Stormwater Fee Simulator for New York City

AN INTERACTIVE MODELING TOOL TO ESTIMATE REVENUE & FEE IMPACTS UNDER MULTIPLE POLICY SCENARIOS

July 2019

This report describes an interactive analytical tool, developed by Valor Water for Riverkeeper and Natural Resources Defense Council (NRDC), that assesses the impacts of potential stormwater fee structures on ratepayers that could be considered in New York City.

About Valor Water Analytics – A Xylem Company

Valor Water Analytics is the leading provider of meter analytics and rates analysis software for the water industry. Our technology is unique, state-of-the-art and developed jointly with a leading research university. Our analytics, algorithms and technology are built upon 15 years of water-specific economics and revenue management research. We employ data scientists, software engineers, economists, and other water professionals to deliver Valor's award-winning products.

Acknowledgements

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EXECUTIVE SUMMARY

Municipalities across the United States are working to reduce the amount of polluted stormwater and wastewater that flows into their local waterways. In New York City, controlling combined sewer overflow events that result in urban runoff into New York Harbor and its tributaries falls under the mandate of the New York City Department of Environmental Protection (DEP). According to the *2017 New York City Harbor Water Quality Survey Report* (DEP, 2017), continued improvements to New York's 14 wastewater treatment plants, and ongoing investments, have resulted in an 80% reduction in combined sewer overflows since the mid-1980s.

However, as municipal governments begin to think concretely about how to achieve their regulatory and water quality goals, developing ways to pay for the needed infrastructure improvements poses a challenge. This research project aims to simulate a stormwater fee for New York City. Utilizing publicly available data, we present a policy simulation model to illustrate strategic choices that New York City could make to initiate stormwater fees and stormwater mitigation programs that can help convert the stormwater management challenge into an opportunity to fund and build infrastructure, equitably apportion stormwater management costs, create jobs, and invest in improvements across the five boroughs.

This report describes an interactive analytical tool, developed by Valor Water for Riverkeeper and Natural Resources Defense Council, that assesses the impacts of potential stormwater fee structures on ratepayers that could be considered in New York City. The purpose of the project is to inform policymakers and the general public in New York City about the implications of restructuring the city's water and wastewater charges to create a separate stormwater fee based on parcel-specific factors that correlate to the amount of stormwater a property generates.

The interactive rate modeling tool focuses especially on the distributional effects of alternative stormwater fee designs by examining how the total water, wastewater, and stormwater bill would change for customers falling into various land use categories. This allows for analysis of the equity implications of adopting a stormwater fee.

Key findings of the report include the following:

A stormwater utility introduces new customers to DEP, namely, unmetered properties, which impacts customer bills and the composition of utility revenue.
A key change under a stormwater utility is that property-level characteristics impact not only the stormwater bill, but which types of properties are considered utility customers. Under the stormwater

fees modeled here, all properties with impervious surface are considered stormwater utility customers. This increases the amount of utility customers from the current roughly 765,000 metered customers to 854,400 customers (metered and nonmetered), an increase of 11.6%. The new unmetered stormwater customers only pay stormwater fees, however, all unmetered properties, regardless of land use category, would see larger increases in their bills than would the averaged metered property, because they receive no bill at all under the current rate structure.

For example, although the average metered customer in the Transportation & Utility and Vacant Land categories would see a decrease in their bill in every stormwater fee scenario modeled here, unmetered properties in those land use categories would see significant increases in their bills. While these land use categories currently account for a negligible share of total utility revenues, they would account for a significant share of stormwater revenue and a much larger share of total utility revenue under any stormwater fee scenario.

Introducing a stormwater fee can reduce costs for homeowners and owners of multi-family buildings.
Multi-family properties see a decrease in their average monthly bills in every stormwater fee scenario modeled in the tool. This is because some of the costs borne by these customers under the current rate structure would be shifted to non-residential customers with larger, more highly-impervious properties.

For example, using DEP's 2016 total revenue needs, and assuming that 10% of that amount is associated with DEP's stormwater management expenses, the average monthly bill for multi-family customers would decrease by $81 to $151 per month (or about $1,000 to $1,800 annually), depending on which stormwater fee design is selected and whether or not a building participates in the Multifamily Conservation Program. This amounts to a savings of about 6% to 8%. If total revenue needs or the share of DEP's revenue needs associated with stormwater are increased, the savings between a stormwater fee rate structure and the status quo rate structure become larger.

Under many of the scenarios modeled in the tool, one- to three-family customers would also see lower average monthly bills. For these customers, the specific stormwater fee design can make the difference between a savings (ranging from $1 to $12 per month) or a bill increase (ranging from $1 to $9 per month). In general, one- to three-family homeowners fare best when a stormwater fee is based on gross area and land use, rather than on impervious area and roadways are treated as stormwater customers. However, some stormwater fee designs yield savings for these customers even when roadway costs are allocated to ratepayers.

It is important to note that customer assistance programs can provide a buffer against bill increases for low-income households, and that a stormwater fee structure can provide an incentive for homeowners to install green infrastructure to lower their bills.

For 1-, 2-, and 3-family residential properties, average stormwater fees do not differ between the "Impervious area" and "Impervious area with flat fee" policy selections, although the fees of individual residential properties may differ.
The impervious area policy option simulates the stormwater fees based on the impervious area of properties. The impervious area based fee policy is based on the concept of Equivalent Residential Unit (or ERU), which is the most common approach according to a national survey by Western Kentucky University (2018); Whereas the impervious area with flat residential policy is a slight variation of the

impervious area policy, in the flat fee policy alternative, residential households are charged a flat rate based on 1 ERU while all other customers pay on a per ERU basis.

The original intention to model the impervious area with flat residential policy was to replicate a policy mentioned in the 2014 Black & Veatch Stormwater Survey (2014), but it turns out that, under a stormwater fee design without a flat residential fee, the average stormwater fee for one-, two-, and three-family dwellings would all correspond almost exactly to 1 ERU, or 2,438 square feet. Therefore, due to the way we define the policies, there is not a material difference in the resulting average monthly fees, or revenue distribution, between the two policy options.

There is also no material difference in the total amount of revenue contribution for each of the residential customer classifications.

However, the choice of whether to use a flat residential fee, as part of an impervious area-based fee structure, would likely still have effects on costs for individual properties. The interactive tool is unable to quantify these differences because the tool's underlying data sources do not include information on the distribution of sizes of properties within each land use category. If that information were available, it would be expected to show that, with a flat fee, one- to three-family residential properties with the largest impervious area (e.g., those with driveways, as is the case in many neighborhoods outside of Manhattan) would pay less, and one- to three-family residential properties with the smallest impervious footprints (e.g., those without driveways) would pay more, than they would under the pure "impervious area-based" option without a flat fee.

Roadway stormwater management cost policy selection greatly affects model outputs and average customer bills.
The inclusion of policy options for "roadway costs allocated to ratepayers" and "roadways pay" is based upon research indicating that not all utilities charge the owners of public roads and sidewalks for the stormwater mitigation costs associated with those spaces. The 2014 Black & Veatch survey states that approximately 37% of United States' stormwater utilities charge roadways for their share of contribution to stormwater mitigation costs. As shown in the model outputs, stormwater fees per customer vary significantly depending on who pays for roadways. This change can be as high as a 20% increase for single residential households under the "roadway costs allocated to ratepayers" policy as compared to the "roadways pay" policy.

Land use classifications determine winners and losers.
Winners and losers in the policy scenarios presented are mainly determined by the type of land use classification the customer falls under. Irrespective of policy choice, average bills would decrease for metered customers in the following land use categories: *Multi-Family Buildings excluding MCP; Multi-Family Buildings under MCP; Mixed Residential & Commercial Buildings; Residential Institutions; Hotels, Hospitals and Health; Stores*; *Office Buildings;* and *Transportation & Utility*. On the other hand, average bills would increase for metered customers in the following categories: *Public Facilities & Institutions; Educational Structures; Parking Facilities; Industrial & Manufacturing Buildings; Open Space & Outdoor Recreation;* and *Roadway and Sidewalk* categories, under any combination of policy choices. The only two land use types for which the choice of policy itself determined whether the average metered customer's bill would see an increase or decrease were *Tax Class 1 - One Family Dwellings* and *Vacant Land*.

Increasing the "total utility revenue" magnifies the distributional impacts of adopting a stormwater fee structure.
The default total utility revenue need of $4 billion is based (approximately) on DEP's 2016 budget. In reality, DEP's revenue needs increase every year, reflecting both increased operational costs and the need for significant new capital investment to improve existing infrastructure. When the user selects an increase in total utility revenue needs, the impacts of a shift from the current rate structure to a new stormwater fee structure increase proportionately. In other words, with a higher utility revenue need, any given stormwater fee scenario results in proportionately larger shifts in revenue distribution among land use categories, and proportionately larger increases or decreases in average bills for properties in each land use category. Conversely, if total utility revenue needs increase but the rate structure remains unchanged, rate increases will magnify current inequities among customers.

Increasing the "stormwater percentage of total utility revenue" magnifies the distributional impacts of adopting a stormwater fee structure.
The default setting in the tool is that stormwater management costs account for 10% of total utility revenue needs. This is the low-end of a rough estimate that DEP developed in 2009. If the user makes a selection closer to the higher-end of DEP's estimate (15% or 20%), the magnitude of redistribution in costs among land uses and changes in average bills for each land use increases proportionately for any given stormwater rate structure, as compared to the status quo rate structure.

The key findings summarized above highlight and reinforce findings for stormwater fee policies in comparable urban areas. Namely, policy choices impact distribution of revenue and customer bill amounts in significant ways. Stormwater fees redistribute revenue to different land use types (customers) according to parcel-level characteristics, with the underlying logic that significant contributors to stormwater-related pollution costs should pay a higher portion for the stormwater treatment costs.

This results in policy winners, customers whose monthly bill decreases, and policy losers, customers whose monthly bill increases. However, adopting a stormwater fee also creates an opportunity to reduce the amount of impervious surface by offering fee credits for green infrastructure retrofits. These credits can reduce or offset bill impacts for participating customers, while spurring green infrastructure investments by private-property owners and helping the city achieve sustainability and stormwater management goals.

BACKGROUND

Municipalities across the United States are working to reduce the amount of polluted stormwater and wastewater that flows into their local waterways. In New York City, controlling combined sewer overflow events that result in urban runoff into New York Harbor and its tributaries falls under the mandate of the New York City Department of Environmental Protection (DEP). According to the *2017 New York City Harbor Water Quality Survey Report* (DEP, 2017d), continued improvements to New York's 14 wastewater treatment plants, and ongoing investments, have resulted in an 80% reduction in combined sewer overflows since the mid-1980s.

However, as municipal governments begin to practically consider how to achieve their regulatory and water quality goals, developing ways to pay for the needed infrastructure improvements poses a challenge. This research project aims to simulate a stormwater fee for New York City. Utilizing publicly available data, we present a policy simulation model to illustrate strategic choices that New York City could make to initiate stormwater fees and stormwater mitigation programs that can help convert the stormwater management challenge into an opportunity to fund and build infrastructure, equitably apportion stormwater management costs, create jobs, and invest in improvements across the five boroughs.

DEP utility customers currently pay a volumetric water fee based on their metered potable water consumption. They also pay a wastewater fee. Wastewater rates are set equal to one hundred fifty-nine percent (159%) of each customer's water charges, including any surcharges, aside from a few special cases. Currently, a portion of total wastewater fee revenue is used to pay for the city's stormwater management expenses. However, the use of water and wastewater fees to pay for stormwater costs may not be the most equitable and efficient manner to allocate the costs across customers. This is because the demands placed on the stormwater system by customers are not related to customers' potable water use; rather, these fees are better aligned with impervious surface area, design attributes of the developed property, and other factors. Many of these costs to treat and control stormwater arise directly from the City's obligations under state and federal law to reduce sewage overflows and stormwater pollution.

DEP manages stormwater through two types of systems: a combined sewer system (CSS), and a municipal separate storm sewer system (MS4). In the CSS, polluted stormwater runoff mixes with

sewage and is sent to sewage treatment plants. During significant rainfall, the mixture overwhelms treatment capacity and is discharged untreated into city waterways. These discharges are called combined sewer overflows (CSOs). In other parts of the city, the MS4 permitting system calls for the collection, conveyance, and discharge of stormwater through stormwater collection systems separate from the sewage collection systems. Stormwater poses significant challenges by triggering CSOs, disrupting sanitary sewage treatment processes, carrying pollution from developed areas into nearby surface waters, and causing flooding.

This research project aims to examine alternative stormwater rate structures that could more equitably support New York City's sustainable management of stormwater into the future. It could be considered that such a clearly defined stormwater rate policy framework may help to define stormwater service as a "third utility service."

This project was jointly commissioned by Riverkeeper and Natural Resources Defense Council to inform policymakers, key stakeholders, and the general public in New York City about the implications of restructuring the city's water and wastewater charges to create a separate stormwater fee based on parcel-specific factors that correlate to the amount of stormwater a property generates. Valor Water Analytics developed an interactive analytical tool to assess the impacts on New York City ratepayers of potential stormwater fee structures. This tool focuses especially on the distributional effects of alternative stormwater fee designs by examining how the total water, wastewater, and stormwater bill would change for customers falling into various land use categories. We also examine how the distribution of utility fee revenue across New York City utility customers changes between the current structure (water and wastewater fees) and a future structure with water, wastewater, and stormwater fees. This allows for an analysis of the equity implications of adopting a stormwater fee.

METHODOLOGY

Riverkeeper and Natural Resources Defense Council contracted with Valor Water Analytics, a nationally recognized expert in water, wastewater, and stormwater rate analytics, to develop a stormwater fee policy scenario assessment tool to accomplish the goals described above. The main project deliverable is a web-based interactive dashboard that allows users to select policy inputs and alternative policy scenarios to test the resultant impacts on DEP customer

groups. The interactive dashboard can be accessed at https://www.nrdc.org/resources/equitable-water-rates-new-york-city-charging-stormwater.

This section describes the data inputs, the interactive tool, and the alternative policy selection process utilized to develop this tool. Additional technical documentation is located in Appendix A.

Data

These analyses and dashboard tools were necessarily constrained by the availability of accurate and sufficiently granular data to generate the high-level policy alternative scenarios described in this report. We only had access to public data; therefore, stormwater-specific infrastructure and operation and maintenance cost data is not included in these analyses. A full reference list is included in the back of the report. Data sources utilized include:

- Citywide Primary Land Use Tax Lot Output (PLUTO) Analysis by Land Use Classification;
- 2017 New York City Certified Annual Financial Report;
- 2009 stormwater cost allocation data, based on 2009 DEP Stormwater Rate Study;
- 2009 revenue requirement data. Based on 2009 DEP Stormwater Rate Study;
- Fiscal Year 2017 DEP Water and Sewer Rates; and
- DEP Customer Assistance data.

Utility Rate Modeling Practices

This analytical model follows industry standards for water and wastewater rate modeling, based on best practices set forth in the American Water Works Association's *M1: Principles of Water Rates, Fees, and Charges*, 7th Edition (2017). Utility rate setting and revenue forecasting is a multi-step process that includes:

1. Determination of system revenue requirements;
2. Functional allocation of costs;
3. Attribution of functionally allocated costs to specific customer classes or individual customers;
4. Design of rates and charges.

This policy simulation tool develops rates under a number of policy scenarios and creates outputs related to step number four in the process, design of rates and charges. The tool goes

further to estimate financial impacts on different customer classes for each policy scenario. A revenue neutrality constraint is imposed on the modelled rates so that the total system revenue remains constant, while the distribution of fees across customer groups and across water, wastewater, and stormwater utilities changes. The number of customers under a stormwater utility also changes as only buildings with meters are currently charged for water and wastewater, while lots and buildings without meters are included as new utility customers in the stormwater fee scenarios.

In regard to revenue neutrality, each policy scenario compares the financial impacts on customer classes for a given level of total utility revenue needs, under the status quo rate structure and under the hypothetical stormwater fee parameters selected by the user. The total utility revenue need is set at a baseline of $4 billion, based approximately on DEP's 2016 budget of $3.887 billion plus a 2.94% adjustment to account for accruals, rounding, and other factors (New York City Municipal Water Finance Authority, 2017). The user may select a higher revenue need to simulate future, higher budgets reflecting the need for new capital investment to improve existing infrastructure.

Scenario Selection Process

To select the fee parameters and policy scenarios for analysis, Valor Water Analytics facilitated a multi-party workshop to discuss policy parameters and scenarios and select those for inclusion in the *Stormwater Fee Simulator* dashboards. The August 2017 workshops included participants from Riverkeeper, Natural Resources Defense Council, New York City Soil & Water Conservation District, Pratt University and the University Neighborhood Housing Program. After Valor completed an initial version of the interactive tool, peer review feedback was gathered from experts at most of those same organizations, as well as from the New York City Department of Environmental Protection, the University of North Carolina Environmental Finance Center, and PennFuture. The policy parameters and scenarios were revised further based on the peer reviewers' comments. See Appendix A for technical documentation of the scenarios and methodologies, including identification of all data sources and assumptions.

Interactive Tool Description

The main analytical tool for this project is a set of web-based dashboards built using Tableau software. This software allows users to select from a range of stormwater fee policy options and compare outcomes under each scenario. Impacts can be assessed between the various policy options, and in reference to the status quo utility fee revenue distribution and customer impacts. The dashboards are designed to explore specific policy questions, namely:

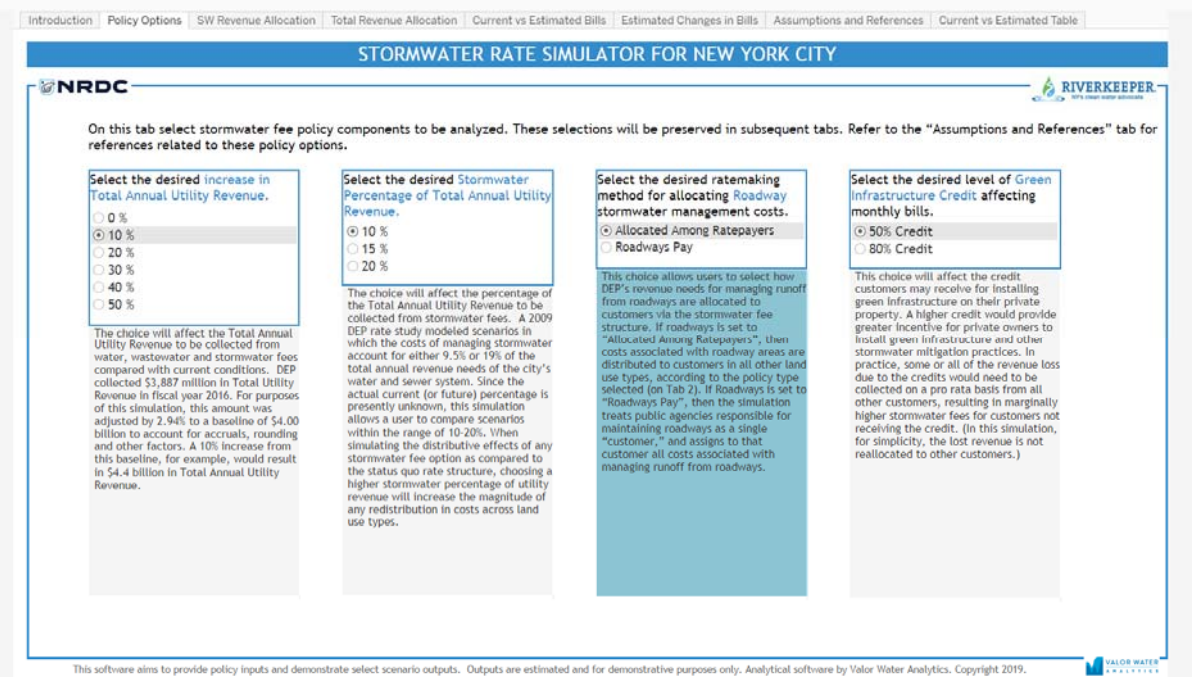
- How do the selected policy options affect the distribution of utility fee revenue across New York's various land use classifications?
- How do the selected policy options affect the average customer bill, with customers defined per land use classification?[1]

This stormwater policy scenario assessment tool has two main components: First, the *Stormwater Fee Policy Options Dashboard* allows for users to select from four policy option sets. Each policy option set is based on our survey of current stormwater fee practices from other large utilities across the United States (see references for Black and Veatch 2014 and Western Kentucky University 2018). When the users log in, they click to access the Policy Options page (see Figure 1 below). This dashboard tab provides four user input policy option selections:

- Different utility fee target revenue increase scenarios;
- Different selections for stormwater revenue as a percent of total utility revenue;
- Selection determining who pays for roadway stormwater management; and
- Selection for level of credits for on-site green infrastructure improvements (e.g. green roof, retention, detention) that reduce the level-of-service requirement for stormwater runoff from a specific property.

[1] New York City's Land Use Classifications are listed and described in Appendix A, Table A1.

FIGURE 1. STORMWATER FEE POLICY OPTIONS DASHBOARD SCREENSHOT



Second, a set of *Stormwater Fee Revenue and Customer Bill Impact Assessment Dashboards* (see Figure 2) takes the policy inputs selections made on the *Policy Options Dashboard* to estimate broadly defined revenue distribution and average customer bill impacts, as compared to revenue distribution and customer bills under the status quo rate structure. When the user selects an increase in total annual utility revenue over the baseline of $4 billion, the Dashboards incorporate that total revenue need into both the status quo scenario and the stormwater fee scenarios, in order to show the effects of a revenue-neutral change from the current rate structure to a new rate structure that includes a stormwater fee.

The user can select additional policy options on this tab. Specifically, the user chooses the stormwater fee type, either: 1) stormwater fee calculated according to impervious area of the property; or 2) stormwater fee calculated according to gross area of the property and land use type (which is less data-intensive for a utility to implement than a fee based on the impervious area of each individual property). Each of these two options has additional sub-options. For the impervious area-based fee, the user can select an option that charges a flat fee to all 1- to 3-family properties, based on the characteristics of an average property of that type. For the gross area/land use option, the user can select among four different "multipliers" that differentiate the per square foot charge between different land use categories, all based on the premise that some land uses are more highly impervious and/or generate higher stormwater pollutant loads than others.

Two examples of the dashboard depicting revenue distribution per land-use type under the selected policy options are shown below in Figures 2A and 2B. 2A depicts the percent of stormwater revenue attributable to each land use type, while Figure 2B shows the percent of total utility revenue contributed by each land use type.

FIGURE 2, A & B. REVENUE IMPACT ASSESSMENT DASHBOARD SCREENSHOTS: DISTRIBUTION OF STORMWATER REVENUE AND TOTAL REVENUE BY LAND USE TYPE

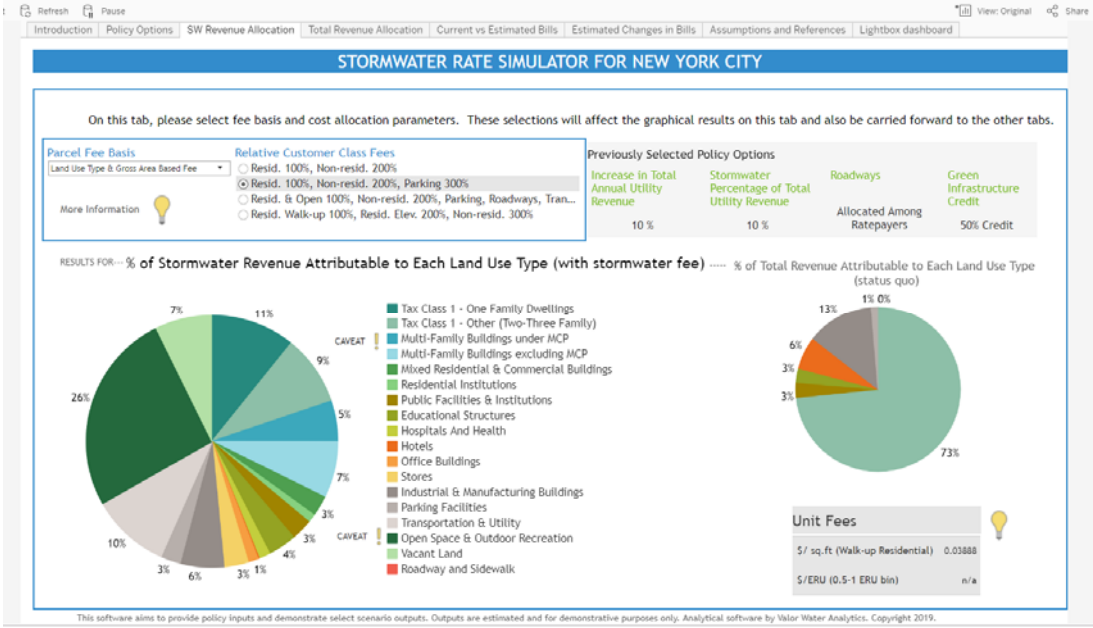


FIGURE 2A: % OF STORMWATER REVENUE PER LAND USE TYPE

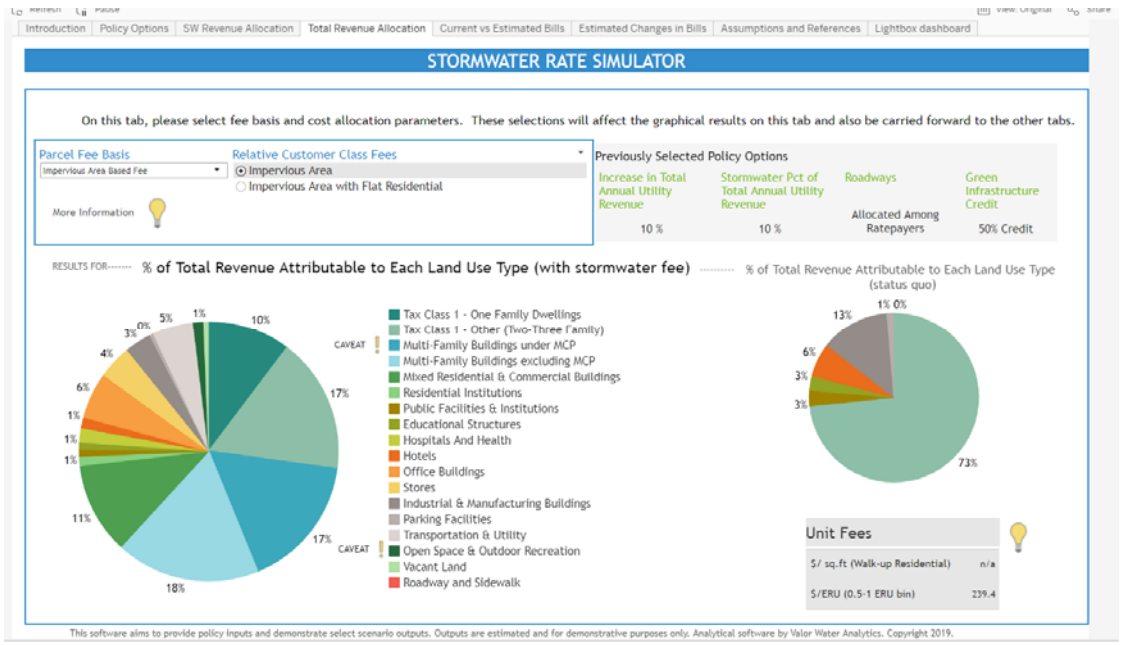


FIGURE 2B: % OF TOTAL UTILITY REVENUE BY LAND USE TYPE

The Dashboard presents the following impacts for any selected stormwater fee scenario:

- Distribution of stormwater fee revenue and total utility revenue across each land use classification for the selected stormwater policy option scenario, as compared to the status quo distribution of total utility revenue (see Figure 2, A & B);
- Average metered and unmetered customer bill (including water, wastewater, and stormwater line items) and total utility revenue for each land use classification under the status quo rate structure and the selected stormwater policy option scenario (see Figure 3); and
- Monthly impact on the average metered customer's total bill, for each land use classification, in the selected stormwater policy option scenario versus the current rate structure (see Figure 4).

FIGURE 3. DASHBOARD SCREENSHOT: AVERAGE CUSTOMER BILLS AND TOTAL UTILITY REVENUE PER LAND USE CATEGORY.

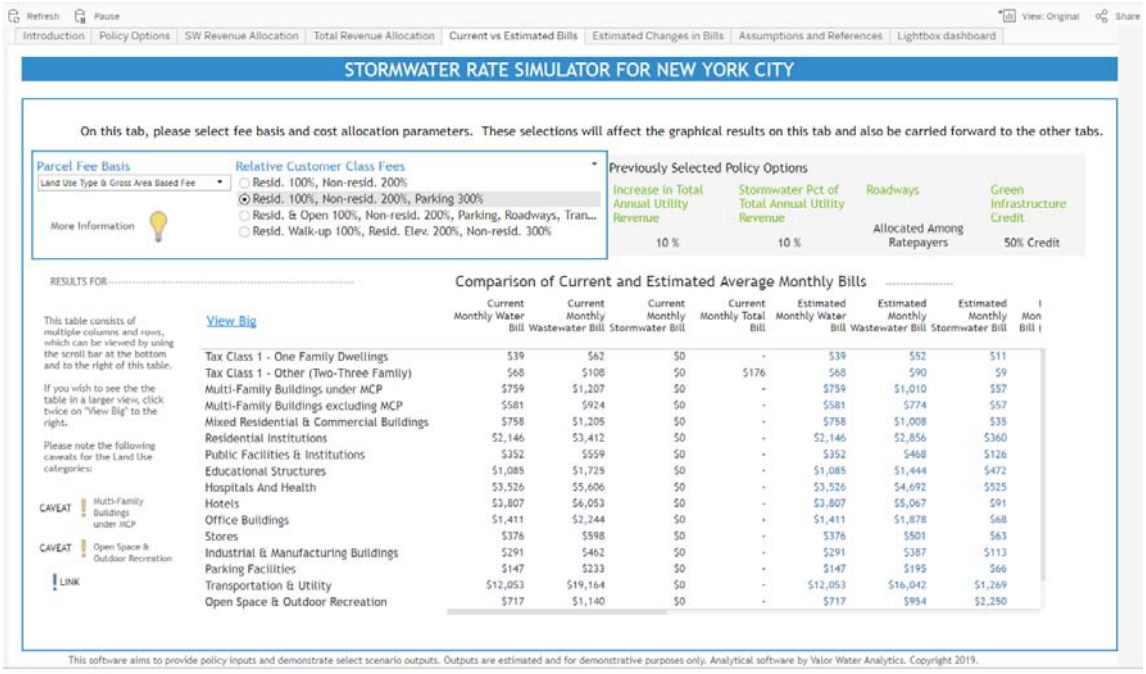
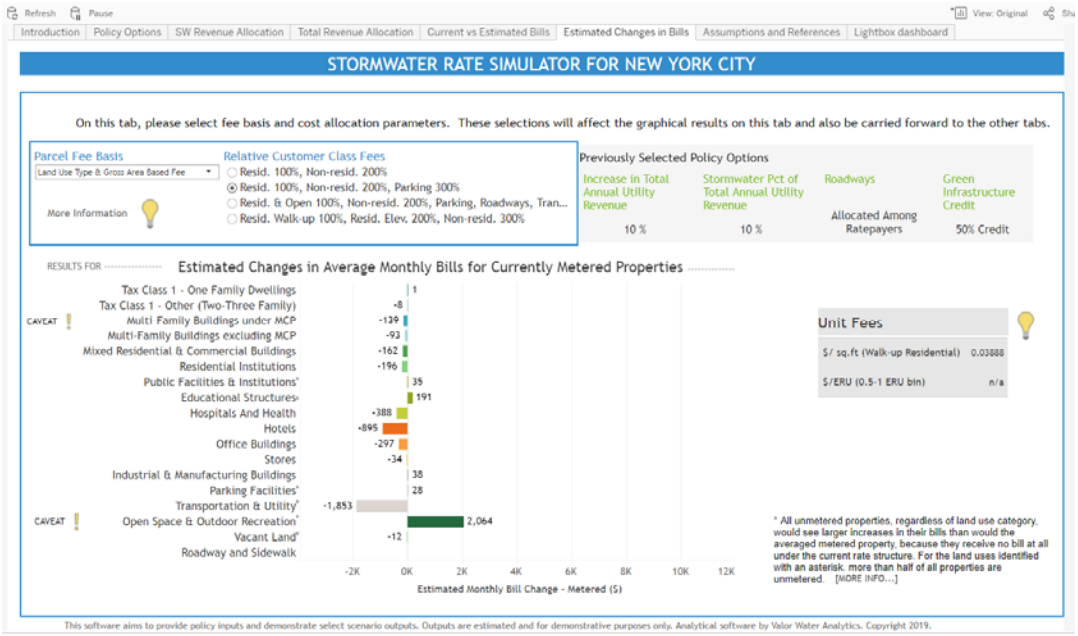


FIGURE 4. DASHBOARD SCREENSHOT: CHANGES IN AVERAGE TOTAL UTILITY BILL PER LAND USE CATEGORY (METERED CUSTOMERS ONLY)



Finally, the interactive tool provides the detailed technical methodology (labeled as "Assumptions and References"), which is also provided in Appendix A of this report.

Basis for Calculating Average Bills

The average stormwater bill in the interactive tool corresponds to a customer with the average gross area and impervious area across all properties in a given land use category. See Table 1 below. Although the tool does not allow a user to simulate directly the stormwater bills for properties that are larger or smaller than average, a user can manually calculate, outside of the tool, the stormwater fee for another hypothetical property by comparing the amount of the property's gross or impervious area to that of the average property.[2]

[2] Specifically, when using the model to simulate the a stormwater fee based on "land use type and gross area," the stormwater bill for a hypothetical property can be derived by calculating the ratio of the property's gross area to that of the average customer in the same land use category, and multiplying the average bill by that ratio. Similarly, when using the when using the model to simulate the a stormwater fee based on "impervious area," the stormwater bill for a hypothetical property can be derived by calculating the ratio of the property's impervious area to that of the average customer in the same land use category, and multiplying the average bill by that ratio; however, when the "impervious area with flat fee" option is selected, the stormwater bill for a 1-, 2-, or 3-family residential property would remain the same regardless of the amount of impervious area on the property.

TABLE 1. AVERAGE CUSTOMER GROSS AND IMPERVIOUS AREA, SQUARE FEET

Land Use Type	Gross Area Per Customer (Sq Ft)	Impervious Area Per Customer (Sq Ft)
Tax Class 1 - One Family Dwellings	3,463	2,442
Tax Class 1 - Other (Two-Three Family)	2,863	2,433
Multi-Family Buildings under MCP	8,834	7,459
Multi-Family Buildings excluding MCP	8,834	7,459
Mixed Residential & Commercial Buildings	5,357	5,035
Residential Institutions	55,491	34,686
Public Facilities & Institutions	19,401	14,602
Educational Structures	72,805	55,712
Hospitals And Health	81,097	48,346
Hotels	14,018	13,200
Office Buildings	10,513	9,870
Stores	9,728	9,339
Industrial & Manufacturing Buildings	17,502	15,667
Parking Facilities	6,749	6,254
Transportation & Utility	195,766	141,925
Open Space & Outdoor Recreation	347,232	111,292
Vacant Land	11,266	3,942
Roadway and Sidewalk	1,958,742,043	1,906,193,027

The average water and wastewater bills, for metered customers correspond to a customer with average metered water use for each land use category; for unmetered customers (except apartment buildings in the Multi-Family Conservation Program), the average water and wastewater bill is zero. The average total bill for a land use classification is the sum of the average water, wastewater, and stormwater bills. This is calculated separately for metered and unmetered customers, as shown in the interactive tool on the tab labeled “Current vs. Estimated Bills.”

KEY FINDINGS

There are many hundreds of possible inputs and thus, the key findings summarized here are indicative of model outputs but do not represent the full set of potential findings from this tool. Users of

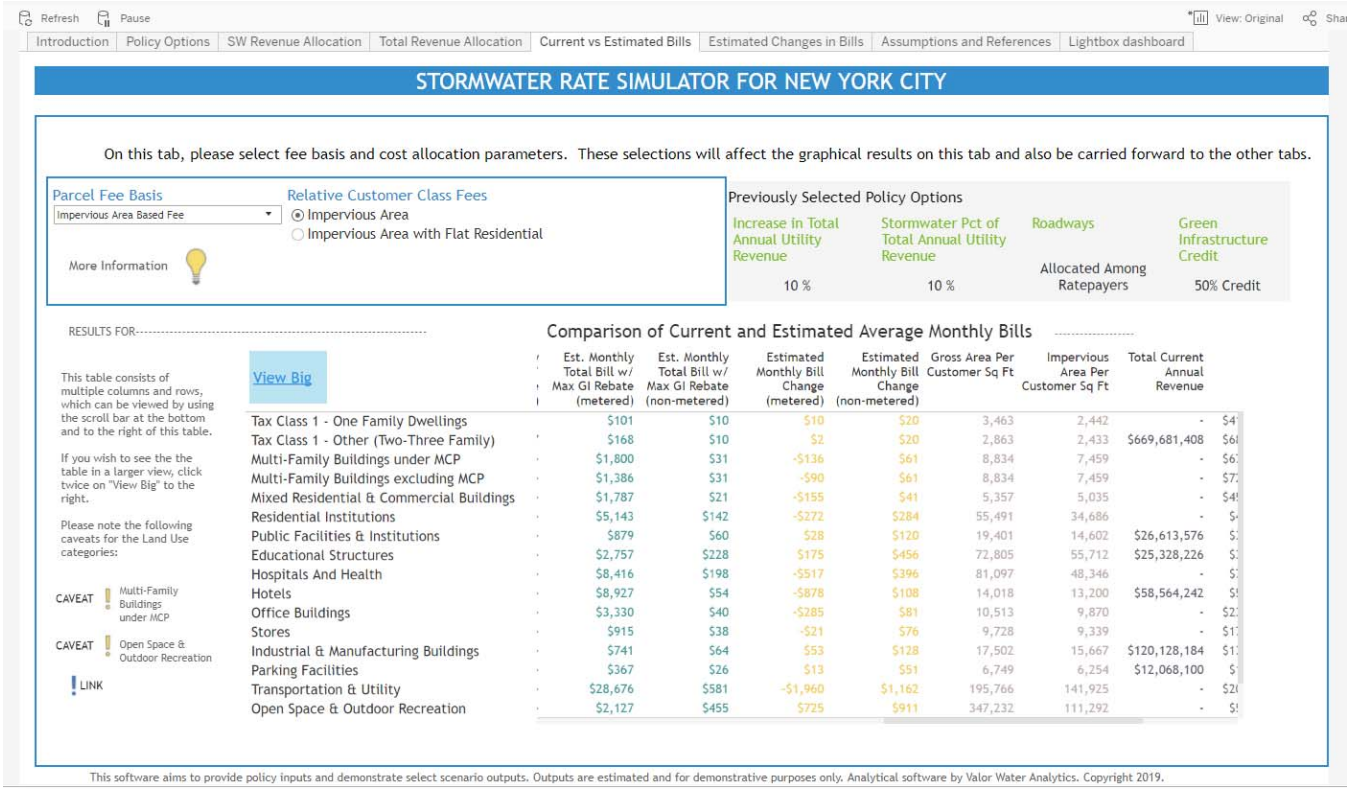
the tool can select policy options to further explore and identify additional insights. Below are several insights from Valor Water's use of the tool.

A stormwater utility introduces new customers to DEP, namely, unmetered properties, which impacts customer bills and the composition of utility revenue.

A key change under a stormwater utility is that property-level characteristics impact not only the stormwater bill, but which types of properties are considered utility customers. Under the stormwater fees modeled here, all properties with impervious surface are considered stormwater utility customers. This increases the amount of utility customers from the current roughly 765,000 metered customers to 854,400 customers (metered and nonmetered), an increase of 11.6%. The new unmetered stormwater customers only pay stormwater fees. However, all unmetered properties, regardless of land use category, would see larger increases in their bills than would the averaged metered property, because they receive no bill at all under the current rate structure.

For example, although the average metered customer in the Transportation & Utility and Vacant Land categories would see a decrease in their bill in every stormwater fee scenario modeled here, unmetered properties in those land use categories would see significant increases in their bills. (See Figure 5 below). While these land use categories currently account for a negligible share of total utility revenues, they would account for a significant share of stormwater revenue and a much larger share of total utility revenue under any stormwater fee scenario. (See Tabs: SW Revenue Allocation & Total Revenue Allocation.)

FIGURE 5. COMPARISON OF CURRENT AND ESTIMATED AVERAGE MONTHLY BILLS SCREENSHOT



Introducing a stormwater fee can reduce costs for homeowners and owners of multi-family buildings.

Multi-family properties see a decrease in their average monthly bills in every stormwater fee scenario modeled in the tool. Some of the costs borne by these customers under the current rate structure would be shifted to non-residential customers with larger, more highly-impervious properties.

For example, using DEP's 2016 total revenue needs, and assuming that 10% of that amount is associated with DEP's stormwater management expenses, the average monthly bill for multi-family customers would decrease by $81 to $151 per month (or about $1,000 to $1,800 annually), depending on which stormwater fee design is selected and whether or not a building participates in the Multifamily Conservation Program. This amounts to savings of about 6% to 8%. If total revenue needs or the share of DEP's revenue needs associated with stormwater are increased, the savings between a stormwater fee rate structure and the status quo rate structure become larger.

Under many of the scenarios modeled in the tool, one- to three-family residential customers

would also see lower average monthly bills with a stormwater fee structure as compared to the status quo rate structure. For these customers, the specific stormwater fee design can make the difference between a savings or a bill increase.

For the average two- to three-family customer, all but one of the modeled scenarios results in a savings. Again, using DEP's 2016 total revenue needs and assuming that 10% of that revenue need is associated with stormwater management, the average saving in those scenarios ranges from $4 to $12 per month (equivalent to 2.5% to 7.5% of the average monthly bill under the current rate structure). For single-family homeowners, potential savings (again using the same total revenue need and stormwater revenue need) range from $1 to $4 per month, in their best-case scenarios. In general, one- to three-family homeowners fare best when a stormwater fee is based on gross area and land use, rather than on impervious area, and roadways are treated as stormwater customers. However, some stormwater fee designs yield savings for these customers even when roadway costs are allocated to ratepayers.

Conversely, certain stormwater fee designs would increase the average monthly bill for single-family and/or two- to three-family homeowners. For single-family homeowners, this increase would range from $1 to $9, while 2- and 3-family homeowners would see an average increase of no more than $2 per month in any scenario. These homeowners fare worst in the scenarios where a stormwater fee is based entirely on impervious area and the cost of managing runoff from roadways is spread across all ratepayers. It is important to note that customer assistance programs can provide a buffer against bill increases for low-income households, and that a stormwater fee structure can provide an incentive for homeowners to install green infrastructure to lower their bills. (In the tool, the tab titled "Current vs. Estimated Bills" includes columns that show the average monthly bill for eligible customers receiving those discounts).

For 1-, 2-, and 3-family residential properties, average stormwater fees do not differ between the "Impervious area" and "Impervious area with flat fee" policy selections, although the fees of individual residential properties may differ.

The impervious area policy option estimates the stormwater fees based on the impervious area of properties in New York City. The impervious area fee policy is based on the concept of ERU,[3] which is the most common approach according to a national survey by Western Kentucky University (2018). Another option is impervious area with flat residential policy, which is a slight variation of the impervious area policy. In this policy alternative, residential households (excluding elevator residential buildings) are charged a flat rate based on 1 ERU while all other customers pay on a per ERU basis.

Due to multi-family apartment buildings not being in the group with a flat fee, there is not a difference in the distribution of fee revenue between these two policy selections. In other words, the flat residential fee option does not measurably impact the distribution of stormwater fees, or average monthly bill for any residential customers. Table 2 below shows the percent of stormwater revenue for each residential land-use classification under the two policy selections. The original intention to model this policy was to replicate a policy mentioned in the 2014 Black & Veatch Stormwater Survey (2014), but it turns out that, under a stormwater fee design without a flat residential fee, one-, two-, and three-family dwellings would all pay a fee corresponding almost exactly to 1 ERU, or 2,438 square feet. To be precise, the change in fee for a one-family dwelling and two- or three-family dwellings is from 0.998 to 1.002. Since this change is so tiny (in the 3rd decimal) the final outputs, under the two policy selections, look almost identical.

Choosing the simpler, impervious area with flat fee may be a simpler policy approach while also not impacting the total amount of revenue contribution from the residential customer classifications.

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[3] What is an ERU? When designing or evaluating a stormwater system, non-residential and residential water demands are estimated based on the typical size of a single-family residential property. The term "equivalent residential unit" (ERU) is commonly used as a basis for this comparison. One ERU in New York City amounts to 2,438 square feet of gross area.

In this model we include customers with metered connections for all calculations for status quo revenue estimates, and metered and unmetered properties for all scenario-based stormwater revenue calculations. It is worth noting that a majority of land classified as "vacant" are not metered. ERU for metered vacant land is 1.6. ERU for un-metered vacant land is 227, according to PLUTO (NYC Department of Planning, 2017).

TABLE 2. REVENUE DISTRIBUTION UNDER IMPERVIOUS AREA FEE POLICY SCENARIOS

Land Use Type	% of stormwater revenue per land use type under impervious area fee w/ flat residential (all paying for 1 ERU)	% of stormwater revenue per land use type under impervious area fee
Tax Class 1: Residential Units including 1, 2, or 3 family homes (mean ERU=1.0)	38%	38%
Multi-family (with and without multi-family conservation program[4]) (mean ERU=3.1)	14%	14%
Mixed residential and commercial (mean ERU=2.1)	3%	3%
	$217.7 per ERU	$217.7 per ERU

Notes: Outputs from Stormwater Revenue per Land Use Type Tab (see Figure 2 for example output for this tab). Policy inputs for this output set are: 10% increase in total revenue; 10% stormwater fee percentage; roadway costs allocated among ratepayers; 50% green infrastructure credit. 1 ERU=2,438 square feet. ERUs are the mean ERU for that land use classification. See Table A3: New York City land Use classification data for details.

Roadway stormwater management cost policy selection greatly affects model outputs and average customer bills.

The inclusion of policy options for "roadway costs allocated to ratepayers" and "roadways pay" is based upon research indicating that not all utilities charge the owners of public roads and sidewalks for the stormwater mitigation costs associated with those spaces. The 2014 Black & Veatch survey states that approximately 37% of United States' stormwater utilities charge roadways for their share of contribution to stormwater mitigation costs. As shown in the model outputs, stormwater fees per customer vary significantly depending on who pays for roadways. This change can be as high as a 20%

[4] What is the Multiple-family Conservation Program (MCP)? The MCP is a per-unit flat-rate billing program designed for buildings with four or more residential units that complete a set of water efficiency measures. Properties with four or more apartments that were billed under the old "frontage" flat-rate program as of July 1, 2012 were automatically converted to the MCP rate on that date. These buildings must be properly metered with meters that are equipped with Automated Meter Reading devices, and they must complete required water efficiency measures by December 31, 2018 to continue to be billed on the MCP rate." Source: New York City DEP. Accessed at http://www.nyc.gov/html/dep/pdf/mcpfaq.pdf

increase for single residential households under the "roadway costs allocated to ratepayers" policy as compared to the "roadways pay" policy.

Land use classifications determine winners and losers.

Winners and losers in the policy scenarios presented are mainly determined by the type of land use classification under which the customer falls. Irrespective of policy choice, average bills for metered customers would decrease for properties in the *Multi-Family Buildings excluding MCP; Multi-Family Buildings under MCP; Mixed Residential & Commercial Buildings; Residential Institutions; Hotels, Hospitals and Health; Stores*; *Office Buildings;* and *Transportation & Utility* categories. On the other hand, average bills for metered customers would increase for properties in the *Public Facilities & Institutions; Educational Structures; Parking Facilities; Industrial & Manufacturing Buildings; Open Space & Outdoor Recreation;* and *Roadway and Sidewalk* categories, under any combination of policy choices. The only two land use types for which the choice of policy itself determined whether the average metered customer's bill would see an increase or decrease were *Tax Class 1 - One Family Dwellings, Tax Class 1 - Other (Two and three-family dwellings),* and *Vacant Land*.

Increasing the "total utility revenue" magnifies the distributional impacts of adopting a stormwater fee structure.

The default total utility revenue need of $4 billion is based (approximately) on DEP's 2016 budget. In reality, DEP's revenue needs increase every year, reflecting both increased operational costs and the need for significant new capital investment to improve existing infrastructure. When the user selects an increase in total utility revenue needs, the impacts of a shift from the current rate structure to a new stormwater fee structure increase proportionately. In other words, with a higher utility revenue need, any given stormwater fee scenario results in proportionately larger shifts in revenue distribution among land use categories, and proportionately larger increases or decreases in average bills for properties in each land use category. Conversely, if total utility revenue needs increase but the rate structure remains unchanged, rate increases will magnify current inequities among customers."

Increasing the "stormwater percentage of total utility revenue" magnifies the distributional impacts of adopting a stormwater fee structure.

The default setting in the tool is that stormwater management costs account for 10% of total utility revenue needs. This is the low-end of a rough estimate that DEP developed in 2009. If the user makes a selection closer to the higher-end of DEP's estimate (15% or 20%), the magnitude of redistribution in costs among land uses and changes in average bills for each land use increases proportionately for any given stormwater rate structure, as compared to the status quo rate structure.

CONCLUSION

The goals of this alternative stormwater fee policy research project included identifying applicable policies for New York City and modeling each policy scenario using interactive tools and available data sources for the city. To that end, the project team sought to model and understand how each policy scenario would impact distribution of utility fee revenue across land use types and how customers' monthly utility bills differ across customer types. We define customer types based on land use classifications.

The key findings summarized above highlight and reinforce findings for stormwater fee policies in comparable urban areas. Namely, policy choices impact distribution of revenue and customer bill amounts in significant ways. Stormwater fees redistribute revenue to different land use types (customers) according to parcel-level characteristics, and adds new customers to the utility customers base, with the underlying logic that significant contributors to stormwater-related pollution costs should pay a higher portion for the stormwater treatment costs.

This results in policy winners, customers whose monthly bill decreases, and policy losers, customers whose monthly bill increases and previously unmetered customers. However, adopting a stormwater fee also creates an opportunity to reduce the amount of impervious surface by offering fee credits for green infrastructure retrofits. These credits can reduce or offset bill impacts for participating customers, while spurring green infrastructure investments on private property owners and helping the city achieve sustainability and stormwater management goals.

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APPENDIX A: STORMWATER FEE SIMULATOR TECHNICAL DOCUMENTATION

Introduction

The Stormwater Fee Simulator is an interactive tool hosted live on the Valor Water portal. It allows users to set policy inputs and view policy choice impacts on stormwater fees in real time. All analyses on the dashboards have been performed prior to hosting it on the portal. Since analyses are not performed live, the pre-calculation set up allows for quick viewing of the impacts of input choices and policy alternatives. An explanation for each input choice and the underlying modeling assumptions associated with them is presented below.

Tab 1: Policy Option Inputs

1. **Total operating revenue rise**

Associated data sources: New York City Municipal Water Finance Authority (2017).

This option sets the percentage of Total DEP operating revenue rise to enable simulation for future purposes. The total utility revenue need is set at a baseline of $4 billion, based approximately on DEP's 2016 budget of $3.887 billion plus a 2.94% adjustment to account for accruals, rounding, and other factors (New York City Municipal Water Finance Authority, 2017). Increase in total utility revenue affects both the current and future estimated rates on the dashboard to allow the user to study the effect of changing the rate structure, independent of any general rate increase (i.e., a revenue neutral change in the rate structure). With this option, the user can see how a future bill would change if DEP needed to generate more revenue under the current rate structure vs. generating more revenue under a new rate structure (i.e., with a stormwater fee).

2. **Stormwater budget allocation**

Associated data sources: New York City Department of Environmental Protection. (2009). *2009 NYC DEP Stormwater Rate Study*; New York City Department of Environmental Protection. (2017a*). Fiscal Year 2017 DEP Water and Sewer Rates.*

This option sets the percentage allocation of Total DEP operating revenue towards stormwater infrastructure operation and maintenance. The base case for the option is set as 10.0%. Thus the revenue goal for the model is theoretically given by:

$$revenue\ goal\ =\ baseline\ revenue\ \times \frac{revenue\ rise + 100}{100} \times\ budget\ allocation$$

where

$$baseline\ revenue = \begin{pmatrix} water\ usage\ \times water\ rate + \\ parking\ lot\ surcharge - \\ customer\ assistance \end{pmatrix} \times revenue\ correction\ factor$$

The revenue correction factor exists because of a discrepancy in the revenue reported by DEP and the calculated revenue from water usage and rates along with adjustments. The revenue correction factor is 1.006. This discrepancy of about 0.6% may be attributed to rounding off errors. For example, DEP charges customers per 100 centum cubic feet (ccf) of water.[5] So if a user consumed 1040 ccf in one year, the user will only be charged for 1000 ccf.

3. Roadways

Associated data sources: NYC DEP (2009) *Stormwater Study.*

This option allows users to set roadways as a separate customer or raise the costs associated with roadways from other paying customers. It is assumed that the current monthly water bill of roadways under the existing rate structure is $0. Thus, projection of percentage of bill change is not possible for roadways. Gross area and impervious area of roadways and sidewalks was obtained from 2009 DEP study.

- Stormwater fee charged to roadways: Roadways is treated as 1 separate customer of land use type “13. Roadways and Sidewalks”.
- No stormwater fee charged to roadways: The area associated with roadways is ignored in the calculation of fee per unit area for the rest of the paying customers. This option allocates the cost associated with roadways to other paying members. The manner of allocation is controlled by the policy alternative.

[5] CCFs represents hundred cubic feet. One CCF is equivalent to 748 gallons of water.

4. Green Infrastructure Credit

Associated data sources: nil

Green infrastructure rebates do not have an impact on the revenue equation, but do impact average bills. The credits are assumed to be paid for by the city. This option is included to answer a hypothetical scenario when a residential user chooses to manage 100% of all stormwater runoff generated by his/her property.

1. High: This option provides a maximum rebate of 80% of typical stormwater monthly bill.
2. Low: This option provides a maximum rebate of 50% of typical stormwater monthly bill.

Tab 2: Stormwater Revenue Percentage per Land Use Classification

1. Land use type and Gross area-based fee policy

Associated data sources: NYC DEP *Stormwater study (2009);* NYC DEP *Water Conservation Report* (2017e), p. 12; New York City Department of City Planning, *PLUTO* (2017).

This policy option allows users to simulate stormwater fees based on gross area of properties with individual weights for property use type. It categorizes the Land Use types into 2 broad categories namely "Residential," and "Non-Residential." For added flexibility to design policies, the simulator allows further break down of each category. "Residential" can be broken down to "Walk-up Residential" and "Elevator Residential" (to roughly distinguish relatively small buildings from larger ones), whereas "Non-Residential" can be broken down to "Non-Residential" (=Non-residential without parking facilities) and "Parking facilities." Another policy option gives user the choice to increase the multiplier specifically to land use types which are expected to have higher stormwater management-related costs (i.e., Parking, Roadways, Transportation, and Industrial). Thus, the four alternatives in this policy option are:

1. *"Property type (Residential/Non-residential=1x/2x)";*
2. *"Property type (Residential/Non-residential/Parking=1x/2x/3x)";*
3. *"Property type (Residential & Open Space/Non-residential/Parking & Roadways & Transport & Industrial=1x/2x/3x)"; and*
4. *"Property type (Walk-up residential/Elevator residential/Non-residential=1x/2x/3x)."*

Assumptions:

1. For Policy Options 1, 2 and 3, multi-family residential buildings are categorized under "Non-residential" because they are presumed to be more similar to commercial buildings.

2. Additionally, "Mixed Residential & Commercial Buildings" are treated the same as multi-family residential buildings. A sample calculation for this policy alternative is shown below:

Policy type: 1. Property type (Residential/Non-residential=1x/2x)

Outputs:

$$\frac{\$}{sq.ft}(Residential) = \frac{revenue\_goal}{1 \times gross\ residential\ area + 2 \times gross\ non-residential\ area}$$

$$Residential\ bill = \frac{\$}{sq.ft}(Residential) \times gross\ area\ (sq.ft)$$

$$\frac{\$}{sq.ft}(Non-Residential) = \frac{2 \times revenue\_goal}{1 \times gross\ residential\ area + 2 \times gross\ non-residential\ area}$$

$$Non-\ Residential\ bill = \frac{\$}{sq.ft}(Non-Residential) \times gross\ area\ (sq.ft)$$

Similarly, other alternatives in this policy type are modelled by using the weights for the respective classes.

This policy alternative is less data-intensive as compared to the impervious area-based policy option. The only data required to charge customers for stormwater is the gross area of property, which is readily available in the Property Land Use Tax Lot Output (or PLUTO) database. A 2014 survey of stormwater utilities conducted by Black and Veatch found that 37% of utilities have a fee based on some kind of gross area (2014, page 13).

2. Impervious area based fee policy

Associated data sources: NYC DEP Stormwater study (2009), Water Conservation Report (2017e), p. 12, New York City Department of City Planning, *PLUTO (2017).*

This policy option allows users to simulate stormwater fees based on impervious area of properties. The impervious area based fee policy is based on the concept of Equivalent Residential Unit (or ERU), which is the most common approach according to a national survey by Western Kentucky University. The policy is designed as follows:

1. "Impervious Area": Each residential customer is binned into either 0.0 - 0.5 ERU, 0.6 - 1.0 ERU or 1.0+ ERU and a monthly charge of 1x, 2x, and 3x (as observed in Fort Worth, TX, Greensboro, NC, and Portland, OR) is charged. All other customers (nonresidential) pay 2x $ per ERU after rounding up to the nearest ERU. This type of a tiered rate structure for residential households and a per-ERU based rates for all non-residential properties is also observed in Ann Arbor, MI, Beaufort, SC and Durham, NC. The value of x is calculated by the model based on the revenue goal. Example case:
    1. If a residential unit has a footprint of 0.7 ERU, the unit falls in the second tier. Hence it pays 2x $ per month.
    2. If a non-residential unit has a footprint of 39.8 ERU, the footprint is rounded up to 40 ERUs, and the unit is charged 40 x 2x = $80x per month
2. "Impervious Area with flat residential": This policy is a slight variation of the impervious area policy. In this policy alternative, residential households (excluding elevator residential buildings) are charged a flat rate based on 1 ERU while all other customers pay on a per ERU basis. Example case:
    1. If a residential unit has a footprint of 0.7 ERU, the unit pays $1x per month regardless of size.
    2. If a non-residential unit has a footprint of 39.8 ERU, the footprint is rounded up to 40 ERU and the unit is charged 40 x 1x = $40x per month.

3. Land Use

Examples of all land use categories used in the analysis are provided in Table A1 below.

TABLE A1: LAND USE CATEGORIES

Landuse	Examples
01. Tax Class 1 - One Family Dwellings	Single family residences
02. Tax Class 1 - Other (Two-Three Family)	Residences occupied by two-three families
03. Multi-Family Buildings excluding MCP	Walk up apartments, Condominiums, Elevator apartments which are not covered by the Multi-family Conservation Program
04. Mixed Residential & Commercial Buildings	Residential buildings with stores, retail space, offices, warehouses
05. Residential Institutions	Child Center, Nursing Home, Adult Care Facility
06. Hotels	Full Service Hotel, Motels, Apartment Hotels
07. Hospitals And Health	Hospitals, Clinics, Dispensary
08. Public Facilities & Institutions	Dormitories, churches, asylum, orphanage, library, museum, community center, fire department, police department, prison, court house, post office
09. Educational Structures	Schools and universities
10. Parking Facilities	Public Parking Area, Parking Garages, Parking Lots
11. Industrial & Manufacturing Buildings	Warehouses, Light Manufacturing, Heavy Manufacturing, Loft Buildings
12. Stores	Retail Building, Department Stores, Shopping Centers , Banking Facilities
13. Office Buildings	Office Buildings with or without commercial retail spaces
14. Open Space & Outdoor Recreation	Parks, playgrounds, beach, golf course, stadiums, sports facilities, amusement parks, boat house, cemetery
15. Transportation & Utility	Gas stations, airports, terminals, piers, all utilities, city departments related to transportation and utilities
16. Vacant Land	Public or private land lying vacant without any development

17. Multi-Family Buildings under MCP	Residential buildings under the Multi-family Conservation Program
18. Roadway and Sidewalk	Roads and sidewalks

Associated data sources: NYC DEP Stormwater study (2009); Water Conservation Report (2017e).

1. Total impervious area and gross area for each land-use type was obtained from the 2009 DEP study. The number of customers known as "Metered Borough, Tax Block and Lots (BBLs)" in the tax lot lexicon was also obtained from the DEP study for the current scenario and "*Total BBLs"* for the future scenario. Here, it is assumed that number of "*Metered BBLs*" in the 2009 DEP Study correspond to the number of billed customers of water and sewer.
2. While applying policy options pertaining to property use type, all properties in the "Mixed Residential & Commercial Buildings" land use category are treated as "Residential."

4. Customer Assistance

Associated data sources: Marks Paneth (2017a). *New York City Water and Sewer System: Combining Financial Statements;* Water Research Foundation. (2017) *Customer Assistance Programs for Multi-Family Residential and Other Hard-to-Reach Customers* – 4557; New York City Department of Environmental Protection. (2017*) Fiscal Year 2017 DEP Water and Sewer Rates.*

Customer assistance under Home Water Assistance Program (HWAP) and Multi-family Conservation Program (MCP) are considered in the model. (The model was not able to account for DEP's Multifamily Water Assistance Program (MWAP) because that program provides credits per housing unit within a multi-family property, rather than credits per property.)

- The current monthly typical bill value for 1- to 3-family residential and multi-family residential is calculated for households ignoring any kind of customer assistance except MCP, which is presented as a separate land-use category. The Multi-Family Conservation Program (MCP) is a per-unit flat-rate billing program for multi-family residential buildings with four or more apartments. Building owners are eligible to participate if they complete a set of water efficiency measures.
- For simplification purposes, it is assumed that 63,700 customers under the HWAP all belong to a single residential household.
- Customers under MCP are modelled differently. Since customers under MCP have a flat fee of $1,005 per year per unit, it is more difficult to estimate the benefit gained by them. Hence customers under MCP were modelled separately as different Land use type:

"*Multi-Family Buildings under MCP.*" From conversations with DEP, we learned that the number of metered BBLs under this land-use type is known to be 4% - 5% of all BBLs. It was thus assumed that 4% of all BBLs are under MCP. This number was chosen to obtain total revenue close to the actual current revenue Thus the land-use classes before and after this change are:

TABLE A2. CUSTOMER CLASSIFICATION UNDER MCP

Before change		After change	
land_use	customers	land_use	customers
03. Multi-Family Buildings	73,425	03. Multi-Family Buildings excluding MCP	42,821
		12. Multi-Family Buildings under MCP	30,604

- It is assumed that the current wastewater bill for customers under MCP is 159/259*1005=$617.

Assumptions

Due to constraints imposed by limited data availability, several assumptions were made while developing the stormwater rate simulator, a list of which is provided below. Wherever applicable, appropriate reasoning for the assumption is also provided.

Input Assumptions

1. **Revenue:** Only retail water revenue for 2016 is used to estimate current bills and model future bills. The total utility revenue need is set at a baseline of $4 billion, based approximately on DEP's 2016 budget of $3.887 billion plus a 2.94% adjustment to account for accruals, rounding, and other factors (New York City Municipal Water Finance Authority, 2017).
2. **Revenue allocation:** For rate modeling purposes, the stormwater fee as percentage of total water fee will be set as 10%, 15% or 20% based on user input. These are based on a range of estimates generated by DEP in its 2009 rate study.
3. **Water use:** Water use segregated by different land use class is derived by adjusting the mean water use from the 2009 DEP study. This is done to represent the water use characteristics according to land use type. Mean water usage per BBL for 2017 is calculated as:

2017 water use per metered BBL = 2009 water use per metered BBL * 0.96

The water use of 2009 is decreased by 4% because that is the overall decrease in water use observed as per water_conservation_report2017.pdf, page 1. Water use segregated by land use class is also available directly from the water_conservation_report2017.pdf, page 12 but it was found that it resulted in severe over estimation of single family residential current bill (as shown earlier). After adjusting water usage from 2009, current estimated bill is $1,099 / year for single residential households, which is found to be within 2% of the actual figure of $1,078 / year as given on page 4 of *Fiscal Year 2017 DEP Water and Sewer Rates* (DEP, 2017a).

4. **Metered BBL (Borough, Block & Lot):** The stormwater simulator considers metered BBLs to estimate current charges under status quo (no stormwater fee) and both metered and non-metered BBLs in the future scenario with a separate stormwater fee. Thus while metered BBLs pay water and waste fee in the current scenario, and water, waste water, and stormwater fee in the future scenario, the non-metered BBLs pay only the stormwater fee in the future scenario consistent with the idea that even though they are not consuming water, they are contributing towards stormwater run-off and hence are expected to contribute towards its management. Number of metered ratepayers, or metered BBLs in each land use class is assumed to have remained constant since 2009. Current estimated bill is $1,099 / year for single residential households, which is found to be within 2% of the actual figure of $1,078 / year as given on page 4 of NYC DEP Rate Report (2017a). We do not have actual figures for current bills for other land use classes.
5. **Area:** Gross area and impervious area for each land use class is assumed to have remained constant since 2009.
6. **Roadways:** It is assumed that no metered water is used for operating and maintaining footpaths and pavements in the current rate structure, resulting in an annual water bill of $0 for all areas associated with roadways.
7. **Customer Assistance:**
    a. $250 credit to single family households in Fiscal Year 2017 is ignored because it was a one-time assistance and not a recurring credit to the households.
    b. Current annual revenue from MCP properties is calculated as
        i. annual_bill_per_MCP_unit * #_units_per_multi_family_elevator_BBL * #_MCP_BBLs

ii. Values and citation for each variable can be found in Table A3 below (Rows 12, 14 and 15).

Modeling Assumptions

1. **Metered BBLs**: The modeling of stormwater fees is limited by the resolution of data. Since data is not available on a finer scale than 1 BBL, all analysis is performed on a per-BBL basis.
2. **Residential**: For applying different stormwater impervious area-based policies, "residential" properties are defined as the collection of 1-, 2-, and 3- family homes, mixed commercial and residential, and multi-family walk-up buildings only.
3. **ERU (Equivalent Residential Unit)**: 1 ERU is defined as the mean impervious area per metered BBL of "residential" household or in other words, single residential and multi-residential walk-up households combined.
4. **Customer Assistance**:
    1. It is assumed that the benefit associated with customer assistance programs namely HWAP and MCP is carried forward in the simulated stormwater fee scenario without any changes in the absolute amount of benefits provided to each customer class.
    2. Since number of customers under customer assistance is known but the number of metered BBLs under customer assistance is not known, it is assumed that the number of customers per BBL for each land use is fixed and is given by the average number of "units" per BBL from PLUTO 2017 data.
    3. It is assumed that the current wastewater bill for customers under the flat-rate Multi-Family Conservation Program is 159/259* $1005 = $ 617.
5. **Green Infrastructure:** Maximum rebate for green infrastructure is assumed to be 50% or 80% of applicable stormwater fees (as compared to 80% maximum rebate in Philadelphia). It is also assumed that the rebate has no impact on revenue generated. It is modelled as an independent hypothetical case with no impact on bills of other customers who choose to not have green infrastructure on their property.

Data Sources

The data source for each model input is given below (see Table A5). Details of each source document are detailed in the References section above. Key inputs include impervious area and equivalent residential unit (ERU) per customer. Details are included in Table A3 below. Additionally, current estimate of water bills on a per BBL basis is presented in Table A4.

TABLE A3: NEW YORK CITY LAND USE CLASSIFICATION DATA

Key-landuse-codes	Metered # BBLs	Unmetered #BBLs	Gross Area (Sq ft)	Impervious Area (sq ft)	Impervious Ratio	Number of Customers	ERU per Customer
01. Tax Class 1 - One Family Dwellings	309,817	14,302	1,122,385,366	791,518,175	0.71	324,119	1.002
02. Tax Class 1 - Other (Two-Three Family)	317,084	8,714	932,882,769	792,746,732	0.85	325,798	0.998
03. Multi-Family Buildings excluding MCP	42,821	-	378,272,112	319,399,578	0.84	42,821	3.100
04. Mixed Residential & Commercial Buildings	21,029	4,461	136,541,676	128,349,175	0.94	25,490	2.100
05. Residential Institutions	714	297	56,101,610	35,067,307	0.63	1,011	14.20
06. Hotels	495	61	7,793,783	7,339,205	0.94	556	5.400
07. Hospitals And Health	676	246	74,771,373	44,574,817	0.60	922	19.80
08. Public Facilities & Institutions	2,435	4,889	142,091,596	106,946,276	0.75	7,324	6.000
09. Educational Structures	751	1,868	190,676,231	145,909,190	0.77	2,619	22.90
10. Parking Facilities	2,650	10,460	88,475,250	81,992,490	0.93	13,110	2.600
11. Industrial & Manufacturing Buildings	13,305	3,320	290,971,493	260,468,298	0.90	16,625	6.400
12. Stores	14,744	1,930	162,208,257	155,719,926	0.96	16,674	3.800
13. Office Buildings	5,732	787	68,533,931	64,343,244	0.94	6,519	4.000
14. Open Space & Outdoor Recreation	496	3,377	1,344,830,069	431,035,593	0.32	3,873	45.70
15. Transportation & Utility	504	2,176	524,653,282	380,358,833	0.72	2,680	58.20
16. Vacant Land	1,237	32,437	379,373,041	132,756,824	0.35	33,674	1.600
17. Multi-Family Buildings under MCP	30,604	-	270,349,588	228,273,620	0.84	30,604	3.100
18. Roadway and Sidewalk	N/A	N/A	1,958,742,043	1,906,193,027	0.97	1	781,982

TABLE A4. NEW YORK CITY WATER USE AND ESTIMATED REVENUE

A	B	C	D	E	F	G	H	I
16-key-landuse-code	2009 Water Use / BBL (GPD) = DEP Study	2017 Water Use / BBL (GPD) = B*0.96	Current_total_annual_bill_dol = C*365*water_rate	Current_total_monthly_bill_dol = D / 12	2017 # metered BBLs = DEP Study	2017 Water Use (GPD) = C*F	Annual Revenue = D*F	Annual Revenue (%)
01. Tax Class 1 - One Family Dwellings	232	223	$1,099	$92	309,817	69,113,023	$340,554,421	9%
02. Tax Class 1 - Other (Two-Three Family)	404	388	$1,914	$160	317,084	123,174,938	$606,944,509	17%
03. Multi-Family Buildings excluding MCP	3,467	3,334	$16,427	$1,369	42,821	142,750,391	$703,402,553	19%
04. Mixed Residential & Commercial Buildings	4,519	4,345	$21,411	$1,784	21,029	91,375,049	$450,250,554	12%
05. Residential Institutions	12,796	12,304	$60,627	$5,052	714	8,784,946	$43,287,822	1%
06. Hotels	22,702	21,829	$107,562	$8,963	495	10,805,279	$53,243,012	1%
07. Hospitals And Health	21,025	20,216	$99,616	$8,301	676	13,666,250	$67,340,447	2%
08. Public Facilities & Institutions	2,098	2,017	$9,940	$828	2,435	4,912,144	$24,204,591	1%
09. Educational Structures	6,470	6,221	$30,655	$2,555	751	4,672,087	$23,021,706	1%
10. Parking Facilities	874	840	$4,141	$345	2,650	2,227,019	$10,973,637	0%
11. Industrial & Manufacturing Buildings	1,733	1,666	$8,211	$684	13,305	22,170,736	$109,246,300	3%
12. Stores	2,243	2,157	$10,627	$886	14,744	31,798,838	$156,688,777	4%
13. Office Buildings	8,417	8,093	$39,880	$3,323	5,732	46,390,619	$228,589,776	6%
14. Open Space & Outdoor Recreation	4,275	4,111	$20,255	$1,688	496	2,038,846	$10,046,414	0%
15. Transportation & Utility	71,876	69,112	$340,547	$28,379	504	34,832,215	$171,635,741	5%
16. Vacant Land	1,953	1,878	$9,253	$771	1,237	2,322,943	$11,446,303	0%
17. Multi-Family Buildings under MCP	NA	NA	$21,440	$1,787	30,604	N/A	$656,159,046	18%
18. Roadway and Sidewalk	0	0	$0	$0	0	0	$0	0%
						Total	$3,667,035,610	100%

TABLE A5. DATA SOURCES FOR EACH MODEL INPUT

Sr. No.	Data	Quantity	Unit	Source	Page/Sheet
1	2017 Annual retail revenue	3,644.98	million $	*Fiscal Year 2017 DEP Water and Sewer Rates.*	Page 4
2	2017 Water + sewer rate	0.0135	$ per gallon	*Fiscal Year 2017 DEP Water and Sewer Rates.*	Page 4
3	2009 Revenue allocated to stormwater management	9.5	% of total revenue	*2009 NYC DEP Stormwater Rate Study*	Cost & Rate Summary
4	2009 metered BBLs per land use	-	-	*2009 NYC DEP Stormwater Rate Study*	Landuse - BBL
5	2009 Water Usage per land use per BBL	-	-	*2009 NYC DEP Stormwater Rate Study*	Usage by BBL
6	2009 Impervious Area per land use	-	-	*2009 NYC DEP Stormwater Rate Study*	Impervious Area Updated
7	2009 Gross Area per land use	-	-	*2009 NYC DEP Stormwater Rate Study*	Impervious Area Updated
8	HWAP no. of customers	63,000	BBLs	Annual Meeting Minutes: May 18, 2018.	Page 7
9	HWAP annual benefit per customer	116	$	Annual Meeting Minutes: May 18, 2018.	Page 7
10	MCP no. of BBLs	4.0	% of all BBls	*Fiscal Year 2017 DEP Water and Sewer Rates*	Page 1
10	MCP annual bill per customers	1005	$	*Fiscal Year 2017 DEP Water and Sewer Rates*	Page 4
13	Number of MCP units per BBL	21.3		*2009 NYC DEP Stormwater Rate Study*	Usage by BBL