Should Every Drop Count? - An Investigation into the Fredonia Water Billing System

Village of Fredonia
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Abstract

This research project focuses on analyzing the sewage charge to residents in the Village of Fredonia. Currently, the sewer is billed solely by the amount of water used, which some residents consider to be unfair due to summer water activities (watering lawns/gardens, washing cars, etc.). The objective of this study is to develop a more fair billing method for sewer charges. To achieve this, we analyzed quarterly water usage data spanning two decades from more than a dozen houses over different seasons and compared it to various characteristics of the homes, such as size and number of rooms. Based on our analysis and research, we proposed several strategies that can improve the water billing system for residents in Fredonia.

1. Introduction and Motivation

1.1 Problem Background

In the Village of Fredonia, the sewer is billed solely on the water usage. Currently, the quarterly sewer charge includes a base rate of \$20, and then \$6.47 for each additional thousand gallons of water used. For example, $\$6.47 \times 10 + \$20 = \$84.70$ will be charged for the current quarter if a customer uses ten thousand gallons of water. This is a common issue with sewer billing systems that rely solely on water usage as an indicator of sewer usage. During the summer months, there is often a higher demand for outdoor water usage, such as watering lawns and gardens or filling swimming pools, which does not necessarily contribute to an increase in sewer usage. As a result, residents may be overcharged for their sewer usage during these months.

1.2 Our recommendation

We studied the water usage of over a dozen of the residents from the village of Fredonia and observed the following: (i) water usage over the time has decreased; (ii) different houses with similar sizes and same house with different owners may have different water usage patterns; (iii) summer water usage varied more than winter for most of the households. Based on the observation, we proposed a cap model to the sewer charge. That is, we suggested setting a limit for the sewer charge based on the winter usage. For the village of Fredonia, we recommend to use the average of the last two February, March, or April meter readings.

2. Initial Approach: estimate sewer usage for each household

2.1 Water in daily life

To start our investigation we wanted to study where water goes in a general sense. According to a study from the United States Environmental Protection Agency the average American family uses more than 300 gallons of water per day at home. Roughly 70 percent of this use occurs indoors. The indoor uses include toilet, shower, faucet, clothes washer, and leaks (see Figure 1 below). Almost all the water used for the toilet, shower, and clothes washer goes to the sewer. Not all the leaked water goes into the sewer; however, it is hard to get accurate leak information from each household. Therefore, we did not consider the leaked water in this project. Some of the water is used for cooking or drinking and they will not enter the sewer. The rest is mainly used for hygiene, which is assumed to enter the sewer. The outdoor uses mainly include watering lawns/gardens, washing cars, filling up pools, and outdoor water activities. This water does not enter the sewer. The Village of Fredonia is located in Western New York and most of these activities occur during June, July, and August.

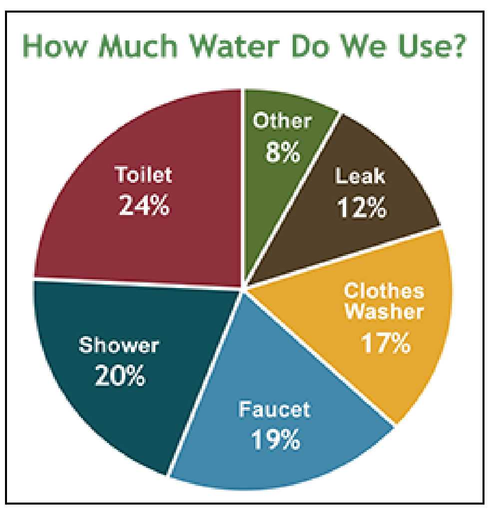

Figure 1. Residential uses of water from the United States Environmental Protection Agency (2016).

2.2 Estimation of sewer usage

2.2.1 House selection

Based on the study above, we can now start to estimate sewer usage. In order to find an estimation model we chose several households, according to bedroom and bathroom numbers and also the size of the yard, and analyzed their water usage history. All the household information was provided by Zillow.com.

Most of the indoor water used that does not enter the sewer is either used for drinking and cooking (the rest is assumed to be leakage). Apparently, the drinking and cooking water amount depends on the number of residents within each household. Unfortunately, we do not have that information for each household's residents; however, it may be reflected by the number of bedrooms and bathrooms. We studied the bedroom and bathroom information for most of the houses listed on Zillow.com and decided to have four different categories of houses: small, medium, large, and extra large, whose number of bedrooms are two, three, four, and five respectively.

Outdoor uses mainly include watering lawns/gardens, washing cars, filling up pools, and outdoor water activities. The water needed to water the lawns/gardens depends on the lot size of the house. The water used to wash cars depends on the number of cars owned by the homeowner. It is not possible to obtain such information; however, the size of the garage may indicate the number. For this reason, from each of the categories listed above, we define four subcategories based on the lot size: less or equal to ¼ acre, between ¼ and ½ an acre, between ½ an acre and 1 acre, and more than 1 acre. Another concern is whether the household has a swimming pool or not since it consumes a certain amount of the water in the summer. Therefore, we decided to choose two households in each subcategory, one with a swimming pool and one without.

According to the discussion above, we should select 32 different houses to study; however, not each category will have a house. For example, a house with two bedrooms is unlikely to have a large yard and swimming pool, yet a house with five bedrooms is unlikely to have a yard that is less than ¼ acre. For this reason, we picked fourteen houses in total. See Table 1 below.

Table 1. Information on 14 selected houses to study in the Village of Fredonia for water usage.

Link	House ID	Bedrooms	Bathrooms	Lot Size (Ft^2)	Pool?	Garage size (cars)	Driveway (cars wide)	Available Lawn (ft^2)
Small 1	1466	2	1	7200	No	0	1	5605
Small 2	724	2	2	14374.8	No	1	2	12276.8
Small 3	2488	2	2	30492	No	1.5	2	28820
Medium 1	903	3	1.5	5972	No	1	1	4692
Medium 2	2320	3	2	15246	No	1	1	13846
Medium 3	1238	3	2	43560	No	2	2	41314
Pool Medium	3139	3	3	10023	Yes	3	3	7660.5
Large 1	1284	4	2	9374	No	2	2	7706
Large 2	801	4	2	16117.2	No	0	2	13896.7
Large 3	1317	4	3	24393.6	No	1	2	22425.6
Pool Large	3093	4	4	688248	Yes	3	6	685605.5
XL 1	1712	5	2	10890	No	0	0	9386
XL 2	82	5	3	13939.2	No	2	2	12173.2
XL 3	1236	5	2	32670	No	3	3	30132

2.2.2 Shortcomings of estimate water usage based on house size

Now we can analyze the water usage for each household. The village of Fredonia provided the quarterly water usage since 1999 for all the houses above. We plotted a graph of quarterly water usage for each individual household and expected to see that houses that were partitioned similarly would have water usage in a comparable range; however, this was not the case. For example, houses 903 and 2320 both have 3 bedrooms and less than 2 bathrooms (Figure 2 and Figure 3), but their water usage is different. We found from Zillow.com that house 903 was transacted in August 2018. It is easy to see that on average it used fifteen thousand gallons of the water for the previous owner and about five thousand gallons for the new owner. Thus, the new owner only used one third of the water compared with the previous owner. House 2320 was sold in November 2022. We can see the previous owner used about four thousand gallons and the new owner used about fifteen thousand.

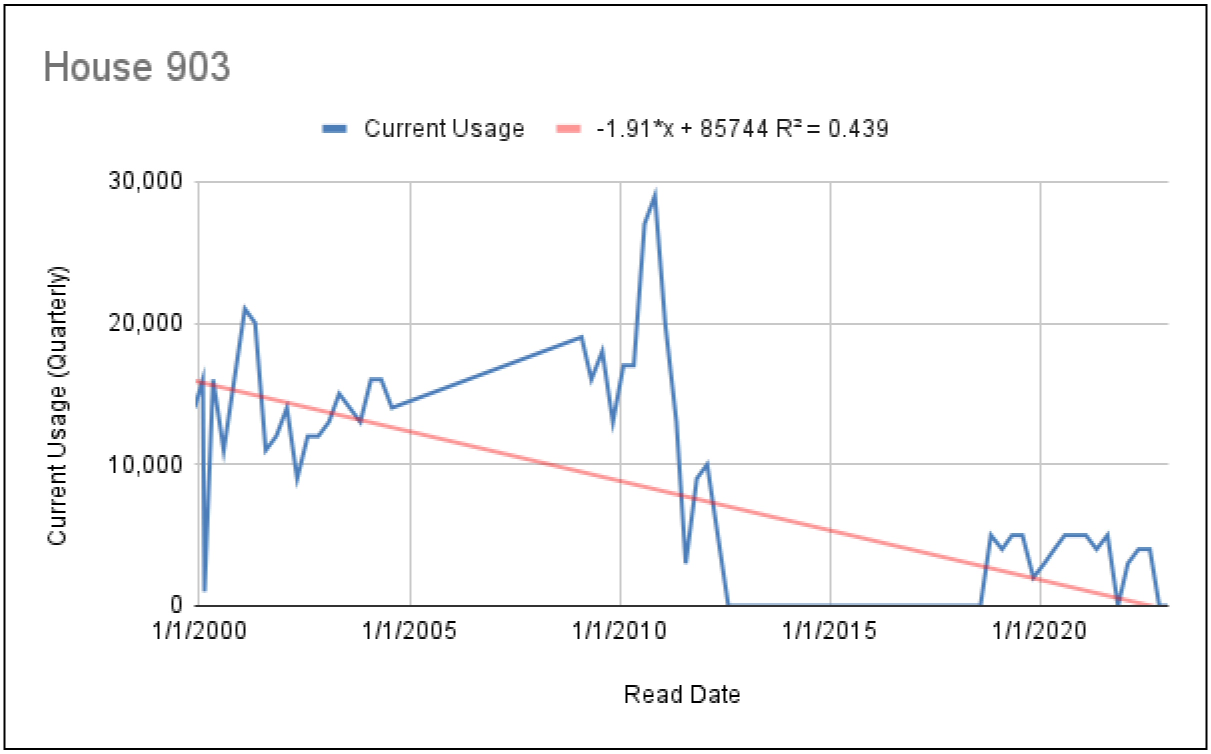

Figure 2. Water usage history for House 903.

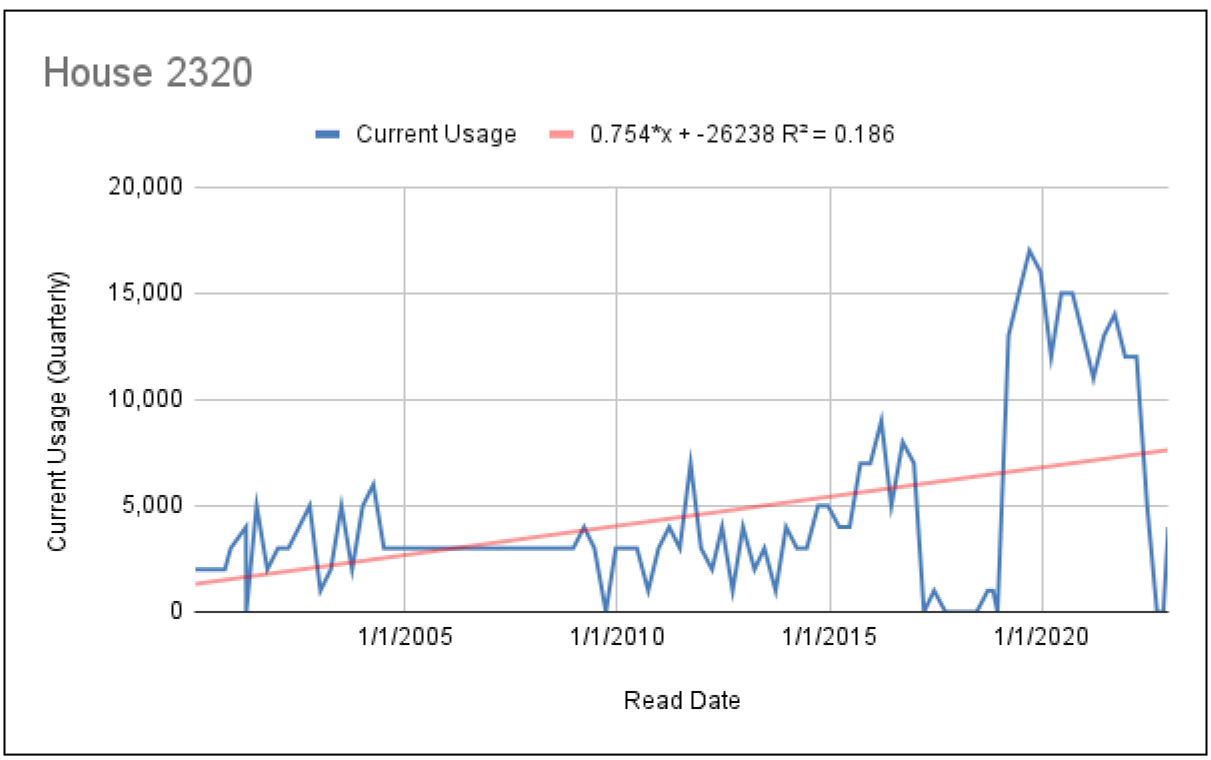

Figure 3. Water usage history for House 2320.

As you can see, not only do houses with similar size do not have similar water usage, the same house can have different water usage with different owners. Apparently, not only the house size, but the household size and the water use habits matter as well. Therefore, we will not be able to estimate the sewer usage without knowing further information, for example the household size. For this reason, instead of trying to estimate the sewer usage rate, we will make recommendations about the sewer billing system.

3. Sewer billing system models

To begin, research was done to learn about sewage billing systems for other places in the United States and found the following few models: e-meter model, swimming pool model, and cap model.

3.1 E-meter (Exclusion Meter)

In Dinwiddie County, Virginia, an e-meter is used. It is used to “give credit on the sewer portion of your water and sewer bill for water that is not returned to the sewer” (Residential Emeter Policy). Typically e-meters are used to measure outdoor water usage, like lawn irrigation or garden watering. In Dinwiddie County, sewer is first billed for all water used. Customers can choose to install an e-meter if they use a significant amount of water to water their lawn or gardens. The e-meter and main water meter will be read at the same time. Customers with the e-meter installed will be given the credit on the sewer of all the water read by the e-meter. Customers will pay for the e-meter, which is $275 including the installation fee, and the Dinwiddie County Water Authority is responsible for maintenance or replacement of the e-meter if necessary. The e-meter allows customers to receive credits for the water that does not enter their sewer. This is the price for the e-meter, policy and process of sewer charge at Dinwiddie County.

The e-meter can be easily adopted by Fredonia. Residents can choose to install the e-meter if they normally use a lot of outdoor water, either used to water the garden/lawn, or other purposes; however, the price to install the e-meter might have increased since the pandemic and this could be a concern.

3.2 Swimming pool water

In order to better understand how to charge the water bill for houses with a swimming pool, research was done to investigate whether there are any special charges for swimming pools in other cities and we came across an interesting example. Two out of fourteen sample houses have swimming pools. In the summer, it consumes water that does not go into the sewer. In High Point, North Carolina, the sewer bills are calculated based on the amount of water you use that month as well as the size of the water meter connection. In High Point, pool water is drained into the sewer, therefore a homeowner will be charged for sewage. This occurs when a customer wants to completely drain their pool. Customers with a pool will be charged for sewage when they initially fill the swimming pool in specific cases where the customer can demonstrate that there is no discharge of water into the sewer system the customer can request a credit. If a leak develops the customer can also fill out a form to receive credit. To receive the credit the water loss must be at least 1,500 gallons. In this city the water from pools is not to be drained into the surface waters or storm drains because of the chemicals needed for a pool. Therefore, you will get charged for this water entering the sewer.

However, in the village of Fredonia, pool water does not enter the sewage system, rather many just drain the water into their lawns. Thus, this model does not apply to Fredonia unless the pool is connected to the sewer system.

3.3 Cap model

The final model we found is called the cap model. In this model, an upper limit sewer charge (or cap) based on the water usage in the winter months is introduced. For example, in Tallahassee, Florida “your protective ‘upper limit’ sewer charge, which is the most you will be charged in any month during the following 12 months, is set at your highest water usage level on bills dated December, January, February, and March” (Sewer Rate Calculations). It not only benefits the homeowner, as they would on average pay less, but also encourages them to use less water in the winter. However, it is important for utilities to ensure that the winter usage accurately reflects typical water usage patterns for each customer. If a customer's winter water usage is unusually high due to leaks or other issues, setting the sewer usage cap based on that usage could result in them being charged unfairly for excess sewer usage during the summer. Other cities also use similar models with winter months: Portland, Oregon; Longview, Texas; and Phoenix, Arizona. Tulsa, Oklahoma uses a model that is slightly different. In Tulsa, "They use the average of December, January, and February for the previous five years or the actual water usage, whatever is lower" (Sewer Charges Explained). Rather than just using the average of the previous year which takes into account only 3 months.

This works for us because we found that more water was used in the summer, but most of the extra water used in summer is for outdoor purposes, therefore it does not enter the sewer and it makes sense that homeowners should not be charged for this. More detailed discussion can be found in the next section about how we can adapt this model to fit for the Village of Fredonia.

4. Cap model for the Village of Fredonia

In the summer, extra water is used to water the lawns, gardens, washing cars, or doing outdoor water activities. In most of these cases the destination of the used water does not end in the sewer and it is logical to bill the homeowner for the sewer based only on the amount of water that goes to it. Installing an e-meter will provide the most accurate reading; however, the cost is expensive and it involves a lot of infrastructure for the government. Hence, the cap model is an easy and relatively reasonable way to solve the problem.

4.1 Declining use of water

We plotted a time series of quarterly usage using all the data provided by Fredonia. It can be observed that water usage over the years has decreased (see Figure 4). This is apparently due to the implementation of water-saving technologies. Now, appliances are more and more water efficient and require less water. If we want to analyze the recent water usage pattern, we should use the most recent years, for example two years.

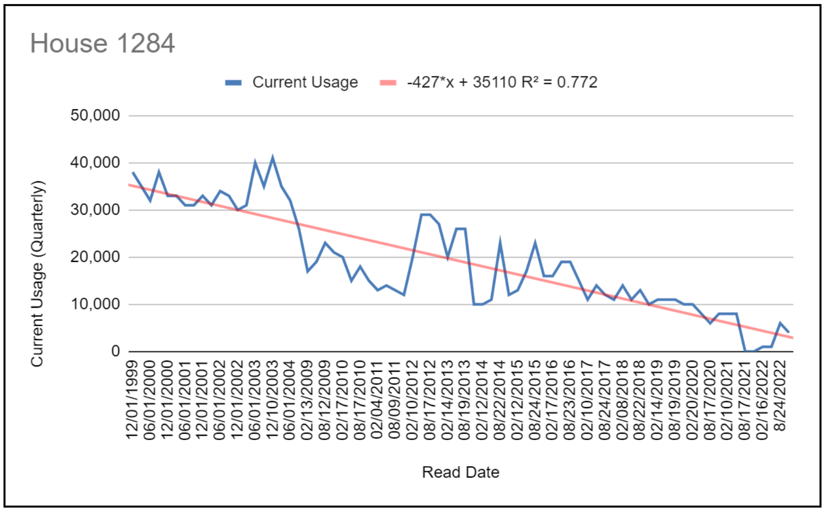

Figure 4. Water usage history for House 1284.

Looking at houses 1284 and 903 (see Figure 2) we can see that water usage decreased over time, even over the various owners. Again, this can be attributed to more water-saving appliances and effective technologies that mitigate leakage. On the contrary, we did see some instances, houses 1236, 1238 and 2320 in specific, that had increased water usage over time.

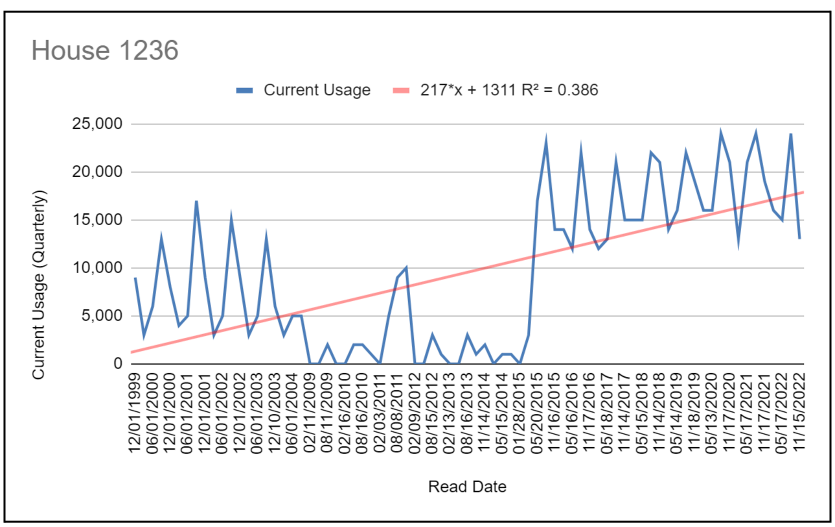

Figure 5. Water usage history for House 1236.

For these houses with increased water usage it is important to consider them on a case-by-case basis with respect to the different owners and the logistics of each respective house. For instance, we can confirm that both houses 1236 and 2320 (see Figure 3) swapped owners twice by observing the “dips” in the data when the water usage went to zero. It is assumed when there was zero water usage that the house was on the market to be sold. This was also confirmed by viewing the houses’ transaction history on Zillow.com. Hence, with the arrival of each new family with various amounts of people and water consumption habits, the water usage trended upward. These houses were also renovated and changed, according to their history on Zillow.com, thus attributing to more time within the household and assumed increased water usage. Thus, putting all these factors into consideration, we can conclude that increased water usage overtime only occurs in certain circumstances and that generally water consumption has decreased overtime in households.

4.2 Water usage for the house occupied by a different owner.

Continuing on the idea that different owners occupying the same household use different amounts of water based on their personal habits, we can notice in Figure 2 with house 903 that overall water usage decreases but in different time periods from different owners there is different usage.

Under the assumption that a water usage of zero signals a change in owners, we can assume that there was one owner from the time period of 2000 to 2013 and another from 2018 to 2021. For the owner from 2000 to 2013 their average usage was around 15,000 gallons of water, while for the owner from 2018 to 2021 their usage was drastically smaller, averaging around 5,000 gallons of water. This allowed us to conclude that we cannot consider the entire dataset provided (that contains all years) when determining the water usage for a household. That is, we concluded that we should only consider a single owner and more specifically the most recent owner who has lived in the house for five years. This allows us to have more accurate data for recent water usage habits and enough data points.

On the contrary, in Figure 3 outlining house 2320, we can see water usage has increased with each new owner as indicated by the big jump in early 2015.

All of the houses we examined have been recently transacted and all the transaction history can be found from Zillow. House 1236 was sold in February 2015, which is when the jump occurred in Figure 5, and we see new homeowners use more water on average than the previous owner did. Apparently, water usage varied a lot when different owners occupied the house, even though the house characteristics (size, number of bedrooms, etc.) remained the same. This also helped us solidify that our previously mentioned assumption of similar houses having similar water usage was not accurate. For this reason, we will only focus on the water history from the current owner within no more than five years.

4.3 Summer/winter water usage

4.3.1 Winter usage

The cap model suggests that the upper limit charge for the sewer is based on the winter water usage. Not all the water used in the winter enters the sewer, for example, the drinking and cooking water does not where on average each person will drink 0.5 gallons of water daily. For a four person household this ends up being about 180 total gallons drank per quarter which is almost negligible compared to the thousands of gallons of water consumed in the household per quarter. Therefore, it is reasonable to assume that all the water used during the winter goes to the sewer.

4.3.2 Summer usage

Most of our sample houses use more water during the summer, see Figure 6 below. Like we discussed above, most of the extra water used in the summer does not enter the sewer and should not be charged for the sewer. Thus, it is necessary for us to introduce the cap model.

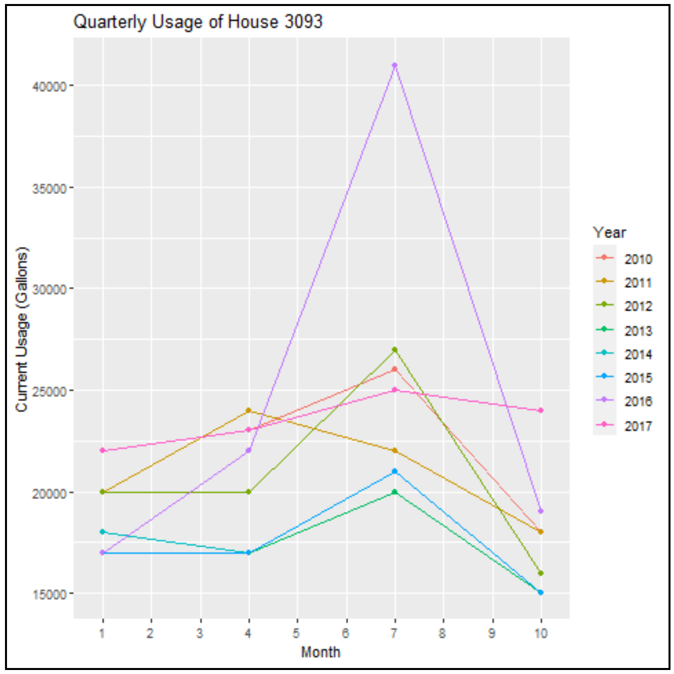

Figure 6. Water usage plot (in gallons) of House 3093 in Fredonia, NY from the years 2010 to 2017 where months are labeled numerically (1 = January, …, 12 = December).

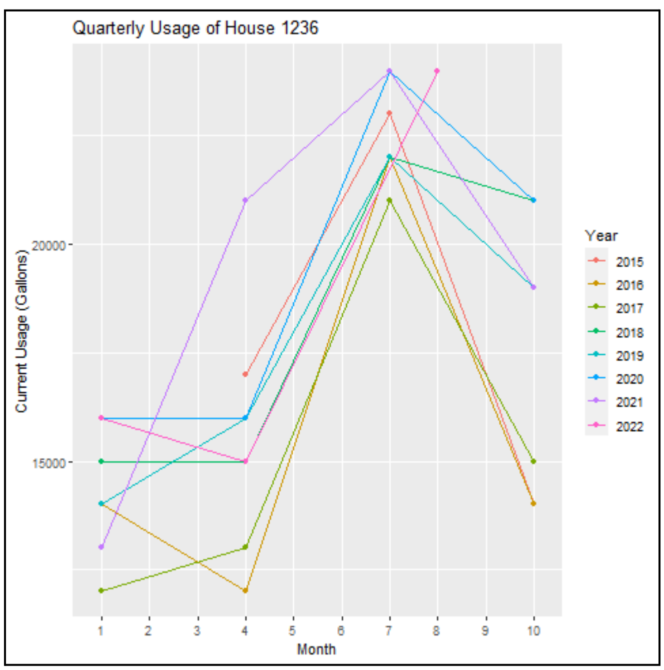

Figure 7. Water usage plot (in gallons) of House 1236 in Fredonia, NY from the years 2015 to 2022 where months are labeled numerically (1 = January, …, 12 = December).

4.4 Cap selection methodology

Based on our study, we see different cities have different ways to set up the sewer cap based on their weather and the frequency of the meter reading. We observed the following for the Village of Fredonia.

4.4.1 Differences in meter reading dates

Most of the cities, using the cap model, will pick the average water usage from December, January and February, which is the typical winter month, as the sewer charge cap. In those cities, the meter is either read monthly or bimonthly, which reflects the water usage for the current month and current season. However, Fredonia only reads meters once every quarter. Quarterly meter readings not only delay the water usage information, but mixes the usage of different seasons. In each quarter, the meter was read at different dates throughout, and the final bill will be sent out for all the households at the end of each quarter. For example, if the meter was read on Jan 1, for house X, it reflects the water usage from October to December, which mixes the fall and winter. But if the meter was read on Mar. 1, for house Y, it reflects the water usage from December to February which is the water usage for winter only. Both house X and Y will receive the water bill at the end of March. If we use the water in this bill as the cap, then it’s unfair to the household X, since they will use more water during the October as they might still need to water the garden or lawn.

4.4.2 Lengthy winters

Fredonia has long winters. Fall and Spring temperatures are relatively low compared with other southern cities. Most of the outdoor activities occur when average temperatures are over 70 degrees Fahrenheit. Therefore, we can assume all the water used from October to the next April enters the sewer.

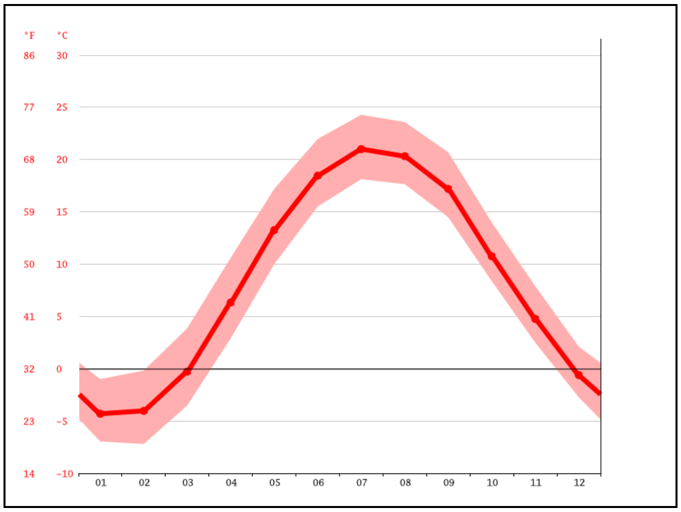

Figure 8. Average monthly temperature in Fredonia, NY from the years 1991 and 2021 where months are labeled numerically (1 = January, …, 12 = December).

4.4.3 Lawn and garden watering

It seems obvious that people will use more water in July and August than other months since they are the hottest months; however, Fredonia has more rainfall in June/July than May/August.

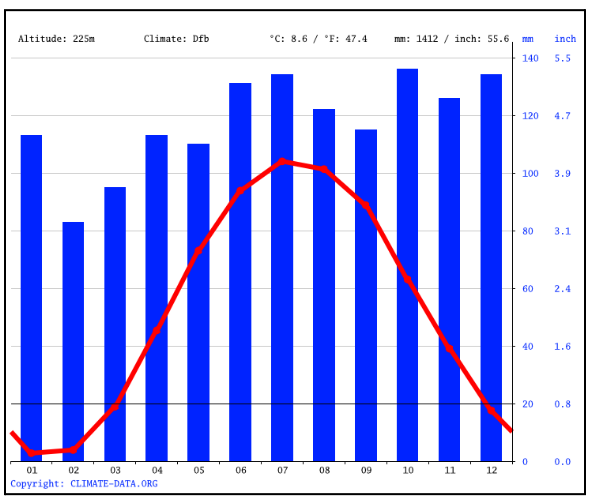

Figure 9. Average monthly precipitation in Fredonia, NY from the years 1999 and 2019 where months are labeled numerically (1 = January, …, 12 = December). The red line represents the average monthly temperature over the years while the blue bars represent the amount of rainfall.

Homeowners might use more water in May to water the lawn than in August. But in August, people might have more water activity outside due to the hotter weather. In either case, there is a general increase in water usage amongst these summer months. Notice the following water usage plots of House 3093 (Figure 17) and 1236 (Figure 5) where the water usage increased historically over these months.

From these two graphs it leads one to notice the decreased use of water in winter months, that is February, March and April, and supports the idea that the increased water usage in summer months is not going to the sewer and instead other places. Hence, the cap model proposed where customers are billed for the winter months water usage is more clear.

4.4.4 Changes in seasonal water usage

Summer water usage variations are larger. Notice Table 2 where smaller variations (standard deviations) in water usage happen most often during the winter season and the largest happen during the summer season. This suggests that water usage can drastically differ in the summer months and be used for a wider array of activities, including lawn watering and car washing. It is a safe assumption that this variant water usage is not going to the sewer, hence the cap model is again supported.

With the data of fourteen households, we did some statistical analysis. First, we computed the water usage difference for each consecutive quarter. For example, house 801 will have the meter read each Feb., May, Aug. and Nov. Then for each year, we computed the difference between each Feb. and May, May and Aug., Aug. and Nov., and then Nov. and the following Feb. and got four water differences. For each year, we will have four water differences, which roughly give the information about the water usage between seasons. Next, we picked the water difference between Feb. and May for each year and computed the mean and standard deviation. Repeat the same process for the other three differences. Comparing the four different means of the water difference between quarters, we found out that the water difference between Feb. and May is the smallest and the difference between May and Aug. is the largest. Both Feb. and May meter reading reflect the water usage for the cold months with less or very limited outdoor water activity. Yet, the Aug. meter reads the water usage from June, Jul. and Aug., which has the most outdoor water activity, therefore its difference from the May reading is the largest. For the other thirteen houses, we did the same statistics calculation and displayed the result below in Table 2. We observed the following with the fourteen sample houses.

Table 2. Average quarterly difference in water meter reading in Fredonia, NY from various households where seasons are color coded according to the legend.

	Smallest Average Quarterly Difference Reading			Largest Average Quarterly Difference Reading		
House	Mean	Standard Deviation	Time Period	Mean	Standard Deviation	Time Period
801	7583.333	4354.959	Feb. - May	34900.000	56428.960	May - Aug.
82	2100.000	2928.566	Jan. - Apr	4250.000	4320.622	Jul. - Oct.
1317	2181.818	2272.364	Nov. - Feb.	3200.000	2658.320	Aug. - Nov.
724	1305.556	744.330	Jan. - Apr	2316.667	1561.249	Oct. - Jan.
1466	1000.000	1000.000	Aug. - Nov.	2500.000	3162.278	Feb. - May
1712	2606.250	1293.234	Nov. - Feb.	4255.556	4044.320	Feb. - May
903	1750.000	2217.356	Aug. - Nov.	4000.000	3162.278	May - Aug.
2320	1142.857	690.066	Dec. - Mar.	2714.286	755.929	June - Sep.
1236	2000.000	2768.875	Feb. - May	7125.000	2167.124	May - Aug.
2488	625.000	517.549	Mar. - June	2000.000	2160.247	Sep. - Dec.
1284	1777.778	2438.123	Nov. - Feb.	5625.000	5396.758	Aug. - Nov.
3093	1875.000	1885.092	Mar. - June	7500.000	6187.545	Sep. - Dec.
3139	1750.000	1488.048	Mar. - June	3375.000	2503.569	Sep. - Dec.
1238	1000	1154.701	May - Aug.	4000	3651.484	Nov. - Feb.

Seasons	Spring/Summer	Summer/Fall	Fall/Winter	Winter/Spring

4.4.5 Cap model for Fredonia

Based on the observations above, now we are ready to propose the following cap model for the village of Fredonia.

To begin the discussion of our proposal let us introduce the variables:

$x = Average\ of\ the\ last\ two\ quarterly\ readings\ on\ Feb.,\ Mar.,\ or\ Apr.\ (thousands\ of\ gallons)$

$y = Current\ water\ usage\ (thousands\ of\ gallons)$

$C_w = Quarterly\ water\ charge\ (dollars)$

$C_s = Quarterly\ sewage\ charge\ (dollars)$

$C_b = Quarterly\ base\ fee\ (dollars)$

$C_t = Total\ quarterly\ water\ charge\ (dollars)$

The functions that we will be implementing into our model are:

$C_w = 4.80y$

$C_s = 6.17[min(x, y)]$

$C_b = 45$

$C_t = C_w + C_s + C_b$

Our equation computes the residents water bill (in dollars) for each quarterly water reading. It is slightly modified from the current equation which the town uses. The current quarterly billing method for the town of Fredonia can be seen below:

$$C_t = 4.80y + 6.17y + 45$$

The only change we suggest making is multiplying the sewer cost (\$6.17) by the minimum of the most recent current quarterly reading (in thousands of gallons) and the previous quarterly reading from February, March, or April. This way if the resident uses more water during the warmer months, they will not be paying extra for water that does not need to be treated. Our proposed quarterly billing method with the cap is below:

$$C_t = 4.80y + 6.17[min(x, y)] + 45$$

5. Future Work and Limitations

For our model, we assumed that the extra water usage in the summer months is not going to the sewer to be treated but instead is being used for outdoor water activities. However, we did not take into account people that have time off during the summer months, like teachers or students. Household owners that have time off in the summer are usually at home more frequently than when working or at school. Therefore, not all the extra water usage during the summer months is being used for outdoor water activities. A solution for this would be the e-meter which we discussed earlier. This way the town of Fredonia would be able to tell exactly how much water needs to be included in the sewer charge.

Another limitation with our model is that we look at only the previous 2 quarterly water readings in either February, March, or April. We do not know what the owner was doing during those months, so the reading may not be accurate for the cap. For instance, what if the owner was on vacation during those months making the water reading unusually low? What if the owner had family members in town leading to increased water usage? With more time and information, we could find out exactly when the owner bought the house and find outliers (if any) in their quarterly water usage.

We had access to water usage data for only 14 total households within Fredonia. If we had more time, we could request access to the data from every household in order to get more accurate results. This way we could come up with a better model and have a larger sample size.

Also, we had plans to use matrices and RStudio to solve a linear equation to estimate the water usage per month for every household. We had this idea because the quarterly reading dates are different for each household and only give us the water usage over the period of three months. However, after coding loops to fill the matrices we ran into multiple errors within the code. Some of the household’s estimated monthly water usage was able to be solved but it was not general enough for every house. In the future, we would be able to focus more on the coding errors and create a general loop to fill a unique matrix for each household, no matter the circumstances.

We only researched how water is used for a couple days. With a better understanding of where water usage goes, we could find out how significantly outdoor water activities affect the total water usage. Finding it to be significant would help strengthen and back up our reasoning for the cap model.

We only studied fourteen houses with different sizes. The sample number is relatively low. In the future, we may try to get more data and then try the dependence test to see if water usage depends on any factors. Then our analysis would be improved.

Acknowledgements

Thank you to Dr. Lan Cheng for her continued support with the project and to the Village of Fredonia for working with the SUNY Fredonia Department of Mathematical Sciences. We greatly appreciate and value the knowledge and education we have received and attribute the success of this report to both parties.

Appendix

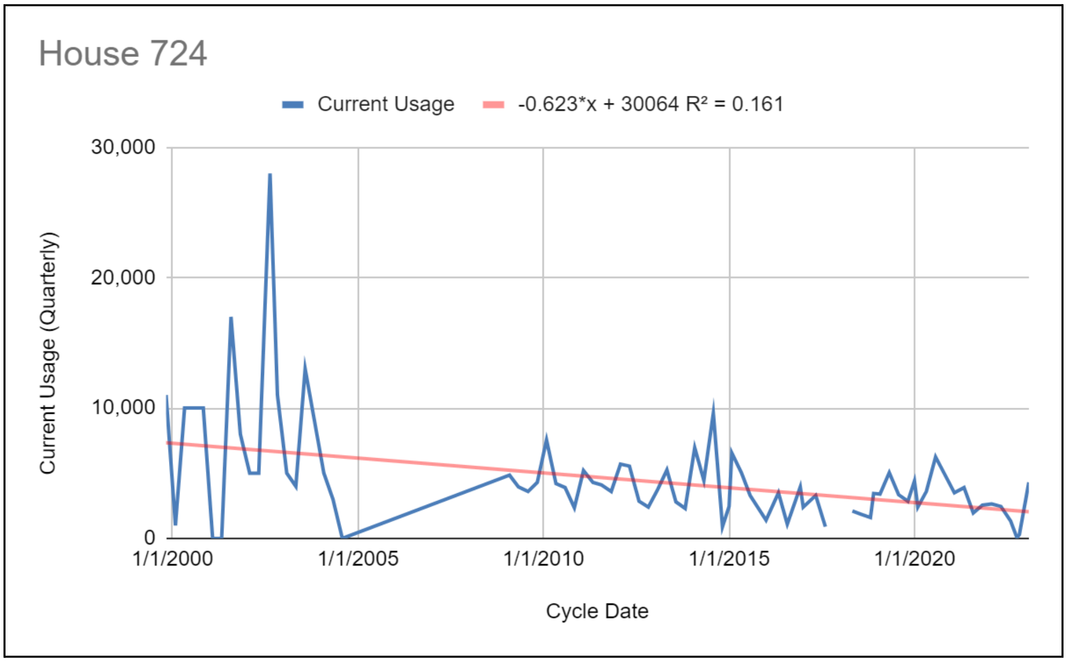

Figure 10. Water usage history for House 724.

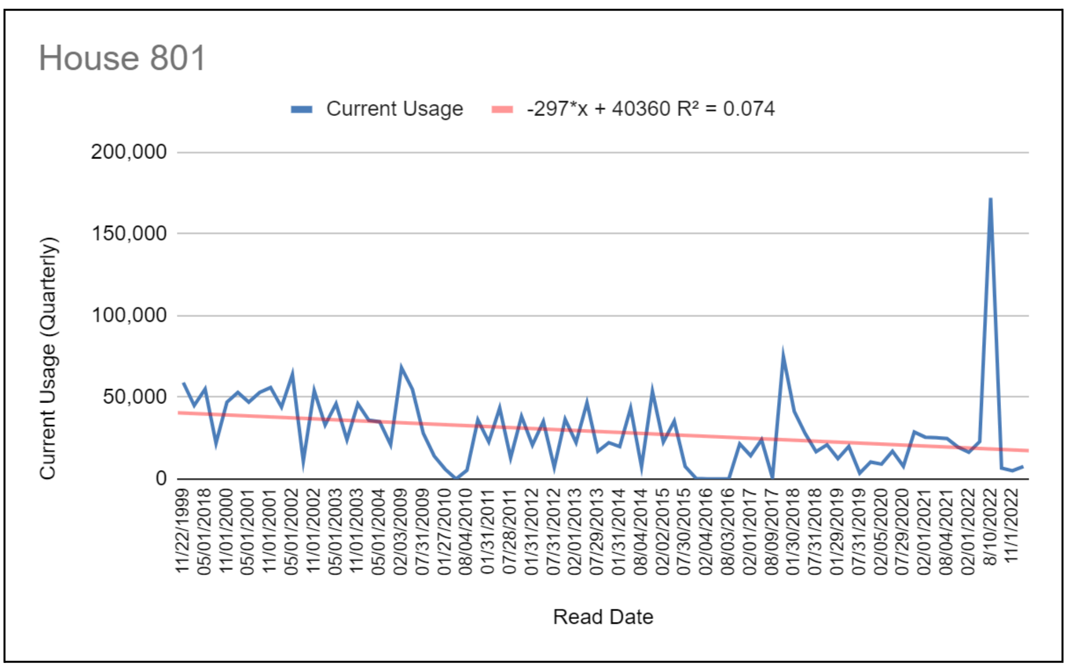

Figure 11. Water usage history for House 801.

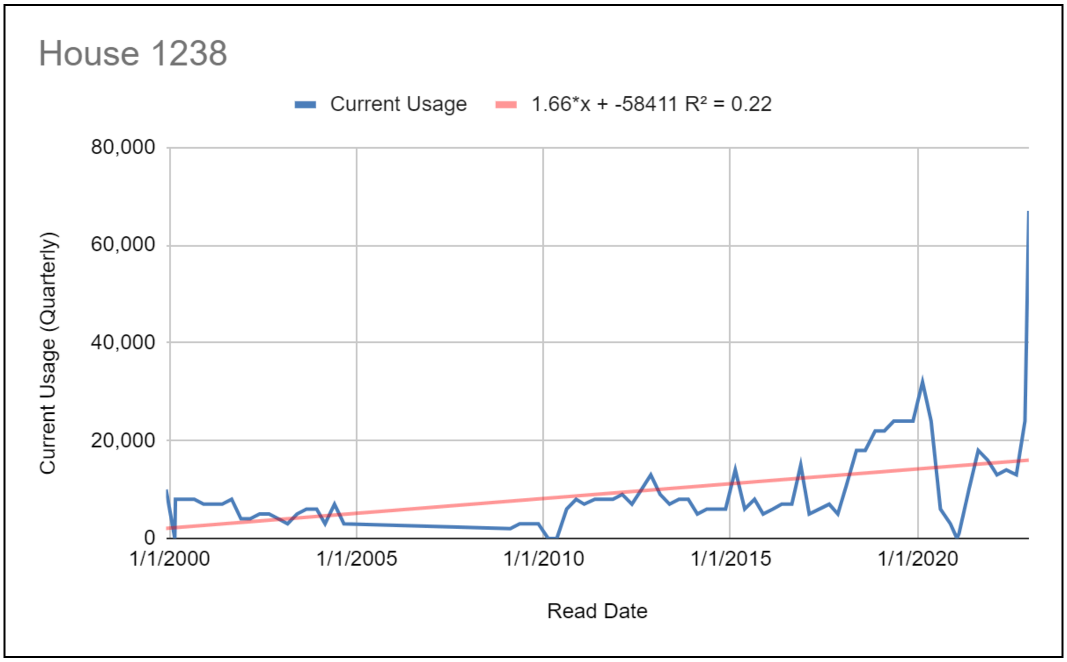

Figure 12. Water usage history for House 1238.

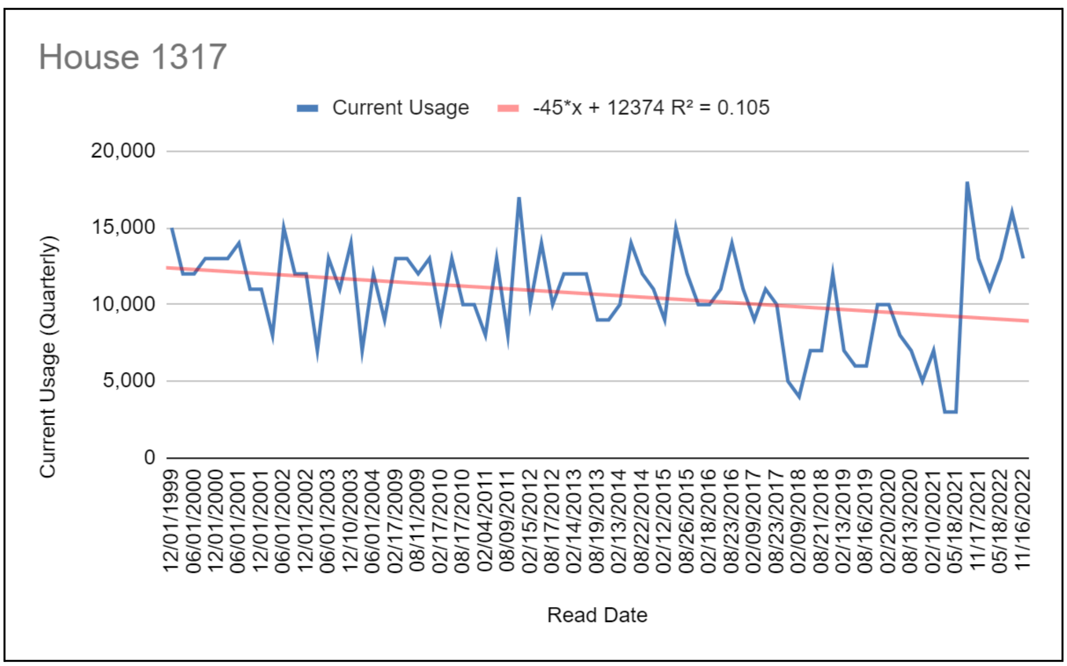

Figure 13. Water usage history for House 1317.

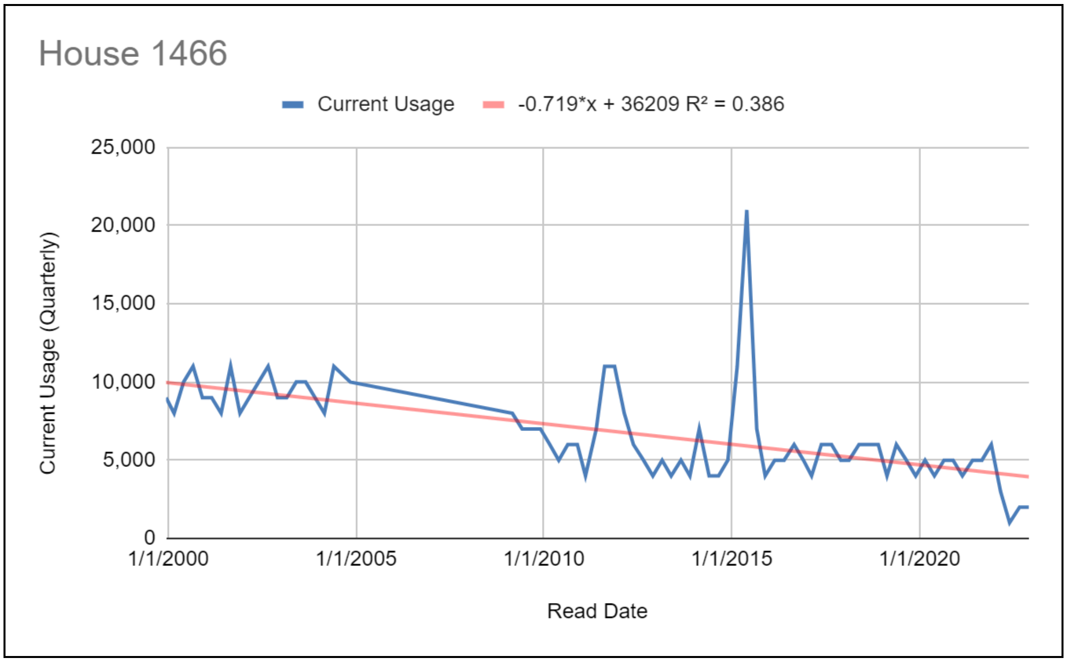

Figure 14. Water usage history for House 1466.

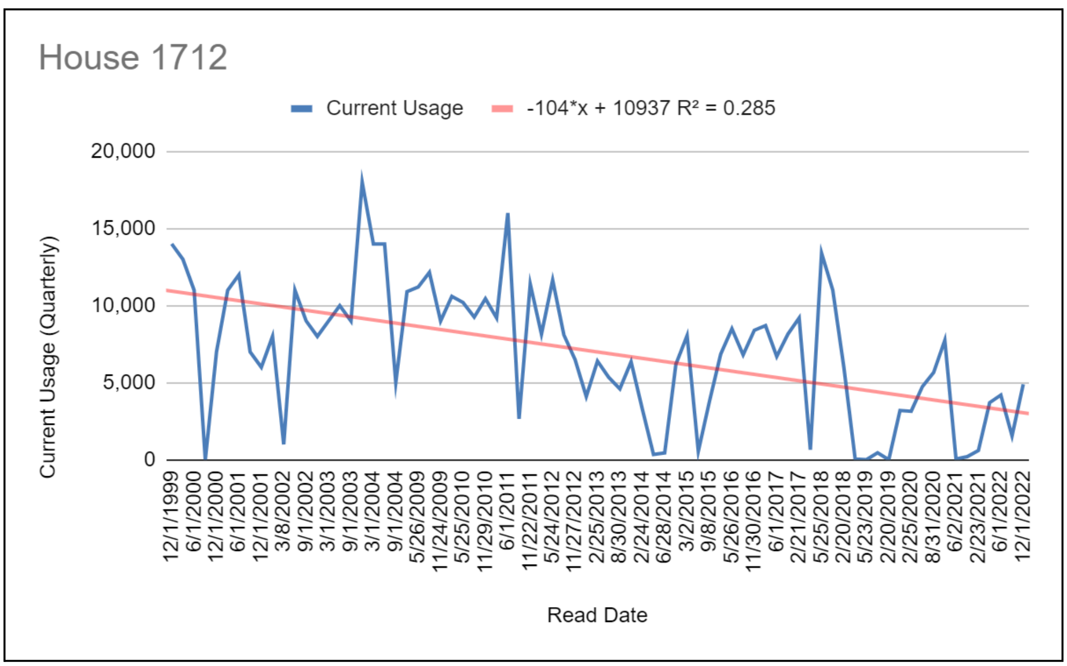

Figure 15. Water usage history for House 1712.

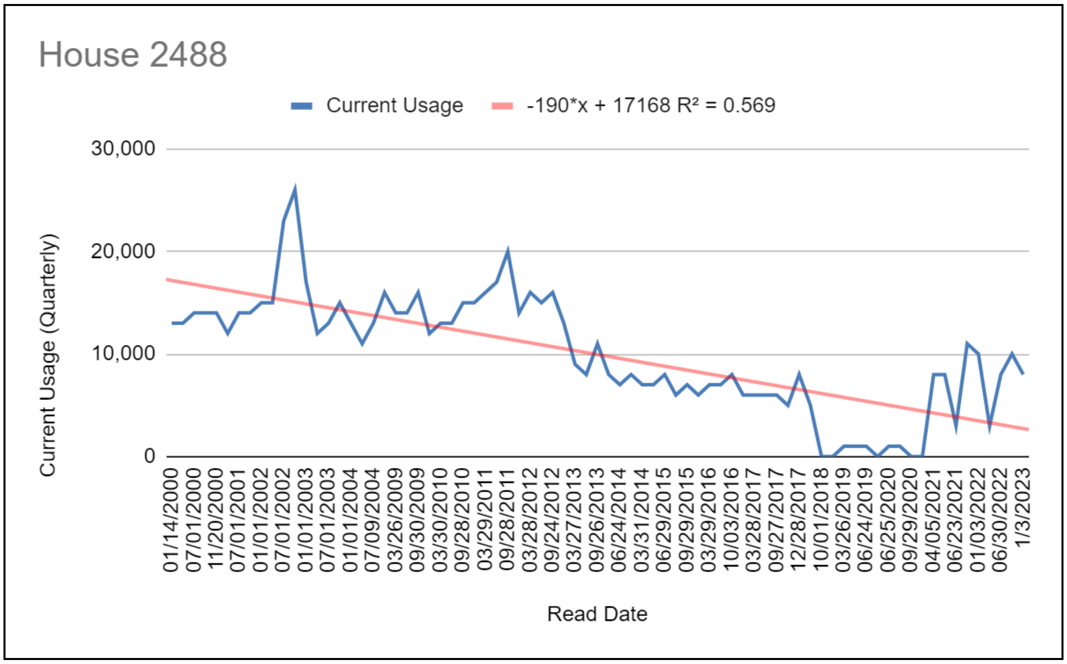

Figure 16. Water usage history for House 2488.

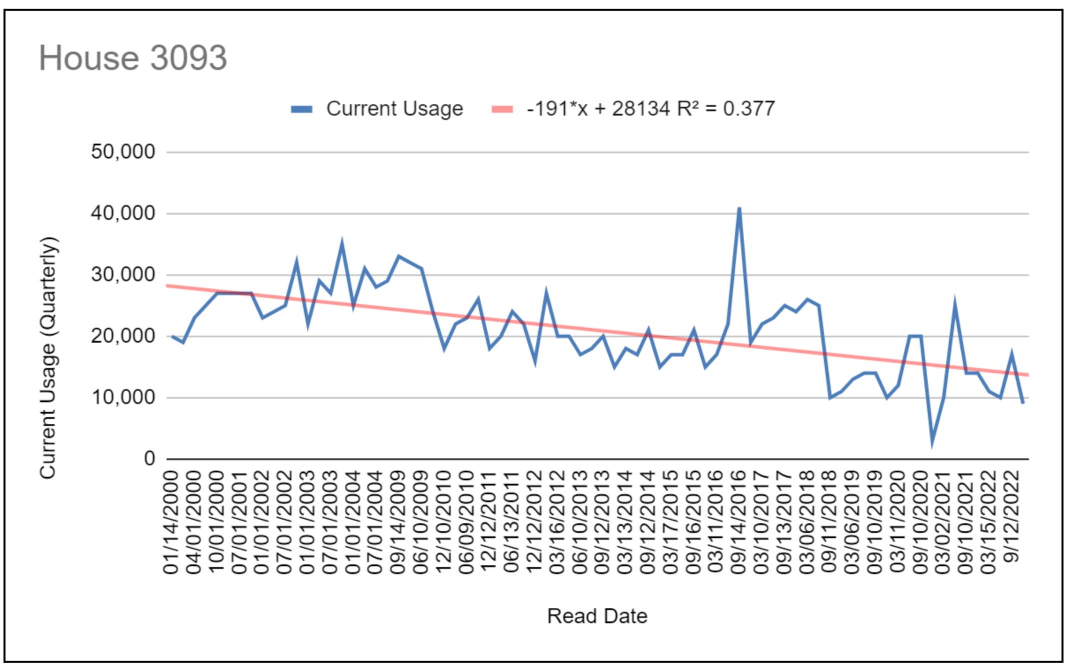

Figure 17. Water usage history for House 3093.

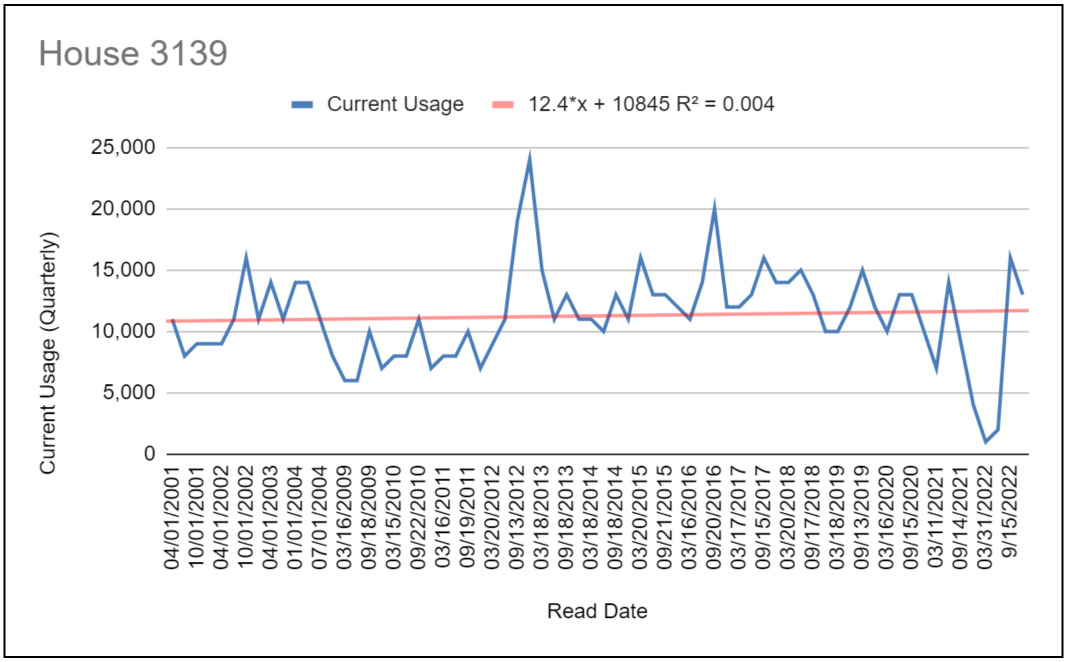

Figure 18. Water usage history for House 3139.

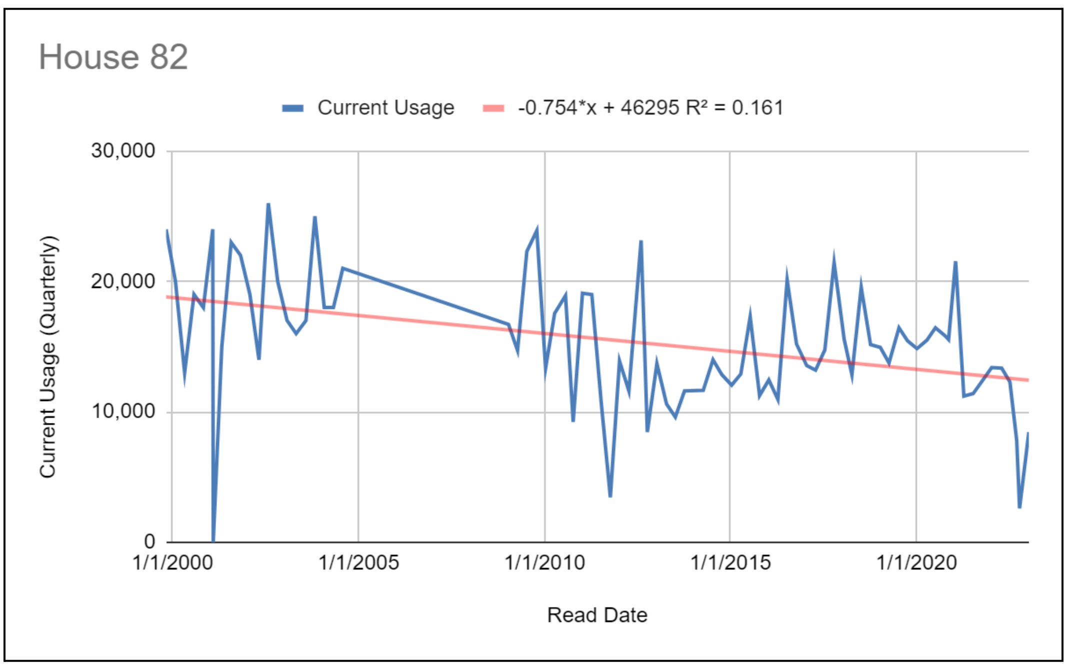

Figure 19. Water usage history for House 82.

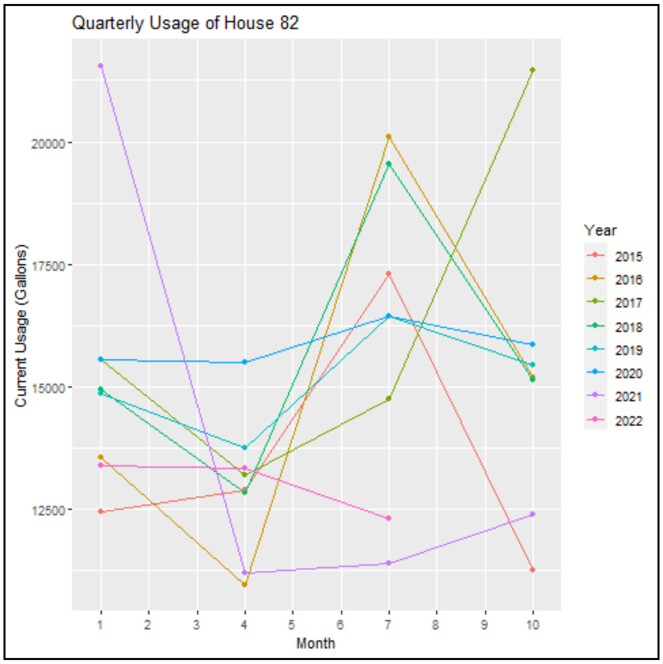

Figure 20. Water usage plot (in gallons) of House 82 in Fredonia, NY from the years 2015 to 2022 where months are labeled numerically (1 = January, …, 12 = December).

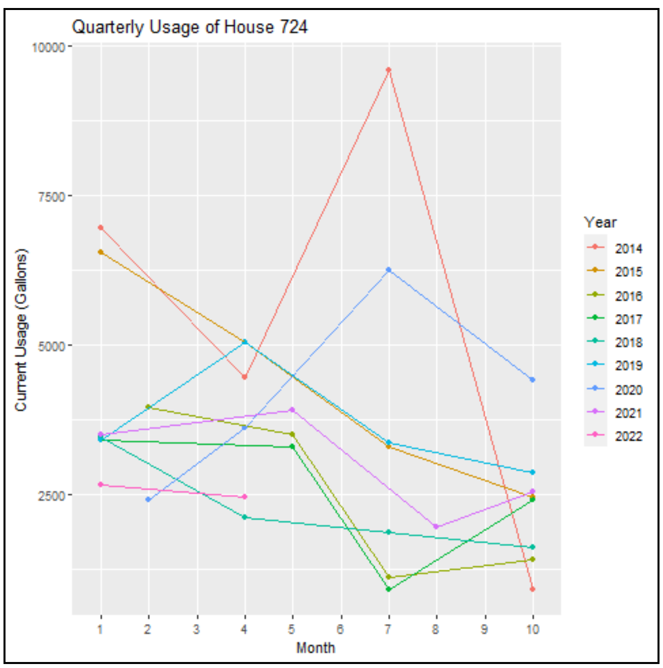

Figure 21. Water usage plot (in gallons) of House 724 in Fredonia, NY from the years 2014 to 2022 where months are labeled numerically (1 = January, …, 12 = December).

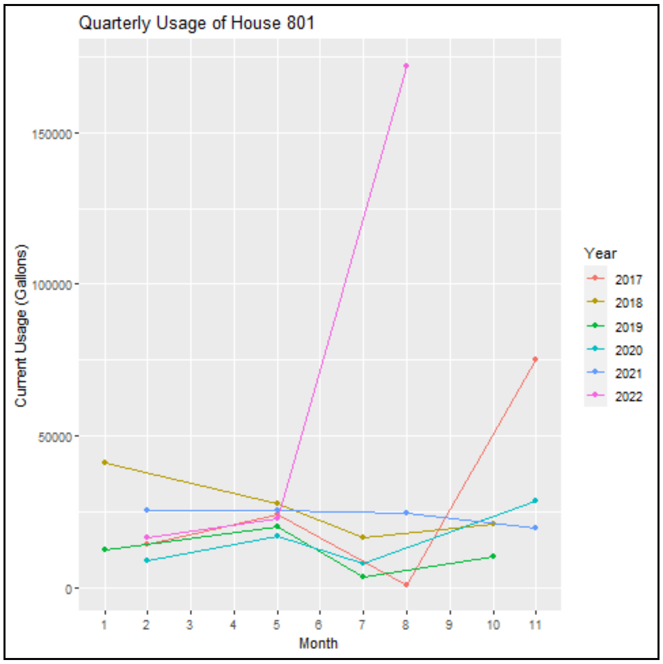

Figure 22. Water usage plot (in gallons) of House 801 in Fredonia, NY from the years 2017 to 2022 where months are labeled numerically (1 = January, …, 12 = December).

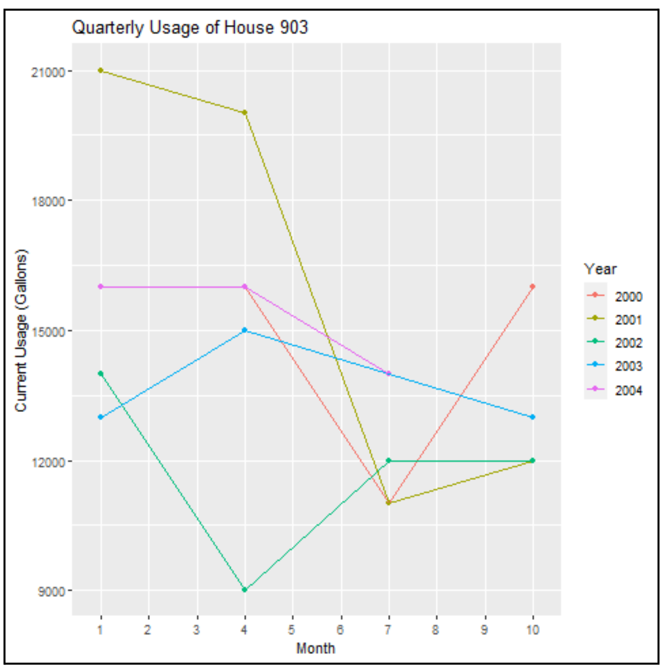

Figure 23. Water usage plot (in gallons) of House 903 in Fredonia, NY from the years 2000 to 2004 where months are labeled numerically (1 = January, …, 12 = December).

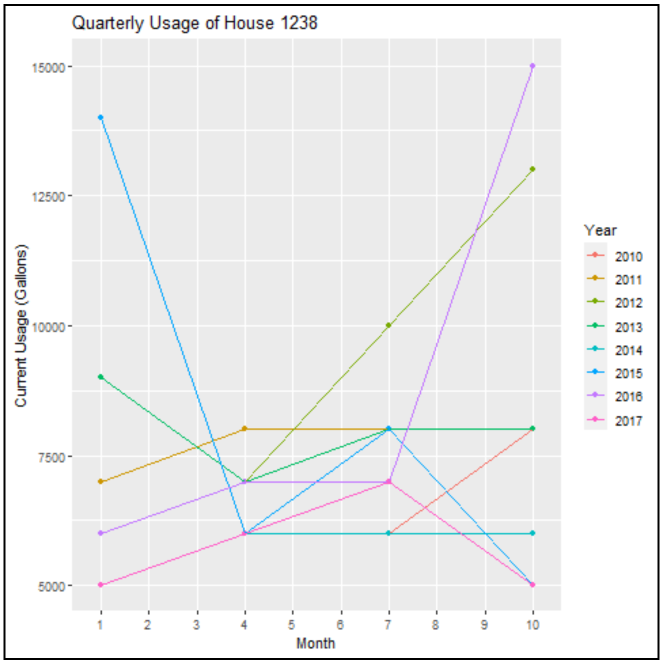

Figure 24. Water usage plot (in gallons) of House 1238 in Fredonia, NY from the years 2010 to 2017 where months are labeled numerically (1 = January, …, 12 = December).

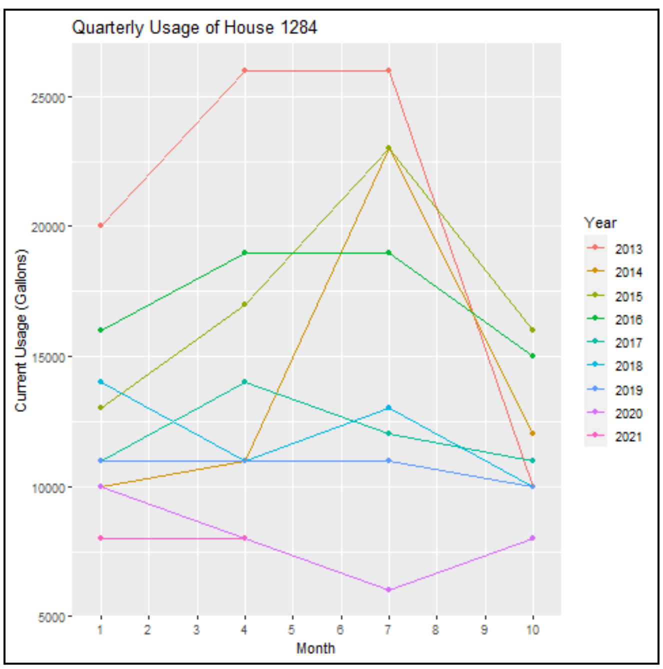

Figure 25. Water usage plot (in gallons) of House 1284 in Fredonia, NY from the years 2013 to 2021 where months are labeled numerically (1 = January, …, 12 = December).

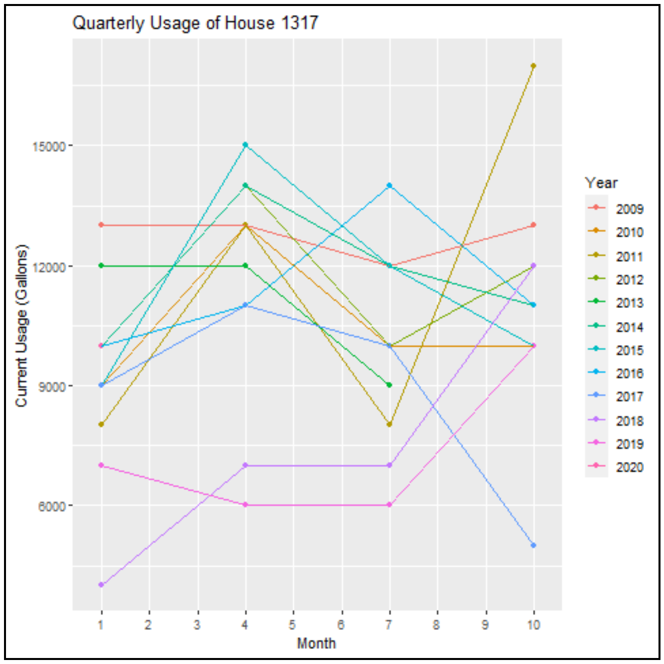

Figure 26. Water usage plot (in gallons) of House 1317 in Fredonia, NY from the years 2009 to 2020 where months are labeled numerically (1 = January, …, 12 = December).

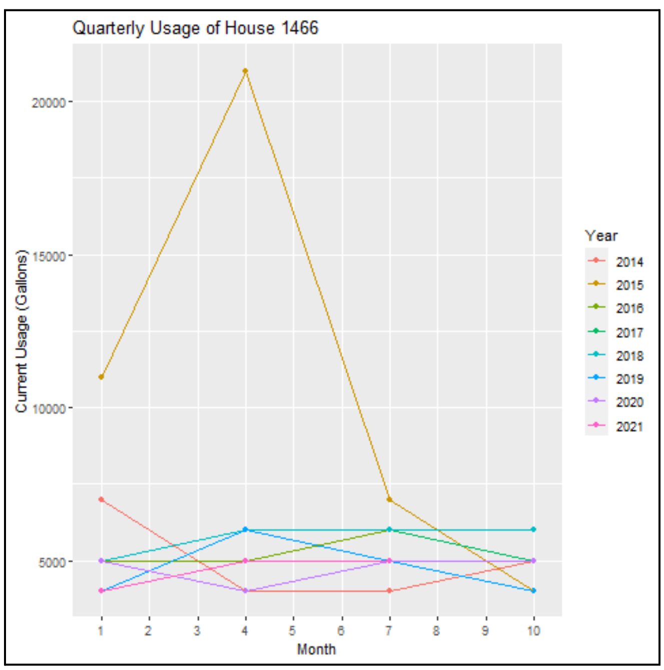

Figure 27. Water usage plot (in gallons) of House 1466 in Fredonia, NY from the years 2014 to 2021 where months are labeled numerically (1 = January, …, 12 = December).

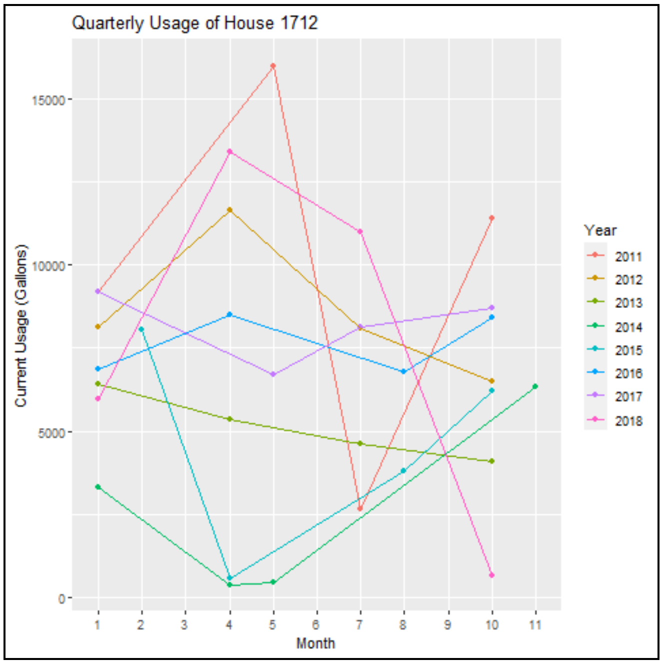

Figure 28. Water usage plot (in gallons) of House 1712 in Fredonia, NY from the years 2011 to 2018 where months are labeled numerically (1 = January, …, 12 = December).

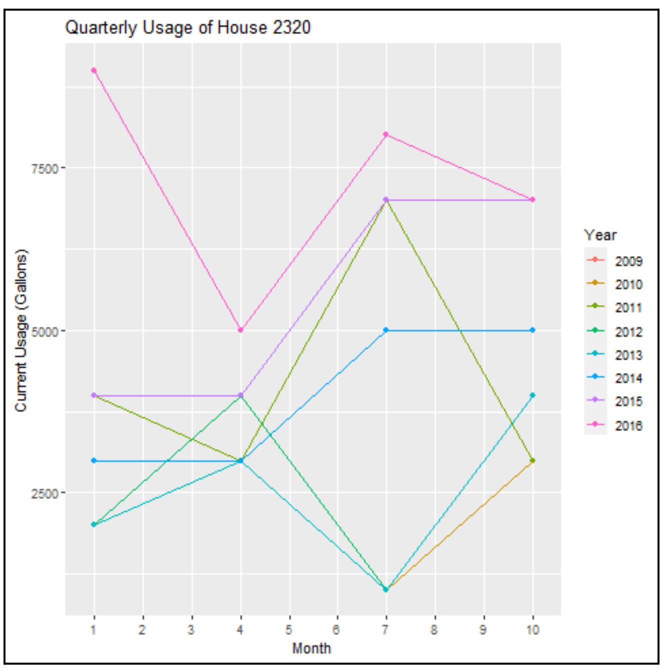

Figure 29. Water usage plot (in gallons) of House 2320 in Fredonia, NY from the years 2009 to 2016 where months are labeled numerically (1 = January, …, 12 = December).

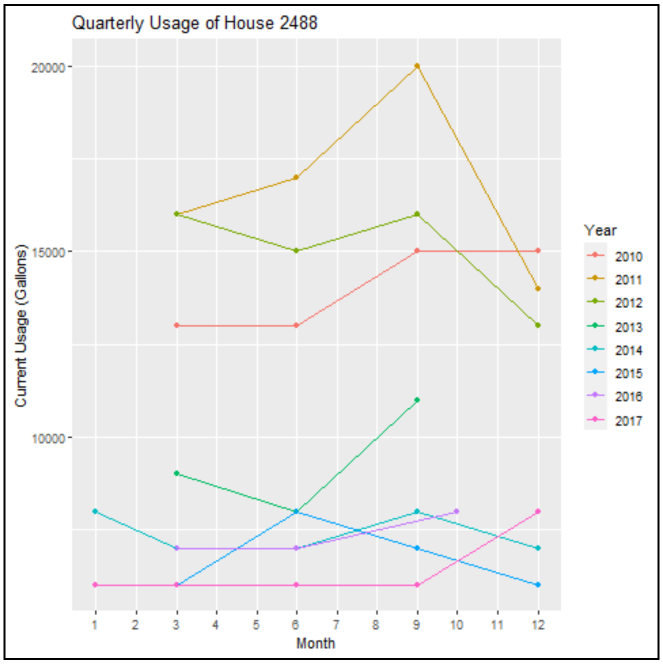

Figure 30. Water usage plot (in gallons) of House 2488 in Fredonia, NY from the years 2010 to 2017 where months are labeled numerically (1 = January, …, 12 = December).

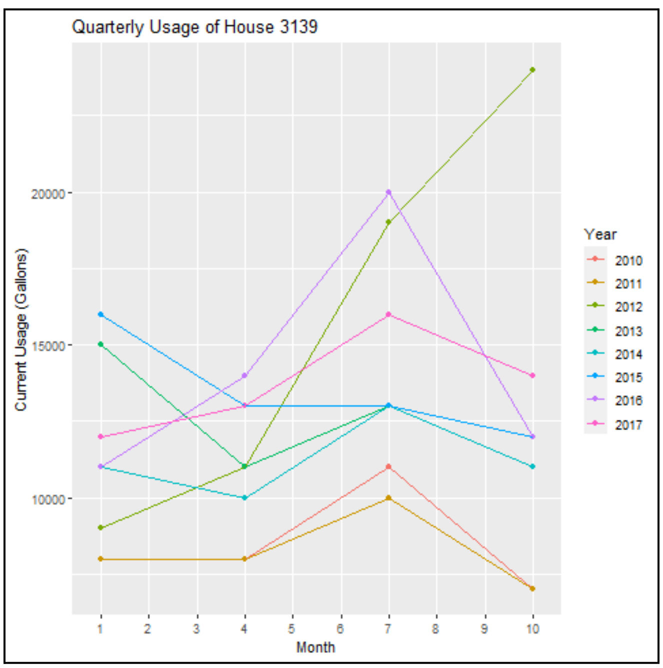

Figure 31. Water usage plot (in gallons) of House 3139 in Fredonia, NY from the years 2010 to 2017 where months are labeled numerically (1 = January, …, 12 = December).

Citations

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