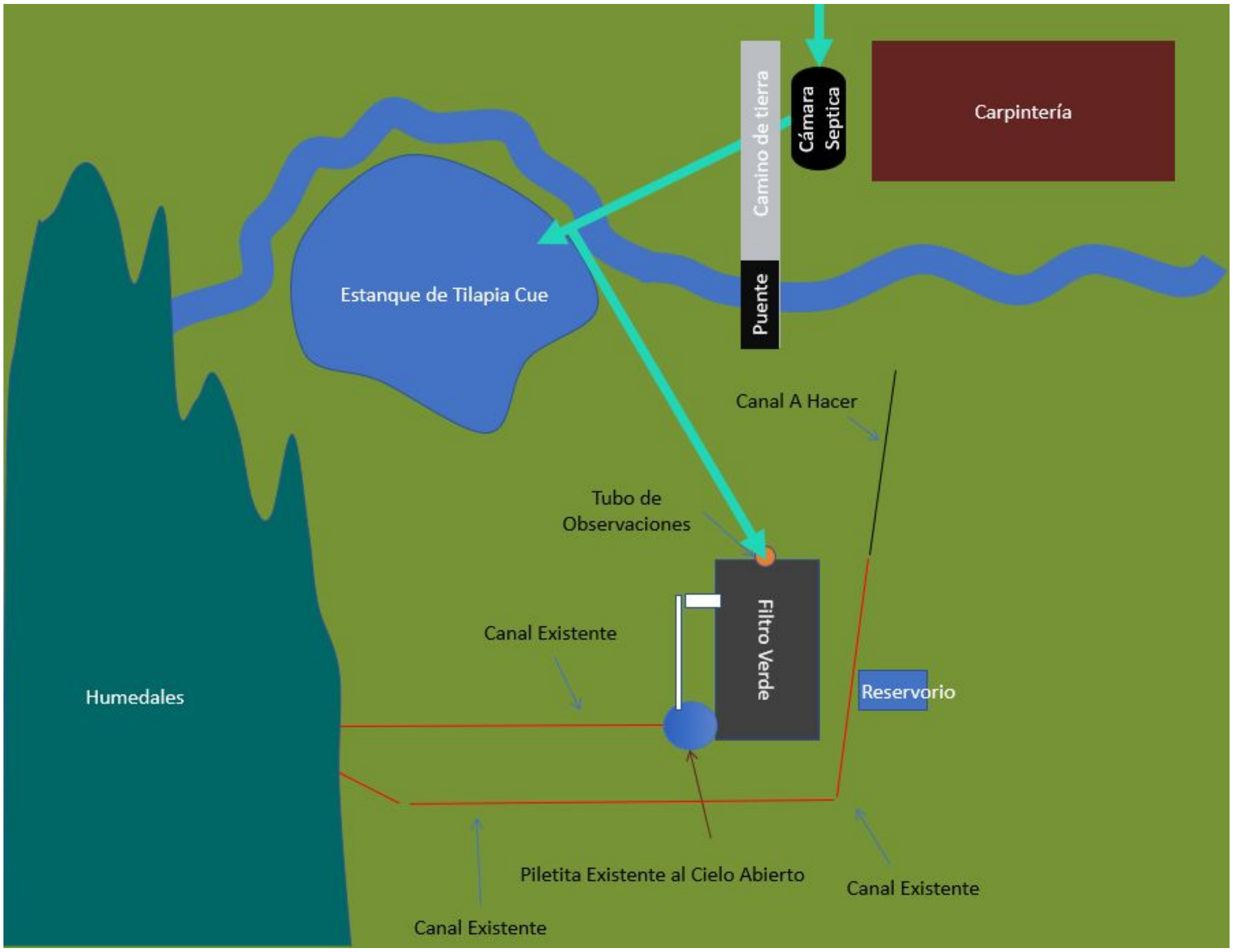

Figure 6: Leach Field Canal Proposal

By expanding and deepening these canals, groundwater will now move around the leach field in the external canal. Additionally, the improvement of the drainage canal exiting the system will help it drain faster. These two combined effects should help remove excess groundwater from the leach field. This will ensure that the majority of the water in the system is wastewater, allowing it to be treated and drained properly.

The elevation profiles of the proposed canals were examined through Google Earth and can be seen below and Figure 7 and Figure 8.

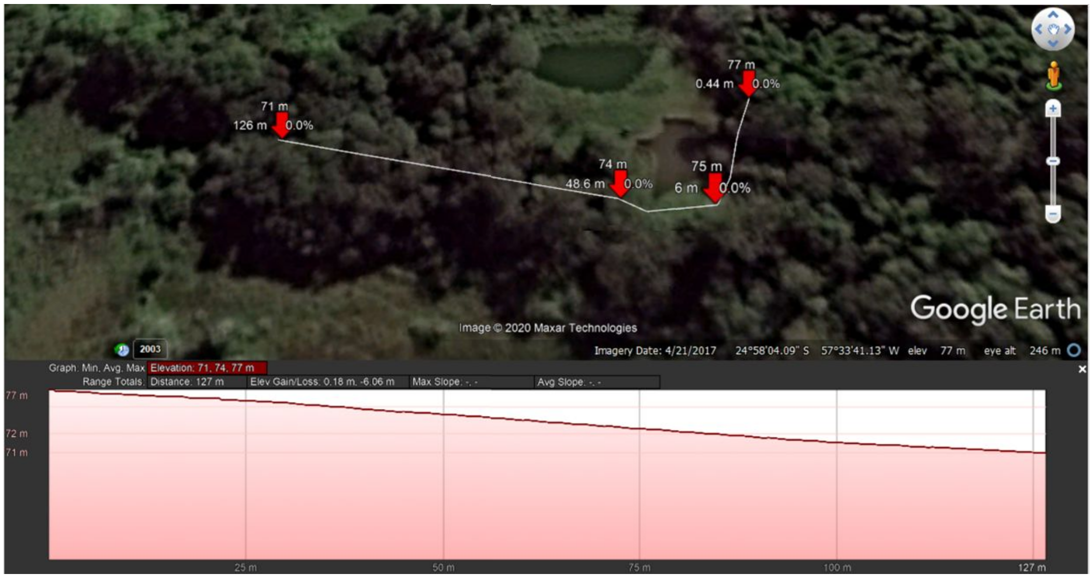

Figure 7: Outer Canal Elevation Profile

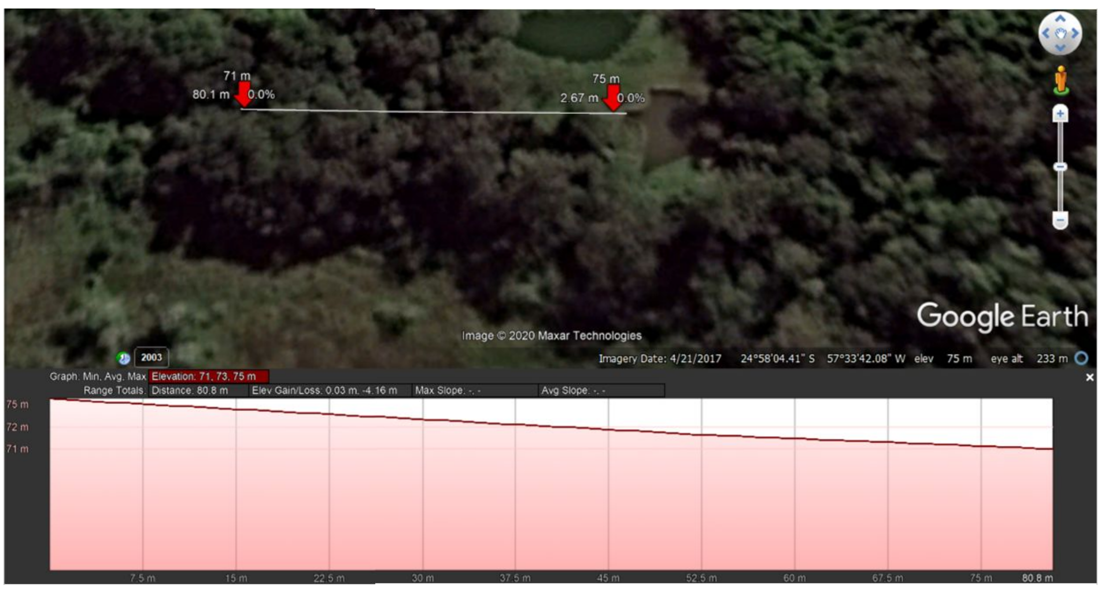

Figure 8: Drainage Canal Elevation Profile

As the figures show, the drop in elevation is over 4 meters in both cases. Given that the trenches only have to be 1.5 meters deep, this gives a net elevation drop of 2.5 meters or more for each trench. In both cases, the elevation drop compared to the horizontal distance traveled is greater than 2%, a value that yields sufficient water flow for landscaped areas (U.S. General

Services Administration 2019). Verifying these elevations was the final step in confirming the validity of the revitalization plan. The execution of the plan found in the discussion section of the paper is to be carried out by Prof. Borges and his students.

4.3 Lesson Plan

The goal of the lesson plan as a deliverable was to develop an educational unit for Prof. Borges to teach his students about wastewater treatment and usage. They have not yet been used in the classroom, however we look forward to hearing if they are successful. At the end of the three lessons, hopefully students will apply their knowledge at school and within their communities.

Prof. Borges and Eng. Salomón emphasized the importance of teaching the students about wastewater systems and were thrilled to include it in the curriculum. The first day also focuses on a brief introduction to water contamination and filtering. The success of this first day will determine student interest and involvement, prompting future plans to be adjusted as necessary.

The second day of the educational unit helps students gain familiarity with their school campus' wastewater system. After learning about septic tanks, leach fields, and cesspools, our maps will be shared with the students as a resource.

Finally, the third lesson plan challenges students to apply what they've learned to an out of class project. Students are encouraged to create their own wastewater treatment plan as a result of interviews, research, and provided criteria for a building. Our three finalized lesson plans can be seen in Appendix A.

4.3 Guidebook

The goal of the wastewater guidebook was to provide comprehensive maps with descriptions of each building's contribution, pictures of the system, and general information. As previously discussed, this guidebook was created based on our septic system map. Each page focuses on different campus buildings and their specific treatment of grey and/or blackwater before being released to the environment. Also included in the guidebook are photos of each building's treatment, whether it be a septic tank, cesspool, or something else. The appendices aim to address information applying to septic systems in general. They were developed from the team's previous research as well as input from our advisors and sponsors. The guidebook in its entirety can be seen in Appendix C of this report.

4.4 Environmental Compliance Report

The goal of the environmental compliance report was to provide an analysis of the school's wastewater system as it relates to Paraguayan law. The intended audience was La Fundacion Paraguaya in general as well as Director Florentín. Our findings indicate that the wastewater system is fully compliant with Paraguayan law and will most likely continue to be in the near future. The previous environmental audit already verified that the cesspool based treatment system was environmentally compliant but the addition of new and more effective treatment systems effectively demonstrate that the school is minimizing their environmental impact beyond what the law requires.

The cesspool and septic tank system meet the environmental regulations, but the broken leach field has remained an area of concern for many years. The law stipulates that this leach field can continue to be non-operational as long as some form of treatment is done to the school's wastewater before it is discharged into the environment and progress continues to be made to revitalize it. First, the leach field is fed by a septic tank that has treated the wastewater for years and has continued to do so since the leach field has broken down. Second, efforts are still made to make the leach field operational again. We have worked in conjunction with those who had firsthand knowledge of the leach field to create a plan that will make the leach field function again. These points allow us to make the determination that the wastewater system of La Escuela Agrícola is fully compliant with the law as it stands today. A summary of this environmental impact study can be found in Appendices D and E.

5. Discussion

For the most part, our results satisfied their intentions. The products aligned with our goals of increasing understanding of the system for all and suggesting possible improvements. This discussion expands on these improvements and provides future recommendations for both future IQP teams and La Escuela Agrícola. Although we haven't seen direct results for some of our deliverables yet, we hope that their use at the school will be helpful.

5.1 Mapping

The map successfully depicted all aspects of wastewater treatment throughout the campus and was incredibly helpful in developing our later deliverables. It sought to provide viewers with a general perspective of the wastewater system at the school. Due to the coronavirus, the team's ability to gain a visual of the campus and wastewater system was greatly impaired. Creating a visual tool helped the team in furthering the project and its goals. As much as the team worked on the maps, there is still a lot of work to be done. There are areas that still need extra information.

Certain buildings such as the animal barns and houses were not included in the maps the team produced. As the school continues to move and plan for the future, prospective infrastructure will also have to be accounted for on the map. One such project that should be added to the map is the new cheese factory that the school plans on building.

5.2 Leach Field Revitalization

The proposed trenches to revitalize the leach field will hopefully solve the leach field's problems, or provide some insight to another solution. The success of this leach field has been a challenge for La Escuela Agrícola throughout the past year. Developing the plan to de-flood it and allow it to work properly was a main objective of this project. The team believes the plan that was developed in collaboration with experienced locals will be effective in completing this task. After the completion of the plan, continuous maintenance will be required to ensure the canals don't become clogged from thick vegetation.

Even with proper maintenance and perfect execution of the plan, it is difficult to measure the effectiveness of the canals given that the team was not on site due to the impacts of COVID-19. Even Prof. Borges can not execute the plan until after the pandemic has ended and stay at home orders are lifted. With that being said, there is a possibility that the flooding of the leach field due to excess groundwater is not the only problem causing its failure. It is difficult to assess what these other problems could be and how to solve them at this time. At the very least, the completion of this plan should be a significant step forward in the revival of the leach field. There may be further action required beyond the scope of this project by the staff of La Escuela Agrícola and/or by future WPI students to ensure the sustainable success of the leach field.

5.3 Lesson Plan

The lesson plan created in collaboration with Prof. Borges was successful in coming up with unique ways to teach students about wastewater and its treatment. Overall, Prof. Borges was incredibly satisfied with our drafts, and looks forward to conducting them in his class. Of course, he knows his students best and will adjust our suggestions as necessary. Since these have yet to be conducted, it is difficult to analyze the outcome. We hope that the students are inspired by this experience to become more involved in their school's sustainability mission.

If the lesson plans are deemed successful, more could be created. They could be expanded to analytically investigate water quality, system efficiency, and more.

5.4 Guide Book

The goal of this guidebook is to act as a resource for anyone at La Escuela Agrícola who is not entirely familiar with septic systems to have access to pertinent information in one document. By increasing overall awareness, the system has potential to be better taken care of. Currently, all information pertaining to the system and how it works is stored in Prof. Borges' head. Although his expertise and familiarity is an incredible tool, accessibility to this information can be difficult. Conveying details to someone new, perhaps an incoming director, would require extensive amounts of time and effort. The wastewater guidebook describes each building's individual contribution to the system, making it simpler to understand than a description of the full campus' system. Depending on the reader, their knowledge regarding septic systems may be limited, hence emphasizing the need for our appendices.

Although our guidebook contains plenty of information, there are areas that could be expanded on. For example, specific information about volume and maintenance procedures could be added. If this document does become a widespread resource, there is significant potential for additions.

5.5 Environmental Compliance Report

Our environmental compliance report verifies the environmental compliance of the school's wastewater system as it stands today and should be reevaluated often. The school must reassess their compliance whenever a new waste-handling structure is added to the business. We know that there are additions planned for the near future such as the cheese factory, but those currently exist only in blueprint form. We can expect them to stay that way for a long while since the COVID-19 virus has caused many businesses to halt their new projects. It is also possible that even though the school may not change their wastewater treatment system, a new regulation may be passed by the Paraguayan government that could cause the school to fall out of compliance. Following relevant laws is crucial to avoiding fines and other consequences.

6. Recommendations

In conjunction with advisors and experienced locals, the team was able to accomplish many goals and deliverables of the project. However, there is still room for improvement and revaluation of wastewater at La Escuela Agrícola. The recommendations described below highlight some areas where the team believes future improvements could be impactful. These recommendations for the system include further investigation of water quality and volume, expanding treatment capacity, proper preventative maintenance, and developing a long-term plan.

The first recommendation is to further investigate the wastewater system. Originally, our group had the intention of visiting Paraguay and performing qualitative tests on the system.

However, due to unforeseen circumstances of a global pandemic, our plans changed. If this project were to continue, students are encouraged to make use of the dye tablet purchased for our team (McMaster-Carr 2020). These tablets assist in evaluating system effectiveness by visualizing where wastewater ends up. Ideally, there are no leaks or failure points, but in most cases this is not true. By understanding surface wastewater presence throughout campus, the system can be updated to reflect the school's sustainability goals.

The second recommendation the team had relates to expanding the capacity of the system to match the growth of the school. A growing school requires a constantly growing wastewater treatment system. Because of this, the team recommends that the school consider adding treatment capacity with each new building that is added to the campus. Additionally, an analysis of the current capacity usage for each building and treatment center would be beneficial to indicate what areas may already be over capacity. To reduce administrative issues and keep all staff moving together, we recommend communicating with Prof. Borges and including wastewater maintenance as part of the annual operating budget for the school.

The third recommendation involves proper preventative maintenance of the system. For example, the school should evaluate what materials are going into the drains of the wastewater system. The kitchen is a critical place to start since there are many different cooking supplies and waste that could potentially be harmful to the septic tanks, the leach field, and system as a whole. Other important factors to examine for their potential impact to the wastewater system include but are not limited to: soaps, cleaning supplies, laundry detergent, solid food waste, grease, fat etc. In all cases, this team recommends using the most biodegradable option possible for two reasons. The first reason is that much of the school's wastewater exits the system through septic tanks and cesspools only, meaning it may not be completely treated when it enters the environment. Non-biodegradable substances could affect the ecosystem of the surrounding areas. On top of that, for the buildings that are serviced by the leach field, non-biodegradable material can potentially be harmful for the microorganisms in the sand that treat the water. Solid material can easily block and clog the leach field, causing it to fail again. Using biodegradable options for any material going into the system is the best way to avoid these problems. Preventative maintenance plans like this will reduce the number of repairs the system needs.

The final recommendation from the team is to develop and maintain a long term plan for the system. As the school continues to grow and expand, the current system will eventually become very difficult to maintain. As can be seen by the map of the system, there is very little consistency in treatment of the wastewater or the locations of treatment centers. Additionally, there is a huge quantity of treatment locations that will only continue to grow. As a result, this team recommends that the school begin to look at alternative treatment systems for the future. An important action to drive this conversation will be the inclusion of Prof. Borges in meetings with leadership at the school related to the Five Year Plan that they have. This will help the school strategically budget and plan the growth of the wastewater system.

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Appendix A: Wastewater Educational Unit

The following appendix contains the complete Wastewater Lesson Plan developed for Professor Borges and his class. The lesson plan was created to provide Professor Borges with material and activities to teach students about the use of water and wastewater in their own lives and around the campus. The lesson plan was made using a profession template and the objectives and recommended times for each day and activity are listed. The lesson plan is written in Spanish. Though the team does not expect Professor Borges will follow the lesson plan minute for minute, we hope that the ideas and activities will be useful templates that he can adapt to his classroom.

Plan de estudios día 1: Agua en general

Objetivos para este día y lecciones:

Aquí se informará a los estudiantes sobre el propósito de esta lección y lo que se espera que aprendan y hagan.

1. Comprender la importancia de agua en general como un recurso valoroso
2. Diferenciar los tipos de aguas residuales y sus fuentes
3. Comprender el propósito del tratamiento de aguas residuales
4. Crear un sistema de filtración

Parte Uno- una discusión sobre agua en general basado en conocimiento previo (5 minutos)

Preguntas:

1. ¿Por qué es importante el agua para nosotros?
2. ¿De dónde viene nuestra agua potable?
3. ¿Cómo varía el acceso al agua en las diferentes comunidades?
4. Dime lo que sabes sobre el ciclo del agua.

Un resumen de respuestas:

- Agua es un recurso valioso
    - Lo usamos para todo
- nuestra agua potable viene del subsuelo
- desafíos que enfrenta la gente para obtener agua limpia

- la misma cantidad de agua ha estado en la tierra por siempre

Parte Dos- actividad sobre hábitos personales de los alumnos (10 minutos)
Los estudiantes entenderán cuánta agua usan diariamente aproximadamente.
Aquí hay una tabla de muestra para mejorar.

¿Cuánta agua usas en un día?

Acción	Veces por dia	Más o menos la cantidad de agua (litros)	Cantidad total de agua utilizada diariamente para este acción
lavando los manos/ la cara		4	
una ducha		95	
se cepillando los dientes (sin agua corriendo)		1	
Tirar el inodoro		15	
Beber agua		8	
Lavando los platos por mano		1	
Lavando la ropa		114	
Regando las plantas		757	

Ahora, considera animales en su vida….

Animal	Consumo Diario de Agua
Cow	57
Pig	7
Goat	8
Chickens(100)	23

Nota: Estos números son estimados y no representan todo el uso de agua que usan los humanos. Los alumnos pueden conversar sobre otras situaciones donde usan agua ya sea diario o no. También, si el profesor lo desea, los estudiantes pueden colectar una representación física de cada litro de agua, como una piedra. Podrían hacer una pila para ver cuánta agua usan. También, podría ser útil mostrar un litro de agua.

Parte Tres: una discusión breve sobre contaminación de agua y un lección sobre tipos de aguas residuales (10 minutos)

Preguntas:

1. ¿Cómo se contamina el agua?
2. ¿A dónde va el agua cuando terminas de usarla? Por ejemplo, agua del baño
3. ¿Por qué es importante devolver agua limpia al medio ambiente?

Resumen:

- el agua puede estar contaminada con productos químicos, residuos de humanos y animales, y muchas más
- No desaparece, va a las cámaras sépticas, poco ciegos, el aire libre, más sobre esto más tarde
- Enfermedades, el medio ambiente, etc

Después de esta discusión, el instructor les enseñará a sus alumnos sobre los tipos de aguas residuales incluyendo aguas grises, negras, y limpias.
El instructor tendrá tres recipientes diferentes para representar el agua limpia, gris y negra y pedirá a los estudiantes que hagan observaciones sobre las diferencias entre los tipos de aguas residuales y que den una breve descripción de cada tipo y, por lo general, de lo que contienen.
El instructor le dirá a los estudiantes cómo se combinan las aguas grises y negras para un tratamiento adicional en el sitio para que pueda regresar al medio ambiente lo más limpio posible.

Parte Cuatro: Una evaluación/actividad de comprensión
Los estudiantes mostrarán lo que han aprendido. Aquí los estudiantes piensan sobre tantas fuentes como puedan pensar de agua gris y negra. Esto también podría ser una actividad de clasificación para más actividades interactivas.

Parte Cinco: Actividad de filtración (10 minutos)
En este parte de la lección, estudiantes pueden ganar una introducción breve a las sistemas sépticas y como funciona, especialmente sobre la importancia de filtración y separaciones.
Los alumnos, en grupos pequenos, crearán su propia sistema de filtración y harán observaciones.
Antes de la lección, un modelo de agua sucia estará preparado con aceites, suelo, basura.

Es importante que haya ejemplos de aguas limpias y también el original para usarlos como los controles.
Materiales:

- Una botella que no tiene el fondo o una tapa
- Algodón
- Arena
- Piedras
- Grava
- Algo para colectar los aguas sucias
- Algo para colectar los aguas filtradas
  Los estudiantes filtrarán aguas a través de su botella lleno de materiales como les gustaría y comparará el resultado final al inicial agua sucia

Parte Seis: Conclusión
Si el tiempo lo permite, haga que los estudiantes reflexionen sobre lo que aprendieron y cómo podría aplicarse al tratamiento de aguas residuales en sus hogares y en La Escuela Agrícola.

Plan de estudios Día 2: Tratamiento de aguas residuales

Objetivos para este día y lecciones:

1. Entender los tipos de tratamiento de aguas residuales en el campus y cómo funcionan
2. Aplicar sus conocimientos aprendidos a un mapa
3. Leer un mapa de elevación

Parte uno: Revisa la información en las clases previos (5 minutos)

a. Preguntar a los estudiantes: Que aprendimos ayer? A donde va el agua y que es la importancia de separación y filtración de aguas residuales?

Parte dos: Esta discusión conducirá a una explicación de tanques sépticos, pozo ciegos, filtros verdes, y registros (15-20 minutos)

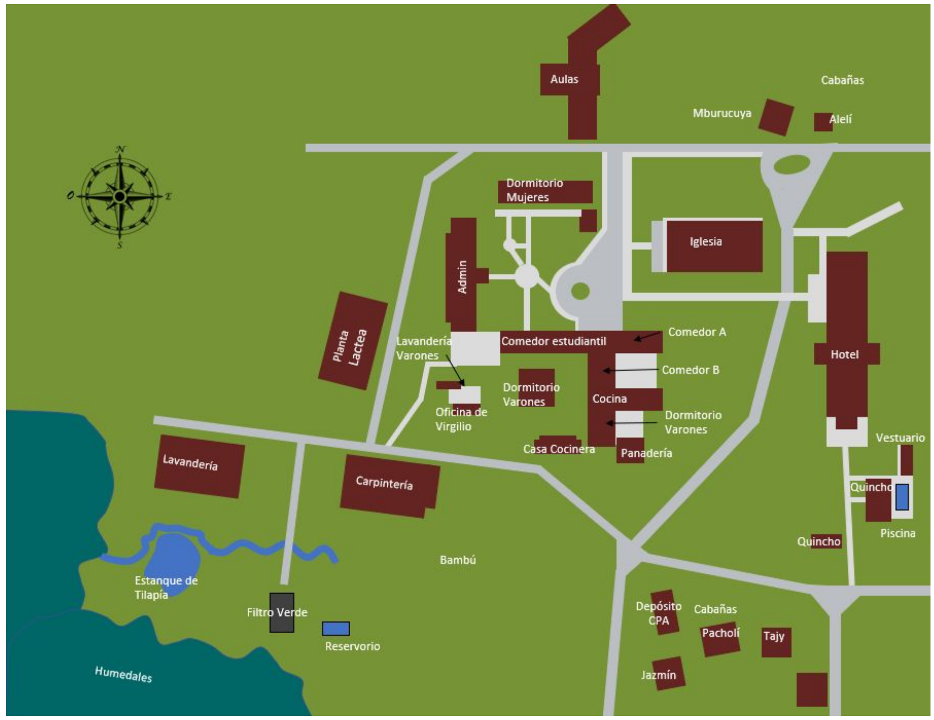
b. Mostrar fotos y diagramas de estas partes
c. Separar a los estudiantes en equipos de 4, los estudiantes deben conversar sobre cómo las partes funcionan.
d. Después de la discusión en equipos, el profesor preguntará a los estudiantes sobre cómo funcionaron.
e. Clarificar y explicar cualquier idea que los estudiantes no aprendieron

Parte tres: Actividad en clase (15-20 minutos)

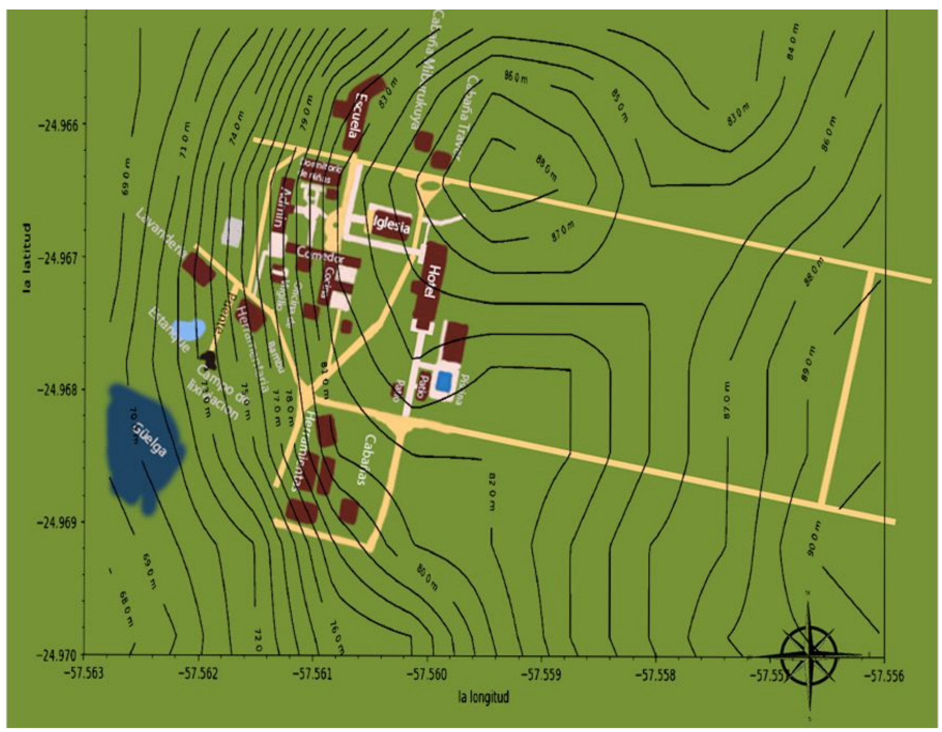
f. Explicar la actividad

i. Separar los estudiantes en los equipos de 4 y darles 2 mapas

1. Un mapa del campus con edificios



2. Un mapa con el perfil de elevación



g. Explicar el perfil de elevación en el mapa y el efecto que tiene sobre el agua.

h. Tendrán 10 tanques sépticos, 6 pozo ciegos, 8 registros, y 2 filtros verdes. Los estudiantes deben dibujar donde piensan estas estructuras encajan mejor.
i. Pueden dibujar tuberías ilimitadas pero es requerido que los estudiantes usan la menor cantidad de tuberías.
j. Fomentar los estudiantes a recordar los siguientes criterios:
    i. Elevacion
    ii. Terreno
    iii. Volumen y tipo de agua
    iv. Coste
    v. Simplicidad de mantenimiento

Preguntar cada equipo que dibujaron en un región específica. Los estudiantes deben explicar por qué eligieron a poner ciertas estructuras.

Plan de estudios día 3: Mantenimiento y Proyecto

Objetivos para este día y lecciones:

1. Aprender la importancia del mantenimiento de sistemas de agua
2. Tendrán mantenimiento y sistemas de tratamiento en la mente si eligen crear su propio sistema en casa.
3. Tener un fuerte compresión de tratamiento de aguas residuales en el campus

Parte Uno: Repasa el dia anterior
5 min: Preguntas para discutir
¿Los estudiantes pueden recordar los tipos de tratamiento de aguas ya discutido en clase?
¿Se pueden recordar cómo trabajan estos sistemas?

Parte Dos: Discusión sobre la importancia de la importancia del mantenimiento
10 min: Aplicaciones en la comunidad
Repasa los planes de tratamiento presentes en la escuela y intenta de formar un costo para construir cada uno. Permite que los estudiantes piensen de maneras de hacer tratamiento más barato.

Cuando los estudiantes tengan una idea del costo de hacer un sistema, piensa de cómo implementar un sistema en sus comunidades o hogares. Anime a los estudiantes a hablar sobre los sistemas que usan en sus hogares y cómo creen que funcionan.

Parte Tres: Discusión sobre técnicas de mantenimiento
10 min: Mantenimiento

Repasa formas de mantenimiento que sean simples pero efectivos. ¿Si no hubiera mantenimiento, que pasara?
Ejemplos pueden incluir cómo la escuela mantiene sus sistemas de aguas residuales (trampa de grasa en la cocina, filtros de sedimento en el filtro verde, limpieza de los pozos ciegos y las cámaras sépticas).
El profesor puede mostrar fotos de sistemas sépticos fallidos.

Parte Cuatro: Proyecto
15 min: Explicación del proyecto: Resuelve el crisis
Divida los estudiantes en 4 o 5 grupos, dependiendo en el tamaño de la clase, y asigna a cada grupo un edificio. Estos edificios pueden ser de La Escuela Agrícola o un edificio bien conocido por los estudiantes. Deja que los estudiantes tengan una oportunidad para identificar los problemas y que propongan sus soluciones ahora que saben cómo sirve el tratamiento de agua. Estas soluciones podrán variar porque cada grupo tendrá su propio edificio.
Ejemplos de edificios incluyen los del campus como el hotel, comedor y cocina, dormitorios de mujeres, dormitorios de varones, edificio de administración. Otros edificios pueden ser una panadería pequeña o un hogar.
Presenta a los estudiantes su misión:
"Alerta! [edificio] no tiene forma de tratar sus aguas residuales y está dejando todo atras del edificio. Para proteger la salud del público, tienes que averiguar cómo deshacerse de todo sin peligro a la gente.
Averigua qué materia sale del edificio, como tratarlo, y cómo se debe deshacer de los residuos. Puedes usar sistemas de tratamiento que no se han explicado en esta clase si será aplicable.
EXTRA: Trata de encontrar una solución que arregla todo pero con la menor cantidad de recursos."

Los estudiantes tienen que identificar las fuentes de aguas residuales en el edificio y sus componentes *(baños y agua negra, lavabos y agua gris)*. Un dibujo de donde pondría su sistema y/o donde dejarán los residuos finales podrá ser una ayuda para que los estudiantes puedan organizar sus ideas.

Parte Cinco: Actividad [continuación del proyecto]
~ min: Presentar los resultados
Después de segurar una manera para proteger la salud del público, deja que los estudiantes presenten sus soluciones a la clase. Cada edificio tuvo problemas únicos entonces cada grupo tendrá una explicación o solución única.

Appendix B: Wastewater Educational Unit (English Draft)

The following appendix is an early draft of the Wastewater Education Unit, written in English. The draft differs slightly in content from the final version in Spanish and was not polished to perfection. We hope it provides a resource for the non-spanish reader who may wish to know what information was in the educational unit.

Lesson Plan Day 1: Water Crash Course

This lesson plan is loosely based on Madeline Hunter's Lesson Plan Format which Rebecca's mom often used during her teaching career.

Objectives

Here students will be made aware of the purpose of this lesson and what is expected for them to learn from it

The objectives for this lesson are as follows:

1. Understand the importance of water as a valuable resource
2. Differentiate types of wastewater as well as their sources
3. Have a broad understanding of on site wastewater treatment and its purpose
4. Create a filtration system to understand the role of separations in wastewater treatment

Getting students set to learn:

Step 1: Review

Since this is the first day of instruction regarding wastewater treatment in general and La Escuela Agrícola this step will be focused on previous knowledge.

5 minutes: Group Discussion (can be small groups or as a class) based on water in general and contamination answering these questions:

- Why is water important to us?
- Where does our drinking water come from?
- How does access to water vary in different communities?
- What do we know about the water cycle?

2 minutes: Summary of answers

- Water is a valuable resource for life as we know it on earth- we use it to keep us healthy, grow plants, personal hygiene, and more
- Our drinking water comes from underground
- Some people encounter many obstacles when it comes to getting fresh water- ex walking miles, contamination, restrictions

- The same amount of water has been on this planet since it started and is cycled through many forms like clouds, rivers, rain, etc

Step 2: Anticipatory Set
The purpose of this step is to get students interested in what they are about to learn through a combination of discussions and hands-on activities.
10 Minutes: Personal Water Usage Activity
In this section of the lesson, students will become aware of their personal water use by saying how many times a day they do a certain action involving water and a rough approximation of how much water that takes. This will hopefully help students understand their personal impact. See sample table below (idea from https://assets.ctfassets.net/7qonaq6zrtkb/522GJtDs1W6UsywCaCkwC4/17e78fd8840df573237e7070ca8140ff/Water_Challenge_Curriculum_FNL.pdf)

How much water do you use in a day?

Action	# of times per day	Amount of water per day (liters)	Total amount of water each day used for this task
Washing hands/face		4	
Taking a shower		95	
Brushing teeth (without water running)		1	
Flushing the toilet		15	
Drinking a glass of water		8	
Washing Dishes (by hand)		1	
Doing Laundry		114	
Watering plants		757	

Now consider animals in your life…

Animal	Daily water consumption
Cow	57

Pig	7
Goat	8
Chickens(100)	23

Source: https://www.engineeringtoolbox.com/farm-use-animals-water-consumption-d_1588.html

Note: The above estimated values for the estimated amount of water used are approximate and could be adjusted to more closely represent systems in Paraguay. The student could discuss other places where they may use water, whether daily or not. Also, if time allows perhaps students could have an object to represent a liter of water used like a rock to have a visual representation of this?

Instruction:

Step 3: Input and Modeling

Presenting new information to students in whatever form that may be

5 min: Group Discussion

Students will be broken into groups to discuss the following questions:

- How can water become contaminated?
- Do you have any idea where water goes once you're done with it? For example flushing the toilet?
- Why is it important to return clean water to the environment?

2 min: Summary of answers:

- Water can be contaminated with chemicals, human/animal waste, minerals, cooking remnants, and many more
- Sure it goes somewhere you don't see it but it definitely doesn't disappear
- We are so reliant on water and could become sick from contaminated water and it is also bad for the environment and ecosystems everywhere

5 min: Understanding types of water demonstration

The instructor will have three different containers to represent clean, grey, and black water and ask students to make observations about the differences between the types of wastewater and give a brief description of each kind and usually what is in them.

The instructor will tell students how both grey and blackwater are combined for further treatment on site so it can return to the environment as clean as possible.

Checking for Understanding:

Step 4: Checking Understanding

5 min: Comprehension Activities

In this activity students will try and come up with as many sources of grey and black water as they can think of and what classifies them into that category. This could also be a sorting activity where students are given a piece of paper with different images on it that they have to cut out and place in the right section

2 min: Review of Activity
Here the instructor will provide a brief description of sources that students may be familiar with that provide grey and blackwater

Step 5: Guided Practice

10 min: Filtering Activity
Similar to the discussion on different types of wastewater this activity will help students understand the role of separations in wastewater treatment.
Inspiration from: https://www.rivanna-stormwater.org/treatment.pdf
And
https://www.caryinstitute.org/eco-inquiry/teaching-materials/water-watersheds/broken-water-cycle/where-does-our-water-go
This activity can be done by students in groups that either create their own filtering system or a precreated one and following directions to put it together and make observations
A fake "dirty water" with oil, debri, soil will be prepared prior to the lesson to save time
Make sure there is a control cup of clear water
Materials:

- Plastic bottle with bottom cut off and lid off
- Large cotton balls
- Sand
- Gravel
- Rocks
- Cup to collect dirty water
- Something for filtered water to go into
  Have students filter a small amount at a time (or large and let them see what happens) and notice how the appearance of the water changes by their creation.
  Students will be encouraged to build their own filter arranging the above materials however they would like

Independent Practice
Step 6: Independent Practice
This will be used as a segway to the next class
If time allows, have students reflect on what they learned and how it could be applied to wastewater treatment at their homes and at La Escuela Agrícola.

Lesson Plan Day 2: Design a Wastewater System

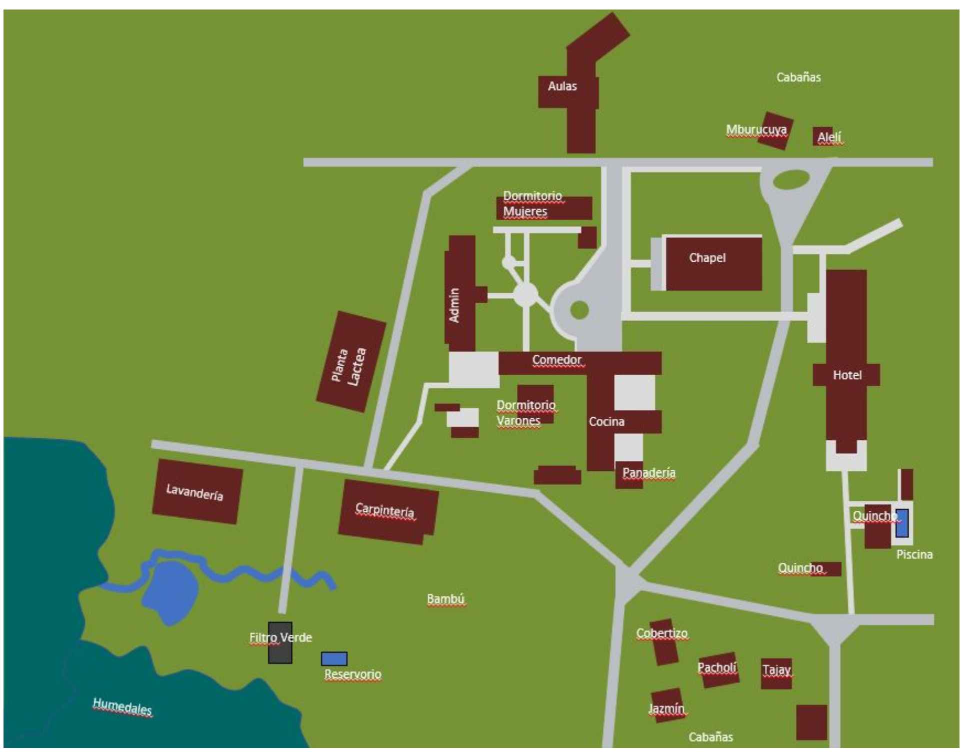
Step 1: Review information in Day 1
5 min: Provoking questions
What did we learn yesterday?

Where does the water go and what is the importance of separation and filtration?

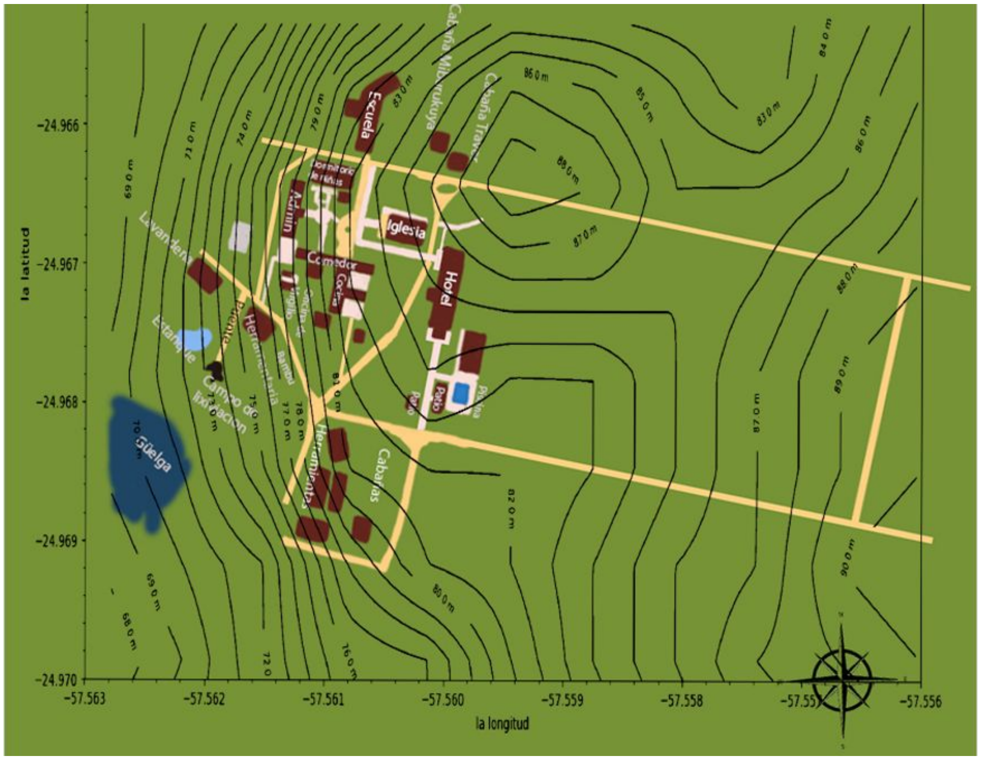
Step 2: Treatment Centers Activity
10 min: Display and Discuss Treatment Centers
Break the students off into groups of four. One by one, display pictures and diagrams of a septic tank, cesspool, leach field, and registro. For each picture have the students discuss what the purpose of the object is and how it might work. For each picture, choose one group to present their thoughts to the class briefly. Following the student mini-presentation, the professor will fill in any gaps before moving to the next treatment center.

Step 3: Wastewater Mapping
15 min: Class Activity
Break students into groups of four and each group will be given two maps of campus

I. A map with the buildings and grounds



II. A map of the elevation profile



The objective of the assignment is to get each group of students to design their wastewater treatment system for the campus. Each group will have an allotment of 10 septic tanks, 6 cesspools, 8 registros and 2 leach fields that they can strategically draw on the map with buildings. The students are allowed to draw unlimited pipes to connect the treatment centers to each building, but encourage them to use as little piping as possible.

Encourage students to keep the following criteria in mind

- Elevation
- Terrain
- Volume and type of water
- Cost
- Ease of Maintenance

Step 4: Presentation and Discussion

10 min: Group mini presentations on what their map looks like

Have each group of students give a brief 2 min presentation about their maps. Provide constructive feedback for each group where possible.

Lesson Plan Day 3: Solve the Crisis

Step 1: Quick Review

5 min: Discussion Questions

Can the students remember the types of water treatment systems already discussed in class?
Can the students remember how those systems work?

Step 2: Activity
15 min: Solve the Crisis
Split the students into 4 or 5 groups, depending on the number of total students, and assign each group a building. These buildings can be on campus or in the neighborhood. Allow the students an opportunity to identify the issues and then propose solutions now that they know how water treatment works. These solutions will vary depending on the campus building each group has been given.
Possible buildings include campus locations such as the hotel, kitchen complex, girls' dormitories, boys' dormitories, administration building. Buildings may also include simple locations such as a small bakery or home.
Present the task to the students:
"Crisis Alert! The [location] does not have a waste treatment system and is piling all their waste behind the building. To save the health of the public, you must find a way to get rid of the waste safely.
Determine what waste comes out of the building, how to treat it, and how the resultant waste product should be handled. You may research and use treatment methods that have not been discussed in class if applicable.
EXTRA: Try to find the way to fix the issue with the least amount of materials."

Students must be able to identify both the sources of wastewater in the building and its general components *(bathrooms and blackwater, sinks and greywater).* A simple sketch of where their system would be placed and/or where the waste would travel is a useful tool for the students to organize their thoughts.

Step 3: Activity: Solve the Crisis [continued]
5 min: Presentation
After finding a way to secure health and safety by treating the waste, have the students present their ideas to the rest of class. Each building had a unique waste profile so each team should have some unique solution or explanation.

Step 4: Discussion
7 min: Look towards the community
Review the types of treatment plans thought of by the students and go over a rough cost. Have the students try to think of any ways to make them more affordable.
Review the types of treatment systems already in place at the school (from Day 2).

Once the students have an idea of the cost to make a system, think of how to implement them in their own communities or homes.

Step 5: Discussion

8 min: Maintenance
Provide an overview of simple, effective maintenance. If maintenance was not there, what would happen?
Examples may include how the school maintains its own wastewater system (grease traps in the kitchen, sediment filters in the green filter, regular cleaning of the cesspools and septic tanks).

Illustrate the importance and cost savings provided by regular maintenance
Examples may include cost of filters vs. cost of replacing a system,

Appendix C: Wastewater Guidebook

The following appendix is the complete wastewater guidebook that was developed as a key deliverable for this project. The intent of the guidebook was to provide a resource for new directors, maintenance managers, or other school faculty who wanted to know more about the system. Professor Borges also indicated that students could use the guidebook to help them give directed tours of the campus to guests. It contains pictures and maps of the locations of treatment centers around the campus as well as descriptions of the different types of wastewater at each location and where it goes. At the end, there are appendices that explain some general information about wastewater. The guide was drafted and written in spanish, so there is no english copy or draft.

La Escuela Agrícola de San Francisco Guía de Aguas Residuales

Agencia Patrocinadora: La Fundación Paraguaya
Asesores: Dr. Robert Traver, Mrs. Dorothy Burt, Professor Virgilio Borges, Ingeniero José Luis Salomón

Juan Arreola
Jacob Borges
Rebecca Dawley
Gregory Kaleshian
04 Mayo 2020

Tabla de contenido

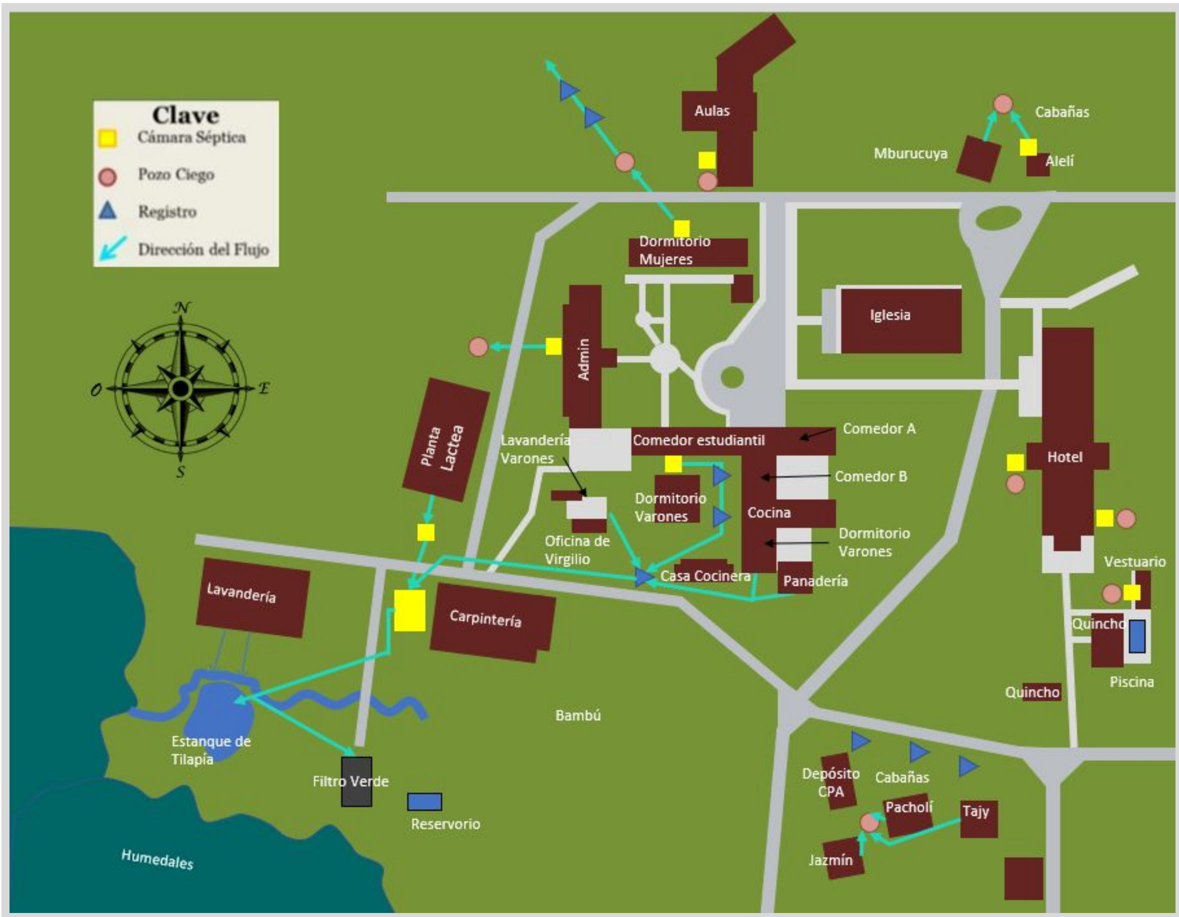
Bienvenidos a La Escuela Agrícola en Cerrito, Paraguay! Siguiente es una guía sobre aguas residuales y sus tratamientos, especialmente con respecto a este campus durante la primavera de 2020.

La Escuela Agrícola tiene un sistema descentralizado que significa que todos los aguas residuales se tratan en el sitio. Este concepto es popular en áreas rurales por todo el mundo. La meta principal de tratamiento de aguas residuales es reutilizar aguas sucios en la tierra. Obviamente, hay muchos opciones para completar el proceso en total. Los sistemas a la escuela eran diseñados para ayudar con esfuerzos y metas de sostenibilidad en mente. Es importante tener el cuidado apropiado de toda la sistema. Aunque puede no ser obvio, los microorganismos hacen posible el tratamiento. Todas las personas de la escuela y el hotel también deben tener en cuenta lo que entra en el sistema, como jabones, grasa y muchas más.

Esta guía comienza con un mapa del campus y una descripción breve de todos los edificios con sistemas de tratamiento de aguas residuales de todos tipos. Si hay alguna confusión sobre cómo los aspectos de la sistema funcionan o otra información lo más probable es que se encuentre después del mapa. También, Profesor Virgilio Borges tiene toda la información en su cabeza!

El principal objetivo de esta guía es para tener toda la información de tratamiento de aguas residuales en un lugar por la administración. A veces es difícil para entender los ubicaciones de ciertos aspectos de esta sistema y esperamos que esto ayude!

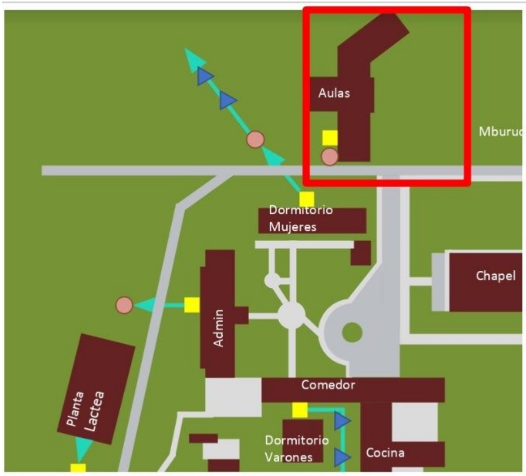
Mapa de la escuela



Las Aulas

Aquí se debe incluir fotos generales de las aulas (fotos reconocibles)

En el mapa:

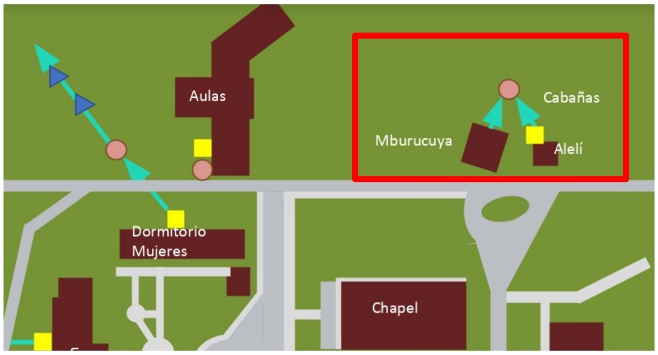


En este edificio, hay un baño pequeño para los profesores de la escuela. Este baño tiene un inodoro y un lavabo. Los aguas residuales (principalmente negras) salen el edificio y va a una cámara séptica (cuadrado amarillo) y luego a un pozo ciego (círculo rosa). A partir de Abril de 2020, Prof. Virgilio nunca ha tenido que limpiarlo.

cámara séptica y pozo ciego del edificio académico

Cabañas Nortes (Mburucuya & Alelí)

Aquí se debe incluir fotos generales de las aulas (fotos reconocibles)

En el mapa: 

Este grupo pequeño de cabañas tiene aguas grises y negras. Primero, la Cabaña Mburucuya no tiene una cámara séptica. Los aguas residuales de aquí van directamente al pozo ciego (círuclo rosa). En cabaña Alelí, aguas grises y negras van a su propia cámara séptica (cuadrado amarillo) primero y luego al pozo ciego que is compartido con el otro. Las flechas azules muestran el flujo de agua cuesta abajo. Los dimensiones del pozo ciego no se conocen porque fue construido hace 40 años más o menos. A partir de Abril de 2020, Prof. Virgilio nunca ha tenido que limpiarlo.

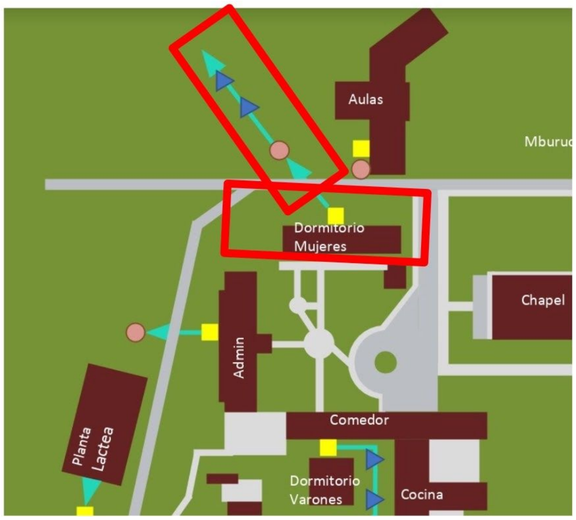
 

cámara séptica (izquierda)
pozo ciego (derecha) Allelí

Pozo Ciego de Mburucuya

Los Dormitorios Mujeres

Aquí se debe incluir fotos generales de las aulas (fotos reconocibles)

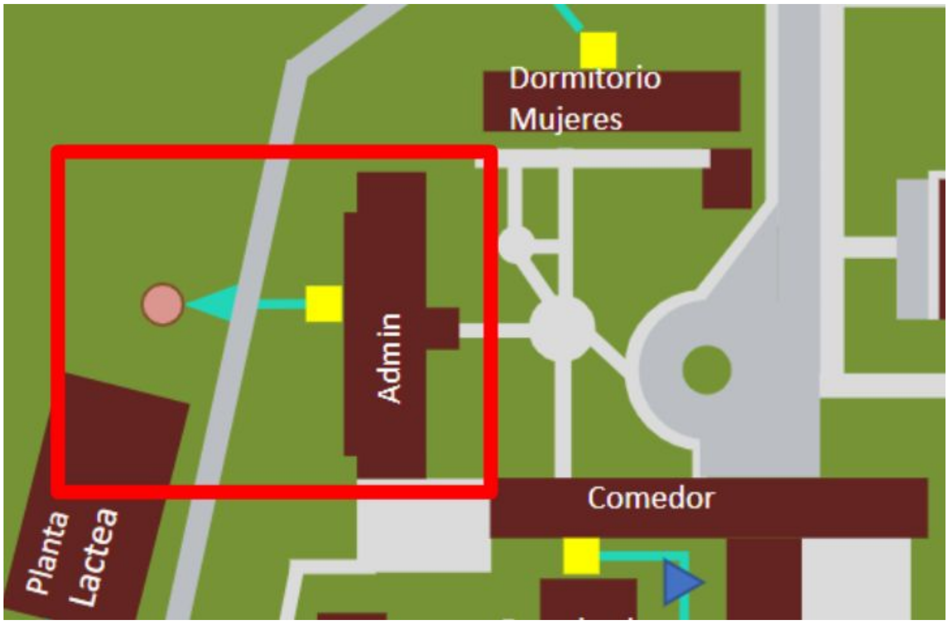
En el mapa: 

Este edificio obviamente tiene efluentes de duchas, inodoros, y lavabos. Los efluentes van a una cámara séptica (cuadrado amarillo). Hay tubos debajo del camino que trae los aguas residuales a un pozo ciego (círculo rosa). Después de eso, hay un válvula de huida en caso del sistema rebosa. Se puede ver esta característica en la línea azul con triángulos en el mapa. A partir de Abril de 2020, Prof. Virgilio nunca ha tenido que limpiar este pozo ciego, aunque hay 60 mujeres que viven aquí. Se asume que el agua del pozo ciego fluyen en las tierras bajas.

cámara séptica y pozo ciego de los dormitorios mujeres

Administración

Aquí se debe incluir fotos generales de la administracion (fotos reconocibles)

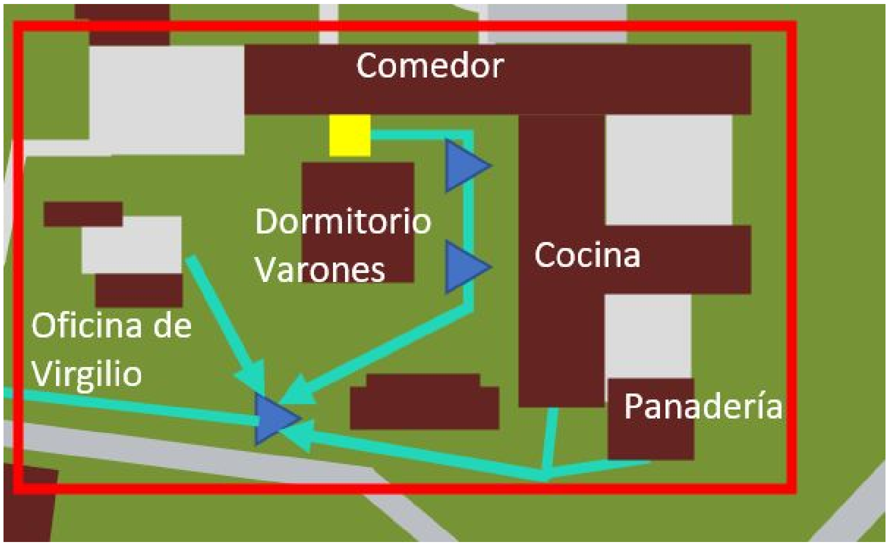
En el mapa: 

En este edificio, hay baños con duchas, inodoros, y lavabos para los profesores de la escuela. Hay cocinas en los apartamentos ubicados en el segundo piso del edificio. Los aguas residuales (principalmente negras) salen el edificio y va a una cámara séptica (cuadrado amarillo). Los aguas viajan debajo del camino y luego a un pozo ciego (círculo rosa). Este pozo ciego construido hace 4 años. A partir de Abril de 2020, Prof. Virgilio nunca ha tenido que limpiarlo.

cámara séptica y pozo ciego de administración

Edificios Centrales

Aquí se debe incluir fotos generales de los edificios centrales (fotos reconocibles)

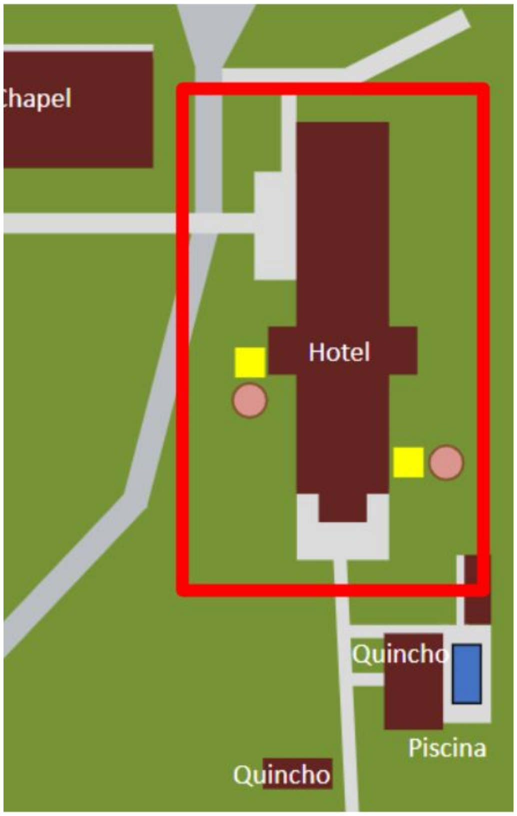
En el mapa: 

En esta sección, hay varios grupos de edificios que usan las mismas cámaras sépticas, tuberías y registros. Primero, el **comedor** consiste en un fregadero donde los estudiantes y los invitados se enjuagan y lavan los platos después de la cena. Produce aguas grises que van directamente a la cámara séptica al sur del comedor. También entrando directamente a esta cámara séptica está el agua del **dormitorio varones**. Esto es agua negra que viene de los baños y se hunde en los dormitorios varones. Desde la fosa séptica, el agua del comedor y los dormitorios varones sigue las tuberías a través de dos registros antes de encontrarse en un tercer registro con agua de las cocinas, la panadería y la oficina de Virgilio. El agua de **la cocina y la panadería** también es de aguas grises. Es producido por los diversos sumideros y desagües. Antes de salir de la cocina y la panadería, el agua pasa por trampas de grasa. Estas trampas de grasa están destinadas a limitar la cantidad de grasa y otras sustancias alimenticias no deseadas que ingresan al sistema de aguas residuales. La fuente final de agua en esta sección es el agua negra que viene de los baños y se hunde en el **edificio de oficinas de Virgilio**. Toda el agua de estas fuentes se combina en el tercer registro. A partir de ahí, es el agua negra que viaja a través de tuberías a lo largo del borde del canal por el camino. Termina en la gran cámara séptica junto a la carpintería antes de ingresar al filtro verde.

cámara séptica de los dormitorios varones

Hotel

Aquí se debe incluir fotos generales del hotel (fotos reconocibles)

En el mapa: 

En el hotel, hay cinco cuartos privados que tienen baños en cada cuarto. Cada bano tiene una ducha, un lavabo y inodoro. Los aguas residuales (principalmente negras) salen el hotel y va a una cámara séptica (cuadrado amarillo) y luego a un pozo ciego (círculo rosa) que se encuentran a la izquierda en este foto. La cámara séptica y el pozo ciego a la derecha de este foto son responsables por un baño en el vestíbulo del hotel. A partir de Abril de 2020, Prof. Virgilio los ha limpiado dos veces en 15 años.

Debajo hay fotos de los sistemas tratamiento en el hotel.

cámara séptica y pozo ciego del hotel (izquierda) y cámara séptica y pozo ciego detrás del hotel (derecha)

cámara séptica y pozo ciego para vestidor del hotel

Lavanderia

Aquí se debe incluir fotos generales del lavanderia (fotos reconocibles)

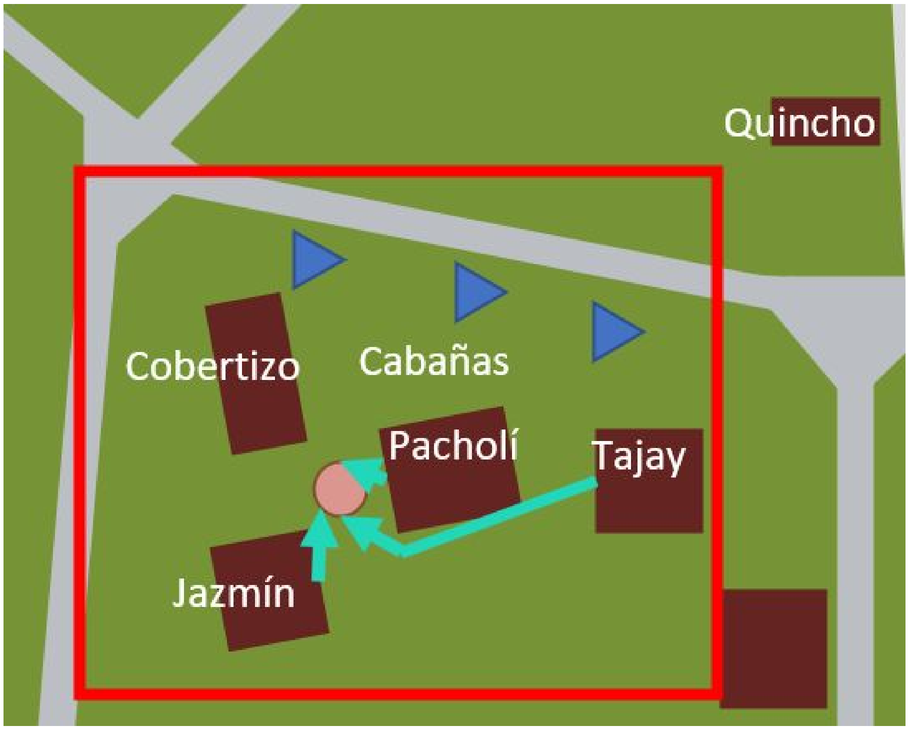
En el mapa: 

En este edificio, hay lavadoras. El agua residual que producen es solo agua gris. Las aguas grises salen del edificio al cielo abierto. Drena en el arroyo que corre alrededor del estanque de tilapia hacia los humedales.

Las Cabanas del Sur (Jazmin, Pacholi, Tajay)

Aquí se debe incluir fotos generales de las cabanas (fotos reconocibles)

En el mapa:

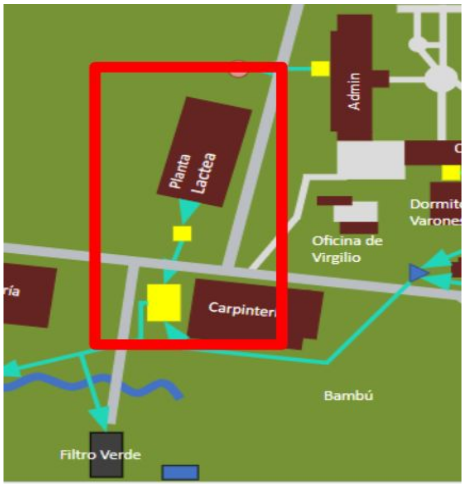


Las cabañas del sur tienen su propio baño pequeño con inodoro, ducha y lavabo. Las aguas residuales que salen de cada cabina son aguas negras con desechos humanos. Las aguas negras de cada cabaña van a un solo pozo ciego entre ellas. El profesor Borges nunca ha tenido que vaciar este pozo ciego. Al norte hay tres registros que solían usarse para mover el agua desbordada del pozo ciego. Sin embargo, las capas freáticas de la zona son mucho más bajas ahora y esos registros no han estado conectados o en uso durante muchos años. .

Registro y cámara séptica de los cabana en el sur del mapa

La Planta Lactea

Aquí se debe incluir fotos actuales de la planta láctea (fotos reconocibles)

En el mapa: 

La planta láctea produce leche, dulce de leche, y quesos para el uso en la escuela y venta al público. La planta láctea produce bastante agua gris como gasto que no se puede usar como un producto. También, para asegurar la salud, la limpieza regular del equipo produce aguas grises. Hay un baño en la planta que es una fuente de agua negra pero no tanto como la cantidad de agua gris hecho por lo de más de la planta láctea. Todas las aguas residuales fluyen a una cámara séptica junto al edificio. Los efluentes de esa cámara fluirán a la cámara séptica general de la escuela y luego el filtro verde.

No hay fecha registrado como la última vez que la cámara séptica fue limpiada.

La capacidad de la cámara séptica junto a la planta láctea no es conocido en este momento.

cámara séptica de planta láctea

La Nueva Planta Láctea

Aquí se debe incluir una foto. Como no existe, incluye los planes?

En el mapa: 

La nueva planta láctea sólo existe como un plan y puede cambiar. Los arquitectos incluyeron varias opciones para el diseño pero falta una aprobación final.

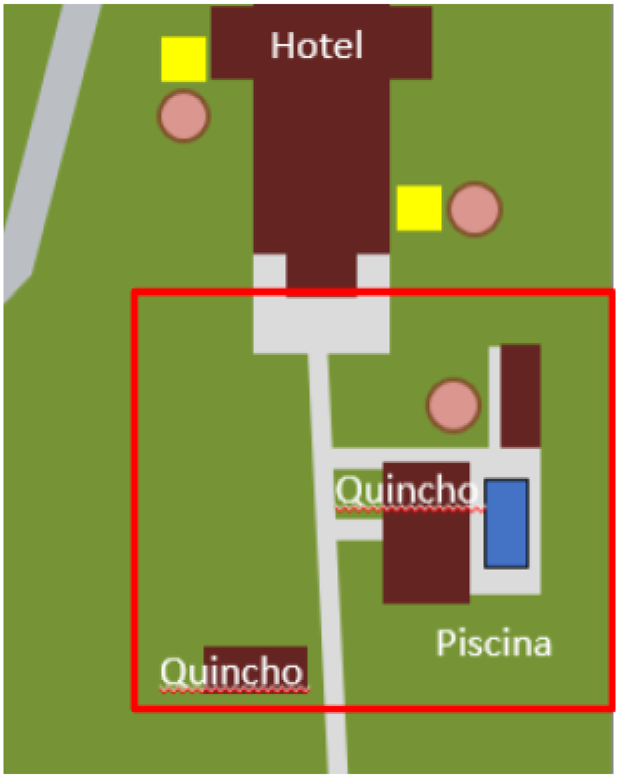
Hay dos baños ilustrados en los planes. Estos baños producen agua negra de una cantidad menor del resto del edificio. Como los demás edificios, las aguas negras pasan por tubos a una cámara séptica para que se separen en sus componentes. El efluente de esta cámara sigue a un pozo ciego para su absorción en el suelo.
Productos lácteos están conocidos a producir bastante agua gris y sistemas de tratamiento tienen que estar listos para proteger la salud de todos. Los planes especifican un pozo de recepción para toda la agua que después fluirá a dos tanques de aireación. Estos tanques de aireación completan el mismo trabajo que una cámara séptica por separar grasas y agua. La agua residual luego sigue a una cámara de cloración para destruir la bacteria y regresar la agua a un nivel de pH neutro. Dos opciones están disponibles. Primero, la agua residual puede ser descargada en los humedales o en un pozo ciego porque ya fue tratado a un nivel que no es peligroso. Segundo, la agua puede ser utilizado para la irrigación de una huerta. El diseño propuesto tratará las aguas grises a un nivel que será aceptable por la ley pero se necesitan muestras para asegurarnos que la salud de la gente no está en riesgo.

Incluye una imagen pero los planes son restringidos

La Piscina

Aquí se debe incluir fotos actuales de los quinchos y piscina (fotos reconocibles)

En el mapa:

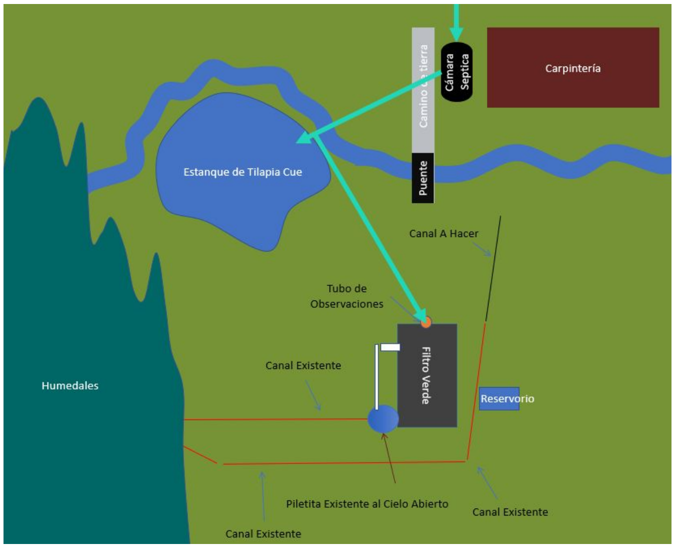


Junto a la piscina hay dos quinchos de dos diferentes tamaños. Los dos quinchos tienes lavabo pero no hay baños. Como no hay baños, estos quinchos solamente producen agua gris. Estas aguas residuales fluyen directamente a un pozo ciego junto a los quinchos.
Junto a la piscina, hay 12 banos
No hay fecha registrado como la última vez que la cámara séptica fue limpiada.
La capacidad del pozo ciego no es conocido en este momento.

El pozo ciego del vestidor

El Filtro Verde

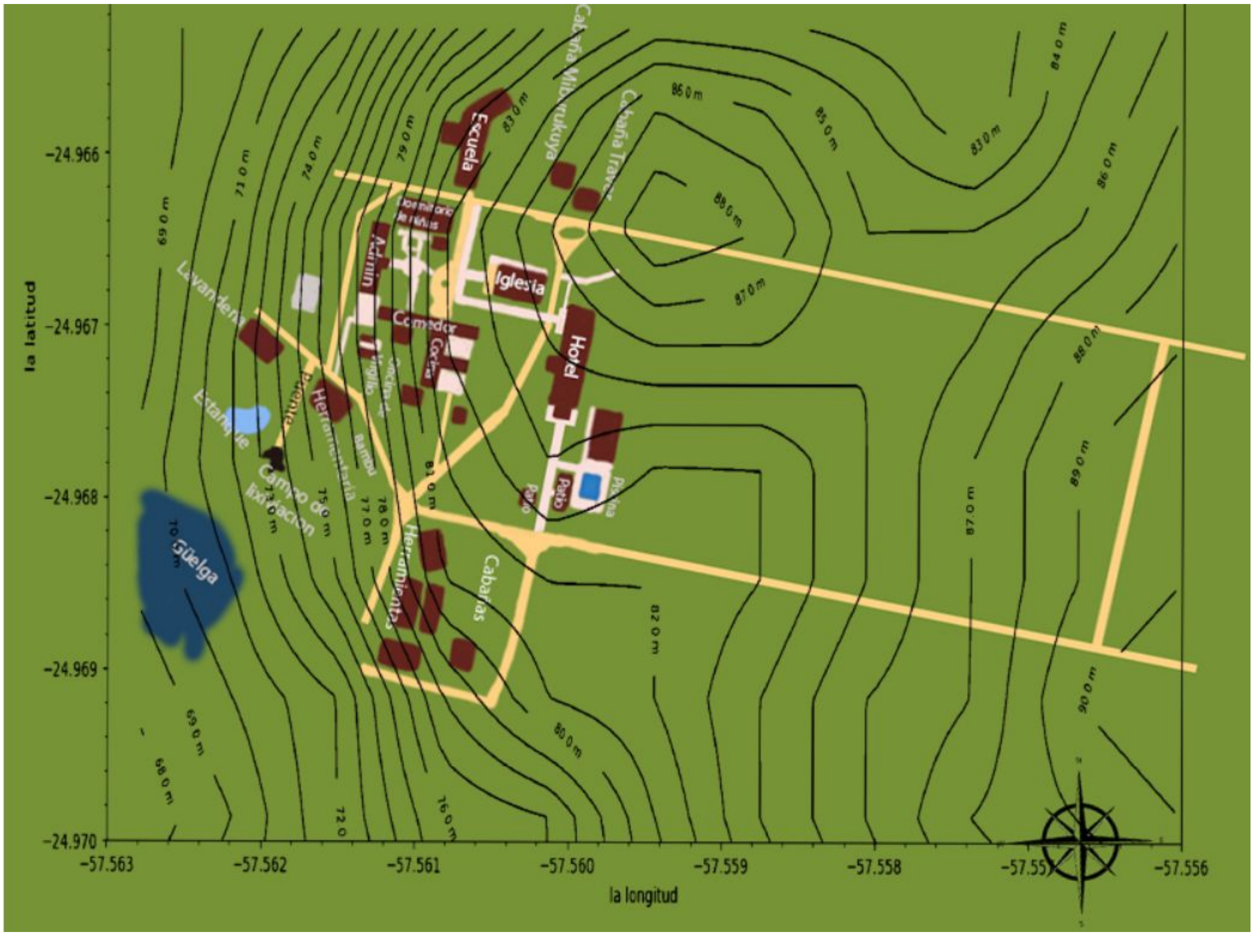
Aquí se debe incluir fotos actuales del filtro verde (fotos reconocibles)

En el mapa: 

El filtro verde es el sistema de tratamiento que da servicio al tanque séptico grande en el lado suroeste del campus. Las aguas residuales que ingresan a ese tanque séptico son aguas negras. Las provienen del dormitorio de los niños, la cocina, el comedor y la planta láctea. El filtro verde está formado por cuatro filas de tuberías perforadas colocadas sobre arena y grava. Fue realizado por estudiantes de WPI en los restos de una vieja piscina. La capacidad estimada del campo de lixiviación cuando se hizo fue de 455 litros de agua por hora. Hay un tubo de observación al comienzo del filtro verde que se puede usar para probar el volumen y la calidad del agua que ingresa al filtro verde. Actualmente, el filtro verde está inundado, por lo que toda el agua que sale del tanque séptico grande va directamente al estanque de tilapia. Se hizo un plan desarrollado por el Profesor Borges y los estudiantes de WPI para cavar canales alrededor del filtro verde como se muestra arriba. Estos canales deberían ayudar a desviar el exceso de agua subterránea del filtro verde, evitando inundaciones.

La cámara séptica grande antes del filtro verde

Mapa de Elevacion



El mapa que se muestra arriba representa el perfil de elevación de la escuela. Se completó utilizando el mapeo de elevación de Google Earth. Cada línea representa la elevación sobre el nivel del mar en ese punto. Esta puede ser una herramienta útil para determinar cómo se moverá el agua por el campus.

Tipos de Aguas

Aguas claras/limpios

Se puede beber con seguridad/ aún no está contaminado

Fuentes: el fregadero, el cielo (en teoría)

Aguas grises:

Aguas residuales sin sólidos. A veces aguas grises tienen cosas tal como jabón, grasa No es totalmente puro pero se puede usarlas para sus jardines o otras aplicaciones.

Fuentes: duchas, lavadoras, fregaderos después de su uso

Aguas negras:

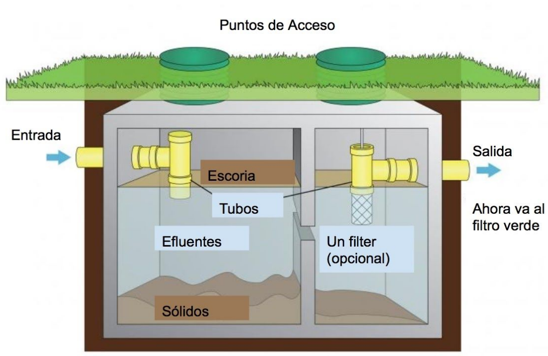
Simplemente, aguas residuales con sólidos. Muy contaminado con heces,orina, y a veces comida. Incluye patógenos malos que no son buena para la salud de humanos y animales.

Fuentes: baños, lavaplatos, desagues

Nota: Los aguas grises y negras usualmente combinan para ser tratado.

Partes de La Sistema

cámaras sépticas:



Aguas residuales fluya desde el fuente. Usualmente aguas grises y negros son dirigidos a un tanque séptico donde es separado por diferencias de densidad. Aceites flotan en la superficie y también es conocido como escoria En el medio, hay líquidos, se llaman efluentes, que fluirán a la segunda parte de tratamiento. En el fondo del tanque, hay sólidos que se han hundido para ser removidos en el futuro. Idealmente, sólo agua participa en las siguiente partes del proceso, cuando aguas residuales regreso al suelo y el ambiente.

Pozo Ciegos:

Un gran agujero hecho de ladrillo en los lados. Hay mínimo tratamiento aquí y el agua sale lentamente del espacio contenido al cielo. Obviamente, la cantidad de los sólidos aumenta con tiempo y puede rebosar. Registros actúan como una válvula de huido y también son usados para fines de observación.

El Filtro Verde:

Agua fluye a través de los tubos perforadas a capas de roca y arena. Microorganismos comen los patógenos malos en los aguas negros. La tierra actúa como un filtro natural y por eso este parte se llame el filtro verde. Eventualmente el agua regresa al nivel freático y se puede usar de nuevo. La meta principal es distribuir los aguas residuales en un área más grande para evitar inundaciones.

La Importancia de Mantenimiento

Como una comunidad, esperamos que el sistema de aguas residuales servirá por mucho tiempo. Aunque no se puede ver lo que está ocurriendo bajo el suelo, procedimientos de mantenimiento son muy importantes. En esta sección de la guía, presentamos los beneficios de un programa regular. Algunas cosas pueden parecer obvias, pero son importantes para considerar en la imagen general.

El uso de recursos

La Escuela Agrícola está cometido a ser autosustentable y tiene metas para completarlo. Una meta es que la escuela tiene que ahorrar lo mas dinero posible para asegurar el éxito de sus estudiantes y sus programas. Cuando los sistemas sépticos fallan, sus reparaciones pueden ser muy caras. Para evitar estas fallas, siguiendo un plan de mantenimiento regularmente prevendrá o encontrará los problemas chicos antes de que necesitaran reemplace. Esto también protegerá los recursos naturales alrededor de la escuela que se usan para sus varios programas.

Contaminación de agua y suelo

Si las aguas residuales no están tratadas suficientemente, los contaminantes pueden ser absorbidos por el suelo y las fuentes de agua. Estas aguas son muy importante para las operaciones Agrícolas porque se usan para irrigación de frutas y vegetales. Si se contaminan los alimentos, la salud de la gente estará en peligro

Longevidad del sistema

El sistema, funciona más eficiente y efectiva cuando hay una plan regular para mantenerlo. También durará por más tiempo.

Daños a edificios y el campus en general

Los tanques, poco ciegos, y el filtro verde pueden rebosar, causando un gran desastre. Aguas residuales regresarán a los edificios, causando aún más problemas, en el presente y el futuro.

Appendix D: Assessment of Environmental Liability (English)

The following document is a summary of La Escuela Agrícola San Francisco's legal compliance regarding their wastewater treatment systems. This summary includes a list of the most pertinent laws and regulations that La Escuela Agrícola must be aware of if they intend to expand their wastewater system in the future.

We, the Wastewater Team, have completed our determination of La Escuela Agrícola San Francisco's (LEASF) liability and legal exposure in the case of an environmental audit. Fines and sanctions for crimes against the environment can be severe. Reviewing all LEASF wastewater systems and their compliance with the law ensures that operations will not stop due to environmental infractions.

Our research into Paraguayan law and water regulations identified several relevant pieces of legislation. These laws cover the discharge of wastewater in areas with human populations or wild areas that provide benefits to humans. The most applicable laws are below.

- Law 3239/2007 - Hydrological Resources of Paraguay
- Law 716/1995 - Sanctions for Crimes Against the Environment
- Regulation 222/2002 - Metrics for Water Quality
- Law 294/1993 - The Evaluation of Environmental Impact
- Decree 453/2013 - Creates Standards for Law 294/1993
- Decree 954/2013 - Amplification of Decree 453/2013

These laws create standards which are meant to protect health above all else. Although buried by legal terms, the overarching principle of regulation is that human life and the environment should not be compromised by industrial waste. By law, LEASF is classified as an industrial entity as it is a business and not a private residence.

LEASF had already been inspected in the 2018 Environmental Audit conducted by Marcelo Gomez and Luis Enrique Resquin. At the time, LEASF's wastewater system was made up of a mix of cesspools and small septic tanks. This wastewater system was found to be compliant and treat wastewater enough to not be damaging to the surrounding wetlands or human health. Still, several recommendations were put forth to better treat the school's blackwater. These recommendations are largely based around the installation and maintenance of septic tanks at various chalets as well as the completion of the green filter. As we began receiving information from Prof. Virgilio Borges and Dorothy Wolf, we learned that all of the septic tank based recommendations are completed and working well. The green filter that was desired by the inspectors is still in the process of being made functional. Legally, it is acceptable for the green filter to be unfinished as long as construction continues and the main septic tank is treating wastewater before it is discharged into the environment.

As specified in Law 3239/2007, discharged industrial effluent should not drastically alter the environment. The law defines significant alteration as a significant change in temperature, biological composition, pH, or sediment amount. By combining their cesspools with septic tanks, LEASF is lessening their impact on the environment by reducing the amount of solid waste that is passed to the environment. The green filter, when completed, will take that even further by breaking down harmful bacteria in the effluent before returning water to the environment. The green filter will also disperse water over a large area to prevent the severe compositional changes that water regulations prohibit.

Anticipating future additions to the school, we attempted to analyze the new cheese factory and how its waste treatment would be in accordance with the law. Dairy production is known to create a tremendous amount of greywater and systems must be in place to handle the waste safely. The blueprints specify a collection tank for all the wastewater that would then split off into aeration tanks. The aeration tanks would separate the oils and fats from the rest of the water so that it can be reused into marketable products. These aeration tanks perform the same operation as a traditional septic tank by separating oil and water. The wastewater would then flow into a chlorination tank to kill any harmful bacteria and return the water to a safe pH level. Two options then become available. The wastewater can then be discharged into the environment or reused for vegetable irrigation. At this stage, wastewater would meet the dispersion requirements if it is decided to be left in the wetlands. However, Regulation 222/2002 provides safe operating limits for water used in crop irrigation. The proposed design of the system would bring the wastewater within regulatory limits but consistent testing is necessary to ensure the health of the crops and people eating them.

As it stands, the complete wastewater system of La Escuela Agrícola San Francisco is compliant with Paraguayan law. All forms of wastewater are being treated in some fashion before reentering the environment. The green filter may be under construction, but it remains within regulatory guidelines since progress to make it operational continues to be made. The new cheese factory is also expected to be compliant with the only area of concern being the resultant water quality if used for crop irrigation. It is the opinion of this group that La Escuela Agrícola San Francisco is in no danger of being fined or losing its environmental license because of its wastewater treatment systems.

Appendix E: Evaluación de Responsabilidad Ambiental (Español)

Este documento es un resumen de cómo el sistema de tratamiento de aguas en La Escuela Agrícola San Francisco cumple con las leyes ambientales. Este documento también tiene una lista de las leyes más importantes que La Escuela debe tener en mente si desean expandir en el futuro.

Nosotros, el Equipo de Aguas Residuales, hemos completado nuestro determinación del riesgo tomado por la Escuela Agrícola San Francisco y sus sistemas de tratamiento de aguas residuales. Los sanciones para crimen contra el ambiente podrán ser grave. Revisando que todos los sistemas para el tratamiento de aguas están alineados con la ley asegura que las operaciones de la escuela no pararán por infracciones ambientales.

Nuestra investigación en leyes Paraguayas y los reglamentos de agua han identificado varias piezas de legislación en este tema. Estas leyes cubren el desagüe de aguas residuales en áreas con poblaciones humanas o en áreas salvajes que benefician humanos. Las leyes más pertinentes están listados.

- Ley 3239/2007 - De los Recursos Hidrológicos de Paraguay
- Ley 716/1995 - Que Sanciona Delitos Contra el Medio Ambiente
- Regulation 222/2002 - El Padrón de Calidad de Aguas
- Ley 294/1993 - Evaluación de Impacto Ambiental
- Decreto 453/2013 - Regulación de Ley 294/1993
- Decreto 954/2013 - Amplificación del Decreto 453/2013

Estas leyes hacen normas para proteger la salud de la población. Aunque está obstruido por términos legales, la idea central de estos reglamentos es que la vida humana y el ambiente no deben ser comprometidos por los residuos industriales. Por ley, la escuela está clasificada como una forma industrial porque es un negocio y no residencia privada.

La escuela fue examinado anteriormente en 2018 por Ing. Marcelo Gomez y Ing. Luis Enrique Resquin durante una auditoría ambiental. En ese tiempo, el sistema de aguas residuales fue hecho de una combinación de pozos ciegos y cámaras sépticas pequeñas. Descubrieron que este sistema trata aguas residuales lo suficiente para no dañar los humedales o la salud humana. Todavía, presentaron recomendaciones para mejor tratar la agua negra de la escuela. Estas recomendaciones están basadas por mayor parte en la construcción de más cámaras sépticas para los chalets y el filtro verde. Después de hablar con Prof. Virgilio Borges y Prof. Dorothy Wolf de Burt, aprendimos que todas las recomendaciones relacionados a cámaras sépticas se han completado y están operando sin problema. El filtro verde que los ingenieros pidieron todavía está bajo construcción. Legalmente, esta aceptable que el filtro verde no esta funcional mientras que la cámara séptica general sigue tratando aguas residuales antes de que se descargan en el ambiente.

Como especificado en Ley 3239/2007, efluente industrial no deberá alterar el ambiente en una forma drástica. La ley considera un cambio drástico como un cambio significativo en temperatura, composición biológica, pH, o cantidad de sedimento. Por combinar los pozos ciegos con cámaras sépticas, la escuela está minimizando la cantidad de residuo sólido que se está depositando en el ambiente. El filtro verde, cuando sea completado, completará más por destruir la bacteria peligrosa en el efluente. El filtro tambien descarga agua sobre una área grande para prevenir los cambios drásticos que la ley trata de prohibir.

Anticipando adiciones a la escuela, tratamos de analizar la nueva fábrica de queso y como su sistema de tratamiento de aguas conformará con la ley. Productos lácteos están conocidos a producir bastante agua gris y sistemas de tratamiento tienen que estar listos para proteger la salud de todos. Los planes especifican un pozo de recepción para toda la agua que después fluirá a dos tanques de aireación. Estos tanques separan aceites y grasas de la agua para que se puedan usar en otros productos. Estos tanques de aireación completan el mismo trabajo que una cámara séptica por separar grasas y agua. La agua residual luego sigue a una cámara de cloración para destruir la bacteria y regresar la agua a un nivel de pH neutro. Dos opciones están disponibles en ese momento. Primero, la agua residual puede ser descargada en los humedales porque ya fue tratado a un nivel que no es peligroso. Segundo, la agua puede ser utilizado para la irrigación de una huerta. Decreto 222/2002 establece niveles seguros para el uso de aguas residuales para irrigación. El diseño propuesto tratará las aguas grises a un nivel que será aceptable por la ley pero se necesitan muestras para asegurarnos que la salud de la gente no está en riesgo.

Como existe hoy, el sistema completo de aguas residuales en la Escuela Agrícola San Francisco cumple con la ley Paraguaya. Todas formas de aguas residuales están tratadas en una forma antes de regresar al ambiente. El filtro verde puede seguir incompleto pero no hay problemas con la ley mientras su construcción sigue. La nueva fábrica de queso también será obediente con la ley con la única preocupación siendo la calidad de agua resultante de su tratamiento si eligen usarlo para irrigación. Es la opinión de este grupo que la Escuela Agrícola San Francisco no está en peligro de ser sancionado por su sistema de tratamiento de las aguas residuales.