

Analysis of Customer Participation in the Charlottesville Toilet Rebate Program

Introduction

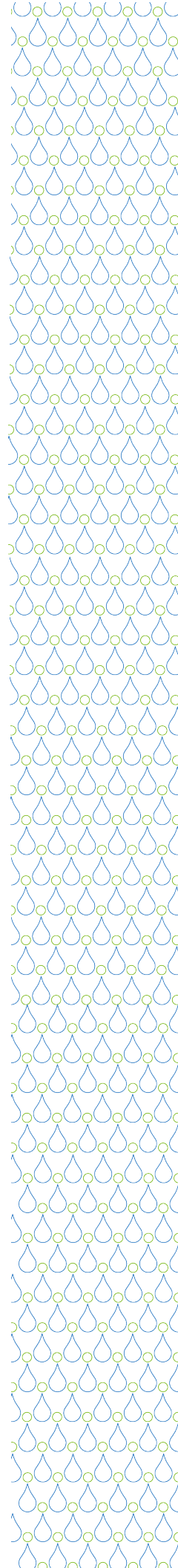
WaterNow Alliance (WaterNow) partnered with the City of Charlottesville (Charlottesville) to review and analyze the current state of the City’s WaterSense Labeled Toilet Rebate Program (Toilet Rebate Program), determining improvement options for the program, and creating a deployment or implementation plan for these updated program elements.

As part of this work, WaterNow analyzed program participation data, identifying trends and gaps in City residents’ engagement in the program. To support equitable and wide-reaching impacts as the program continues to be implemented, this analysis explores whether participation in the Toilet Rebate Program has occurred at the same spatial frequency and saturation levels across Charlottesville’s neighborhoods, paying particular attention to characteristics such as the primary language(s) spoken, renter-occupied housing, educational attainment levels, and median household income. The analysis aimed to consider the diverse demographics present in Charlottesville and determine which populations and neighborhoods may benefit from dedicated outreach.

Executive Summary & Key Findings

Our analysis found significant variation in the level of participation in the rebate across the neighborhoods of Charlottesville (Figure 6). Neighborhoods with the highest rates of participation included Johnson Village, Greenbrier, and Locust Grove, while those with the lowest rates of participation included Rose Hill, Jefferson Park Avenue, and 10th and Page (see Table 3 for all rates of participation by neighborhood). Neighborhoods with the highest levels of participation were most likely to have a greater percentage of residents with bachelor’s degrees (Figure 8), a lower percentage of renter-occupied homes (Figure 9), and a greater percentage of homes with access to the internet (Figure 10). High participation rates were also correlated with higher median household incomes, though our statistical analysis found that income was not the most effective predictor of variation in rates of participation, with other variables held constant.

Across all neighborhoods, participation in the rebate program was dominated by single-family residential properties. While the largest individual rebates in the program’s history were administered to multi-family large apartment properties, these made up only a small portion of



the total number of toilets rebated throughout the program’s history (defined as 2002 – 2022 in this analysis) (Figure 3).

In total, we found that 37% of all eligible premises had participated in the rebate program over the course of its history. These findings show a higher participation rate than suggested by the recent Water Conservation Survey (University of Virginia, 2023), which showed a 13.2% participation rate for individual respondents in the City of Charlottesville. Our higher estimate is likely a result of calculating participation by premise rather than by resident, more heavily weighting the less-dense single-family homes which make up the bulk of rebate participants.

The distribution of participation rates across Charlottesville and across the different sociodemographic profiles present in the data suggests three possible options for pathways forward, not mutually exclusive:

- **Strategies for Increasing Large Multifamily and Commercial Rebates:** The relatively large number of toilet replacements and water savings accomplished through relatively few rebates suggests the potential value to further encouraging applications from large property owners and apartment managers.
- **Loosening Eligibility Requirements:** Broadening eligibility to newer homes and moderately efficient toilets may invigorate rebate participation in neighborhoods which have already shown strong willingness to participate in the program. However, this approach will likely not improve participation in neighborhoods which do not already participate at high rates, suggesting this option might be best pursued in concert with other pathways forward.
- **Improving Outreach and Uptake in Low-Engagement Neighborhoods:** A third option for revamping the Toilet Rebate program will be to identify strategies to increase participation in neighborhoods which have historically participated at lower rates. This could include higher-touch, face-to-face outreach campaigns, targeted outreach that could overcome or address the conditions which make residents less likely to participate in the Toilet Rebate, or other strategies for adding value to the rebate program’s offerings, like a direct-install program.

The following project phases focused on identifying insights, benchmarks, and lessons learned from exemplary toilet rebate programs and issue experts, and speaking with local community stakeholders, who can provide additional insights on drivers and barriers to participation. Cross-referencing these results with any demographic trends captured in the City’s recent Water Conservation Survey would also provide helpful additional context and detail regarding these findings.

Methods

Data Sources

Data from the [Charlottesville Open Data Portal](#), the US Census Bureau American Community Survey, and data acquired directly from the City were the key sources of data for the analysis. See Table 1 for a complete list of data sources and the scales at which they were available. Variables were selected based on their relevance to the key social and economic demographic trends we aimed to explore in this analysis.

Table 1. Key Variables and Data Sources

Variable	Data Source	Scale ¹
Toilet rebates	City of Charlottesville Water Conservation Program	Parcel scale
Parcels and parcel boundaries	Charlottesville Open Data Portal (2019)	Parcel scale
Neighborhood boundaries	Charlottesville Open Data Portal (2019)	Neighborhood scale
Year built	Charlottesville Open Data Portal (2019)	Parcel scale
Parcel use codes	Charlottesville Open Data Portal (2019)	Parcel scale
Attic insulation rebates	City of Charlottesville Utility Department	Parcel scale
Tankless water heater rebates	City of Charlottesville Utility Department	Parcel scale
Population	Total Population. U.S. Census, 5-Year American Community Survey ²	US Census Block Group
Race	U.S. Census, 5-Year American Community Survey	US Census Block Group

¹ For additional details about US Census Block Groups and Tracts, see the [US Census Glossary](#) and [this visualization from ArcGIS](#).

² The full citation for the US Census, 5-Year American Community Survey is: US Census Bureau. (2022). 2017-2021 American Community Survey 5-Year Estimates. <https://data.census.gov/cedsci/>.

Age	U.S. Census, 5-Year American Community Survey	US Census Block Group
Levels of education	Educational Attainment for Population 25 Years and Older, U.S. Census, 5-Year American Community Survey	US Census Tract
Percentage of rental/homeowner occupancy	Total Population in Occupied Housing by Tenure by Units in Structure, U.S. Census, 5-Year American Community Survey	US Census Tract
Median household income	Median Household Income in the Past 12 Months (in 2021 Inflation-Adjusted Dollars), U.S. Census, 5-Year American Community Survey	US Census Block Group
Percent of population living in Poverty Status (based on their income over the past 12 months)	Poverty Status of Individuals in the Past 12 Months by Living Arrangement, U.S. Census, 5-Year American Community Survey	US Census Tract
Language isolation	Household Language by Household Limited English Speaking Status, U.S. Census, 5-Year American Community Survey	US Census Block Group
Internet access	Internet Subscription in Household. U.S. Census, 5-Year American Community Survey	US Census Block Group

Analysis

To evaluate summary statistics for the Toilet Rebate Program participants, the list of rebates acquired from the City was matched by address against the parcel-level residential and commercial details available through the Charlottesville Open Data Portal. Summary statistics were evaluated for the year rebated premises were built, the year rebates occurred, and number of toilets in each rebate. Participation in two newer rebates administered by the Utility Department was also examined.

The key metric for the spatial analysis was the proportion of “eligible parcels” which had participated in the rebate in each of the City’s 38 Census block groups. Eligible parcels were categorized as those which contained a building built before 1994, according to the Use Code and Date Built fields in the parcel details available through the Charlottesville Open Data Portal.

Only buildings built before 1994 are currently eligible to participate in the rebate, although some exceptions have been made for commercial and apartment rebates.

Eligible parcels were categorized into residential, commercial, and apartment groups and enumerated by Census block group and neighborhood. Rebate records were geocoded using the Google Maps API, and the total number of residential, commercial, and apartment rebates were enumerated by Census block group and neighborhood. The ratio of rebate records to eligible parcels for each category in a particular Census block group was used to calculate a Residential Rebate Participation Rate, a Commercial Rebate Participation Rate, and an Apartment Rebate Participation Rate for each block group and each neighborhood. Because of discrepancies between properties listed as apartments in their Use Codes and properties treated as apartments for the purposes of the Toilet Rebate Program, the Apartment Rebate Participation Rate was unreliable and is not reported here. The Residential Rebate Participation Rate served as the dependent variable for our subsequent linear regression analysis.

Multivariate linear regression revealed several correlations and potential variables of interest among the independent variables listed in [Table 1](#). Model selection using the Corrected Akaike Information Criterion (AICc)³ was used to identify the multiple regression model which most effectively captured the greatest amount of variation in rebate participation rate.

Results

Descriptive Statistics: Exploring the Rebate Records

The 5,003 rebate records provided by the City were able to be matched to 3,881 premises with details available through the Open Data Portal. These premises were predominantly single-family homes ($n = 2,849$, 73% of all rebate premises, [Figure 1](#)) with a median year built of 1957 ([Figure 2](#)). The majority of rebates were for one toilet ($n = 2,575$, 66% of all rebate premises) or two toilets ($n = 1,262$, 33% of all rebate premises), with a few very large rebates of over 100 toilets contributing a small portion of the total volume of toilets rebated ([Figure 3](#)). The rebates were distributed unevenly across the history of the rebate program ([Figure 4](#)), with the most common years being 2002 ($n = 599$, 15% of all rebate premises), the first year of the rebate, followed by 2003 ($n = 367$, 9% of all rebate premises). A wave of increased participation in the rebate in 2009-2011 was followed by a steady declining trend, continuing to the present day.

³ The Akaike information criterion (AIC) is a mathematical method for evaluating how well a model fits the data it was generated from and is used in statistics to compare different possible models and determine which one is the best fit for the data, based on the number of independent variables used to build the model and how well the model reproduces the data. The corrected Akaike information criterion (AICc) modifies this approach to small sample sizes.

This trend can be compared to the annual participation in the newer Attic Insulation and Tankless Water Heater Rebates offered through the City of Charlottesville’s Utility Department. Though each of the newer rebates shows fewer participants per year than the toilet rebate, their rates of participation are relatively steady year over year since their inception, with the exception of a sharp dip in 2020 and a spike in 2021, likely due to the COVID pandemic (Figure 4, Figure 5). Participants in each rebate were relatively likely to take advantage of the other rebates as well. Nearly half of participants in the Tankless Water Heater Rebate (50 out of 115, or 43%) and the Attic Insulation Rebate (18 out of 41, or 44%) participated in at least one other rebate (Table 2). Although an in-depth analysis of the rates of participation in these Utility Department rebates is beyond the scope of this memo, these rates suggest that cross-promoting the Toilet Rebate Program with these and other rebates offered by the City is likely to be a fruitful approach. Participants in the Toilet Rebate Program participated at lower rates in the Tankless Water Heater Rebate (49 out of 3,825, or 1.2%) and the Attic Insulation Rebate (17 out of 3,825, or 0.4%). The lower rate of overlap between Toilet Rebate participation and participation in the other rebates results from the much greater total participation in the Toilet Rebate, which in turn is due to the many years in which the Toilet Rebate Program operated before the beginning of these other programs; the Toilet Rebate Program has been active since 2002, while the Tankless Water Heater Rebate has been active since 2015, and the Attic Insulation Rebate has been active since 2020.

Table 2. Overlap between participation in Charlottesville’s Toilet Rebate Program, Tankless Water Heater Rebate, and Attic Insulation Rebate. A program’s intersections with itself indicate premises which participated in only one program.

	Toilet Rebate	Tankless Water Heater Rebate	Attic Insulation Rebate
Toilet Rebate	3776	49	17
Tankless Water Heater Rebate		65	3
Attic Insulation Rebate			23

The Toilet Rebates were unevenly distributed across the neighborhoods of Charlottesville. Neighborhoods with the highest rates of participation by premise included Johnson Village (64% of eligible premises), Greenbrier (57% of eligible premises), and Locust Grove (48% of eligible premises), while those with the lowest rates of participation by premise included Rose Hill (19% of eligible premises), Jefferson Park Avenue (21% of eligible premises), and 10th and Page (23% of eligible premises). See Table 3 for all rates of participation by neighborhood, and Figure 6, Figure 7, and Figure 8 for maps of rebate participation rates across the City. Overall, 40% of all eligible residential premises and 8% of all eligible commercial premises have participated in the Toilet Rebate Program, for a total 37% of all eligible premises participating.

Table 3. Rebate Participation Rates by Neighborhood. Participation rates were not calculated for neighborhoods with few (<10) eligible premises for a given category; these excluded rates are denoted “NA” in the table.

Neighborhood	Residential Rebate Participation Rate	Commercial Rebate Participation Rate	Total Rebate Participation Rate
Johnson Village	65%	NA	64%
Greenbrier	57%	NA	57%
Locust Grove	50%	NA	48%
Barracks / Rugby	44%	16%	44%
Fry's Spring	42%	21%	41%
Barracks Road	47%	NA	41%
Woolen Mills	40%	25%	40%
The Meadows	48%	4%	40%
Lewis Mountain	38%	42%	37%
Martha Jefferson	46%	4%	37%
Fifeville	35%	NA	33%
Belmont	34%	8%	32%
Ridge Street	30%	7%	30%
Venable	35%	9%	30%
North Downtown	36%	7%	27%
Starr Hill	53%	2%	23%
10th & Page	25%	4%	23%
Jefferson Park Avenue	22%	35%	21%
Rose Hill	24%	9%	19%

Regression Analysis: Patterns in Rebate History

Model selection by AICc was used to identify the best candidate multilinear regression model, which captured the greatest amount of variation in residential rebate participation using the fewest number of variables as inputs. The analysis found strong statistical evidence that residential rebate participation rate:

- Increased with a greater percentage of residents in a block group with a bachelor's degree as their highest level of educational attainment (Figure 9);
- Decreased with a greater percentage of households who were renting their homes (Figure 10);
- Decreased with a greater percentage of households with no access to the internet at home (Figure 11); and
- Increased with a greater percentage of households where no resident over 14 years old spoke English very well (Figure 12).

These results also found a correlation between a higher rate of rebate participation and higher median household income. While household income was not found to be the most effective predictor of participation with all other variables being held constant, its importance as an economic driver merits its inclusion in our discussion of the results.

Discussion

Overall, the findings of this analysis appear to align with the findings of the project's background research. The rebate program to date has primarily seen small, one- or two-toilet rebates originating in single-family homes, with a few exceptions in the form of mid-sized commercial rebates and larger apartment complex rebates. The analysis suggests three possible pathways forward for the rebate program, which are not mutually exclusive:

Strategies for Increasing Apartment and Commercial Rebates

Participation from commercial properties and apartment complexes has been much lower than residential participation, meaning that many inefficient toilets likely remain to be replaced. Identifying strategies to engage large property owners and apartment managers may lead to new large rebate opportunities, extending the reach and impact of the program.

Loosening Eligibility Requirements

Loosening the eligibility guidelines for the program (e.g., age of home, number of toilets eligible for a rebate, ability of renters to participate directly) could further increase the number of eligible premises in neighborhoods that have already shown a strong willingness to participate in the program. This approach may result in new momentum towards participation from single-family homeowners, as past participants could be made eligible to re-apply under the new guidelines, increasing word-of-mouth for the program and leading to community engagement in these already high-participation neighborhoods. This new wave of engagement could lead to the replacement of moderately efficient toilets with highly efficient ones. However, simply adjusting eligibility requirements will likely not result in greater rates of participation in neighborhoods

where participation has historically been low. The spatial analysis indicates that many eligible premises in these neighborhoods have not taken advantage of the Toilet Rebate over the 20 years since its creation; this suggests that ineligibility may not be the primary barrier to participation for residents in these neighborhoods. One exception to this may be found in removing the restriction on renters participating directly in the program – rental properties are already eligible to participate in the program, but action must currently be taken by the landlord to receive the rebate. Allowing renters to participate more easily may result in more participation from residents in neighborhoods where high proportions of renters may have slowed widespread participation in the past.

Improving Outreach and Uptake in Low-Engagement Neighborhoods

The spatial analysis also highlights the potential gains in participation that could be realized by improving participation rates among residents of neighborhoods where participation is currently lower. For example, this could involve targeting these neighborhoods for face-to-face outreach or other high-touch methods of engagement, while also focusing on strategies that address the characteristics of these neighborhoods. Including research on innovative methods of outreach that may appeal to lower-income, less well-educated residents, who may not have access to the Internet, during Phase 3 of this project might be one way to pursue this pathway. The development of a direct-install program could also be a way to address this goal by offering a greater-value service than the rebate alone. Additionally, identifying strategies that could make the Toilet Rebate Program more accessible to small landlords might drive greater participation in neighborhoods where renting is more prevalent.

Areas of Continued Exploration

While this spatial analysis has produced useful insights to guide the next steps of the Toilet Rebate Review and Revamp, additional research and exploration will continue to clarify and put into perspective the findings described here. One particularly counterintuitive finding is in the relationship between Toilet Rebate participation and language barriers. While we might expect that neighborhoods with larger numbers of households where no adult speaks English very well would be less likely to participate in the rebate program, Census block groups with a greater proportion of these households participated at a higher rate, with all other variables held constant. This may be a result of existing outreach to the Spanish-speaking community, but the result remains hard to explain. Cross referencing these results with any demographic data collected in future project phases and with community-based organizations offers a key opportunity to ground-truth this and other insights from this analysis, and to shed additional light on additional factors that may be driving or inhibiting participation across different neighborhoods.

Other directions for further research include opportunities for non-spatial analysis. Some information about knowledge of, and participation in, the Toilet Rebate Program was gathered in the recent Water Conservation Survey (University of Virginia, 2023). Data from the Survey could clarify the relationship between participation in the Toilet Rebate Program and variables that do not vary consistently across space, e.g. homeowner age, age of the home, and others. It would also be helpful to see if the trends in participation according to language spoken are also reflected in the Survey data, or if these trends are seen primarily at the block group level.

An additional avenue for continued exploration will be evidence gathered through conversations and interviews with the administrators of other rebate programs during upcoming phases of research. This will create an opportunity to explore similarities and differences between Charlottesville's Toilet Rebate Program and rebate programs in other regions and contexts. For example, these interviews could help contextualize the overall uptake of the program and differences in sociodemographic patterns in participation across other programs.

Figures

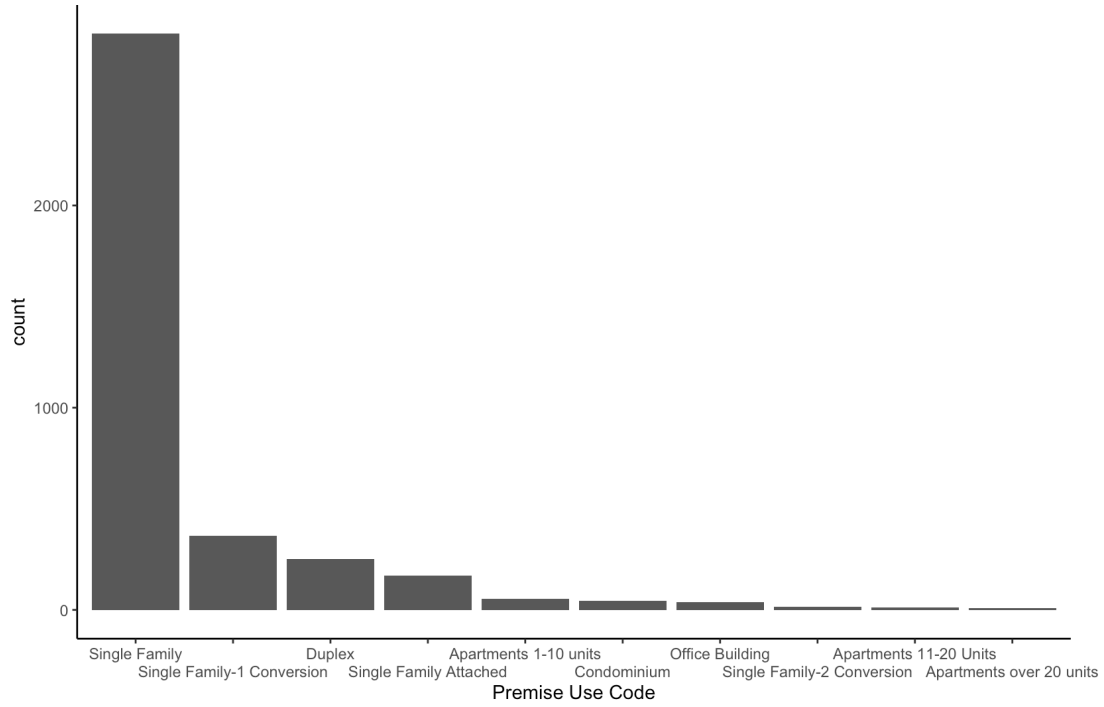


Figure 1. Ten Most Common Premise Use Codes Across All Toilet Rebates Between 2002 and 2022

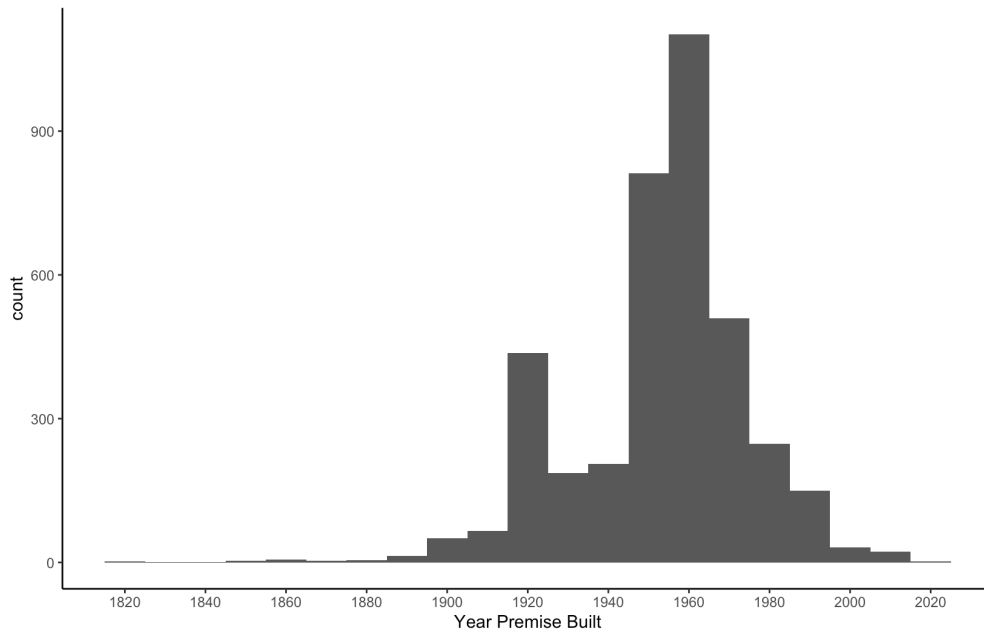


Figure 2. All Toilet Rebates Issued between 2002 and 2022, by Year Premise Built

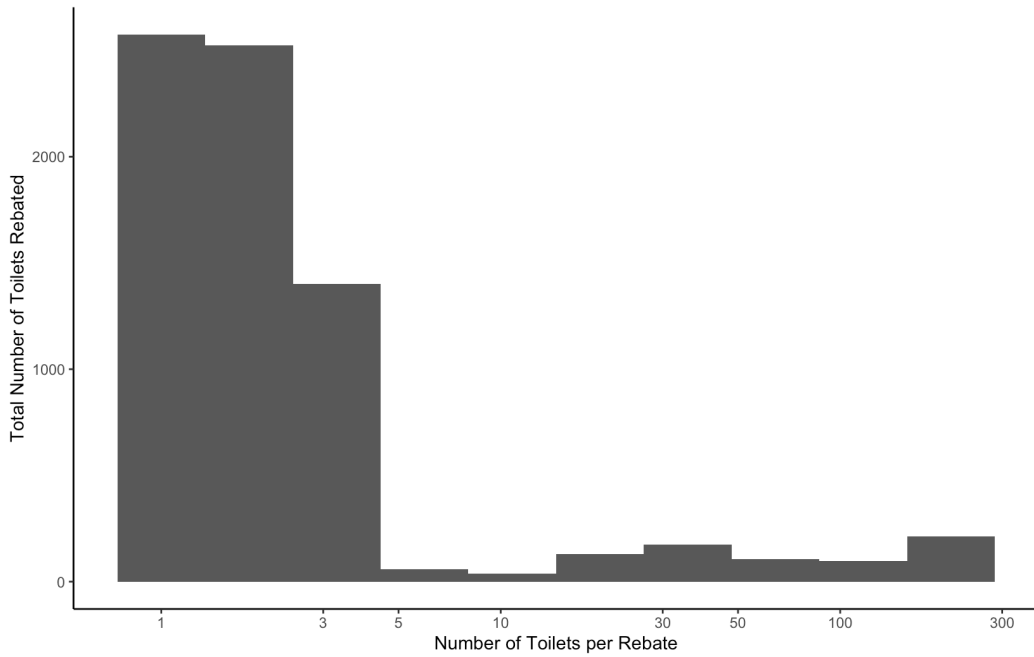
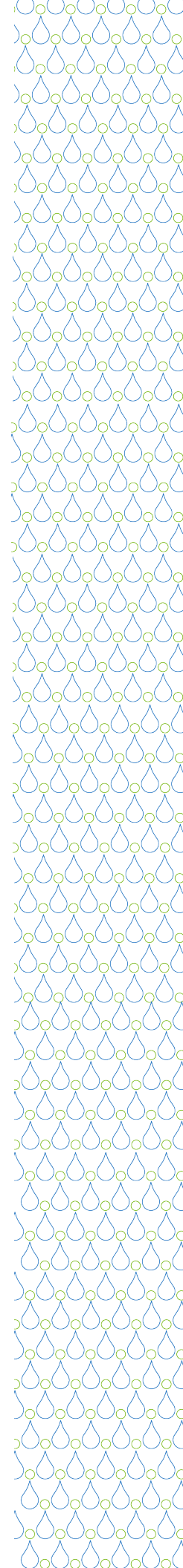


Figure 3. Total Number of Toilets Rebated by Number of Toilets Per Rebate Between 2002 and 2022



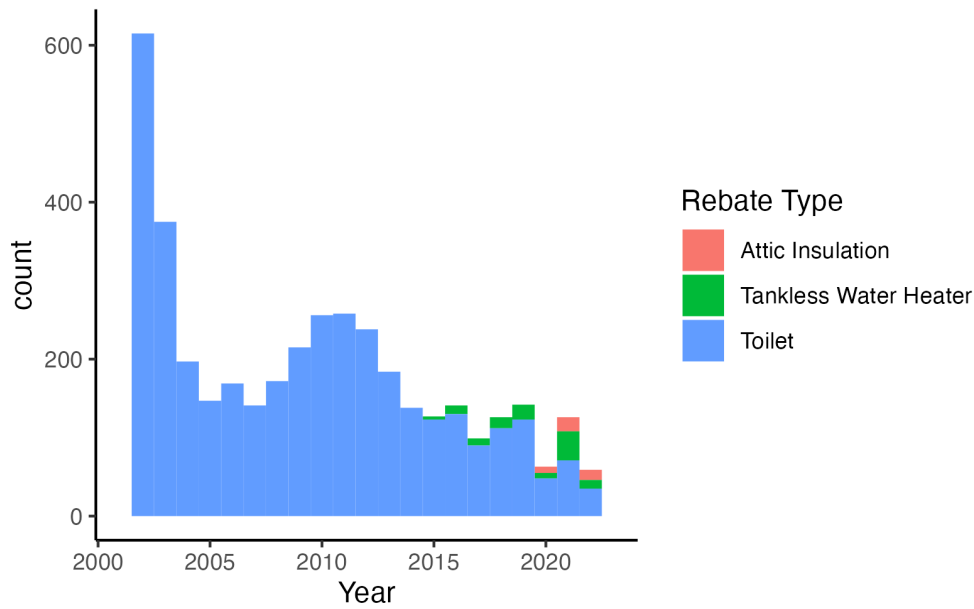


Figure 4. Toilet, Attic Insulation, and Tankless Water Heater Rebates Issued by Year Between 2002 and 2022. This analysis includes 3,837 toilet rebates, 39 attic insulation rebates, and 112 tankless water heater rebates. The Toilet Rebate Program has been active since 2002, the Attic Insulation Rebate Program has been active since 2020, and the Tankless Water Heater Program has been active since 2015.

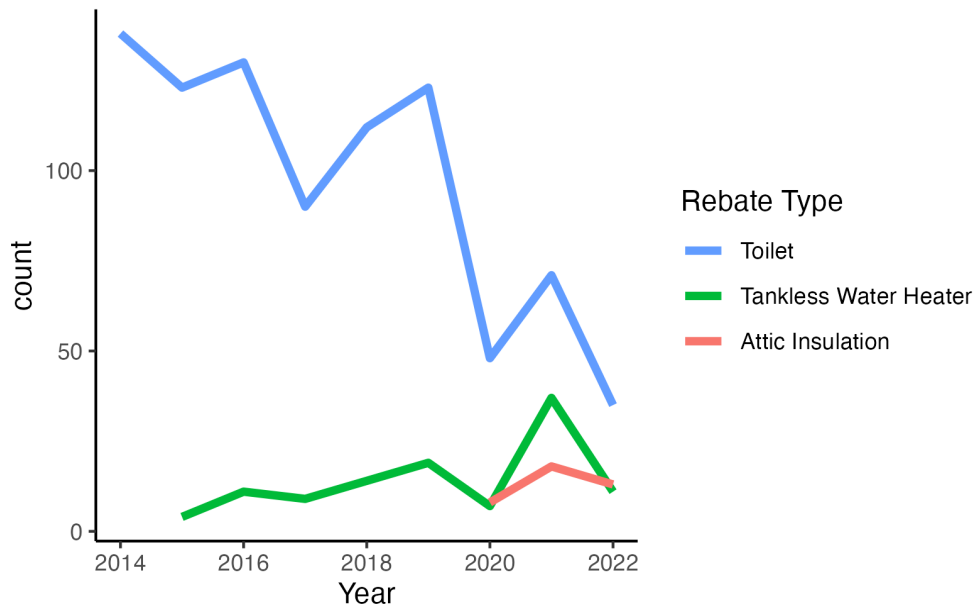


Figure 5. Toilet, Attic Insulation, and Tankless Water Heater Rebates by Year from 2014 Through 2022. Each rebate showed a dip in participation in 2020, followed by a surge in 2021. Participation in the tankless water heater rebate has remained fairly steady year over year, while the rate of toilet rebates has declined.

Total Rebate Participation by Neighborhood

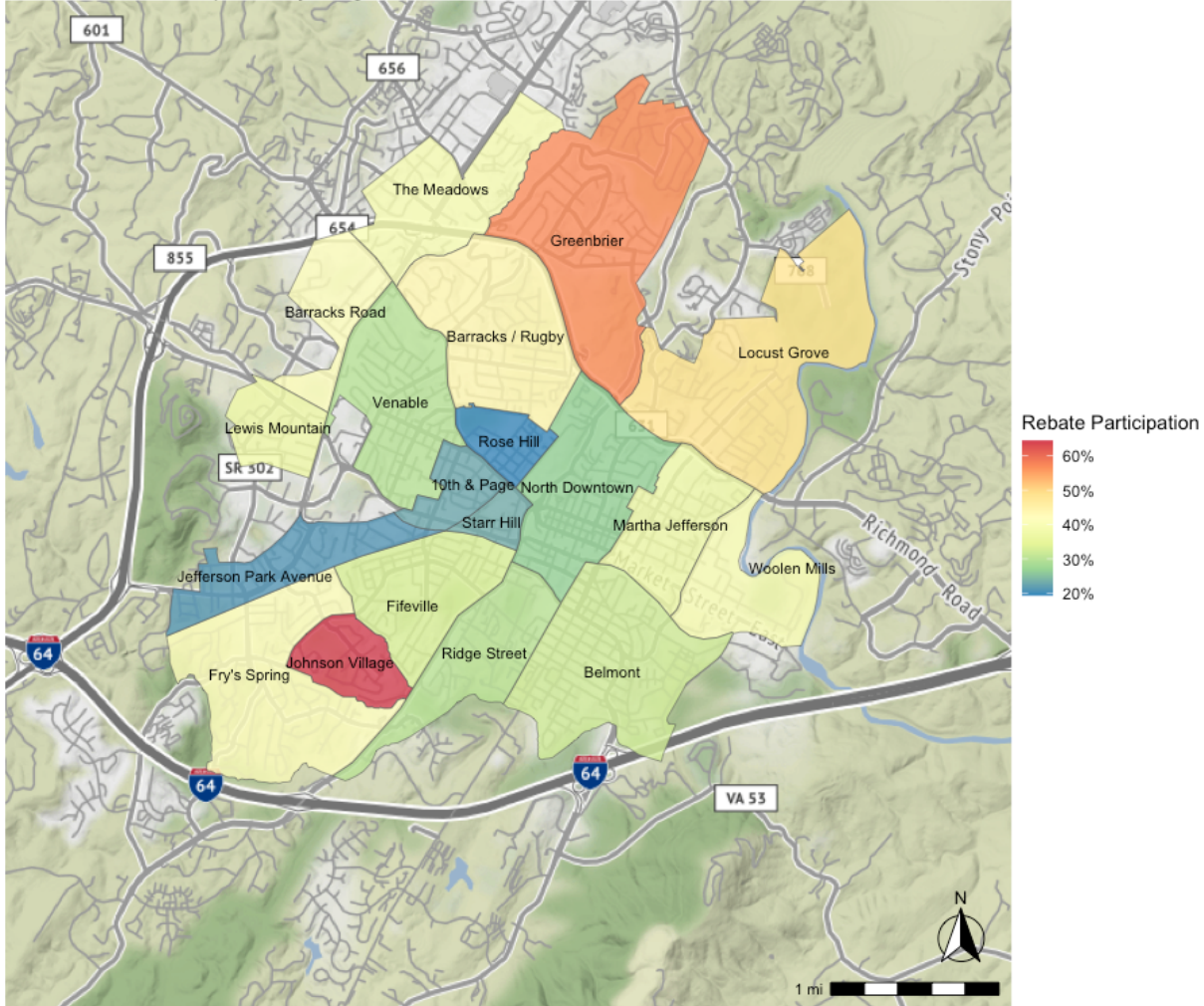
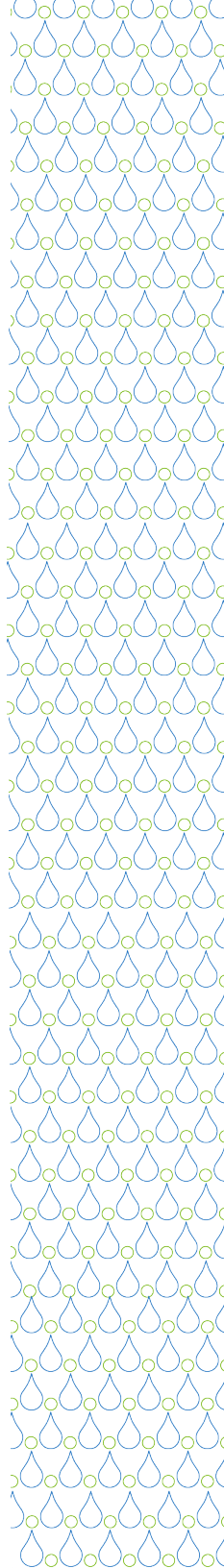


Figure 6. Total Toilet Rebate Participation Rates by Neighborhood, as a Fraction of All Eligible Premises in Each Neighborhood, during 2002-2022.



Residential Rebate Participation by Neighborhood

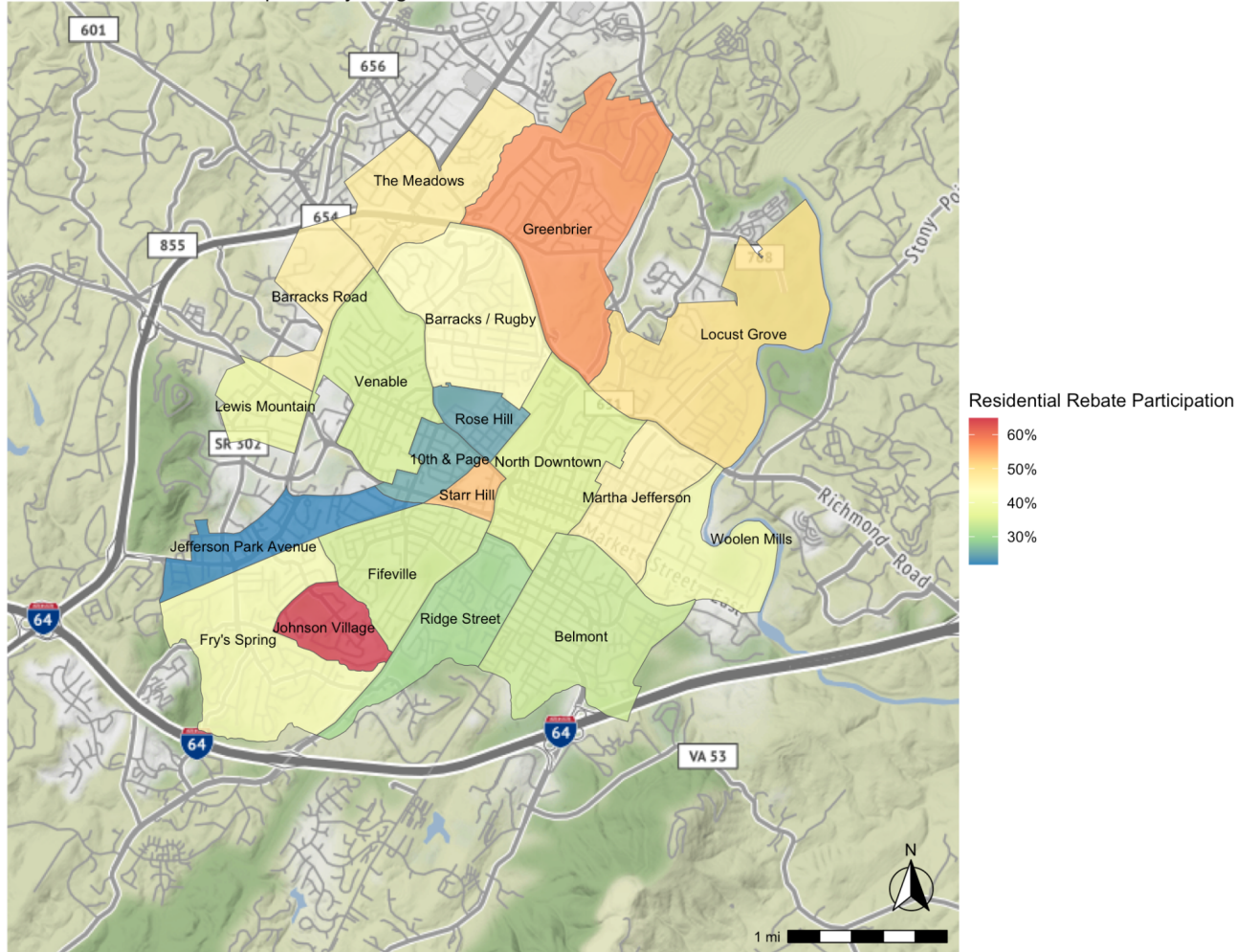
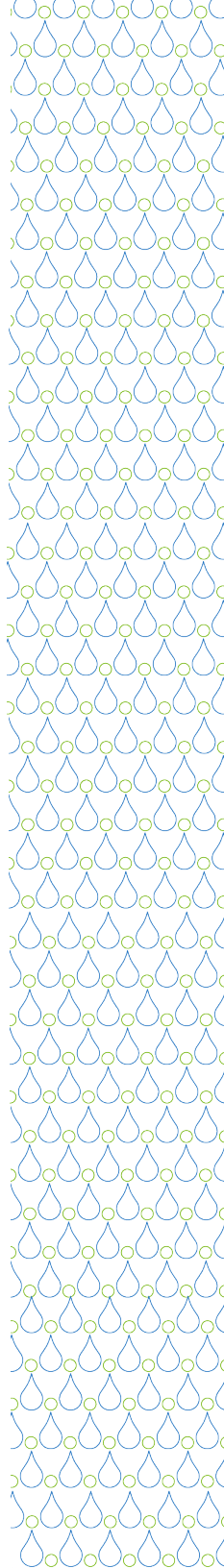


Figure 7. Residential Toilet Rebate Participation Rates by Neighborhood, as a Fraction of all Eligible Residential Premises in Each Neighborhood, during 2002-2022.



Commercial Rebate Participation by Neighborhood

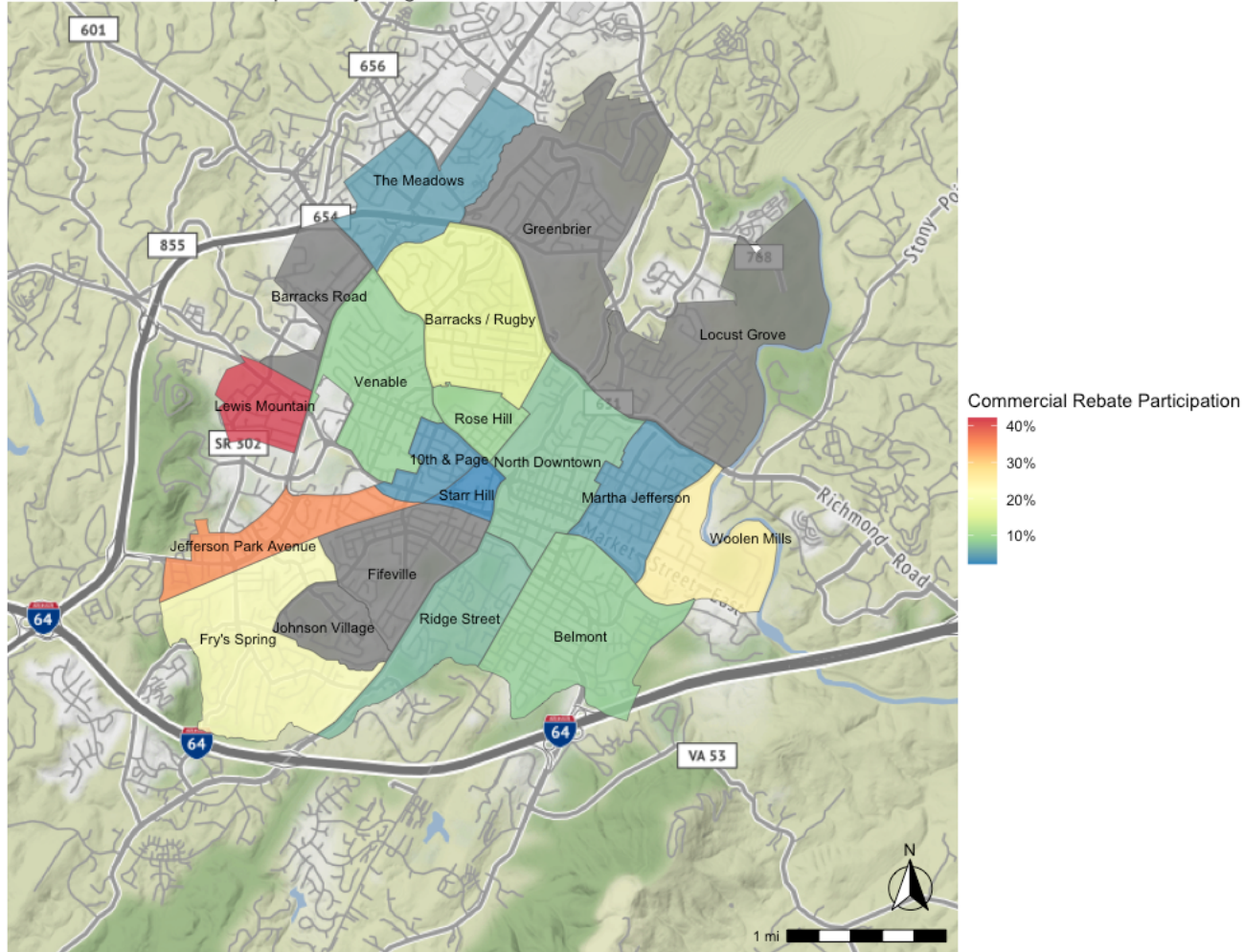
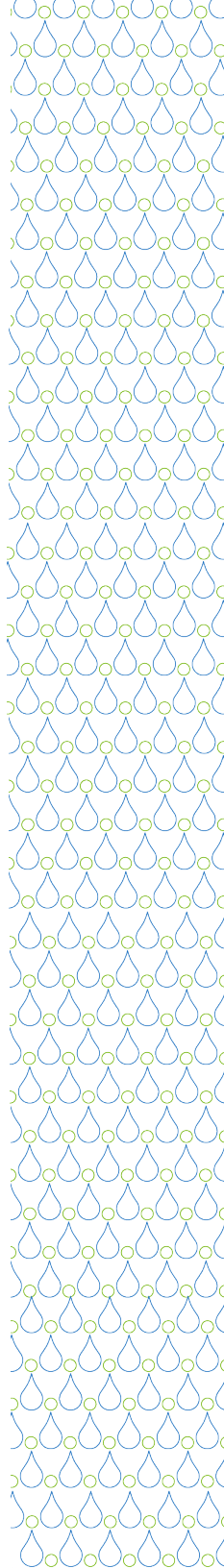


Figure 8. Commercial Toilet Rebate Participation Rates by Neighborhood, as a Fraction of all Eligible Commercial Premises in Each Neighborhood, during 2002-2022. Neighborhoods with fewer than 10 eligible commercial premises are greyed out.



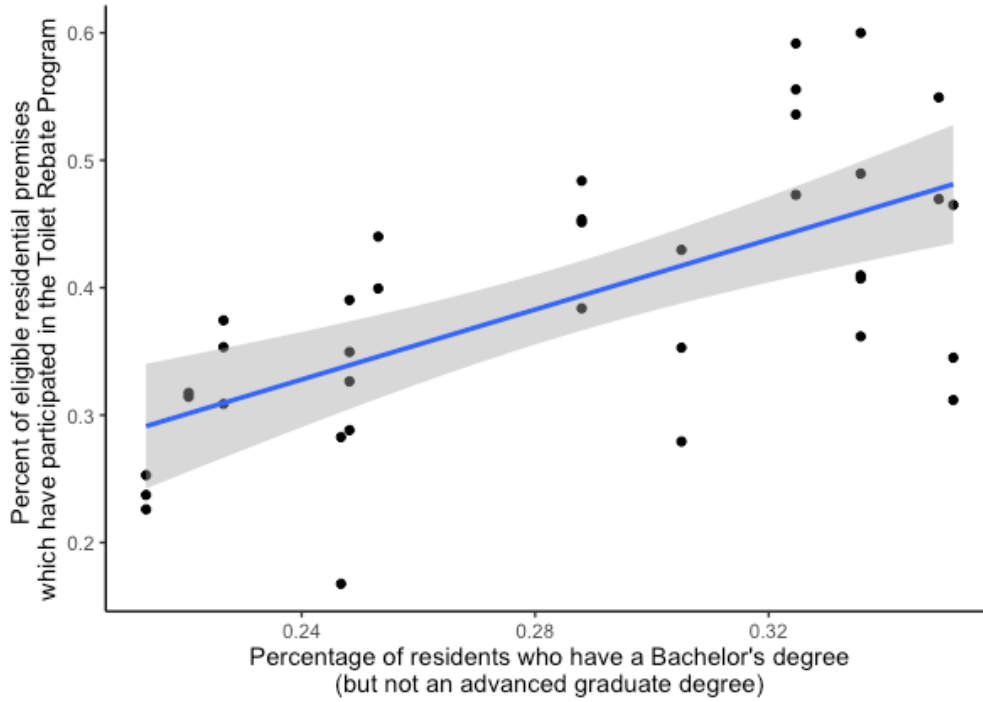


Figure 9. Residential Toilet Rebate Participation by Percentage of Residents with a Bachelor's degree (2002-2022)

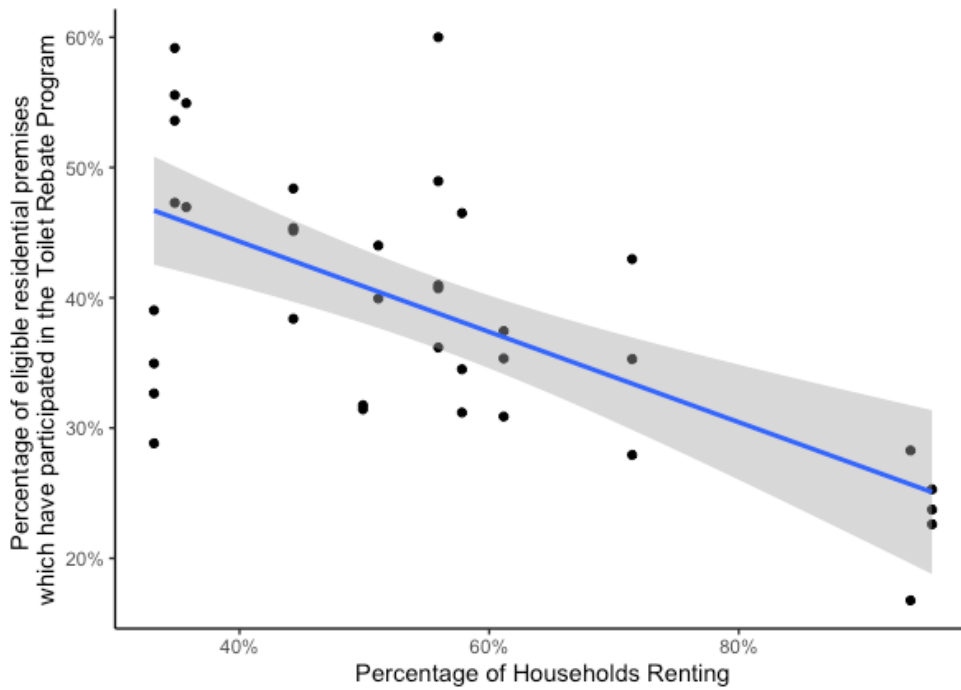
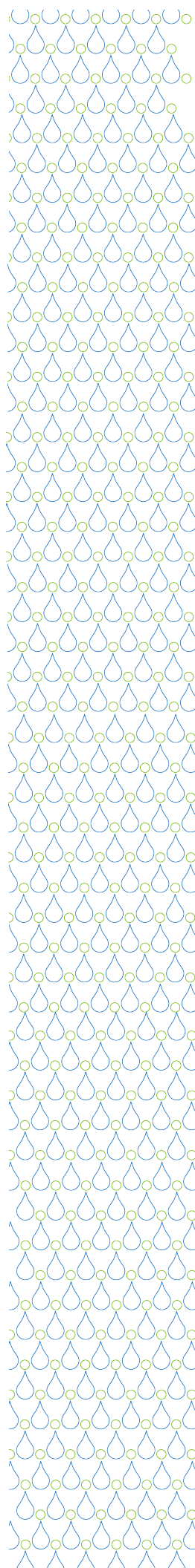


Figure 10. Residential Toilet Rebate Participation by Percentage of Households Renting (2002-2022)



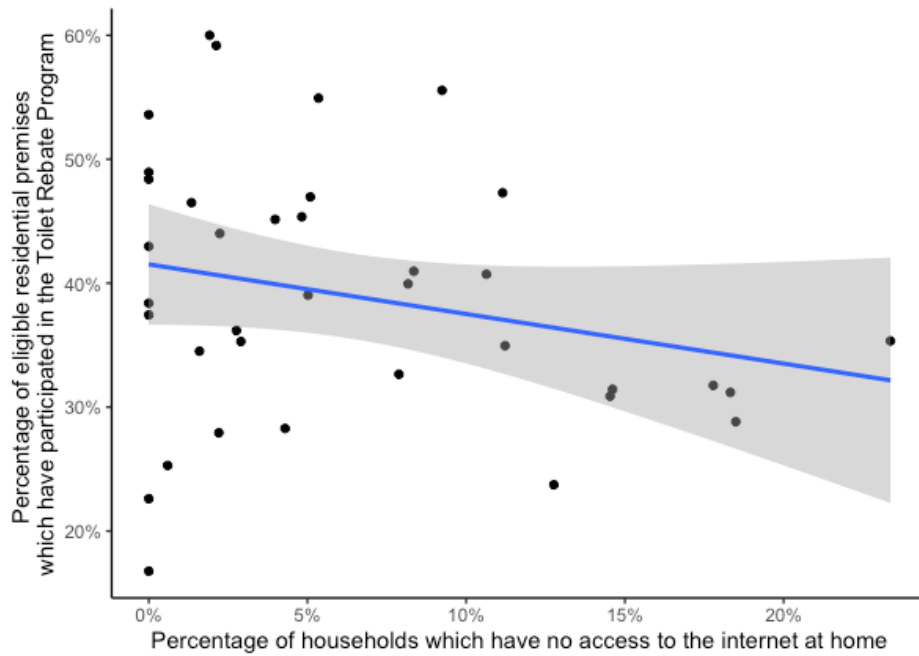


Figure 11. Residential Toilet Rebate Participation by Internet Access (2002-2022)

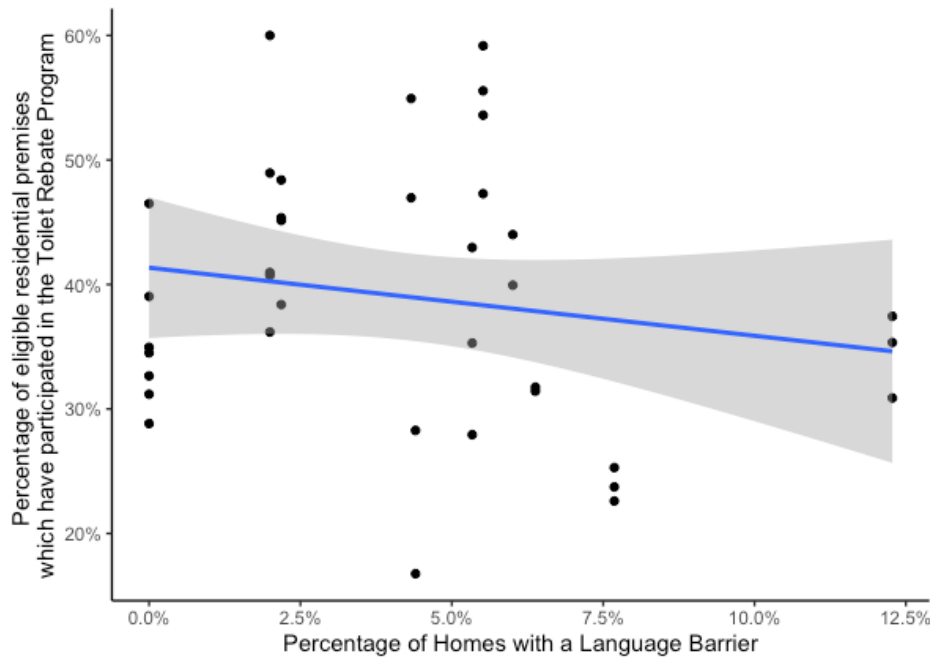


Figure 12. Residential Toilet Rebate Participation by Percentage of Homes with a Language Barrier (2002-2022)

