Basement Flooding in Toronto: Ward-Level Analysis of Service Requests*

Identifying the Need for Proactive Planning Across Toronto Wards throug an Analysis of Basement Flooding and Sewage Service Requests Across Toronto Wards from 2005 to 2022

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This analysis examines basement flooding and sewage service requests across Toronto wards from 2005 to 2022. The study identifies long-term trends and highlights ward-level variations in service requests, providing a clearer picture of which areas are most affected by these issues. The findings emphasize the need for targeted urban planning and infrastructure improvements to mitigate future risks. This work offers valuable insights for city planners and policymakers to better allocate resources and prevent future flooding, in order to enhance urban resilience and prepardness.

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*Code and data are available at: RayanAlim/Toronto_flooding_analysis

1 Introduction

Urban environments face persistent challenges from basement flooding and sewage-related issues, often exacerbated by aging infrastructure, extreme weather events, and accelerated urbanization (City of Toronto 2023). The consequences of these problems are far-reaching, affecting homeowners, businesses, and municipal resources, and demanding focused attention in urban planning and infrastructure development. As Toronto experiences increasing precipitation and more frequent storm events, analyzing the spatial and temporal patterns of basement flooding service requests becomes crucial for informed mitigation strategies and proactive urban planning.

This study examines service requests related to basement flooding and sewage backups in Toronto from 2013 to 2022. The data, sourced from the City of Toronto, encompasses all 25 wards and provides a better view of the geographic distribution and temporal trends of these incidents. By identifying vulnerable areas and trends, this analysis offers essential insights into the most affected wards, enabling city planners to strategically target resources and investments.

Although citywide trends are significant, this paper fills a critical knowledge gap by focusing on ward-level analysis. Understanding how service requests evolve over time and which wards are most impacted enables more effective infrastructure investments and policy decisions.

Preliminary findings indicate that certain wards experience disproportionately high frequencies of flooding, with a notable increase in service requests over the years. These results highlight

the necessity of targeted infrastructure improvements and proactive planning, especially in high-risk areas. This study's can be invaluable for guiding policy-making, resource allocation, and urban planning efforts aimed at mitigating the future risk of basement flooding in Toronto (City of Toronto- BFPP 2023).

The paper is structured as follows: we first provide background on the causes of basement flooding and current prevention measures. Following that, we detail our methodology and data sources. We then present findings focused on temporal trends and ward-level variations, concluding with a discussion of the implications and recommendations for future urban planning in Toronto.

1.1 Causes of Basement Flooding

Several factors contribute to basement flooding in Toronto:

- Heavy rainfall: Extreme precipitation events can overwhelm the city's sewer system, leading to backups and flooding.
- Sewer system overload: During heavy rain, sewers can become overloaded, increasing pressure on the system and potentially causing basement flooding.
- Improper lot grading: If a property's lawn slopes towards the house instead of away from it, rainwater can pool near the foundation and seep into the basement.
- Sump pump failure: In areas built on former marshland, a malfunctioning sump pump can lead to serious flooding damage.
- Sewer line issues: Damaged or clogged sewer lines can cause water to back up into basements.

1.2 Prevention Measures

The City of Toronto has implemented several programs to address basement flooding:

- Basement Flooding Protection Subsidy Program: This program offers homeowners subsidies of up to $3,400 to install flood protection devices.
- Basement Flooding Protection Program: The city is taking steps to reduce the overloading of the sewer system through various infrastructure improvements.
- Mandatory Downspout Disconnection: This initiative aims to reduce the risk of basement flooding by disconnecting downspouts from the sewer system. (City of Toronto- BFPP 2023)

2 Data

2.1 Data Source

This analysis utilizes two primary datasets sourced from the City of Toronto's Open Data Portal (Gelfand 2022). These include:

1. Basement Flooding and Sewage Service Requests: This dataset covers reports of basement flooding and sewage issues from 2013 to 2022 across all 25 Toronto wards.
2. Ward Boundary Shapefiles: Geospatial data defining the boundaries of Toronto's wards, which is essential for conducting spatial analysis.

The context in which this data was collected is tied to both increasing urbanization and the escalating impacts of climate change, which have led to more frequent and intense precipitation events in Toronto. These events, coupled with aging infrastructure, have led to a rise in basement flooding incidents and sewage backups. The City of Toronto collects this data to identify problematic areas, allocate resources efficiently, and guide infrastructure improvement plans aimed at mitigating future flooding risks. The dataset reflects direct reports by residents who experienced flooding, making it an ethically sound form of participatory data that prioritizes public input.

Data management, cleaning, and visualization were carried out using the R language (R Core Team 2023), utilizing the following packages: tidyverse (Wickham et al. 2019), ggplot2 (Wickham 2016), here (Kirill Müller 2020), dplyr (Hadley Wickham 2023), and knitr (Xie 2023).

2.2 Dataset 1- Basement Flooding and Sewage Service Requests

The first dataset records service requests related to basement flooding incidents in Toronto's 25 wards. These service requests are direct reports from residents and businesses experiencing issues such as:

- Blocked Drains: Obstructions in the drainage system causing water to accumulate.
- Sewer Backups: Reverse flow of sewage into buildings due to overloaded or blocked sewer lines.
- Surface Flooding: Accumulation of water on the ground surface resulting from extreme weather events like heavy rainfall.

The basement flooding dataset spans from 2013 to 2022 and includes the following variables (Table 1 provides a sample of the dataset) and Summary Statistics for the dataset are provided in Table 3.

- Ward: Numeric ID for each of the 25 Toronto wards.

Table 1: **?(caption)**

(a) Sample of Basement Flooding Service Requests by Ward (First 5 Rows)

Ward	Ward Name	Year	# of Service Requests
01	Etobicoke North (1)	2005	306
02	Etobicoke Centre (2)	2005	379
03	Etobicoke-Lakeshore (3)	2005	397
04	Parkdale-High Park (4)	2005	230
05	York South-Weston (5)	2005	716

- Ward Name: Descriptive name corresponding to each ward. -Year: The year the service request was made, ranging from 2013 to 2022. -Service Requests: The number of service requests filed in each ward per year, related to basement flooding and sewage issues.

2.3 Dataset 2- Ward Boundaries Shapefile

The second dataset consists of the geospatial boundaries of Toronto's 25 wards in the form of a shapefile. This dataset includes:

- Ward ID: Matching the ward numbers in Dataset 1.
- Geographic Coordinates: Spatial data defining the boundaries of each ward.
- Area Descriptions: Additional metadata about each ward.

2.4 Merging the Datasets

To perform a spatial analysis of the flooding data, the basement flood service request data was merged with the ward boundaries shapefile. This was done using the unique ward ID, creating a combined dataset that links each ward to the corresponding number of service requests for each year.

3 Measurement and Data Considerations

The primary measure used in this analysis is the number of basement flooding and sewage service requests filed by residents and businesses across Toronto's 25 wards from 2013 to 2022. These service requests represent direct reports of flooding incidents, sewer backups, blocked drains, and surface flooding experienced by the public. The number of requests serves as a proxy for flood-related issues in each ward. Geographically, each service request is associated

with one of the 25 wards in Toronto. The ward-level data enables spatial analysis, where wards serve as the primary spatial unit for measuring and comparing the distribution of service requests.

3.1 Limtations of Measurement

The reliance on service requests as a proxy for basement flooding and sewage issues introduces some limitations:

- Reporting Bias: The data captures only reported incidents, meaning that areas where residents are less likely to report issues (due to lack of awareness, access, or trust in municipal systems) may be underrepresented.
- Inconsistent Reporting Practices: Differences in how individuals and businesses report issues across wards could result in varying levels of data accuracy.
- Exclusion of External Factors: The measure does not account for external variables that could influence flooding (e.g., rainfall intensity, land use changes, or infrastructure conditions). Future studies should integrate these factors to improve the explanatory power of the data.

3.2 Ethical Considerations

The use of service requests as data raises ethical considerations, particularly around equitable access to city resources and reporting mechanisms. The data inherently reflects reporting bias: it is more likely to capture incidents from residents who have knowledge of and access to reporting systems, potentially underrepresenting marginalized or low-income communities. This bias must be acknowledged when interpreting the results. The City of Toronto collects and makes this data available with the intent to improve service delivery, but it is important to ensure that policy decisions based on this data do not inadvertently prioritize areas with higher reporting rates over areas with significant but underreported needs.

3.3 Justificatin for data selection

While alternative datasets such as rainfall records, soil drainage data, or infrastructure quality reports could have been considered, the focus on service requests offers a direct measure of citizen-reported issues. This aligns with the goals of this analysis: identifying specific areas for targeted governmental intervention based on actual reported incidents, which is more actionable for policy and infrastructure planning.

4 Data Characteristics

4.1 Summary Statistics

Summary Statistics of the data, arranged by average number of requests between 2005 and 2022:

4.2 Overall Trends

The overall trend in the number of basement flooding and sewage service requests from 2005 to 2022 is depicted in Figure 1 The data reveals significant fluctuations in service requests over time, with notable spikes in certain years, often correlating with major storm events or other extreme weather conditions.

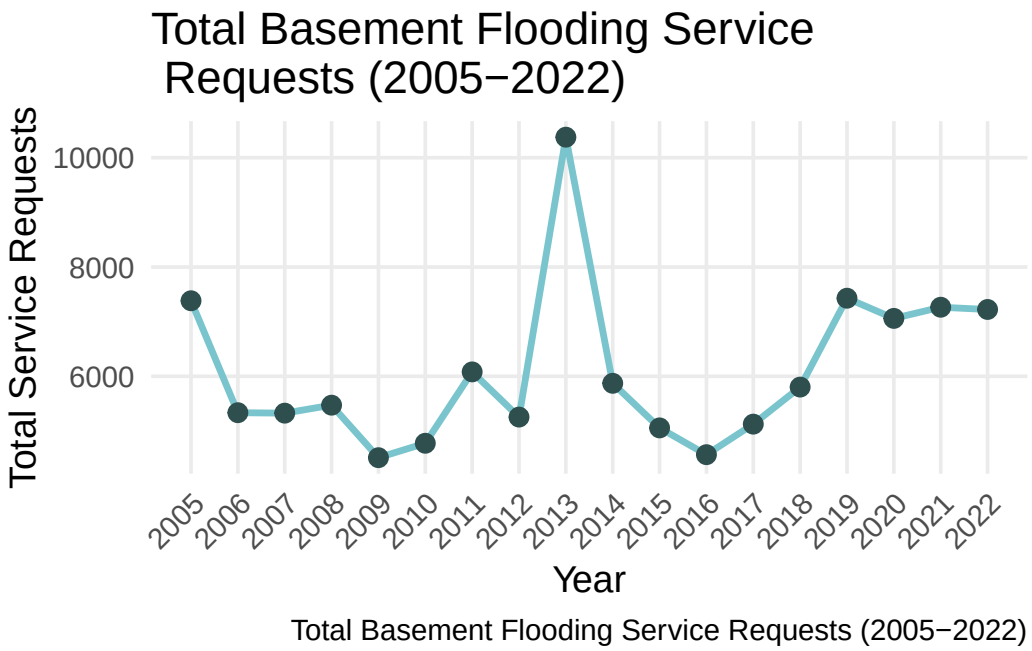

Figure 1: Total Basement Flooding Service Requests (2005-2022)

4.3 Ward-Level Analysis

Figure 2 illustrates the total number of service requests by ward between 2005 and 2022. Certain wards, such as Ward 9 and Ward 13, stand out for consistently reporting higher levels of service requests compared to others. This disparity may reflect variations in local infrastructure, geographic factors, and maintenance practices across wards.

Table 3: **?(caption)**

(a) Summary Statistics of Service Requests by Ward (2005–2022)

Ward Name	Total Requests	Average Requests	Max Requests
Beaches-East York (19)	7027	390	666
Scarborough-Agincourt (22)	6613	367	829
Scarborough Southwest (20)	6507	362	475
Etobicoke North (1)	5434	302	621
Toronto-St. Paul's (12)	5297	294	448
Don Valley North (17)	5099	283	597
Parkdale-High Park (4)	4806	267	616
Etobicoke Centre (2)	4763	265	469
Davenport (9)	4712	262	398
Etobicoke-Lakeshore (3)	4666	259	446
Willowdale (18)	4533	252	802
Don Valley West (15)	4455	248	498
Scarborough-Guildwood (24)	4224	235	464
University-Rosedale (11)	4059	226	675
York Centre (6)	4039	224	622
Don Valley East (16)	4013	223	472
Scarborough Centre (21)	3831	213	470
Scarborough-Rouge Park (25)	3791	211	383
York South-Weston (5)	3747	208	716
Eglinton-Lawrence (8)	3584	199	255
Spadina-Fort York (10)	3271	182	261
Toronto Centre (13)	3194	177	301
Toronto-Danforth (14)	2952	164	352
Scarborough North (23)	2708	150	416
Humber River-Black Creek (7)	2585	144	262

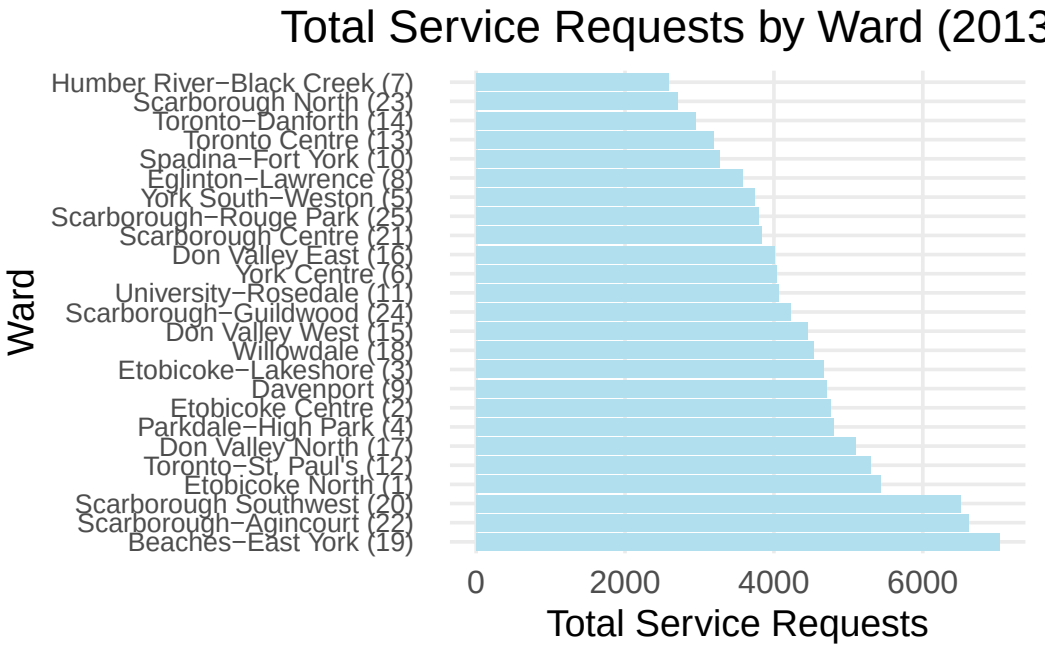

Figure 2: Total Service Requests by Ward (2013-2022)

5 Discussion

5.1 Increasing service requests

The data shows that service requests have fluctuated over time, with certain years experiencing significant spikes, often associated with severe weather events, such as major storms or rapid snowmelts. This indicates that extreme weather plays a key role in basement flooding and sewage issues. Understanding these temporal trends is critical for planning future infrastructure resilience and proactive flood management strategies.

5.2 Ward-Level Service Disparities

Wards show distinct variations in the number of service requests, with some reporting consistently higher rates. For instance, Wards 9 and 13 have reported a higher volume of service requests over the years, potentially due to aging infrastructure, geographic vulnerabilities (e.g., low-lying areas), and proximity to water bodies. These disparities highlight the need for tailored infrastructure solutions and more localized planning efforts to address ward-specific challenges.

5.3 Need for Forecasting Future Flood Risks

Predictive models based on historical data can help city planners anticipate future flooding incidents and prioritize investments in infrastructure upgrades. If current trends continue, certain wards may experience unsustainable levels of service demands. Investing in modern drainage systems, proactive maintenance, and flood prevention measures, particularly in the most affected wards, will enhance the city's resilience to future climate risks.

5.4 Weaknesses and next steps

The analysis is limited by the exclusion of external variables such as rainfall patterns, urbanization rates, and population growth, which likely influence service request trends. Future studies should integrate these variables to develop a better understanding of the causes behind the fluctuations in service requests. Additionally, analyzing data at a more granular level (e.g., monthly service requests) could uncover seasonal trends and improve the city's preparedness for flood risks.

Next steps are to make models that incorporate both infrastructure data and climate projections.

A Appendix

A.1 Data Cleaning Process

The raw basement flooding dataset was cleaned as follows: - Unnecessary Rows: Removed rows containing metadata and empty values that were not informative for the analysis. - Column Names: Standardized column names to ensure clarity and consistency. - Data Transformation: The data was transformed from a wide format (with years as columns) to a long format, where each row corresponds to a ward-year combination. This simplified the analysis of trends over time. - Filtering: Non-numeric values in the "Year" column were removed, and both the "Year" and "Service Requests" columns were converted to integer types for accurate analysis.

For the shapefile dataset:

- Unnecessary Columns: Removed irrelevant metadata, effective and expiry dates, and other feature descriptions that were not required for analysis.
- Data Type Adjustments: Converted the unique ward ID to an integer type, allowing it to be merged with the service request data for spatial analysis.

References

City of Toronto. 2023. "Basement Flooding Protection." https://www.toronto.ca/services-payments/water-environment/managing-rain-melted-snow/basement-flooding/.

City of Toronto- BFPP. 2023. "Basement Flooding Protection Program." https://www.toronto.ca/services-payments/water-environment/managing-rain-melted-snow/basement-flooding/basement-flooding-protection-program/.

Gelfand, Sharla. 2022. "Access the City of Toronto Open Data Portal." https://sharlagelfand.github.io/opendatatoronto/.

Hadley Wickham, Lionel Henry, Romain François. 2023. *Dplyr: A Grammar of Data Manipulation*. https://CRAN.R-project.org/package=dplyr.

Kirill Müller, Jennifer Bryan. 2020. *Here: A Simpler Way to Find Your Files*. https://CRAN.R-project.org/package=here.

R Core Team. 2023. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Wickham, Hadley. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. https://ggplot2.tidyverse.org.

Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D'Agostino McGowan, Romain François, Garrett Grolemund, et al. 2019. "Welcome to the tidyverse." *Journal of Open Source Software* 4 (43): 1686. https://doi.org/10.21105/joss.01686.

Xie, Yihui. 2023. *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. https://yihui.org/knitr/.