SFD
Promotion Initiative

Canton of Alajuela
Costa Rica

This SFD Report – Comprehensive SFD level – was created by the Inter-American Development Bank in collaboration with the Municipality of Alajuela, Costa Rica.

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SFD Canton of Alajuela, Costa Rica, 2020

Produced by:
Diana Madrigal Barquero
Sergio Pérez Monforte
Editing: Lars Schöbitz

FOREWORD

The Inter-American Development Bank, through the saniBID platform, seeks to promote the development and implementation of optimal and non-conventional sanitation solutions in the Latin America region. The first step to identify solutions is to characterize the state of the sanitation situation that could serve as a baseline in the areas of intervention.

One well-known and globally accepted tool to analyse the sanitation service delivery chain to identify its strengths and weaknesses in any given area, is the Shit Flow Diagram (SFD) graphic. The tool was developed by the SFD Promotion Initiative (SFD PI), a consortium of partners working together to improve excreta management in urban areas. The SFD PI is supported by the Bill & Melinda Gates Foundation and managed by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) as part of the Sustainable Sanitation Alliance (SuSanA).

An SFD is an advocacy tool that aims to assist technical and non-technical stakeholders in order to implement plans and programs related to urban sanitation. The SFD methodology is increasingly being used to analyse the extent of safely-managed sanitation in urban areas, providing users and stakeholders with a valuable picture of the prevailing sanitation condition, from containment to disposal. As such, it is a widely recognised advocacy and decision support tool that aims to understand, communicate, and visualize how wastewater and faecal sludge move within a city or town. As stated on the SuSanA website, the SFD methodology offers "*a new and innovative way to engage sanitation experts, political leaders and civil society in coordinated discussions about excreta management in their city*".

The SFD graphic is made by a free online tool, the Graphic Generator (GG): https://sfd.susana.org/data-to-graphic and, to date, over 140 SFD reports, which must pass a review process before publication to assure the quality control mechanism of the SFD PI, have been uploaded to the SuSanA website.

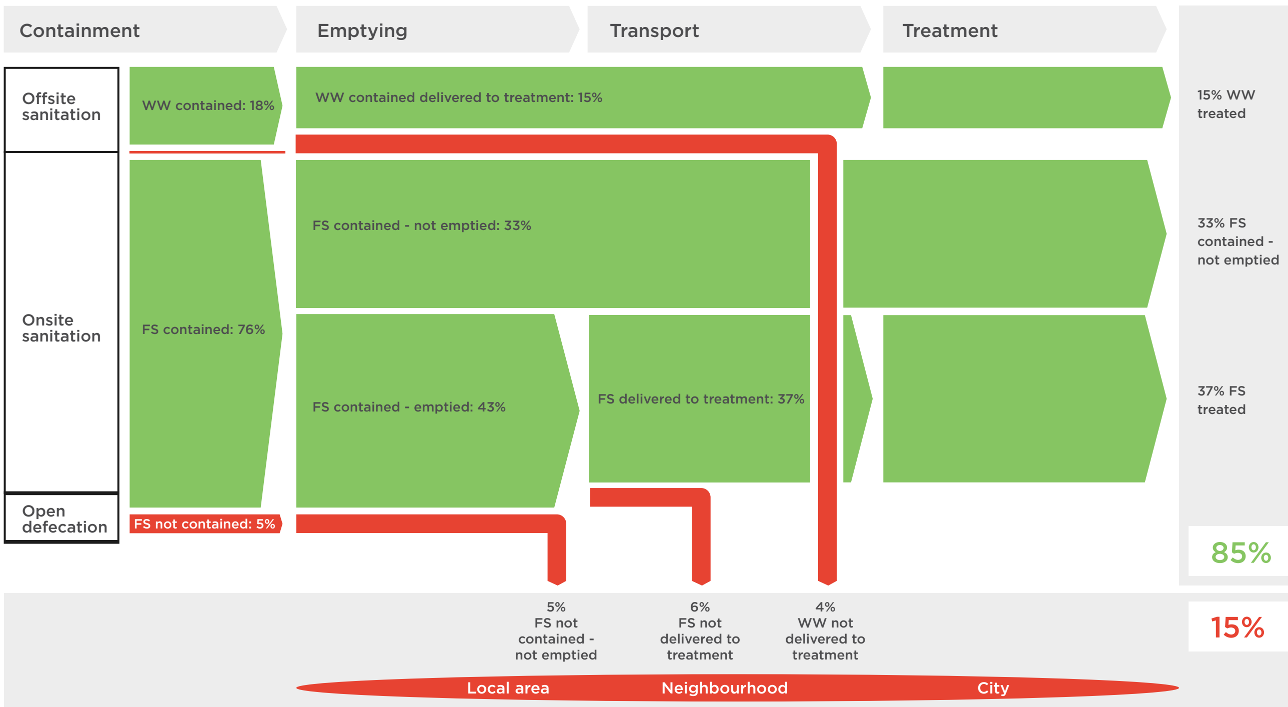
The production and publication of an SFD report for Alajuela (Costa Rica) would help to visualise the current sanitation situation in the city, resulting in a potential to shift current activities and efforts towards more efficient investments in the places of the sanitation chain that need more attention, thereby improving the urban sanitation situation and the surrounding environment of the city.

The structure of this SFD report consists of an executive summary and the SFD report. The latter includes: i) general city information describing its main characteristics; ii) sanitation service outcomes, with a thorough explanation of the SFD graphic outcome and the assumptions made; iii) the service delivery context analysis, which contains information on the regulatory framework of water and sanitation at country and city levels, also describing the city plans, budget and future projects to improve the sanitation situation; and iv) a detailed description of the surveys, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) conducted, as well as the key stakeholders involved, field visits carried out and references used to develop this SFD report.

1. The Diagram

Alajuela, Alajuela, Costa Rica
Version: Reviewed
SFD Level: 3 - Comprehensive SFD

Date prepared: 4 Nov 2020
Prepared by: IDB



Key: WW: Wastewater, FS: Faecal sludge, SN: Supernatant — Safely managed — Unsafely managed

The SFD Promotion Initiative recommends preparation of a report on the city context, the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at: sfd.susana.org

2. Diagram infomation

SFD level:
This SFD is a level 3 - comprehensive report.

Produced by:
Diana Madrigal, Consultant IDB
Sergio Pérez, Water and Sanitation Senior Specialist IDB

Collaborating partners:
Municipality of Alajuela

Status:
Final SFD report

Date of production:
4/07/2019

3. General city infomation

The Canton of Alajuela is located within the province of Alajuela in the north-central part of Costa Rica, covering an area of approximately 388.43 km². The canton is geopolitically sub-divided into 14 districts, holding a population of approximately 254,567. Eighty-eight percent of its population is living in urban areas.

There are approximately 45 slums reported in the canton, housing about 10,000 people. The districts of Desamparados, Río Segundo and San José and San Rafael hold the highest percentage of families per slum (Municipality of Alajuela, 2012).

The canton has two well-defined climatic seasons: a dry season that extends from December to March, and a rainy season from May to October. According to Arias Salguero (2016), records define an annual rainfall of 3,452.7 mm, with October being the rainiest (514.1 mm), and March the driest (64.9 mm).

In general, the average monthly temperature presents little variation from one month to another, averaging close to 20.3°C. (Arias Salguero, 2016).

4. Service outcomes

According to the National Wastewater Sanitation Policy (2016), in Spanish *Política Nacional de Saneamiento en Aguas Residuales*, the containment phase of the sanitation service chain in Costa Rica is divided into three main groups: 76.42% of the country's wastewater is treated through septic tanks, 21.43% through the sanitary sewage systems and the remaining 2.15% use wells, latrines or practice open defecation to a lesser extent.

Only 14.4% of wastewater connected to the sewage system is treated. Mechanical emptying and transport services are available and predominate for most of the population using septic tanks.

Despite the above, there is no precise data about the sludge that, once extracted from septic tanks, manages to reach a treatment plant. This is largely due to the following circumstances: i) numerous service providers transport sludge that is not formal and do not take the sludge to the faecal sludge treatment plant; ii) there is only one private faecal sludge treatment plant (the Sanitary Water Company) in the country, with a capacity of treating 300m^3 of FS per day, allowed to receive sludge from other emptying and transportation service providers, other than its own trucks; and iii) there is no mandatory compliance guideline as to how often a septic tank should be emptied or monitoring mechanisms on behalf of the government, so this may vary depending on the capacity of the tank, the condition of the tank (whether it has fissures, or is built properly) and users' knowledge concerning its maintenance. According to the Sanitary Water Company, it receives approximately 260 m^3 of sludge per day.

With respect to the service outcomes along the service chain in the Canton of Alajuela for its containment phase, approximately 18% of the population is connected to the sewerage system and 80% uses septic tanks. The remaining 2% is a sum of direct outflow to a river, pit, or latrine, and to a lesser extent, open defecation. The preceding figures roughly reflect what happens at country level as well.

Mechanical emptying and transport services predominate. Truck sizes vary widely, from 5 m^3 to 21 m^3 per truck. These services are provided by independent providers or small private companies.

Regarding faecal sludge management, two primary treatment plants are found in the canton: 1) The Sanitary Water Company faecal sludge treatment plant, previously mentioned, and 2) Villa Bonita's Municipal Wastewater Treatment Plant, which was recently modified to be able to receive wastewater from the existing sewage system and faecal sludge as well.

No reuse is given to the dried sludge produced by the treatment plants mentioned above. To date, both treatment plants dispose of faecal sludge directly to the landfill.

The SFD graphic shows that 85% of the excreta generated is safely managed in the Canton of Alajuela, and 15% of the excreta generated is unsafely managed.

5. Service delivery context

Legislation related directly or indirectly to wastewater and Faecal Sludge Management (FSM) presents a robust legal framework related to some extent with sanitation. Among relevant legislation, there is the National Wastewater Sanitation Policy (2016), which supplies the framework to harmonise the actions that need to be taken to secure the well-being of the population and the environment through the treatment of wastewater and Faecal Sludge (FS). The policy also establishes a guideline of specific actions that the country needs to execute towards the achievement of the Sustainable Development

Goals (SDGs). Yet, there is no specific mention about Faecal Sludge Management (FSM), nor the sanitation service chain.

Additionally, the Regulation for the Handling and Final Disposal of Faecal Sludge and Biosolids (2015) is the main regulation addressing FS directly, focusing on the regulation of all services along the sanitation chain, provided by public or private companies. The regulation excludes wastewater from sanitary cabins or mobile latrines, which must be treated and comply with the provisions of the Regulation of Discharge and Reuse of Wastewaters (2007).

6. Overview of stakeholders

Stakeholders can be divided into four main groups, as can be seen in Table 1 (public institutions, private sector, development donors and others). From these, the Municipality of Alajuela has a key role as the main provider of water and sanitation services in the canton.

Following the sanitation service chain, master builders have been considered key stakeholders, given their role in a construction site and directing the construction crew when building or installing a septic tank.

The private sector also plays an important role both in the provision of emptying, transportation, and treatment of excreta. Stakeholders in the informal sector, specifically the emptying and transportation service providers, are working informally given that they are not complying with some or any of the legal requirements established by law for the provision of these services. Yet, both formal and informal emptying and transportation service providers are needed given the large percentage of the national population that uses septic tanks as a sanitation solution.

In the case of donors, the Municipality of Alajuela has been provided with a donation from the Canadian International Development Agency for the development of a pre-design of the project to address the wastewater problem in the canton. The German Federal Ministry for Economic Cooperation and Development, in cooperation with *Stad Lahr L*, provided economic assistance to rehabilitate Villa Bonita Wastewater Treatment Plant.

The Inter-American Development Bank financed a household survey to determine the knowledge, construction practices, use and maintenance of septic tanks in the canton, and was responsible for the preparation of this document.

Table 1. Overview of Stakeholders

KEY STAKEHOLDERS	Institutions / Organizations
PUBLIC INSTITUTIONS	Municipality of Alajuela Ministry of Health
PRIVATE SECTOR	The Sanitary Water Company Emptying and transportation service providers
DEVELOPMENT PARTNERS, DONORS	Canadian International Development Agency German Federal Ministry for Economic Cooperation and Development, in cooperation with Stad Lahr L Inter-American Development Bank (IDB)
OTHERS	Master builders Septic tank users

7. Credibility of data

The provided "SFD Source Evaluation Tool" was used to score the credibility of data sources. In total, 11 sources scored either medium or high if they were official, well-documented studies and had been conducted within the past few years.

Three surveys were implemented by the IDB for this report:

1. Household Survey
2. Emptying and Transportation Service Providers Survey
3. Master Builders Survey.

8. Process of SFD development

The process of development of this SFD graphic includes:

1. Literature review
2. Data derived from the National Household Survey and the 2011 National Census, used for population estimates
3. Key informant surveys conducted by telephone to septic tank builders, emptying and transportation service providers and prefabricated septic tank vendors
4. A random survey conducted among 543 households not connected to the sewerage system in the Alajuela Canton, under the assumption that these would be the users of septic tanks
5. Field visits were carried out to the Sanitary Water Company and Villa Bonita Wastewater Treatment Plant
6. The Graphic Generator was then used to develop the SFD graphic
7. Additionally, a validation workshop of the results obtained was held in August 2020 with the participation of key stakeholders from the four main groups mentioned in Table 1.

9. List of data sources

- The Sanitary Water Company's effluent reports
- Villa Bonita's WWTP effluent reports
- Hydrogeological studies provided by the Municipality of Alajuela
- Environmental Improvement Report City of Alajuela, provided by the Municipality of Alajuela
- Interviews with 500 households with septic tanks, developed by the Inter-American Development Bank
- Interviews with emptying service providers, developed by the Inter-American Development Bank
- Interviews with master builders, developed by the Inter-American Development Bank
- Interview with the owner of The Sanitary Water Company
- Interview with head of Sanitation Department of the Municipality of Alajuela
- Field visits to Villa Bonita Treatment Plant
- Field visits to The Sanitary Water Company
- Field visits to the Canton of Alajuela

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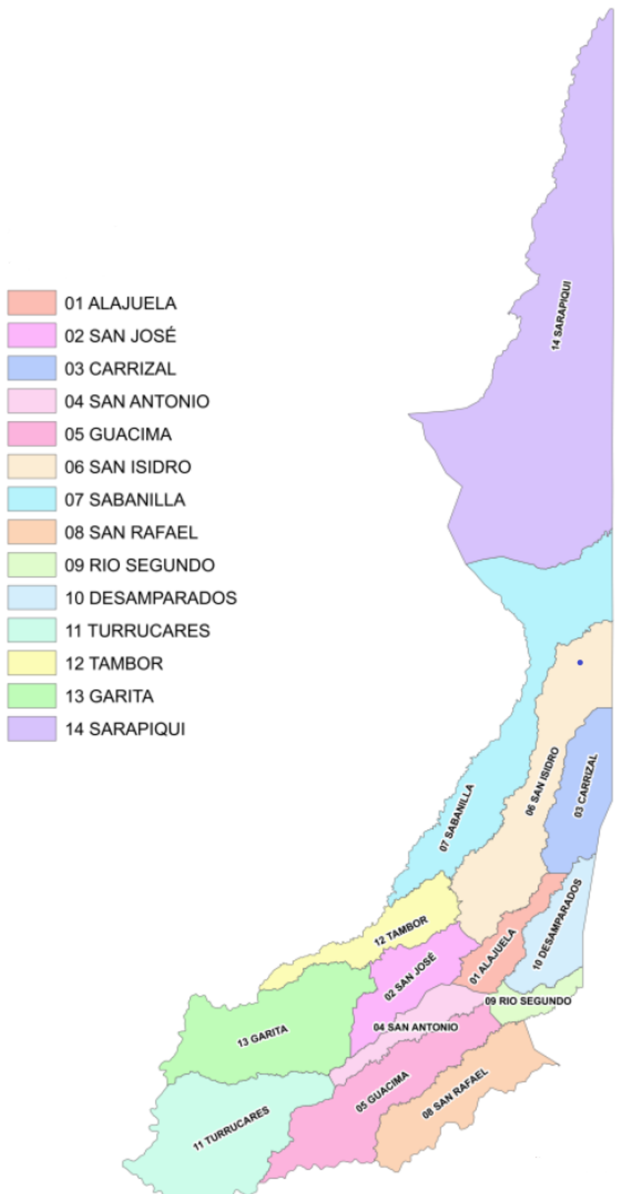
Acronyms

ASADAS	Associations of Communal Sewerage Systems
AyA	Costa Rican Institute of Aqueducts and Sewerage
CVR	Central Volcanic Range
CEMSSA	Municipal Environmental Sanitation Services Centre
CIVCO	Centre for Housing Research and Instruction
ENAHO	National Household Survey
FSM	Faecal Sludge Management
ESPH	Public Services Company of Heredia
FS	Faecal Sludge
IDB	Inter-American Development Bank
INEC	National Institute of Statistics and Censuses
INVU	National Institute of Housing and Urbanism
ITCR	Technological Institute of Costa Rica
MINSA	Ministry of Public Health
MINAE	Ministry of Environment
ProDUS-UCR	Research Program on Sustainable Urban Development of the University of Costa Rica
SFD-PI	Shit Flow Diagram Promotion Initiative
SPI	Social Progress Index
ST	Septic Tank
SENARA	National Irrigation and Drainage System
WWTP	Wastewater Treatment Plant
FSTP	Faecal Sludge Treatment Plant

1. City Context

The Canton of Alajuela is located within the province of Alajuela in the north-central part of Costa Rica, covering an area of approximately 388.43 km^2. The canton is geopolitically sub-divided into 14 districts as seen in Figure 1: Alajuela, San José, Carrizal, San Antonio, Guácima, San Isidro, Sabanilla, San Rafael, Río Segundo, Desamparados, Turrúcares, Tambor, Garita, Sarapiquí.

Figure 1: Geopolitical Map of the Canton of Alajuela and its Districts



1.1. Population

The canton has a population of approximately 254,567, with 88% of the population living in urban areas. The ratio of people to households is 3.4. The most populated districts are Alajuela, San José, San Rafael, Desamparados and San Antonio, which altogether represent 64% of the total population of the canton (National Institute of Census, 2011).

Over the last decade, the canton has seen economic growth, focusing on the development of industrial parks, particularly in the districts of San José (specifically in the area of el Coyol), Garita and Turrúcares, allowing them to have the highest economic value. The canton ranked 45th out of 81 cantons by the Social Progress Index (IPS, 2019). It is also important to mention that the district of Río Segundo holds the main international airport in the country.

There are approximately 45 slums reported in the canton, housing about 10,000 people. The districts of Desamparados, Río Segundo, San José and San Rafael hold the highest percentage of families per slum (Municipality of Alajuela, 2012).

1.2. Topography

The topography of the canton varies considerably from north to south. A hydrogeological study carried out by ProDUS (2010) for the Municipality of Alajuela mentions that according to previous studies and literature, two aquifers are located west of the central zone, in an area called Montecillos.

1.3. Climate

The canton has two well-defined climatic seasons: a dry season that extends from December to March, and a rainy season from May to October. The months of April and November are the transition from one season to another. According to Arias Salguero (2016), records define an annual rainfall of 3,452.7 mm, with October being the rainiest (514.1 mm), and March the driest (64.9 mm).

1.4. Temperature

The month of April presents the highest average temperature values of the year, reaching an average 22.6°C; however, the months of February and March, typical months of the dry season, present temperature values very similar to April. In the latter, minimum average temperature values recorded are 12.1°C. In general, the average monthly temperature presents little variation from one month to another, averaging close to 20.3°C. (Arias Salguero, 2016).

1.5. Precipitation

According to the National Meteorological Institute (IMN), the months of September and October are the rainiest, being the months with the highest number of rainy days, with an average 27 rainy days per month. Annual rainfall is 244 days, and as the rainy season begins, there is a gradual increase in precipitation (Arias Salguero, 2016).

The driest months are February and March, with an average of nine days of rain, a low precipitation rate compared to other months. The month of July shows a tendency to decrease in rainfall, caused by a change in wind circulation. Both seasons average precipitation values of 2,608.7 mm (Arias Salguero, 2016).

1.6. Key physical and geographic features

Most of the canton has a well-defined river network, comprised of 74 river basins and sub-basins; of these, 28 basins' drainage areas are partially or entirely contained within the Canton of Alajuela.

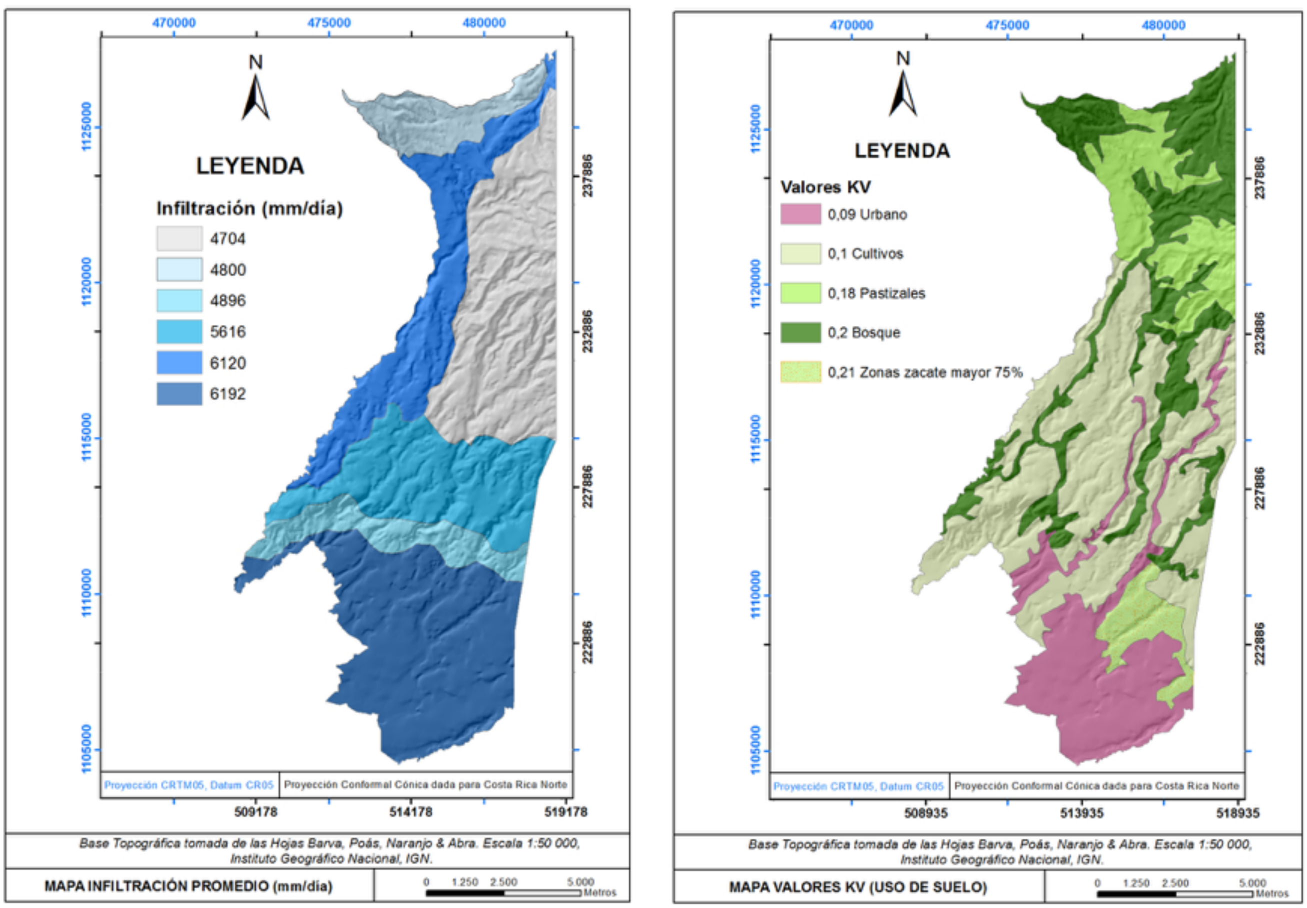
The canton is made up of flat relief (117.79 km^2 - 30%). However, the upper part (Santa Bárbara and the Carrizal District), correspond to the slopes of the Poás Volcano, where a radial and sub dendritic drainage pattern predominate.

The drainage system evidenced in the high density of tributaries indicates the presence and predominance of materials of fine granulometry (ashes and clays). These facilitate the origin of water currents on the land and this, in turn, increases erosion. Additionally, from the National Irrigation and Drainage System (SENARA) database, Arias Salguero (2016) identified 1,564 wells within the canton (excluding Turrúcares and Sarapiquí Districts).

The geographic and hydrographic features make the canton prone to natural hazards, such as landslides and floods, particularly in the districts of Sarapiquí and Turrúcares. The consequences of natural hazards are intensified by the occupation of river flood plains, particularly those with illegal settlements, the deforestation of upper and middle watersheds, and the lack of sustainable natural resource programs.

Additionally, according to a study developed by Arias Salguero (2015), the canton has infiltration ranges that vary from 4,704 to 6,192 mm per day, as can be seen in Figure 2. Overall, the study area averages a remarkable infiltration rate of 5,388 mm/day. The areas with highest infiltration ranges also coincide with the most urbanised areas, as can be seen in Figure 2.

Figure 2: Left: Average Infiltration in the Canton of Alajuela (Districts of Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro and Sabanilla). Right: Use of Land in the Canton of Alajuela (Districts of Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro and Sabanilla). Source: Arias Salguero (2015).



2. Service Outcomes

2.1. Overview

This section presents the range of sanitation infrastructure/technologies, methods and services designed to support the management of faecal sludge through the sanitation service chain in the Canton of Alajuela.

2.1. Containment

Sewerage system

The Municipality of Alajuela is the leading provider of sewage services in the canton. The municipal system has 12,000 connections (central subsystem and subsystems of urbanisation), of which about 10,000 are for housing and the rest for commercial premises, industries, and institutions. Additionally, there are some abandoned networks and two small systems which altogether serve an estimated population of approximately 40,787 people (Census, 2011).

Apart from sewerage systems mentioned above, the canton holds areas with an abandoned sewerage system and treatment plant whose administration is the responsibility of the AyA or Associations of Communal Sewage Systems (ASADAS). According to ProDus-UCR (2010), it is meant to serve an estimated population of approximately 4,140 people.

These systems correspond to the 18% of the population of the canton who have a sanitary sewerage system; however, according to an interview with the Sanitation Department of the Municipality of Alajuela, it is estimated that only 15% of the 18% is being treated, as described below:

1. **Central subsystem:** Provides service to the centre of the city and is the most extensive system, with approximately 7,000 connections, which supply about 23,000 people. This system is connected to the Wastewater Treatment Plant (WWTP) of Villa Bonita.
2. **Subsystems of urbanisations:** These correspond to 13 independent networks of different urbanisations located around the centre of the city. Altogether, the networks sum approximately 5,000 connections, supplying about 17,000 people. Each subsystem has a small WWTP, except for six network systems with no treatment plant, which discharge directly to the nearest river or creek. These networks work illegally since the municipality never authorised their use because they are simply "sanitary provisions." These were required by the National Institute of Housing and Urbanism (INVU) in the past, in the event of the future construction of a WWTP. The municipality intends to incorporate them in the short-term to the central subsystem by a pumping system.
3. **Two other small systems and treatment plants** are managed by the AyA. Villa Verano has 40 connections and supplies approximately 140 people, and Los Reyes has 185 connections, supplying approximately 647 people.
4. **There are three inoperative and abandoned sewerage system and treatment plants** whose administration belongs to AyA, according to a study developed for the Municipality of Alajuela by ProDUS-UCR (2010). However, when consulted, AyA mentioned that these systems were never legally transferred to AyA, and are still the responsibility of the INVU. These networks supply about 4,000 people.

Septic tanks

The Septic Tank (ST) is the main sanitation system in use in the country (76% of generated excreta are treated through a septic tank). This is reflected in 80% of the households that use these systems in the Canton of Alajuela (Census, 2011). According to a survey of 534 homes with septic tanks in the Canton of Alajuela, which was implemented by the IDB in June 2019, 77.1% of the sample claimed to have a conventional septic tank with one chamber, and 12.2% had a septic tank with a double chamber. Remaining respondents had another type of system or claimed not to know the kind of system in place.

In another survey of 34 septic tank emptying and transportation service providers and master builders (who are in charge of building or installing STs) carried out by the IDB (2019), it was also determined that the most common septic tank in place is the single-chamber tank of 1,100L (1m^3), which is the one recommended for a household of four people.

The performance and maintenance of these systems is questionable since there is no monitoring or standardised maintenance practice in the country. However, most households surveyed (59%) claimed to have constructed or installed their septic tank two or fewer years ago, with only 23.8% reporting that they built their tanks more than two years ago. The majority (93%) said they have had no problems with their septic tanks to date. However, the main issues encountered by other users (7%) included the blockage of pipes or sludge overflow.

Most households (63.1%) from the sample had emptied their ST at least once. The remaining (35.4%) respondents had never emptied their septic tanks or did not answer (1.5%). Of the percentage of households that reported never to have emptied their tanks, only 4% of them had built or installed their ST less than two years ago. This suggests that most of the 35.4% of households that have never cleaned their ST's may have leaks or are not functioning correctly. According to the IDB (2019) household survey, the average cost for emptying a ST is ¢25,531.00 (US$ 44). An interesting finding was that the average price charged by service providers is ¢40,833.00 (US$ 71.80), which is almost double the amount mentioned by households. This finding implies that many households may be calling service providers that are able to charge less given their informality; they avoid paying for permits and treatment, and dispose sludge directly into sewer drains or the river, which is illegal. The interviewed service providers mentioned that the amount they charge varies according to the size of the tank and the distance that the service provider must travel to reach the house, and the difficulty in accessing the ST within the house. It is important to mention that the price given by the service providers was based on an average of 1,100L ST.

Table 1 and Table 2 show the STs that are the most used and commonly installed, according to master builders and suppliers of prefabricated septic tanks who were interviewed.

Table 1: Left: Single Chamber Tank. Right: Vertical Chamber Tank

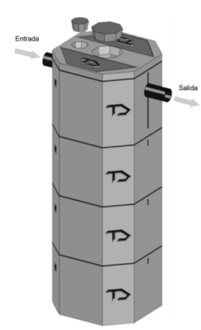
	CAPACITY (L)	PEOPLE		CAPACITY (L)	PEOPLE
	750	1-3		975	1-5
	1100	4-5		1250	6-8
	1700	6-8		1525	8-10
	2500	8-10		1550	10-15
BRAND	Durman		BRAND	Tanque Diez	
MATERIAL	Polyethylene		MATERIAL	High strength concrete	
COST 1,100L	CRC 120,000.00 (US$ 199)		COST 975 L	CRC 485,000.00 (US$ 804)	
REMOVAL OF ORGANIC MATTER	ND		REMOVAL OF ORGANIC MATTER	98%	

Table 2: Single Chamber and Double Tank

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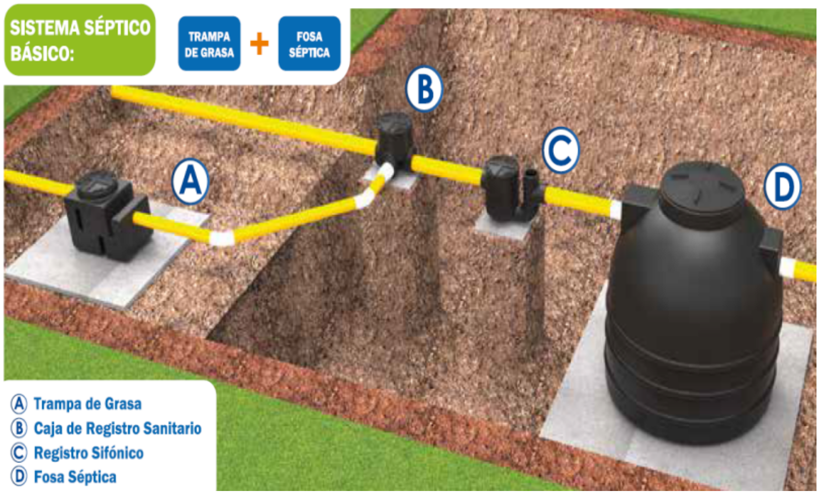
<tr><td rowspan="5">
</td><td>CAPACITY (L)</td><td>PEOPLE</td></tr>
<tr><td>750</td><td>1-3</td></tr>
<tr><td>1100</td><td>4-5</td></tr>
<tr><td>1950</td><td>4-9</td></tr>
<tr><td>2500</td><td>8-10</td></tr>
<tr><td>BRAND</td><td colspan="2">Ecotanque</td></tr>
<tr><td>MATERIAL</td><td colspan="2">Polyethylene</td></tr>
<tr><td>COST 1,100L</td><td colspan="2">CRC 472,000.00 (US$ 782)</td></tr>
<tr><td>REMOVAL OF ORGANIC MATTER</td><td colspan="2">40% - 80%</td></tr>
</table>

Constructed Septic Tanks

Guidelines for the construction of septic tanks are stated and defined by the Code of Hydraulic and Sanitary Installations in Buildings. The code defines the dimensions of a septic tank and drainage trenches. It also details the requirements for the installation of a septic tank, e.g., soil absorption capacity, the separation between the bottom of the discharge points in the subsoil and the water table, and the storage volume of the septic tank according to the number of users, among other factors.

Another source used as a guide is the document called "Septic Tank, Theoretical Concepts Basis and Application," prepared by the Centre for Housing Research and Instruction (CIVCO). This document promotes the use of improved septic tanks (additional chambers), which are recommended in conditions of clay or very high groundwater levels and include at least two to three chambers (see Figure 3). Besides this, the guide emphasises how to calculate the volume of the tank, infiltration tests, and the sludge treatment procedure.

Figure 3: The Improved Septic Tank under Construction. Source: Sanitarios Jiménez.

2.1.2. Emptying and transportation

Mechanical emptying and transport services

Most emptying and transportation service providers are not exclusive to the Canton of Alajuela nor the province of Alajuela. Most expand their services throughout different cantons and even through other regions. The results of the service providers survey substantiate that only 63% of the sample provides ST emptying services and transportation in the Canton of Alajuela, but their services were not exclusive to the canton.

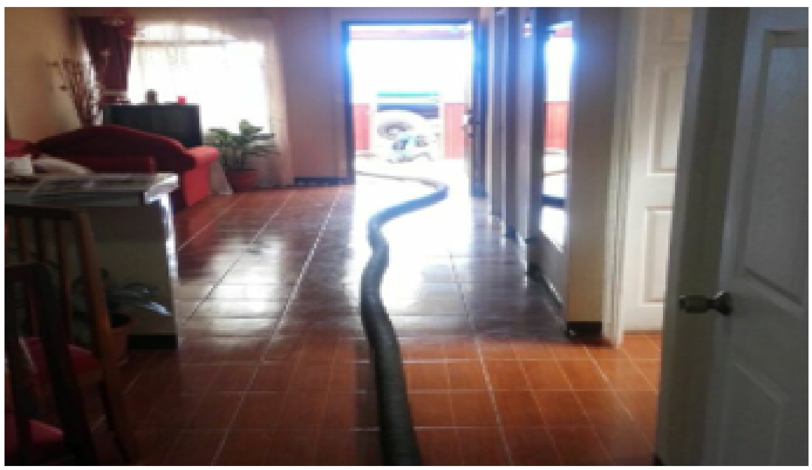
Based on the analysis of the surveys and electronic records, the number of service providers is estimated at 200. Approximately 110 of these are independent emptying and transportation service providers who operate a single truck. A smaller number of private companies operate more than one truck and, in some cases, have a small Faecal Sludge Treatment Plant (FSTP).

The type of emptying service provided is mechanical, and it is done through vacuum trucks. Truck capacity varies widely, from 5 to 21 m^3. Most of these trucks have been adjusted to be able to empty sludge and were not initially designed for this. To be able to provide their services, each provider must obtain at least four permits from different institutions, including the Ministry of Health, Ministry of Transportation and Public Works, and the municipality, among others. Only 68% of the sample interviewed said they had all the permits and requirements up to date.

Given the large capacity of the trucks versus the capacity of an average septic tank (1.1 m^3), service providers indicated that the frequency of discharging sludge to a treatment plant is variable. The average number of times that a truck visits the treatment plant can be eight times per month (equivalent to twice a week). This figure is highly variable given the time of the year (rainy or dry season) and services provided, since most wait until the tank is full to visit the FSTP. Also, the number of trips and discharges performed in an FSTP depends on the service provided since most suppliers also offer emptying services for hotel and restaurant grease traps and condominium or industrial treatment plants. Many interviewees also mentioned that given the increase in the number of suppliers, there is more competition; therefore, the demand is diluted among many suppliers.

Unlike sewerage treatment services, emptying and transportation service provision is not regulated by any entity. The average cost charged for emptying a septic tank is CRC 40,000, equivalent to US$ 70 per m^3. However, as many suppliers operate in the informal sector, some may charge as low as CRC 25,000, equivalent to US$ 44. These prices are also subject to change depending on the difficulty of emptying the septic tank and the distance each service provider must travel. Septic tanks are often located in the back of the house, where most residents usually have a garden, and can be difficult to empty since the hose must pass through the entire house or property (Figure 4).

Figure 4: Emptying Hose through a House. Source: Sanitarios Jiménez



2.1.3. Treatment infrastructure

Sanitary Water Company

The *Compañía de Aguas Sanitarias,* or Sanitary Water Company, is the only private treatment plant in the country that receives FS from independent service providers. This company arose from the need of the owner himself, who was providing services for emptying septic tanks and did not have a suitable site for the disposal of faecal sludge. This was also the case for most ST emptying service providers. The FSTP has operated since 2011 with a small system of activated sludge. It has a capacity to treat 300m^3 of FS per day (or 12 hours, which is what they currently work). The average number of clients (trucks) per day is 23, equivalent to approximately 260 m^3 per day. It is important to mention that this plant is in the Canton of Alajuela but services clients from all over the country. Despite keeping a record of clients and the amount of sludge or grease that each one brings, it is difficult to determine the origin of the sludge that each truck brings, since each truck may empty several septic tanks in different parts of the country. In addition, only 38% of the service providers consulted kept a record of the tanks they cleaned with basic information such as customer name and number. The WWTP of the Sanitary Water Company consists of the FS intake, the FS homogenizer and the aerobic reactor and sedimentation unit (Figure 5).

Figure 5: WWTP of the Sanitary Water Company. Upper Left: FS Intake. Upper Right: FS Homogenizer. Bottom: Aerobic Reactor and Sedimentation Unit

Villa Bonita WWTP

The Municipality of Alajuela recently rehabilitated the Villa Bonita WWTP with economic assistance from the German Federal Ministry for Economic Cooperation and Development, in cooperation with *Stad Lahr L.* The cost of the rehabilitation was CRC ¢577,500,000, equivalent to US $1,018,435.96. This WWTP is an activated sludge system, which currently receives an average daily water flow of 60 l/s (approximately 5,000 m^3/d); it can receive a maximum of 120 l/s (approximately 10,000 m^3/d). Since this WWTP was rehabilitated, it was also adapted to receive wastewater and faecal sludge. FS will be brought to the WWTP once the municipality starts providing emptying of septic tanks services. The provision of this service, as a municipal service, will be paid for by charging a per household fee. It is intended to be offered gradually, starting with pilot sectors defined by the municipality, and only sludge collected by the municipality within the canton will be accepted.

Plant operation is divided into several phases. Wastewater initially enters the treatment system independently and is then combined with FS, passing through pre-treatment (HUBER Rotamat® Complete Plant Ro5), then through a rotating drum sieve, an aerated desander and a grease removal system. Through pre-treatment, the plant removes solids from the wastewater that cause problems in subsequent aerobic treatment. Finally, the wastewater is treated employing an aerobic reactor with a capacity to treat 40l/s, as can be seen in Figure 6.

Figure 6: Villa Bonita WWTP. Upper Left: Wastewater Intake. Upper Right: FS Intake. Bottom Left: HUBER Rotamat® Pretreatment Machine. Bottom Right: Aerobic Wastewater Treatment, Primary Sedimentation and Digestion Reactor

Additionally, the WWTP has a second aerobic reactor tank. This will be used when the wastewater inflow increases by joining the 11 WWTPs of the subsystems to WWTP of Villa Bonita. Additional inflow of FS will be introduced once the Faecal Sludge Management (FSM) is implemented. This reactor will also treat 40l/s.

The implementation of the FSM service (see Section 3.2.2) will possibly have an impact on the sludge received at FSTP of the Sanitary Water Company. However, since the Sanitary Water Company FSTP is the only plant that receives sludge from third parties, the impact is not considered to be significant. Besides, the amount of sludge treated at the WWTP in Villa Bonita will increase gradually. The distance between these two plants is only 8.5 km.

2.1.4. End-use / Disposal

Villa Bonita WWTP: The water effluent from the plant is discharged into El Barro Creek. Operational reports of March and June 2019 (see Appendix 7.3) include all the universal parameters of obligatory analysis for the disposal of ordinary and special wastewater mentioned previously, and show that the measured parameters comply with the maximums established in the Regulation of Reuse and Discharge of Wastewater. No other end-use is currently carried out with sludge; thus, it is sent to the sanitary landfill.

Sanitary Water Company: Water effluent from the plant is discharged into the Alajuela River. Operational reports of March and June 2019 (see Appendix 7.4), which include all the universal parameters of obligatory analysis for the disposal of ordinary and special wastewater (Flow, Biochemical Oxygen Demand, Chemical Oxygen Demand, Hydrogen Potential (pH), Fats and Oils (GyA), Sedimentary Solids (SSed), Total Suspended Solids (TSS), Methylene Blue Active Substances (SAAM) and Temperature (T), show that the measured parameters comply with the maximums established in the Regulation of Reuse and Discharge of Wastewater for both periods.

For the dried sludge, there is no end-use in place; thus, sludge is sent to the sanitary landfill.

2.2. SFD matrix

The following sections include a detailed explanation of all assumptions to derive percentages for the final SFD graphic presented and discussed in Section 2.3. Figure 7 shows the SFD selection grid and Figure 8 depicts the SFD matrix.

Figure 7: SFD Selection grid

LIST A: WHERE DOES THE TOILET DISCHARGE TO? (I.E. WHAT TYPE OF CONTAINMENT TECHNOLOGY, IF ANY?)	LIST B: WHAT IS THE CONTAINMENT TECHNOLOGY CONNECTED TO? (I.E. WHERE DOES THE OUTLET OR OVERFLOW DISCHARGE TO, IF ANYTHING?)									
	To centralised combined sewer	To centralised foul/separate sewer	To decentralised combined sewer	To decentralised foul/separate sewer	To soakpit	To open drain or storm sewer	To water body	To open ground	To 'don't know where'	No outlet or overflow
NO ONSITE CONTAINER. TOILET DISCHARGES DIRECTLY TO DESTINATION GIVEN IN LIST B	T1A1C1				Significant risk of GW pollution Low risk of GW pollution	T1A1C6				Not applicable
SEPTIC TANK					Significant risk of GW pollution T1A2C5					
FULLY LINED TANK (SEALED)					Significant risk of GW pollution T1A3C5			T1A3C8		
LINED TANK WITH IMPERMEABLE WALLS AND OPEN BOTTOM	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution			T1A4C8		Significant risk of GW pollution Low risk of GW pollution
LINED PIT WITH SEMI-PERMEABLE WALLS AND OPEN BOTTOM										Significant risk of GW pollution Low risk of GW pollution
UNLINED PIT										Low risk of GW pollution T1A6C10
PIT (ALL TYPES), NEVER EMPTIED BUT ABANDONED WHEN FULL AND COVERED WITH SOIL	Not applicable									Significant risk of GW pollution Low risk of GW pollution
PIT (ALL TYPES), NEVER EMPTIED, ABANDONED WHEN FULL BUT NOT ADEQUATELY COVERED WITH SOIL										
TOILET FAILED, DAMAGED, COLLAPSED OR FLOODED										
CONTAINMENT (SEPTIC TANK OR TANK OR PIT LATRINE) FAILED, DAMAGED, COLLAPSED OR FLOODED										
NO TOILET. OPEN DEFECATION	Not applicable									Not applicable

Figure 8: SFD Matrix

SYSTEM LABEL	POP	W4A	W5A	W4C	W5C	F3	F4	F5
SYSTEM DESCRIPTION	Proportion of population using this type of system	Proportion of wastewater in sewer system, which is delivered to centralised treatment plants	Proportion of wastewater delivered to centralised treatment plants, which is treated	Proportion of wastewater in open sewer or storm drain system, which is delivered to treatment plants	Proportion of wastewater delivered to treatment plants, which is treated	Proportion of wastewater delivered to treatment plants, which is treated	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants which is treated
T1A1C1 Toilet discharges directly to a centralised combined sewer	18.0	83.0	100.0					
T1A1C6 Toilet discharges directly to open drain or storm sewer	1.0			0.0	0.0			
T1A2C5 Septic tank connected to soak pit	12.0					57.0	86.0	100.0
T1A3C5 Fully lined tank (sealed) connected to a soak pit	63.0					57.0	86.0	100.0
T1A3C8 Fully lined tank (sealed) connected to open ground	4.0					0.0	0.0	0.0
T1A4C8 Lined tank with impermeable walls and open bottom connected to open ground	1.0					0.0	0.0	0.0
T1A6C10 Unlined pit, no outlet or overflow	1.0					0.0	0.0	0.0

2.2.1. Step 1: Containment

For the Canton of Alajuela, information on the type of technologies in place were categorized by the National Census (2011) as sewerage system (18%), septic tanks (80%), direct exit to ditch - river or estuary (1%), pit, cesspit or latrine (1%), and no system in place (0%). ST represents the primary containment technology in use in the canton. Table 3 shows the respective estimates for population numbers and percentages, which are rounded to the nearest integer.

Additionally, the IDB (2019) household survey was able to determine the type of tanks in use out of the 80% reported by the National Census (2011). The vast majority (77.2%) reported to have a traditional single chamber ST. Double chamber ST were less common (12.2%). 4.6% reported to have "other" kinds of ST; however, it was determined that these were possibly not sealed and may have open bottoms. One last group, as expected, did not know what type of tank they had (6.1%).

The SFD-PI methodology uses a set of defined containment technologies, so the information obtained in the survey conducted by the IDB (2019) was reclassified, redistributing the percentages as follows: toilet discharges directly to a centralised combined sewer (system T1A1C1, 18%); toilet discharges directly to open drain or storm sewer (system T1A1C6, 1%); septic tank connected to soak pit (T1A2C5, 12%); fully-lined tank (sealed) connected to a soak pit (system T1A3C5, 63%); fully-lined tank (sealed) connected to open ground (system T1A3C8, 4%); lined tank with impermeable walls and open bottom connected to open ground (system T1A3C8, 1%); and unlined pit, no outlet or overflow (system T1A1C6, 1%).

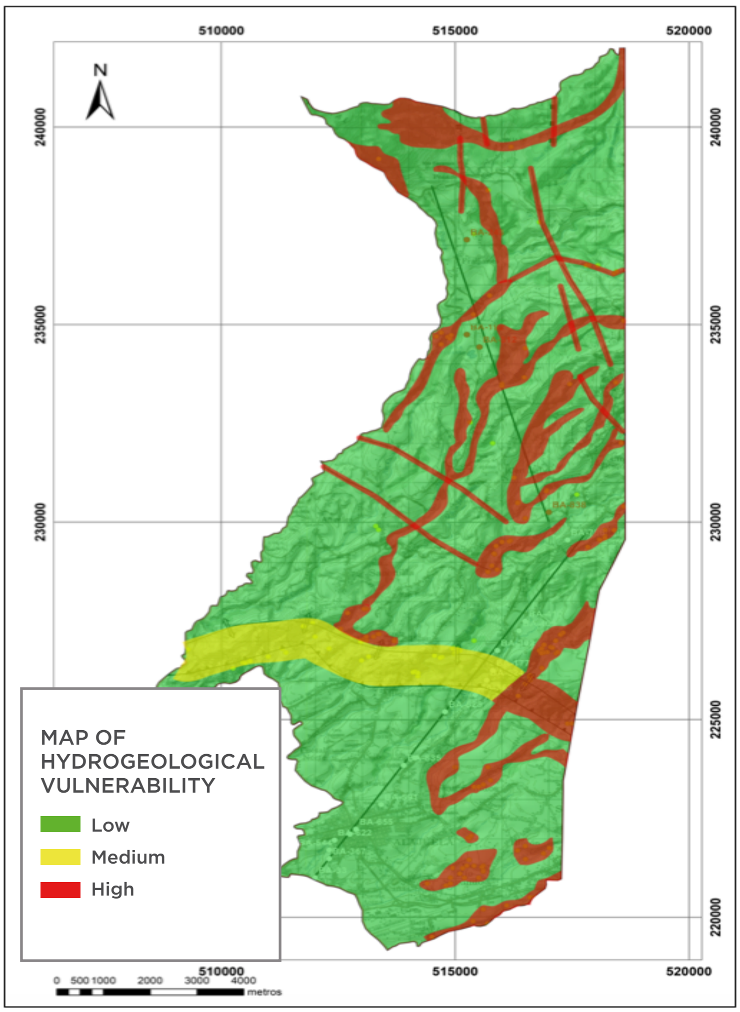
Table 3: Type of Containment Technologies in Canton of Alajuela

	Alajuela canton Household treatment systems (national census, 2011)					
DISTRICT	**SEWERAGE SYSTEM**	**SEPTIC TANK**	**DIRECT EXIT TO DITCH, RIVER, OR ESTUARY**	**PIT OR LATRINE**	**NO SANITARY SYSTEM IN PLACE**	**TOTAL HOMES**
Alajuela	7,400	5,652	152	35	13	13,252
San José	1,465	10,501	111	38	16	12,131
Carrizal	-	1,785	9	35	3	1,832
San Antonio	465	6,659	32	5	4	7,165
Guacima	331	5,095	27	52	3	5,508
San Isidro	-	4,581	36	151	17	4,785
Sabanilla	-	2,145	4	198	14	2,361
San Rafael	687	5,752	51	22	7	6,519
Río Segundo	448	2,536	99	44	6	3,133
Desamparados	1,940	5,182	138	50	5	7,315
Turrúcares	137	1,933	5	8	4	2,087
Tambor	-	2,939	8	53	10	3,010
Garita	-	2,048	8	18	6	2,080
Sarapiquí	-	828	1	21	3	853
TOTAL	**12,873**	**57,636**	**681**	**730**	**111**	**72,031**
PERCENTAGE	**18%**	**80%**	**1%**	**1%**	**0%**	**100%**

2.2.2. Step 2: Groundwater pollution

Arias Salguero (2015) developed a hydrogeological vulnerability map of the districts of Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro y Sabanilla (Figure 9) using a methodology that considers three parameters: degree of hydraulic confinement, occurrence of overlying substrate, and distance to the water table.

Figure 9: **Hydrogeological Vulnerability (Districts of Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro y Sabanilla).**



Source: Arias Salguero (2015)

The above information was considered in answering the following questions and determining the risk of contamination to groundwater:

Q1: Vulnerability of the aquifer

According to Arias Salguero (2015), a clay and silt texture predominates towards the south and east of the study area. On the other hand, towards the northwestern sector of the study area, sand textures tend to be equal to the percentage of clay, and lavas of the andesitic type, caused by activity of the Poás Volcano, predominate towards the northwestern sector. The study only covers six out of 14 districts (Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro and Sabanilla), given that most of the water catchments of the Municipality of Alajuela are in these districts.

The results in Figure 9 show that the canton has a mixture of vulnerability zones, but low vulnerability predominates. Additionally, some partial studies reveal there are two aquifers (upper and lower) west of the central zone of Alajuela in an area called Montecillos (see Section 1.6 and Appendix 7.2 for further information). According to ProDUS (2010), the upper aquifer is between 20 and 30m below ground level, covered by clays and lahars. This upper aquifer may be semi-confined or confined, and its water table would be approximately 10m below ground level. The lower aquifer would be around 85m below ground level, seemingly being semi-confined or confined, and its water table would be approximately 22m below ground level. It is separated from the upper aquifer by aquitards/aquicludes of tuff and clays. Overall, considering the information available, the aquifer is predominantly at low risk.

Result: Low Risk.

Q2: Lateral separation

Despite the fact that 80% of the population is using septic tanks, considering the information above on the distance of the groundwater table, the percentage of sanitation facilities that are located < 10m from groundwater sources is considered less than 25%. However, given most of the population uses a ST, and that this population is spread out through the canton, the percentage of sanitation facilities located uphill of a groundwater source was considered greater than 25%.

Result: Significant Risk

Q3 and Q4: Water supply and production

In the canton, the Municipality of Alajuela supplies drinking water to approximately 42% of its population through 20 wells and 38 springs, with depths ranging from 66m to 140m. About 40% is supplied by AyA, but the source of this water was not obtained, and the remaining 18% is supplied by ASADAS, most of which is provided from springs. Additionally, it was determined through the study by Arias Salguero (2016) that the majority has an adequate protection area, and the water is purified.

Result: Low Risk

Overall risk: Low Risk

2.2.3. Step 3: Emptying

The surveyed households with septic tanks revealed that these were emptied on average every two years. In other interviews conducted by the IDB (2019) with the emptying service providers, it was reported that the frequency of emptying was on average, once per year. Yet, service providers mentioned that this might vary according to the area and its infiltration capacity and the size of the ST, and, in most cases, emptying is practised when the containment becomes full, and not as a maintenance practice.

Of the sample of households with septic tanks interviewed, only 63.2% had emptied their septic tank at least once. Of these, 94.4% emptied their septic tank through a service provider who mechanically emptied it. The remaining 5.2% said they emptied their tanks manually with the help of household members, and 0.4% did not answer. It can be assumed that the FS emptied manually does not receive treatment.

2.2.4. Step 4: Transport

As mentioned in Section 2.1.1, 18% of the population is served by a sewerage system. However, according to the Municipality of Alajuela, it is estimated that only 15% out of the 18% of households connected to the sewerage system reach a treatment plant, and 3% is leaked or lost since there are still some subsystems that have not been incorporated to the Central Subsystem, and three inoperative and abandoned sewerage systems.

FSM service providers interviewed had one or more trucks. They all stated that they transported FS to a FSTP. The dimensions and capacity of these tanks vary widely (between 5 and 21 m^3), so there is no standardised truck size for this type of service. Regarding the transportation of FS once collected, it is not possible to assume that all service providers bring their FS to the FSTP. This was reaffirmed by service providers, who stated that many colleagues do not have permits, and unload the FS clandestinely into sewages or directly into rivers. Additionally, this was confirmed by the household survey, where approximately 4% of respondents said they had seen a truck dumping sludge into the river illegally within the canton.

2.2.5. Step 5: Treatment

Regarding wastewater, of the 15% of wastewater that reaches the Villa Bonita WWTP or an individual treatment plant (in case of the two small systems mentioned in Section 2.1.1), we assumed that under regular operating circumstances, the percentage of FS treated is 100%, as shown on the SFD matrix.

Regarding faecal sludge, despite not being able to verify if all emptied FS is brought to the FSTP, we assume that all FS that does reach the Sanitary Water Company FSTP and Villa Bonita WWTP is treated adequately under regular operating circumstances. Therefore, the percentage of FS treated is indicated as 100% on the SFD matrix.

2.2.6. Summary of Assumptions

The proportion of FS in septic tanks, fully-lined tanks, lined tanks with impermeable walls and open bottom and all types of pits were all set to 100%, as the guidance given in the Frequently Asked Questions (FAQs) in the Sustainable Sanitation Alliance (SuSanA) website.

Offsite sanitation systems

- **T1A1C1 - Toilet discharges directly to a centralized combined sewer (18%)**
  - **W4a - 83%** According to the Municipality of Alajuela, it is estimated that 15% out of the 18% of households connected to the sewer system reach the Villa Bonita WWTP. This is due to leaks, abandoned networks and small systems with no treatment in place.
  - **W5a - 100%.** Under normal circumstances, all wastewater delivered to the WWTP is treated by the Villa Bonita WWTP of the Municipality of Alajuela. According to records provided by Villa Bonita WWTP, the effluent meets all standards established in the Regulation of Reuse and Discharge of Wastewater, as stated in Section 2.1.3.
- **T1A1C6 - Toilet discharges directly to water body (1%)**
  - According to the 2011 Census, 1% of the waters discharge directly to an open drain or water body with no treatment at all. Thus, variables W4c and W5c were both set to 0%.

Onsite sanitation systems

Containment

According to the 2011 Census and, as can be seen in Table 3, 80% of Alajuela households have a septic tank as a sanitation system, and 1% of the population uses an unlined pit or, to a lesser extent, practices open defecation (the latter was considered negligible and not shown in the SFD graphic).

Given that Arias Salguero (2015) identifies most of the area of the districts of Alajuela, Desamparados, Río Segundo, Carrizal, San Isidro and Sabanilla as being classified as low hydrogeological vulnerability, all onsite sanitation systems were considered as located in areas that have low risk of groundwater contamination.

According to the SFD-PI methodology, well designed and functioning septic tanks are those having at least two chambers. The single chamber tanks are considered to be fully-lined tanks. Although the 2011 census does not specify the type of septic tank (single or double) a household has, the household survey implemented by the Inter-American Development Bank in 2019 elaborated on this question.

In accordance with the above, 80% of the population determined by the 2011 census was broken down as follows according to the results of the household survey:

- ✓ 77.1% have a one-chamber septic tank.
- ✓ 12.2% have a double-chamber septic tank.
- ✓ 4.6% have another type of septic tank.
- ✓ 6.1% did not know what type of septic tank they had.

Calculating the percentage of each tank type (one-chamber, double-chamber or other) over the 80% of total households from the 2011 census, the results obtained are:

- ✓ 80% x 0.771 = 61.68% - have a one-chamber septic tank.
- ✓ 80% x 0.122 = 9.76% - have a double-chamber septic tank.
- ✓ 80% x 0.046 = 3.69% - have another type of septic tank.
- ✓ 80% x 0.061 = 4.88% - did not know what type of septic tank they had.

From the above, the 4.88% who "did not know what type of septic tank they had" was divided into the three categories in the following way:

- ✓ 61.68% + 1.5% = 63.2% - have a one-chamber septic tank.
- ✓ 9.76% + 1.5 % = 11.7% - have a double-chamber septic tank.
- ✓ 3.69% + 1.9% = 5.5% - have another type of septic tank, which were further divided as fully-lined tanks (sealed) connected to open ground (1%) and lined tanks with impermeable walls and open bottom connected to open ground (1%). The latter system was included to reflect that few people also use barrel septic tanks (Figure 11) or another more simplified type of tank that does not necessarily have a sealed bottom.

The previous data lead us to assume the following results for the containment (Table 4):

Table 4: Types of Septic Tanks and Corresponding Containment According to the SFD-PI Methodology, Including Percentages of Population Using Each System

TYPE OF SEPTIC TANK	SFD-PI METHODOLOGY	FINAL PERCENTAGE
One-chamber	Fully-lined tank (sealed) connected to a soak pit (T1A3C5)	63%
Double-chamber	Septic tank connected to soak pit (T1A2C5)	12%
Other type	Fully-lined tank (sealed) connected to open ground (T1A3C8)	4%
	Lined tank with impermeable walls and open bottom connected to open ground (T1A3C8)	1%

Emptying

According to the household survey, 63.1% of the households said they have emptied their septic tanks; 35.4% responded that they never emptied their septic tanks; and 1.5% did not provide an answer.

It has been assumed that the volume of all tanks is 1,100 litres, of which 1,000 litres (1 m^3) are emptied, that is, the emptying efficiency is (1 m^3/ 1.1m^3) x 100 = 91%.

For variable F3, the percentage of emptied tanks (63%) is taken and multiplied by the emptying efficiency (91%). Thus, variable F3 = 63% x 0.91 = 57%.

This resulted in setting variable F3 to 57% for systems T1A2C5 (septic tank connected to soak pit and T1A3C5 (fully-lined tank (sealed) connected to a soak pit). For systems T1A3C8 (fully- lined tank (sealed) connected to open ground), T1A4C8 (lined tanks with impermeable walls and open bottom connected to open ground) and T1A6C10 (unlined pit, no outlet or overflow), variable F3 was set to 0% since it was estimated that households with these systems do not have emptying services.

Transport

It was estimated that:

- ✔ the total volume of faecal sludge generated is = 57,636 (total number of tanks) x 1.1m^3/ 31 months (average frequency of emptying) = 2,045m^3/ month.
- ✔ the total volume of faecal sludge emptied is 2,045m^3/ month x 0.57 = 1,172m^3/ month.

According to the survey's "FS treatment plant data" (see Annex 7.5), the volume of fecal sludge that reaches the treatment plant is 7,800 m^3/ month. However, this volume comes from FS originated from Alajuela and other locations.

A more precise value for estimating the volume of fecal sludge that reaches the treatment plant and only originates from Alajuela was obtained from the "FS Service Provider" survey (see Annex 7.5), where the estimated volume of faecal sludge that reaches the treatment plant is 1,009 m^3/ month.

Thus, variable F4, which is the proportion of faecal sludge emptied and then delivered to treatment plants, was estimated as the volume of faecal sludge that reaches treatment divided by the volume of emptied fecal sludge, that is, F4 = (1,009 m^3/ 1,172m^3) x 100 = 86%.

This resulted in setting the value for variable F4 to 86% for systems T1A2C5 (septic tank connected to soak pit and T1A3C5 (fully-lined tank (sealed) connected to a soak pit). For systems T1A3C8 (fully-lined tank (sealed) connected to open ground), T1A4C8 (lined tanks with impermeable walls and open bottom connected to open ground) and T1A6C10 (unlined pit, no outlet or overflow), variable F4 was set to 0% since it was estimated that households with these systems do not have emptying services, as previously stated.

Treatment

Finally, it was assumed that under normal circumstances, the 100% of the faecal sludge delivered to the faecal sludge treatment plant is treated as stated in Section 2.1.4. This resulted in setting the value for variable F5 to 100% for systems T1A2C5 (septic tank connected to soak pit and T1A3C5 (fully-lined tank (sealed) connected to a soak pit). For systems T1A3C8 (fully-lined tank (sealed) connected to open ground), T1A4C8 (lined tanks with impermeable walls and open bottom connected to open ground) and T1A6C10 (unlined pit, no outlet or overflow), variable F5 was set to 0% since these systems do not have emptying services, as previously stated.

Summary of onsite systems

- **T1A2C5 - Septic tank connected to soak pit (Low risk of GW pollution). 12%**

  F3 - 57% Proportion of this type of system from which faecal sludge is emptied.

F4 - 86% Proportion of faecal sludge emptied and then delivered to treatment plants.

F5 - 100% Proportion of faecal sludge delivered to treatment plants, which is treated.

- **T1A3C5 – Fully-lined tank sealed to soakpit (Low risk of GW pollution). 63%**

  F3 - 57% Proportion of this type of system from which fecal sludge is emptied.

  F4 - 86% Proportion of faecal sludge emptied and then delivered to treatment plants.

  F5 - 100% Proportion of faecal sludge delivered to treatment plants, which is treated.

- **T1A3C8 – Fully-lined tank sealed to open ground (Low risk of GW pollution). 4%**

  F3 - 0% Proportion of this type of system from which faecal sludge is emptied.

  F4 - 0% Proportion of faecal sludge emptied and then delivered to treatment plants.

  F5 - 0% Proportion of faecal sludge delivered to treatment plants, which is treated.

- **T1A4C8 - Lined tank with impermeable walls and open bottom connected to open ground (Low risk of GW pollution). 1%**

  F3 - 0% Proportion of this type of system from which faecal sludge is emptied.

  F4 - 0% Proportion of faecal sludge emptied and then delivered to treatment plants.

  F5 - 0% Proportion of faecal sludge delivered to treatment plants, which is treated.

- **T1A6C10 - Unlined pit (Low risk of GW pollution). 1%**

  F3 - 0% Proportion of this type of system from which faecal sludge is emptied.

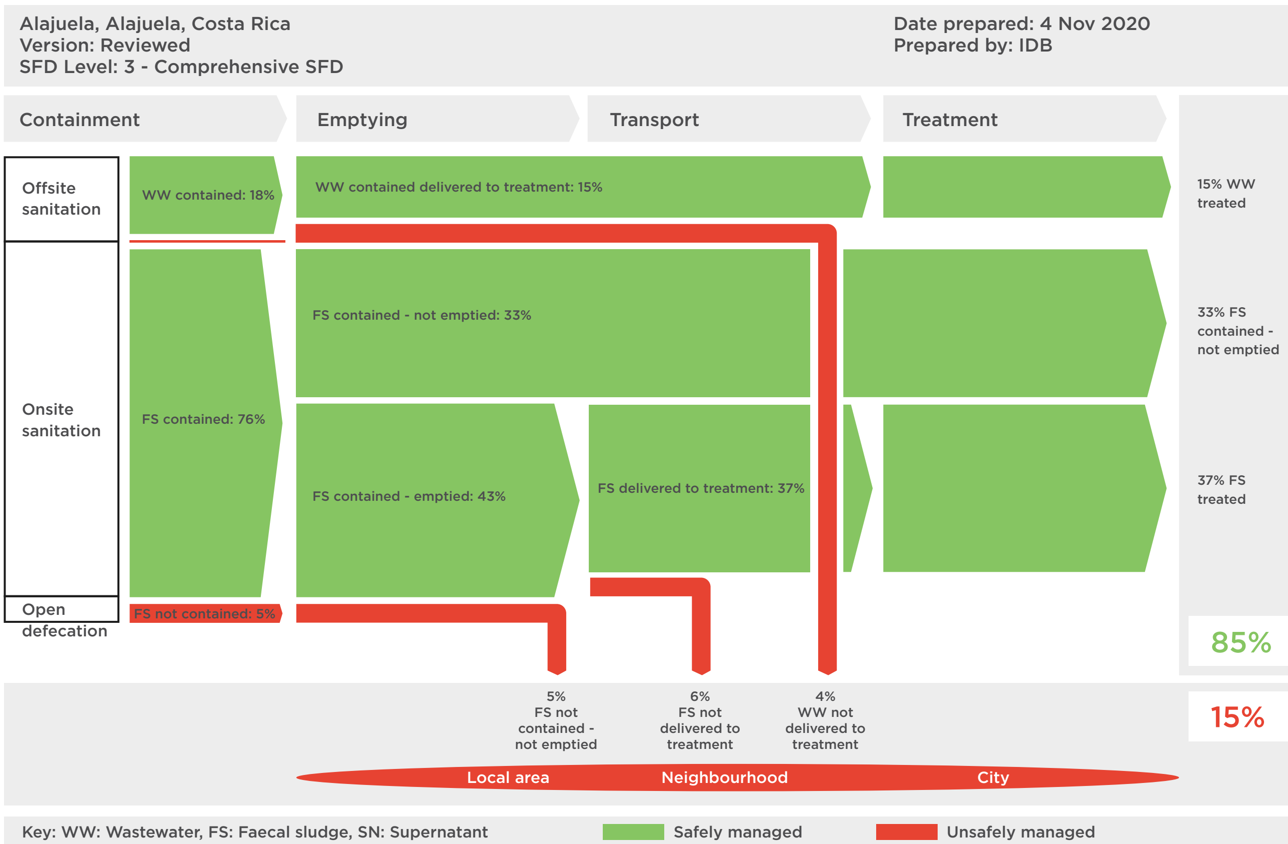
  F4 - 0% Proportion of faecal sludge emptied and then delivered to treatment plants.

  F5 - 0% Proportion of faecal sludge delivered to treatment plants, which is treated.

2.3. SFD graphic

The resulting SFD graphic is presented in Figure 10. The assessment shows that 85% of the excreta generated is safely managed in the Canton of Alajuela, and 15% of the excreta generated is unsafely managed.

Figure 10: Final SFD Graphic for the City of Alajuela



The SFD Promotion Initiative recommends preparation of a report on the city context, the analysis carried out and data sources used to produce this graphic.
Full details on how to create an SFD Report are available at: sfd.susana.org

85% of excreta safely managed originates from: 15% of wastewater contained, delivered to treatment and treated; 37% of FS contained, emptied, delivered to treatment and treated; and 33% of FS contained but not emptied from septic tanks and fully-lined tanks connected to soak pits. Despite this latter value of 33% of FS not emptied, it is considered to be safely managed and is depicted as a green arrow in the SFD graphic. It is important to highlight that:

I. From the household survey data, it is suggested that most of the 35.4% of households that have never cleaned their ST's may have leaks or are not functioning correctly. Therefore, the percentage of safely contained FS might have been overestimated. FS from these systems is considered to be safely managed because these systems are located in areas of low risk of groundwater pollution. A further analysis is needed to determine a higher degree of accuracy.

II. These onsite systems (tanks and fully-lined tanks) would require emptying services in the short- to medium-term. Thus, a new FSM plan still needs to be implemented in Alajuela to cope with this future demand of emptying services. It is foreseen that the percentage of faecal sludge that would be treated in the future will reach 100% once the municipality develops a new sanitation strategy and implements a better FSM service.

In addition, the percentage of wastewater that is treated may go from 15% to 18% with the rehabilitation plan of networks and WWTPs by the Municipality of Alajuela.

The 15% of excreta not safely managed consists of: 4% of wastewater not delivered to treatment that may be leaked; 6% of FS contained and emptied but not delivered to treatment from septic tanks and fully-lined tanks connected to soak pits; and 5% of FS not contained - not emptied from fully-lined tanks and lined tanks with impermeable walls and open bottom, connected to open ground.

The 6% of FS contained, emptied but not delivered to treatment may be explained, but also underestimated, given the following data extracted from the household survey:

1. 5.2% of the 63% who said they have emptied their ST had done so manually. This means that the sludge from these tanks, which are emptied manually, do not receive any treatment since the FSTP does not receive sludge from individuals, only service providers.
2. Four percent of the respondents reported seeing trucks emptying faecal sludge in their community.
3. The FS service provider survey interviewed clients of the FSTP or were found online; however, a vast majority claimed there are numerous colleagues who dump sludge into drains or the river.

2.4. Quality/credibility of data sources

The "SFD Source Evaluation Tool" (see Appendix 7.1) provided was used to score the credibility of data sources. In total, 11 sources scored either medium or high if they were official, well-documented studies and were conducted within the past few years.

Three surveys were implemented for this report and are described below:

1. Household Survey: The IDB conducted a survey to a sample of 534 homes with septic tanks in the Canton of Alajuela from July 2nd to July 12th, 2019. The surveys were randomly implemented in the 14 districts with the technique of face-to-face collection. The objectives of the survey were: i) to identify septic tank users regarding the location and type of septic tank in place; ii) identify maintenance practices; and iii) identify users' willingness to pay for the municipal faecal sludge management service.
2. Emptying and Transportation Service Providers Survey: The IDB surveyed a sample of 34 service providers selected from a population of 110 service providers, from February 15th to July 19th, 2019. The survey was implemented with the technique of a phone call interview. It is important to mention that from the sample of 34 service providers, only 23 provided services (not exclusively) in the Canton of Alajuela.
3. Master Builders Survey: The IDB interviewed five master builders from July 1st to July 15th, 2019. The interviews were implemented with the technique of a phone call interview. A master builder's role consists of following the instructions of engineers or architects in construction work and directing the construction crew. Therefore, they were considered key stakeholders. The objective of the survey was to identify the most common practices in the construction and installation of septic tanks.

Learnings:

Precisely knowing the amount of faecal sludge that is extracted in the Canton of Alajuela represents great difficulty given: i) the lack of records that determine the amount and the place of faecal sludge collected; ii) the presence of many informal service providers whose faecal sludge does not reach the FSTP; and iii) households do not know whether service providers work formally or informally, nor where sludge is taken once collected. Despite this, 95.5% of the households interviewed indicated that they were interested in knowing whether their faecal sludge was adequately treated and not improperly disposed of in a storm drain or river.

Recommendations:

1. It is recommended that the municipality carry out a study of transit of pollutants to the aquifers to determine the risk and likelihood of pollution to groundwater, and make recommendations for mitigating this hazard.

2. For the implementation of the FSM service, it is recommended to consider hiring companies or service providers that currently work in the canton and have all the permits, avoiding their displacement and economic impact.

4. Inhabitants of the informal settlements or slums are generally in complex land tenure situations that inhibit the possibility of accessing public services. Despite their situation, most households in slums have STs. It is therefore suggested that the municipality extends the service to informal settlements, possibly under another modality. Otherwise, in the absence of this, households in informal settlements are highly likely to resort to using informal service providers.

5. Given the large number of ST users, it is recommended that the municipality carry out campaigns promoting behavioural change about good practices and maintenance of STs. This is made even more relevant by foreseeing that the municipality is planning to provide the service. Additionally, according to the interviews held with the master builders, it was mentioned that in many municipalities, it is obligatory for new household construction to place STs in the front of the house to facilitate access for emptying. It is considered that this is a practice that can be adopted by the Municipality of Alajuela, facilitating easier access for trucks, avoiding hoses crossing the household, and eventually facilitating the connection to the sewerage system.

6. As a result of the Validation Workshop, it was determined that in the sector surrounding the construction and maintenance of septic tanks, there is a lack of knowledge from the engineers who sign the building plans, the master builders who construct, the municipal inspectors who supervise the construction, and finally, the users. However, this does not only happen in the canton, but also at the national level, and it is an issue that requires a broader approach.

3. Service Delivery Context Analysis

3.1. Policy, legislation, and regulations

3.1.1. Policy

Legislation that addresses wastewater and Faecal Sludge Management (FSM) can be found in Table 5. The National Wastewater Sanitation Policy 2016 supplies the framework to harmonise the actions that need to be taken to secure the well-being of the population and the environment through the treatment of wastewaters and faecal sludge. The policy also establishes a guideline of specific actions that the country needs to execute towards the achievement of the Sustainable Development Goals (SDGs). For this report, only those policies/regulations that are related more specifically to FSM will be elaborated upon and can be found highlighted in bold in Table 5.

Table 5: Costa Rican Legal Framework Related to Wastewater and FSM

YEAR	LAW OR REGULATION
1942	Water Law #276
1953	Drinking Water Law #1634
1961	Constitutive Law of the Institute of Aqueducts and Sewages #2726
1968	Urban Planning Law #4240
1973	General Health Law #5395
1983	Constitutive Law of the National Groundwater, Irrigation and Drainage Institute #6877
1991	Code of Hydraulic and Sanitary Installations in Buildings
1992	Law of the Conservation of Wildlife #7317
1995	Organic Environmental Law #7554
1996	Forest Law #7575
1996	Constitutive Law of Regulatory Authority of Public Services (ARESEP)
1998	Law of Conservation and Land Use Management #7779-MINAE
2002	Regulation of Aqueduct and Sewage Services #30413-MP-MINAE-S-MEIC.
2004	Decree: Declaration of public interest and social need for the design, financing, execution, operation, and maintenance of works for the collection, treatment and final disposal of wastewater generated in urban centres #32133-S
2005	Canon on Water Use #32868-MINAE
2007	Regulations for Evaluation and Classification Quality of Water Bodies Superficial # 33903-MINAE-S.
2007	Regulation of Discharge and Reuse of Wastewaters #33601-S MINAE
2008	Environmental Canon for Dumpling #34431-MINAE
2015	Regulation for the Handling and Final Disposal of Sludge and Biosolids # 39316-S
2016	Regulation for the Approval and Operation of Treatment Systems for Waste Waters #39887-S-MINAE
2016	National Wastewater Sanitation Policy

National Health Law (1973):

Article 276 establishes that it is only with the permission of the Ministry of Health that one may drain or proceed to discharge solids, liquids or other waste or residues that may contaminate surface, underground or maritime water.

Code of Hydraulic and Sanitary Installations in Buildings (1991):

This code establishes, among other items, a methodology for calculating the septic tank volume, and recommends a series of dimension combinations for rectangular septic tanks.

Law of the Conservation of Wildlife (1992):

The law prohibits the dumping of sewage, waste or any contaminating substance in springs, rivers, streams, permanent or non-permanent streams, lakes, marshes and natural or artificial reservoirs, for fresh and brackish or salty water.

Decree: Declaration of public interest and social need for the design, financing, execution, operation, and

maintenance of works for the collection, treatment and final disposal of wastewater generated in urban centres (2004):

The decree considers that the existing sanitary sewerage systems in urban areas have almost reached their useful life and are in inadequate conditions and have insufficient capacity for the due fulfilment of their functions. Many pipes that make up these systems have been invaded with the construction of buildings, which requires comprehensive strategies involving various actors and must take into account the design, investment, implementation, operation and maintenance of projects that prove to be technically and economically viable. The decree also declares that the operating entities of sewerage systems must gradually develop the necessary structure to comply with current regulations.

Regulation of Discharge and Reuse of Wastewaters (2006):

The regulation establishes physical/chemical parameters and guidelines for the reuse and disposal of wastewaters. It also prohibits the dumping of sludge from wastewater treatment systems, water purification systems and septic tanks into bodies of water and sewerage systems.

Regulation for the Handling and Final Disposal of Faecal Sludge and Biosolids (2015):

This regulation is mainly regarding FS, addressing the management and final disposal of faecal sludge, ordinary and special biosolids. It regulates the provision services along the service chain, provided by public or private companies. The regulation excludes wastewater from sanitary cabins or mobile latrines, which must be treated and must comply with the provisions of the Regulation of Discharge and Reuse of Wastewaters.

This regulation replaced the 1992 "Regulation for the Handling of Sludge from Septic Tanks" # 21297-S, extending its reach to different types of biosolids. However, it is important to mention that this new regulation excludes or dilutes the responsibility of the public institution to provide FS treatment. Consider that previously, in the 1992 regulation, the following was mentioned:

"*Within a year, each region of the country must have an appropriate place for the sludge disposal to avoid transporting FS for long distances and illegal dumping*."

Notwithstanding the above, the 1992 regulations did not assign responsibility to a specific institution, nor did it clarify which regions it referred to (provinces, cantons, governing areas of the Ministry of Health). Most importantly, no public FS treatment plant was built during the whole period of validity of the regulation (23 years). There is only one small private Faecal Sludge Treatment Plant (FSTP) in the country (Sanitary Water Company), built in 2011, that receives faecal sludge from third parties (private emptying and transport service providers) and is located within the Canton of Alajuela.

Regulation for the Approval and Operation of Treatment Systems for Waste Waters (2016):

The regulation establishes the limits and requirements for the construction of wastewater treatment systems.

National Wastewater Sanitation Policy (2016):

The NWWS Policy established five central axes with their respective objectives to be met by 2045.

1. **Institutional and policy strengthening for water sanitation**

   Objective: Achieve the articulation of the sanitation and wastewater treatment sector under the regulatory review and the coordination and strengthening of institutions.

2. **Integrated management for wastewater treatment**

   Objective: Strengthen the management of ordinary and special wastewater treatment, using existing instruments and the creation of new ones, if required.

3. Infrastructure and investment in sanitation

Objective: Improve sewage and wastewater treatment coverage through the planning, prioritisation, and execution of safe, universally designed physical infrastructure.

4. Financial sustainability and tariff model

Objective: Improve the financial sustainability of the sanitation sector through a model of integral financing, and participation with a social and permanent focus.

5. Citizen participation

Objective: Encourage citizen participation with knowledge and information for the development of a national structure that promotes the proper sanitary management of wastewater.

3.1.2. Institutional roles

At the country level, the structure of institutions in the sanitation sector and their roles are summarised below and are divided in four categories: management and policy, regulation, control and monitoring and operation. It is important to point out that the competencies of these institutions are often entangled, generating conflict or confusion in the delineation of their functions.

1) Management and policy

Ministry of Environment (MINAE): According to Water Law No. 276, Organic Law on the Environment No. 7 554 and ARESEP Law No. 7,593, MINAE is responsible for and the governing body of all centralised, decentralised, and public water and sewerage service providers. As such, it has the power to determine the use, governance, protection, and monitoring of public waters.

Ministry of Health (MINSA): According to Organic Law on Health No. 5,395, MINSA is responsible for controlling water pollution, as well as regulating and monitoring the quality of water the population receives, especially with regard to drinking water supply services, disposal of faecal sludge and sewage on water effluents, and waste management services. It is also responsible for approving and monitoring projects for sanitary sewerage, excreta disposal and wastewater treatment (and industrial) and their location; and for authorizing the discharge of wastewater into the sanitary sewerage system. Since the political function in the country corresponds to the country's ministries, MINSA and MINAE are responsible for issuing the National Wastewater Sanitation Policy.

Costa Rican Institute of Aqueducts and Sewerage (AyA): AyA is responsible for the management and policy of matters related to the drinking water supply and the collection and disposal of sewage and liquid industrial waste.

Regulation

Ministry of Environment (MINAE): MINAE issues rules and regulations concerning the management and protection of surface and groundwater resources.

Ministry of Health (MINSA): MINSA issues rules and regulations concerning the quality of both drinking water and treatment of wastewater, ensuring public health.

Costa Rican Institute of Aqueducts and Sewerage (AyA): AyA establishes and implements standards and regulations, focusing mainly on technical criteria of water and sanitation services.

Public Services Regulatory Authority (ARESEP): ARESEP is the economic regulator (setting tariffs) of public services, in this case the provision of water and sanitation services. Given the relationship that must exist between tariffs and quality of service, it has the power to regulate quality of services.

Control and monitoring

Ministry of Environment (MINAE): The surveillance and control of the sanitation sector is the responsibility of MINAE, which ensures the protection of the environment.

Ministry of Health (MINSA): MINSA ensures the protection of health.

Costa Rican Institute of Aqueducts and Sewerage (AyA): AyA must ensure the operation and maintenance of wastewater treatment plants in urbanizations and private housing developments.

Public Services Regulatory Authority (ARESEP): ARESEP supervises the providers and the quality of the service delivered.

General Comptroller of the Republic (CGR): The CGR controls and oversees the use of public funds.

Operation

Finally, in the role of operation, we find different providers of drinking water and sanitation services, which are described in Section 3.1.3.

3.1.3. Service provision

AyA is the main water and sanitation operator in the country (47%), followed by the Associations of Communal Sewerage Systems (29%), municipalities (14%), ESPH (5%) and private developments with their own systems (5%).

In the case of the Canton of Alajuela, the municipality is not only the main water and sanitation service provider for the canton, but part of 28 municipalities (out of 81) that operate and provide their water systems. Of the 28 municipalities mentioned previously, only five operate a sanitation system. As these are local governments, the Comptroller General of the Republic has regulatory powers to set the rates for the services provided by these municipalities.

3.1.4. Service standards

As noted in Section 3.1, there is a robust legal framework that, through various regulations, establishes the parameters for wastewater discharging and disposal of faecal sludge and biosolids. MINAE and MINSA not only issue these regulations, but also have the challenging task of enforcing them.

An important gap remains for service standards related to FSM, given that, beyond the Code of Hydraulic and Sanitary Installations in Buildings, (which is mainly seen as a manual of good practices), and the Regulation for the Handling and Final Disposal of Faecal Sludge and Biosolids, which addresses the management and final disposal of faecal sludge, there is no entity that ensures and enforces the construction, proper maintenance, and compliance of these systems. There is no services standard nor regulation entity that ensures the quality and cost of emptying and transportation of faecal sludge.

3.2. Planning

3.2.1. Service targets

The Municipality of Alajuela is determined to extend its sewage network to the population. However, given the topographical characteristics of the canton, it is not planned to achieve 100% coverage. For this purpose, a Faecal Sludge Management Service is planned. This will be discussed in detail in the next section.

3.2.2. Investments

BPR Envir Aqua Proposal (2004)

In 2004, the Municipality of Alajuela signed a donation agreement with the Canadian International Development Agency (CIDA) for nearly 500,000 Canadian dollars to develop the pre-design of a project to address the problem of wastewater in the canton. The resulting study, named "Alajuela Wastewater Sanitation Plan", was carried out by the Canadian company, BPR Envir Aqua, Inc., in 2007.

According to ProDUS (2010), the proposal put forward by BPR Envir Aqua, Inc. considered the construction of a centralised WWTP, in which all the wastewater produced by the municipal sewage system would be treated. This implied that the individual treatment plants (described in Section 2.1.1) of urbanisation subsystems would be taken out of operation, as well as the Villa Bonita Treatment, and all the wastewater would be sent through the primary collector, to a new WWTP, which was intended to be built on a 15.7-hectare property acquired by the municipality. However, estimated costs for the proposal reached approximately US$12 million (excluding rehabilitation of existing networks), which exceeded the budget of the Municipality of Alajuela. Given this situation, in 2009 the Municipality of Alajuela requested the Research Program on Sustainable Urban Development of the University of Costa Rica (ProDUS-UCR) to review in detail the study and propose an alternative solution that addressed the wastewater situation a lower cost.

ProDus-UCR Proposal (2010)

ProDus-UCR's technical proposal included a series of phases, adjusted to the current revenue, via municipal tariff so that it would be self-financed. The phases are summarised below:

- **Preliminary phase:** This stage involves rehabilitating and putting into operation small wastewater treatment plants (WWTP) built around the city. Some of them date back to 1980s and vary widely with respect to the type of technology employed. Some of the technologies include Imhoff systems, anaerobic plants and activated sludge. Many of these systems were built by various real estate development companies and were subsequently transferred to the municipality along with all the public infrastructure (drinking water system, streets, parks, etc.) within those housing complexes. At the time of their reception of those systems, the municipality did not have a Sanitation Department until 2004; therefore, the WWTPs received poor or null maintenance and stopped working and remained inoperative and abandoned until recently. This preliminary phase also involved the rehabilitation of the Villa Bonita WWTP (estimated cost US$ 0.19 million).

- **Phase I:** This stage incorporates the construction of a collector between the current Villa Bonita WWTP and a new WWTP in the city, which would be built throughout the railway's right-of-way, which is contiguous to the Villa Bonita's WWTP (estimated cost US$ 2.25 million).

- **Phase II:** This stage incorporates a section of the main collector that connects the area of Paso Flores with the Villa Bonita's WWTP. This section is of vital importance to incorporate into the system's sectors that currently have sewages but are not connected to any treatment plants and discharge wastewater without any treatment directly to the river. These areas of Tropicana, Paso Flores, Cafetal and Llobet (estimated cost US$ 0.50 million).

- **Phase III:** This stage includes the construction of the collector between Paso Flores and the district of Desamparados, allowing to connect this zone and two small WWTPs (Independencia and Silvia Eugenia). This phase would also include the incorporation of the sanitary networks of the area of INVU Las Cañas, which were abandoned, into the municipal system (estimated cost US$ 0.35 million).

- **Future projects:** These include the provision of a sanitary network to urbanisations that currently have septic tanks and could be easily replaced for a sewerage system and connected by gravity to the proposed system of new collectors.

Of all the stages proposed, phase I is the one that requires the most investment but has technical and legal feasibility. Phases II and III are less costly but still need technical and legal feasibilities assessed.

It is important to emphasise that the proposal only covers six of the 14 districts of the canton: Alajuela, San José, San Antonio, San Isidro, Río Segundo and Desamparados. In an optimistic scenario, it is expected that by 2030, in the central district, 90% of the population will be connected to the sewerage system, in the case of Desamparados 75%, in San José 30% and the remaining districts about 15%. This is mainly due to the topographic characteristics of the districts that allow for the sewerage system to be built and the fact that approximately 80% of the population of the canton is concentrated within these districts.

Finally, ProDus-UCR's economic proposal reached US$ 4.3 million, including US$ 1.2 million for designs, inspections, contingencies, and administration works, in its most favourable condition. The most critical scenario of the proposal amounted to nearly US$10 million, which would include operation and maintenance costs. The difference between both scenarios (more favourable and less favourable) was mainly due to increments associated with unforeseen civil works, design, and inspection. In addition, these amounts did not take into account the rehabilitation of networks in existing urbanisations, nor the expansion of the WWTP.

This economic proposal raised the need to look for financing options that would allow the municipality to pay for this investment. The proposal also raised the need to establish a tariff mechanism that would help pay for financing options and generate necessary income for future maintenance and expansion of the project.

Faecal Sludge Management

- Given that the technical proposal was not intended to supply the entire canton with a sewerage system, ProDus-UCR's proposal carried out a legal analysis to determine the possibility of the municipality to provide Faecal Sludge Management services. Two scenarios were considered feasible: i) creating a public limited company or ii) providing a new public service. In the event of either of the two options materialising, the local government would need to consider, among other factors:

- the specific legal framework that underpins and authorises the creation of the septic tank emptying and transportation service as a commercial activity

- carry out the necessary consultations with the Regulatory Authority for Public Services and the General Comptroller of the Republic

- issue the regulation for the correct development of the commercial activity

- establish the municipal budget for the creation and operation of the activity

- develop the necessary infrastructure

- train human resources to provide service

- formulate logistics for service delivery

- comply with all existing regulations to carry out the septic tank emptying and transportation service

Municipality of Alajuela (2011-2020)

After the development of both proposals (BPR Envir Aqua, Inc and ProDUS-UCR) a Sanitation Department in the Municipality of Alajuela was consolidated, which brought to management a new team that analysed both proposals and their recommendations. Given the above, and the lack of resources, the municipality opted for and executed the following:

1. Rehabilitation of the Villa Bonita WWTP, which expanded its capacity to receive a maximum of 1.20 m^3/s and incorporated a pre-treatment process that separates fats and solids. The WWTP was also adapted to receive FS from septic tanks.

2. Rehabilitation of abandoned WWTPs and the adaptation of small WWTPs to pumping stations. The pumping stations will pump the wastewater to the Villa Bonita WWTP.

3. Development of the strategy for the provision of the public service for septic tank emptying. To accomplish this, the municipality is in the process (since mid-2019) of approval and publication of the regulation that will allow the municipality to provide service and charge a tariff. If approved, this would be the first step towards the collection of a municipal sanitation service tariff to both households served by the sewerage system or to those with a septic tank. For those with a septic tank, the tax would cover the provision of an FSM service. According to the municipality's Sanitation Department, in the new sanitation regulation

to be published in late 2020, the tariff will be calculated by the sum of all costs of the service, plus 10% for reinvestment in the construction of new sewerage networks and treatment plants. The tariff is expected to be approximately CRC 2000-3000 (US$ 4-8) per month. The cost of the service includes emptying the septic tank, transportation, treatment, and final disposal.

The above-mentioned will allow the municipality to accelerate its financial capacity to expand the sewerage network. The provision of the service is intended to be provided gradually, starting as a pilot project for specific sectors of the Canton of Alajuela. The tariff will allow subscribers to empty their septic tank once every two years. A call centre will be available to request and schedule a FSM service. To accomplish this, the municipality would outsource both the emptying and transportation services through a public bidding process.

According to preliminary calculations of the Sanitation Department of the Municipality of Alajuela, a demand of emptying 100-120 septic tanks per day is expected once the service is provided to all the canton. Such demand will require 10-12 trucks of approximately 10 m^3.

The population to be covered by the combination of the rehabilitation of the Villa Bonita WWTP, the abandoned subsystem's WWTPs and by the FS emptying and transportation services is presented in Table 6.

It is important to note that the implementation of FSM service is intended to be available to all the population that has a septic tank, progressively. At the same time, the scope of the sewerage system will be expanded. This will therefore lead to a reduction in the percentage of the population using septic tanks and increase the share of people with the sewerage system.

Table 6: Expected Scope of Service Provision

	VILLA BONITA WWTP AND ABANDONED SUBSYSTEMS	FSM SERVICES
PERCENTAGE	18	80
POPULATION	45,822	203,653.6
TOTAL	249,475.6	

Additionally, it is expected that there will always be a percentage of the population that, due to the informal situation and the location within the canton, will not be covered by either service in the short- or medium-term.

Initially, the sludge would be treated at the Villa Bonita WWTP, which was adapted to receive both wastewater and faecal sludge. However, as proposed by ProDus-UCR (2010) and BPR Envir Aqua, Inc., a new treatment plant with greater capacity would be built on a property acquired by the Municipality of Alajuela, which has approximately 17 hectares. The Municipal Environmental Sanitation Services Centre (CEMSSA) is currently being developed on this property. The treatment plant intended to be built at CEMSSA would treat ordinary wastewater, faecal sludge, and special water from some types of industry. The municipality does not yet have a preliminary design for CEMSSA's WWTP. However, according to the Sanitation Department of the Municipality of Alajuela, the following is the desired preliminary process:

1. Pre-treatment: fully automated by grids, screens, a desander and an automatic degreaser.
2. Primary treatment: removal of primary sludge through a sedimentation system.
3. Secondary treatment: aerobic Sequencing Batch Reactors (SBR) are preferred to carry out the denitrification in the same tank.
4. Tertiary treatment: sand filtration and chlorine disinfection.
5. Septic sludge line: stabilisation with lime is the process being considered, followed by mechanical dehydration though a solar/thermal combination. The dried sludge will be incinerated to produce electrical energy and useful heat for drying.

In addition to the WWTP, CEMSSA intends to include a solid waste separation and recovery plant, the main office of the Environmental and Sanitation Departments of the Municipality and the call centre for customer service to make appointments for households to have the ST emptied. If the septic tank emptying service is successful, and resources are available to build a new WWTP, the municipality would also consider expanding its services and provide them to nearby municipalities.

3.3. Equity

3.3.1. Current choice of services for the urban poor

According to a situation analysis developed by Madrigal (2015) on informal settlements in Costa Rica, the main sanitation solution used by urban poor were septic tanks or a similar artisan-crafted system such as "barrel septic tanks," as seen in Figure 11, which are a lined pit with an open bottom. The study also identified that most septic tank users turned to service providers for mechanical emptying and transportation of faecal sludge. However, it is difficult to distinguish whether these providers were formal or informal.

The situation analysis also determined that there is no service regulator for the provision of FSM and there was no differentiated tariff for low-income households. However, the study did find that many service providers claimed to lower or raise prices according to the apparent socio-economic conditions of a household. Additionally, given that service providers charge per m^3 of faecal sludge, many of these septic tanks tend to be small given the reduced space that characterises this type of house and community; therefore, prices are charged accordingly.

3.3.2. Plans and measures to reduce inequity

The municipality is not currently considering providing sewerage system nor septic tank emptying services in informal settlements in the canton, given the informal situation in which these communities find themselves. Within the canton, there are approximately 45 informal settlements, which add up to around 10,000 people. According to the Municipality of Alajuela (2012), on average, there are about 58 families per settlement. The largest number of informal settlements are in the districts of San José, Alajuela, and San Isidro, which together represent 58% of the population living in informal settlements. This seems to be caused by elements such as population concentration and economic activity, given that in the more rural districts (Sarapiquí and Turrúcares) there are fewer or no settlements reported.

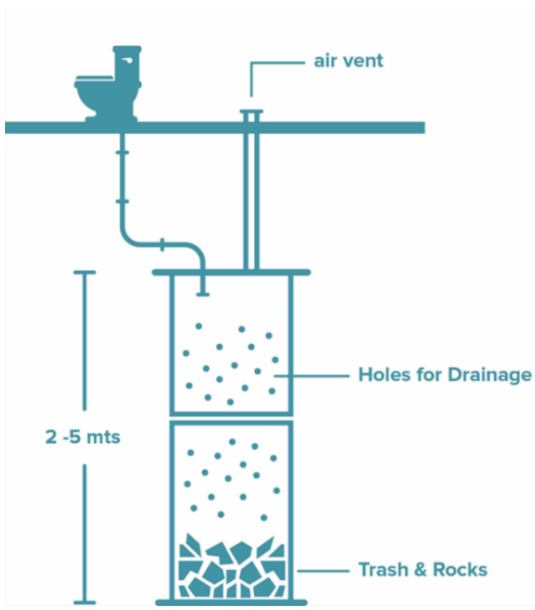
It is important to note that most inhabitants of informal settlements also use septic tanks as sanitation systems or similar artisan-crafted system such as "barrel septic tanks". The barrel septic tank consists of two or three barrels (oil drums) welded together. Rocks, trash, or other materials are added in the bottom according to the users, to create a sort of filter; small holes are made for drainage around the barrel. The barrels are then buried, two to five meters deep outside the house and then covered with cement. In some cases, an air vent is installed, and the whole assembly is connected to the toilet inside the house (Madrigal, 2015).

According to a situation analysis developed by Madrigal (2015) on informal settlements in Costa Rica, the users of the barrel septic tank consider this technology "good" because it takes a long time to fill up. Once filled, they close the barrel and install another one next to it. This suggests that there may be barrel fields of FS buried around a community, with no consideration of the water table. These communities in most cases are located next to rivers, which implies that the water table is probably high. Another aspect to consider is the material; barrels are made of steel, which experiences corrosion in contact with sulphates. Figure 11 provides an example of the described system.

3.4. Output

3.4.1. Capacity to meet service needs, demands and targets

Figure 11: Design of a Barrel Septic Tank. Source: Madrigal (2015).



To attend to the new WSF service to be provided by the municipality, faecal sludge collection service will be subcontracted to private companies. Treatment of faecal sludge will be done in the municipal treatment plant, whose management is also subcontracted. Therefore, the municipality considers that it has the capacity to meet service demands.

3.4.2. Monitoring and reporting access to services

Customer service, as well as the supervision and quality control of the contracted collection services, will be carried out by the municipality in the Municipal Environmental Sanitation Services Centre (CEMSSA) building, where a call centre will be set up.

3.5. Expansion

3.5.1. Stimulating demand for services

The promotion and dissemination of the services will be done, in the first instance, through the Department of Communication of the Municipality, which will establish advertising guidelines for social networks, such as the press. In later stages, other forms of marketing will be included, such as promotional videos, educational campaigns, and information stands, among others.

3.5.2. Strengthening service provider roles

As the municipality will subcontract the service providers for the emptying and transport of faecal sludge to either a company or a consortium of providers, this will ensure that services are provided through strict quality controls and that the FS is delivered to the Villa Bonita WWTP and, eventually, the new WWTP built by the municipality. In addition, the municipality and the Sanitary Water Company are responsible for ensuring that the treatment of their wastewater and sewage sludge complies with the parameters set by the Ministry of Health through monthly operational reports.

4. Stakeholder Engagement

The proposed tools of the SFD-PI methodology were used for stakeholder engagement and data collection. All planning and execution of engagement activities were carried out jointly with the municipality.

Key informant interviews, surveys and field visits

A visit was made to the FSTP and an interview was conducted with its director in May 2018.

Between April 2018 and April 2019, three field visits were made to the WWTP of Villa Bonita in Alajuela, where information was collected and meetings were held with the director of the sanitation area of the Sanitation Department of the Municipality of Alajuela.

Between September 2018 and June 2019, surveys were conducted among septic tank emptying and transportation service providers, and interviews were conducted with master builders, responsible for the installation and construction of septic tanks in Costa Rica.

During July 2019, a survey was carried out to a sample of septic tank-using households in the Canton of Alajuela.

Finally, in August 2019, a workshop for validation of results was carried out with key stakeholders.

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7. Appendices

7.1. Appendix 1: SFD Source Evaluation

NAME OF THE SOURCE	TYPE OF SOURCE	REPRESENTATIVENESS	DEPTH OF DATA OR SCALE	CONFIDENCE	DOCUMENTATION	SUM OF VALUES	CREDIBILITY
Sanitary Water Company WWTP Effluent Reports	Municipal, utility or private local service provider records	2	0	2	3	7	MEDIUM
Villa Bonita WWTP Effluent Reports	Municipal, utility or private local service provider records	2	0	2	3	7	MEDIUM
Hydrogeological Studies	Documented studies	3	0	3	3	9	HIGH
Environmental Improvement Report City of Alajuela	Documented studies	3	0	3	2	8	HIGH
Interview to 500 households with Septic Tanks Developed by IDB	Interviews and FGDs	3	3	2	3	11	HIGH
Interviews to Vacuum Service Providers developed by IDB	Interviews and FGDs	3	2	3	3	11	HIGH
Interviews to Master Builders	Interviews and FGDs	3	2	3	3	11	HIGH
Interview with Sanitary Water Company FSTP owner	Interviews and FGDs	3	3	2	3	11	HIGH
Interview with Head of Sanitation Department Municipality of Alajuela	Interviews and FGDs	3	3	2	3	11	HIGH
Field visits to Villa Bonita WTTP	Observation	3	3	2	3	11	HIGH
Field visits to Sanitary Water Company FSTP	Observation	3	3	2	3	11	HIGH

7.2. Appendix 2: Additional Information about the City Context

7.2.1. Population

According to the projections made by the Municipality of Alajuela (2012), the population of the canton will increase to approximately 319,033 by 2020. Table 7 shows the population distribution and projections.

Table 7: Population Distribution and Projections

	DISTRICTS	POPULATION OF 2011	DISTRIBUTION OF THE POPULATION	SOCIAL DEVELOPMENT INDEX RANKING
1	Alajuela	42,970	**17%**	**59,9**
2	San José	41,650	**16%**	**58,7**
3	Carrizal	6,856	3%	54,3
4	San Antonio	24,971	**10%**	52,8
5	Guácima	20,183	8%	**63,1**
6	San Isidro	17,358	7%	48,7
7	Sabanilla	9,009	4%	48,3
8	San Rafael	26,061	**10%**	56,6
9	Río Segundo	10,661	4%	56,5
10	Desamparados	26,108	**10%**	53,8
11	Turrúcares	7,630	3%	**58,8**
12	Tambor	10,992	4%	53,0
13	Garita	7,276	3%	**61,4**
14	Sarapiquí	2,842	1%	50,5
	TOTAL CANTON	**254,567**	**100%**	

Source: Municipality of Alajuela (2012)

7.2.2. Topography

The northern sector of the canton is made up of the districts of Sarapiquí, San Isidro, Sabanilla, Carrizal and the northern part of the districts of Tambor and Desamparados is characterised by diverse topography, vast forests, and the development of agricultural activities.

The districts of San José, the northern part of the districts of Garita and San Antonio, where the largest concentration of industries and industrial parks are located, are characterised by one of the flattest topographies.

The central zone of the canton is composed mainly of the district of Alajuela, the northeastern and northwestern part of the districts of San José and Río Segundo, San Antonio and Desamparados. It is characterised by flat topography, holds the largest urbanised area of the Canton and the largest concentration of shops and services.

7.2.3. Climate

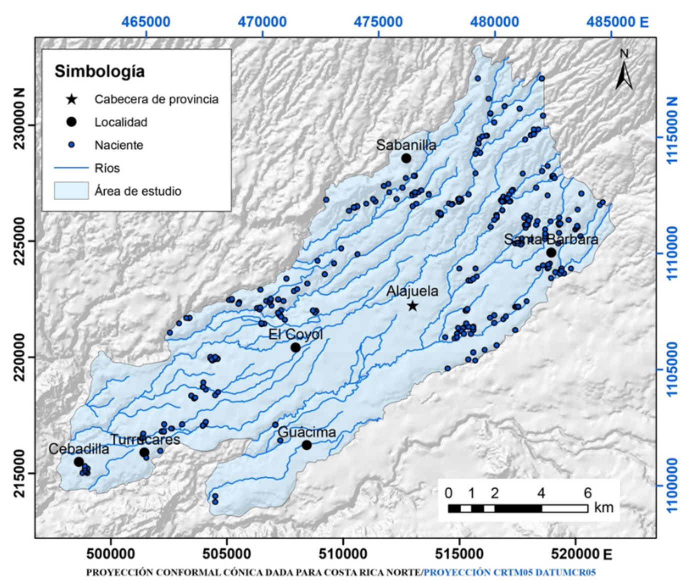
Table 8: Average monthly rainfall (mm)

MONTH	FRAIJANES STATION (1976-2011)	JUAN SANTAMARIA STATION (1999-2012)
Jan	116.1	7.8
Feb	74.5	13.3
Mar	64.9	17.1
April	126.0	69.0
May	401.7	264.9
June	417.0	112.9
July	334.2	157.6
Aug	385.5	236.0
Sept	507.4	315.9
Oct	514.1	285.1
Nov	334.9	148.6
Dec	176.4	36.5
ANNUAL	3,452.7	1,764.7

7.2.4. Key physical and geographic features

Figure 12: Drainage Pattern and Location of Registered Springs within the Canton of Alajuela. Source: Arias Salguero (2016)

Figure 12 shows the drainage flow pattern and the location of the 481 registered springs within the canton (excluding the Sarapiquí District) (Arias Salguero, 2016).



The distribution of the registered springs and wells can be seen in Figure 13 and Figure 14.

Figure 13: Location of Registered Springs. Source: Arias Salguero (2016)

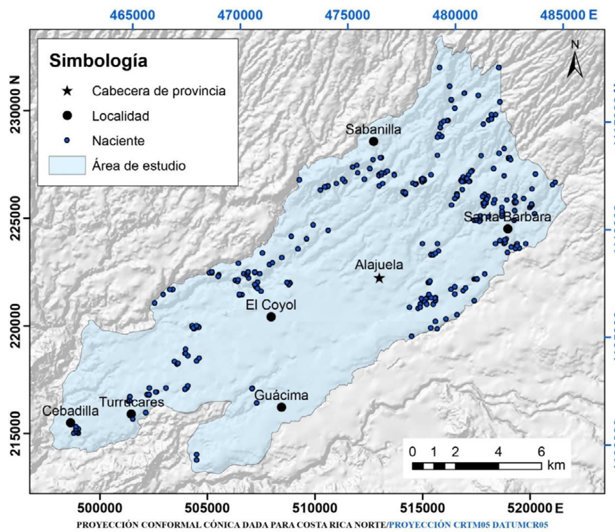
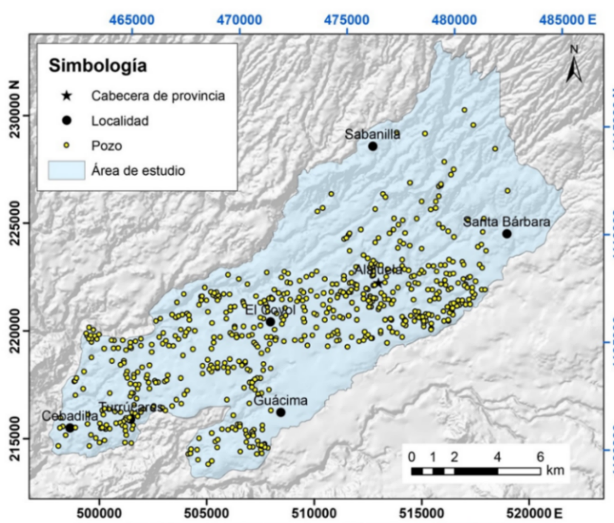


Figure 14: Location of Registered Wells. Source: Arias Salguero (2016)



The Canton of Alajuela is located within the Central Volcanic Mountain Range, which encompasses the country's entire Central Valley. The aquifers of the Central Volcanic Range (CVR), are constituted by two general types of volcanic rocks, which are presented as layers or interstratified lenses. These two general types of rocks are the lavas and pyroclasts, which include tuffs and ignimbrites and lahars. The natural discharge of these aquifers is produced through springs located on the edges of the different lava beds when they are cut by the topography, river and stream beds (ProDUS, 2010).

The aquifers in the Central Valley, on the Pacific side of CVR, have been studied more than those on the Northern side. There are several lenses and lava beds on the Pacific slope of the Canton of Alajuela, sometimes overlapping in-depth, forming aquifers interspersed with flows between 1 and 15 l/s. These aquifers, which have been understudied and not evaluated, seem to correspond to the Barva and Colima aquifers (ProDUS, 2010).

7.3. Appendix 3. Operational Reports Villa Bonita WWTP

10/4/2019 https://apps01n.ministeriodesalud.go.cr/ords/ugsi_tmp/ROAROWN.SHOW_FORM_REPORTE?P_COD_FORMULARIO=20317

MINISTERIO DE SALUD COSTA RICA BIENESTAR PARA TODOS

0 2 ... 2019 ... Norte
Vanessa Marín Salazar
1972

REPORTE OPERACIONAL

AGUAS RESIDUALES

(REGLAMENTO DE VERTIDO Y REUSO DE AGUAS RESIDUALES)

Decreto DE-33601-S-MINAE

1. DATOS GENERALES

Código Ente Generador:	RCN_DARSAJ1_159		
Ente Generador:	PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES VILLA BONITA (MUNICIPALIDAD DE ALAJUELA)	*CIIU:* 3700	
Descripción de la(s) actividad(es):	Alcantarillado Sanitario (Comercio, urbanizaciones, fraccionamientos, similares)		
Provincia: ALAJUELA	*Cantón:* ALAJUELA	*Distrito:* ALAJUELA	
Dirección: De la entrada de la UTN, 75 oeste, 250 sur, entrada sobre línea del tren			
Página en Internet:			
Permiso sanitario de funcionamiento:	No.	*Rige:*	*Vence:*
Patente Municipal:	No.	*Rige:*	*Vence:*
Número del Reporte: 1		*Fecha del Reporte:*	10/04/2019
Periodo reportado:	*del: 01/01/2019*	*al: 31/03/2019*	
Frecuencia de presentación del Reporte: TRIMESTRAL			
Propietario o Representante legal del Ente Generador:	LAURA MARIA CHAVES QUIROS		
Tel: 2436-2334	*Fax:*	*Apartado Postal:*	
Correo Electrónico:	luis.alpizar@munialajuela.go.cr		
Responsable Técnico del Reporte:	CHRISTIAN ARTURO GUERRERO VARGAS		
Tel: 8636-7007	*Fax:*	*Apartado Postal:*	
Correo Electrónico: xguerrerov8@gmail.com		*N° _Registro MS: RRO-849-17-AR*	

2. DISPOSICIÓN DE LAS AGUAS RESIDUALES

https://apps01n.ministeriodesalud.go.cr/ords/ugsi_tmp/ROAROWN.SHOW_FORM_REPORTE?P_COD_FORMULARIO=20317 1/3

CUERPO RECEPTOR

Nombre del cuerpo receptor: Quebrada Barro
Nombre del EAAS:

3. MEDICIÓN DE CAUDALES

Método empleado: Caudalímetro electromagnético

La medición de caudales debe hacerse en la salida de la última unidad de tratamiento.

4. RESULTADOS DE LAS MEDICIONES DE PARÁMETROS POR PARTE DEL ENTE GENERADOR

Descripción	No. de Veces	Promedio	Desviación Estándar	Mínimo	Máximo
TEMPERATURA °C	12	23,670	0,650	23,000	25,000
CAUDAL (m^3/d)	12	1.840,000	67,870	1.708,900	1.931,000
pH	12	7,000	0,000	7,000	7,000
SOLIDOS SEDIMENTABLES (mL/L)	12	0,190	0,100	0,400	0,100

La información de la tabla anterior, corresponde a los valores de los parámetros medidos por el ente generador y anotados en la bitácora de manejo de las aguas residuales.

En caso de que se cuente con un sistema de tratamiento, debe indicar el caudal de diseño, en m^3/día: 2160

5. RESULTADOS DE LOS ANÁLISIS FÍSICO-QUÍMICOS Y MICROBIOLÓGICOS

ANÁLISIS FÍSICO-QUÍMICO:

Nombre del Laboratorio: LABORATORIO LAMBDA S.A.
Fecha : 25/03/2019
N° de análisis: 469867

Parámetro	Valor	Incertidumbre	Límite
TEMPERATURA °C	24,100	0,200	40
pH	6,320	0,040	9
DEMANDA QUÍMICA OXÍGENO (DQO) mg/L	20,000	1,000	150
DEMANDA BIOQUÍMICA OXÍGENO (DBO5,20) mg/L	4,000	1,000	50
SÓLIDOS SUSPENDIDOS TOTALES (SST) mg/L	16,600	6,000	50
SÓLIDOS SEDIMENTABLES (S. SED) ml/L	0,200	0,200	1
GRASAS Y ACEITES (GY A) mg/L	3,000	3,000	30
SUSTANCIAS ACTIVAS AZUL METILENO (SAAM) mg/L	0,050	0,050	5
CAUDAL m^3/d	1.900,800	67,000	2161

PARÁMETROS COMPLEMENTARIOS

https://apps01n.ministeriodesalud.go.cr/ords/ugsi_tmp/ROAROWN.SHOW_FORM_REPORTE?P_COD_FORMULARIO=20317 2/3

Nombre del Laboratorio:
Fecha :
N° de análisis:

Tipo Parámetro	Parámetro	Valor	Incertidumbre	Límite

ANÁLISIS MICROBIOLÓGICO

Nombre del Laboratorio:
Fecha :
N° de análisis:

Parámetro	Valor	Incertidumbre	Límite

Adjuntar los originales de los análisis de laboratorio con su respectivo refrendo del Colegio Federado de Químicos e Ingenieros Químicos de Costa Rica.

6. EVALUACIÓN DE LAS UNIDADES DE TRATAMIENTO

Se presenta reporte operacional. Los resultados de los análisis muestran que los parámetros medidos cumplen con los máximos establecidos en el Reglamento de Reuso y Vertido de aguas residuales, decreto 33601-S-MINAE

7. PLAN DE ACCIONES CORRECTIVAS

No hay acciones correctivas que implementar

8. REGISTRO DE PRODUCCIÓN

Para el cálculo se toma el promedio de la carga contaminante en términos de DBO5 de 890 kg/día al ingreso del sistema de tratamiento

Fill &

9. NOMBRE Y FIRMA:

9.1 PROPIETARIO O REPRESENTANTE LEGAL DEL ENTE GENERADOR

Nombre: Laura Chaves Quirós **Firma**

MUNICIPALIDAD DE ALAJUELA ALCALDÍA MUNICIPAL

9.2 RESPONSABLE TÉCNICO DEL REPORTE:

Nombre: Christian Guerrero Vargas **Firma**

LABORATORIO QUIMICO LAMBDA
Tels.: 2286-1168 / 2226-4462 • Fax: (506) 2226-4462 • Apartado: 877-1011 San José, Costa Rica
e-mail: lambda@racsa.co.cr • www.laboratoriolambda.com

RESULTADO DE ANALISIS # 469,867

---RESULTADO DE ANALISIS QUIMICO---

FECHA: 2 DE ABRIL DE 2019

SOLICITANTE: VILLA BONITA

ATENCION: ING. CHRISTIAN GUERRERO

REFERENCIA: MUESTRA DE AGUA DEL REACTOR DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES Y QUE SE VIERTE HACIA LA QUEBRADA BARRO, RECOLECCION DE MUESTRA COMPUESTA POR EL SEÑOR JUNIOR CADENA, FUNCIONARIO DEL LABORATORIO LAMBDA, EL DIA 25 DE MARZO DE 2019, EN SUS INSTALACIONES UBICADAS EN ALAJUELA, 100 m AL OESTE Y 300 m AL SUR DE LA UTN, ENTRE LAS 11:15 am A LAS 1:30 pm, SUBMUESTRAS (5) DE 500 mL CADA 30 MINUTOS, CAUDAL DE VERTIDO IGUAL A 22 L/seg.

ANALISIS SOLICITADO:	RESULTADO PROMEDIO	PROCEDIMIENTO	REFERENCIA
pH*/ ± 0,04	6,32	LAMBDA PT- 08	4500-H B
TEMPERATURA*/ °C	24,1 ± 0,2	LAMBDA PT- 15	2550 B
SOLIDOS TOTALES*/ mg/L	464 ± 14	LAMBDA PT- 03	2540 B
SOLIDOS DISUELTOS**/ mg/L	448 ± 13	LAMBDA PT- 04	2540 C
SOLIDOS SUSPENDIDOS TOTALES*/ mg/L	16 ± 6	LAMBDA PT- 06	2540 D
SOLIDOS SEDIMENTABLES*/ ml/L	MENOR A 0,2	LAMBDA PT- 05	2540 F
DEMANDA QUIMICA DE OXIGENO (DQO)*/ mg/L	MENOR A 20	LAMBDA PT- 02	5220
DEMANDA BIOQUIMICA DE OXIGENO (DBO_5)*/ mg/L	4 ± 1	LAMBDA PT- 01	5210 B
GRASAS Y ACEITES*/ mg/L	MENOR A 3	LAMBDA PT- 16	5520 B
SUSTANCIAS ACTIVAS AL AZUL DE METILENO (SAAM)*/ mg/L	MENOR A 0,05	LAMBDA PT- 19	5540 C

OBSERVACIONES:

- ** ENSAYO NO ACREDITADO * ENSAYO ACREDITADO
- VER ALCANCE DE ACREDITACION DEL LABORATORIO LAMBDA EN LA DIRECCION ELECTRONICA: www.eca.or.cr.
- PROCEDIMIENTOS UNICAMENTE DE REFERENCIA: STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER 23rd 2017.
- MUESTRA CÓDIGO LAMBDA: 0395-U01.

ALBERTO A. COTO GRIJALBA
N.I. CQCR 986

COLEGIO DE QUIMICOS DE COSTA RICA — CQCR — Bachiller Química Alberto A. Coto Grijalba N.I. 986

NOTA: Refiérase al código lambda para cualquier consulta.

N° DE PERMISO SANITARIO DE FUNCIONAMIENTO: CS-ARSSEM-891-2018
RIGE: 4-07-2018; VENCE: 4-07-2023.

LAMBDA R-04

MINISTERIO DE SALUD COSTA RICA BIENESTAR PARA TODOS

Ministerio de Salud y Desarrollo Social
Dirección Regional de Rectoría de la Salud Central Norte
Área Rectora de Salud Alajuela 1
Firma 04/07/2019
DOCUMENTACIÓN RECIBIDA

REPORTE OPERACIONAL

AGUAS RESIDUALES

(REGLAMENTO DE VERTIDO Y REUSO DE AGUAS RESIDUALES)

Decreto DE-33601-S-MINAE

1. DATOS GENERALES

Código Ente Generador:	RCN_DARSAJ1_159		
Ente Generador:	PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES VILLA BONITA (MUNICIPALIDAD DE ALAJUELA)	*CIIU:* 3700	
Descripción de la(s) actividad(es):	Alcantarillado Sanitario (Comercio, urbanizaciones, fraccionamientos, similares)		
Provincia: ALAJUELA	*Cantón:* ALAJUELA	*Distrito:* ALAJUELA	
Dirección: De la entrada de la UTN, 75 oeste, 250 sur, entrada sobre linea del tren			
Página en Internet:			
Permiso sanitario de funcionamiento:	No.	*Rige:*	*Vence:*
Patente Municipal:	No.	*Rige:*	*Vence:*
Número del Reporte: 2		*Fecha del Reporte:*	25/06/2019
Periodo reportado:	*del: 01/04/2019*	*al: 30/06/2019*	
Frecuencia de presentación del Reporte: TRIMESTRAL			
Propietario o Representante legal del Ente Generador:	LAURA MARIA CHAVES QUIROS		
Tel: 2436-2334	*Fax:*	*Apartado Postal:*	
Correo Electrónico:	luis.alpizar@munialajuela.go.cr		
Responsable Técnico del Reporte:	CHRISTIAN ARTURO GUERRERO VARGAS		
Tel: 8636-7007	*Fax:*	*Apartado Postal:*	
Correo Electrónico: xguerrerov8@gmail.com		*N° _Registro MS: RRO-849-17-AR*	

2. DISPOSICIÓN DE LAS AGUAS RESIDUALES

CUERPO RECEPTOR

Nombre del cuerpo receptor: Quebrada Barro
Nombre del EAAS:

:

3. MEDICIÓN DE CAUDALES

Método empleado: Caudalímetro electromagnético

La medición de caudales debe hacerse en la salida de la última unidad de tratamiento.

:

4. RESULTADOS DE LAS MEDICIONES DE PARÁMETROS POR PARTE DEL ENTE GENERADOR

Descripción	No. de Veces	Promedio	Desviación Estándar	Mínimo	Máximo
TEMPERATURA °C	12	23,670	0,650	23,000	25,000
CAUDAL (m^3/d)	12	1.860,120	76,300	1.740,960	1.968,190
pH	12	7,000	0,000	7,000	7,000
SOLIDOS SEDIMENTABLES (mL/L)	12	0,220	0,100	0,100	0,400

La información de la tabla anterior, corresponde a los valores de los parámetros medidos por el ente generador y anotados en la bitácora de manejo de las aguas residuales.

En caso de que se cuente con un sistema de tratamiento, debe indicar el caudal de diseño, en m^3/día: 2160

5. RESULTADOS DE LOS ANÁLISIS FÍSICO-QUÍMICOS Y MICROBIOLÓGICOS

ANÁLISIS FÍSICO-QUÍMICO:

Nombre del Laboratorio: LABORATORIO QUÍMICO LAMBDA, S. A.
Fecha : 14/06/2019
N° de análisis: 477640

Parámetro	Valor	Incertidumbre	Límite
TEMPERATURA °C	25,400	0,200	40
pH	6,630	0,040	9
DEMANDA QUÍMICA OXÍGENO (DQO) mg/L	33,000	2,000	150
DEMANDA BIOQUÍMICA OXÍGENO (DBO5,20) mg/L	18,000	1,000	50
SÓLIDOS SUSPENDIDOS TOTALES (SST) mg/L	12,600	6,000	50
SÓLIDOS SEDIMENTABLES (S. SED) ml/L	0,200	0,100	1
GRASAS Y ACEITES (GY A) mg/L	3,000	1,000	30
SUSTANCIAS ACTIVAS AZUL METILENO (SAAM) mg/L	0,350	0,030	5
CAUDAL m^3/d	1.900,800	7,000	2160

PARÁMETROS COMPLEMENTARIOS

Nombre del Laboratorio:
Fecha :
Nº de análisis:

Tipo Parámetro	Parámetro	Valor	Incertidumbre	Límite

ANÁLISIS MICROBIOLÓGICO

Nombre del Laboratorio:
Fecha :
Nº de análisis:

Parámetro	Valor	Incertidumbre	Límite

Adjuntar los originales de los análisis de laboratorio con su respectivo refrendo del Colegio Federado de Químicos e Ingenieros Químicos de Costa Rica.

6. EVALUACIÓN DE LAS UNIDADES DE TRATAMIENTO

Se presenta reporte operacional. Los resultados de los análisis muestran que los parámetros medidos cumplen con los máximos establecidos en el Reglamento de Reuso y Vertido de aguas residuales, decreto 33601-S-MINAE

7. PLAN DE ACCIONES CORRECTIVAS

No hay acciones correctivas que implementar

8. REGISTRO DE PRODUCCIÓN

Para el cálculo se toma el promedio de la carga contaminante en términos de DBO5 de 868 kg/día al ingreso del sistema de tratamiento

9. NOMBRE Y FIRMA:

9.1 PROPIETARIO O REPRESENTANTE LEGAL DEL ENTE GENERADOR

Nombre: Laura Chaves Quiros Firma

MUNICIPALIDAD DE ALAJUELA
ALCALDÍA MUNICIPAL

9.2 RESPONSABLE TÉCNICO DEL REPORTE:

Nombre: Christian Guerrero Vargas Firma

LABORATORIO QUIMICO LAMBDA

Tels.: 2286-1168 / 2226-4462 • Fax: (506) 2226-4462 • Apartado: 877-1011 San José, Costa Rica
e-mail: lambda@racsa.co.cr • www.laboratoriolambda.com

RESULTADO DE ANALISIS # 477,640

ilac-MRA | ECA
Laboratorio de Ensayo
Alcance de Acreditación N°. LE-002
Acreditado a partir de: 16.04.1997
Alcance disponible en www.eca.or.cr

---RESULTADO DE ANALISIS QUIMICO---

FECHA: 21 DE JUNIO DE 2019

SOLICITANTE: URBANIZACION VILLA BONITA

ATENCION: ING. CHRISTIAN GUERRERO

REFERENCIA: EFLUENTE DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES Y QUE SE VIERTE HACIA LA QUEBRADA BARRO, RECOLECCION DE MUESTRA COMPUESTA POR EL SEÑOR OSCAR MARTINEZ ARGUEDAS, FUNCIONARIO DEL LABORATORIO LAMBDA, EL DIA 14 DE JUNIO DE 2019, EN SUS INSTALACIONES UBICADAS EN ALAJUELA, 150 m AL OESTE DE LA UTN, ENTRE LAS 8:00 am A LAS 10:00 am, SUBMUESTRAS (5) DE 500 mL CADA 30 MINUTOS, CAUDAL DE VERTIDO IGUAL A 22 L/s.

ANALISIS SOLICITADO:	RESULTADO PROMEDIO	PROCEDIMIENTO	REFERENCIA
pH*/ ± 0,04	6,63	LAMBDA PT- 08	4500-H B
TEMPERATURA*/ °C	25,4 ± 0,2	LAMBDA PT- 15	2550 B
SOLIDOS TOTALES*/ mg/L	236 ± 9	LAMBDA PT- 03	2540 B
SOLIDOS DISUELTOS**/ mg/L	224 ± 9	LAMBDA PT- 04	2540 C
SOLIDOS SUSPENDIDOS TOTALES*/ mg/L	12 ± 6	LAMBDA PT- 06	2540 D
SOLIDOS SEDIMENTABLES*/ ml/L	0,2 ± 0,1	LAMBDA PT- 05	2540 F
DEMANDA QUIMICA DE OXIGENO (DQO)*/ mg/L	33 ± 2	LAMBDA PT- 02	5220
DEMANDA BIOQUIMICA DE OXIGENO (DBO_5)*/ mg/L	18 ± 1	LAMBDA PT- 01	5210 B
GRASAS Y ACEITES*/ mg/L	3 ± 1	LAMBDA PT- 16	5520 B
SUSTANCIAS ACTIVAS AL AZUL DE METILENO (SAAM)*/ mg/L	0,35 ± 0,03	LAMBDA PT- 19	5540 C

OBSERVACIONES:

- ** ENSAYO NO ACREDITADO * ENSAYO ACREDITADO
- VER ALCANCE DE ACREDITACION DEL LABORATORIO LAMBDA EN LA DIRECCION ELECTRONICA: www.eca.or.cr.
- PROCEDIMIENTOS UNICAMENTE DE REFERENCIA: STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER 23rd 2017.
- MUESTRA CÓDIGO LAMBDA: 3312-U01.

ALBERTO A. COTO GRIJALBA
N.I. CQCR 986

NOTA: Refiérase al código lambda para cualquier consulta.

N° DE PERMISO SANITARIO DE FUNCIONAMIENTO: CS-ARSSEM-891-2018
RIGE: 4-07-2018; VENCE: 4-07-2023.

LAMBDA R-04

7.4. Appendix 4. Operational Reports of the Sanitary Water Company

LABORATORIO QUIMICO LAMBDA

Tels.: 2286-1168 / 2226-4462 • Fax: (506) 2226-4462 • Apartado: 877-1011 San José, Costa Rica
e-mail: lambda@racsa.co.cr • www.laboratoriolambda.com

RESULTADO DE ANALISIS # 467,324

---RESULTADO DE ANALISIS QUIMICO---

FECHA: 8 DE MARZO DE 2019

SOLICITANTE: COMPAÑÍA DE AGUAS SANITARIAS S.A.

ATENCION: SR. NATALY ARIAS PORRAS

REFERENCIA: EFLUENTE DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES Y QUE SE VIERTE HACIA EL RIO ALAJUELA, RECOLECCION DE MUESTRA COMPUESTA POR EL SEÑOR KENNETH MONTOYA ZAMORA, FUNCIONARIO DEL LABORATORIO LAMBDA, EL DIA 1 DE MARZO DE 2019, EN SUS INSTALACIONES UBICADAS EN LA GARITA, ALAJUELA, 1,5 km AL ESTE DE RECOPE, ENTRE LAS 8:00 am A LAS 10:00 am, SUBMUESTRAS (5) DE 500 mL CADA 30 MINUTOS, CAUDAL DE VERTIDO IGUAL A 265 m^3/DIA.

ANALISIS SOLICITADO:	RESULTADO PROMEDIO	PROCEDIMIENTO	REFERENCIA
pH*/ ± 0,04	5,81	LAMBDA PT- 08	4500-H B
TEMPERATURA*/ °C	31,1 ± 0,2	LAMBDA PT- 15	2550 B
SOLIDOS TOTALES*/ mg/L	1 960 ± 58	LAMBDA PT- 03	2540 B
SOLIDOS DISUELTOS**/ mg/L	1 932 ± 57	LAMBDA PT- 04	2540 C
SOLIDOS SUSPENDIDOS TOTALES*/ mg/L	28 ± 6	LAMBDA PT- 06	2540 D
SOLIDOS SEDIMENTABLES*/ ml/L	MENOR A 0,2	LAMBDA PT- 05	2540 F
DEMANDA QUIMICA DE OXIGENO (DQO)*/ mg/L	100 ± 5	LAMBDA PT- 02	5220
DEMANDA BIOQUIMICA DE OXIGENO (DBO_5)*/ mg/L	27 ± 2	LAMBDA PT- 01	5210 B
GRASAS Y ACEITES*/ mg/L	7 ± 1	LAMBDA PT- 16	5520 B
SUSTANCIAS ACTIVAS AL AZUL DE METILENO (SAAM)*/ mg/L	0,16 ± 0,03	LAMBDA PT- 19	5540 C

OBSERVACIONES:

- ** ENSAYO NO ACREDITADO   * ENSAYO ACREDITADO
- VER ALCANCE DE ACREDITACION DEL LABORATORIO LAMBDA EN LA DIRECCION ELECTRONICA: www.eca.or.cr.
- PROCEDIMIENTOS UNICAMENTE DE REFERENCIA: STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER 23rd 2017.
- MUESTRA CÓDIGO LAMBDA: 9482-T00.

ALBERTO A. COTO GRIJALBA
N.I. CQCR 986

COLEGIO DE QUIMICOS DE COSTA RICA — Bachiller Química Alberto A. Coto Grijalba N.I. 986

NOTA: Refiérase al código lambda para cualquier consulta.

N° DE PERMISO SANITARIO DE FUNCIONAMIENTO: CS-ARSSEM-891-2018 ... VENCE: 4-07-2023.

LAMBDA R-04

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RESULTADO DE ANALISIS # 467,324

ECA — Laboratorio de Ensayo, Alcance de Acreditación Nº. LE-002, Acreditado a partir de: 18.04.1997, Alcance disponible en www.eca.or.cr

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COLEGIO DE QUIMICOS DE COSTA RICA — CQCR — Bachiller Química Alberto A. Coto Grijalba N.I. 986

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Nº DE PERMISO SANITARIO DE FUNCIONAMIENTO: CS-ARSSEM-891-2018
VIGE: 4-07-2018; VENCE: 4-07-2023.

LAMBDA R-04

LABCEN
Laboratorios Analíticos Centroamericanos S.A

Tel: 4702-1862
Email: analisis@labcencr.com
Alajuela, Río Segundo, Bodegas Terrum #11

REPORTE DE ANÁLISIS QUÍMICO
Nº B101-01

Fecha de reporte: 19 de junio de 2019

I. INFORMACIÓN DEL CLIENTE

Atención: NATALY ARIAS PORRAS
COMPAÑÍA DE AGUAS SANITARIAS

II. INFORMACIÓN DE LA MUESTRA

Lugar de Muestreo: COMPAÑÍA DE AGUAS SANITARIAS
Dirección: ALAJUELA, ALAJUELA, GARITA.
1,5 KM ESTE DE RECOPE LA GARITA

Muestreado por LABCEN *
D. ALVAREZ

Fecha de muestreo: 7/6/2019 — Hora de inicio: 07:00
Fecha de ingreso: 7/6/2019 — Hora Final: 09:00

ID Muestra	DESCRIPCIÓN DE LA MUESTRA
B101-01	Muestra: EFLUENTE DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES.
	Muestreo: COMPUESTO DE 2 HORAS, cinco submuestras de 500mL cada 30 minutos.
	Dispocición Final: RIO ALAJUELA

III. RESULTADOS DE LOS ANÁLISIS SOLICITADOS

Análisis	Resultado	Procedimiento
pH	7,09 ± 0,04	LBCN-PR-009-E
Temperatura, (°C)	25,5 ± 0,3	LBCN-PR-015-M
Demanda Química de Oxígeno, DQO, (mg/L)	72 ± 2	LBCN-PR-002-E
Demanda Biológica de Oxígeno, DBO, (mg/L)	36 ± 4	LBCN-PR-001-E
Grasas y Aceites, (mg/L)	MENOR A 3,0	LBCN-PR-008-E
Sustancias Activas al Azul de Metileno, SAAM, (mg/L)	1,73 ± 0,04	LBCN-PR-010-E
Sólidos Totales, (mg/L)	884 ± 18	LBCN-PR-013-E
Sólidos Disueltos, (mg/L)	864 ± 18	LBCN-PR-011-E
Sólidos Suspendidos, (mg/L)	21 ± 6	LBCN-PR-014-E
Sólidos Sedimentables, (mL/L)	MENOR A 0,2	LBCN-PR-012-E
Caudal, (m3/día)	240,0	LBCN-PR-018-M

7.5. Appendix 5. Alajuela Canton Faecal Sludge Quantities

Data analysis

1. Household Survey

The IDB implemented a household survey in the 14 districts of the Canton of Alajuela. The purpose of this survey was to collect data on the management of sanitation infrastructure. The survey included 31 questions and was implemented among 543 households of the 57,636 households with a septic tank in the canton according to the 2011 Census. Variables relevant for a calculation of FS quantities are as follows:

V1: Type of technology

Table 9 shows the percentage of the type of sanitation technology used at the household level. Among the households that have a septic tank (ST), 77.2% have a traditional ST, 12.2% have a double chamber ST, 4.6% have "other with waterproof walls and open bottom or completely open" and 6.1% did not know.

Table 9: Percentage of the type of sanitation technology used at household level

TYPE OF TECHNOLOGY	%
Traditional	77.2%
Double chamber	12.2%
Other with waterproof walls and open bottom or completely open	4.6%
N/A	6.1%

V2: Ever emptied

Table 10 shows the percentage of households that have and have not emptied their sanitation technologies. A total of 63.1% state that they have emptied their systems, 35.4% indicate that they have not yet emptied their system and 1.5% do not know. The 35.4% should be compared with the age of the system to identify whether emptying might not have been needed yet.

Table 10: Percentage of households that have and have not emptied their sanitation technologies

EVER EMPTIED THE ST	%
Yes	63.1%
No	35.4%
N/A	1.5%

V3: When last emptied or "desludging interval"

The average of desludging for the 63.1% who said they had emptied the tank was 2.5 years = 31 months (Table 11).

Table 11: Desludging frequency of septic tanks

YEARS	%
1 or less	28.2%
2 years	9.4%
More than 2 years	21.2%
No Answer	4.4%
N/A	36.8%
AVERAGE	**2.55 YEARS**

Final calculations

For the final calculations, the following assumptions were used:

- Total households in Alajuela with septic tank, based on data from 2011 Census: 57,636.
- Desludging interval: 31 months (2.55 years).
- Volume of septic tank: 1.100 L (assumed 100% of all households).
- Volume removed from septic tank per desludging event: 1,000 Litres; = 1m$^{3.}$ Thus, the emptying efficiency is (1 m^3/ 1.1m^3) x 100 = 91%.

With the above assumptions, these calculations were made:

- Variable F3 = 63% x 0.91 = 57%
- The total volume of fecal sludge generated is 57,636 (total number of tanks) x 1.1m^3/ 31 months (average frequency of emptying) = 2,045m^3/ month.
- The total volume of faecal sludge emptied is 2,045m^3/ month x 0.57 = 1,172m^3/ month.

2. FS service provider survey

The IDB implemented a phone call survey to 36 service providers. From these, only 23 provide emptying services in ST in Alajuela. The purpose of this survey was to collect data on emptying, transportation and delivery of FS. The survey included 16 questions. The data collected from the FS service provider have been used to prepare an estimate for monthly FS quantities that accumulate and are collected in the Canton of Alajuela (Table 12).

Three variables were used for the estimate:

1. Number of days per month that a service provider delivers FS to a treatment plant
2. Volume of the truck
3. Approximate percentage of FS collected in Alajuela city per month

Table 12: Outcome of the FS Service Provider Survey

SERVICE PROVIDER	# OF DAYS PER MONTH THAT A SERVICE PROVIDER DELIVERS FS TO A TREATMENT PLANT	VOLUME OF THE TRUCK (M^3)	APPROXIMATE PERCENTAGE OF FS COLLECTED IN ALAJUELA CITY PER MONTH	TOTAL VOLUME (M^3)
1	30	18	20%	108
2	N/A	18	10%	NR/N/A
3	20	12	15%	48
4	12	10	40%	24
5	20	12	30%	48
6	N/A	10	90%	N/A
7	10	10	10%	20
8	25	15	70%	75
9	12	12	10%	29
10	20	10	10%	40
11	N/A	14	10%	N/A
12	10	20	10%	40
13	20	15	60%	60
14	20	13	20%	52
15	12	13	100%	31
16	15	20	40%	60
17	10	17	100%	34
18	20	14	40%	56
19	10	11	30%	22
20	10	23	15%	46
21	15	11	10%	33
22	15	12	15%	36
23	15	49	10%	147
FAECAL SLUDGE COLLECTED (M^3 PER MONTH)				**1,009**

Final calculations

Variable F4, which is the proportion of faecal sludge emptied, which is delivered to treatment plants, was estimated as:

- ✓ F4 = Volume of faecal sludge that reaches treatment, divided by the volume of emptied fecal sludge. Thus, F4 = (1,009 m^3 / 1,172m^3) x 100 = 86%.

3. FS treatment plant data

Interviews at the FS treatment plant in Coyól have indicated that approximately 260 m^3 /day or 7,800 m^3/month (at 30 days/month) are discharged at the treatment plant. However, the FS Treatment Plant receives FS from trucks that come from different parts of the country. However, this value could be overestimated by the FS treatment plant operator (only a single number was provided).

Given the estimated amount of faecal sludge collected by the FS service providers and the amount of sludge treated by the FSTP, the following calculation was made to determine the percentage of FS that is being treated by the FSTP from the Canton of Alajuela:

- ✓ Percentage of FS treated from Alajuela = (1,009 m3/ 7,800 m^3) x 100 = 12.9%

SFD Promotion Initiative