User Guide: Voting Location Resource Calculator

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Introduction

Simulation modeling is a tool commonly used to represent complex processes and estimate performance metrics. The manufacturing, healthcare, and transportation industries frequently use simulations to inform decisions and enhance their operational processes. In elections, academics have explored the application of simulations for resource allocation and estimating voter wait times. However, most tools available to perform simulation analyses require advanced technical training and are costly to use (e.g., commercial simulation software), while publicly available simulation tools designed for election officials may not be flexible enough to accommodate the wide variety of voting processes across the United States. To remedy this, the U.S. Election Assistance Commission (EAC) partnered with the University of Rhode Island's URI VOTES to create the Voting Location Resource Calculator, providing a customizable, advanced simulation tool to help election officials estimate the expected performance of voting locations. The Voting Location Resource Calculator offers a solution that enables election officials to simulate unique voting processes, input information specific to their voting locations, and harness the utility of simulation with little to no technical experience.

The Voting Location Resource Calculator allows election officials to simulate the voting process in one or more voting locations to estimate voter wait times and identify potential bottlenecks. This tool automatically simulates voting location performance based on information provided by election officials, including the steps required to vote in each jurisdiction and the setup and resources of the voting

location(s). Election officials can also run the simulation multiple times, adjusting resource quantities to identify where additional voting equipment has the potential to minimize voter wait times.

Definitions

Voting Day – A nine-hour or 13-hour period in which voting locations are open and voters are processed.

Number of In-Person Voters – The number of voters expected to vote at a voting location during a single voting day.

Arrival Pattern of Voters – The number of voters arriving at a voting location throughout a voting day per hour.

Proportion of Voters with a Disability – The proportion of individuals, at the county level, who report having one or more disabilities, according to the American Community Survey.

Voting Process – The steps required to vote in a voting location.

Processing Time – The amount of time required to perform a step in the voting process.

> Default Processing Time – Processing times estimated from time studies performed by URI VOTES and fit to a statistical distribution.
>
> Estimated Processing Time – Processing times estimated from minimum, average, and maximum values or estimates fit to a triangular statistical distribution.
>
> Time Study Processing Time – Processing times estimated from data uploaded by the user and automatically fit to a statistical distribution.

Check-In – A step in the voting process when poll workers check voters into the voting location, allowing them to receive and mark a ballot.

> Paper Poll Book – A physical, paper list of eligible and registered voters used to admit individuals to receive, mark, and cast a ballot.
>
> Electronic Poll Book – An electronic device, such as a tablet or laptop, containing a list of eligible and registered voters used to admit individuals to receive, mark, and cast a ballot.
>
> Voter ID Required – A check-in process that requires all voters to present a valid form of ID or voter card before receiving, marking, and casting a ballot.

Voting a Ballot – A step in the voting process when voters make selections on ballot contests and questions.

Electronic Voting Machine Stations (accessible) – Electronic devices that facilitate ballot marking, offering accessibility features such as audio ballots, accessible keypads with Braille text, and high-contrast screen options. One voting machine station is equal to one device used for ballot marking.

Electronic Voting Machine Stations (non-accessible) – Electronic devices that enable voters to mark ballots through a touchscreen interface but do not offer accessibility features (see Electronic Voting Machine Stations (accessible), above). One voting machine station is equal to one device used for ballot marking.

Hand-Marked Ballot Voting Stations – A location where paper ballots may be hand-marked by voters, such as tables with plastic or cardboard privacy screens or individual booths. One privacy booth is equal to a single station where a voter hand-marks their ballot.

Casting a Ballot – A step in the voting process when voters submit their ballot to be counted before exiting the voting location.

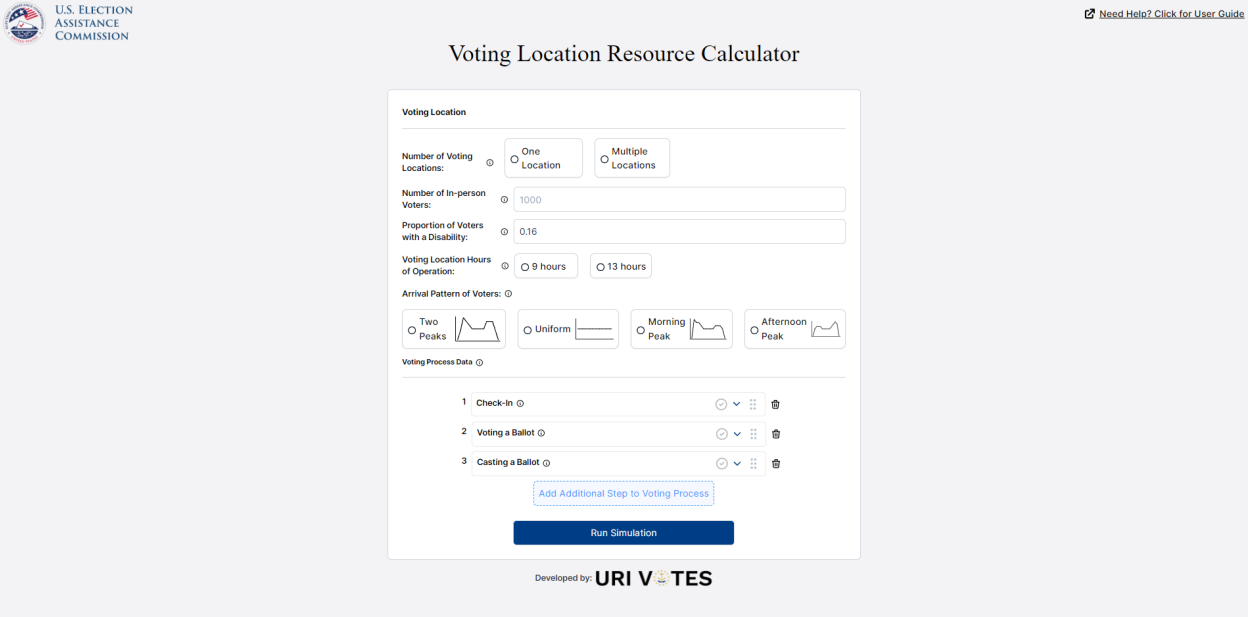
Electronic Ballot Scanner – An electronic device that accepts paper ballots, scans and determines voter marks, and tallies votes.

Ballot Box – A non-electronic container in which voters insert their marked ballots to be counted at a central facility.

Voter Wait Time – The time that voters spend waiting in lines throughout the voting process, and not performing voting steps.

Time Spent in the Voting Location – The length of time a voter spends within a voting location from the time they enter to the time they exit, including all waiting time and time performing voting steps.

Getting Started



What You Will Need:

To effectively use the Voting Location Resource Calculator, you will need some information about one or more voting locations, the voting process in those locations, and an idea of the question you want to answer with this tool. Common uses of simulation are to Represent a Known Process or to Investigate 'What-If' Scenarios.

Represent a Known Process:

To use the Voting Location Resource Calculator to represent a known process, information about the process can be obtained from previous elections or best estimates based on experience. For example, if a specific voting location is being investigated, values for voter turnout, the quantity of voting equipment, and processing times may be obtained from previous elections. If one or more of these values is unknown from previous elections, then best estimates may be substituted, or in the case of processing times, Default values in the Voting Location Resource Calculator may be used. Using previous election information will estimate the voting location's past performance. To predict future performance, values for voter turnout, the quantity of voting equipment, or processing times may be adjusted to reflect what is expected in a future election.

Investigate 'What-If' Scenarios:

To use the Voting Location Resource Calculator to investigate 'What-If' scenarios, information about the voting process as it was operated previously and information about a process change must be available. For example, if the use of an alternative ballot marking device is being investigated, then values for voter turnout, the number of check-ins and ballot casting equipment, and processing times for check-in and ballot casting may be obtained from previous elections or best estimates. However, information on the processing time and expected quantity of the new ballot marking devices must be obtained. When investigating 'What-If' scenarios, it is often difficult to obtain information and data for hypothetical changes. While best guesses may be used in place of data, the accuracy of simulation results may vary.

Simulation Mechanics:

Before using the Voting Location Resource Calculator, it is important to understand the mechanics of the simulation. The simulation has several inherent assumptions about the voting process. These include:

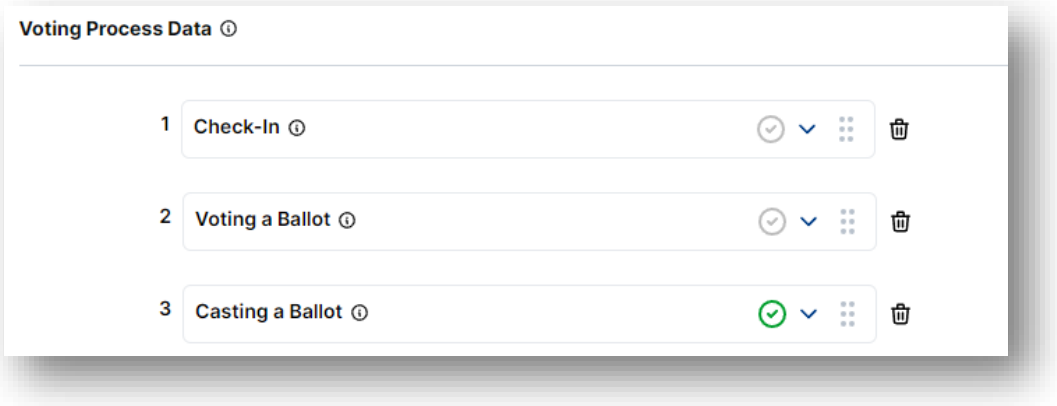
- Voters are permitted to wait between voting process steps, not being held at check-in when other stations are at capacity.
- Voters with disabilities will always use accessible voting equipment.
- All voters who arrive at the voting location are eligible to vote.
- Steps outlined in the Voting Process Data menu occur in order, and all voters perform each step.

While these assumptions may not exactly match the reality of a voting process, the simulation results may be useful to generate estimates of voting location performance.

It is also important to note that simulation models estimate predicted performance and cannot capture the reality of what has or will occur in a process. The use of randomness in processing times, the arrival of voters, and the number of voters turning out to vote attempts to improve the accuracy of estimated values, and simulations are automatically replicated in the Voting Location Resource Calculator. These replications capture a range of performance values, demonstrating the variability in what may occur. See this document's Simulation Outputs section for more information.

Application Notes:

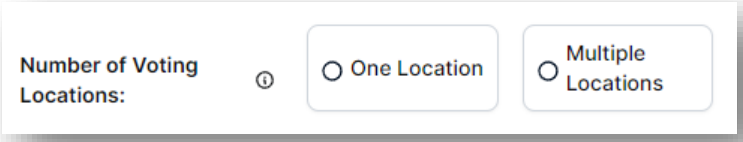
The Voting Location Resource Calculator is deliberately designed to be flexible to meet the needs of many voting processes. To avoid potential errors or unrealistic results, ensure that all settings have been selected and all values have been entered before running the simulation model. Validation checks are included next to each input, represented by checkmarks, as shown in the figure below. If the checkmark is gray, additional input is required before running the simulation. If the checkmark is green, then that input is satisfied. All checkmarks must be green to press the Run Simulation button.



Few limits are set on the inputs of the Voting Location Resource Calculator. This means that you may enter very large numbers in quantity fields or upload thousands of data points when using the features of this tool. While the tool has the functionality to handle large quantities of data, this may impact the time required to simulate the described voting process. For example, if 100,000 is entered for the Number of In-Person Voters, the simulation may take 10 to 20 minutes to more than an hour to complete. The tool also will not flag instances where values are unrealistic. For example, if 3,000 is entered for the Number of In-Person Voters, but the quantity of Check-In stations is set to 1, the simulation will still run and generate performance estimates. Be sure to check all input values before using the simulation results.

Voting Location Information

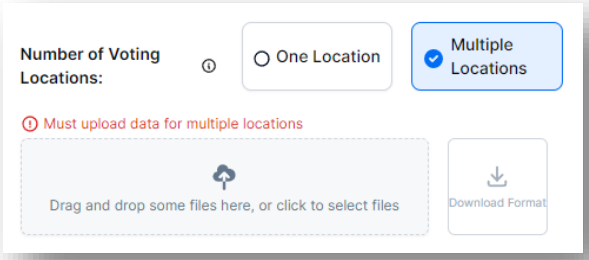
Number of Voting Locations:



One Location:

The One Location option allows you to simulate a single voting location. If this option is selected, a single turnout value may be entered into the Number of In-Person Voters field, and equipment quantities must be set in the Voting Process Data menu for each voting process step.

Multiple Locations:



The Multiple Location option allows you to simulate several voting locations from uploaded data. To use this option, first select Multiple Locations, define the voting process steps in the Voting Process Data window, and adjust all settings to describe the process. Next, download the template file from the Number of Voting Locations menu. Open this file and modify the columns to match the voting process you created in the Voting Process Data menu. The column titles must be in the format of the template file, such that:

Voting Location Name Column: *VotingLocation_Name*

Number of In-Person Voters Column: *InPersonVoters*

Check-in Quantity Column:[1] *CI_Quantity*

[1] This value should represent the number of separate check-in stations available to voters. For paper poll books that are separated alphabetically or otherwise, each binder should count as one station. For example, poll books split such that voters with the last name A-M

Electronic Voting Machine (non-accessible) Quantity Column: *Non_Accessible_VM_Quantity*

Electronic Voting Machine (accessible) Quantity Column: *Accessible_VM_Quantity*

Hand-Marked Voting Station Quantity Column: *Hand_Marked_VM_Quantity*

Ballot Casting Station Quantity Column: *BC_Quantity*

Created Voting Step Quantity Columns: *Created_Step1*, *Created_Step2*, etc.

For example, suppose a voting process consists of a Check-In step, a custom user-created step called Ballot Printing, a Voting a Ballot step, and a Casting a Ballot step. In this case, the spreadsheet should have the following columns:

VotingLocation_Name, *InPersonVoters*, *CI_Quantity*, *Created_Step1*, *Non_Accessible_VM_Quantity*, *Accessible_VM_Quantity*, *Hand_Marked_VM_Quantity*, and *BC_ Quantity*.

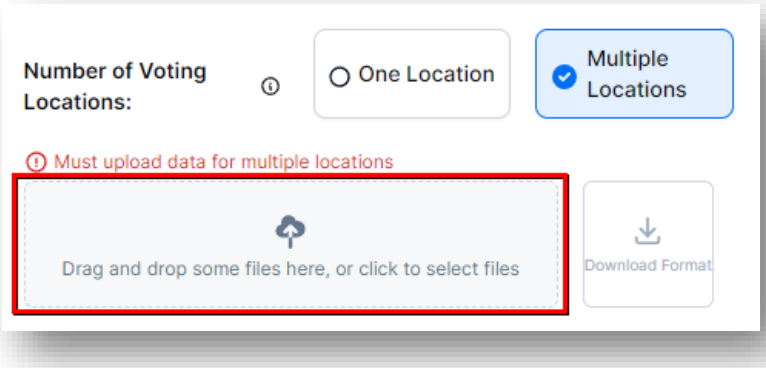
The columns containing the quantities of voting equipment should be in order, from left to right, in the order that voters would experience them. In the case of *Accessible_VM_Quantity*, this column should always be directly to the right of the *Non_Accessible_VM_Quantity* column. If a process included in the template file is not used and was deleted from the Voting Process Data menu on the application, the corresponding column may be excluded or removed from the CSV file. However, for the Voting a Ballot process step, *Non_Accessible_VM_Quantity*, *Accessible_VM_Quantity*, and *Hand_Marked_VM_Quantity* columns must be included in the CSV file. If one or more of these ballot marking methods are not used in your jurisdiction, enter zeros in those columns.

	A	B	C	D	E	F	G	H	I
1	VotingLocation_Name	InPersonVoters	CI_Quantity	Created_Step1	Non_Accessible_VM_Quantity	Accessible_VM_Quantity	Hand_Marked_VM_Quantity	BC_Quantity	
2	Location1	1200	3	3	8	1	0	1	
3	Location2	500	2	2	5	1	0	1	
4	Location3	2300	5	7	15	1	0	1	
5	Location4	897	2	5	6	1	0	1	
6	PollingPlace7	134	1	4	4	1	0	1	
7									
8									

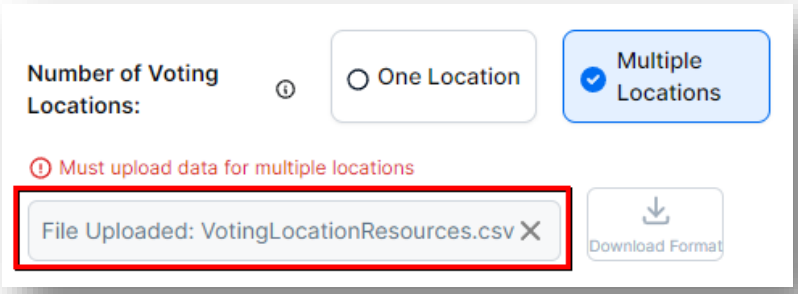
After defining the appropriate columns, you may copy and paste or enter values for each voting location you wish to simulate. The template file contains data for sample voting locations, which should be deleted before entering new data. Ensure that there are no blank values in rows containing voting location information. Once data for all desired voting locations are entered, save the file as a Comma Separated Variable (CSV) file, and upload it to the Voting Location Resource Calculator by clicking on the File Upload button (shown in the figure below) in the

use one check-in station and voters with the last name N-Z use a different station, the check-in quantity should be 2.

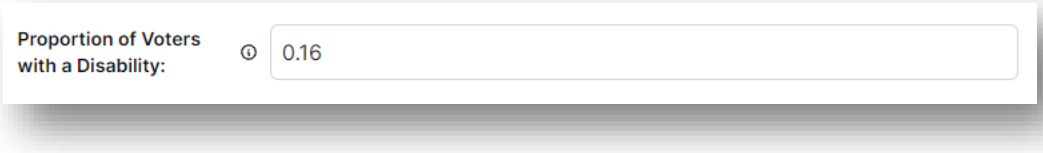
Number of Voting Locations menu and locating and selecting the file from the File Explorer.



When you see the name of your file on the File Upload button, additional changes to the Voting Location settings and Voting Process Data settings may be made. However, if voting process steps are added or removed, or if the order of steps is adjusted, an alert will appear describing the error. To resolve this error, the Multiple Location file must be modified to match the Voting Process Data menu and reuploaded following the steps above.



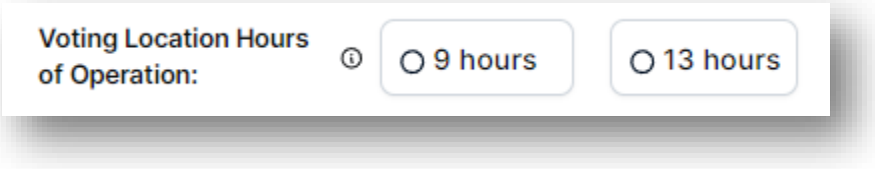
Proportion of Voters with a Disability:



The Proportion of Voters with a Disability input can be set to the proportion of individuals who report having a disability within a jurisdiction. A link to the United States Census Bureau is included at the bottom of the menu, which contains disability rates at county, city, and town levels. This value is internally adjusted by the calculator to account for the proportion of voters with disabilities who choose to vote in person.[2] By default, this value is set to 0.16, indicating that 16% of voters who turn out to vote have a disability. This default value is calculated from the 2022 American Community Survey and represents the average proportion of the voting-age population with disabilities in counties across the United States. To determine the 'Proportion of Voters with a Disability' value for your jurisdiction, you can utilize the EAC's video on Estimating the Voting Age Population with Disabilities, which provides step-by-step instructions. A written version of these instructions is provided in Appendix A.

Note: the proportion of the population with disabilities reported by the American Community Survey includes individuals who are not of voting age or may be otherwise ineligible to vote. Additionally, certain groups are excluded or underrepresented in the data from the American Community Survey, such as individuals who are institutionalized.

Voting Location Hours of Operation:

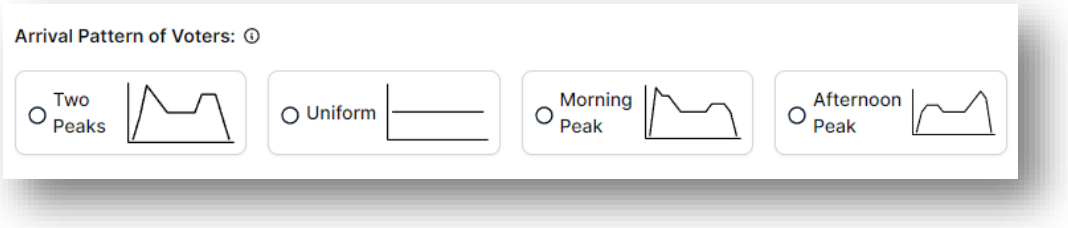


The Voting Location Hours of Operation option can be set to represent a nine-hour or 13-hour voting day. If the hours of operation for a particular voting location are not listed, select the closest option. If the actual hours of operation are shorter than the option selected, wait times may be slightly longer than the estimates generated

[2] It is assumed that 26% of voters with disabilities vote in person. See: United States Election Assistance Commission, 2021a. New data: 17.7 million Americans with disabilities voted in 2020, a significant increase over 2016. URL: https://www.eac.gov/news/2021/07/07/new-data-177-million-americans-disabilities-voted-2020-significant-increase-over.

by this calculator. If actual hours are longer than the option selected, wait times may be slightly shorter than the estimates.

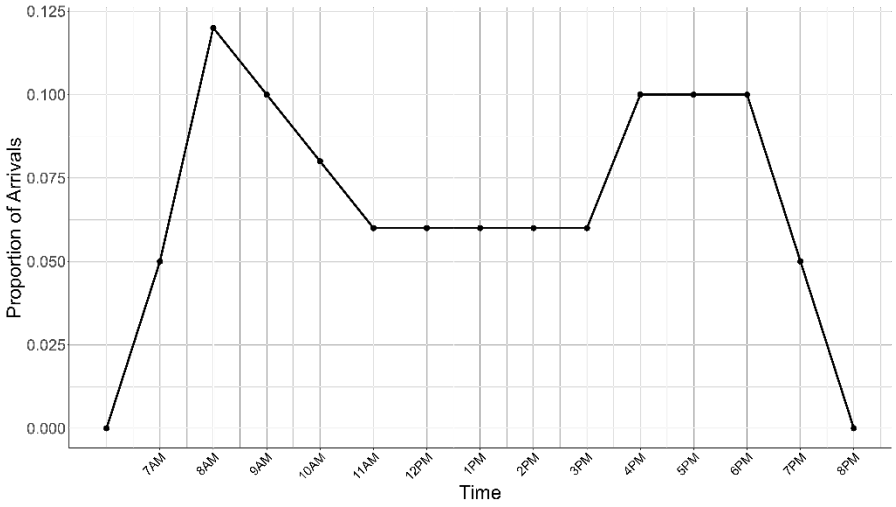
Arrival Pattern of Voters:



The Arrival Pattern of Voters option allows you to adjust how voters arrive at a voting location throughout a voting day to best represent voters in your jurisdiction. These arrival patterns are presented in more detail below, using a 13-hour voting day:

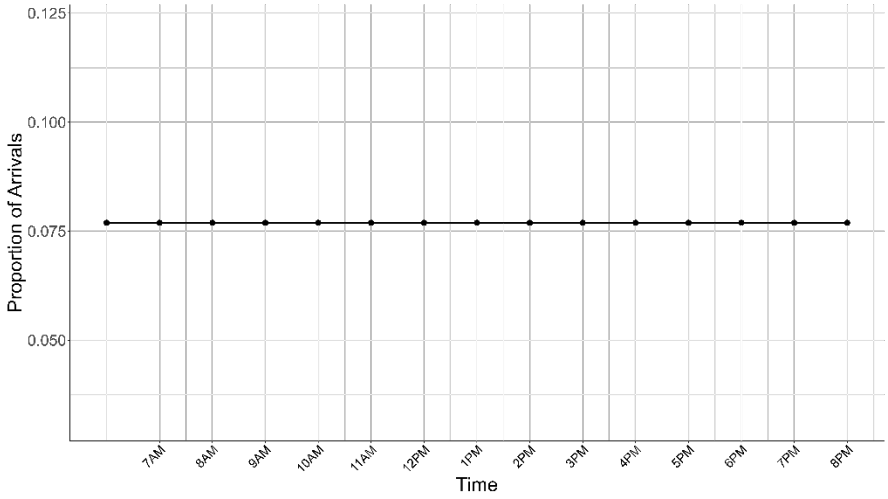
Two Peaks Arrival Pattern:

The Two Peaks Arrival Pattern exhibits a large proportion of voters arriving in the morning, between 7 a.m. and 10 a.m., with another increase in voter arrivals from 4 p.m. to 7 p.m.



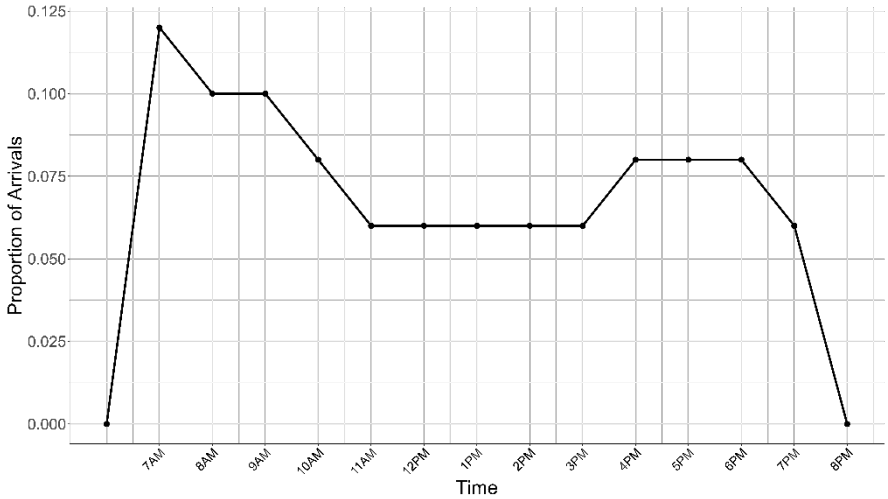
Uniform Arrival Pattern:

The Uniform Arrival Pattern exhibits a pattern of voter arrivals that is consistent throughout the voting day. The simulation will create some randomness in voter arrivals throughout the voting period to more accurately reflect actual voter arrivals, but the proportion of arrivals does not fluctuate throughout the voting period.



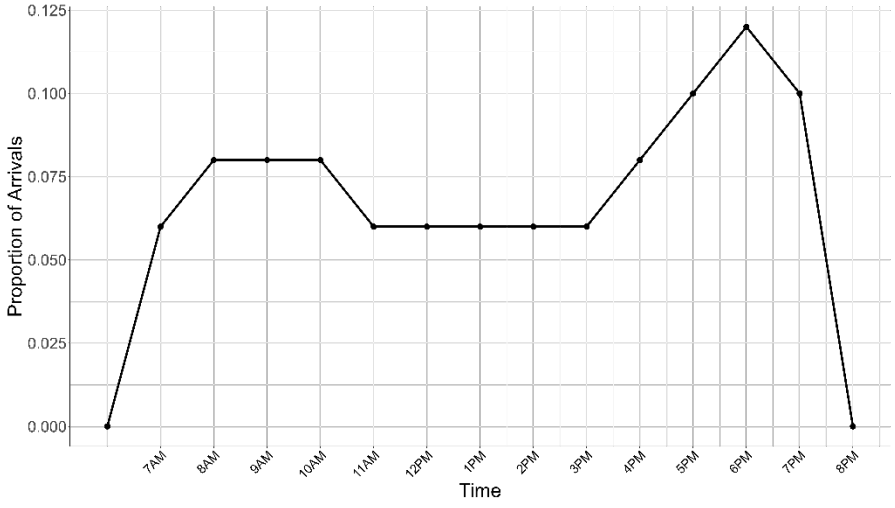
Morning Peak Arrival Pattern:

The Morning Peak Arrival Pattern exhibits a large proportion of voters arriving in the morning during the voting period between 7 a.m. and 10 a.m. Voter arrivals then decrease and remain consistent between 11 a.m. and 3 p.m., with a slight increase in arrivals from 4 p.m. to 6 p.m.

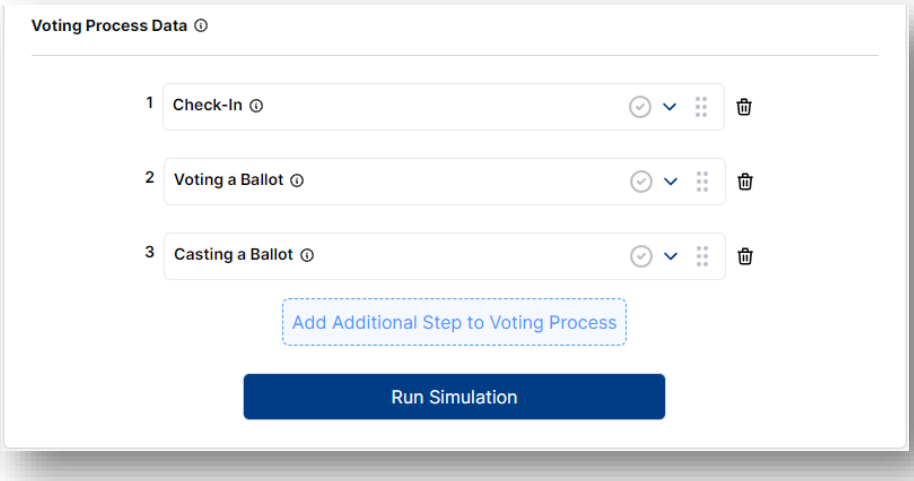


Afternoon Peak Arrival Pattern:

The Afternoon Peak Arrival Pattern exhibits a large proportion of voters arriving from 4 p.m. to 7 p.m. Voter arrivals remain relatively consistent throughout the morning and early afternoon of the voting period, with slightly more arrivals occurring from 8 a.m. to 10 a.m.

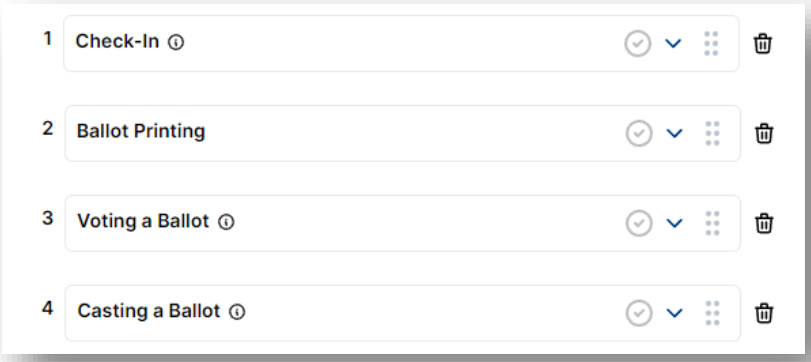


Voting Process Data



Defining the Voting Process:

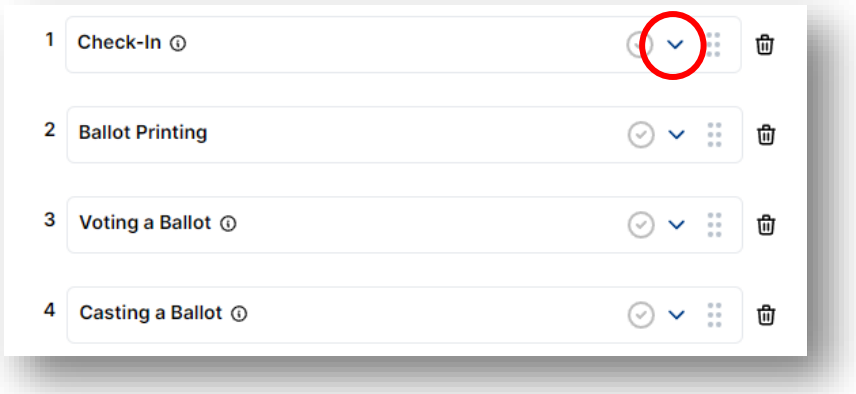
The Voting Process Data options allow you to build a representation of your voting process. By default, voting steps for Check-In, Voting a Ballot, and Casting a Ballot are provided in this window. However, these steps may be deleted, and new steps can be created to best match your voting process. The order of these steps should reflect the order of the voting process as it is experienced by voters, with the first step at the top of the list and the final step before exiting the voting location at the bottom. The numbers to the left of each step represent the order in which steps are performed. For example, the voting process shown in the figure below consists of 1) voters first checking in, 2) having a ballot printed, 3) voting their ballot, and 4) casting their ballot as the final step in the voting process.



To adjust the order of voting steps, click and drag the task using the six gray dots to the right of the processing step.

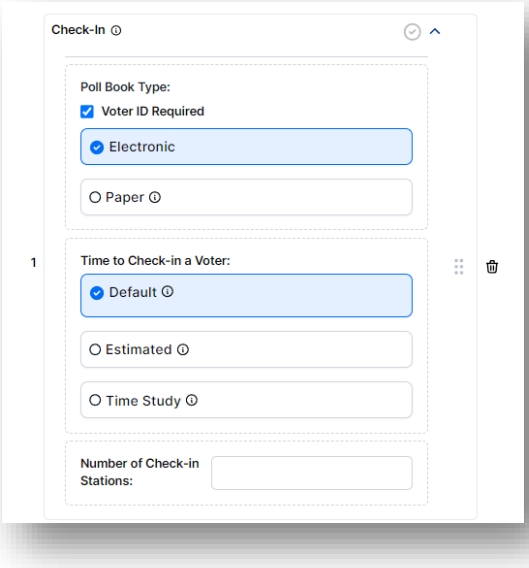
Adjusting Each Voting Step's Settings:

Within each voting step presented as part of the voting process, settings must be adjusted. Using the downward-facing arrow shown in the figure below, settings can be accessed for each voting step.

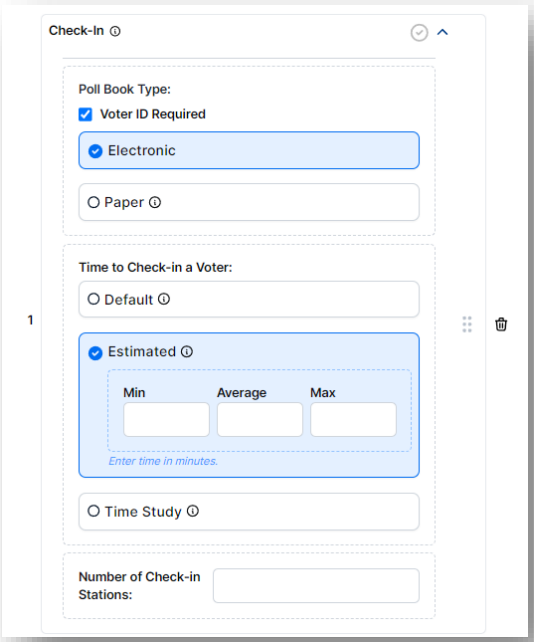


Within each voting step, you must enter the quantity of equipment (if One Location is selected) and the processing time, and adjust additional settings, such as the type of equipment in use (not applicable for user-created steps). The quantity input should represent the number of stations available for a voting step that can serve voters. For example, if five voters can be checked in to a voting location simultaneously, then the quantity of check-ins should be set to "5".

Processing times may be defined in several ways. If there is limited data that describes your specific voting step, Default processing times may be selected. These Default processing times are generated from data collected by URI VOTES in actual elections.

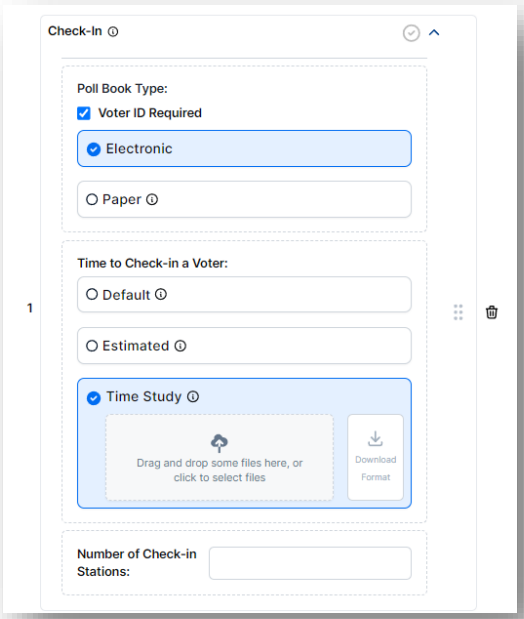


Alternatively, Estimated or Time Study options can be selected. If you have a rough idea of how long a voting step will take, select Estimated and enter minimum, average, and maximum values for how long the step takes. All values should be entered in minutes. When the Estimated option is selected, the Voting Location Resource Calculator automatically fits the minimum, average, and maximum processing time values to a triangular distribution to generate processing times.



Selecting the Time Study option allows you to upload data from time studies for a voting step. At least 20 observations are required to use this processing time option. The file containing the data must:

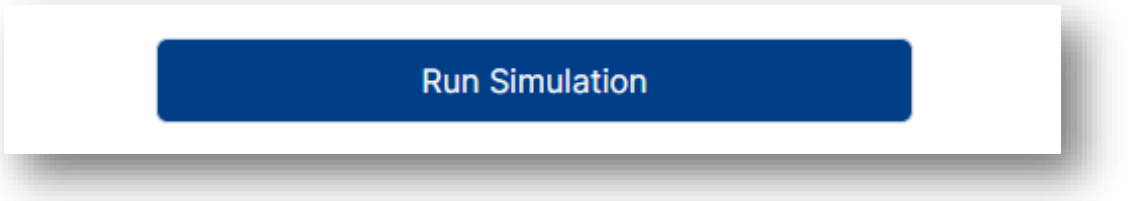
- Be saved as a Comma Separated Variable file (.csv)
- Contain only one column, titled “minutes” or “Minutes,”
- Have at least 20 rows of timing data in that column, with minute values entered numerically (e.g., 5.5 for 5 minutes, 30 seconds)



An example of this data formatting is presented in the figure below – note that Date Time data formats (e.g., 5:30.00) will not be accepted by the application. A sample data file can be downloaded and modified by clicking the 'Download Format' button in the Time Study option.

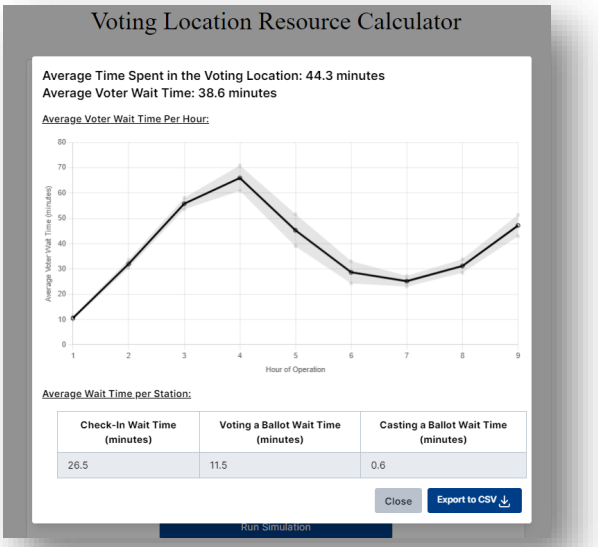
	A	B
1	Minutes	
2	0.76667	
3	0.41667	
4	0.61667	
5	1.48333	
6	0.56667	
7	1	
8	1.45	
9	0.81667	
10	0.78333	
11	0.46667	

Once all voting process and voting step settings are completed, the simulation can be run by clicking the Run Simulation button (pictured below).



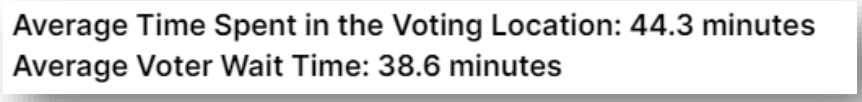
Simulation Outputs

Single Location Outputs:



Simulation results for a single voting location model include 1) Numeric Outputs, 2) Hourly Voter Wait Times, and 3) Station Wait Times. When the simulation model finishes running, an output window will appear that presents model results, including:

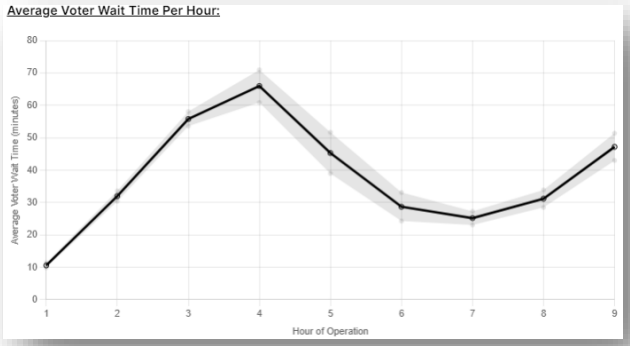
1) Numeric Outputs



At the top of the results window, two numeric values represent the Average Time Spent in the Voting Location and the Average Voter Wait Time. The Average Time Spent in the Voting Location represents the average duration voters spend within

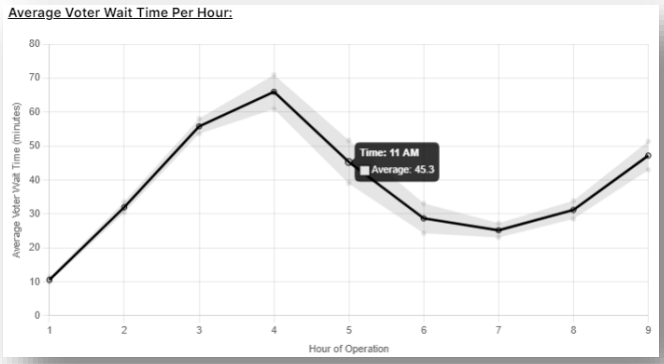
the voting location, including time spent waiting and time spent performing voting steps. The Average Voter Wait Time represents the amount of time that voters wait throughout the entire voting process. For example, if the voter waits 20 minutes to check in, 4.6 minutes to mark a ballot, and 10 minutes to submit their ballot, the voter wait time is 34.6 minutes.

2) Hourly Average Wait Times

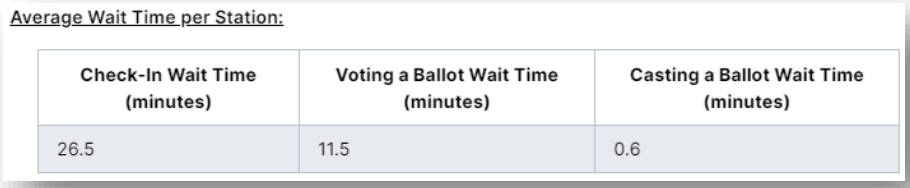


The line plot in the output window presents the average of average voter wait time per hour throughout the voting day across replications (black line) and the range of average values per hour across replications (upper and lower gray lines). The black line represents the expected average voter wait time per hour. The gray line below the black line represents the lower bound of the 95% confidence interval of the average voter wait time per hour, while the gray line above the black line represents the upper bound of the 95% confidence interval of the average voter wait time per hour across all replications.[3] These gray lines represent outliers in average voter wait time estimates and the range in average voter wait time that may be experienced. The figure below shows a sample Hourly Average Wait Time plot for a three-step voting process. Hovering over a point on the black or gray lines displays the time of day and the average voter wait time at that hour. In the figure below, the expected average voter wait time at 11 a.m. is 45.3 minutes. However, the gray lines indicate that the average voter wait time at 11 a.m. can range from 39 minutes to 51.7 minutes.

[3] A 95% confidence interval represents the statistical range containing an estimated value 95% of the time. This statistical range best represents the likely bounds of the performance metric, in this case, Average Voter Wait Time.



3) Station Wait Times



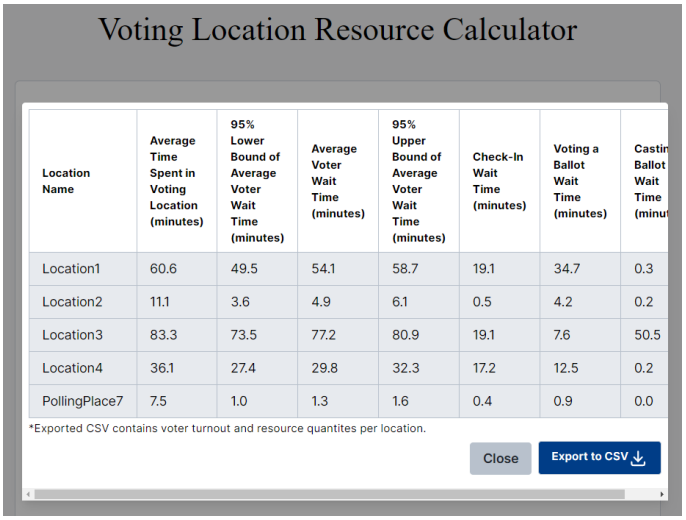
Average Wait Time per Station:

Check-In Wait Time (minutes)	Voting a Ballot Wait Time (minutes)	Casting a Ballot Wait Time (minutes)
26.5	11.5	0.6

The table at the bottom of the output window presents the estimated average wait time for each station. These values represent the expected amount of time that a voter spends waiting to use each station.

Results can be downloaded using the Export to CSV button at the bottom of the output window.

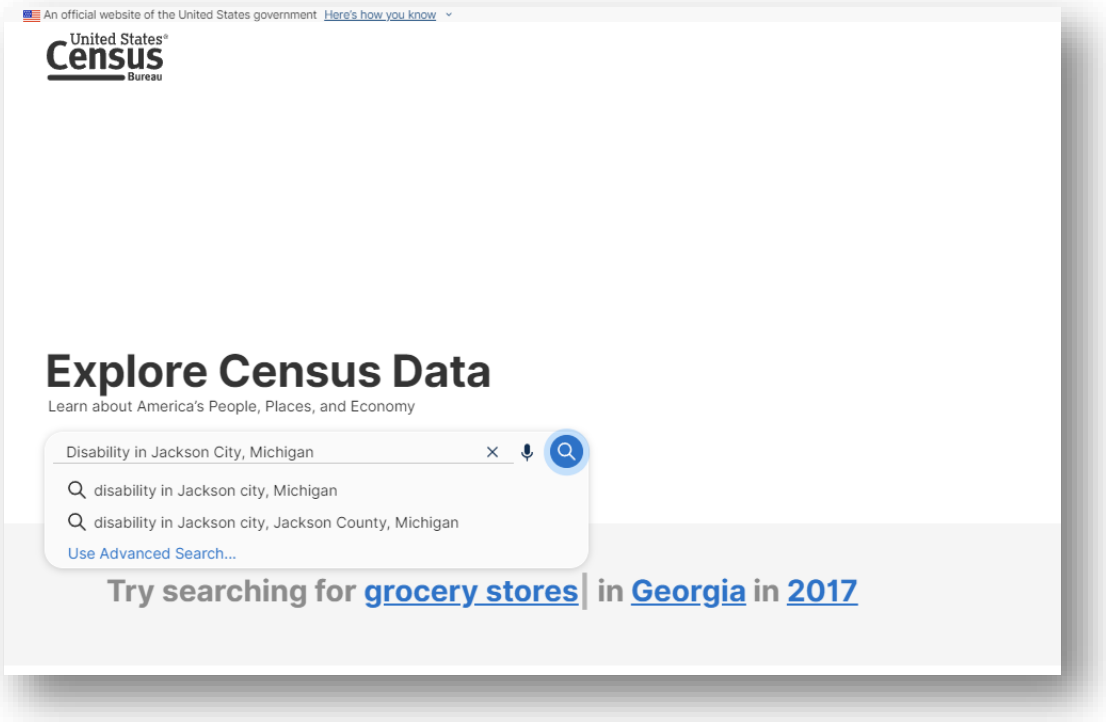
Multiple Voting Locations Output:



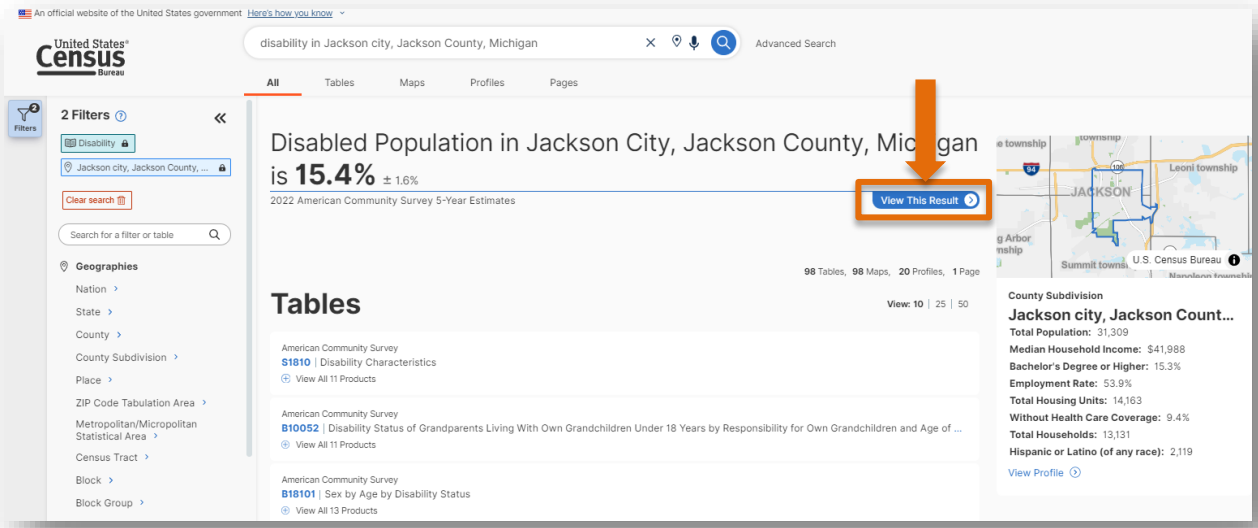
Simulation results for Multiple Locations models are displayed numerically in a table format, as shown in the figure above. For each voting location name, 95% confidence interval lower bound (95% Lower Bound), average, and 95% confidence interval upper bound (95% Upper Bound) values for Voter Wait Time, the average of Average Time Spent in the Voting Location, and Wait Time per station are presented. The average values represent the most likely cases, while the 95% Lower Bound and 95% Upper Bound values represent the range of potential values that contain 95% of all observations due to inherent process randomness. For example, in the figure above, the average wait time for Voting Location 4 has a 95% likelihood of being between 27.4 and 32.3 minutes. The table of results may be downloaded as a Comma Separated Variable (CSV) file using the Export to CSV button, which can be opened in Microsoft Excel, Google Sheets, or other spreadsheet software.

Appendix A: Determining the Percentage of Voters with Disabilities for a Jurisdiction

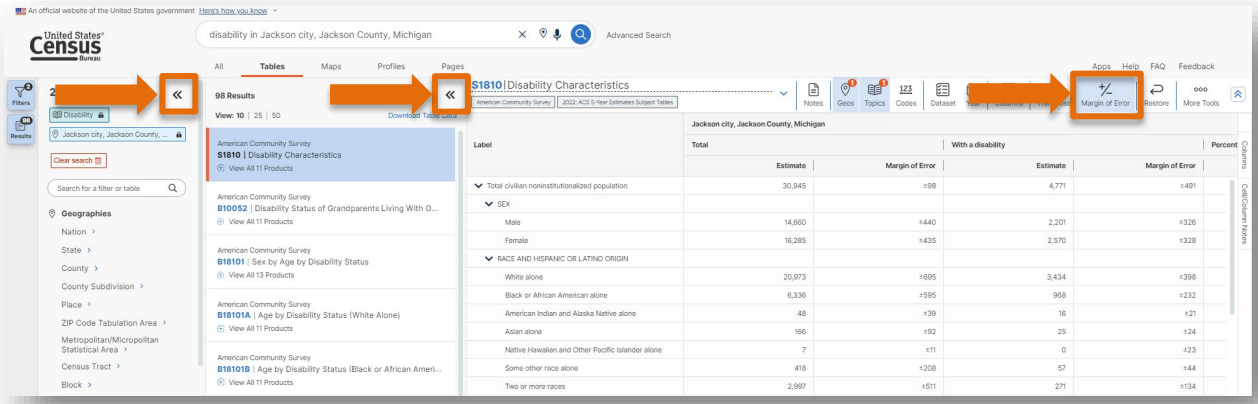
1. Navigate to data.census.gov.
2. Using the search bar, type in "Disability in" and the name of your jurisdiction. In the figure below, we are searching for "Disability in Jackson City, Michigan".



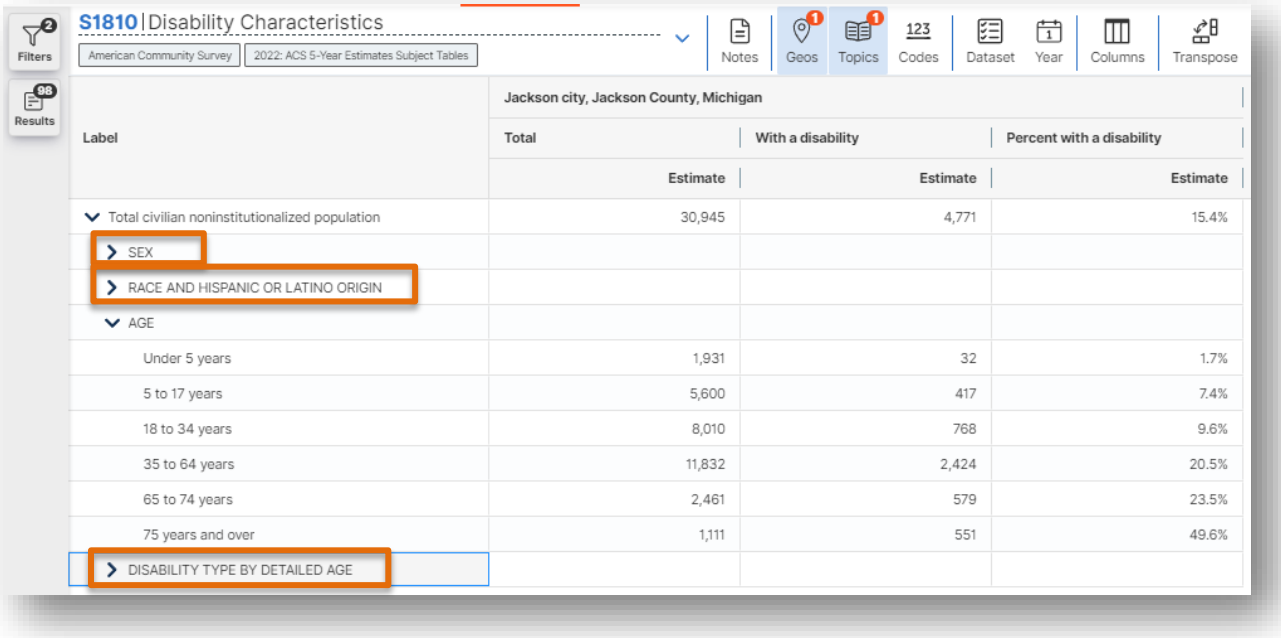
3. To make sure we see the correct results, use the dropdown menu under the search bar to select the correct search terms. In this case, we will select "disability in Jackson City, Jackson County, Michigan."
4. The page will now provide an overview of the data and a list of tables containing relevant information. To see the disability data that we need, click on the "View This Result" button under the overview (see chart below).



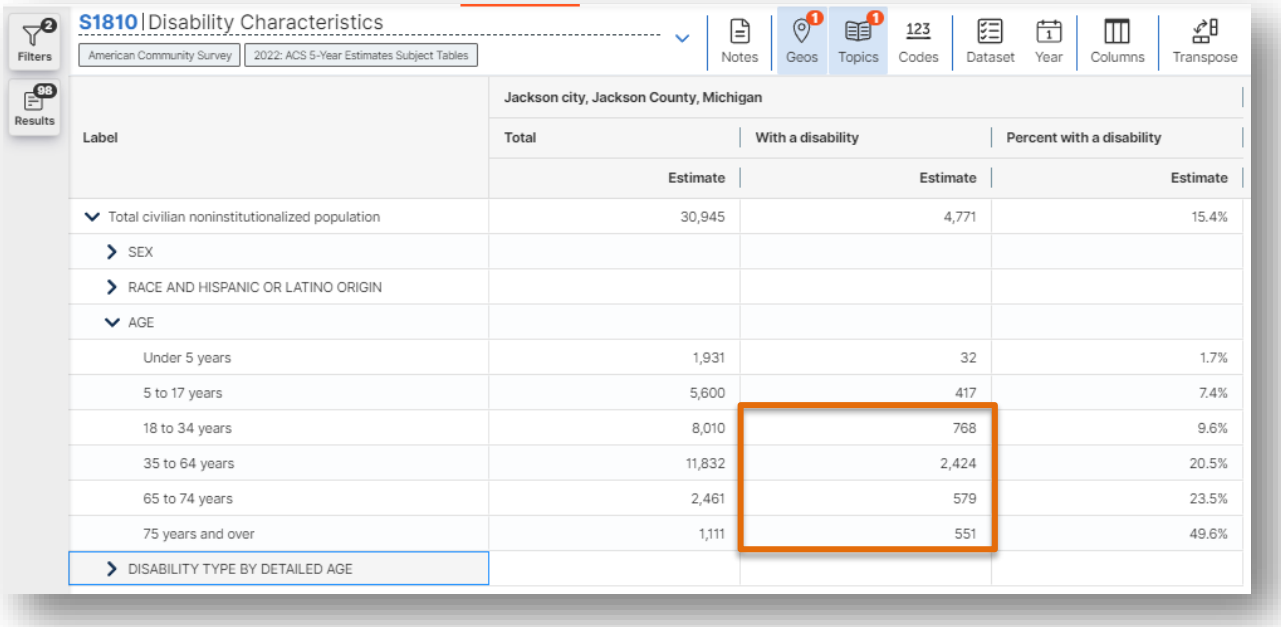
5. To simplify the new page, collapse the menus to the right side of the screen by clicking on the arrows at the top of each menu and deselect the "Margin of Error" button, as we do not need these data columns.



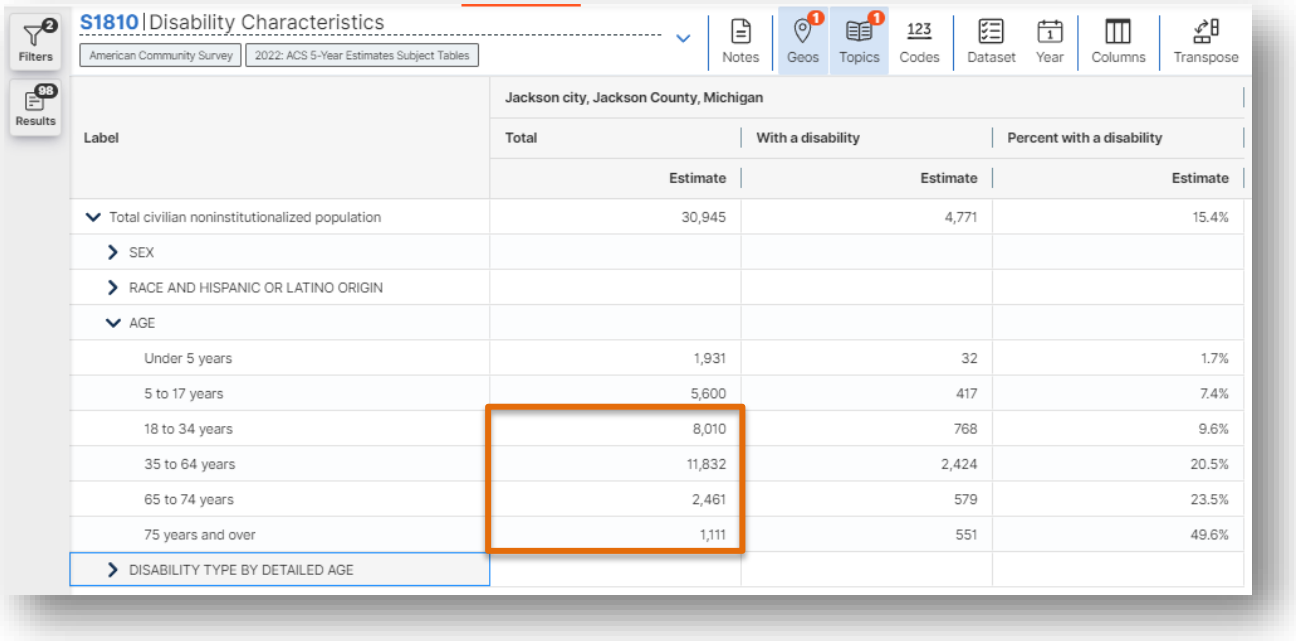
6. We can now hide rows of data that we do not need. Make sure that the "AGE" columns are visible in the table and hide others that you do not wish to see in the table. Here, we have hidden "SEX," "RACE AND HISPANIC OR LATINO ORIGIN," and "DISABILITY TYPE BY DETAILED AGE."



7. To calculate the percentage of the voting-age population with disabilities, we first sum values in the "With a Disability" column (above) for age ranges that represent eligible voters. In this case, 4,322 people over the age of 18 have disabilities in Jackson City, Michigan.



8. Next, we sum up the total voting-age population in the "Total" column. This equals 23,414 people over the age of 18.



Finally, to calculate the percentage of the voting-age population with disabilities, we must divide the population with disabilities by the total population. In this case, we divide 4,322 by 23,414, which provides a proportion of 0.185, or 18.5%. This means that approximately 18.5% of eligible voters in Jackson City, Michigan, have a disability.