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The Effects and Costs of Changes in River Flooding in New Jersey

Yousef Alagrabawi

Abstract

The purpose of this research is to quantify the flood risks of rivers in various locations in New Jersey and how they have changed over time. This is important because the change is likely to continue over time as climate change continues. ArcGIS, HEC-SSP, and online sources such as Trulia (www.trulia.com) were used to understand where flooding is most likely to occur, which streets, and how many homes will be affected and estimate the cost of damages from a potential 100-year flood. I compiled information such as annual peak river discharge from the USGS river gages on the Delaware River in Trenton, Raritan River in Manville, Ramapo River in Pompton Lakes, Hackensack River in New Milford, and the Musconetcong River in Lake Hopatcong. I analyzed either a 1/9 or 1/3 arc-second Digital Elevation Model (DEM) to map the floodplains. These DEMs allowed for the area covered by floods to be mapped. HEC SSP was used to calculate the discharges for various flood frequencies over three time periods: 1959-1988, 1989-2018, and then the overall time period of 1959-2018. I compared the differences in flood magnitudes to see if there was a change in flooding over time.

Based on the information from HEC-SSP, I mapped the 1% annual exceedance chance floodplain using ArcGIS for the new 30-year data and the total 60-year data. I was then able to compare where the flood water extended against a map from the real estate website, Trulia, to see how many homes would be flooded during a 1% flood and the total cost of potential damage. Due to the influence of climate change and a rise of impervious surfaces over the past 30 years, the recent 30-year data showed a total of 1,369 homes are at risk of flooding with potential damages of $456,482,000. This number is almost double that of the 60-year data which is at 820 homes totaling $273,087,000 in damage.

Keywords: Flood, Rivers, New Jersey, Property Damage, Climate Change, Urbanization.

MONTCLAIR STATE UNIVESITY

The Effects and Costs of Changes in River Flooding in New Jersey

By

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Table of Contents

List of Figures

List of Tables

Introduction

Attempting to understand the power and dangers of river flooding and damage can become overwhelming rather quickly. However, it is important to keep studying and understanding rivers in order to help us in matters of health, safety, economics, and the environment. Rivers have a large effect on how we live our lives whether we live within 50 feet or 50 miles of them. We are seeing and feeling the effects of climate change day by day and catastrophes such as flooding also arise with the ever-changing climate. Warmer climate and weather lead to greater levels of moisture which is an essential flooding ingredient. Studies estimate a change in flood risk such as a rise in discharge, increased urbanization, and damages not only within NJ but also throughout the entire world (Wobus et al., 2019).

The most common form of river flood data used within the United States is the 100-year or 1% flood. A 100-year flood does not mean that a flood will occur every 100 years. A 100-year flood has an annual chance of occurrence of 1%, which is a more complicated but more accurate way of describing the flood. If someone is looking to purchase a home, business, or any piece of property, it is important to know what the 1% flood is in that area so that the buyer knows the flood risk levels they face. Billions of dollars of flood damages occur annually in the United States and there is an average of $38,000 of insurance claim payments in New Jersey annually per household. Flooding in New Jersey has been a prominent issue for many decades and has accelerated in recent years due to warming atmospheres caused by climate change. Combating floods is a daunting task when people are ill-prepared for it. Depending on the volume of water that flows, the best course of action may be to evacuate the property and let flood insurance cover damages. There are not many ways to protect an individual property against flooding if it is in a flood zone.

New Jersey contains over 6,400 miles of rivers from the Ramapo River in northern New Jersey down to the Maurice River in South Jersey near the Delaware Bay. Each of these rivers like the ones researched here can contain as low as zero gages operated by the United States Geological Survey (USGS) to as many as five or more gages, with a total of 550 in New Jersey. These gages record crucial data on a day-to-day basis. These data can be used to understand the stream water level, river height, discharge, and more. The annual peak streamflow (the largest discharge recorded in a water year October 1 to September 30) of the rivers can vary widely both spatially and temporally, so analyzing multiple gages will improve our understanding of the flood risks and potentially devastating impacts these rivers can cause.

While modeling and analyzing the flood risks of rivers are beneficial for research purposes it is just as, if not more, important to share the results with the general public, specifically home-buyers. When applying for a home loan it should be just as important to discuss flood risk for the upcoming years and even as far as decades down the line. Since the start of a national flood mapping program done by FEMA in 1967, only a third of the rivers in the United States have been properly modeled by FEMA, and of those models, only a quarter of them have been updated in the past five years (2017-2022) (Wing et al., 2022). FEMA models are not required to account for climate change, and they simulate a limited number of flood frequencies, which results in a limited calculation of yearly flood losses.

The following research was conducted to understand how river flooding in New Jersey has changed and how those changes have affected nearby properties. Using data gathered from the United States Geological Survey (USGS), online home-pricing websites, and previous articles of similar work, it is possible to understand how devastating a 100-year flood can cause. Programs such as Excel, HEC-SSP, and ArcGIS are crucial in gathering the data from the USGS and plotting it all into a table and map to help visualize all the numbers better.

Literature Review

Reviewing previous research done on rivers can assist in understanding how to better manage them. Wing et al. (2022) reviewed how river flooding research often relies heavily on historical flood data which often fails to account for the changing nature of floods. Flood records show that a changing and warming climate increases flood risks by amplifying the intensity of the hydrologic cycle. Literature to understand more about how rising global temperatures affect river flooding is also important to see the correlation between them.

More research should be done on changes in river flood frequency, especially at the local scale (Dottori et al., 2018). Even though river flooding is a costly natural disaster, how floods will change with the rising global temperatures is still under-researched. The article estimated how much economic damage and deaths would occur if the planet's temperatures were to increase by 1.5^{o}C to 3^{o}C. They concluded that a 1.5^{o}C increase in global temperature would lead to an estimated 70-83% human losses and direct flood damage would increase by 160-240%. A 2ºC and a 3ºC would dramatically increase those numbers.

The previous journals discussed in this paper mention projections of what could happen with rising global temperatures from 1.5ºC to 3ºC. The Paris Agreement aims to limit the global temperature increase to no more than 1.5ºC and has caused scientists to explore other options for reducing warming as well as understanding the socioeconomic impact of warming the earth leading to natural disasters. Alfieri et al. (2016) estimated the economic damage as well as the population affected by river flooding on a global scale. They used high-resolution climate projections as well as modeling river discharge simulations to represent the climate not only for today but in the future as well. The article also mentions modeling simulated temperature increases of 1.5ºC, 2ºC, and 4ºC to see how each scenario would play out. The journal concluded that there was a positive correlation between the rising global temperatures and the risks of river flooding. At an extreme scale, a 4ºC increase would see a 500% increase in flood risk in areas holding over 70% of the earth's population. The increase in flood risk mostly applied to Asia, Europe, and the United States.

Increased urbanization leads to a higher risk of river flooding. To combat the increase in population and urbanization, we tend to manipulate rivers and other waterways in such a way that it makes it easier for us to develop new land to build on (Rubinato et al., 2019). The increase of impermeable surfaces leads to a greater chance of flooding due to precipitation. Rubinato et al. (2019) found that 2.7 million properties in England as of 2013 were at risk of flooding, and that number doubled by the year 2017. They also analyzed flood risks in China and found that as many as 137 million people are at risk of flooding and high-intensity flash floods have already occurred.

Munoz et al. (2017) propose that extreme weather events can influence heavier and more damaging river floods. However, the floods cause more damage when they are also influenced by El Niño. In this situation, about six months to a year before the Mississippi river floods, El Niño releases enough rainwater throughout the Mississippi basin that it saturates the soil. This means that when the river floods, it causes more water to runoff and damage nearby towns since it has nowhere to infiltrate. Therefore, it is important to consider climate variability in flood prediction. They stated that to improve the prediction of floods throughout the Mississippi basin, it is important to understand whether there are links between flood occurrences and climate variability and if there are, what are those links and how can we use that to prevent and forecast floods. Gudundsson et al. (2021) researched thousands of extreme hydrological events and river flows. They then compared that with simulations of the average global water cycle to estimate a difference in the trend of rising flood risks due to climate variability. Their results showed that the trends of the changing river flow can only be explained if climate change effects are included in the observation. The researchers were able to conclude that no other simulation they did could answer the increase or even decrease of river flow other than human-influenced climate change. Some areas of the globe saw a reduced river flow which leads to drying of the area whereas other parts of the world saw over saturation of the land due to a heavy increase in river flow. Blöschl et al. (2019) demonstrated how climate change can also reduce precipitation and river flooding to cause a dryer climate. They documented how an increase in precipitation in the fall and winter seasons in northwestern Europe have led to an increase in flooding whereas a decrease in the rain, as well as an increase in evaporation, has led to decreasing floods in southern Europe. Flood discharge trends in Europe have ranged from an increase of 11% to a decrease of 23% due to the reduction of rainfall and increase in evaporation.

Booij (2005) used HEC-RAS to model river flow in one dimension and floodplain flow in two dimensions. Booij (2005) also used soil data from the United States Geological Survey and the European Soil Bureau to understand how different soils affect flooding. Soil porosity and soil parent material were used to calculate the soil moisture levels and how much river flooding would increase the moisture content (Booij 2005). They also noted that with climate change there is a small increase of extreme river discharges as well as an increase in discharge variability and uncertainty.

The Russian River in Northern California is flood-prone and after multiple years of field observations and data analysis, Ralph et al. (2006) found that atmospheric rivers played a critical role in flooding the Russian River in California. They combined field research with a Special Sensor Microwave Imager (SSM/I) satellite observations to understand how these rivers create precipitation that causes these flooding events. Ralph et al. (2006) recorded seven flood events in the Russian River and noted that a warmer climate and increased precipitation led to an increase in flood damage from the river but that not all floods were caused by the river's influence on atmospheric changes. Other floods were instead by heavy precipitation and low permeability leading to surface runoff. Additionally, the article states that if the soil surrounding the river was dry, it would absorb most of the rainwater and lead to less of a flood hazard. This research assisted in my observation that a more permeable environment could help reduce the risk of flooding in an otherwise heavily urbanized location. That work was an important note for how it ties into the research that I am doing and how a more permeable surface and adding more green spaces can reduce the risk of flooding via a river or precipitation.

In the summer of 2020, the Yangtze River in China flooded and took the lives of 142 people and affected 45.5 million people. Economically, there was a total loss of 16.5 billion US dollars. (Wei et al., 2020). This was their worst recorded flood since 1998. Since the 1998 flood, China took many preventative measures such as dams, levees, reservoirs, and green infrastructure. The technology could help reduce flood damages with improved weather and hydrological forecasts and planning. With China's urbanization levels rapidly increasing that also means that the infiltration of water is rapidly decreasing and runoff increasing unless mitigations efforts such as those mentioned above are implemented. It is evident that river flooding can be seen and is usually researched in countries outside of the U.S but seeing their research and how they come to understand river flooding can become a guide for us.

Jongman et al. (2012) used different methods to estimate the global exposure to river and coastal flooding over an 80-year period (1970-2050). By using population density data, flooding data, and national income data, Jongman et al. (2012) estimated $46 trillion in 2010 from damages stemming from coastal and river flooding and by 2050, the estimate more than tripled to $158 trillion. They forecasted increasing population and the associated changes in land-use change to calculate a flood exposure of $27 trillion for 2010 and $80 trillion for 2050. To make matters worse, Jongman et al. (2012) stated that there is a systematically larger continued growth of population in areas that are within the flood hazard zone. There is a strong correlation between the increase in flood risk and population, however, they are not caused by each other.

Suriya and Mudgal (2012) documented how urbanization has disrupted the hydrologic cycle. A rise in impervious areas reduces the infiltration of water and increases runoff and causes greater flood peaks (Suriya & Mudgal, 2012). Even if rainfall does not last for a long period of time, we can still see a heavy increase in runoff volume in heavily urbanized areas such as cities like New York or Chicago. The cost of mitigation efforts will only increase as floods rage stronger with each passing year. Changing land use where it could fit in sustainably with river flow and precipitation is a crucial first step that Suriya and Mudgal (2012) are suggesting to prevent any further damage from river flooding.

Methods

The New Jersey Stream Flow Table (www.waterdata.usgs.gov/nj/) provided the names of the five rivers that contained the best data for this research as well as their gage locations and the number of the stations. The five river gages that I chose for my research were done after I did extensive calculations on a total of 40 gages and determined that those five would fit best for my work (Figure 1). This assisted in understanding the available list of gages as well as some data such as discharge, gage height, and more. Once the rough list of rivers is gathered the filtering of rivers to find any that fit the following criteria. For a river and its specific gage to work for the research, it must have data spanning from the year 1959 to 2018. This 60-year timeline was chosen because I wanted to have at least 30 years of data to get a good sample size. After, I decided on comparing it to the 30 years before that so that I can calculate the difference in flood frequency.

Methods 1.1 HEC-SSP

The Hydrologic Engineering Center's Statistical Software Package (HEC-SSP Version 2.2) was used to statistically analyze river data such as flood flow frequency. The program also allows for other hydrologic data such as volume frequency analysis on high or low flows. It gives me access to any river gage I needed throughout New Jersey and the gage's hydrologic data.

Before using the HEC-SSP program, I needed to make sure that all the gages had continuous peak annual flow data from 1959-2018. I separated that data into 1959-2018, 1959-1988, and 1989-2018 so that I may have three timelines showing the most recent 30 years, previous 30 years, and total data. HEC-SSP considers 10 or more years of data as enough to continue the work since that is the minimum requirement through the program, but I needed 30 as this is the recommended time for analyzing changes in climate (e.g., WMO 2017). During the research I found onto many gages that gave me error codes warning me of lack of data, so carefully cross-checking every gage's data was crucial in ensuring all the data was available.

I accessed the New Jersey's River gages through the USGS data tab and selected the one gage I wanted to extract data for. I did this for dozens of rivers to give me a larger sample size to work with. I used the Bulletin 17B option for the analysis and set the dates I wanted to analyze the data. Bulletin 17B is a feature of the HEC-SSP program that is used as a guide for the development of peak flow frequency analyses in the United States (www.hec.usace.army.mil, 2022). I ensured that I started and ended the 30^{th} of September or each timeline I used as those dates that indicate a water year. A water year is what the USGS uses in reports that deal with surface-water supply. I used HEC-SSP to determine the various flood magnitudes for different flood frequencies for the gages which are the 2-year (50%), 5-year (20%), 10-year (10%), 20-year (5%), 50-year (2%), 100-year (1%), 200-year (.5%), and 500-year (.2%) floods.

Methods 1.2 Excel

I exported the HEC-SSP files into Microsoft Excel (Version 2019) for further analysis. I downloaded the computed curve flow data from HEC-SSP and moved it into Excel (Table 1). The output from HEC-SSP is a comma-separated-value (CSV) file, which can be imported into excel and makes for easier handling of the information and data. I analyzed the flood frequencies from the 2 to 500-year floods or 0.2% to 50% chance annual chance of occurrence. I then calculated the percent change of flow between the 1959-1988 (old) data points and the 1989-2018 (new) data points as well as the 1959-2018 (60 years) data points and the 1989-2018 (new) data points.

(Table 2) shows an example of what this data sheet looks like with 60 years of data separated into three parts as well as all the calculations and results. Once that is completed, I chose five gages with data that have non-overlapping 95% confidence interval numbers results from HEC-SSP for me to use for the calculations and Geographic Information System (GIS) work that I would like done and the GIS steps will be discussed in further detail in the next section. I first built a rating curve using peak annual flow data from every single year as well as the gage height from these five rivers, those being the Delaware River in Trenton, Raritan River in Manville, Hackensack River in New Milford, Ramapo River in Pompton Plains, and the Musconetcong River in Lake Hopatcong. Figure 2 shows the rating curve is a logarithmic equation that I can then use to calculate river depth from the computed river discharges from HEC-SSP.

Methods 1.3 ArcGIS

ArcGIS Pro 2.9 was used to map the extent of the various floods for the studied rivers. I was able to find the coordinates for all five rivers and begin creating my map on ArcGIS Pro. When I had all the coordinates, I created a feature class well as found the DEM by using another program called the National Map Data provided by the United States Geological Survey. A feature class is a collection of geographic features that share the same geometry type and the same attribute fields for a common area. I used the smallest arc second provided so that I do not pull extra details that won't be entirely necessary so 1/9 arc second is preferred though there are times when 1/3 arc second is needed as 1/9 may not cover enough area. When creating the feature class, I had to create a polygon around each of the five gages identified earlier, and that polygon needed to be surrounding the gage far enough where I get enough area coverage to roughly 200’ in each direction. Once the polygon is converted into a raster, I created new rasters, each with one meter more value by using the gage height provided to me through the United States Geological Survey website. As I am using the calculator, I added one meter of depth to each layer starting from the base layer five times so that I may calculate the flood risk accurately. For example, if a gage is at one foot above sea level, I would start the roster calculator at one and then create five layers after they are adding one to each one so going from one to five. To differentiate the floodplain of the 60-year data and the recent 30-year data, I represented the 60- year with a blue line and the 30-year with a red line to visualize the extent of the flood.

Methods 1.4 Trulia

Once a map was generated (Figure 2), I was able to go street by street in GIS to see what homes will be affected by a potential 1% flood and how much the cost would be. I did this twice to compare the 60-year data shown in a blue line and the recent 30-year data shown as the red line in Figure 2. I then accessed the real estate website Trulia (https://www.trulia.com) and went street by street and wrote down the name of the street, how much each home costs on that street, and then added the home values (as of May 13th 2022) so that I can compare the values of the ones affected by the floods.

Trulia showed many parks, centers, industrial buildings, and businesses that would also be affected by the flood, however, there was no estimated value for it as Trulia only shows the value of residential homes. This limits the data on affected property values to strictly residential areas within the mapped floodplain of the rivers.

Results

Results 1.1 Raritan River at Manville

The flood data for the Raritan River in Manville, NJ showed a 100-year flood percent change of 42% from the 60-year data to the new 30-year data. There is nearly a 26,000 cfs difference in the computed curve between the two data sets (Table 2). Even though it has a low chance of occurrence, the 500-year flood shows a nearly 60,000 cfs difference in the computed curve and is notable as that is a 61% change between the recent 30-year data and the 60-year data. The depth calculated from the rating curve (Figure 4) shows a depth increase of about three feet between the 60-year and the new 30-year depth.

Results 1.1.1 Total Home Value: Raritan River at Manville

The Raritan River at Manville data shows a total of 985 homes that would be damaged from a potential 100-year flood with a total value of $353,980,000 versus 60-year data of $197,359,000 making a total increase of $156,621,000 (Table 3). This evidence of potential housing damage can be seen on Lincoln Avenue as well as Boesel Avenue (Table 3), which has a total potential damage estimate of $56 million. The most notable of this scenario can be seen in Huff Avenue which has a total potential damage of $47,362,000 and that data remains the same between the 60-year data in the new most recent 30-year data.

Results 1.2 Delaware River at Trenton

Delaware River in Trenton, NJ shows large flooding numbers such as the 100-year computed curve flow of almost 350,000 cfs for the new data versus nearly 255,000 cfs for the 60-year data; a 37% (95,000 cfs) difference (Table 1). The largest percent change is from the 500-year flood showing a nearly 62% (209,000 cfs) difference between the recent 30-year and 60-year flood data. The depth calculated using the rating curve shows an average increase of three feet from the 100-year flood to the 500-year flood and a little under two feet of difference from the 5-year to the 50-year flood (Table 1).

Results 1.2.1 Total Home Value: Delaware River at Trenton

The Delaware River located in Trenton, NJ does not only affect the streets in West Central New Jersey but also some homes located in the neighboring state of Pennsylvania totaling 215 homes in the floodplain for the new 30-year data. Table 4 shows that the Pennsylvania streets would suffer the same possible flood extent during a 100-year flood either through the 60 year or the last 30 years with a $1,455,000 total difference. Across the state border is an entirely different situation as every street except for S. Warren Street, (Table 4), will have major damage from the new data as opposed to no damage from the old data totaling $14,919,000 or 136 homes flooded.

Results 1.3 Ramapo River at Pompton Lakes

When compared to the Raritan and Delaware river numbers, the Ramapo River seems less of a worry. But with a 19% (~5000 cfs) increase in the computed curve flow, there are still many homes in danger of being hit by a 100-year flood. The Ramapo River starts to show an increase of major flood risk at about the 10% chance point (Table 5) where the percent change from the 60-year data to the 30-year data is only four percent but then rises significantly to 19% at the 100-year flood mark and then 32% at the 500-year flood mark (Table 5). The depth was calculated with a rating curve (Figure 4) and a consistent increase in depth of about one foot from the 60-year to the 30-year data starting from the 10-year to the 500-year flood.

Results 1.3.1 Total Home Value: Ramapo River at Pompton Lakes

The Ramapo River in Pompton Lakes contains 149 homes in the floodplain. There is a $62,312,000 total damage done between all the homes within the observed flood zone from the new data and $51,912,000 from the 60-year data (Table 6). A $10,400,000 difference in damage between the 60-year data and the new data shows the increased risk of damage to residential areas, mostly in streets such as Pine Street and Central Avenue, (Table 6), which account for about six million USD in damage alone across 37 homes.

Results 1.4 Hackensack River in New Milford and Musconetcong River in Lake Hopatcong

In terms of percentage, the Musconetcong River in Lake Hopatcong, NJ has a significant rise (Table 7). With a 119% increase in computed curve flow for the 100-year flood between the 60-year to the 30-year data, the Musconetcong River shows more than two times the rise of flood risk from a 100-year flood. This percentage is compared from 991 cfs to 2,166 cfs, however, it is still a big increase in terms of numbers that have been previously expected of this river. The river depth shows an average increase of about two feet from the 100-year flood to the 500-year flood (Table 7). The Hackensack River in New Milford shows a more consistent increase of percentages from the 20-year flood to the 500-year flood starting at 30% up to 43% but it drops drastically below the 20-year flood. The rating curve for the Hackensack River (Figure 7) shows a similarity in consistency for the change in depth between the 60-year data and the 30-year data. From the 20-year floor up to the 500-year flood we see the 60-year data start at about 6000 cfs and end in the low to middle 8,000 cfs peaking at 8,800 cfs (Table 8).

Results 1.4.1 Total Home Value: Hackensack River in New Milford and Musconetcong River in Lake Hopatcong

The Hackensack and Musconetcong Rivers show the least amount of difference in damage among the five rivers with 21 homes in the floodplain. All the data combined shows a potential of $1,647,000 in damages to a total of 20 homes. The data does not change between the new and 60-year data and a total of five streets will be affected (Tables 9 & 10).

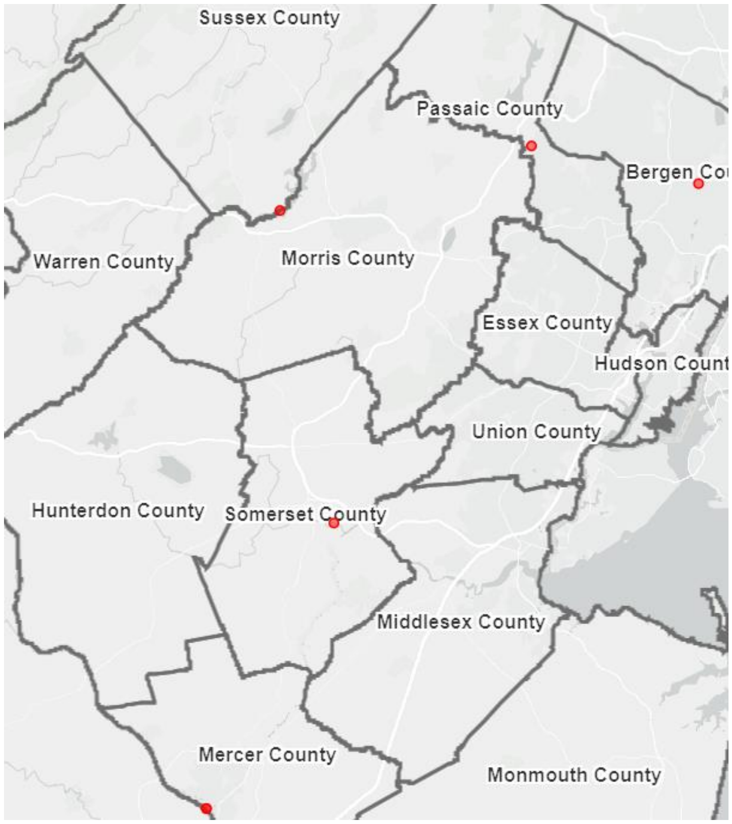

Figure 1. Map showing the locating of all five river gages. Hackensack River is in Bergen County, Ramapo River in Passaic County, Musconetcong River in Morris/Sussex County, Raritan River in Somerset County, and the Delaware River in Mercer County.

Delaware (Trenton)									
Year flood	**% chance**	**60 Years (cfs)**	**1959-1988 (cfs)**	**1989-2018 (cfs)**	**% change old to new**	**% change 60 years to new**	**Old Depth (ft)**	**60 years Depth (ft)**	**New Depth (ft)**
500	0.2	340,290	181,616	549,719	2.03	0.62	21.85	25.77	28.77
200	0.5	290,254	174,266	426,901	1.45	0.47	21.59	24.78	27.19
100	1	255,185	167,650	349,915	1.09	0.37	21.35	23.98	25.95
50	2	222,257	159,888	284,401	0.78	0.28	21.06	23.11	24.65
20	5	181,551	147,323	212,442	0.44	0.17	20.55	21.85	22.83
10	10	152,433	135,411	167,077	0.23	0.10	20.02	20.76	21.33
5	20	124,111	120,366	127,855	0.06	0.03	19.28	19.47	19.66
2	50	85,322	91,217	82,056	-0.10	-0.04	17.55	17.14	16.89

Table 1. The data was extracted from HEC-SSP for the Delaware River in Trenton, NJ. The table displays the different year floods with the percent chance as well as the data gathered from all the time periods and the percent change of old to new data.

Raritan (Manville)									
Year flood	**% chance**	**60 Years (cfs)**	**1959-1988 (cfs)**	**1989-2018 (cfs)**	**% change old to new**	**% change 60 years to new**	**Old Depth (ft)**	**60 years Depth (ft)**	**New Depth (ft)**
500	0.2	96,030	46,765	155,077	2.32	0.61	24.38	30.14	33.98
200	0.5	74,303	40,889	111,581	1.73	0.50	23.31	28.09	31.34
100	1	60,859	36,765	86,372	1.35	0.42	22.46	26.49	29.29
50	2	49,540	32,882	66,333	1.02	0.34	21.57	24.85	27.18
20	5	37,254	28,061	46,026	0.64	0.24	20.30	22.56	24.26
10	10	29,601	24,587	34,275	0.39	0.16	19.24	20.72	21.90
5	20	23,052	21,178	24,880	0.17	0.08	18.05	18.72	19.33
2	50	15,516	16,431	14,991	-0.09	-0.03	16.02	15.56	15.28

Table 2. Excel table showing data extracted from HEC-SSP for the Raritan River in Manville, NJ. The table displays the different year floods with the percent chance as well as the data gathered from all the time periods and the percent change of old to new data.

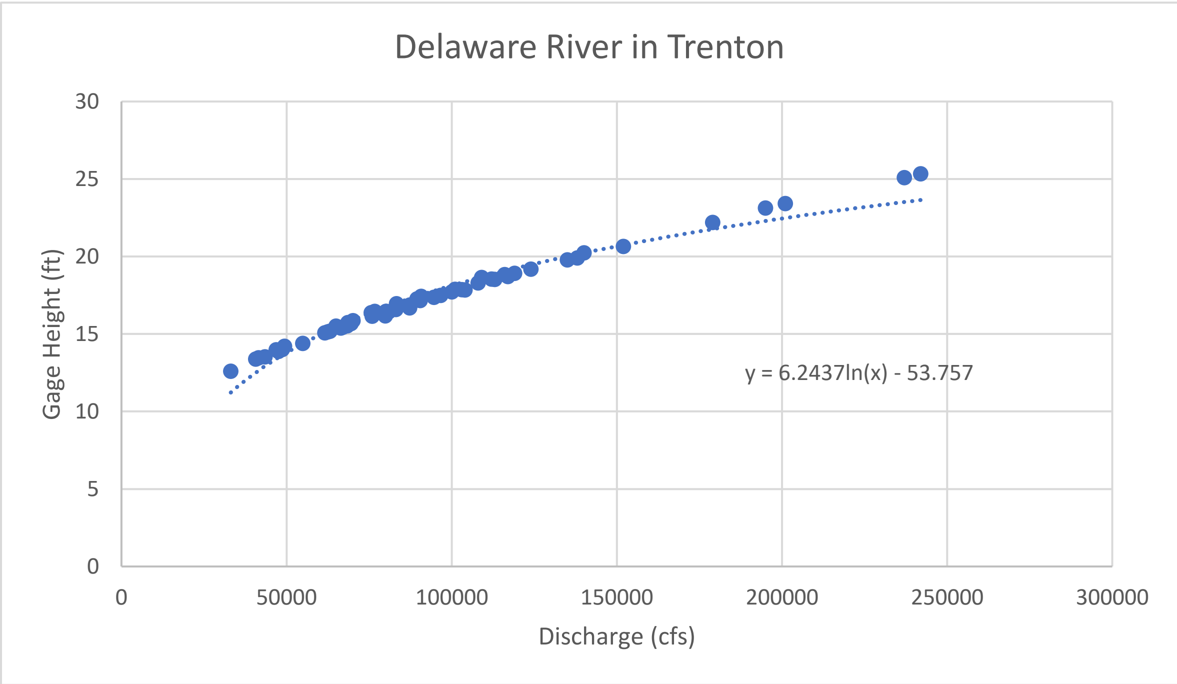

Figure 2. Rating curve for the Delaware River in Trenton, NJ to show a correlation between gage height and river discharge. This assisted in understanding the changing depth of the river.

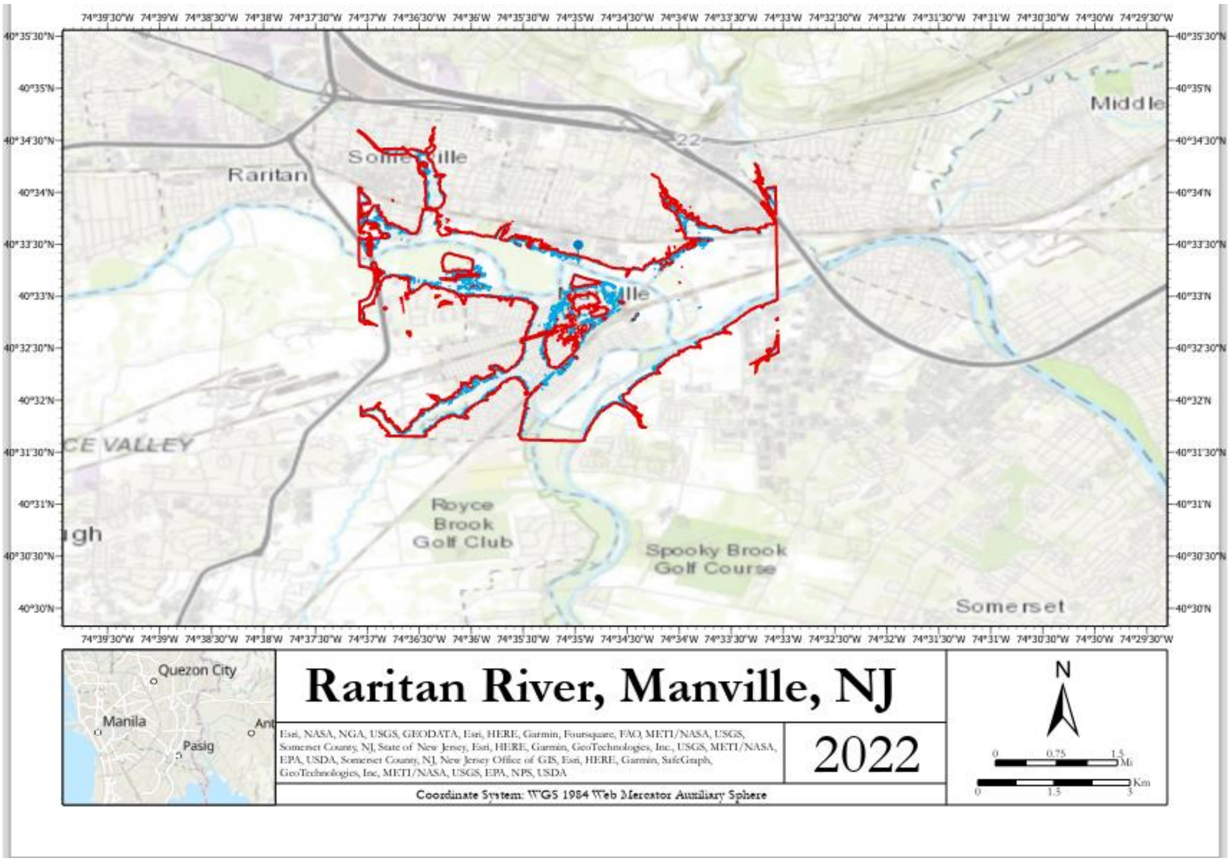

Figure 3. ArcGIS map of the Raritan River in Manville, NJ showing the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red

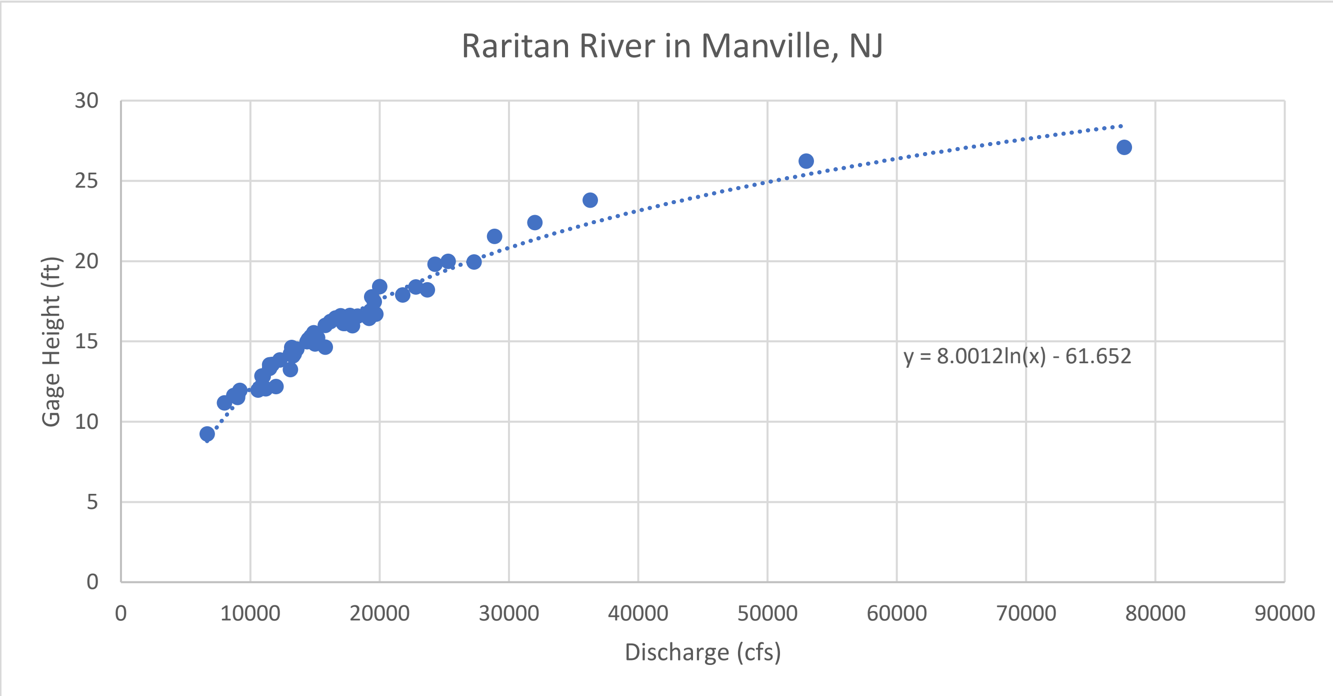

Figure 4. Rating curve for the Raritan River in Manville, NJ to show a correlation between gage height and river discharge. Assisted in understanding the changing depth of the river.

Raritan Manville Cost of Homes Affected Per Street New Data vs 60 Year Data					
Street Name	Estimated Damage in USD (New Data)	Estimated Damage in USD (60-Year Data)	Difference	# of homes (New Data)	# of homes (60-Year Data)
William Street	1,117,000	0	1,117,000	2	0
Grove Street	2,087,000	0	2,087,000	5	0
E. Cliff Street	10,702,000	0	10,702,000	32	0
Park Avenue	3,174,000	3,174,000	0	9	9
E. High Street	1,475,000	521,000	954,000	3	1
S. Bridge Street/4th Street	1,081,000	341,000	740,000	3	1
S. Bridge Street/5th Street	60,000	46,000	414,000	2	2
Holly Glen Road	334,000	0	334,000	1	0
Codlington Street	459,000	0	459,000	1	0
E. Main Street	2,211,000	1,307,000	904,000	5	3
Kline/Morton/Market Street	406,000	0	406,000	1	0
Hanken Road	10,140,000	10,140,000	0	4	0
Lincoln Avenue	20,948,000	20,948,000	0	28	28
Boesel Avenue	35,763,000	35,763,000	0	61	61
May Place	501,000	501,000	0	105	105
Benjamin Street	702,000	702,000	0	2	2
John Place	541,000	541,000	0	2	2
Kyle Street	1,993,000	1,993,000	0	2	2
S. Orchard Street	1,704,000	0	1,704,000	6	6
S. Arlington Street	1,963,000	1,963,000	0	5	
S. Weiss Street	1,032,000	1,032,000	0	3	3

S. Bridge Street	653,000	653,000	0	1	1
S. Reading Street	1,061,000	1,061,000	0	3	3
S. Bank Street	624,000	624,000	0	2	2
S. Park Street	635,000	635,000	0	2	2
Huff Avenue	47,362,000	47,362,000	0	139	139
Angle Avenue	2,312,000	2,022,000	290,000	7	6
Manville Avenue	288,000	288,000	0	1	1
Rosalie Street	2,619,000	0	2,619,000	8	0
Gladys Avenue	8,218,000	0	8,218,000	24	0
N. Orchard Street	5,323,000	0	5,323,000	14	0
N. Arlington Street	4,076,000	0	4,076,000	13	0
N. Weiss Street	3,822,000	0	3,822,000	12	0
N. Bridge Street	1,793,000	0	1,793,000	6	0
N. Reading Street	2,756,000	0	2,756,000	8	0
N. Bank Street	2,040,000	0	2,040,000	6	0
N. Park Street	701,000	361,000	340,000	2	1
E. Camplain Road	21,717,000	12,550,000	9,167,000	58	33
Valerie Drive	16,833,000	0	16,833,000	46	0
Louise Drive	11,902,000	0	11,902,000	31	0
Florence Court	2,427,000	0	2,427,000	6	0
Claire Street	1,544,000	0	1,544,000	4	0
N. 1st Avenue	4,627,000	4,627,000	0	14	14
N 2nd Avenue	9,238,000	9,238,000	0	27	27
N. 3rd Avenue	5,854,000	5,854,000	0	16	16
Dukes Parkway East	18,212,000	14,877,000	3,335,000	44	44
Knopf Street	9,300,000	853,000	8,447,000	26	24
Louise Street	744,000	744,000	0	2	2
N. 7th Avenue	6,943,000	0	6,943,000	18	0
N. 6th Avenue	2,782,000	0	2,782,000	8	0
N. 8th Avenue	6,303,000	0	6,303,000	21	0

N. 9th Avenue	8,153,000	0	8,153,000	23	0
N. 10th Avenue	4,762,000	0	4,762,000	13	0
St. John Street	6,383,000	4,704,000	1,679,000	18	13
Gress Street	10,222,000	6,732,000	3,490,000	28	18
Clinton Avenue	2,574,000	705,000	1,869,000	7	2
Dailey Place	1,119,000	0	1,119,000	3	0
N. 13th Avenue	1,305,000	0	1,305,000	4	0
Marion Place	2,369,000	0	2,369,000	6	0
Taylor Avenue	2,328,000	0	2,328,000	5	0
Hammler Road	450,000	0	450,000	1	0
Kimberly Road	5,909,000	4,497,000	1,412,000	12	9
Johanson Avenue	6,904,000	0	6,904,000	14	0
	Total (New Data): 353,980,000	Total (60 Year Data): 197,359,000	Total Difference: 156,621,000	985	587

Table 3. A list of all the streets for the Raritan River in Manville, NJ showing the number of homes and total economic loss per data set if there were to be a 1% (100 year) flood.

Delaware Trenton Cost of Homes Affected Per Street New Data vs 60-Year Data					
Street Name	Estimated Damage in USD (New Data)	Estimated Damage in USD (60-Year Data)	Difference	# of homes (New Data)	# of homes (60-Year Data)
N. Delmorr Avenue (PA)	7,581,000	7,269,000	312,000	26	25
E. Franklin Street (PA)	475,000	475,000	0	2	2
Park Avenue (PA)	4,458,000	4,458,000	0	17	17
Central Avenue (PA)	7,839,000	6,696,000	1,143,000	31	26
S. Delmorr Avenue (PA)	443,000	443,000	0	3	3
S. Warren Street	2,828,000	2,828,000	0	17	17
Steel Street	2,314,000	0	2,314,000	12	0
Iron Works Way	2,021,000	0	2,021,000	11	0
Union Street	2,654,000	0	2,654,000	15	0
Ferry Street	739,000	0	739,000	8	0
Asbury Street	2,788,000	0	2,788,000	31	0
Power Street	650,000	0	650,000	10	0
Steamboat Street	537,000	0	537,000	7	0
Lamberton Street	1,627,000	0	1,627,000	13	0
Daymond Street	1,430,000	0	1,430,000	11	0

Newell Avenue	159,000	0	159,000	1	0
	Total (New Data): 38,543,000	Total (60 Year Data): 22,169,000	Total Difference: 16,374,000	215	90

Table 4. A list of all the streets for the Delaware River in Trenton, NJ showing the number of homes and total economic loss per data set if there were to be a 1% (100-year) flood.

Ramapo (Pompton Lakes)									
Year flood	**% chance**	**60 Years (cfs)**	**1959-1988 (cfs)**	**1989-2018 (cfs)**	**% change old to new**	**% change 60 years to new**	**Old Depth (ft)**	**60 years Depth (ft)**	**New Depth (ft)**
500.00	0.20	31,404.40	26,076.10	41,319.40	0.58	0.32	14.04	14.56	15.32
200.00	0.50	24,227.30	20,917.70	30,083.80	0.44	0.24	13.43	13.84	14.44
100.00	1.00	19,669.30	17,483.50	23,391.10	0.34	0.19	12.94	13.26	13.74
50.00	2.00	15,755.00	14,409.90	17,955.40	0.25	0.14	12.40	12.65	13.01
20.00	5.00	11,422.70	10,837.50	12,322.20	0.14	0.08	11.61	11.76	11.97
10.00	10.00	8,681.00	8,456.80	8,997.00	0.06	0.04	10.93	11.00	11.10
5.00	20.00	6,313.70	6,302.80	6,301.00	0.00	0.00	10.11	10.12	10.11
2.00	50.00	3,579.50	3,661.40	3,428.70	-0.06	-0.04	8.61	8.55	8.43

Table 5. Excel table showing data extracted from HEC-SSP for the Ramapo River in NJ. The table displays the different year floods with the percent chance as well as the data gathered from all the time periods and the percent change of old to new data.

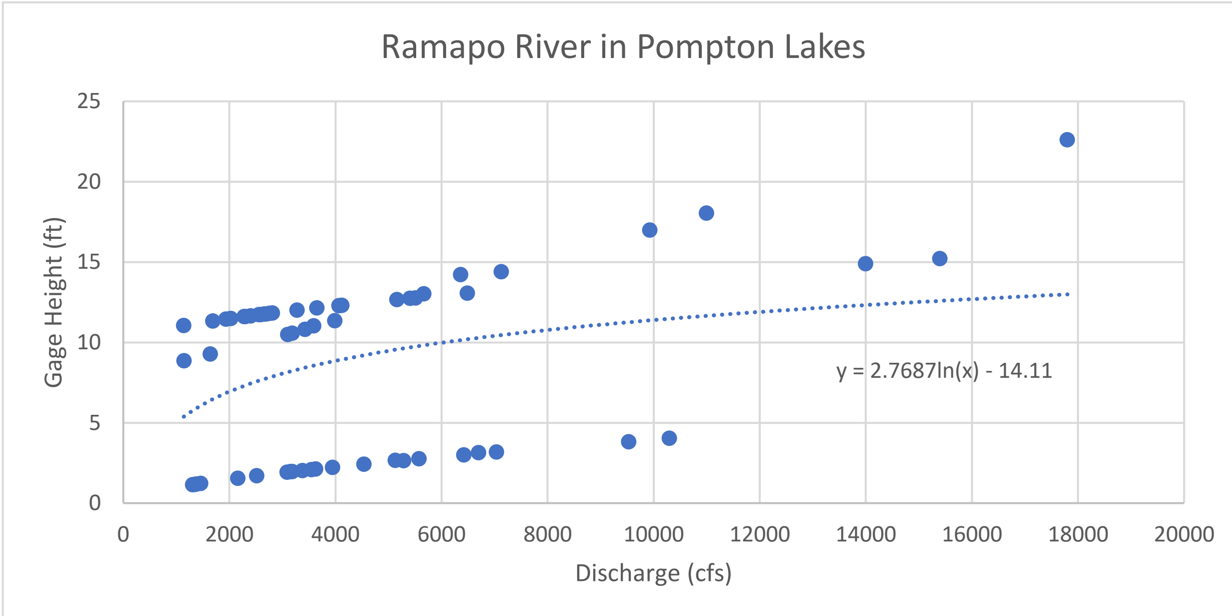

Figure 5. Rating curve for the Ramapo River in Pompton Lakes, NJ to show a correlation between gage height and river discharge. Assisted in understanding the changing depth of the river.

Ramapo Pompton Lakes Cost of Homes Affected Per Street New Data vs 60 Year Data					
Street Name	Estimated Damage in USD (New Data)	Estimated Damage in USD (60-Year Data)	Difference	# of homes (New Data)	# of homes (60-Year Data)
Elm Avenue	1,511,000	1,511,000	0	3	3
Poplar Avenue	8,906,000	8,906,000	0	19	19
Magnolia Avenue	5,067,000	5,067,000	0	11	11
Sunset Road	3,458,000	2,540,000	918,000	7	5
Pine Street	6,531,000	3,452,000	3,079,000	15	8
Central Avenue	8,786,000	5,967,000	2,819,000	22	14
Lincoln Avenue	4,621,000	4,621,000	0	10	10
Washington Avenue	3,262,000	3,262,000	0	9	9
Riveredge Drive	4,842,000	4,842,000	0	12	12
Madison Place	1,714,000	1,261,000	453,000	5	4
Dawes Highway	9,694,000	8,326,000	1,368,000	26	22
Harldson Place	3,920,000	2,157,000	1,763,000	10	6
	Total (New Data): 62,312,000	Total (60 Year Data): 51,912,000	Total Difference: 10,400,000	149	123

Table 6. A list of all the streets for the Ramapo River in Pompton Lakes, NJ showing the number of homes and total economic loss per data set if there were to be a 1% (100 year) flood.

Musconetcong (Lake Hopatcong)									
Year flood	**% chance**	**60 Years**	**1959-1988**	**1989-2018**	**% change old to new**	**% change 60 years to new**	**Old Depth (ft)**	**60 years Depth (ft)**	**New Depth (ft)**
500.00	0.20	1,535.50	378.40	5,546.40	13.66	2.61	4.56	7.87	10.91
200.00	0.50	1,203.00	376.00	3,247.80	7.64	1.70	4.54	7.29	9.64
100.00	1.00	991.10	372.80	2,166.50	4.81	1.19	4.52	6.84	8.69
50.00	2.00	808.20	367.70	1,445.10	2.93	0.79	4.49	6.35	7.73
20.00	5.00	604.30	355.90	846.00	1.38	0.40	4.41	5.66	6.46
10.00	10.00	473.70	340.10	564.20	0.66	0.19	4.30	5.09	5.50
5.00	20.00	359.40	313.30	376.10	0.20	0.05	4.11	4.44	4.54
2.00	50.00	223.70	240.30	220.00	-0.08	-0.02	3.48	3.31	3.27

Table 7. Excel table showing data extracted from HEC-SSP for the Musconetcong River in NJ. The table displays the different year floods with the percent chance as well as the data gathered from all the time periods and the percent change of old to new data.

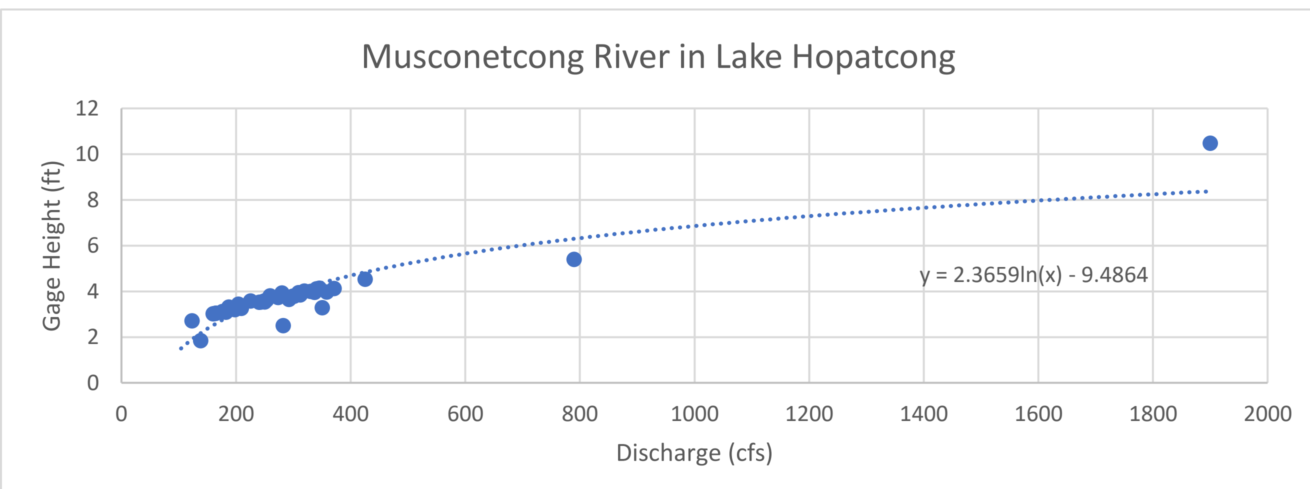

Figure 6. Rating curve for the Musconetcong River in Lake Hopatcong, NJ to show a correlation between gage height and river discharge. Assisted in understanding the changing depth of the river.

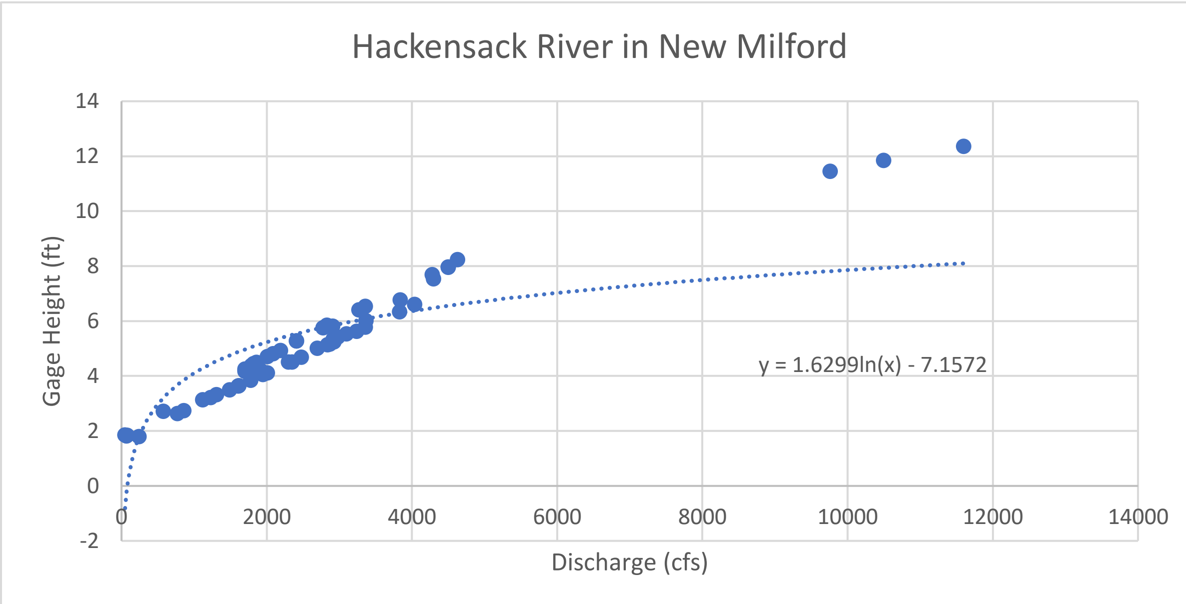

Figure 7. Rating curve for the Hackensack River in New Milford, NJ to show a correlation between gage height and river discharge. Assisted in understanding the changing depth of the river.

Hackensack (New Milford)									
Year flood	**% chance**	**60 Years**	**1959-1988**	**1989-2018**	**% change old to new**	**% change 60 years to new**	**Old Depth (ft)**	**60 years Depth (ft)**	**New Depth (ft)**
500.00	0.20	6,176.70	4,150.00	8,815.50	1.12	0.43	6.42	7.07	7.65
200.00	0.50	6,140.80	4,148.70	8,649.10	1.08	0.41	6.42	7.06	7.62
100.00	1.00	6,086.50	4,145.80	8,440.50	1.04	0.39	6.42	7.05	7.58
50.00	2.00	5,986.90	4,137.60	8,117.60	0.96	0.36	6.42	7.02	7.51
20.00	5.00	5,718.00	4,101.00	7,408.60	0.81	0.30	6.40	6.94	7.37
10.00	10.00	5,312.60	4,013.00	6,536.60	0.63	0.23	6.37	6.82	7.16
5.00	20.00	4,574.70	3,767.20	5,227.20	0.39	0.14	6.26	6.58	6.80
2.00	50.00	2,632.40	2,657.10	2,565.70	-0.03	-0.03	5.69	5.68	5.64

Table 8. Excel table showing data extracted from HEC-SSP for the Hackensack River in New Milford, NJ. The table displays the different year floods with the percent chance as well as the data gathered from all the time periods and the percent change of old to new data.

Hackensack New Milford Cost of Homes Affected Per Street New Data vs 60 Year Data					
Street Name	Estimated Damage in USD (New Data)	Estimated Damage in USD (60-Year Data)	Difference	# of homes (New Data)	# of homes (60-Year Data)
Columbia Street	2,910,000	2,910,000	0	5	5
W. Park Drive	3,306,000	3,306,000	0	6	6
Lenox Avenue	2,059,000	2,059,000	0	4	4
Washington Avenue	1,814,000	1,814,000	0	3	3
	Total (New Data): 1,089,000	Total (60 Year Data): 1,089,000	Total Difference : 0	18	18

Table 9. A list of all the streets for the Hackensack River in New Milford, NJ showing the number of homes and total economic loss per data set if there were to be a 1% (100 year) flood.

Musconetcong Lake Hopatcong Cost of Homes Affected Per Street New Data vs 60 Year Data					
Street Name	Estimated Damage in USD (New Data)	Estimated Damage in USD (60-Year Data)	Difference	# of homes (New Data)	# of homes (60-Year Data)
Brooklyn Stanhope	558,000	558,000	0	2	2
	Total (New Data): 558,000	Total (60-Year Data): 558,000	Total Difference : 0	2	2

Table 10. A list of all the streets for the Musconetcong River in Lake Hopatcong, NJ showing the number of homes and total economic loss per data set if there were to be a 1% (100-year) flood

Discussion

River flooding in New Jersey is a growing risk and needs more attention sooner rather than later. My research examines how flood frequency has changed in five gages across New Jersey and how those floods would affect home values. These gages recorded increases in flooding and showed more areas would deal with an increased risk of river flooding. The data I am comparing is data retrieved from the last 30 years which is shown as (new data) versus the total 60-year data. This is important because FEMA has only modeled a third of the rivers in the United States since 1967 and only a quarter of them have been updated in the past five years.

The results of the damage done to all the homes from the rivers is shocking but not too much of a surprise once the GIS work was completed and displayed what could potentially happen. The most notable river, the Raritan River in Manville, has the most homes that will, unfortunately, be affected if there is a major flood. This increase in potentially damaged properties is from increased flood magnitudes and flooded area. The Delaware River at Trenton as well as the Ramapo River at Pompton Lakes also show a large number of homes that will be affected by a 100-year flood whereas the Hackensack River in New Milford and the Musconetcong River at Lake Hopatcong show very little to no differences in damages.

The first issue that arises in the data is that some streets show the exact same estimated damage in the new 30-year data versus that of the 60-year total data (Tables 9 & 10), meaning that this information has been known for many years yet no changes or warnings (as far as research has shown) have been made. Notable findings include the difference in the potential cost of a flood to certain areas between the total 60-year data and the new most recent 30-year data. Gages such as the Raritan in Manville, Delaware in Trenton, and the Ramapo in Pompton Lakes displayed those differences in the cost of flooding. The more than $183 million total differences in home values between older and newer time periods for those three gages that would be affected but a 100-year flood is staggering (Tables 3, 4, & 6). That is 549 more homes potentially affected by expanded flood zones in the last 30 years, and this does not account for new properties that did not exist 30 years ago. The directly affected people would firstly be those living in all the homes that could be flooded.

There are a few potential causes of the rise in flood risks observed in this study. The first is urbanization and the use of land. Urbanization decreases infiltration and increases runoff by increasing the number of impermeable surfaces (Rubitano et al., 2019). As the soil and vegetation are replaced with concrete and asphalt, all the runoff rushes into a river causing a flood.

Climate change also heavily influences river flooding. With the changing climate becoming more unstable, we tend to see a rise in flash flooding events from more intense precipitation. The warming weather leads to more evaporation and transpiration that then brings down more frequent and heavier rainfall (Wobus et al., 2019). As mentioned earlier, heavier rainfall does not always lead to the flooding of a river or stream however when the water has nowhere in the ground to go it runs off into a river and rises the water level quickly.

River flooding can potentially be controlled and reduced significantly. We can re-introduce nature back to where it was with the addition of green spaces (Rubitano et al., 2019). If we can include low-impact design concepts such as green roofs, more parks, green walkways, trees, and many other forms of vegetation, that will lead to an increase in water infiltration and a decrease in runoff. Green roofs help to infiltrate precipitation instead of it becoming runoff. Having more parks in cities would serve as a great catch basin for water and snowfall.

My findings are similar to those by Dottori et al. (2018) in that the increased flood damages and the economic damages have changed over time. Other articles such as Booij et al. (2005) as well as Ralph et al. (2006) mention their methods of using programs such as HEC-SSP to also find increases in flood risks in other parts of the world.

The flood data I analyzed is limited to a single gage in five locations in New Jersey and is relatively small in comparison to an entire river system. The flooding is likely to extend further upstream and downstream of any of the five rivers I researched. I was only able to study the small location that I did and ideally someone would expand on it by doing more technical flood routing of the entirety of each river or including more rivers in New Jersey. However, I analyzed all the gages I could in New Jersey, so the analysis could be expanded beyond New Jersey. The Passaic River and the Delaware River in its entirety are rivers that deserve more studies in the future as they cover heavily urbanized areas and flow through densely populated cities that rely on the rivers for power and more. A similar analysis could be done for properties in New Jersey affected by increased coastal flooding.

This paper could be expanded in many ways for the next student or scholar that would like to continue the work. Ideas such as looking at a larger area of the floodplain from the rivers, researching more rivers, and getting more exact numbers from places such as commercial buildings or industrial areas and even parks to get a greater and more detailed understanding of the catastrophic damage that every flood could cause. Another step to expand this work is to possibly publish it and release it to the public so that it gets a larger audience in hopes of more awareness. Understanding the demographics of a flood-prone area to see if there is a correlation between river flooding and the people that live in the area is another step that should be taken to extend this research. This is an environmental justice issue, as certain groups of people could be more affected by flood damages.

Conclusion

River flooding in New Jersey has become an increasing issue as time passes, urbanization increases and climate change continues to rage. My research shows the towns, streets, and homes that will be affected by a 1% flood from the Ramapo, Delaware, Raritan, Hackensack, and Musconetcong Rivers at specific gages. The datasets that I analyzed showed a great difference between the previous data recorded from the rivers versus the more recent 30 years of data. Along with climate change and urbanization, the risk of a major flood damaging over a thousand homes and costing over $450 million becomes more and more likely.

I analyzed data put together with programs such as HEC-SSP and ArcGIS to get a better visual and quantitative understanding of exactly where and who will be affected by a potential flood of these rivers. The Raritan River in Manville, NJ shows the highest potential of damage with 63 streets affected totaling 985 homes and almost $354 million in damage. The Ramapo River shows that there will be 12 streets damaged by a flood totaling 149 homes and a potential economic loss of $62 million. The Delaware River in Trenton has more homes that will be damaged than the Ramapo River with 215 but the economic loss drops to $38.5 million. The Hackensack in New Milford and Musconetcong in Lake Hopatcong Rivers combine for a total of five streets to be potentially flooded with a loss of $1.6 million for a total of 20 homes.

Proper action can be taken if people come together and speak up for change. More sustainable and permeable cities could be created for water to infiltrate rather than just flooding over the asphalt streets. More action towards climate change will also prevent any further damage. Proper levee and dam management can prevent overconsumption of water and flood water coming into residential homes.

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Appendix 1

Hackensack @ New Milford 1959-2018			
Computed Curve	% chance	0.05	0.95
6,176.70	0.2	8,594.50	4,695.50
6,140.80	0.5	8,538.60	4,670.10
6,086.50	1	8,454.20	4,631.70
5,986.90	2	8,299.70	4,561.20
5,718.00	5	7,884.80	4,370.10
5,312.60	10	7,265.30	4,079.70
4,574.70	20	6,157.60	3,543.90
2,632.40	50	3,389.90	2,076.00
948.4	80	1,214.10	716.6
445.8	90	599.3	309.5
211.1	95	304.7	131.7
37.8	99	66.5	17.8
Hackensack @ New Milford 1959-1988			
Computed Curve	% chance	0.05	0.95
4,150.00	0.2	6,124.30	3,045.10
4,148.70	0.5	6,122.20	3,044.20
4,145.80	1	6,117.10	3,042.20
4,137.60	2	6,102.90	3,036.60
4,101.00	5	6,039.90	3,011.60
4,013.00	10	5,888.70	2,951.20
3,767.20	20	5,471.50	2,781.20
2,657.10	50	3,681.10	1,984.80
1,142.90	80	1,535.30	808.2
570.4	90	806.9	357
277.9	95	430.3	147.7
49.6	99	100.7	16.9
Hackensack @ New Milford 1989-2018			
Computed Curve	% chance	0.05	0.95
8,815.50	0.2	16,286.50	5,588.30
8,649.10	0.5	15,916.70	5,493.70
8,440.50	1	15,455.70	5,374.70
8,117.60	2	14,747.30	5,189.40
7,408.60	5	13,217.20	4,778.40
6,536.60	10	11,385.20	4,263.80
5,227.20	20	8,747.60	3,469.20
2,565.70	50	3,902.20	1,743.00
791.7	80	1,180.00	487.1
346.2	90	553.6	182.6
155.4	95	275	68.2
25.6	99	59.7	7.1

Table 10. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Hackensack River in New Milford, NJ.

Delaware @ Trenton 1959-2018			
Computed Curve	% chance	0.05	0.95
340,290.60	0.2	443,970.10	278,415.40
290,254.20	0.5	368,844.70	241,970.20
255,185.60	1	317,571.90	215,897.50
222,257.00	2	270,609.50	190,932.50
181,551.50	5	214,399.70	159,254.20
152,433.00	10	175,700.90	135,854.30
124,111.80	20	139,609.40	112,237.30
85,322.20	50	93,665.80	77,659.80
60,063.00	80	66,454.60	53,340.90
50,458.30	90	56,515.80	43,898.80
43,901.70	95	49,775.70	37,481.30
34,195.80	99	39,764.90	28,127.70
Delaware @ Trenton 1959-1988			
Computed Curve	% chance	0.05	0.95
181,616.20	0.2	232,492.80	152,957.40
174,266.70	0.5	220,904.30	147,595.80
167,650.50	1	210,601.70	142,721.90
159,888.20	2	198,678.50	136,941.30
147,323.60	5	179,779.50	127,423.00
135,411.80	10	162,363.00	118,182.10
120,366.60	20	141,158.40	106,129.80
91,217.00	50	103,243.90	81,019.90
64,171.30	80	72,629.60	55,000.30
51,728.30	90	59,694.60	42,541.60
42,557.20	95	50,318.50	33,489.20
28,262.30	99	35,516.20	20,073.60
Delaware @ Trenton 1989-2018			
Computed Curve	% chance	0.05	0.95
549,719.00	0.2	948,775.90	384,032.80
426,901.40	0.5	688,843.40	310,910.60
349,915.60	1	535,980.30	263,093.30
284,401.10	2	413,109.80	220,794.50
212,442.20	5	287,294.20	171,981.90
167,077.90	10	214,031.10	139,346.70
127,855.30	20	155,587.00	109,245.20
82,056.10	50	95,386.60	70,164.30
57,301.00	80	67,221.20	46,813.00
48,998.10	90	58,272.90	38,863.00
43,708.60	95	52,630.80	33,845.60
36,499.30	99	44,951.00	27,132.50

Table 11. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Delaware River in Trenton, NJ.

Raritan @ Manville 1959-2018					
Computed Curve		% chance		0.05	0.95
96,030.00	|	0.2	|	133,752.40	74,967.00
74,303.70	|	0.5	|	99,059.40	59,863.60
60,859.80	|	1	|	78,466.10	50,220.00
49,540.70	|	2	|	61,756.40	41,866.90
37,254.70	|	5	|	44,421.30	32,470.50
29,601.00	|	10	|	34,161.80	26,364.40
23,052.10	|	20	|	25,834.10	20,892.50
15,516.50	|	50	|	17,013.20	14,104.30
11,539.50	|	80	|	12,760.30	10,254.70
10,243.10	|	90	|	11,417.30	8,979.10
9,437.90	|	95	|	10,588.60	8,187.40
8,388.40	|	99	|	9,510.80	7,160.40
Raritan @ Manville 1959-1988					
Computed Curve		% chance		0.05	0.95
46,765.40	|	0.2	|	63,308.10	38,307.10
40,889.40	|	0.5	|	53,418.80	34,236.90
36,765.10	|	1	|	46,718.80	31,308.20
32,882.90	|	2	|	40,614.60	28,484.90
28,061.30	|	5	|	33,345.00	24,862.80
24,587.50	|	10	|	28,362.30	22,142.60
21,178.40	|	20	|	23,738.40	19,332.70
16,431.70	|	50	|	17,929.30	15,016.40
13,264.90	|	80	|	14,547.70	11,801.50
12,038.40	|	90	|	13,316.30	10,514.80
11,193.00	|	95	|	12,481.50	9,626.50
9,930.40	|	99	|	11,244.80	8,308.90
Raritan @ Manville 1989-2018					
Computed Curve		% chance		0.05	0.95
155,077.60	|	0.2	|	300,256.00	100,615.40
111,581.00	|	0.5	|	197,787.90	76,475.80
86,372.40	|	1	|	143,098.40	61,711.50
66,333.90	|	2	|	102,657.10	49,396.20
46,026.30	|	5	|	65,076.90	36,147.70
34,275.60	|	10	|	45,329.00	27,931.40
24,880.60	|	20	|	30,952.80	20,863.80
14,991.20	|	50	|	17,748.40	12,547.10
10,269.30	|	80	|	12,289.00	8,183.20
8,821.70	|	90	|	10,694.10	6,833.10
7,948.60	|	95	|	9,740.40	6,026.40
6,843.50	|	99	|	8,535.70	5,020.90

Table 12. The three different raw data sets of new, old, and total years results are separated into three tables with their computed HEC-SSP data for the Raritan River in Manville, NJ

Musconetcong @ Lake Hopatcong 1959-2018			
Computed Curve	% chance	0.05	0.95
1,535.50	0.2	2,254.40	1,156.20
1,203.00	0.5	1,690.50	934.1
991.1	1	1,346.00	788.1
808.2	2	1,059.90	658.5
604.3	5	755.6	508.4
473.7	10	571.1	408
359.4	20	418.2	315.9
223.7	50	252.3	197.8
149.1	80	169.8	127.7
123.7	90	142.9	103.5
107.4	95	125.6	88.1
84.9	99	101.7	67.1
Musconetcong @ Lake Hopatcong 1959-1988			
Computed Curve	% chance	0.05	0.95
378.4	0.2	476.2	318.9
376	0.5	472.5	317
372.8	1	467.7	314.6
367.7	2	460.1	310.8
355.9	5	442.4	301.7
340.1	10	419.2	289.5
313.3	20	380.5	268.4
240.3	50	281.6	207.6
154.2	80	179.2	128.4
112.6	90	134.4	88.4
83	95	103	60.8
41.7	99	57.5	25.6
Musconetcong @ Lake Hopatcong 1989-2018			
Computed Curve	% chance	0.05	0.95
5,546.40	0.2	15,556.90	2,948.30
3,247.80	0.5	7,677.00	1,909.90
2,166.50	1	4,506.70	1,372.90
1,445.10	2	2,651.70	984.4
846	5	1,324.40	629.7
564.2	10	791.8	444.2
376.1	20	483.5	306.6
220	50	268.9	175.8
166.9	80	205.9	127.5
155.7	90	193.1	117.3
150.8	95	187.5	112.8
147.2	99	183.3	109.5

Table 13. The three different raw data sets of new, old, and total years results are separated into three tables with their computed HEC-SSP data for the Musconetcong River in Lake Hopatcong, NJ.

Ramapo @ Pompton Lakes 1959-2018				
Computed Curve		% chance	0.05	0.95
31,404.40	|	0.2 |	47,457.60	23,011.60
24,227.30	|	0.5 |	35,062.70	18,308.50
19,669.30	|	1 |	27,513.20	15,226.50
15,755.00	|	2 |	21,272.40	12,502.10
11,422.70	|	5 |	14,687.70	9,373.00
8,681.00	|	10 |	10,743.40	7,304.50
6,313.70	|	20 |	7,524.00	5,433.90
3,579.50	|	50 |	4,114.40	3,108.60
2,140.00	|	80 |	2,489.60	1,791.70
1,669.20	|	90 |	1,976.00	1,357.20
1,373.60	|	95 |	1,653.80	1,088.00
976.6	|	99 |	1,216.40	735.5
Ramapo @ Pompton Lakes 1959-1988				
Computed Curve		% chance	0.05	0.95
26,076.10	|	0.2 |	47,027.80	17,616.70
20,917.70	|	0.5 |	35,623.30	14,634.20
17,483.50	|	1 |	28,442.00	12,573.70
14,409.90	|	2 |	22,337.80	10,664.10
10,837.50	|	5 |	15,693.90	8,340.70
8,456.80	|	10 |	11,591.90	6,705.00
6,302.80	|	20 |	8,163.60	5,132.90
3,661.40	|	50 |	4,458.00	3,001.80
2,180.30	|	80 |	2,679.20	1,680.40
1,679.10	|	90 |	2,112.70	1,230.80
1,360.10	|	95 |	1,753.80	952.2
927	|	99 |	1,259.70	592.3
Ramapo @ Pompton 1989-2018				
Computed Curve		% chance	0.05	0.95
41,319.40	|	0.2 |	85,068.00	25,672.60
30,083.80	|	0.5 |	56,946.00	19,685.00
23,391.10	|	1 |	41,471.30	15,929.20
17,955.40	|	2 |	29,762.40	12,732.00
12,322.20	|	5 |	18,635.50	9,217.50
8,997.00	|	10 |	12,678.70	6,995.60
6,301.00	|	20 |	8,291.40	5,060.50
3,428.70	|	50 |	4,228.70	2,761.90
2,043.80	|	80 |	2,551.50	1,543.30
1,614.00	|	90 |	2,057.50	1,165.20
1,350.70	|	95 |	1,756.20	938.9
1,005.70	|	99 |	1,358.30	653.1

Table 14. The three different raw data sets of new, old, and total years results are separated into three tables with their computed HEC-SSP data for the Ramapo River in Pompton Lakes, NJ

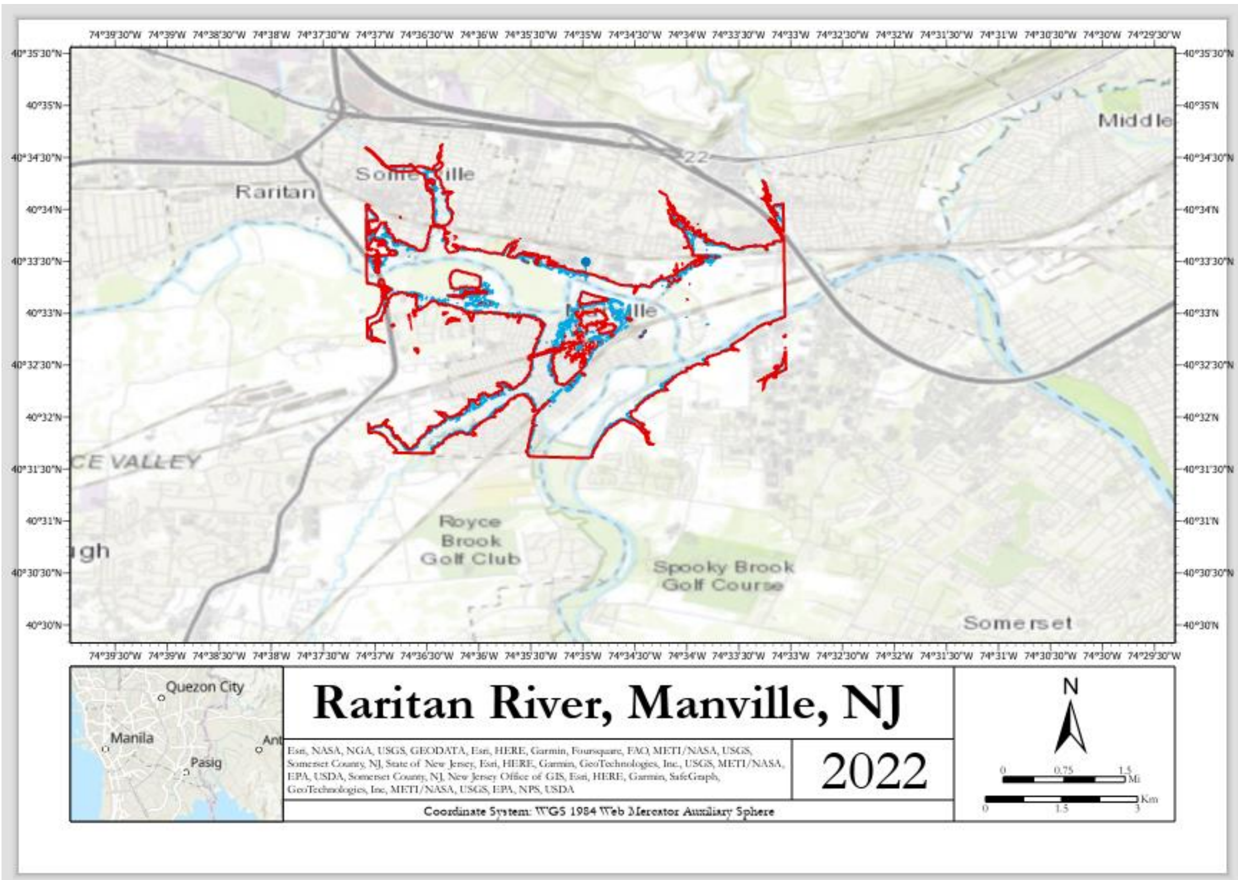

Figure 8. ArcGIS map of the Raritan River in Manville, NJ shows the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red.

Figure 9. ArcGIS map of the Delaware River in Trenton, NJ showing the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red.

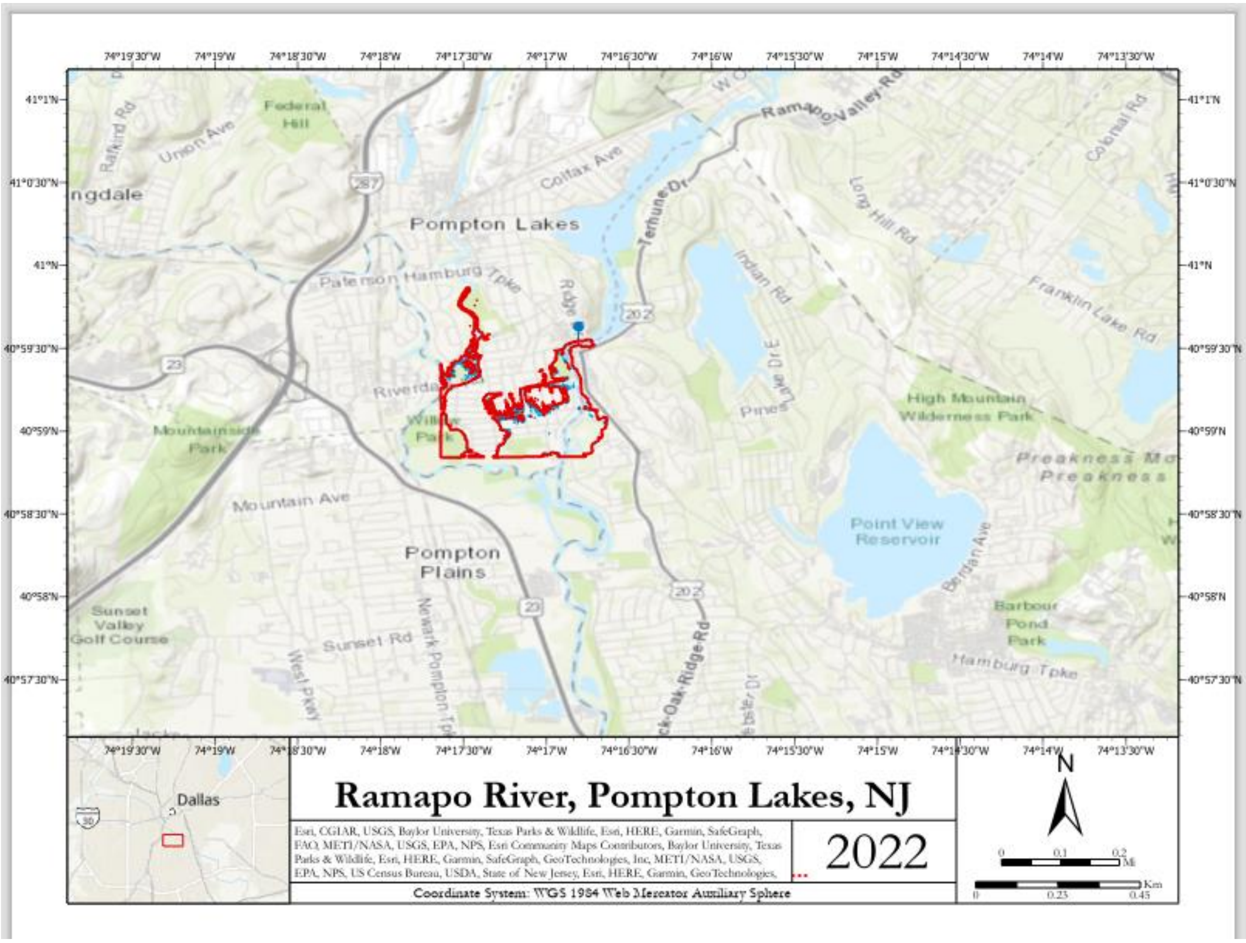

Figure 10. ArcGIS map of the Ramapo River in Pompton Lakes, NJ shows the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red.

Figure 11. ArcGIS map of the Musconetcong River in Lake Hopatcong, NJ shows the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red.

Figure 12. ArcGIS map of the Hackensack River in New Milford, NJ shows the 100-year floodplain for the 60 years shown with the blue line versus the new 30-year data shown in red.

Appendix 2

The following gages were analyzed in HEC SSP but the discharges between the time periods were not statistically different.

Passaic @ Chatham 1959-2018			
Computed Curve	% chance	0.05	0.95
4,589.50 |	0.2 |	5,815.50	3,841.10
3,928.80 |	0.5 |	4,850.40	3,349.90
3,470.60 |	1 |	4,198.40	3,002.30
3,044.10 |	2 |	3,605.80	2,672.50
2,521.70 |	5 |	2,902.40	2,258.10
2,151.20 |	10 |	2,421.50	1,954.70
1,793.10 |	20 |	1,975.30	1,650.50
1,305.10 |	50 |	1,409.60	1,206.90
987.5 |	80 |	1,073.90	895
866.3 |	90 |	950.6	773.1
783.2 |	95 |	866.9	689.6
659.5 |	99 |	742.4	566.3

Passiac @ Chatham 1959-1988			
Computed Curve	% chance	0.05	0.95
5,252.50 |	0.2 |	7,724.60	4,078.50
4,361.90 |	0.5 |	6,104.00	3,492.80
3,772.10 |	1 |	5,080.90	3,092.20
3,245.00 |	2 |	4,204.90	2,723.20
2,630.30 |	5 |	3,236.70	2,275.50
2,216.90 |	10 |	2,624.40	1,959.10
1,836.80 |	20 |	2,097.60	1,650.90
1,355.10 |	50 |	1,500.90	1,217.50
1,069.80 |	80 |	1,192.50	932.5
969 |	90 |	1,089.40	829.1
903.5 |	95 |	1,023.30	761.8
812.9 |	99 |	932.6	669.5

Passaic @ Chatham 1989-2018			
Computed Curve	% chance	0.05	0.95
4,520.90 |	0.2 |	6,625.50	3,510.30
3,871.50 |	0.5 |	5,447.50	3,082.00
3,418.20 |	1 |	4,657.80	2,774.70
2,994.00 |	2 |	3,945.80	2,479.20
2,471.20 |	5 |	3,109.40	2,101.90
2,098.00 |	10 |	2,545.20	1,820.40
1,735.40 |	20 |	2,029.70	1,532.00
1,237.90 |	50 |	1,394.80	1,096.10
911.9 |	80 |	1,033.90	777.9
786.9 |	90 |	904.1	652.6
701.1 |	95 |	816.2	567.2
572.9 |	99 |	685.2	442

Table 15. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Passaic River in Chatham, NJ.

<table>
<tr><td colspan="2">Passaic @ Little Falls 1959-2018</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>26,584.30</td><td>|</td><td>0.2</td><td>|</td><td>34,799.30</td><td>21,664.80</td></tr>
<tr><td>23,231.40</td><td>|</td><td>0.5</td><td>|</td><td>29,753.30</td><td>19,226.20</td></tr>
<tr><td>20,762.10</td><td>|</td><td>1</td><td>|</td><td>26,120.60</td><td>17,398.30</td></tr>
<tr><td>18,341.50</td><td>|</td><td>2</td><td>|</td><td>22,636.70</td><td>15,575.20</td></tr>
<tr><td>15,194.20</td><td>|</td><td>5</td><td>|</td><td>18,238.00</td><td>13,147.80</td></tr>
<tr><td>12,824.00</td><td>|</td><td>10</td><td>|</td><td>15,040.80</td><td>11,265.00</td></tr>
<tr><td>10,412.30</td><td>|</td><td>20</td><td>|</td><td>11,914.90</td><td>9,282.00</td></tr>
<tr><td>6,926.30</td><td>|</td><td>50</td><td>|</td><td>7,706.70</td><td>6,227.40</td></tr>
<tr><td>4,552.30</td><td>|</td><td>80</td><td>|</td><td>5,105.20</td><td>3,980.30</td></tr>
<tr><td>3,637.80</td><td>|</td><td>90</td><td>|</td><td>4,145.00</td><td>3,097.20</td></tr>
<tr><td>3,015.20</td><td>|</td><td>95</td><td>|</td><td>3,494.20</td><td>2,501.60</td></tr>
<tr><td>2,107.20</td><td>|</td><td>99</td><td>|</td><td>2,535.60</td><td>1,655.10</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Passaic @ Little Falls 1959-1988</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>24,804.80</td><td>|</td><td>0.2</td><td>|</td><td>36,869.40</td><td>19,013.80</td></tr>
<tr><td>21,838.90</td><td>|</td><td>0.5</td><td>|</td><td>31,421.40</td><td>17,072.00</td></tr>
<tr><td>19,637.60</td><td>|</td><td>1</td><td>|</td><td>27,510.90</td><td>15,596.70</td></tr>
<tr><td>17,463.80</td><td>|</td><td>2</td><td>|</td><td>23,771.90</td><td>14,106.00</td></tr>
<tr><td>14,611.00</td><td>|</td><td>5</td><td>|</td><td>19,071.80</td><td>12,086.20</td></tr>
<tr><td>12,439.50</td><td>|</td><td>10</td><td>|</td><td>15,676.10</td><td>10,485.70</td></tr>
<tr><td>10,206.00</td><td>|</td><td>20</td><td>|</td><td>12,381.40</td><td>8,758.70</td></tr>
<tr><td>6,923.20</td><td>|</td><td>50</td><td>|</td><td>8,021.60</td><td>5,980.50</td></tr>
<tr><td>4,637.90</td><td>|</td><td>80</td><td>|</td><td>5,402.20</td><td>3,826.40</td></tr>
<tr><td>3,742.60</td><td>|</td><td>90</td><td>|</td><td>4,445.40</td><td>2,962.80</td></tr>
<tr><td>3,126.80</td><td>|</td><td>95</td><td>|</td><td>3,794.60</td><td>2,378.90</td></tr>
<tr><td>2,217.40</td><td>|</td><td>99</td><td>|</td><td>2,824.50</td><td>1,552.10</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Passaic @ Little Falls 1989-2018</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>29,877.60</td><td>|</td><td>0.2</td><td>|</td><td>47,112.80</td><td>22,030.40</td></tr>
<tr><td>25,628.40</td><td>|</td><td>0.5</td><td>|</td><td>38,850.20</td><td>19,353.30</td></tr>
<tr><td>22,572.20</td><td>|</td><td>1</td><td>|</td><td>33,138.50</td><td>17,374.80</td></tr>
<tr><td>19,639.80</td><td>|</td><td>2</td><td>|</td><td>27,861.10</td><td>15,425.80</td></tr>
<tr><td>15,927.10</td><td>|</td><td>5</td><td>|</td><td>21,502.80</td><td>12,867.90</td></tr>
<tr><td>13,210.80</td><td>|</td><td>10</td><td>|</td><td>17,118.40</td><td>10,911.50</td></tr>
<tr><td>10,523.20</td><td>|</td><td>20</td><td>|</td><td>13,052.10</td><td>8,873.10</td></tr>
<tr><td>6,788.90</td><td>|</td><td>50</td><td>|</td><td>7,998.80</td><td>5,763.70</td></tr>
<tr><td>4,361.50</td><td>|</td><td>80</td><td>|</td><td>5,172.00</td><td>3,517.50</td></tr>
<tr><td>3,455.10</td><td>|</td><td>90</td><td>|</td><td>4,184.90</td><td>2,664.30</td></tr>
<tr><td>2,847.90</td><td>|</td><td>95</td><td>|</td><td>3,529.40</td><td>2,104.50</td></tr>
<tr><td>1,977.60</td><td>|</td><td>99</td><td>|</td><td>2,579.10</td><td>1,338.30</td></tr>
</table>

Table 16. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Passaic River in Little Falls, NJ.

Passaic @ Millington 1959-2018			
Computed Curve	% chance	0.05	0.95
3,339.40	0.2	4,340.70	2,739.50
2,861.10	0.5	3,625.10	2,390.20
2,523.80	1	3,133.40	2,138.90
2,205.30	2	2,680.20	1,897.00
1,809.00	5	2,133.90	1,588.10
1,523.40	10	1,754.80	1,358.40
1,243.80	20	1,398.60	1,125.20
857.4	50	941	780.7
603.2	80	667.2	536
506	90	566.6	440.3
439.4	95	498.2	375.2
340.6	99	396.3	279.9
Passaic @ Millington 1959-1988			
Computed Curve	% chance	0.05	0.95
3,022.80	0.2	4,312.10	2,391.60
2,588.60	0.5	3,544.40	2,100.50
2,288.90	1	3,035.30	1,893.80
2,010.90	2	2,580.30	1,697.00
1,671.90	5	2,051.00	1,448.40
1,432.50	10	1,697.50	1,264.80
1,202.10	20	1,377.20	1,078.50
889.9	50	987.3	799.6
688.1	80	768	598.8
611.5	90	689.7	520.3
559.3	95	637.1	466.9
481.9	99	559.7	388.8
Passaic @ Millington 1989-2018			
Computed Curve	% chance	0.05	0.95
4,407.30	0.2	7,306.70	3,153.10
3,600.30	0.5	5,660.70	2,660.70
3,059.50	1	4,613.00	2,319.10
2,571.90	2	3,712.10	2,000.90
1,998.60	5	2,714.70	1,610.60
1,610.60	10	2,084.90	1,332.30
1,252.80	20	1,545.10	1,060.30
798.7	50	937	678.9
529.4	80	626.2	428
433.4	90	522	337.3
370.3	95	454	278.5
280.5	99	357	197.7

Table 17. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Passaic River in Millington, NJ.

Ramapo @ Mahwah 1959-2018			
Computed Curve	% chance	0.05	0.95
30,454.80	0.2	46,418.30	22,187.00
23,025.50	0.5	33,487.10	17,346.70
18,428.00	1	25,836.60	14,248.80
14,566.60	2	19,666.40	11,565.60
10,400.90	5	13,337.10	8,556.00
7,833.00	10	9,653.30	6,614.50
5,665.90	20	6,719.50	4,895.40
3,230.20	50	3,699.90	2,813.20
1,980.50	80	2,296.10	1,664.80
1,576.60	90	1,857.00	1,290.30
1,323.90	95	1,582.80	1,058.60
985.2	99	1,212.40	754.5
Ramapo @ Mahwah 1959-1988			
Computed Curve	% chance	0.05	0.95
25,526.50	0.2	46,861.80	17,063.50
20,091.90	0.5	34,645.90	13,955.20
16,563.40	1	27,178.90	11,854.90
13,473.50	2	20,991.60	9,945.80
9,972.60	5	14,452.80	7,675.80
7,700.50	10	10,536.10	6,115.30
5,692.50	20	7,348.10	4,646.90
3,299.90	50	4,007.80	2,708.90
1,995.00	80	2,446.80	1,540.90
1,558.70	90	1,954.70	1,148.30
1,281.80	95	1,644.10	905.1
905.8	99	1,217.40	589.3
Ramapo @ Mahwah 1989-2018			
Computed Curve	% chance	0.05	0.95
40,188.70	0.2	83,839.60	24,791.60
28,517.40	0.5	54,296.10	18,615.40
21,780.00	1	38,641.20	14,845.60
16,450.00	2	27,159.60	11,710.30
11,089.40	5	16,621.20	8,354.60
8,019.80	10	11,172.70	6,290.00
5,594.40	20	7,273.30	4,532.80
3,087.30	50	3,776.10	2,503.30
1,914.30	80	2,370.40	1,460.60
1,556.50	90	1,962.40	1,142.10
1,339.30	95	1,716.30	952.3
1,058.50	99	1,396.70	713.6

Table 17. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Ramapo River in Mahwah, NJ.

Hackensack @ Rivervale 1959-2018			
Computed Curve	% chance	0.05	0.95
6,015.40	0.2	8,612.30	4,572.70
5,144.30	0.5	7,183.90	3,979.30
4,501.50	1	6,156.50	3,532.80
3,872.60	2	5,176.50	3,087.40
3,061.80	5	3,955.10	2,497.60
2,461.70	10	3,087.80	2,046.60
1,867.50	20	2,267.40	1,582.90
1,060.00	50	1,236.50	910.3
571.7	80	673.7	471.9
405.5	90	489.6	321.3
302	95	374.5	229.7
169	99	223.1	117.5
Hackensack @ Rivervale 1959-1988			
Computed Curve	% chance	0.05	0.95
4,473.20	0.2	7,478.00	3,166.50
3,816.70	0.5	6,127.90	2,768.10
3,340.30	1	5,187.40	2,470.90
2,880.40	2	4,314.30	2,176.20
2,295.40	5	3,260.20	1,787.30
1,867.00	10	2,534.90	1,489.10
1,444.70	20	1,867.30	1,179.30
867.6	50	1,055.20	714.7
507.8	80	621.6	393.6
379.8	90	477.4	278.4
297.2	95	384.7	206.3
185.1	99	256.2	114.5
Hackensack @ Rivervale 1989-2018			
Computed Curve	% chance	0.05	0.95
5,900.50	0.2	9,915.20	4,131.50
5,284.60	0.5	8,644.40	3,758.80
4,786.90	1	7,646.90	3,451.70
4,260.00	2	6,621.40	3,119.80
3,514.40	5	5,230.30	2,636.00
2,908.20	10	4,157.90	2,227.40
2,256.90	20	3,075.10	1,767.70
1,284.70	50	1,630.90	1,020.00
655.4	80	834.2	484.7
440.3	90	581.1	301.7
309.3	95	426.4	195.8
150	99	229.9	79.3

Table 18. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Hackensack River in Rivervale, NJ.

Pequannock @ Macopin Intake Dam 1959-2018			
Computed Curve	% chance	0.05	0.95
3,625.30 |	0.2 |	5,334.20	2,649.90
3,562.50 |	0.5 |	5,229.70	2,607.70
3,483.40 |	1 |	5,098.70	2,554.40
3,360.50 |	2 |	4,895.90	2,471.30
3,088.70 |	5 |	4,452.20	2,286.10
2,751.10 |	10 |	3,909.90	2,053.10
2,236.60 |	20 |	3,105.20	1,691.00
1,155.50 |	50 |	1,519.20	892.2
387.3 |	80 |	507.9	283.7
179.4 |	90 |	247.9	120
85.1 |	95 |	126.5	51
15.9 |	99 |	28.7	7.2

Pequannock @ Macopin Intake Dam 1959-1988			
Computed Curve	% chance	0.05	0.95
4,898.50 |	0.2 |	10,242.10	2,877.60
4,638.20 |	0.5 |	9,582.10	2,742.30
4,370.00 |	1 |	8,911.90	2,601.70
4,022.00 |	2 |	8,057.40	2,417.10
3,405.40 |	5 |	6,589.20	2,083.40
2,794.30 |	10 |	5,197.60	1,742.90
2,042.60 |	20 |	3,587.30	1,307.20
859.5 |	50 |	1,346.10	564.9
240.5 |	80 |	371.9	140.7
103.1 |	90 |	171.7	51.4
46.4 |	95 |	85.4	19.3
8 |	99 |	19.3	2.1

Pequannock @ Macopin Intake Dam 1989-2018			
Computed Curve	% chance	0.05	0.95
3,200.20 |	0.2 |	4,975.30	2,316.40
3,165.00 |	0.5 |	4,908.70	2,293.60
3,119.40 |	1 |	4,822.70	2,264.00
3,046.40 |	2 |	4,685.60	2,216.40
2,877.70 |	5 |	4,372.70	2,105.50
2,656.60 |	10 |	3,970.70	1,958.00
2,296.40 |	20 |	3,337.10	1,712.10
1,427.90 |	50 |	1,935.10	1,081.10
641.5 |	80 |	853.9	451.3
363.6 |	90 |	508.5	228.1
209.3 |	95 |	314.9	114.6
60 |	99 |	110.5	23.3

Table 19. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Pequannock River in Macopin, NJ.

Delaware @ Belvidere 1959-2018					
Computed Curve		% chance		0.05	0.95
325,574.70	|	0.2	|	439,888.60	259,528.90
269,991.20	|	0.5	|	353,600.40	220,054.60
232,240.80	|	1	|	296,775.90	192,605.30
197,781.70	|	2	|	246,364.00	166,987.30
156,636.80	|	5	|	188,329.30	135,494.20
128,295.60	|	10	|	150,026.80	113,022.60
101,711.90	|	20	|	115,707.80	91,091.10
67,109.80	|	50	|	74,341.10	60,508.00
45,914.40	|	80	|	51,311.40	40,297.70
38,182.30	|	90	|	43,225.20	32,791.40
33,021.20	|	95	|	37,857.10	27,809.90
25,572.80	|	99	|	30,078.00	20,738.00

Delaware @ Belvidere 1959-1988					
Computed Curve		% chance		0.05	0.95
155,096.80	|	0.2	|	204,227.60	128,175.10
147,610.30	|	0.5	|	192,079.40	122,824.00
141,009.90	|	1	|	181,523.20	118,053.90
133,411.90	|	2	|	169,559.70	112,496.20
121,402.50	|	5	|	151,089.80	103,545.60
110,304.50	|	10	|	134,547.90	95,059.20
96,637.90	|	20	|	114,971.50	84,247.40
71,142.10	|	50	|	81,401.00	62,512.90
48,556.20	|	80	|	55,579.90	41,027.50
38,511.10	|	90	|	45,014.10	31,124.80
31,256.10	|	95	|	37,493.30	24,098.80
20,227.50	|	99	|	25,882.40	13,988.50

Delaware @ Belvidere 1989-2018					
Computed Curve		% chance		0.05	0.95
557,397.90	|	0.2	|	1,028,446.40	372,828.50
417,432.10	|	0.5	|	713,034.60	292,867.30
332,737.80	|	1	|	535,540.20	242,115.50
262,866.00	|	2	|	398,249.50	198,394.90
188,920.50	|	5	|	263,915.50	149,535.60
144,135.40	|	10	|	189,415.10	117,990.60
106,827.80	|	20	|	132,552.30	89,845.00
65,391.20	|	50	|	77,178.60	55,006.20
44,280.60	|	80	|	52,798.70	35,439.10
37,479.20	|	90	|	45,341.50	29,067.60
33,240.80	|	95	|	40,736.10	25,141.90
27,615.20	|	99	|	34,625.00	20,034.00

Table 20. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Delaware River in Belvidere, NJ.

Delaware @ Delaware Water Gap 1959-2018			
Computed Curve	% chance	0.05	0.95
338,850.60 |	0.2 |	489,452.20	258,982.40
279,221.20 |	0.5 |	388,907.60	218,792.20
238,696.80 |	1 |	322,988.70	190,744.10
201,712.40 |	2 |	264,801.20	164,496.50
157,610.50 |	5 |	198,321.60	132,148.10
127,321.60 |	10 |	154,893.30	109,028.30
99,040.20 |	20 |	116,445.60	86,457.30
62,598.60 |	50 |	71,080.80	55,064.20
40,686.80 |	80 |	46,641.10	34,557.30
32,838.90 |	90 |	38,262.10	27,095.30
27,665.90 |	95 |	32,765.90	22,230.10
20,327.40 |	99 |	24,909.10	15,500.50
Delaware @ Delaware Water Gap 1959-1988			
Computed Curve	% chance	0.05	0.95
136,857.10 |	0.2 |	186,977.80	110,856.20
131,722.10 |	0.5 |	178,136.30	107,276.60
126,924.50 |	1 |	169,982.10	103,899.60
121,118.10 |	2 |	160,256.30	99,767.10
111,388.30 |	5 |	144,329.40	92,717.70
101,871.30 |	10 |	129,236.10	85,646.70
89,566.30 |	20 |	110,517.00	76,183.90
65,308.80 |	50 |	76,835.20	56,007.00
43,031.60 |	80 |	50,445.40	35,153.40
33,121.10 |	90 |	39,804.30	25,543.80
26,056.20 |	95 |	32,340.10	18,882.60
15,645.10 |	99 |	21,090.30	9,794.20
Delaware @ Delaware Water Gap 1989-2018			
Computed Curve	% chance	0.05	0.95
623,347.90 |	0.2 |	1,352,468.80	384,842.70
463,851.30 |	0.5 |	918,006.60	302,024.70
367,132.00 |	1 |	676,405.80	249,035.00
287,283.40 |	2 |	491,799.30	203,095.00
202,832.10 |	5 |	314,184.50	151,406.80
151,813.70 |	10 |	217,738.90	117,829.70
109,499.90 |	20 |	145,748.10	87,740.40
62,923.40 |	50 |	77,979.00	50,361.10
39,510.40 |	80 |	49,439.90	29,465.20
32,025.10 |	90 |	40,879.10	22,776.70
27,366.80 |	95 |	35,598.80	18,710.20
21,157.30 |	99 |	28,529.70	13,491.00

Table 21. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Delaware River in Delaware Water Gap, NJ.

Delaware @ Riegelsville 1959-2018			
Computed Curve	% chance	0.05	0.95
372,442.20	0.2	499,406.40	298,665.30
312,863.60	0.5	407,451.30	256,138.40
271,706.80	1	345,753.80	226,097.80
233,570.60	2	290,116.00	197,666.70
187,206.20	5	224,804.60	162,118.30
154,651.80	10	180,802.60	136,291.30
123,567.80	20	140,624.80	110,655.60
82,136.20	50	90,997.70	74,069.50
56,077.00	80	62,660.20	49,217.70
46,416.60	90	52,563.80	39,829.90
39,917.50	95	45,809.50	33,553.40
30,463.70	99	35,936.60	24,585.90
Delaware @ Riegelsville 1959-1988			
Computed Curve	% chance	0.05	0.95
192,234.80	0.2	253,491.30	158,743.00
182,714.70	0.5	238,017.20	151,947.20
174,363.60	1	224,643.00	145,918.40
164,793.20	2	209,557.70	138,923.80
149,744.90	5	186,398.40	127,714.90
135,911.60	10	165,773.10	117,139.90
118,956.10	20	141,486.70	103,726.00
87,508.30	50	100,097.60	76,907.00
59,788.00	80	68,425.00	50,525.20
47,482.30	90	55,485.10	38,390.30
38,596.40	95	46,276.10	29,780.70
25,077.90	99	32,052.30	17,374.40
Delaware @ Riegelsville 1989-2018			
Computed Curve	% chance	0.05	0.95
629,400.00	0.2	1,157,976.50	422,951.50
477,813.60	0.5	815,491.60	336,210.00
384,697.10	1	619,509.30	280,396.20
306,870.60	2	465,743.10	231,734.70
223,238.80	5	312,804.00	176,569.80
171,762.30	10	226,525.20	140,403.90
128,248.80	20	159,681.70	107,673.10
78,983.20	50	93,396.30	66,341.90
53,308.30	80	63,659.90	42,536.40
44,899.50	90	54,438.50	34,653.70
39,606.80	95	48,688.70	29,753.50
32,484.00	99	40,949.20	23,304.40

Table 22. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Delaware River in Riegelsville, NJ.

Wanaque @ Awosting 1959-2018			
Computed Curve	% chance	0.05	0.95
5,849.00 |	0.2 |	9,174.30	4,164.60
4,467.60 |	0.5 |	6,701.60	3,283.70
3,592.10 |	1 |	5,200.90	2,707.00
2,842.70 |	2 |	3,966.20	2,198.40
2,018.30 |	5 |	2,674.00	1,617.00
1,501.30 |	10 |	1,909.00	1,235.60
1,060.20 |	20 |	1,293.60	894.4
562.4 |	50 |	658.5	479.7
310.7 |	80 |	368.6	254.2
231.4 |	90 |	280.3	182.9
182.9 |	95 |	226.2	140
120 |	99 |	154.8	86.2
Wanaque @ Awosting 1959-1988			
Computed Curve	% chance	0.05	0.95
5,589.80 |	0.2 |	10,895.50	3,581.80
4,407.90 |	0.5 |	8,079.70	2,931.80
3,627.50 |	1 |	6,328.50	2,485.50
2,935.50 |	2 |	4,859.20	2,074.70
2,142.10 |	5 |	3,289.90	1,580.30
1,622.90 |	10 |	2,344.40	1,237.50
1,163.10 |	20 |	1,575.80	914.2
620.6 |	50 |	781.9	492.1
335 |	80 |	426.4	247.1
243.9 |	90 |	319.5	169.2
188.1 |	95 |	254	123.3
116.2 |	99 |	167.8	67.9
Wanaque @ Awosting 1989-2018			
Computed Curve	% chance	0.05	0.95
6,705.90 |	0.2 |	14,328.60	4,061.90
4,858.10 |	0.5 |	9,534.50	3,100.60
3,757.20 |	1 |	6,898.80	2,497.10
2,863.80 |	2 |	4,908.70	1,983.40
1,940.00 |	5 |	3,025.50	1,419.50
1,397.00 |	10 |	2,024.30	1,064.10
959.5 |	20 |	1,293.30	756.2
499 |	50 |	626.6	395
281.7 |	80 |	358.2	207.8
215.5 |	90 |	280.7	151
175.4 |	95 |	233.9	117.7
123.7 |	99 |	172.6	76.5

Table 23. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Wanaque River in Awosting, NJ.

Wanaque @ Wanaque 1959-2018					
Computed Curve		% chance		0.05	0.95
11,416.60	|	0.2	|	20,962.80	7,100.90
9,868.50	|	0.5	|	17,732.90	6,228.60
8,593.80	|	1	|	15,134.00	5,498.10
7,240.80	|	2	|	12,443.40	4,708.50
5,366.00	|	5	|	8,849.60	3,584.20
3,924.90	|	10	|	6,217.40	2,689.00
2,522.60	|	20	|	3,797.30	1,780.70
876.4	|	50	|	1,218.00	637.1
224.5	|	80	|	315.9	151
96.7	|	90	|	144.3	58.9
44.9	|	95	|	72.1	24.6
8.9	|	99	|	17.1	3.8
Wanaque @ Wanaque 1959-1988					
Computed Curve		% chance		0.05	0.95
24,596.50	|	0.2	|	80,307.30	10,855.20
19,701.00	|	0.5	|	60,978.40	8,967.30
16,071.30	|	1	|	47,403.30	7,519.20
12,580.40	|	2	|	35,058.60	6,076.80
8,317.80	|	5	|	21,133.20	4,225.60
5,481.00	|	10	|	12,757.20	2,913.50
3,095.70	|	20	|	6,468.00	1,729.90
835.7	|	50	|	1,478.60	482.8
166	|	80	|	294.5	81.2
62.6	|	90	|	121.4	25.4
26.1	|	95	|	56.4	8.7
4.2	|	99	|	12	0.9
Wanaque @ Wanaque 1989-2018					
Computed Curve		% chance		0.05	0.95
5,291.70	|	0.2	|	10,561.60	3,248.70
4,861.90	|	0.5	|	9,516.30	3,017.50
4,469.90	|	1	|	8,583.40	2,803.70
4,011.50	|	2	|	7,519.60	2,549.60
3,291.40	|	5	|	5,911.40	2,139.80
2,652.90	|	10	|	4,558.90	1,763.50
1,932.40	|	20	|	3,130.30	1,319.60
870.8	|	50	|	1,271.70	608.4
296.3	|	80	|	430.7	186.4
149.3	|	90	|	230.7	82.4
79.3	|	95	|	132.7	37.9
20.5	|	99	|	42	7

Table 24. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Wanaque River in Wanaque, NJ.

Elizabeth @ Ursino Lake 1959-2018			
Computed Curve	% chance	0.05	0.95
6,475.50 |	0.2 |	8,002.10	5,517.70
5,744.60 |	0.5 |	6,960.40	4,963.80
5,209.20 |	1 |	6,212.90	4,551.40
4,685.80 |	2 |	5,496.50	4,141.80
4,005.70 |	5 |	4,589.50	3,597.90
3,491.70 |	10 |	3,925.40	3,175.20
2,964.10 |	20 |	3,268.10	2,726.90
2,183.10 |	50 |	2,358.70	2,019.90
1,623.70 |	80 |	1,765.30	1,472.00
1,396.40 |	90 |	1,534.40	1,243.50
1,235.20 |	95 |	1,372.20	1,081.80
986.2 |	99 |	1,121.10	834.9
Elizabeth @ Ursino Lake 1959-1988			
Computed Curve	% chance	0.05	0.95
4,961.30 |	0.2 |	6,598.40	4,091.70
4,578.00 |	0.5 |	5,966.50	3,821.50
4,274.40 |	1 |	5,477.10	3,603.90
3,956.30 |	2 |	4,975.70	3,372.00
3,506.50 |	5 |	4,288.10	3,036.00
3,134.70 |	10 |	3,741.60	2,749.30
2,720.00 |	20 |	3,159.60	2,416.20
2,033.60 |	50 |	2,280.40	1,817.00
1,481.20 |	80 |	1,666.20	1,277.50
1,241.70 |	90 |	1,419.40	1,035.20
1,067.40 |	95 |	1,242.70	860.4
792.6 |	99 |	963	593.9
Elizabeth @ Ursino Lake 1989-2018			
Computed Curve	% chance	0.05	0.95
9,064.20 |	0.2 |	13,405.20	7,012.00
7,513.50 |	0.5 |	10,568.70	5,995.80
6,487.70 |	1 |	8,780.40	5,301.20
5,571.60 |	2 |	7,251.20	4,661.70
4,504.60 |	5 |	5,563.80	3,886.60
3,787.60 |	10 |	4,498.40	3,339.30
3,129.40 |	20 |	3,583.10	2,806.80
2,295.70 |	50 |	2,547.80	2,058.60
1,802.40 |	80 |	2,013.30	1,566.80
1,627.90 |	90 |	1,834.50	1,388.30
1,514.30 |	95 |	1,719.60	1,272.10
1,356.90 |	99 |	1,561.60	1,112.30

Table 25. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Elizabeth River in Ursino Lake, NJ.

Musconetcong @ Bloomsbury 1959-2018			
Computed Curve	% chance	0.05	0.95
10,237.00	0.2	14,055.70	8,047.70
8,691.70	0.5	11,620.60	6,962.60
7,588.80	1	9,928.90	6,171.80
6,538.40	2	8,358.90	5,403.50
5,221.80	5	6,456.80	4,414.10
4,270.30	10	5,136.90	3,675.00
3,341.20	20	3,904.10	2,925.70
2,078.20	50	2,350.90	1,837.50
1,283.40	80	1,465.40	1,098.70
994.7	90	1,156.40	826.2
804.7	95	953.5	649.2
538.7	99	665.7	408.8

Musconetcong @ Bloomsbury 1959-1988			
Computed Curve	% chance	0.05	0.95
10,963.60	0.2	18,550.30	7,712.80
9,173.00	0.5	14,825.00	6,634.80
7,915.50	1	12,325.30	5,854.10
6,735.70	2	10,078.70	5,099.60
5,284.20	5	7,465.80	4,133.80
4,256.50	10	5,734.90	3,416.10
3,273.30	20	4,192.90	2,690.40
1,975.80	50	2,385.70	1,636.70
1,188.80	80	1,446.30	928.3
910.4	90	1,134.80	675.3
729.9	95	933.9	515.7
481.4	99	652.9	307.7

Musconetcong @ Bloomsbury 1989-2018			
Computed Curve	% chance	0.05	0.95
9,611.30	0.2	15,297.30	7,045.00
8,197.00	0.5	12,522.50	6,159.40
7,187.70	1	10,621.90	5,509.40
6,226.20	2	8,880.30	4,873.10
5,019.10	5	6,802.60	4,044.50
4,144.10	10	5,385.00	3,415.90
3,285.70	20	4,083.10	2,766.10
2,106.90	50	2,485.90	1,785.70
1,350.30	80	1,603.90	1,086.60
1,069.90	90	1,298.10	823.3
882.8	95	1,095.70	651.2
615.3	99	803.1	416.1

Table 26. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Musconetcong River in Bloomsbury, NJ.

Rockaway @ Boonton 1959-2018			
Computed Curve	% chance	0.05	0.95
10,646.20	0.2	14,427.20	8,462.50
8,917.00	0.5	11,735.50	7,237.00
7,720.60	1	9,926.70	6,369.80
6,610.80	2	8,294.10	5,548.10
5,260.70	5	6,377.30	4,519.90
4,313.10	10	5,086.80	3,773.00
3,409.60	20	3,910.70	3,032.80
2,210.80	50	2,464.50	1,981.70
1,464.10	80	1,646.80	1,275.30
1,190.20	90	1,358.40	1,011.70
1,007.30	95	1,166.70	837
744.2	99	889	591
Rockaway @ Boonton 1959-1988			
Computed Curve	% chance	0.05	0.95
9,630.00	0.2	15,079.30	7,142.00
8,196.50	0.5	12,310.00	6,235.00
7,183.00	1	10,432.00	5,575.30
6,224.80	2	8,724.60	4,934.20
5,032.20	5	6,704.80	4,106.30
4,174.10	10	5,336.80	3,482.90
3,337.10	20	4,086.60	2,841.80
2,191.90	50	2,557.30	1,877.30
1,454.30	80	1,708.30	1,186.70
1,178.30	90	1,410.80	923.4
992.4	95	1,212.40	749
722.7	99	922.4	505.6
Rockaway @ Boonton 1989-2018			
Computed Curve	% chance	0.05	0.95
12,309.20	0.2	20,479.80	8,780.80
10,096.60	0.5	15,951.10	7,433.90
8,602.30	1	13,043.30	6,493.00
7,246.10	2	10,524.30	5,611.10
5,639.40	5	7,712.30	4,521.40
4,543.50	10	5,922.20	3,739.00
3,526.60	20	4,377.70	2,970.00
2,226.70	50	2,625.00	1,884.50
1,451.50	80	1,725.20	1,166.70
1,175.10	90	1,423.50	907
993.2	95	1,226.70	739.1
735.5	99	946	509.8

Table 27. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Rockaway River in Boonton, NJ.

Saddle River @ Lodi 1959-2018			
Computed Curve	% chance	0.05	0.95
6,537.60	0.2	8,216.00	5,492.90
5,873.70	0.5	7,255.70	4,995.20
5,366.80	1	6,535.90	4,609.40
4,853.10	2	5,819.80	4,212.90
4,157.00	5	4,873.10	3,664.30
3,608.40	10	4,149.60	3,220.50
3,024.70	20	3,406.60	2,733.30
2,124.40	50	2,334.30	1,934.70
1,461.00	80	1,616.00	1,298.40
1,191.10	90	1,336.70	1,033.20
1,001.80	95	1,142.00	848.4
716.1	99	845.8	575.9
Saddle River @ Lodi 1959-1988			
Computed Curve	% chance	0.05	0.95
5,506.30	0.2	7,647.80	4,392.70
5,145.50	0.5	7,029.90	4,144.50
4,840.50	1	6,517.30	3,931.70
4,502.50	2	5,960.40	3,692.30
3,992.90	5	5,144.80	3,323.50
3,545.40	10	4,454.70	2,989.80
3,021.00	20	3,682.40	2,583.80
2,111.10	50	2,459.70	1,821.40
1,371.10	80	1,599.80	1,130.60
1,061.10	90	1,267.20	832.9
844.5	95	1,037.40	629.7
528.1	99	695.2	350.4
Saddle River @ Lodi 1989-2018			
Computed Curve	% chance	0.05	0.95
9,808.70	0.2	15,315.70	7,319.70
7,961.40	0.5	11,758.90	6,149.20
6,758.20	1	9,562.30	5,359.00
5,698.70	2	7,718.30	4,639.80
4,485.50	5	5,728.60	3,780.00
3,685.20	10	4,502.20	3,182.20
2,962.90	20	3,471.40	2,609.40
2,068.70	50	2,336.10	1,822.50
1,551.40	80	1,765.00	1,317.60
1,370.20	90	1,575.90	1,136.80
1,252.40	95	1,454.50	1,019.70
1,088.60	99	1,286.40	858.7

Table 28. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Saddle River in Lodi, NJ.

Saddle River @ Ridgewood 1959-2018			
Computed Curve	% chance	0.05	0.95
11,244.60	0.2	17,431.40	8,104.50
7,973.30	0.5	11,655.00	5,995.10
6,104.90	1	8,532.60	4,740.00
4,638.30	2	6,197.10	3,718.10
3,173.70	5	3,996.30	2,651.00
2,339.40	10	2,820.90	2,011.20
1,681.70	20	1,950.80	1,479.30
1,001.90	50	1,129.90	884.4
684.4	80	780.3	586.7
588.6	90	677.9	495.9
531.4	95	616.9	442
460	99	540.9	375.2

Saddle River @ Ridgewood 1959-1988			
Computed Curve	% chance	0.05	0.95
7,295.50	0.2	12,997.10	4,979.70
5,747.70	0.5	9,617.50	4,077.20
4,748.70	1	7,563.50	3,470.90
3,877.70	2	5,868.10	2,922.30
2,894.70	5	4,081.50	2,272.80
2,258.20	10	3,012.40	1,827.60
1,695.90	20	2,140.80	1,408.70
1,023.10	50	1,221.80	853.3
651.4	80	785.4	514
525.2	90	645.5	397.8
444.2	95	556.5	324.5
332.5	99	432.8	227

Saddle River @ Ridgewood 1989-2018			
Computed Curve	% chance	0.05	0.95
18,873.30	0.2	42,526.10	11,128.90
11,757.00	0.5	23,292.00	7,515.00
8,202.10	1	14,753.90	5,566.90
5,709.10	2	9,336.70	4,108.00
3,519.30	5	5,096.40	2,722.60
2,427.60	10	3,229.70	1,968.60
1,662.00	20	2,061.70	1,391.00
983.6	50	1,169.40	814.4
728.9	80	875.3	579.6
668	90	807.4	523.1
638.1	95	774.4	495.4
611.2	99	744.7	470.5

Table 29. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Saddle River in Ridgewood, NJ.

Manasquan @ Squankum 1959-2018				
Computed Curve		% chance	0.05	0.95
8,627.90			0.2		12,611.30	6,488.60
6,654.70			0.5		9,311.20	5,163.80
5,416.60			1		7,325.50	4,305.90
4,363.00			2		5,698.60	3,554.40
3,207.00			5		3,995.30	2,699.20
2,480.10			10		2,980.20	2,137.70
1,854.00			20		2,152.30	1,631.20
1,128.20			50		1,270.80	999.1
740			80		842.5	635.4
610.6			90		704.5	512.6
528.2			95		617	435.1
415.7			99		496.9	330.7
Manasquan @ Squankum 1959-1988				
Computed Curve		% chance	0.05	0.95
2,252.20			0.2		2,889.80	1,892.20
2,168.60			0.5		2,757.70	1,831.20
2,091.70			1		2,637.70	1,774.60
1,999.80			2		2,496.30	1,706.30
1,848.00			5		2,267.10	1,591.50
1,701.10			10		2,051.40	1,477.90
1,512.40			20		1,784.10	1,327.40
1,140.00			50		1,296.70	1,008.20
790.4			80		898.6	673.9
629.8			90		730.7	514.1
512			95		609.6	398.8
330.6			99		420.2	230.8
Manasquan @ Squankum 1989-2018				
Computed Curve		% chance	0.05	0.95
14,828.80			0.2		30,560.10	9,209.60
10,758.60			0.5		20,364.80	7,041.50
8,345.00			1		14,784.70	5,686.90
6,392.10			2		10,581.20	4,537.60
4,376.80			5		6,606.10	3,279.10
3,192.30			10		4,488.40	2,486.50
2,235.40			20		2,934.80	1,798.40
1,220.00			50		1,502.20	984.1
732.2			80		912.6	554
581.1			90		739.2	420.8
488.6			95		633.6	341
367.5			99		494.3	240.3

Table 30. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Manasquan River in Squankum, NJ.

Rahway @ Rahway 1959-2018				
Computed Curve		% chance	0.05	0.95
12,885.30 |		0.2 |	18,690.10	9,749.20
9,919.40 |		0.5 |	13,766.50	7,746.70
8,068.80 |		1 |	10,821.50	6,456.80
6,501.00 |		2 |	8,419.50	5,331.90
4,789.10 |		5 |	5,917.10	4,057.60
3,717.40 |		10 |	4,432.10	3,224.70
2,797.50 |		20 |	3,225.00	2,475.90
1,734.70 |		50 |	1,943.50	1,544.10
1,167.60 |		80 |	1,321.80	1,009.40
978.8 |		90 |	1,121.60	828.9
858.8 |		95 |	994.9	714.9
695.3 |		99 |	821.8	561.6
Rahway @ Rahway 1959-1988				
Computed Curve		% chance	0.05	0.95
9,779.20 |		0.2 |	16,165.00	7,005.20
8,053.30 |		0.5 |	12,654.10	5,950.30
6,882.20 |		1 |	10,387.00	5,210.20
5,814.80 |		2 |	8,413.30	4,514.10
4,543.90 |		5 |	6,196.70	3,650.00
3,672.30 |		10 |	4,776.70	3,026.50
2,859.40 |		20 |	3,544.20	2,410.90
1,813.00 |		50 |	2,134.90	1,536.40
1,184.10 |		80 |	1,405.50	953.3
958.7 |		90 |	1,159.90	741.2
810 |		95 |	999.3	603.7
598.8 |		99 |	769.6	415.5
Rahway @ Rahway 1989-2018				
Computed Curve		% chance	0.05	0.95
18,207.80 |		0.2 |	35,827.80	11,694.30
12,901.20 |		0.5 |	23,141.40	8,777.30
9,876.30 |		1 |	16,506.70	7,018.40
7,505.50 |		2 |	11,683.80	5,569.10
5,141.80 |		5 |	7,288.20	4,032.20
3,797.30 |		10 |	5,024.30	3,093.30
2,738.50 |		20 |	3,404.80	2,296.60
1,645.90 |		50 |	1,948.80	1,376.30
1,137.10 |		80 |	1,361.00	906.1
984.4 |		90 |	1,192.60	763.7
893.7 |		95 |	1,093.50	679.8
781.7 |		99 |	971.3	577.6

Table 31. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Rahway River in Rahway, NJ.

Rahway @ Springfield 1959-2018			
Computed Curve	% chance	0.05	0.95
18,244.40	0.2	28,830.90	12,966.60
12,604.10	0.5	18,694.30	9,377.20
9,469.20	1	13,383.90	7,292.50
7,064.80	2	9,515.40	5,630.20
4,727.20	5	5,978.10	3,936.10
3,432.40	10	4,147.30	2,945.80
2,436.60	20	2,828.70	2,141.20
1,440.20	50	1,626.30	1,268.90
993.3	80	1,134.10	850.3
863.1	90	994.5	727.1
787.2	95	913.6	655.7
696.3	99	816.6	570.5
Rahway @ Springfield 1959-1988			
Computed Curve	% chance	0.05	0.95
9,917.80	0.2	17,533.60	6,824.40
7,549.50	0.5	12,408.60	5,434.80
6,098.00	1	9,476.00	4,543.60
4,886.60	2	7,173.50	3,768.60
3,586.40	5	4,879.00	2,892.30
2,786.50	10	3,580.50	2,319.00
2,110.10	20	2,570.80	1,800.60
1,343.40	50	1,563.80	1,146.00
943.7	80	1,108.90	769.4
813.2	90	968	644.7
731.5	95	880.6	567.3
622.8	99	764.6	465.9
Rahway @ Springfield 1989-2018			
Computed Curve	% chance	0.05	0.95
27,380.40	0.2	60,871.60	16,247.10
18,030.40	0.5	35,818.20	11,476.10
13,057.30	1	23,810.70	8,761.80
9,385.50	2	15,708.50	6,635.50
5,971.50	5	8,932.20	4,512.00
4,168.50	10	5,745.80	3,295.50
2,840.10	20	3,640.00	2,322.60
1,581.30	50	1,918.70	1,287.00
1,050.00	80	1,289.90	809.8
901	90	1,121.00	675.5
816	95	1,025.30	599.7
716.3	99	913.3	512

Table 32. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Rahway River in Springfield, NJ.

Toms River @ Toms River 1959-2018			
Computed Curve	% chance	0.05	0.95
4,370.80 |	0.2 |	5,981.50	3,448.70
3,641.70 |	0.5 |	4,835.80	2,935.50
3,139.40 |	1 |	4,069.90	2,573.80
2,675.50 |	2 |	3,382.00	2,232.40
2,114.10 |	5 |	2,579.30	1,807.10
1,722.40 |	10 |	2,042.70	1,499.90
1,351.30 |	20 |	1,557.20	1,197.20
863.6 |	50 |	966.3	771.3
563.8 |	80 |	636.7	488.8
454.9 |	90 |	521.5	384.5
382.6 |	95 |	445.4	315.9
279.5 |	99 |	335.9	220.1
Toms River @ Toms River 1959-1988			
Computed Curve	% chance	0.05	0.95
3,270.90 |	0.2 |	4,952.50	2,478.70
2,839.10 |	0.5 |	4,145.00	2,199.50
2,525.80 |	1 |	3,580.20	1,991.70
2,222.60 |	2 |	3,052.50	1,785.50
1,834.30 |	5 |	2,407.30	1,512.20
1,546.20 |	10 |	1,954.40	1,300.70
1,256.80 |	20 |	1,526.60	1,077.40
844.8 |	50 |	979.6	728.6
567.2 |	80 |	661.6	467
460.4 |	90 |	547.3	364.1
387.4 |	95 |	470	295
280.1 |	99 |	355.6	197.2
Toms River @ Toms River 1989-2018			
Computed Curve	% chance	0.05	0.95
5,690.70 |	0.2 |	9,928.50	3,934.50
4,570.90 |	0.5 |	7,530.70	3,273.10
3,830.20 |	1 |	6,030.20	2,819.10
3,170.50 |	2 |	4,760.10	2,400.40
2,406.90 |	5 |	3,382.10	1,893.40
1,899.40 |	10 |	2,531.90	1,537.50
1,440.10 |	20 |	1,819.90	1,195.50
873.6 |	50 |	1,044.00	729
550.6 |	80 |	663.9	434.5
439 |	90 |	540.3	331.7
366.8 |	95 |	460.9	266.6
266.6 |	99 |	349.7	179.7

Table 33. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Toms River in Toms River, NJ.

Lamington @ Pottersville 1959-2018			
Computed Curve	% chance	0.05	0.95
6,836.20	0.2	10,383.40	4,994.10
5,164.30	0.5	7,483.10	3,901.90
4,132.00	1	5,771.30	3,204.50
3,266.60	2	4,393.40	2,601.50
2,334.70	5	2,982.60	1,926.40
1,761.20	10	2,162.80	1,491.50
1,277.70	20	1,510.50	1,106.90
734.6	50	839.4	641.3
455.7	80	526.9	384.2
365.4	90	429	300.2
308.8	95	367.8	248.1
232.8	99	285.1	179.6

Lamington @ Pottersville 1959-1988			
Computed Curve	% chance	0.05	0.95
8,435.50	0.2	17,072.90	5,299.10
6,207.50	0.5	11,584.80	4,099.20
4,865.50	1	8,523.40	3,339.40
3,765.10	2	6,179.60	2,687.20
2,611.50	5	3,921.30	1,963.10
1,922.30	10	2,694.60	1,500.40
1,357.20	20	1,779.20	1,093.40
746.3	50	917.7	603.2
446.9	80	556.1	338.9
353	90	448.5	255.9
295.1	95	382.6	206
218.9	99	295	142.6

Lamington @ Pottersville 1989-2018			
Computed Curve	% chance	0.05	0.95
5,726.30	0.2	10,469.30	3,843.80
4,443.50	0.5	7,598.80	3,107.70
3,628.90	1	5,888.80	2,620.20
2,928.80	2	4,501.80	2,184.50
2,152.30	5	3,070.30	1,676.50
1,658.90	10	2,232.60	1,333.90
1,230.40	20	1,563.30	1,016.70
729.6	50	875.7	605.1
460.3	80	558	360.7
370.4	90	457.9	278.5
313.3	95	394.7	227.2
235.2	99	307.7	159.6

Table 34. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Lamington River in Pottersville, NJ.

Pompton @ Pompton Plains 1959-2018					
Computed Curve		% chance		0.05	0.95
40,230.30	|	0.2	|	58,278.80	30,364.20
33,255.30	|	0.5	|	46,706.60	25,654.30
28,394.30	|	1	|	38,888.30	22,293.80
23,868.80	|	2	|	31,820.80	19,093.70
18,362.30	|	5	|	23,546.40	15,080.90
14,518.10	|	10	|	18,028.30	12,175.50
10,897.80	|	20	|	13,080.80	9,326.50
6,249.60	|	50	|	7,221.90	5,409.90
3,549.50	|	80	|	4,146.60	2,958.40
2,630.60	|	90	|	3,139.00	2,116.00
2,049.90	|	95	|	2,501.50	1,593.20
1,277.50	|	99	|	1,638.00	923.9
Pompton @ Pompton Plains 1959-1988					
Computed Curve		% chance		0.05	0.95
38,562.20	|	0.2	|	69,047.20	26,099.40
31,872.50	|	0.5	|	54,351.10	22,216.50
27,201.10	|	1	|	44,573.20	19,416.10
22,845.60	|	2	|	35,864.80	16,722.70
17,538.90	|	5	|	25,871.90	13,301.20
13,831.30	|	10	|	19,368.80	10,786.00
10,340.00	|	20	|	13,692.10	8,279.10
5,866.40	|	50	|	7,265.80	4,741.10
3,283.70	|	80	|	4,099.50	2,482.10
2,411.30	|	90	|	3,096.20	1,717.50
1,863.30	|	95	|	2,467.20	1,253.80
1,140.80	|	99	|	1,618.50	681.7
Pompton @ Pompton Plains 1989-2018					
Computed Curve		% chance		0.05	0.95
44,778.70	|	0.2	|	80,782.20	30,207.50
36,353.40	|	0.5	|	62,143.90	25,338.80
30,634.10	|	1	|	50,142.00	21,915.80
25,430.00	|	2	|	39,746.50	18,695.30
19,265.90	|	5	|	28,190.70	14,708.60
15,079.90	|	10	|	20,905.80	11,852.90
11,232.60	|	20	|	14,713.60	9,068.70
6,434.80	|	50	|	7,902.60	5,236.50
3,716.80	|	80	|	4,604.80	2,835.80
2,799.00	|	90	|	3,558.10	2,022.20
2,218.30	|	95	|	2,898.20	1,522.90
1,439.90	|	99	|	1,997.40	891.2

Table 35. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Pompton River in Pompton Plains, NJ.

South Branch Raritan @ High Bridge 1959-2018			
Computed Curve	% chance	0.05	0.95
10,477.90	0.2	14,362.00	8,260.60
8,651.10	0.5	11,487.00	6,976.50
7,411.10	1	9,595.80	6,083.70
6,280.10	2	7,920.60	5,250.80
4,931.90	5	5,997.00	4,228.10
4,005.70	10	4,732.00	3,499.70
3,139.90	20	3,603.50	2,791.00
2,020.40	50	2,253.60	1,809.30
1,342.40	80	1,511.30	1,168.10
1,097.70	90	1,253.40	932.8
935.5	95	1,083.30	778
703.7	99	838.5	560.9
South Branch Raritan @ High Bridge 1959-1988			
Computed Curve	% chance	0.05	0.95
10,387.90	0.2	17,047.30	7,477.20
8,576.40	0.5	13,387.90	6,364.90
7,344.60	1	11,018.30	5,583.20
6,219.70	2	8,950.10	4,846.70
4,876.90	5	6,620.00	3,930.40
3,953.30	10	5,121.70	3,267.80
3,089.40	20	3,816.70	2,611.70
1,972.30	50	2,316.60	1,675.60
1,296.80	80	1,535.30	1,047.50
1,053.60	90	1,270.90	817.8
892.7	95	1,097.70	668.4
663.4	99	849.2	463
South Branch Raritan @ High Bridge 1989-2018			
Computed Curve	% chance	0.05	0.95
11,494.00	0.2	19,142.90	8,201.40
9,330.60	0.5	14,711.70	6,885.20
7,893.80	1	11,920.50	5,979.40
6,608.20	2	9,541.60	5,141.50
5,110.40	5	6,934.80	4,121.70
4,105.90	10	5,306.20	3,401.00
3,187.70	20	3,923.40	2,702.00
2,034.70	50	2,383.40	1,731.30
1,358.40	80	1,604.60	1,100.20
1,118.90	90	1,344.90	873.2
961.6	95	1,176.00	726.4
738.7	99	935.7	524.6

Table 36. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the South Branch Raritan River in High Bridge, NJ.

South Branch Raritan @ Stanton 1959-2018					
Computed Curve		% chance		0.05	0.95
20,466.60	|	0.2	|	27,825.20	16,209.10
17,493.90	|	0.5	|	23,185.10	14,106.40
15,355.60	|	1	|	19,933.30	12,563.30
13,304.80	|	2	|	16,891.10	11,054.30
10,711.60	|	5	|	13,169.20	9,095.50
8,819.00	|	10	|	10,558.00	7,619.00
6,953.30	|	20	|	8,093.40	6,108.90
4,382.00	|	50	|	4,941.90	3,886.70
2,736.20	|	80	|	3,113.80	2,351.70
2,131.20	|	90	|	2,468.60	1,778.20
1,730.50	|	95	|	2,042.30	1,403.10
1,165.30	|	99	|	1,433.30	889.5

South Branch Raritan @ Stanton 1959-1988					
Computed Curve		% chance		0.05	0.95
13,953.80	|	0.2	|	20,332.20	10,783.30
12,825.40	|	0.5	|	18,305.40	10,032.20
11,899.60	|	1	|	16,679.90	9,405.80
10,901.50	|	2	|	14,968.30	8,718.90
9,448.40	|	5	|	12,558.80	7,693.50
8,219.70	|	10	|	10,606.70	6,797.50
6,833.40	|	20	|	8,513.60	5,744.30
4,558.60	|	50	|	5,399.30	3,868.60
2,831.30	|	80	|	3,361.30	2,284.00
2,142.40	|	90	|	2,608.70	1,638.00
1,674.90	|	95	|	2,102.10	1,211.60
1,014.00	|	99	|	1,369.80	647.7

South Branch Raritan @ Stanton 1989-2018					
Computed Curve		% chance		0.05	0.95
30,331.40	|	0.2	|	54,484.80	20,580.80
23,940.90	|	0.5	|	40,418.00	16,874.40
19,796.20	|	1	|	31,823.10	14,373.40
16,168.00	|	2	|	24,698.60	12,101.80
12,055.80	|	5	|	17,158.30	9,401.30
9,383.10	|	10	|	12,628.70	7,543.20
7,014.70	|	20	|	8,926.40	5,790.70
4,174.90	|	50	|	5,016.00	3,462.80
2,606.70	|	80	|	3,162.10	2,041.50
2,075.80	|	90	|	2,570.10	1,556.40
1,736.00	|	95	|	2,193.70	1,252.30
1,269.10	|	99	|	1,672.20	850.5

Table 37. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the South Branch Raritan River in Stanton, NJ.

Second River @ Belleville 1959-2018				
Computed Curve		% chance	0.05	0.95
8,682.10	|	0.2 |	11,518.00	7,078.00
7,707.20	|	0.5 |	9,986.60	6,382.20
6,980.90	|	1 |	8,873.50	5,854.10
6,260.70	|	2 |	7,795.70	5,320.80
5,309.70	|	5 |	6,417.20	4,598.40
4,579.90	|	10 |	5,399.90	4,026.10
3,822.20	|	20 |	4,389.10	3,408.50
2,688.90	|	50 |	2,995.30	2,414.80
1,877.60	|	80 |	2,105.10	1,635.70
1,551.60	|	90 |	1,766.10	1,314.50
1,323.40	|	95 |	1,531.10	1,091.50
978.2	|	99 |	1,173.30	762.6

Second River @ Belleville 1959-1988				
Computed Curve		% chance	0.05	0.95
9,370.80	|	0.2 |	14,118.30	7,147.30
8,098.90	|	0.5 |	11,738.50	6,323.10
7,188.90	|	1 |	10,100.80	5,717.50
6,318.70	|	2 |	8,590.90	5,123.20
5,219.20	|	5 |	6,772.30	4,345.40
4,414.30	|	10 |	5,514.60	3,750.50
3,614.60	|	20 |	4,340.70	3,128.10
2,488.30	|	50 |	2,859.30	2,163.60
1,733.00	|	80 |	2,003.20	1,441.90
1,441.00	|	90 |	1,694.10	1,156.10
1,240.30	|	95 |	1,484.30	962.1
941.4	|	99 |	1,170.80	682.6

Second River @ Belleville 1989-2018				
Computed Curve		% chance	0.05	0.95
8,247.60	|	0.2 |	13,997.90	6,164.20
7,484.90	|	0.5 |	12,176.50	5,706.10
6,898.00	|	1 |	10,834.70	5,344.20
6,298.70	|	2 |	9,521.60	4,964.50
5,478.00	|	5 |	7,823.90	4,424.10
4,822.90	|	10 |	6,560.60	3,970.20
4,116.00	|	20 |	5,302.90	3,448.30
2,999.80	|	50 |	3,595.70	2,509.80
2,148.30	|	80 |	2,562.70	1,671.20
1,791.40	|	90 |	2,180.90	1,309.20
1,536.10	|	95 |	1,915.60	1,057.50
1,140.70	|	99 |	1,504.80	692.8

Table 38. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Second River in Belleville, NJ.

Great Egg Harbor@ Folsom 1959-2018			
Computed Curve	% chance	0.05	0.95
1,578.40 |	0.2 |	2,118.40	1,263.60
1,334.70 |	0.5 |	1,742.50	1,089.70
1,164.00 |	1 |	1,486.50	965.2
1,004.00 |	2 |	1,252.60	846.1
806.7 |	5 |	974	695.3
666.3 |	10 |	783.5	584.3
530.6 |	20 |	607.4	472.9
347.4 |	50 |	386.6	312
230.9 |	80 |	259.2	201.6
187.6 |	90 |	213.7	159.8
158.6 |	95 |	183.3	132
116.5 |	99 |	139	92.6
Great Egg Harbor@ Folsom 1959-1988			
Computed Curve	% chance	0.05	0.95
988.8 |	0.2 |	1,398.30	782.4
896.1 |	0.5 |	1,236.30	719.6
824.1 |	1 |	1,113.50	669.9
749.8 |	2 |	990.3	617.7
647.2 |	5 |	826.1	543.5
564.7 |	10 |	699.8	481.7
475.2 |	20 |	569.7	411.7
333.9 |	50 |	383.6	291.3
227.6 |	80 |	262.4	190.2
183.9 |	90 |	216.2	147.5
153.2 |	95 |	184.2	118
107 |	99 |	135.4	75.5
Great Egg Harbor@ Folsom 1989-2018			
Computed Curve	% chance	0.05	0.95
2,163.60 |	0.2 |	3,676.60	1,522.20
1,758.30 |	0.5 |	2,830.10	1,278.70
1,487.10 |	1 |	2,292.80	1,109.90
1,242.90 |	2 |	1,832.10	952.9
956.7 |	5 |	1,324.30	760.6
763.7 |	10 |	1,005.50	623.9
586.7 |	20 |	734.1	490.9
363.9 |	50 |	431.6	306
233.7 |	80 |	279.5	186.3
187.9 |	90 |	229.2	143.7
158 |	95 |	196.6	116.3
116 |	99 |	150.6	79.4

Table 39. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Great Egg Harbor River in Folsom, NJ.

Maurice @ Norma 1959-2018			
Computed Curve	% chance	0.05	0.95
4,456.70 |	0.2 |	6,653.90	3,298.20
3,402.30 |	0.5 |	4,854.30	2,600.90
2,745.40 |	1 |	3,781.00	2,152.10
2,190.10 |	2 |	2,908.70	1,761.30
1,586.20 |	5 |	2,004.90	1,319.70
1,210.20 |	10 |	1,472.80	1,032.50
889.8 |	20 |	1,044.00	775.8
524 |	50 |	595.2	460.2
332.3 |	80 |	381.8	282.3
269.3 |	90 |	314	223.3
229.6 |	95 |	271.3	186.3
175.8 |	99 |	213.2	137.2
Maurice @ Norma 1959-1988			
Computed Curve	% chance	0.05	0.95
3,090.80 |	0.2 |	5,222.30	2,178.70
2,561.60 |	0.5 |	4,122.80	1,859.80
2,196.20 |	1 |	3,399.30	1,632.40
1,858.40 |	2 |	2,759.60	1,415.60
1,449.80 |	5 |	2,029.30	1,142.40
1,165.30 |	10 |	1,554.30	942.4
896.9 |	20 |	1,137.50	742.8
548.1 |	50 |	656.8	457
338.6 |	80 |	408.9	266.8
264.4 |	90 |	326.5	198.6
216 |	95 |	273.2	155.2
148.6 |	99 |	197.9	97.6
Maurice @ Norma 1989-2018			
Computed Curve	% chance	0.05	0.95
6,736.10 |	0.2 |	14,152.80	4,143.90
4,633.30 |	0.5 |	8,804.30	3,034.00
3,464.80 |	1 |	6,097.20	2,378.70
2,569.30 |	2 |	4,184.90	1,848.70
1,700.10 |	5 |	2,500.10	1,299.30
1,219.90 |	10 |	1,663.80	971.9
851.8 |	20 |	1,084.90	700.7
484.9 |	50 |	584.8	397.8
320.3 |	80 |	390.9	249
271.9 |	90 |	336.5	205
243.3 |	95 |	304.5	179.3
208 |	99 |	265.2	148.2

Table 40. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Maurice River in Norma, NJ.

Salem @ Woodstown 1959-2018			
Computed Curve	% chance	0.05	0.95
8,758.10 |	0.2 |	14,677.40	5,966.20
6,759.50 |	0.5 |	10,821.00	4,753.00
5,461.90 |	1 |	8,426.60	3,939.00
4,329.60 |	2 |	6,422.50	3,206.60
3,059.20 |	5 |	4,290.70	2,351.50
2,249.60 |	10 |	3,014.00	1,780.00
1,552.70 |	20 |	1,983.30	1,262.80
767.3 |	50 |	930.4	632.6
381.3 |	80 |	468.9	298.5
265.2 |	90 |	335	198.1
196.7 |	95 |	255.6	140.6
112.7 |	99 |	155.5	73.5
Salem @ Woodstown 1959-1988			
Computed Curve	% chance	0.05	0.95
8,634.50 |	0.2 |	18,455.30	5,207.30
6,537.10 |	0.5 |	12,999.10	4,119.50
5,208.80 |	1 |	9,775.40	3,398.70
4,074.30 |	2 |	7,192.60	2,756.40
2,832.50 |	5 |	4,585.20	2,014.20
2,060.90 |	10 |	3,109.60	1,522.30
1,410.90 |	20 |	1,979.00	1,078.80
696.4 |	50 |	901	537.4
352.2 |	80 |	461	250.7
249 |	90 |	336.3	165.8
187.9 |	95 |	262.3	117.7
112.2 |	99 |	168.1	62.1
Salem @ Woodstown 1989-2018			
Computed Curve	% chance	0.05	0.95
9,703.10 |	0.2 |	23,878.50	5,515.40
7,573.10 |	0.5 |	17,253.70	4,493.80
6,164.70 |	1 |	13,188.60	3,786.70
4,917.00 |	2 |	9,831.20	3,132.60
3,493.50 |	5 |	6,331.80	2,342.50
2,571.90 |	10 |	4,294.10	1,794.70
1,769.10 |	20 |	2,703.50	1,281.00
856 |	50 |	1,174.50	624.7
408.7 |	80 |	564.2	267.8
276.2 |	90 |	396.4	164.9
199.3 |	95 |	298.6	109
107.3 |	99 |	177.1	48.9

Table 41. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Salem River in Woodstown, NJ.

Swimming @ Red Bank 1959-2018				
Computed Curve		% chance	0.05	0.95
8,134.70 |		0.2 |	11,292.60	6,330.30
7,066.20 |		0.5 |	9,592.20	5,585.50
6,264.20 |		1 |	8,345.40	5,016.40
5,466.90 |		2 |	7,134.10	4,440.50
4,417.40 |		5 |	5,588.80	3,663.30
3,621.80 |		10 |	4,461.30	3,055.80
2,814.20 |		20 |	3,365.00	2,416.70
1,673.60 |		50 |	1,928.70	1,454.70
946.6 |		80 |	1,101.00	793.4
688.5 |		90 |	819.1	555.6
523.6 |		95 |	638.7	406.7
305 |		99 |	394.1	217.9
Swimming @ Red Bank 1959-1988				
Computed Curve		% chance	0.05	0.95
8,097.10 |		0.2 |	13,548.80	5,730.50
6,883.80 |		0.5 |	11,051.40	4,994.80
6,009.30 |		1 |	9,324.70	4,449.30
5,169.90 |		2 |	7,732.20	3,911.10
4,109.20 |		5 |	5,823.40	3,205.20
3,337.40 |		10 |	4,519.80	2,667.20
2,581.10 |		20 |	3,327.20	2,111.40
1,554.10 |		50 |	1,886.10	1,282.50
916.5 |		80 |	1,119.70	712
689.5 |		90 |	864.5	507.1
542.7 |		95 |	700.3	378.6
342.6 |		99 |	471.8	213.7
Swimming @ Red Bank 1989-2018				
Computed Curve		% chance	0.05	0.95
8,454.80 |		0.2 |	14,126.20	5,958.90
7,463.10 |		0.5 |	12,089.90	5,356.60
6,690.50 |		1 |	10,554.10	4,877.10
5,897.80 |		2 |	9,028.70	4,373.80
4,815.80 |		5 |	7,038.40	3,664.60
3,966.00 |		10 |	5,560.60	3,084.50
3,078.30 |		20 |	4,112.50	2,448.80
1,788.60 |		50 |	2,234.10	1,440.20
959.2 |		80 |	1,203.10	722.1
670 |		90 |	868.2	470.7
489.4 |		95 |	659	320.4
259.8 |		99 |	383.6	145.5

Table 42. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Swimming River in Red Bank, NJ.

Mullica @ Batsto 1959-2018			
Computed Curve	% chance	0.05	0.95
3,100.50	0.2	4,459.00	2,358.70
2,456.60	0.5	3,398.20	1,921.40
2,038.70	1	2,735.40	1,629.50
1,672.70	2	2,174.40	1,366.90
1,257.10	5	1,564.70	1,058.40
986.3	10	1,186.70	849.1
745.5	20	867.7	654.7
454.8	50	513.1	402.4
292.3	80	333.3	250.6
236.8	90	273.9	198
200.9	95	235.8	164.4
151.2	99	182.6	118.7
Mullica @ Batsto 1959-1988			
Computed Curve	% chance	0.05	0.95
3,215.80	0.2	5,633.80	2,213.90
2,618.50	0.5	4,349.20	1,862.10
2,214.10	1	3,523.80	1,615.60
1,846.80	2	2,809.50	1,384.10
1,412.10	5	2,015.00	1,097.90
1,116.60	10	1,512.70	892.9
844.2	20	1,083.60	692.5
501.3	50	606.2	414
303.1	80	369.7	235.8
234.7	90	293	173.8
190.7	95	243.9	135
130.3	99	175.6	84.2
Mullica @ Batsto 1989-2018			
Computed Curve	% chance	0.05	0.95
3,062.90	0.2	5,456.90	2,095.70
2,341.30	0.5	3,883.30	1,674.50
1,895.60	1	2,974.90	1,402.40
1,521.30	2	2,256.60	1,164.40
1,116.60	5	1,535.30	893.5
865.8	10	1,124.10	715
652.4	20	802.3	552.7
408.6	50	478.8	346.4
280.2	80	331.5	226.4
237.8	90	285.5	186.3
211.1	95	256.7	161.3
175.1	99	217.9	128.2

Table 43. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Mullica River in Batsto, NJ.

<table>
<tr><td>Oswego @ Harrisville 1959-2018</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>2,242.00</td><td>|</td><td>0.2</td><td>|</td><td>3,133.80</td><td>1,742.00</td></tr>
<tr><td>1,822.80</td><td>|</td><td>0.5</td><td>|</td><td>2,461.50</td><td>1,451.40</td></tr>
<tr><td>1,542.80</td><td>|</td><td>1</td><td>|</td><td>2,027.60</td><td>1,252.40</td></tr>
<tr><td>1,291.30</td><td>|</td><td>2</td><td>|</td><td>1,649.70</td><td>1,069.10</td></tr>
<tr><td>996.9</td><td>|</td><td>5</td><td>|</td><td>1,224.60</td><td>847.8</td></tr>
<tr><td>798.6</td><td>|</td><td>10</td><td>|</td><td>951.2</td><td>693.1</td></tr>
<tr><td>616.7</td><td>|</td><td>20</td><td>|</td><td>712.3</td><td>545.1</td></tr>
<tr><td>387.7</td><td>|</td><td>50</td><td>|</td><td>434.7</td><td>345.3</td></tr>
<tr><td>253.4</td><td>|</td><td>80</td><td>|</td><td>286.9</td><td>219</td></tr>
<tr><td>205.9</td><td>|</td><td>90</td><td>|</td><td>236.6</td><td>173.7</td></tr>
<tr><td>174.8</td><td>|</td><td>95</td><td>|</td><td>203.7</td><td>144.2</td></tr>
<tr><td>130.9</td><td>|</td><td>99</td><td>|</td><td>157.1</td><td>103.5</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oswego @ Harrisville 1959-1988</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>1,764.20</td><td>|</td><td>0.2</td><td>|</td><td>2,880.40</td><td>1,271.80</td></tr>
<tr><td>1,486.30</td><td>|</td><td>0.5</td><td>|</td><td>2,321.60</td><td>1,100.60</td></tr>
<tr><td>1,290.80</td><td>|</td><td>1</td><td>|</td><td>1,945.50</td><td>976.5</td></tr>
<tr><td>1,107.00</td><td>|</td><td>2</td><td>|</td><td>1,606.20</td><td>856.5</td></tr>
<tr><td>880</td><td>|</td><td>5</td><td>|</td><td>1,209.10</td><td>702.4</td></tr>
<tr><td>718.3</td><td>|</td><td>10</td><td>|</td><td>943.8</td><td>587.3</td></tr>
<tr><td>562.3</td><td>|</td><td>20</td><td>|</td><td>704.9</td><td>470.1</td></tr>
<tr><td>353.3</td><td>|</td><td>50</td><td>|</td><td>419.6</td><td>297.4</td></tr>
<tr><td>222.9</td><td>|</td><td>80</td><td>|</td><td>266.7</td><td>177.8</td></tr>
<tr><td>175.5</td><td>|</td><td>90</td><td>|</td><td>214.6</td><td>133.7</td></tr>
<tr><td>144.2</td><td>|</td><td>95</td><td>|</td><td>180.5</td><td>105.2</td></tr>
<tr><td>100</td><td>|</td><td>99</td><td>|</td><td>131.6</td><td>66.8</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oswego @ Harrisville 1989-2018</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Computed Curve</td><td></td><td>% chance</td><td></td><td>0.05</td><td>0.95</td></tr>
<tr><td>3,372.50</td><td>|</td><td>0.2</td><td>|</td><td>6,140.30</td><td>2,278.30</td></tr>
<tr><td>2,497.00</td><td>|</td><td>0.5</td><td>|</td><td>4,194.10</td><td>1,773.60</td></tr>
<tr><td>1,976.90</td><td>|</td><td>1</td><td>|</td><td>3,121.80</td><td>1,458.50</td></tr>
<tr><td>1,554.30</td><td>|</td><td>2</td><td>|</td><td>2,306.40</td><td>1,190.80</td></tr>
<tr><td>1,114.60</td><td>|</td><td>5</td><td>|</td><td>1,523.40</td><td>896.4</td></tr>
<tr><td>852.8</td><td>|</td><td>10</td><td>|</td><td>1,097.00</td><td>709.3</td></tr>
<tr><td>638</td><td>|</td><td>20</td><td>|</td><td>776.5</td><td>544.5</td></tr>
<tr><td>404.1</td><td>|</td><td>50</td><td>|</td><td>470.4</td><td>344.2</td></tr>
<tr><td>288.2</td><td>|</td><td>80</td><td>|</td><td>338.7</td><td>234.9</td></tr>
<tr><td>251.9</td><td>|</td><td>90</td><td>|</td><td>299.5</td><td>200.2</td></tr>
<tr><td>229.8</td><td>|</td><td>95</td><td>|</td><td>275.8</td><td>179.3</td></tr>
<tr><td>201.7</td><td>|</td><td>99</td><td>|</td><td>245.8</td><td>152.9</td></tr>
</table>

Table 44. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Oswego River in Harrisville, NJ.

Pequest @ Pequest 1959-2018					
Computed Curve		% chance		0.05	0.95
2,199.10	|	0.2	|	2,538.70	1,967.40
2,106.90	|	0.5	|	2,416.50	1,893.40
2,026.20	|	1	|	2,310.30	1,828.00
1,933.60	|	2	|	2,189.80	1,752.60
1,787.50	|	5	|	2,002.20	1,632.00
1,652.20	|	10	|	1,831.70	1,518.30
1,484.30	|	20	|	1,625.10	1,374.00
1,163.10	|	50	|	1,250.70	1,083.70
863	|	80	|	931.1	790
721.5	|	90	|	788.3	646.6
614.6	|	95	|	681.6	538.5
441	|	99	|	507.3	366.7
Pequest @ Pequest 1959-1988					
Computed Curve		% chance		0.05	0.95
2,193.00	|	0.2	|	2,767.20	1,870.00
2,082.50	|	0.5	|	2,594.70	1,789.10
1,988.90	|	1	|	2,450.70	1,719.60
1,884.60	|	2	|	2,293.00	1,641.30
1,725.80	|	5	|	2,058.20	1,519.60
1,583.70	|	10	|	1,854.60	1,407.90
1,413.00	|	20	|	1,619.30	1,268.90
1,100.00	|	50	|	1,221.70	993.6
818.7	|	80	|	910.5	716.7
688.6	|	90	|	777.9	583
590.9	|	95	|	680.3	483.4
432.5	|	99	|	521.2	327.4
Pequest @ Pequest 1989-2018					
Computed Curve		% chance		0.05	0.95
2,137.30	|	0.2	|	2,625.00	1,851.70
2,070.40	|	0.5	|	2,523.80	1,801.40
2,008.70	|	1	|	2,431.50	1,754.60
1,934.80	|	2	|	2,322.10	1,698.10
1,811.80	|	5	|	2,143.30	1,602.50
1,691.60	|	10	|	1,972.80	1,507.20
1,535.00	|	20	|	1,757.80	1,379.20
1,216.40	|	50	|	1,351.90	1,099.80
900.9	|	80	|	1,000.90	790.4
748.1	|	90	|	845.2	633.4
631.7	|	95	|	728.9	514.8
442.1	|	99	|	538	329.4

Table 45. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Pequest River in Pequest, NJ.

Pequest @ Huntsville 1959-2018			
Computed Curve	% chance	0.05	0.95
1,592.10	0.2	2,237.90	1,236.10
1,301.60	0.5	1,766.00	1,036.00
1,107.00	1	1,460.60	898.3
931.4	2	1,193.80	771.1
724.9	5	892.5	616.6
585.1	10	697.9	507.9
456	20	527.2	403.2
292	50	327.5	260
194.5	80	220.2	168
159.7	90	183.4	134.6
136.8	95	159.3	112.7
104.2	99	124.8	82.2
Pequest @ Huntsville 1959-1988			
Computed Curve	% chance	0.05	0.95
1,174.00	0.2	1,830.30	874.6
985.4	0.5	1,467.60	755
855.7	1	1,228.90	670.1
735.8	2	1,017.30	589.4
590.5	5	774.4	487.7
488.8	10	614.6	413
391.9	20	472.3	337.9
263.1	50	303.3	227.8
182.2	80	211.5	150.8
152.1	90	179.5	121.7
131.9	95	158.2	102.3
102.3	99	127	74.8
Pequest @ Huntsville 1989-2018			
Computed Curve	% chance	0.05	0.95
1,968.70	0.2	3,602.40	1,341.90
1,596.80	0.5	2,745.30	1,128.60
1,348.60	1	2,206.70	980.6
1,125.70	2	1,748.90	842.7
864.9	5	1,249.90	673.5
689.5	10	940.5	553
528.9	20	680.3	435.2
327.6	50	395.6	270.3
210.3	80	255.8	163
169.1	90	210.1	125
142.3	95	180.6	100.7
104.6	99	138.9	68.2

Table 46. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Pequest River in Huntsville, NJ.

Flat Brook @ Flatbrookville 1959-2018			
Computed Curve	% chance	0.05	0.95
11,924.20	0.2	17,135.70	9,083.90
9,278.50	0.5	12,781.70	7,285.80
7,607.80	1	10,141.70	6,115.00
6,177.60	2	7,963.00	5,084.30
4,596.50	5	5,661.70	3,903.50
3,593.70	10	4,275.90	3,122.30
2,722.40	20	3,134.50	2,412.20
1,699.80	50	1,902.20	1,515.10
1,144.00	80	1,293.30	990.4
956.6	90	1,094.90	811.1
836.7	95	968.5	697
671.8	99	794.2	542.3

Flat Brook @ Flatbrookville 1959-1988			
Computed Curve	% chance	0.05	0.95
8,028.10	0.2	12,941.80	5,854.10
6,592.90	0.5	10,092.00	4,962.80
5,630.90	1	8,275.30	4,344.80
4,762.90	2	6,709.90	3,769.10
3,740.50	5	4,970.60	3,062.00
3,046.40	10	3,866.80	2,557.00
2,404.00	20	2,915.30	2,061.80
1,582.40	50	1,832.90	1,361.80
1,088.80	80	1,271.10	895
910.8	90	1,080.50	723.6
792.7	95	955.3	611.3
623.4	99	775.5	454.4

Flat Brook @ Flatbrookville 1989-2018			
Computed Curve	% chance	0.05	0.95
15,805.40	0.2	29,384.30	10,508.40
11,959.20	0.5	20,647.80	8,322.80
9,594.40	1	15,639.70	6,915.70
7,617.40	2	11,707.20	5,688.70
5,493.80	5	7,795.70	4,298.60
4,188.20	10	5,591.20	3,388.70
3,086.90	20	3,886.20	2,567.70
1,845.10	50	2,200.60	1,537.60
1,201.80	80	1,448.40	948.9
991.9	90	1,215.70	755.2
859.8	95	1,070.60	635.1
681.7	99	874.3	477.5

Table 47. The three different raw data sets of new, old, and total years results separated into three tables with their computer HEC-SSP data for the Flat Brook River in Flatbrookville, NJ.

Beaver Brook @ Belvidere 1959-2018			
Computed Curve	% chance	0.05	0.95
2,878.80 |	0.2 |	4,087.10	2,221.10
2,366.70 |	0.5 |	3,244.30	1,871.10
2,020.00 |	1 |	2,693.10	1,628.00
1,704.70 |	2 |	2,207.50	1,401.30
1,330.10 |	5 |	1,653.90	1,123.40
1,073.80 |	10 |	1,293.00	925.7
835.3 |	20 |	973.8	733.7
529.3 |	50 |	597.3	468.4
345.9 |	80 |	394.1	296.3
280.3 |	90 |	324.3	233.7
237 |	95 |	278.5	192.8
175.6 |	99 |	213.1	136.1
Beaver Brook @ Belvidere 1959-1988			
Computed Curve	% chance	0.05	0.95
2,287.30 |	0.2 |	3,612.70	1,687.70
1,928.20 |	0.5 |	2,913.40	1,461.80
1,678.10 |	1 |	2,447.10	1,299.70
1,444.70 |	2 |	2,029.40	1,143.90
1,158.50 |	5 |	1,543.70	945.6
955.9 |	10 |	1,220.70	798.4
761.1 |	20 |	930.2	649.1
499.5 |	50 |	581.9	428.2
334.1 |	80 |	392	273
272.8 |	90 |	326	214.4
231.7 |	95 |	282.2	175.7
172.1 |	99 |	218.3	121.6
Beaver Brook @ Belvidere 1989-2018			
Computed Curve	% chance	0.05	0.95
3,637.60 |	0.2 |	7,053.80	2,410.40
2,947.90 |	0.5 |	5,349.10	2,028.00
2,485.90 |	1 |	4,278.20	1,761.30
2,069.90 |	2 |	3,369.40	1,511.90
1,582.20 |	5 |	2,381.40	1,204.50
1,253.80 |	10 |	1,771.70	984.6
953.1 |	20 |	1,262.00	769.1
576.9 |	50 |	711.1	466.8
359.6 |	80 |	446	270.8
284 |	90 |	360.6	202.4
235.1 |	95 |	305.8	159.3
167.3 |	99 |	229.1	102.7

Table 48. The three different raw data sets of new, old, and total years results are separated into three tables with their computer HEC-SSP data for the Beaver Brook River in Belvidere, NJ.