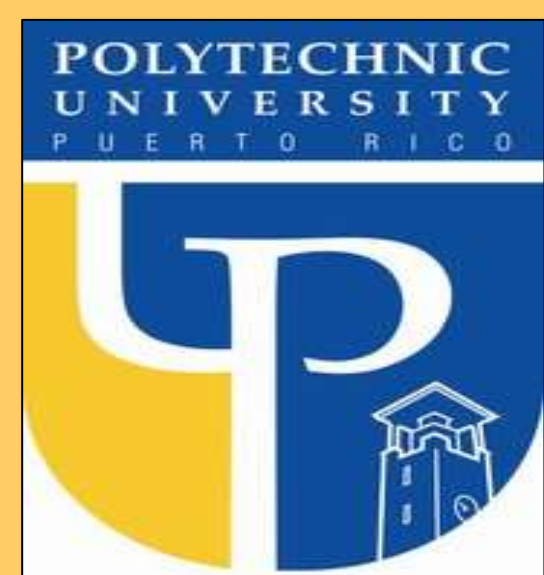


Improvements to the water supply, wastewater disposal, and solid waste management systems for the Vacas III Community, Villalba, PR



Environmental Engineering and Civil Engineering Senior Design Project, WI-15 and SP-16

Members: Adina Anton, Omar Báez, Luis Santos, and Edward Westerband

Mentor: Prof. José Borrageros



ABSTRACT

Vacas III is a rural community in the mountain area of Puerto Rico with 500 habitants. Currently, a well and a natural spring provide the water that is consumed by the community. The water does not comply with the Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA) since it is not filtered. The sewage generated at each housing unit is disposed either in septic tanks/cesspools or directly over the terrain. The solid wastes are handled by the Villalba Municipality and disposed at the Yauco sanitary landfill. The recycling materials are recovered by the L&M Waste Company.

Several alternatives were analyzed in order to improve the water supply, wastewater and solid waste management systems. The selected options were: a slow sand filter, two-chamber septic tanks with an outlet filter, and an aerobic composting system. These are the most feasible options from an environmental, public health, sustainability, and economical perspectives.

BACKGROUND

Vacas III is a community composed of 181 homes, three local businesses, and one elementary school. A population growth analysis forecasted that the community will not increase in the next 25 years and its water average daily demand will remain at 32,830 GPD. Current water sources provide 69,000 GPD.

The existing water supply system does not comply with the SDWA drinking water standards. This was confirmed by the water quality data provided by the Puerto Rico Department of Health and by the sampling and analysis done during the study period. Therefore, a water quality improvement is needed in order to satisfy the regulatory parameters established by the Environmental Protection Agency (EPA).

According to a survey conducted at the community, each home/commerce disposes its sewage either in septic tanks/cesspools or discharges over the adjacent terrain. These practices represent an environmental and public health risk.

A solid waste production study indicated that in the next 25 years the community will continue generating approximately 1,000 kg/day of garbage, which includes 200 kg/day of the organic matter. In order to reduce the amount of garbage that is conveyed to the Yauco sanitary landfill, the diversion of such material from the disposal facility is recommended.

OBJECTIVES

1. Improve the existing water supply system in order to comply with the SDWA.
2. Upgrade the wastewater management system.
3. Develop an integrated solid waste management plan.

DESIGN PROCESS

Several alternatives were evaluated and preliminarily designed in order to improve the water supply, wastewater, and solid waste management systems. Comparative tables and Leopold Matrices were used to select the most feasible options from an environmental, public health, sustainability, and economical perspectives.

Final designs of the selected alternatives were done utilizing the: Environmental Protection Agency Manuals, Environmental Quality Board of Puerto Rico Design Rules, Puerto Rico Authority of Solid Wastes Guidelines, American Concrete Institute Codes, Portland Cement Association Design Manual, American Society for Testing and Materials International Standards.

FINAL DESIGN

Table 1: Estimated cost of selected alternatives

	Slow sand filter	Two-chambers septic tanks	Aerobic composting system	Total
Cost	\$15,786	\$449,604	\$15,024	\$480,414

The slow sand filter was designed for the next 25 years based on the Peak Hour Demand (PHD). Considering a water filtration rate of 32.8 ft/d through the filter media, the required surface area of the filter is of 300.9 ft².

Table 2: Slow sand filter dimensions

PHD	Width	Length	Height
9,874.0 ft ³ /d	12 ft - 4 in	24 ft - 8 in	9 ft - 3 in

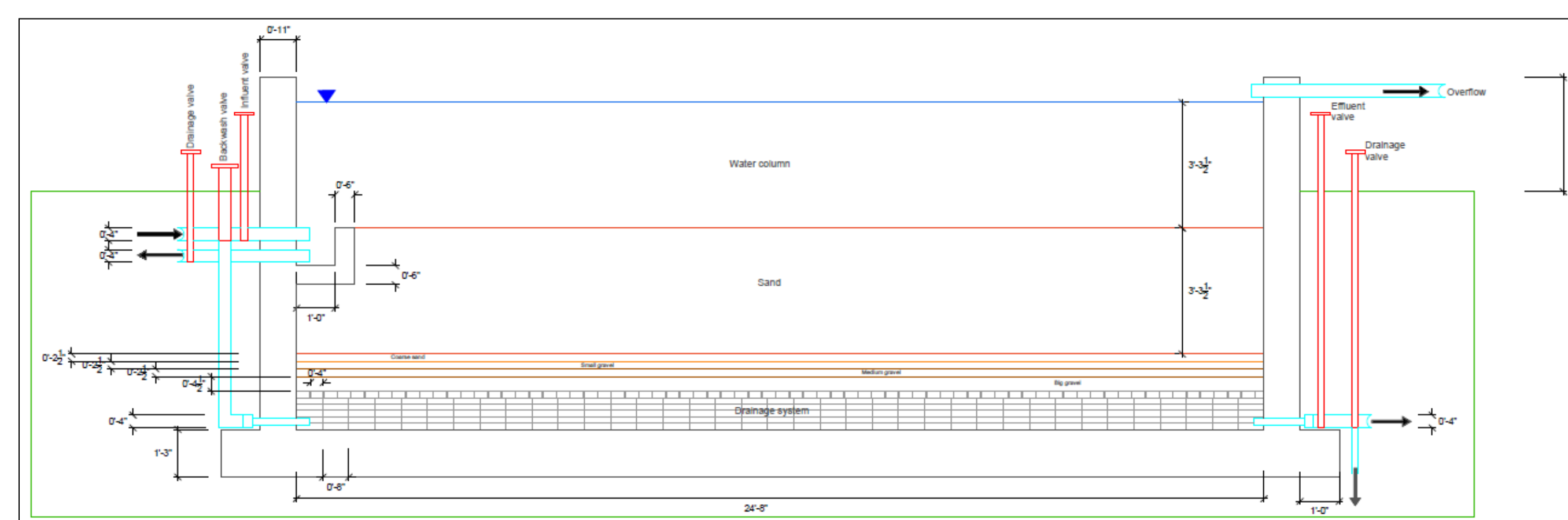


Fig. 1: Side view of the slow sand filter

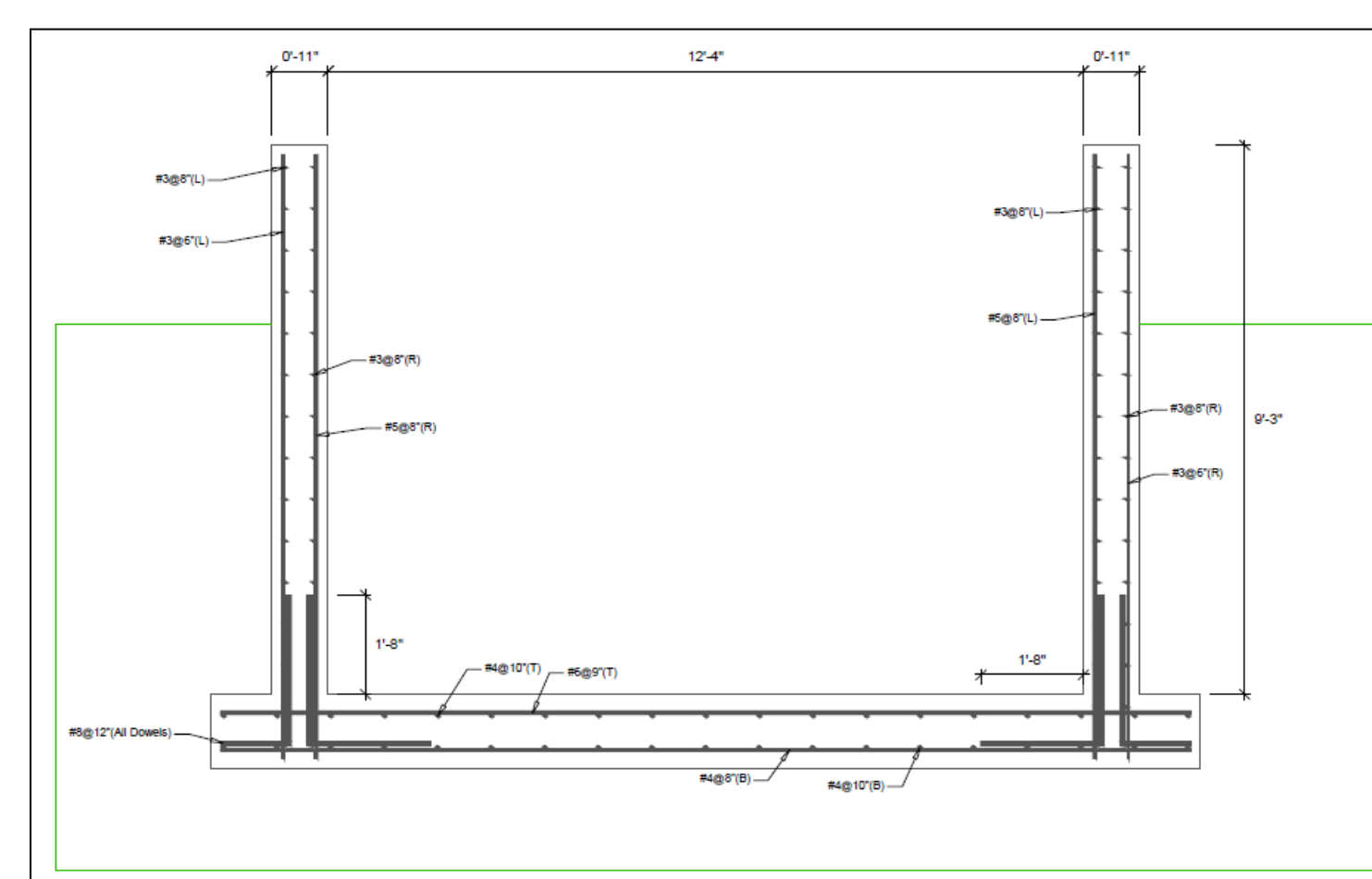


Fig. 2: Front view of the reinforcement details of the slow sand filter

The proposed septic tank was designed following the EPA suggested bedroom-based-guidelines. Using the community population and the amount of houses, around three to four bedrooms were estimated at each residence. Therefore, an on-site septic tank of at least 146.3 ft³ is necessary to handle all the domestic wastewater generated at each property.

Table 3: Septic tank dimensions

	1st Compartment	2nd Compartment
Height	4 ft - 8 in	4 ft - 8 in
Width	3 ft - 0 in	3 ft - 0 in
Length	7 ft - 0 in	3 ft - 8 in

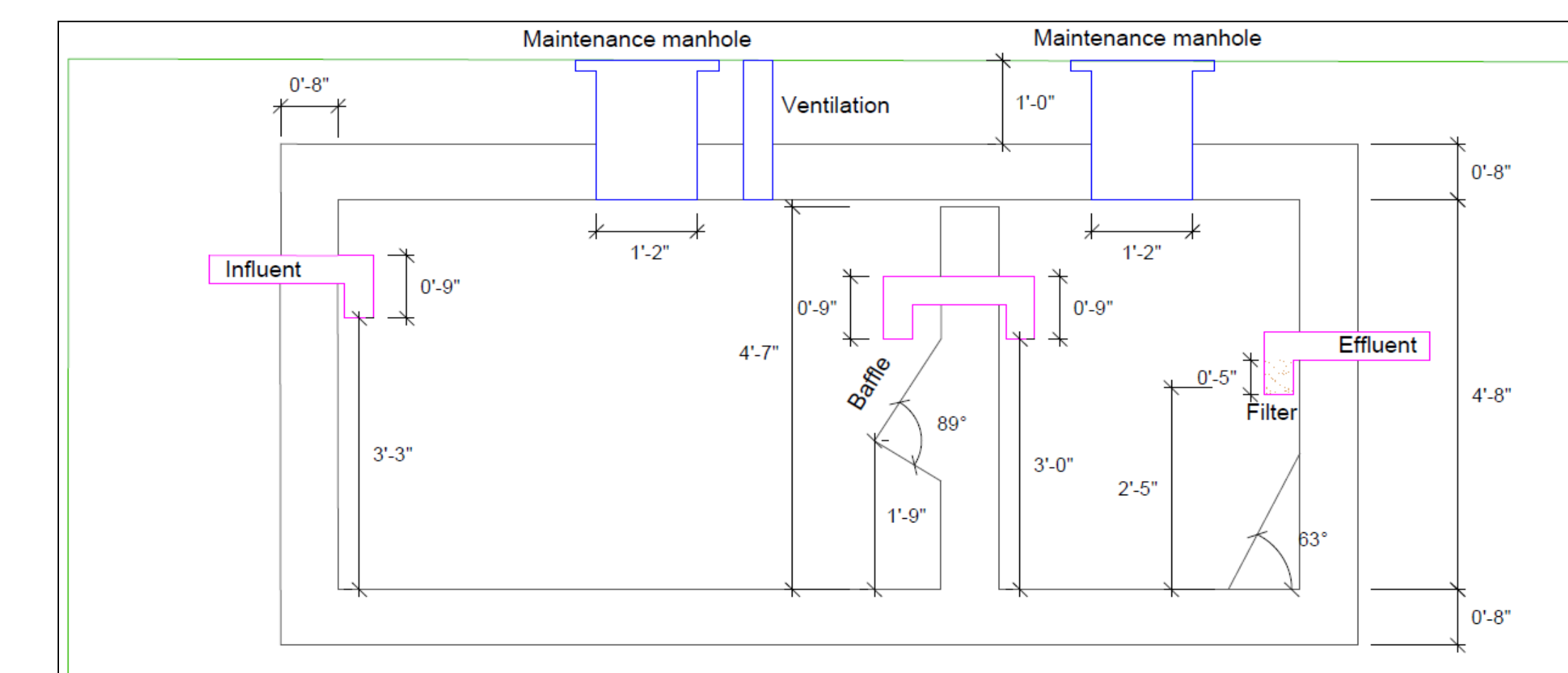


Fig. 3: Side view of the septic tank

The community will produce 154 m³ of organic matter during a 20 week composting production cycle. This amount was calculated considering a 2.2 kg/person of solid waste generation per day and that 20% of the garbage is of organic origin. An area of 4,200 ft² is required for the aerobic composting system.

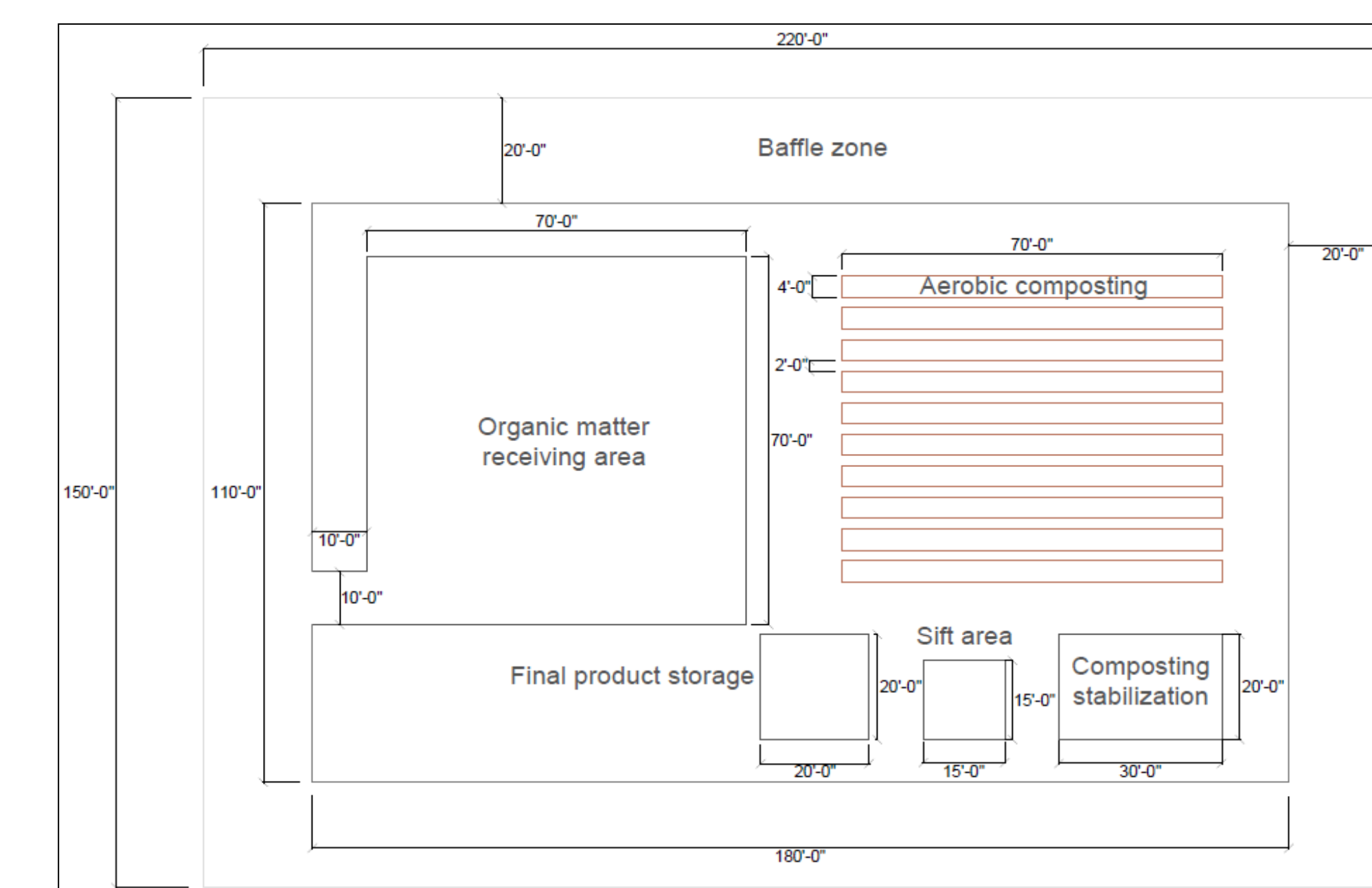


Fig. 4: Top view of the aerobic composting system

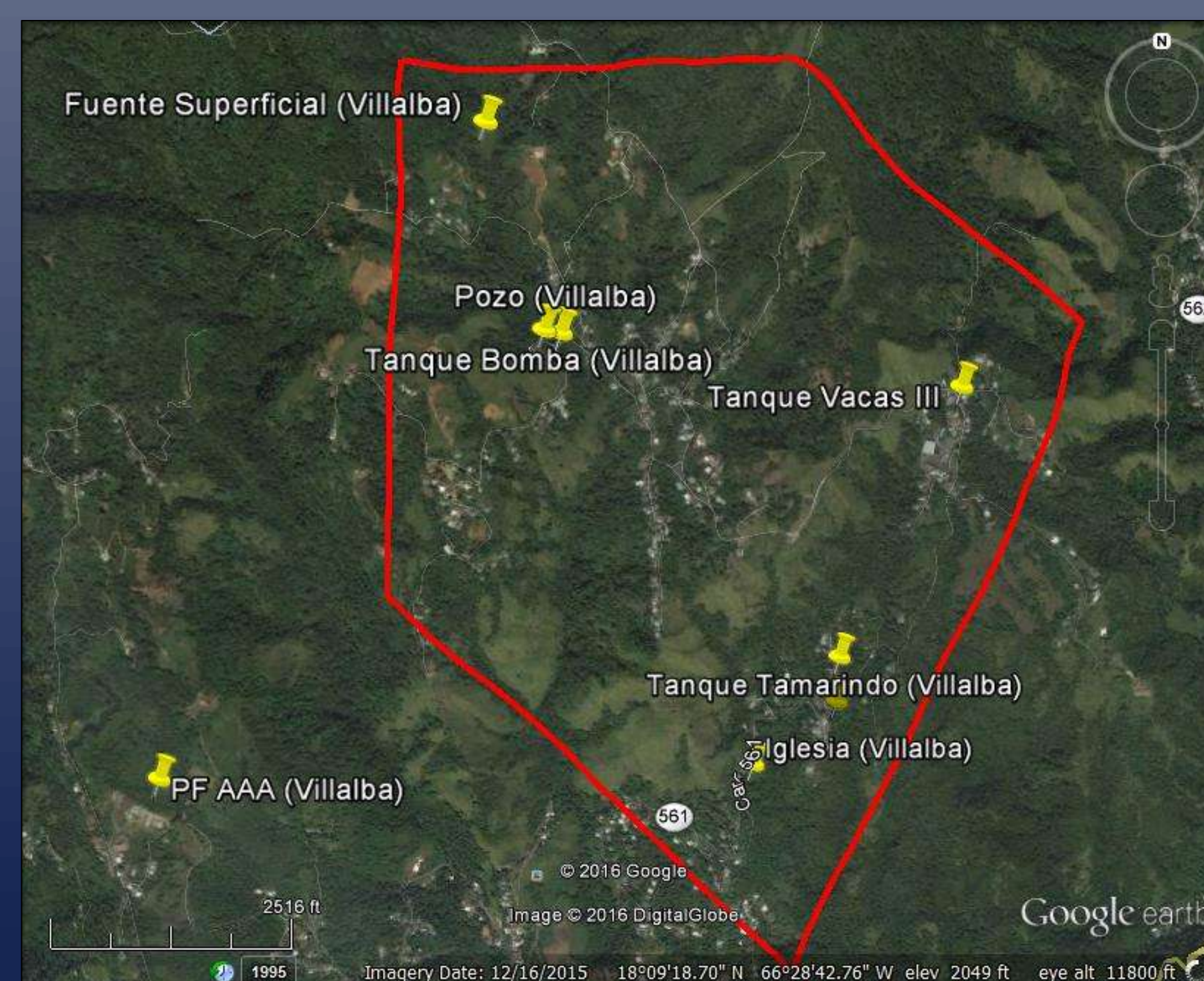


Fig. 5: Community boundaries

CONCLUSION

Through the implementation of the slow sand filter, the drinking water quality will be improved and should satisfy the SDWA standards. In combination with the existing disinfection system, the slow sand filter will guarantee a safe and secure water for consumption. The elimination of sewage discharges into the ground surface and the usage of the designed septic tanks will reduce the public health risk. The diversion and biodegradation of the organic matter in the aerobic composting system represent a collective benefit by increasing the life of the Yauco landfill facility.

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