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OF THE WESTERN PACIFIC
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The work reported herein was conducted in cooperation with the Guam Waterworks Authority (GWA) and administrated through the Water and Environmental Research Institute of the Western Pacific (WERI) at the University of Guam. The content of this report does not necessarily reflect the views and policies of the GWA, nor does the mention of trade names or commerical products constitute their endorsement by any involved party.

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ABSTRACT

Food Service Establishments (FSEs) on Guam were surveyed to determine how they manage and discard kitchen fat, oil, and grease (FOG) to assist the Guam Waterworks Authority (GWA) in development of a FOG management program to reduce the number of sewer system overflows (SSOs). A total of 79 FSEs were approached during the spring of 2014 and of those 72 participated in the survey. Of the respondents, 62% have a grease trap installed, 29% have a grease interceptor installed, 3% have both, and 5% have neither. In addition, 82% of the respondents collect their used FOG, and 18% pour their FOG down the drain.

The FOG production was estimated for each FSE based on the type of food served. Based on this criterion, 24% of the grease traps were cleaned prior to reaching capacity, 72% were not cleaned until after reaching design capacity, and for 4% it could not be determined. In addition, the recommended grease interceptor size was determined based on the Universal Plumbing Code standard, by which it was determined that 41% of the grease interceptors were sized properly and 55% were not.

A statistical test for comparing two proportions was applied to evaluate and compare the FOG management methods used by FSEs located upstream of SSOs and those not in the vicinity of SSOs. This was done to determine the effectiveness of management methods that are employed in hopes of preventing SSOs from occurring. By this analysis, grease interceptors were considered to be more effective than grease traps with a confidence level of 88%; however, the other methods addressing grease trap cleaning, grease interceptor size, and FOG disposal methods did not demonstrate any significant beneficial effects.

This study does not to demonstrate any definitive sources for the FOG induced SSOs occurring in GWA sewer lines, but it does provide GWA with information on the FOG management practices being employed. This data is important as a baseline of information for the early stages of developing a FOG Management Plan. Future studies could shift the focus into residential zones, which could potentially be large sources of sewer FOG.

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ABBREVIATIONS AND ACRONYMS

FOG	Fat, oil, and grease
FSE	Food Service Establishment
GIS	Geographic Information System
GWA	Guam Waterworks Authority
Ha	Alternative Hypothesis
Ho	Null Hypothesis
SSO	Sewer System Overflow

1. INTRODUCTION

1.1. Fat, Oil, and Grease (FOG)

It is estimated that 30% of the foods we eat contain FOG (Okazaki, 2006). As such, food service establishments (FSEs) and multi- and single-family dwellings are major sources of FOG (Staffer et al., 2003). FOG is often referred to as yellow or brown grease. Yellow grease is typically vegetable or cooking oil used for frying foods, which can be collected and recycled. Brown grease, or trap grease, is that which is collected in grease traps, or other grease-removal devices, commonly used by FSEs to separate FOG from domestic wastewater drainage prior to discharge to the sewer line (Staffer et al., 2003). On an annual basis, brown grease produced in U.S. cities ranges from 2 to 27 lbs per person and 800 to 17,000 lbs per restaurant (Wiltsee, 2009).

1.2. Sewer System Overflows (SSOs)

FOG from restaurants, homes, and industrial sources is the most common cause of reported sewer blockages, accounting for nearly 47% of these events nationwide (U.S. EPA, 2012). The presence of FOG in public sewer lines is problematic because it solidifies and reduces the conveyance capacity, thus inhibiting the flow of sewage. On Guam, blockages in sewer lines due to FOG are costing the Guam Waterworks Authority (GWA) an estimated $500,000 annually (Losinio, 2013). It is considered to be the most frequent cause of sewer back-ups on Guam.

These frequent blockages of sewer lines can cause SSOs, which occur when backed-up sewer lines spew raw sewage onto streets, storm drains, surface waters, and beaches. The release of raw sewage can contaminate groundwater and surface water, causing water quality problems and threatening drinking water supplies. This poses human health risks to the community by spreading viruses and bacteria, which can lead to stomach flu, upper respiratory infections, skin rashes and cholera; in addition, public and private property can be damaged and recreation and tourism can suffer (U.S. EPA, 2000).

1.3. Hot Spot Cleaning Plan

In 2012, GWA released a report titled "Hot Spot Cleaning Plan," which identified 40 known areas that have experienced frequent SSOs. The report attributed a majority of these blockages to FOG build-up and structural issues within the collection line (Calvo et al., 2012). It was speculated in the report that the frequent blockages could be attributed to improper disposal of FOG into sewer lines by FSEs. However, no study has been conducted to identify the sources of FOG at the hot spots listed in the report. Gathering the information pertaining to this issue is essential to developing a FOG-control program and to determine the best remedial options (Shaffer et al., 2003).

Since the release of the "Hot Spot Cleaning Plan," GWA has initiated the further documentation of these overflows in SSO Quarterly Reports. These reports include the date, time, location, root cause, and action taken at the time of response.

1.4. FOG Management

A common method used by FSEs to collect FOG is that of installing a FOG removal device. In these devices, the separation of FOG from wastewater is based on Stokes Law, which describes the rising or settling of a particle in a fluid, such as water, under non-turbulent conditions (Shaffer et al., 2003). Yellow grease is lighter than water and rises to the top of the FOG removal device, while brown grease is heavier and falls to the bottom.

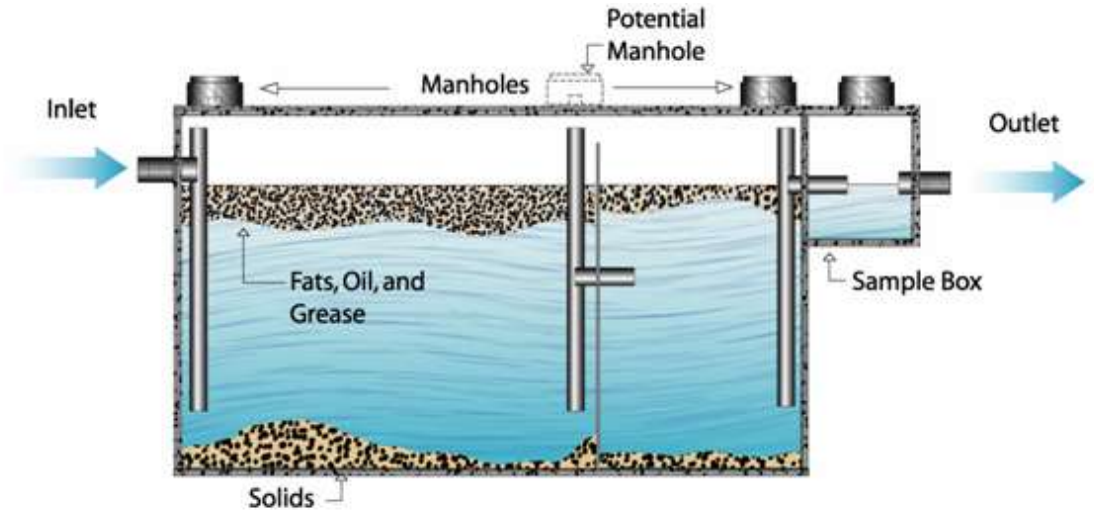


Figure 2.1. Schematic of a FOG removal device. (Shaffer et al., 2003)

FOG removal devices include two categories: Grease interceptors and grease traps, though the two terms are often incorrectly used interchangeably. Grease interceptors are the larger of the two, with a minimum capacity of 750 gal and average size of 1,500 gal. Due to their size, they are typically located outside the kitchen and are intended to handle all of the FSE's greywater discharge. Grease traps are similar to interceptors but are typically only 50 gal or less in volume, small enough to conveniently fit under the sink in a kitchen (Staffer et al., 2003). Due to the larger size, grease interceptors do not have to be cleaned frequently, typically just two or three times a year. Grease traps quickly fill up with FOG because of their smaller size and must be cleaned and maintained more often to operate effectively.

1.5. Assessment of Grease Interceptor Performance, 2008

The Water Environment Research Foundation (WERF) conducted a study in 2008 to evaluate grease interceptor separation efficiency and cleaning cycles. The study was considered necessary as there are limited technical studies evaluating the performance of grease interceptors. It was found that a laboratory-scale grease interceptor, with a volume of 300 gal, achieves 78% FOG removal with a 20-minute residence time, and 90% FOG removal with a one-hour residence time. The higher removal percentage was attributed to the lower velocities associated with the longer wastewater residence time.

The study also found that there was a lack of compliance in the geometry of grease interceptors with design standards, such as for tank sizing and depth-to-width-to-length ratios. It concluded that further research is needed to develop better alternatives for grease removal in order to achieve a grease removal efficiency of 99-100% (Ducoste et al., 2008).

2. OBJECTIVES AND SCOPE OF WORK

2.1. Objectives

The objective of this study is to assist GWA in the evaluation the FOG management practices of FSEs on Guam. This information is important in order to develop an effective FOG control program, as it must first determine where the FOG is coming from and where blockages will most likely occur (Shaffer et al., 2003). In addition, this study will attempt to identify causes of SSOs by evaluating the relationship between FOG build-up in the sewer lines and the FOG management practices employed by the FSEs. This objective was met by the following tasks:

- Determining how restaurants on Guam manage their FOG.
- Determining if restaurants on Guam properly maintain grease traps.
- Evaluating if restaurants on Guam have properly-sized grease interceptor.
- Evaluating if restaurants on Guam properly dispose of their used kitchen FOG.
- Evaluating the correlation between FOG management methods employed by FSEs and their locations relative to SSOs.
- Creating shape files of SSO data using ArcGIS to provide a better method of tracking SSOs on Guam.

2.2. Scope of Work

In this study, local FSEs were surveyed and asked about their FOG management practices. The SSO data were obtained from GWA SSO Quarterly Reports spanning from October 2011 to February 2014. The location and frequency of the SSOs obtained from the report were displayed on a map of GWA sewers lines using ArcGIS. This information was used to determine if there is any correlation between restaurant FOG management and reported SSOs on Guam.

3. DATA COLLECTION

3.1. Data Collection Overview

FSEs on Guam were surveyed over the course of approximately two months during the spring of 2014. All of the surveyed FSEs were directly visited and asked questions using a prepared questionnaire form (see Appendix A). The kitchens were not entered and inspected due to health safety codes. Grease traps, grease interceptors, and grease storage bins were visually inspected and measured when located outside the kitchens

3.2. Survey of FSEs

A total of 79 FSEs on Guam were surveyed. 72 of the FSEs agreed to answer the survey questions. The restaurants were initially chosen depending on their location being "upstream" of reported SSOs on the GWA Hot Spot Report. However, after receiving the SSO Quarterly Reports it was discovered that SSOs occurred over a wider range of locations than those reported in the Hot Spot Report. Thus, the decision was made to survey restaurants within a broader area to get a better picture of FOG management practices rather than limiting the survey to FSEs in the proximity of known SSOs.

The restaurants were asked questions based on the type of FOG management device being used. The initial questions were:

- Do you have a FOG removal device?
- Is it a grease trap or grease interceptor?

For grease traps, the following information was asked to determine the required maintenance:

- What are your hours of operation?
- Approximately how many customers do you serve per day?
- Does a contractor collect the grease and/or maintain the grease trap?
- How frequently is your grease trap pumped and cleaned?

For grease interceptors, the following information was asked to determine the required size:

- What is the maximum seating capacity of the FSE? (Or, if in a food court, how many customers do you serve in your busiest hour?)
- What are your hours of operation?

All surveyed FSEs were also asked the following questions regarding the disposal of used kitchen FOG:

- How do you dispose used FOG, i.e., is it poured down the drain or stored in a container?
- Does a contractor collect the used FOG?
- How frequently does a contractor collect the used FOG?

A manager or an employee familiar with the maintenance of the FSE was typically the person interviewed. At the end of the interview, a GWA FOG brochure was provided, explaining the importance of FOG management.

3.3. Demographics of FSEs

The FSEs were divided into 13 categories (Table 3.1, Figure 3.1). FSEs labeled as "Fast Food" were classified as restaurants that did not have reusable plates or forks and served their food using wrappers, paper plates, cardboard containers, etc. "Family" diners were sit-down FSEs with silverware and reusable plates. "Bakery/Pastry" stores were FSEs that only sold bread or small desserts. "Chinese" diners were FSEs that sold traditional Chinese-style cuisines. "Mexican" diners were FSEs that sold Mexican-style cuisine, including Mexican-style fast food. "Pizza" diners were FSEs whose primary product was pizza, even though it may serve other types of food, such as pasta. "Japanese" diners were FSEs that sold traditional Japanese-style food. Filipino, Korean, Vietnamese, Thai, and Mongolian diners were placed under the "Asian" category as they sold similar food and the numbers were too small to be placed into separate categories. The category "Other" contained an ice cream shop and a vegetarian FSE because they did not fit well into any other category.

Table 3.1. Types of FSEs surveyed in this study.

Restaurant Type	Total	Percentage
Fast Food	14	18%
Family	14	10%
Bakery/Pastries	3	2%
Chinese	11	9%
Mexican	3	3%
Pizza	4	4%
Japanese	8	7%
Sandwich	3	3%
Cafe/Smoothies	4	4%
Bar	2	2%
Italian	2	2%
Asian	9	10%
Other	2	2%
TOTAL	**79**	**100%**

Limitations of the Survey

Generally, only FSEs that were expected to require a FOG removal device were targeted, such as fast-food eateries and restaurant chains. Other FSEs such as grocery stores, mom-and-pops shops, or gas stations were generally not targeted, as they likely did not require a FOG removal device. This was done to get more useful results within the limited time and resources for our survey.

FSEs located in hotels were also left out of the survey, as we could not obtain information from the hotel FSEs about their grease removal methods. Survey questionnaires left with hotel managers and e-mails were not responded to.

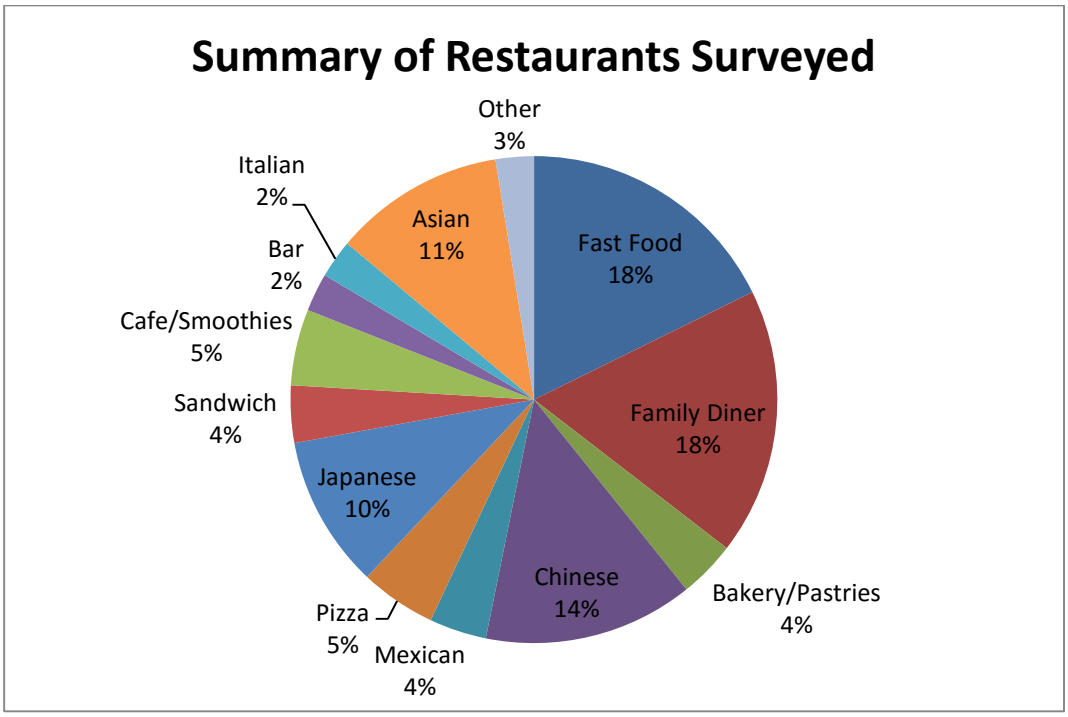


Figure 3.1. Types of FSEs surveyed in this study.

3.4. SSO Quarterly Reports

GWA Quarterly Reports on SSOs were gathered and analyzed as a part of this study. The reports date back to October 2011 when GWA began preparing them. This study only focused on the SSOs that were reportedly caused by FOG build-up. Overall, 362 reported SSOs were recorded, occurring at 239 different manhole locations. This information was displayed on a map of the GWA sewer system and used in the analysis to determine the possible influence of a surveyed FSE on a reported SSO.

4. RESULTS AND ANALYSES

4.1. FOG Management

A survey was conducted during the spring of 2014 to determine if FSEs on Guam properly manage their FOG by using a proper removal device and to determine if used FOG is properly disposed of. FSEs were approached between the hours of 8 am and 5 pm and during non-peak hours to avoid lunch crowds. Managers were asked if they used a FOG removal device, whether it was a grease trap or a grease interceptor, and how often it gets maintained. If the FSE had a grease interceptor outside of the restaurant, its dimensions were measured and recorded.

4.2. FOG Removal Devices

A majority of the FSEs surveyed had a grease trap, with 45 FSEs (57% of the participants) responding they had one installed in their kitchen; conversely, 21 FSEs (27%) responded that they had a grease interceptor installed. Two FSEs (2%) had both a grease trap and a grease interceptor installed. Four FSEs (5%) did not have a FOG removal device, and seven FSEs (9%) were not willing to participate in the survey.

Table 4.1. FOG removal devices used by the FSEs.

Grease Removal Device	Number	Percentage
Grease Trap	45	57%
Grease Interceptor	21	27%
Both	2	2%
None	4	5%
Did Not Participate	7	9%
Total	**79**	**100%**

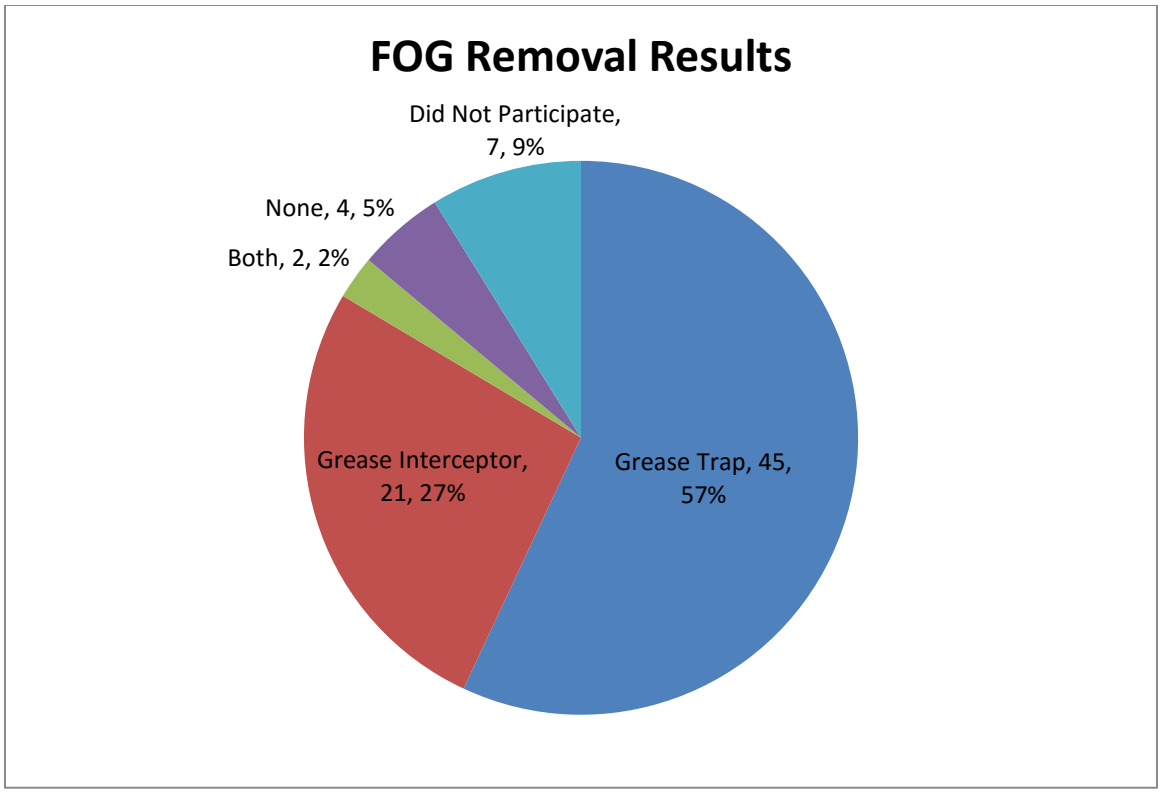


Figure 4.1. FOG removal devices used by the FSEs.

Limitations of the Data

As stated in Section 3.1, not all of these results were verified visually; thus, it could be that some of the responses from the FSEs concerning their method of FOG removal may have been less than truthful, for fear of being penalized. In addition, the manager being interviewed may have mistakenly stated that a grease interceptor was installed, when it actually was a grease trap. Only grease interceptors installed outside of the FSE kitchen were confirmed visually.

4.3. FOG Disposal Methods

The method of FOG disposal is important information in a FOG management plan because FOG poured into a sewer collection network eventually solidifies and obstructs the flow of wastewater. Increasing the number of FSEs that refrain from pouring their FOG down the drain could potentially aid in preventing the occurrence of SSOs.

Fifty-nine FSEs (75% of the participants) stated that they collect their used FOG in a storage container. Thirteen FSEs (16%) responded that they pour their used FOG down the

drain, and seven FSEs (9%) did not participate in the survey. Many of the FSEs use 55-gal drums located outside of their restaurant for FOG storage. The FSEs at the Guam Premium Outlets (GPO) food court had a common grease storage container provided by the management of the mall.

Table 4.2. Methods for disposal of used FOG by the FSEs.

FOG Disposal		
Method used	**Number**	**Percentage**
Collect in container	59	75%
Pour down drain	13	16%
Did Not Participate	7	9%
Total	**79**	**100%**

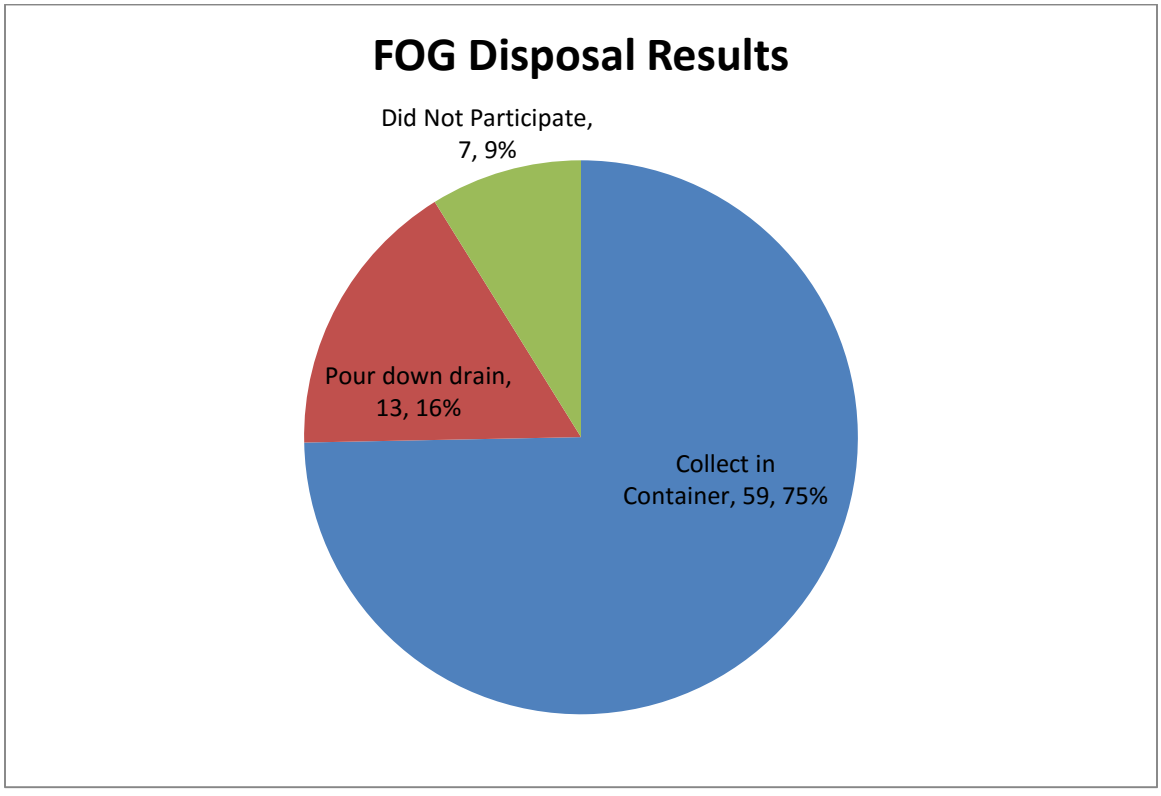


Figure 4.2. Methods for disposal of used FOG by FSEs.

Limitations of the Data

The survey asked the participating FSEs if they store used FOG, but the size of the collection container was not considered. Though most of the FSEs used 55-gal drums, there were some respondents who did not know the size. Most of the containers were visually verified during the survey; however, there was no way to verify that all of the used FOG was disposed of in the containers.

4.4. Grease Trap Maintenance

Grease traps are the smaller of the two FOG removal devices, thus requiring maintenance much more frequently than grease interceptors. Cleaning of grease traps is important for maintaining FOG removal efficiency. During the survey, FSEs were asked to disclose the companies that serviced their grease traps. The majority of FSEs (57% of the participants) stated that Detry serviced their grease traps and the second most common company was Todo Mauleg, which served nine FSEs (19%). Four FSEs (9%) cleaned their grease trap in house, meaning their own employees clean and maintain it. One FSE (2%) reported that Gresco and one (2%) reported that Ben Lugan serviced their grease traps. Five (11%) of the participating FSEs responded that they did not know the name of the company that cleaned their grease trap.

Table 4.3. Local companies that service the grease traps of the FSEs.

Company	Number of FSEs	Percentage
Detry	27	57%
Todo Mauleg	9	19%
In-House	4	9%
Gresco	1	2%
Ben Lugan	1	2%
Unknown	5	11%
Total	**47**	**100%**

The FSEs were also asked how often their grease traps were maintained and cleaned. The results show an increasing trend of the number of FSEs with longer cleaning intervals up to a maximum of 19 FSEs at a 30-day interval. The numbers of FSEs then falls off greatly for cleaning intervals greater than 30 days.

Table 4.4. Grease trap cleaning intervals used by the FSEs.

Intervals (days)	Number of FSEs	Percentage
<7	1	2%
7	4	9%
14	8	17%
30	19	40%
60	3	6%
90	7	15%
90+	3	6%
Unknown	2	4%
Total	**47**	**100%**

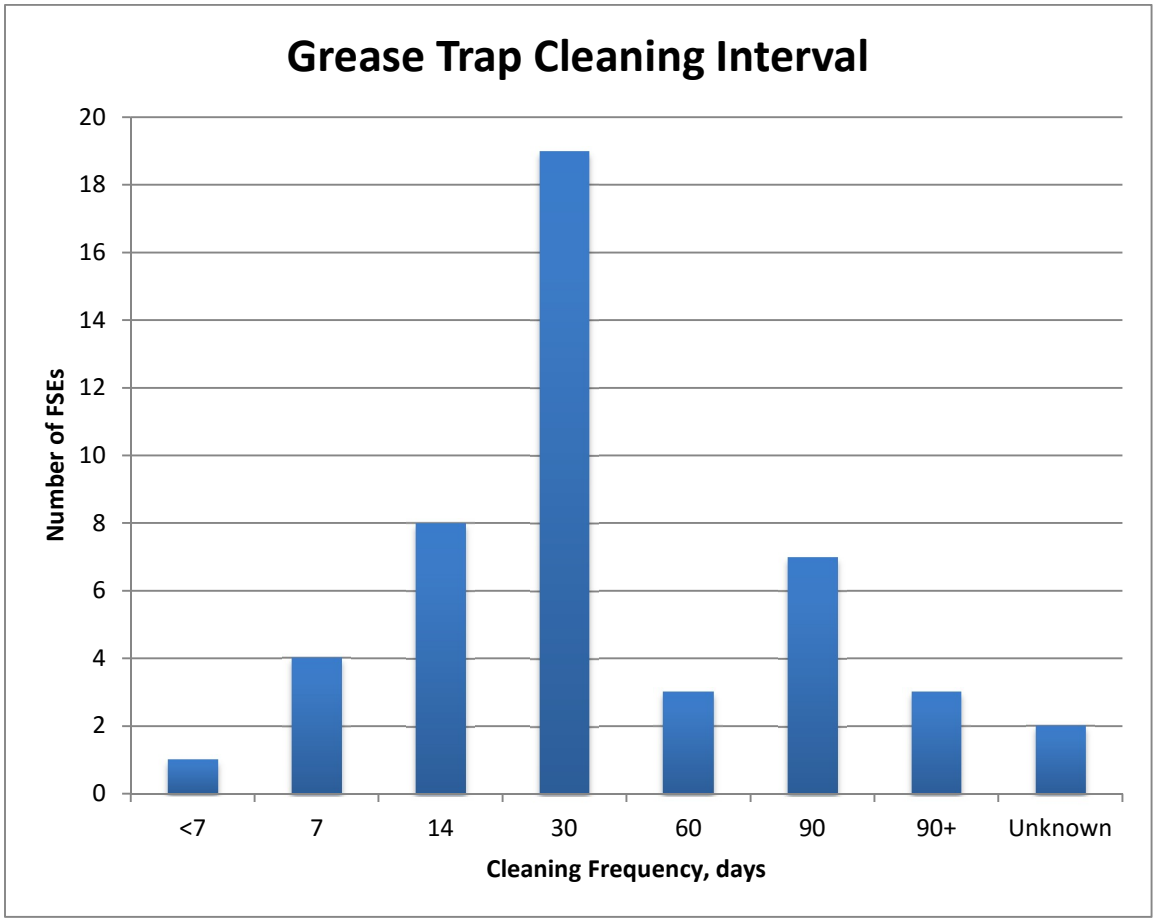


Figure 4.3. Grease trap cleaning intervals used by the FSEs.

The number of days that were reported by the FSE for their grease trap cleaning interval was typically based on a set schedule agreed upon contractually with the cleaning company through a contract. Some FSEs also reported that they have their grease trap cleaned when it unexpectedly overflows.

4.5. Required Frequency for Cleaning of Grease Traps

To calculate how often a grease trap must be cleaned, one must first determine how much FOG an FSE produces on average each day. Using a chart (Figure 4.4) formulated by Shier Products, a grease trap manufacturing company, an analysis can be conducted to estimate how much FOG a restaurant produces per meal based on the type of food served provided, e.g., sandwiches, Chinese, Japanese, etc. Firstly, the FSEs were asked approximately how many customers they served per day. The amount of FOG produced per day was then calculated by taking the value from Figure 4.4, in lbs/meal, and multiplying it by the number of customers (meals) per day. This produces a value of lbs/day of grease (i.e., FOG).

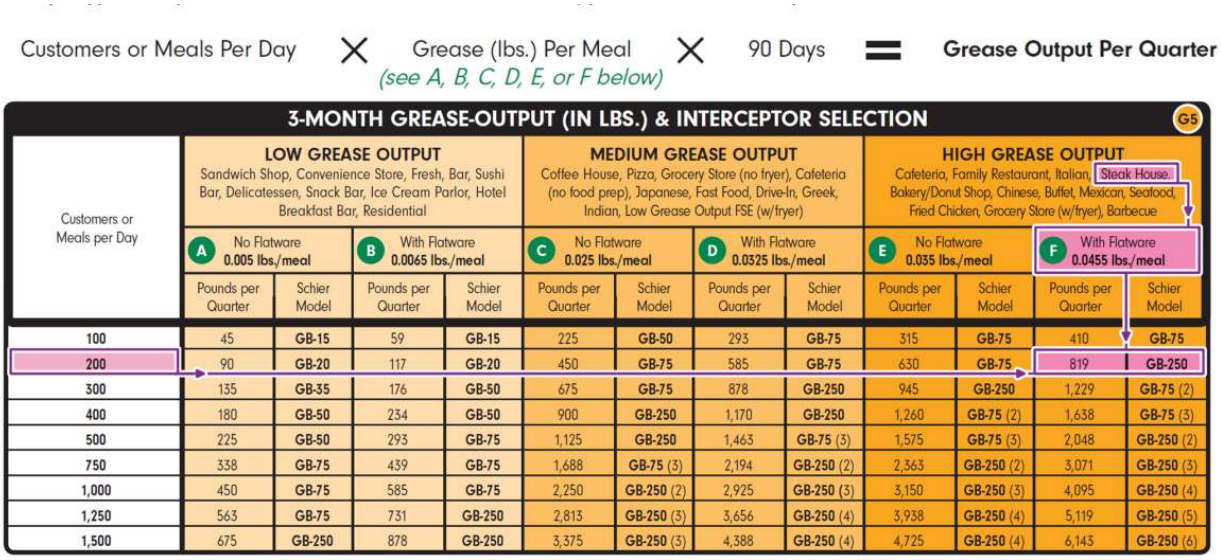


Figure 4.4. Grease-output chart by Shier Products used to size grease traps. (Duffy, 2012)

The Uniform Plumbing Code defines a grease trap as a device that captures up to 100 lbs of grease (Shaffer, 2004). Since grease trap sizes do not vary significantly, and the actual sizes at the FSEs could not be verified, this study assumes that each grease traps could handle a

maximum of 100 lbs. However, the EPA recommends that grease traps be cleaned out at 75% of the grease-holding capacity to maintain effectiveness (Ducoste et al., 2008). To determine the number of days before a grease trap would have to be cleaned, 100 lbs is multiplied by 0.75, and then is divided by the lbs/day value, resulting in a final number of days.

Example:

FSE Information: Fast food, no flatware (only paper plates and plastic utensils)

Grease Production Per Meal: 0.025 lbs/meal (Figure 4.4)

Number of Meals Per Day (based on estimated customers): 200 meals/day

Grease Production Per Day: 200 meals/day x 0.025 lbs/meal = 5.0 lbs/day

Recommended Cleaning Interval (10- lb grease trap): $\left(100\ lbs\ \div\ 5.0\frac{lbs}{day}\right) * 0.75 = 15\ days$

Actual Cleaning Interval: 7 days

Conclusion: Since 7 days is less than the recommended 15 days, the cleaning interval employed by the FSE is more than adequate.

Table 4.5. Data from the survey used to determine the recommended cleaning intervals for grease traps.

	FSE with Grease Trap	Village	Restaurant Type	Approximate Customers per day	Grease per meal, based on Figure 4.4 (lbs)	Grease Output (lbs/day)	Recommended Cleaning Interval-100 lbs Grease Trap (days)	Actual Cleaning Interval (days)	Adequate Cleaning Interval
1	Pizza Hutt	Hagatna	Pizza	300	0.0325	9.75	8	7	Yes
2	Taco Bell	Hagatna	Mexican Food	200	0.035	7	11	14	No
3	Tapanade	Hagatna	Family Restaurant	300	0.0455	6.825	11	14	No
4	Beard Papas	Tumon	Pastry	15	0.035	0.525	143	90	Yes
5	Ebisu	Tumon	Japanese	70	0.0325	2.275	33	30	Yes
6	Subway	Tumon	Deli/Sandwich	200	0.0065	1.3	58	90	No
7	Tai Ryo	Tumon	Japanese	100	0.0325	3.25	23	30	No
8	Fuji-Ichiban	Tumon	Japanese	1000	0.0325	32.5	2	7	No
9	EN	Tumon	Japanese	600	0.0325	19.5	4	14	No
10	California Pizza Kitchen	Tumon	Pizza	400	0.0325	13	6	14	No
11	House of Chin Fe	Hagatna	Chinese	1130	0.0455	51.415	1	1	Yes
12	Chode Mart	Hagatna	Other	300	0.035	10.5	7	30	No
13	Song Huong	Hagatna	Asian	75	0.0325	2.4375	31	30	Yes
14	Horse and Cow	Tamuning	Bar/Restaurant	200	0.0065	1.3	58	90	No
15	Lone Star	Tamuning	Family Restaurant	300	0.0455	13.65	5	7	No
16	Table 35	Tamuning	Family Restaurant	200	0.0455	9.1	8	90	No
17	Payless (deli)	Hagatna	Deli/Sanhwich	240	0.035	8.4	9	30	No
18	Froots	Hagatna	Smoothies	200	0.005	1	75	180	No

19	Pretzel Maker	Hagatna	Pretzels	100	0.005	0.5	150	90	Ye
20	Tony Roma's	Hagatna	Family Restaurant	250	0.0455	11.375	7	30	N
21	369	Hagatna	Chinese	220	0.035	7.7	10	60	N
22	Tokyo Mart Express	Hagatna	Japanese	250	0.025	6.25	12	14	N
23	KFC (GPO)	Tamuning	Fast Food	220	0.035	7.7	10	30	N
24	Sbarro	Tamuning	Pizza	400	0.025	10	8	60	N
25	China Wok	Tamuning	Chinese	300	0.035	10.5	7	30	N
26	My Kusina	Tamuning	Asian	150	0.035	5.25	14	30	N
27	Burger King	Tamuning	Fast Food	200	0.025	5	15	30	N
28	Lous Seaside Restaurant	Agat	Fast Food	80	0.025	2	38	30	Ye
29	Sunset Grill	Asan	Bar and Grill	150	0.025	3.75	20	7	Ye
30	KFC (Micronesia Mall)	Dededo	Fast Food	280	0.035	9.8	8	14	N
31	Panda Express (Micronesia Mall)	Dededo	Chinese	600	0.035	21	4	30	N
32	Burger King (Micronesia mall)	Dededo	Fast Food	200	0.025	5	15	14	Ye
33	Taco Bell (Micronesia mall)	Dededo	Mexican Food	300	0.035	10.5	7	30	N
34	Sun Hawaii (Micronesia Mall)	Dededo	Chinese	300	0.035	10.5	7	30	N
35	198 Dim Sum (Micronesia mall)	Dededo	Asian	100	0.035	3.5	21	90	N
36	Kracked Egg	Tumon	Family Restaurant	200	0.0455	9.1	8	30	N
37	Seagrill	Tumon	Family Restaurant	350	0.0455	15.925	5	30	N
38	Vitales	Tumon	Italian	100	0.0455	4.55	16	30	N
39	Dulce Frutti	Tumon	Other	200	0.005	1	75	180	N

40	South Seas Coffee/Hot Diggidy Dog/Godzilla Burger	Tumon	Fast Food	75	0.025	1.875	40	30	Ye
41	Beach N' Shrimp	Tumon	Family Restaurant	300	0.0455	13.65	5	30	N
42	Jamacan Grill	Tumon	Family Restaurant	100	0.0455	4.55	16	14	Y
43	The Cafeteria	Harmon	Fast Food	150	0.025	3.75	20	90	N
44	Cilantro	Harmon	Asian (Filipino)	50	0.035	1.75	43	60	N
45	Kinh-Do	Hagatna	Chinese	10	0.0455	0.455	165	180	N

Table 4.6. FSEs that clean, or do not clean, their grease traps at the recommended intervals based on FOG production.

Category	Number of FSEs	Percentage
Meets recommended cleaning interval (for 100-lb grease trap)	11	23%
Does not meet recommended cleaning interval (for 100-lb grease trap)	34	72%
Incomplete information	2	4%
Total	47	100%

Forty-seven of the FSEs surveyed reported to have grease traps installed (two of which had both a grease trap and a grease interceptor); and of the 47 participants, 45 provided enough information to adequately estimate the FOG production and the recommended maintenance schedule. After performing the grease trap maintenance calculations, it was found that 11 (23%) of the FSEs with grease traps had their grease traps cleaned at or before reaching 75% of its maximum capacity. Thirty-four (72%) of the FSEs were estimated to not have their grease traps maintained often enough to prevent it from reaching its maximum capacity. Two (4%) of the participating FSEs did not know how often their grease traps were maintained, so a comparison could not be conducted.

Limitations of the Analysis

This analysis provides an estimate based on various assumptions. The first is that the information provided by the FSE is accurate. The survey did not require the FSE to provide any documentation proving a company periodically maintains its grease traps, so it depends on the knowledge and contrition of the interviewee. The analysis also makes the assumption that the installed grease trap has at least a 100-lb (50-gal) capacity, though this size may vary. Also, the estimate of FOG production is a rough approximation based on an estimation of the number of customers served, which could vary greatly from day to day. It also depends on the accuracy of the grease production chart used by Shier Products Co. The assumptions made in this analysis could potentially have a significant effect on the results, but due to the limited ability to accurately measure the grease entering into the grease trap, this approximation was used to produce a general picture of grease trap maintenance by FSEs in this study.

4.6. Sizing of Grease Interceptors

Grease Interceptors are larger versions of grease traps, typically having a minimum size of 750 gal, being located underground in order to accommodate its large size (Shaffer et al., 2004). When determining the required size of a grease interceptor for an FSE, most cities in the U.S. use the Uniform Plumbing Code sizing method, which follows the equation in Figure 4.5.

Uniform Plumbing Code Appendix H
Interceptor Sizing

Number of meals per peak hour (1)	X	Waste Flow Rate (2)	X	Retention Time (3)	X	Storage Factor (4)	=	Interceptor Size (liquid capacity in gallons)

(1) Number of meals served per peak hour - or maximum seating capacity

(2) Waste Flow Rate - per device

a. With dishwashing machine connected to interceptor (not normally allowed)	6 gallon flow
b. Without dishwashing machine connected to interceptor	5 gallon flow
c. Single Service Kitchen (paper plates and utensils only)	2 gallon flow
d. Food waste disposer	1 gallon flow

(3) Retention Time

a. Commercial Kitchens	2.5 hours
b. Single Service Kitchen	1.5 hours

(4) Storage Factors

Fully equipped commercial kitchen

a. 8 hour operation	1
b. 16 hour operation	2
c. 24 hour operation	3
Single Service Kitchen (normal hours)	1.5

Figure 4.5. Uniform Plumbing Code equation used to size grease interceptors.

The Uniform Plumbing Code equation provides an analysis for the sizing of a grease interceptor yielding an estimate of the required size in gallons based on the number of meals served per peak hour, waste flow rate, retention time, and storage factors. During the survey, managers of FSEs who have a grease interceptor installed were asked to approximate how many customers they had in their busiest hour, and if that was not known, the maximum seating capacity of the building was recorded. They were also asked the hours of operation. This

information, along with observations of whether they were a single-service kitchen (without use of dishes or utensils) or a commercial kitchen (with use of dishes and utensils) was used to calculate the required grease interceptor size. In addition, the volume of the installed grease interceptor was examined if the size was not known. The length and width were measured; the depth of the interceptor, though, could not be measured, so the surface area was compared to charts of grease interceptor sizes to estimate the volume. The grease interceptor chart used herein is in Appendix C. Table 4.7 shows the results from the required grease interceptor size calculations. Table 4.8 summarizes the results from the survey, comparing the number of FSEs having an adequately sized grease interceptor with those having an inadequately sized grease interceptor installed.

Table 4.7. Data from the survey used to determine the required size of grease interceptors. The final column indicates if the unit does, or does not, meet the recommended size requirement.

	Restaurant	Village	Maximum Seating Capacity	Waste Flow Rate	Retention Time	Storage Factor	Size Required (gal)	Estimated Size Installed (gal)	Recommended Size
1	Shirleys	Hagatna	150	5	2.5	2	3,750	1500-1700	No
2	HardRock	Tumon	580	5	2.5	2	14,500	15,000	Yes
3	TGIF	Tumon	450	5	2.5	1	5,625	1,500-2,000	No
4	Chode Mart	Hagatna	300	2	1.5	1.5	1,350	200	No
5	Flamingos	Hagatna	90	5	2.5	1	1125	270	No
6	KFC	Hagatna	50	2	1.5	1.5	225	185	No
7	Horse and Cow	Tamuning	200	5	2.5	2	5,000	1000-1500	No
8	Noodle House	Tamuning	105	5	2.5	1	1,313	1000	No
9	Oriental Restaurant	Tamuning	40	5	2.5	1	500	300-400	No
10	Pizza Hut	Tamuning	77	5	2.5	1	963	1000-1300	Yes
11	Wendy's	Hagatna	100	2	1.5	1.5	450	1000-1100	Yes
12	Panda Express	Hagatna	90	2	1.5	1.5	405	1700-1800	Yes
13	Ruby Tuesday	Tamuning	240	5	2.5	1	3,000	2000-2500	No
14	Chili's	Tamuning	160	5	2.5	1	2,000	Unknown	Unknown
15	Wendy's	Tamuning	50	2	1.5	1.5	225	200	No
16	Imperial Garden	Tamuning	100	5	1.5	1.5	1,125	1200	Yes
17	Aji-Ichi	Tamuning	30	5	1.5	1.5	338	300-500	Yes
18	Charley's Steakery	Tamuning	30	5	1.5	1.5	338	400-600	Yes
19	Burger King	Tumon	88	2	1.5	1.5	396	1000	Yes
20	Pika's Café	Upper Tumon	75	5	2.5	1	938	900	No
21	Ninja Buffet	Upper Tumon	200	5	2.5	1	2,500	900-1000	No
22	Hao Mai	Yigo	80	5	1.5	1.5	900	1000-1100	Yes

Table 4.8. Summary of the calculated results for the required size of grease interceptors.

Category	Number of FSEs	Percentage
Meets recommended size	9	41%
Does not meet the recommended size	12	55%
Unknown	1	5%

Nine (41%) of the surveyed FSEs met the recommended grease interceptor size. Twelve (55%) of the FSEs did not meet the recommended grease interceptor size. Only one (5%) of the FSEs did not have enough information to determine if it has a properly sized interceptor because the interceptor was installed underground and covered with pavement, so the dimensions could not be measured.

Limitations of the Survey

A major limitation of these results, as with the grease traps, is the inability to know the actual size of the grease interceptor. The depth of the grease interceptors was not measured to avoid opening and tampering with them. Thus, the sizes under the category *Interceptor Installed* are only an estimation based on the surface area of the interceptor, so the actual sizes could vary from those used in the analysis.

5. DISCUSSION

5.1. Quarterly Reports

The GWA "Hot Spot Cleaning Plan" was used initially to identify the locations of SSOs for this study. However, it was later determined that there were significantly more SSO locations on Guam being reported in the GWA SSO Quarterly Reports. Thus, for the purpose of this study it was decided to include SSOs noted in the quarterly reports spanning from October 2011 to February 2014, as shown in Table 5.1.

Table 5.1. Breakdown of SSOs by municipality as reported by GWA from 10/2011-2/2014.

No.	Municipality	SSOs	Percentage
1	Agana Heights	24	7%
2	Agat	25	7%
3	Asan	4	1%
4	Barrigada	11	3%
5	Chalan Pago-Ordot	4	1%
6	Dededo	44	12%
7	Hagatna	16	4%
8	Inarajan	8	2%
9	Mangilao	20	6%
10	Merizo	6	2%
11	Mongmong-Toto-Maite	9	2%
12	Piti	2	1%
13	Santa Rita	19	5%
14	Sinajana	11	3%
15	Talofofo	2	1%
16	Tamuning/Tumon	112	31%
17	Umatac	2	1%
18	Yigo	21	6%
19	Yona	21	6%
	Total	361	100%

Of the SSOs named on the SSO Quarterly Reports, only the FOG-related cases were used. Information provided in the reports pertaining to cases of concern included manhole number, village, and date of each SSO event.

5.2. GIS Database

The locations of the SSOs were transferred to a shapefile on ArcGIS to display the locations in the GWA sewer collection system as shown in Figure 5.1. These locations were entered with the following information:

- Manhole_ID – The GWA designated manhole ID number
- Municipality – The village in which the SSO occurred
- Root_Cause – FOG, Structural, etc. (in this study only FOG was included)
- Last_Reported – The most recent date an SSO was reported at that location
- Frequency – Number of times an SSO was reported at that location

Each location was given a color based on the frequency of the SSO:

- Green – 1 reported SSO
- Yellow – 2-4 Reported SSOs
- Red – 5 or more reported SSOs

The overall map of the SSOs is displayed in Figure 5.1. Maps displaying the individual categories of frequencies are provided in Appendix B. As shown in Figure 5.2, the locations and general information for each FSE surveyed were also included in the map on ArcGIS:

- Municipality – The village where the FSE is located
- FSE_Type – The category of food it serves
- FOG_Management – Grease trap, interceptor, both, or neither
- Date_Surveyed – The date the FSE was surveyed for this study

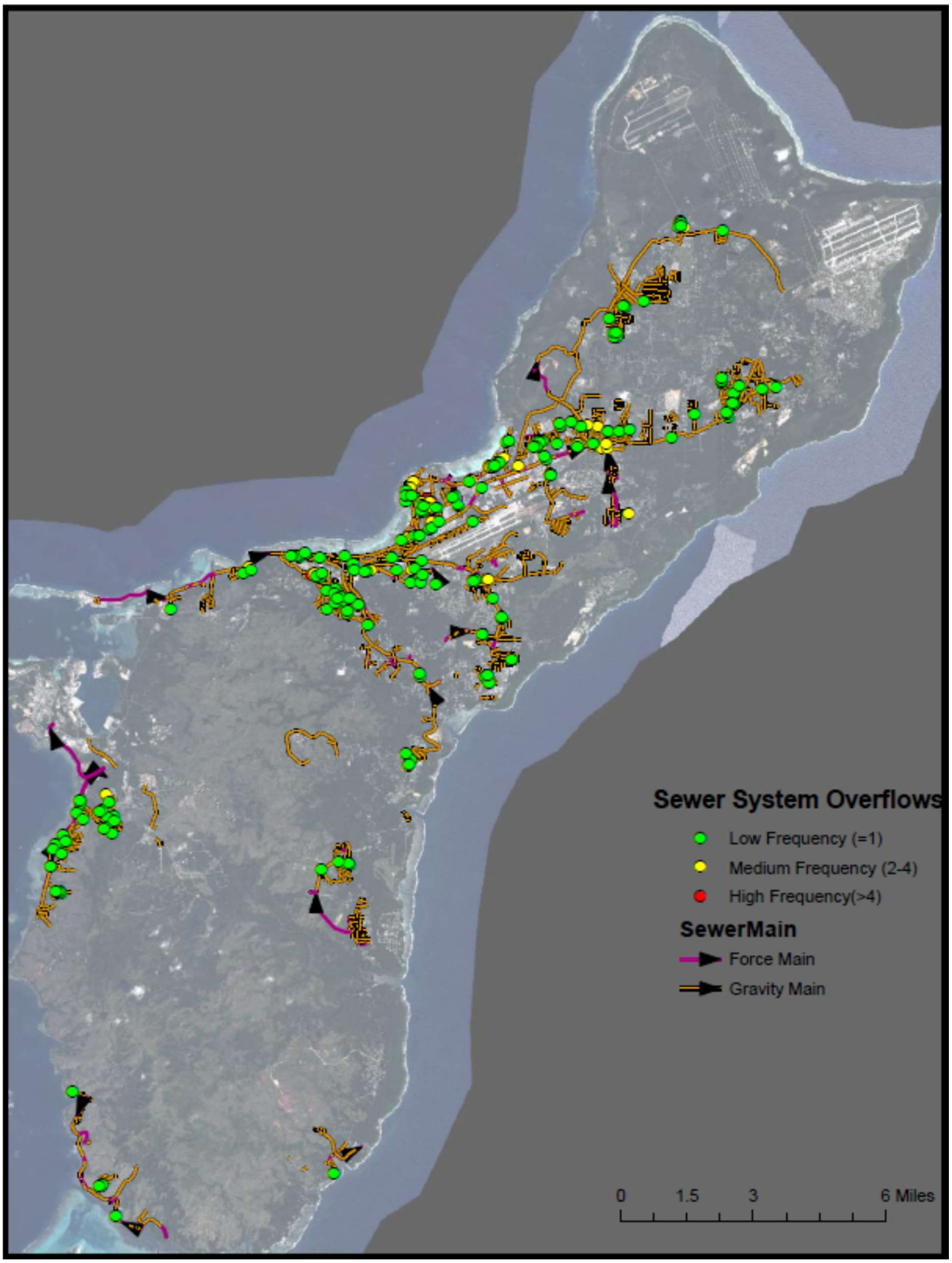


Figure 5.1. GIS map of the GWA sewer collection system showing locations of SSOs.

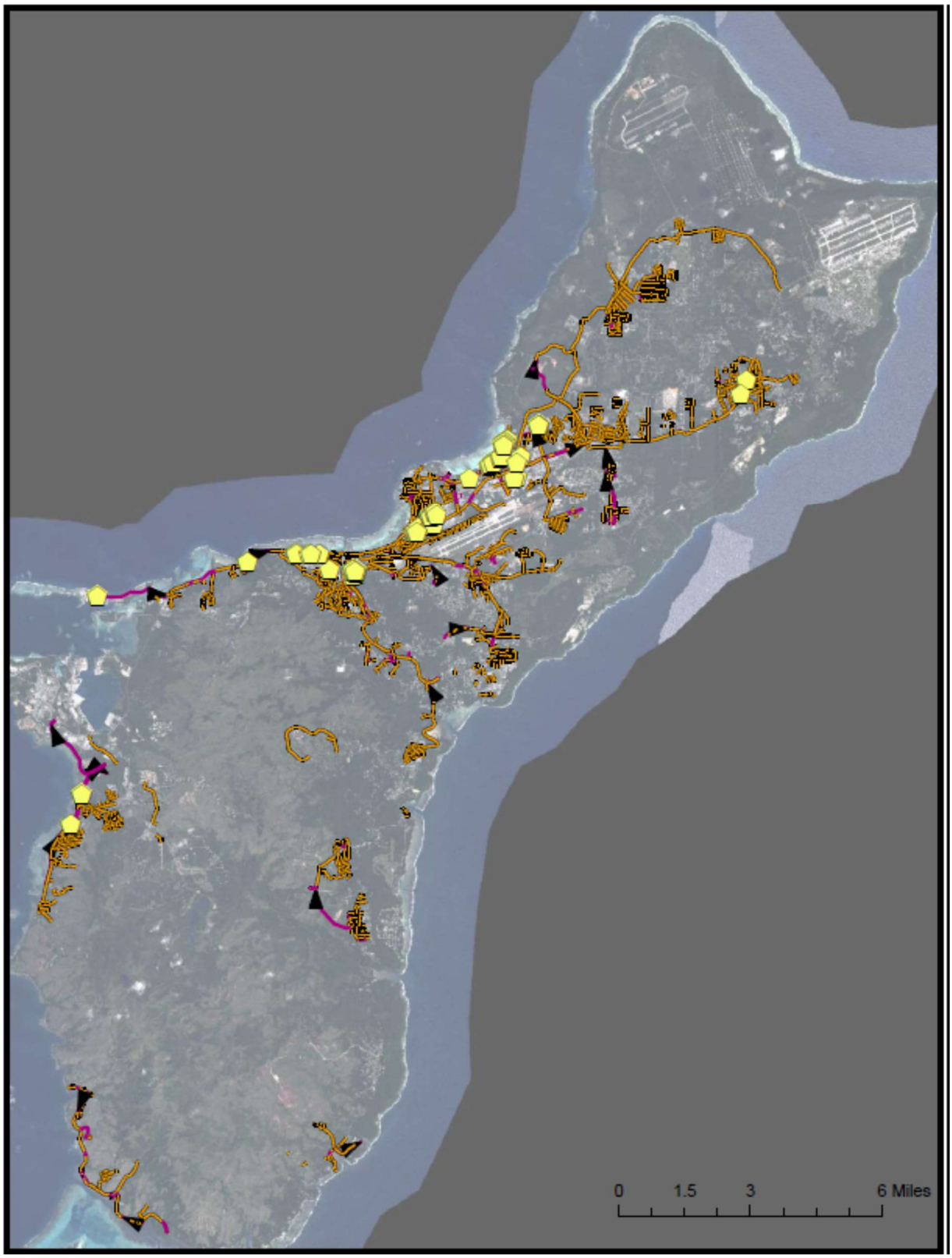


Figure 5.2. GIS map showing the locations of the FSEs surveyed in this study.

5.3. FOG Management by FSEs vs. SSO Locations

In order to evaluate the effectiveness of FOG management by the FSEs, they were divided into two categories: SSO and non-SSO. "SSO" implies that the FSE is located upstream or directly at a reported SSO site, and "non-SSO" means that it is not located in the vicinity of a reported SSO site. This categorization was made at the discretion of the authors using the map on ArcGIS to determine if the FSE was close enough to potentially have a direct effect on the FOG loading at the site of an SSO. Thirty-five (44%) of the FSEs surveyed were located upstream or directly at a reported SSO site. Forty-four (56%) of the FSEs surveyed were not located near a reported SSO site.

Table 5.2. Breakdown of FSEs in SSO and non-SSO areas.

	FSE Surveyed	
Category	**Number**	**Percentage**
SSO	35	44%
non-SSO	44	56%
Total	**79**	**100%**

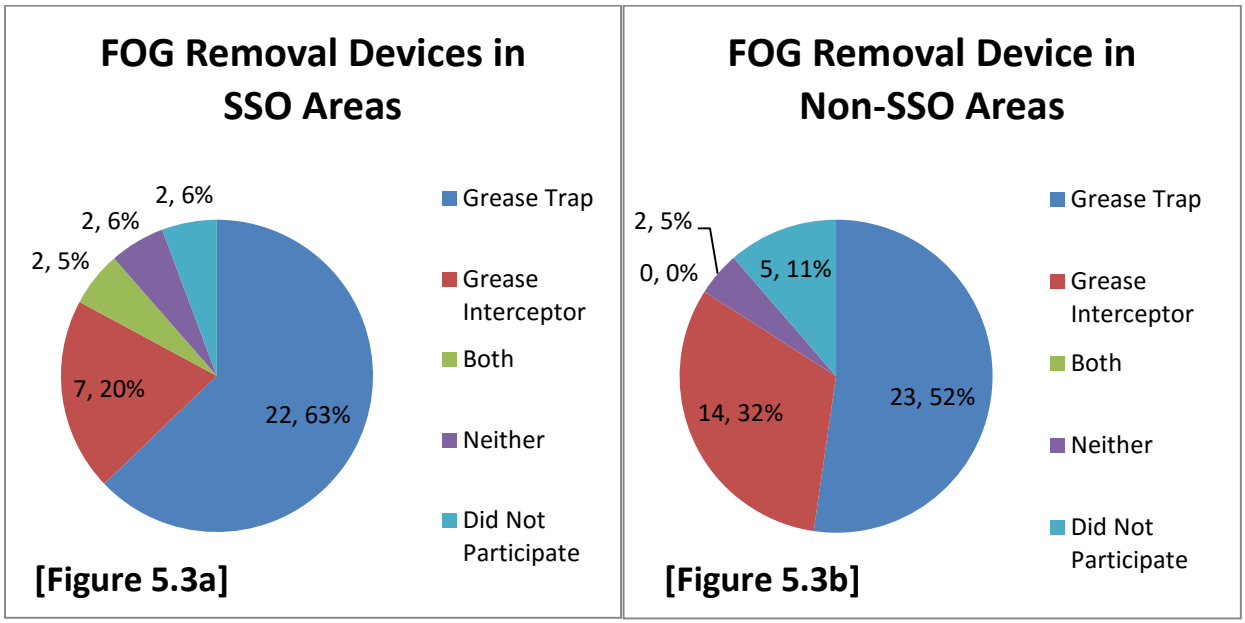
A statistical analysis was then conducted using the FOG management data collected in the surveys to compare the management practices of FSEs located in SSO and non-SSO areas. The four categories used in the comparison were: 1) FOG removal device, 2) FOG disposal method, 3) Grease trap cleaning interval, and 4) Grease interceptor size.

FOG Removal Device

This category allows for an evaluation of the type of FOG removal device used by the FSEs in SSO and non-SSO areas.

Table 5.3. Types of FOG removal devices used at FSEs in SSO and non-SSO areas.

	SSO		non-SSO	
FOG Removal Device	**Number of FSEs**	**Percentage**	**Number of FSEs**	**Percentage**
Grease trap	22	63%	23	52%
Grease interceptor	7	20%	14	32%
Both	2	6%	0	0%
Neither	2	6%	2	5%
Did not participate	2	6%	5	11%
Total	**35**	**100%**	**44**	**100%**



Figures 5.3a and 5.3b. Types of FOG removal devices used at FSEs in SSO and non-SSO areas.

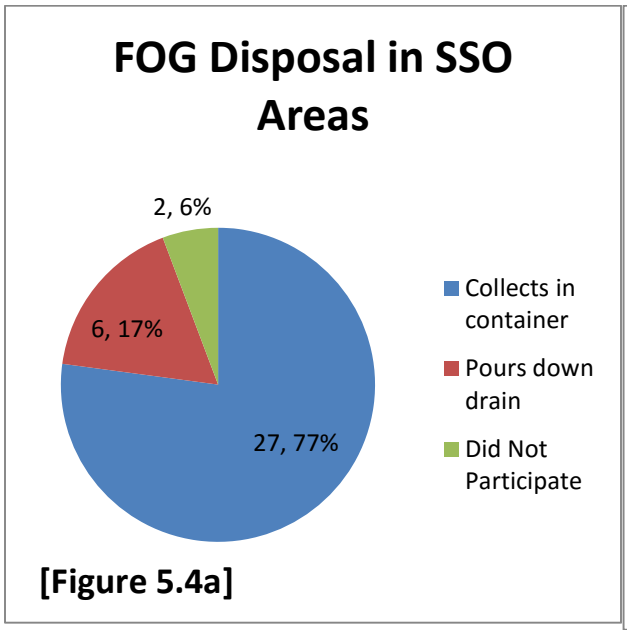
The results show that for FSEs in the SSO areas, 22 (63%) used only a grease trap, seven (20%) used only grease interceptors, two (6%) used both, two (6%) used neither, and two (6%) did not participate. Conversely, the results show that for FSEs in the non-SSO areas 23 (52%) used only a grease trap, 14 (32%) used only a grease interceptor, two (5%) used neither and five (11%) did not participate in the survey.

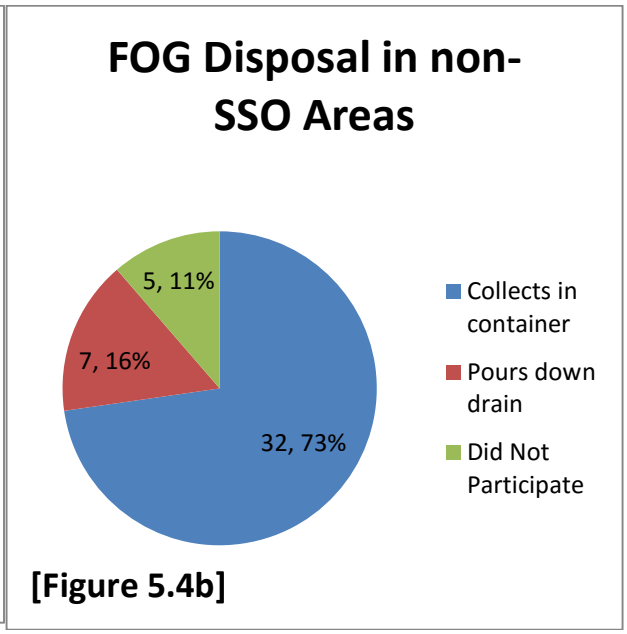
FOG Disposal

This category allows for an evaluation of the practices of FSEs collecting used kitchen FOG in SSO and non-SSO areas.

Table 5.4. FOG disposal methods used at FSEs in SSO and non-SSO areas.

	SSO		Non-SSO	
FOG Disposal	**Number of FSEs**	**Percentage**	**Number of FSEs**	**Percentage**
Collects in container	27	77%	32	73%
Pours down drain	6	17%	7	16%
Did not participate	2	6%	5	11%
Total	**35**	**100%**	**44**	**100%**





Figures 5.4a and 5.4b. FOG disposal methods used at FSEs in SSO and non-SSO areas.

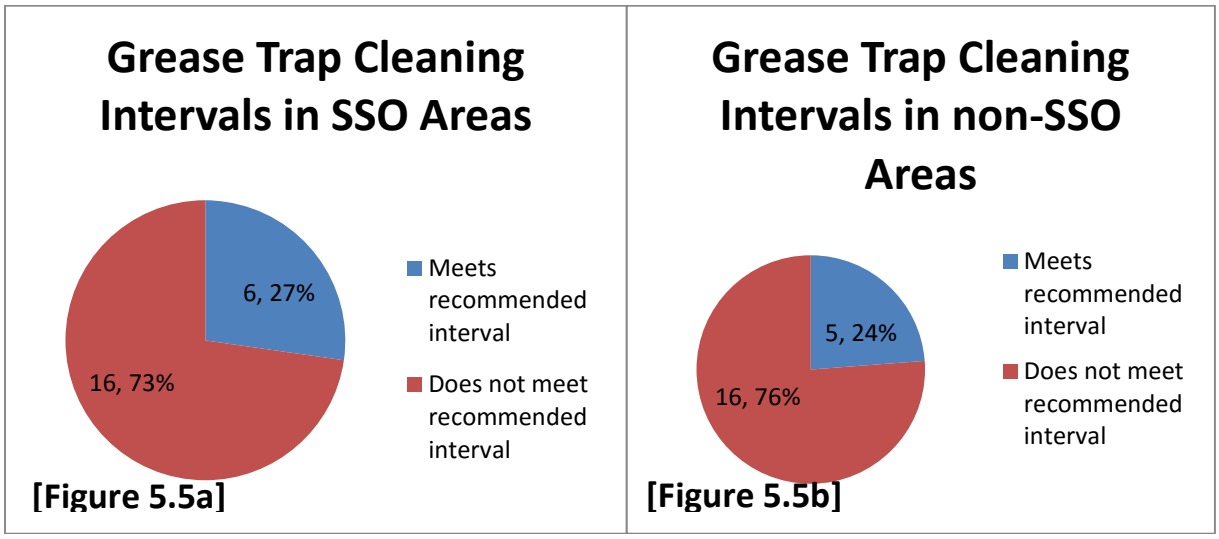
The results show that for FSEs in the SSO areas, 27 (77%) collect their used FOG, while six (17%) pour their used FOG down the drain, and two (6%) did not participate in the survey. For FSEs in the Non-SSO areas, 32 (73%) collect their used FOG, while seven (16%) pour their used FOG down the drain, and five (11%) did not participate in the survey.

Grease Trap Cleaning Interval

The next calculation compared the cleaning intervals of grease traps in SSO vs. Non-SSO areas based on the grease trap maintenance calculation shown in Section 4.5. Only the FSEs with a grease trap that provided enough information to perform the cleaning frequency calculation were included in this analysis.

Table 5.5. Cleaning intervals used at FSEs in SSO and non-SSO areas.

	SSO		Non-SSO	
Grease Trap Cleaning Interval	**Number of FSEs**	**Percentage**	**Number of FSEs**	**Percentage**
Meets recommended interval	6	27%	5	24%
Does not meet recommended interval	16	73%	16	76%
Total	**22**	**100%**	**21**	**100%**



Figures 5.5a and 5.5b. Cleaning intervals used at FSEs in SSO and non-SSO areas.

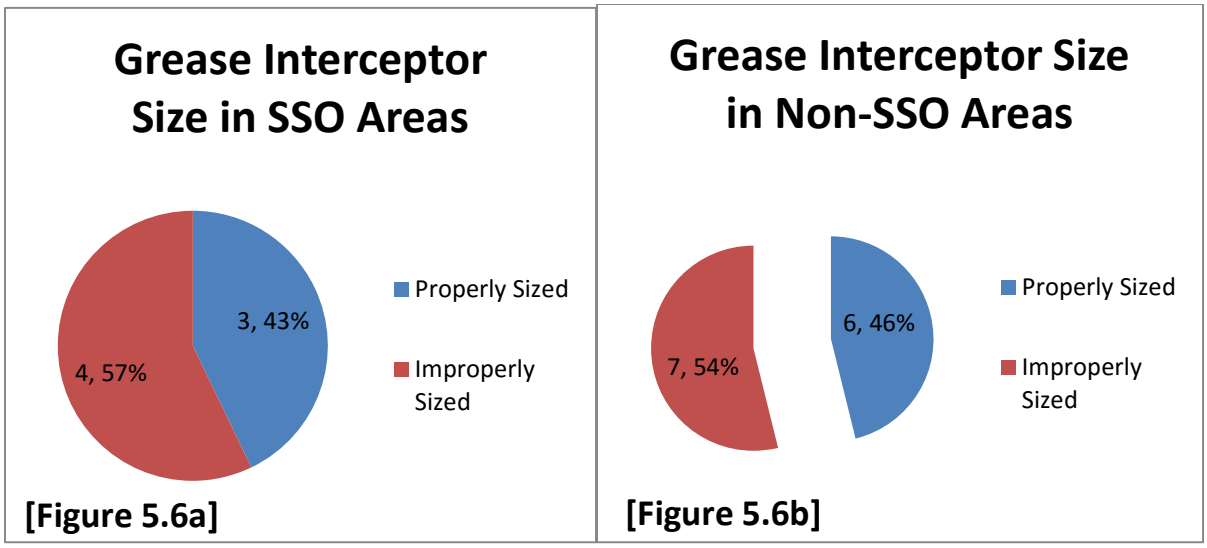
The results show that for FSEs in the SSO areas, 16 (73%) do not clean their grease traps at the recommended interval as required by their calculated grease production, while six (27%) do clean their grease traps at the recommended interval. Conversely, for the FSEs in non-SSO areas, 16 (76%) do not clean their grease traps at the recommended interval, while 5 (24%) do clean their grease traps at the recommended interval.

Grease Interceptor Size

The next calculation allows for an evaluation of the sizes of grease interceptors in SSO and non-SSO areas, making use of the sizing calculations from Section 4.6. Only the FSEs that provided enough information to perform the grease interceptor size calculations were included in this analysis.

Table 5.6. Grease-interceptor sizing used at FSEs in SSO and non-SSO areas.

	SSO		Non-SSO	
Grease Interceptor Size	**Number of FSEs**	**Percentage**	**Number of FSEs**	**Percentage**
Properly Sized	3	43%	6	46%
Improperly Sized	4	57%	7	54%
Total	**7**	**100%**	**13**	**100%**



Figures 5.6a and 5.6b. Grease-interceptor sizing used at FSEs in SSO and non-SSO areas.

These results show that for FSEs in the SSO areas, three (43%) have a properly sized grease interceptor installed, while four (57%) do not have a properly sized interceptor installed. Conversely, of the FSEs surveyed for Non-SSO areas, six (46%) have a properly sized grease interceptor installed, while seven (54%) do not have a properly sized grease interceptor installed.

5.4. Statistical Analysis of Results

A statistical analysis was performed to determine the effectiveness of FOG management practices as applied at FSEs in preventing SSOs. The four categories of management practices discussed in the previous section were examined statistically using the Test for Comparing Two Proportions, which uses the z-distribution to test a hypothesis. It uses the following formula:

$$z = \frac{\pi 1 - \pi 2 - \Delta}{\sqrt{\pi(1-\pi)(\frac{1}{n1} + \frac{1}{n2})}} \quad and \quad \pi = \frac{x1 + x2}{n1 + n2}$$

Where π1 and π2 are the sample proportions, Δ is their hypothesized difference (for null hypothesis (H_o), Δ = 0), n1 and n2 are sample sizes, and x1 and x2 are the number of "successes" in each sample.

A one-tailed test was performed, where for the H_o, π1 ≤ π2; and for the alternative hypothesis (H_a), π1 > π2. The H_o implies there is no difference in results attributable to the two methods in non-SSO areas. The H_a implies that one FOG management method (π1) is more effective than the other (π2) in non-SSO areas (i.e., method 1 is more effective in preventing SSOs). The significance of the results is discussed at the end of this Section.

FOG Removal Device

For the FOG removal device category, the differences in performance of grease interceptors and grease traps are evaluated. The value of n1 is the total number of grease interceptors, and n2 is the total number of grease traps. The value of π1 is the proportion of grease interceptors in non-SSO areas to the total number of grease interceptors, and π2 is the proportion of grease traps in non-SSO areas to the total number of grease traps. The values of x1 and x2 are the numbers of grease interceptors and grease traps, respectively, in non-SSO areas. The H_o implies there is no difference in the outcomes of the two methods. The H_a implies grease interceptors are more effective than grease traps. The comparison of the two proportions yields α = 0.118. Table 5.7 shows the results of the analysis for this category.

Table 5.7. Results of statistical analysis for grease removal devices: H_a is that grease interceptors are more effective than grease traps.

Grease Removal Device			H_o: The two are **NOT** different						
	Grease Interceptor	Grease Trap	n1	n2	$\pi 1$	$\pi 2$	π	z	α
Non-SSO	14	23	21	45	0.667	0.511	0.561	1.186	0.118
SSO	7	22							
Total	21	45							

FOG Disposal Method

For the category of FOG disposal, FSEs that practice collection and storage of their used FOG were evaluated to see if they are more effective than FSEs that dispose of their used FOG by pouring it down the drain. The value of n1 is the total number of FSEs that collect used FOG, and n2 is the total number of FSEs that dispose of used FOG. The value of $\pi 1$ is the proportion of FSEs that collect used FOG in Non-SSO areas to the total number of those that collect used FOG, and $\pi 2$ is the proportion of those that dispose of used FOG in non-SSO areas to the total number of those that dispose of used FOG. The values of x1 and x2 are the numbers of those that collect used FOG and dispose of used FOG, respectively, in non-SSO areas. The H_a is that collecting used FOG is more effective in preventing SSOs than pouring used FOG down the drain. The comparison of the two proportions yields $\alpha = 0.490$. Table 5.8 shows the results of the analysis for this category.

Table 5.8. Results of statistical analysis for FOG disposal methods: H_a is that collecting used grease is more effective in preventing SSOs than pouring used grease down the drain.

FOG Disposal			H_o: The two are **NOT** different						
	Used FOG is collected	Used FOG is poured down drain	n1	n2	$\pi 1$	$\pi 2$	Π	z	α
Non-SSO	27	6	59	13	0.458	0.462	0.458	-0.026	0.490
SSO	32	7							
Total	59	13							

Grease Trap Cleaning Interval

For the category of Grease Trap Cleaning Interval, FSEs that clean their grease traps at recommended intervals are tested to see if they are more effective than FSEs that do not clean their grease traps at recommended intervals. The value of n1 is the total number of FSEs that clean their grease traps at recommended intervals, and n2 is the total number of FSEs that do not clean their grease traps at recommended intervals. The value of $\pi 1$is the proportion of those that clean their grease trap at recommended intervals in non-SSO areas to the total number of grease traps that are cleaned at recommended intervals, and $\pi 2$ is the proportion of those that do not clean their grease trap at recommended intervals in non-SSO areas to the total number of those that do not clean grease traps at recommended intervals. The values of x1 and x2 are the number of those that clean their grease traps at recommended intervals and those that do not clean their grease traps at recommended intervals, respectively, in non-SSO areas. The H_a is that cleaning a grease trap at the recommended interval is more effective at preventing SSOs. The comparison of the two proportions yields α=0.398. Table 5.9 shows the results of the analysis for this category:

Table 5.9. Results of statistical analysis for grease trap cleaning intervals: H_a is that cleaning a grease trap at the recommended interval is more effective at preventing SSOs.

Grease Trap Cleaning Interval			H_o: The two are **NOT** different						
	Meets Recommended Interval	**Does Not Meet Recommended Interval**	**n1**	**n2**	**$\pi 1$**	**$\pi 2$**	**Π**	**z**	**α**
Non-SSO	**5**	**16**	**11**	**32**	**0.455**	**0.500**	**0.488**	**-0.260**	**0.398**
SSO	**6**	**16**							
Total	**11**	**32**							

Grease Interceptor Size

For the category of Grease Interceptor Size, FSEs with properly sized grease interceptors were tested to see if they are more effective than FSEs with improperly sized grease interceptor. The value of n1 is the total number of FSEs that have a properly sized grease interceptor, and n2 is the total number of FSEs that do not have a properly sized grease interceptor. The value of $\pi 1$ is the proportion of those with a properly sized interceptor in non-SSO areas to the total number

of those with a properly sized interceptor, and π2 is the proportion of those that have an improperly sized interceptor in non-SSO areas to the total number of those that have an improperly sized interceptor. The values of x1 and x2 are the numbers of FSEs with a properly sized grease interceptor and the number of FSEs with an improperly sized interceptor, respectively, in non-SSO areas. The H_a is that a properly sized grease interceptor is more effective in preventing SSOs. The comparison of the two proportions yields α=0.444. Table 5.10 shows the results of the analysis for this category:

Table 5.10. Result of statistical analysis for grease interceptor sizes: H_a is that a properly sized grease interceptor is more effective in preventing SSOs.

Grease Interceptor Size			H_o: The two are **NOT** different						
	Properly Sized	Improperly Sized	n1	n2	π1	π2	Π	z	α
Non-SSO	6	7	9	11	0.636	0.667	0.650	-0.141	0.444
SSO	3	4							
Total	9	11							

Statistical Interpretation

Based on the typically acceptable cut-off criteria of α = 0.10, the confidence level would be at 90%. To reject the H_o – i.e., to say the method being evaluated does have a significantly beneficial effect – the resulting α value would have to be $\alpha < 0.10$. Under this test, all four of the H_o are accepted with a confidence level of 90%. This would mean that none of the FOG management categories being evaluated are significantly more common in Non-SSO areas. One could then conclude, for example, that FSEs that maintain their grease traps at an adequate cleaning frequency are not more common in Non-SSO areas than FSEs that fail to properly maintain their grease traps. However, for the category of FOG removal device, results here do indicate that with a confidence level of 88% grease interceptors are more effective than grease traps.

The small sample sizes may contribute to the rather inconclusive statistical results in some cases. There were only 13 FSEs that reported pouring FOG down the drain, 11 FSEs that cleaned their grease trap at the recommended interval, 9 grease interceptors that were properly

sized, and 11 grease interceptors undersized. Only the FOG removal device category demonstrated sample sizes suitable for robust statistical analysis, with 21 FSEs employing a grease interceptor and 45 FSEs having a grease trap, thus allowing for drawing conclusions with more statistical significance. Availability of more data in the future could allow for a more accurate determination of the efficacy of the methods being evaluated.

6. SUMMARY AND CONCLUSIONS

6.1. FOG Removal Device

Of the FSEs that were interviewed during the survey, 84% had some kind of FOG removal device installed. This result was unexpected as it was initially suspected that many FSEs did not have FOG removal devices due to the large number of SSOs occurring in GWA sewer lines. Many of the managers whom we spoke to understood the importance of preventing FOG from entering into the drainage system to prevent clog formation and drainage back-ups. The most common type of FOG removal device was the grease trap, amounting to 57% of the survey respondents. This result was expected, as it is cheaper and easier to install because of its smaller size.

About one third (27%) of the surveyed FSEs had a grease interceptor installed. An additional 5% of the surveyed FSEs did not have any kind of FOG removal device, and 9% of the FSEs did not respond to the survey. Some of the FSEs that did not wish to take the survey appeared to be too busy and thus unable to take time to answer the survey questions. Others claimed that they were busy even when there were no customers present, or claimed not to speak English. It is these FSEs that are suspected of not having any FOG removal device installed. The remaining 2% of the respondents had both a grease trap and grease interceptor installed.

6.2. FOG Disposal

As with the FOG removal devices, a majority of the surveyed FSEs responded that they collect their used FOG in a container rather than allowing it to go down the drain. Of the surveyed FSEs, 75% responded that they collect and store their used FOG. Most of the FSEs use 55-gal drums located outside their kitchen, while at the Guam Premium Outlets the mall management provides the FSEs in the food court with a communal container for used FOG. Having 75% of the respondents say that they collect their used FOG demonstrates their understanding of the importance of keeping FOG out of the sewer lines. Only 16% of the surveyed FSEs responded that they do collect their used FOG. This is understandable, as some FSEs do not produce enough FOG to warrant the need for a storage bin, such as sandwich shops or cafés. The remaining 9% of the FSEs did not wish to participate in the survey.

6.3. Grease Trap Cleaning Interval

There were mixed results from the survey addressing grease trap cleaning intervals at the FSEs. A majority of the FSEs responded that they have contracts with companies to periodically clean out the grease trap and collect the contents. This ensured that the grease traps were being maintained regardless of the availability of FSE employees. Of the FSEs that had grease traps installed, 80% had a contract with a company to maintain their grease trap, while 9% did it in-house. Only 11% were not sure how their grease traps were maintained.

After performing estimations on the FOG production of the FSEs and comparing it to the actual cleaning intervals of the grease traps, it was estimated that only 23% of the FSEs have their grease traps cleaned at the recommended intervals. Most FSEs develop their cleaning intervals based on past experience of how long it takes before their grease trap becomes full, and begins to overflow. However, the EPA recommends cleaning out a grease trap at 75% capacity. By this standard, a majority of the FSEs do not properly clean their grease traps as often as they should for it to work efficiently. This conclusion, however, is based on the assumption that the grease traps installed at the FSEs handle a typical amount of 100 lbs. of grease. It is likely that some grease traps installed are capable of handling more FOG than this.

6.4. Grease Interceptor Size

Using the Uniform Plumbing Code standard for sizing grease interceptors, it was determined that 41% of the FSEs with grease interceptors installed had properly sized interceptors, and 55% did not have properly sized interceptors. This is a higher percentage than the results obtained for grease trap cleaning intervals, but it is still fewer than 50% of the total FSEs with grease interceptors.

A possible explanation for the low percentage is that the Uniform Plumbing Code formula at times leads to larger than necessary sizes (Shaffer et al., 2003). If the grease interceptor is too large, it can lead to longer than necessary retention times, making the wastewater septic and more corrosive (Shaffer et al., 2003). Though it is more favorable to have a grease interceptor installed than a grease trap because of the greater capacity, it is still important not to have one that is over-sized.

6.5. GIS Data Integration

The map of the reported SSOs on ArcGIS reveals its distribution in GWA's sewer lines. This makes it easier for GWA to track the locations of SSOs and the information in the geo-database and provides the history for that location, so problem areas are much easier to track. The data can aid in creating a FOG management program by identifying possible sources or causes of SSOs, such as FSEs, residential areas, and if neither, then identify possible structural problems. It could also be used by crews to anticipate the location and timing of potential SSOs so that they can be prevented, helping to save time and resources.

6.6. Recommendations for Further Work

Of the four FOG management methods examined in the survey, as shown in Table 6.1, the type of FOG removal device demonstrated the highest statistical significance of preventing SSOs, i.e. with a confidence level of 88% we can say that grease interceptors are more effective than grease traps. However, the other categories addressing grease trap cleaning intervals, grease interceptor size, and FOG disposal methods cannot reasonably be said to have significant effects with the data available here.

Table 6.1. FOG management practices examined in this study and their alpha (α) values and confidence levels in descending order of statistical significance.

FOG Management Practice	Alpha (α)	Confidence Level
FOG Removal Device	0.118	88%
Grease Trap Cleaning Interval	0.398	60%
Grease Interceptor Size	0.444	56%
FOG Disposal	0.490	51%

As discussed in the Statistical Interpretation, the FOG removal device may have the highest significance due to the higher sample sizes for each sub-category. In addition, it must be noted that there were many variables in this study that could have affected the final results. Examples would include that some FSEs are producing a lot of FOG but are not able to catch all of their output, leaving the remainder to flow down the drain. Another variable could be FSEs that clean their grease trap at the recommended interval may not be fully cleaning them, thus

leading to an inefficiently operating grease trap. This study does not conclude that the FOG management practices discussed here do not effectively prevent SSOs, but rather it can be interpreted that preventing SSOs is a very complicated process that must take into consideration many different factors, not just one method of FOG management.

This study does not to demonstrate any definitive sources for the FOG induced SSOs occurring in GWA sewer lines, but it does provide GWA with information on the FOG management practices of local FSEs. This data is important as a baseline of information for the early stages of developing a FOG Management Plan. It provides insight into the current practices of FSEs, which could lead to future regulations and requirements that would help manage the FOG on Guam. Future studies could shift the focus into residential FOG management, especially for apartments and townhouses, which could potentially be large sources of sewer FOG.

7. REFERENCES

Calvo, Jude, Prudencio Aguon, Paul Kemp, Paul Franquez, Martin Roush, P.E. "Hot Spot Cleaning Plan." Guam Waterworks Authority (2012).

Ducoste, Joel J., Kevin M. Keener, John W. Groninger, Leon M. Holt. "Assessment of Grease Interceptor Performance." Water Environment Research Foundation (2008).

Duffy, Sean. "If It's a Grease Interceptor, Then Why Not Size by Grease Production?" Schier Products Company (2012).

Losinio, Louella. "Fats, grease costing GWA $500K annually." Marianas Variety (2013). Online: Accessed Oct. 2013 at http://mvguam.com/local/news/31091-fats-grease-costing-GWA-500k-annually.html.

Okazaki, Wendy K. "Identification and Assessment of Food Waste Generators in Hawaii." University of Hawaii Library (2006).

Shaffer, John, Stan Steinbach, P.E., Tom Titus, Bart Hamlett, Mike Ijams, Wyatt Troxel, Frank Dryden, P.E., Nancy Wheatly, Don McIntyre. "Orange County Fats, Oils, and Grease (FOG) Control Study: FOG Control Research Study Report, FOG Control Building Blocks." Environmental Engineering and Contracting, Inc. (2003).

Wiltsee, G. "Urban Waste Grease Resource Assessment." National Renewable Energy Laboratory (1998).

"Benefits of Protecting Your Community from Sanitary Sewer Overflows." US EPA (2000).

"Hypothesis Testing: Upper-, Lower-, and Two-Tailed Tests." Boston University School of Public Health (2012). Online: Accessed Oct. 13, 2014, at: http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_HypothesisTest-Means-Proportions/BS704_HypothesisTest-Means-Proportions3.html.

"National Pretreatment Program: Controlling Fats, Oils, and Grease Discharges from Food Service Establishments." US EPA (2012).

8. APPENDICES

8.1. Appendix A: Survey Questionnaire

FOG Inspection Questionnaire

Date: _____

Hot Spot No.:_____

Basic Information

Facility Name:	
Facility Address:	Facility Phone:
GWA Customer # (if none, landlord name):	
Owner:	
Correspondent(s) During Inspection:	
Inspection Time (Start to Finish):	

Facility Information

Facility Classification:

__Single Service Kitchen __Commercial Kitchen

Type of Facility:

__ Fast Food __Diner __Grocery __Bakery __Deli __Meat Market __Donut Shop

__Ice Cream __Other (Description:

_____)

Seating Capacity: _____ Business Hours: _____

No. Of Customers:_____

Grease Removal System

Installed: ___Yes ___No

Type:

__Grease Trap __Grease Interceptor __Other

(Description:_____)

Size: Length_____ Width_____ Depth_____ Volume:_____

Number of Inlets to Grease Trap:_____

Location (Include Photo):_____

Grease Trap/Interceptor Disposal:_____

Maintenance Records: ___Yes ___ No Date Last Serviced: _____

Note Condition: _____

Best Management Practices (BMP)

Grease Storage Unit: __Yes __No Location:_____
Size: _____

Method of Grease Disposal: _____

Garbage Disposal Unit: ___Yes ___No Method of Solids Disposal:_____

Delivered GWA FOG Brochure to Facility: __Yes __No

Additional Notes: _____

_____

8.2. Appendix B: Sewer System Overflow Maps

B-1 Low Frequency

B-2 Medium Frequency

B-3 High Frequency

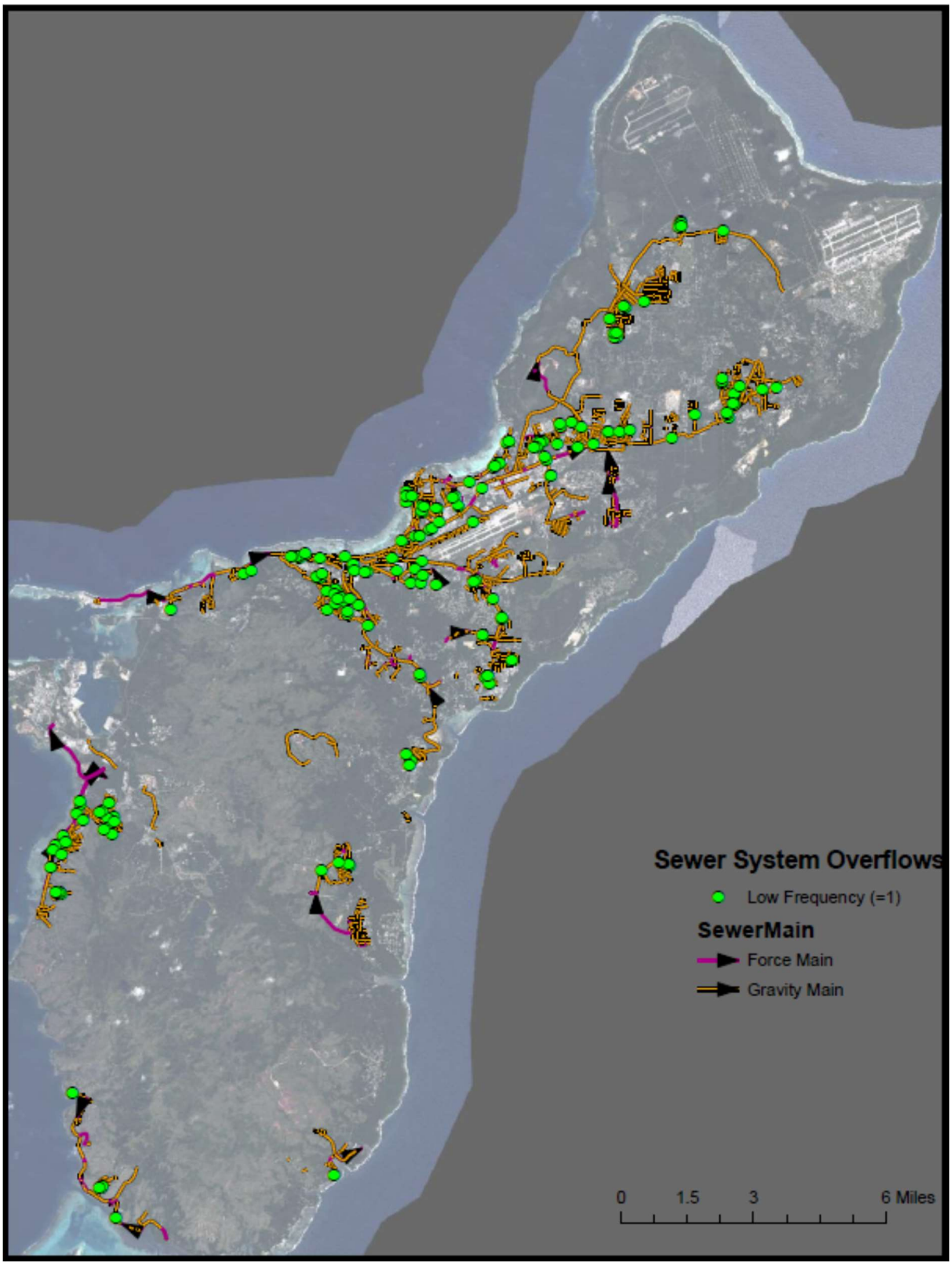


Figure B.1. Sewer system overflows with low frequency.

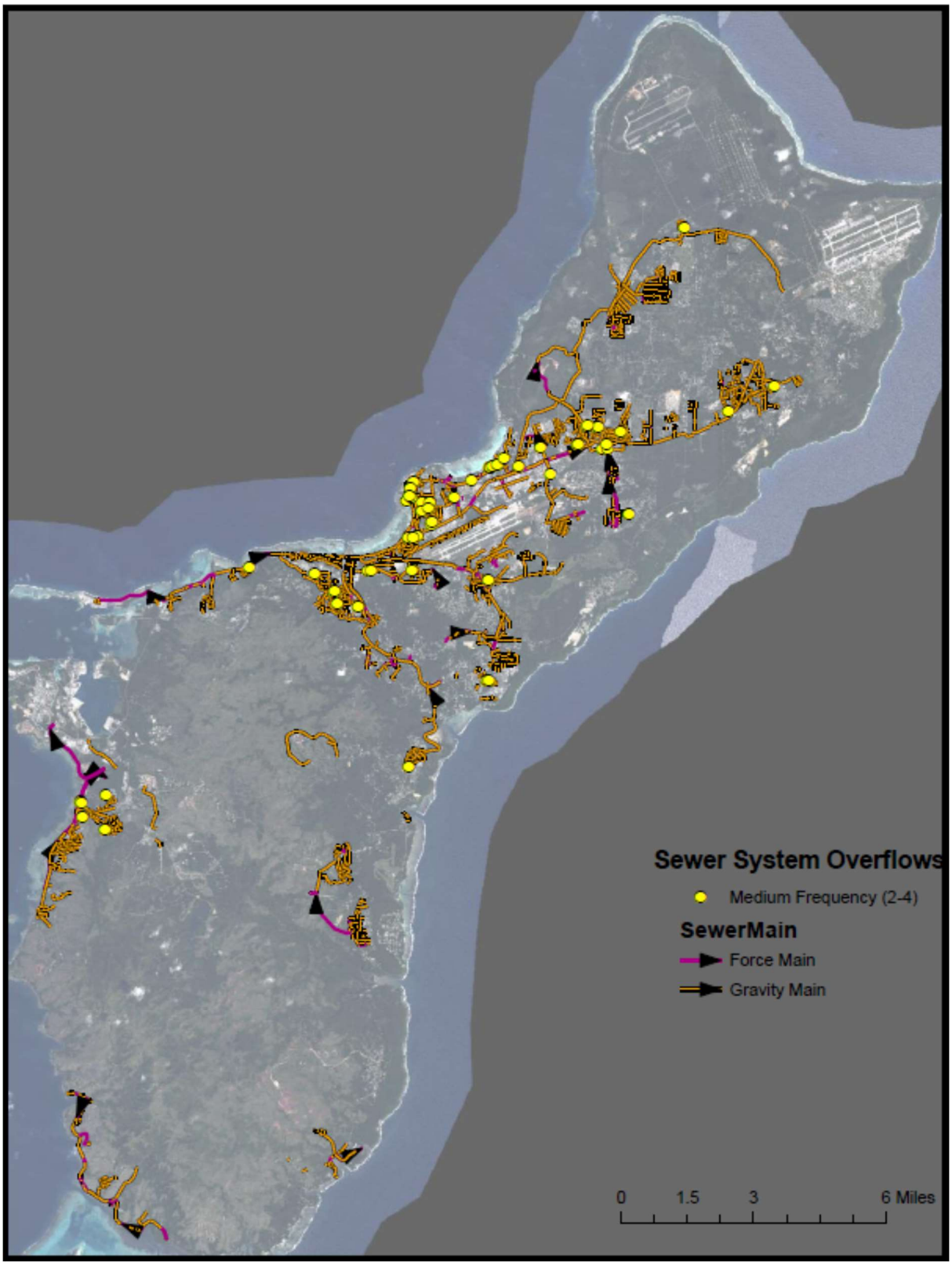


Figure B.2. Sewer system overflows with medium frequency.

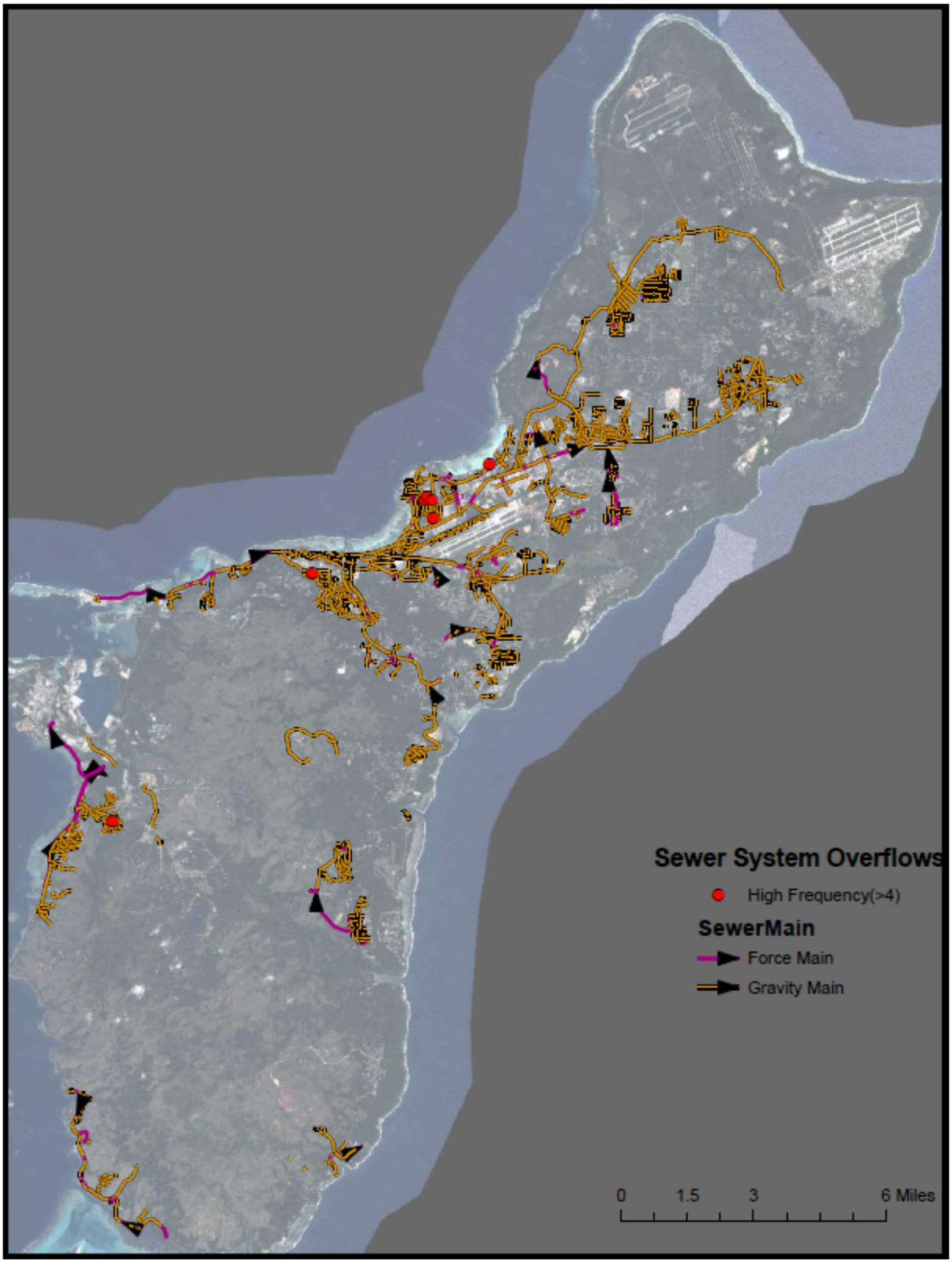
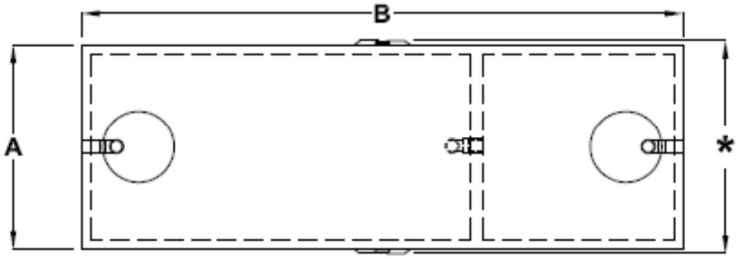


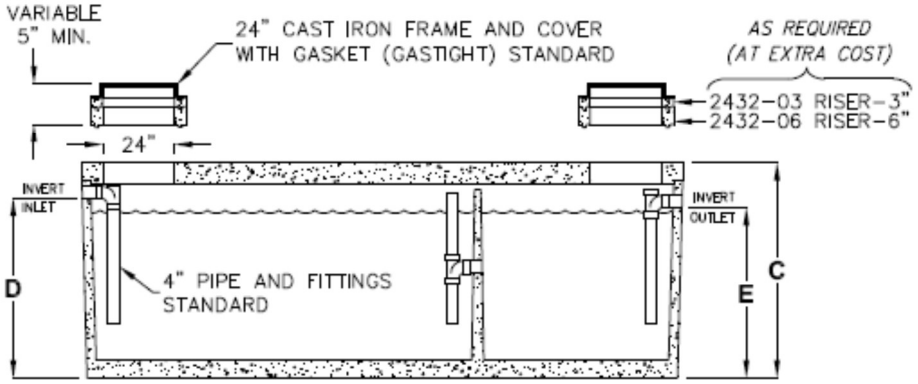
Figure B.3. Sewer system overflows with high frequency.

8.3. Appendix C: Grease Interceptor Specifications

320-5000 GALLON GREASE INTERCEPTORS



PLAN VIEW (COVERS REMOVED)



SIDE SECTION VIEW

MODEL NUMBER	LIQUID CAPACITY (GALLONS)	DIM A	DIM B	DIM C	DIM D	DIM E	MINIMUM EXCAVATION WIDTH	MINIMUM EXCAVATION LENGTH	DEPTH OF BURY
JP320EE-G	320	3'-0"	7'-0"	4'-6"	3'-7"	3'-4"	4'-0"	8'-0"	1' TO 8'
JP500EE-G	500	4'-0"	6'-0"	5'-10"	4'-10"	4'-7"	5'-0"	7'-0"	1' TO 6'
JP750EE-G	750	4'-0"	8'-1"	6'-0"	5'-0"	4'-9"	5'-3"	9'-1"	1' TO 6'
JP1000EE-G	1000	5'-1"	8'-2"	6'-0"	5'-0"	4'-9"	6'-4"	9'-2"	1' TO 6'
JP1200EE-G	1200	5'-9"	8'-6"	6'-0"	5'-0"	4'-9"	7'-0"	9'-6"	1' TO 6'
JP1500EE-G	1500	5'-7"	10'-8"	6'-0"	5'-0"	4'-9"	6'-10"	11'-8"	1' TO 6'
JP2000EE-G	2000	4'-11"	15'-11"	6'-0"	5'-0"	4'-9"	5'-11"	16'-11"	1' TO 6'
JZ2500EE-G	2500	5'-9"	16'-10"	6'-0"	5'-0"	4'-9"	6'-9"	17'-10"	1' TO 5'
JZ3000EE-G	3000	5'-9"	16'-10"	6'-9"	5'-9"	5'-6"	6'-9"	17'-10"	1' TO 5'
JZ4000EE-G	4000	7'-8"	16'-7"	6'-9"	5'-6"	5'-3"	8'-8"	17'-7"	1' TO 5'
JZ5000EE-G	5000	7'-8"	16'-7"	7'-11"	6'-9"	6'-6"	8'-8"	17'-7"	1' TO 4'

*OVERALL WIDTH CAN VARY WITH TANK MODEL. USE EXCAVATION WIDTH FOR SITE PLANNING.

BOX DESIGN LOAD: H-20 TRAFFIC

FOR COMPLETE DESIGN AND PRODUCT INFORMATION
CONTACT JENSEN PRECAST.

4/18/2008
JP320-JZ5000_GREASE_NONV_B.DWG