FLOOD RISK IN A CHANGING CLIMATE

IMPACTS TO HRSD'S FACILITIES

MAY 2023

HRSD

Purpose

HRSD is a regional wastewater authority serving 1.9 million people in 20 cities and counties in coastal southeastern Virginia. HRSD is responsible for over 150 facilities that collect, convey, and treat wastewater generated by the region. The low topography, climatology, and coastal proximity of this region make many of HRSD's facilities susceptible to flooding—now and in the future—because of climate change.

This summary documents HRSD's climate change planning study intended to better understand HRSD's exposure to flooding, manage financial and service risks associated with this exposure, and provide a foundation for future updates necessary to address the next 80 years of flooding-related climate change impacts. The study is informed by the latest climate change science available and builds upon the work of local, regional, and statewide committees currently involved in flood protection and climate resilience planning, including the Hampton Roads Planning District Commission (HRPDC) and Virginia Coastal Resilience Technical Advisory Committee (TAC).

Flooding at North Avenue in Newport News.

Mowbray Arch in Norfolk.

Glossary

- **Annual chance event:** the chance in any given year of a flood of a certain size occurring.
- **Annualized losses:** a 2020 dollar value representing the annual risk to a facility due to flooding, considering likelihood and consequences. The metric of annualized losses allows HRSD to understand the flood risk in any given year—no matter what kind of event it is. This helps HRSD decide when to take action to reduce flood risk and by how much at any given facility and across all considered facilities.
- **Asset:** major pieces of equipment or processes at a wastewater treatment plant or pumping facility.
- **Criticality:** a ranking of the importance of an asset to the treatment plant or pumping facility.
- **Climate Change Risk Assessment:** a process that identifies what is at risk, when it is at risk, and how severe the risk is for a given location. It can be thought of as a series of screening steps that help to prioritize efforts and focus on those locations and facilities that are more at risk.
- **Consequences:** the costs that result from HRSD's wastewater facilities becoming inoperable because of a flooding event, made up of physical and downtime damages.
- **Downtime damages:** the costs associated with the number of days it might take to get a facility back into operation using temporary equipment.
- **Exposure:** the presence of flood waters at a treatment plant or pumping facility.
- **Flood mitigation concept:** a design concept that prevents or reduces the impact of flood waters entering a building and damaging assets. Dry floodproofing, floodwalls and berms, flood gates, and elevation flood mitigation concepts were considered.
- **Flood pathway:** the location where water can enter a building or structure. Each access route, or opening, in the walls of a structure is a potential flood pathway.
- **Height of flood protection:** the maximum height of flood water that a mitigation concept is effective for.
- **Hazard:** a physical process or event that can harm human health, livelihoods, the environment, or natural resources. The hazard modeled for this study is flooding for existing and future conditions.
- **Likelihood:** the probability of a flooding event to occur at a given location, based on the annual chance of flooding events modeled.
- **Physical damages:** the costs to replace a damaged asset such as a motor or electrical panel. Physical damages also include the costs for renting or buying temporary equipment that can help in getting essential facilities back into operation before full repairs can be made.
- **Return-on-investment (ROI):** a metric to determine whether a mitigation concept makes financial sense.
- **Risk:** the product of likelihood (exposure to flooding) times consequences (losses). For this study, risk is monetized based on the annualized losses that result from the exposure to a flooding event.

Hurricane Matthew approaching the eastern coast of the United States.

Context and Background

In the fall of 2016, an intense and destructive storm formed over the warm waters of the Caribbean. This was Hurricane Matthew.

The hurricane pummeled Cuba and Haiti before turning north toward the United States, resulting in preparedness plan activations and evacuations throughout the Southeast. The storm caused severe storm surge and wind damage along the coastline of the Carolinas but is especially remembered in Hampton Roads for the extreme rainfall it caused across the area.

Flooding along Bridge Street at the Tidegate Vault.

Flooding along Hanover Avenue in 2012.

The Hampton Roads region of coastal Virginia already had experienced 12 inches of rain in just over 2 weeks leading up to Hurricane Matthew. The ground was saturated with water—when Matthew arrived on the coast, there was nowhere for the water to go. **Matthew was downgraded to a tropical storm by the time it arrived in Virginia, but nonetheless, the region experienced another 12 inches of rain—this time in less than 12 hours.** The Federal Emergency Management Agency (FEMA) received over 2,500 Approved Individual Assistance Applications and designated the region a disaster area to provide access to individual and public assistance—$26.7 million in total—to support the region's recovery.

Since its inception in 1940, HRSD has served the region of coastal Virginia by conveying and treating wastewater to protect public health and the environment. HRSD provides service to 20 cities and counties of southeast Virginia and the Eastern Shore, an area of nearly 5,000 square miles with a population of more than 1.9 million. HRSD facilities include eight major treatment plants and eight smaller plants, with a combined treatment capacity of 225 million gallons per day, over 100 pump stations, and more than 500 miles of pipe.

Flooding at North Hope Street and Yukon Street in Hampton.

HRSD was prepared for Hurricane Matthew with active hurricane preparedness plans. The storm caused widespread flooding throughout Hampton Roads, negatively impacting the lives and livelihoods of communities. **The effects of hurricanes like Matthew, however, were not new to HRSD. Matthew followed years of flooding at HRSD treatment plants and pumping facilities over the decades from Hurricane Isabel (2003), the 2009 Nor'easter, Superstorm Sandy (2012), Tropical Storm Hermine (2016), and many other unnamed storms.**

The Hampton Roads region is among the most vulnerable in the United States to the impacts of flooding, which are projected to increase in severity for decades to come because of climate change. The combination of land subsidence and rising ocean levels increase the risk of higher tides and higher storm surges. Additionally, heavy rainfall events are projected to increase in intensity and frequency, which may result in localized flooding as streams overtop their banks and stress existing stormwater systems.

York River Treatment Plant.

Approximately 1 year after Hurricane Matthew, another hurricane swept through the United States, this time stalling over Houston, Texas, for days and producing over 50 inches of rainfall in some places. Hurricane Harvey devastated the greater Houston area. This was an eye-opening event for HRSD leadership, in part because utility providers in both areas serve a similarly sized population (HRSD 1.9 million, Houston over 2 million). It was natural to think about how HRSD may react in a similar situation.

Flooding in Houston from Hurricane Harvey in 2017.

Nearly half of the Houston's wastewater treatment plants were underwater, and some pumping stations were completely submerged. While many facilities could be brought back online quickly, others required much more work: electrical and mechanical equipment was badly damaged and in need of repairs, cleaning, or replacement. **HRSD leadership saw the impacts caused by Hurricane Harvey and wanted to better understand the potential impacts to HRSD and HRSD customers in Hampton Roads if a similar storm impacted Hampton Roads.** What facilities would be impacted? How could facilities be protected? What would be the financial impact to HRSD?

Flooding in Houston from Hurricane Harvey in 2017.

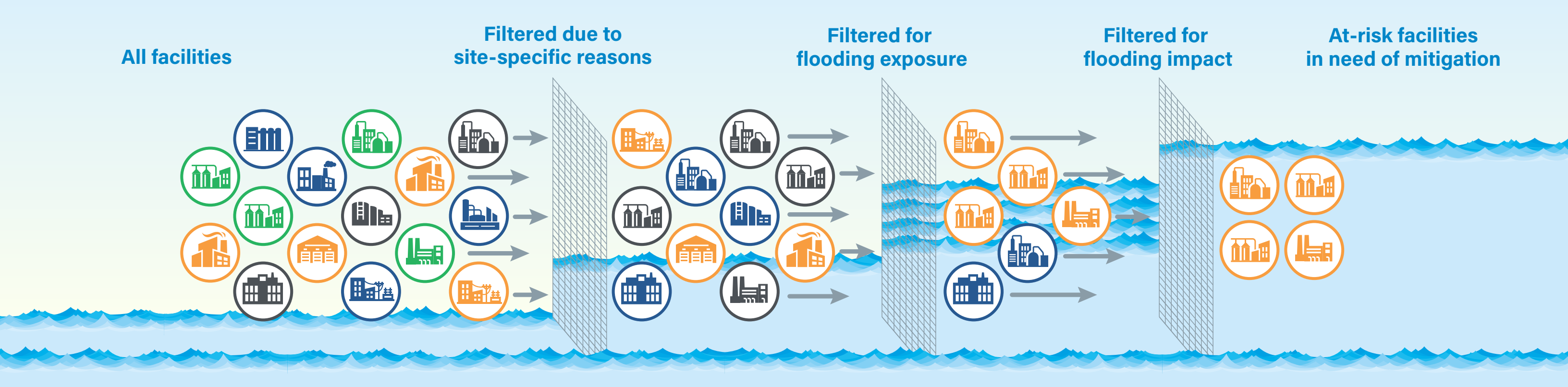
The following sections present the results of the flood risk assessment for HRSD treatment plants and pumping facilities. The section describes the procedures used to determine cost, and a preliminary schedule for flood mitigation concepts for consideration in HRSD's CIP to prepare for the next 80 years of flooding-related climate change impacts. Climate risk and resilience planning is an ongoing process to be refined as additional science becomes available and resilience actions are taken. The study should be adapted based on what local and regional flood protection measures are planned and deployed in the future.

Climate change undermines HRSD's ability to convey and treat wastewater to protect public health and the environment. This climate change planning study used innovative analyses to quantify flood levels, perform economic evaluations of existing and future flood risk, determine potential flood mitigation concepts, and calculate return on investment for these potential options. This study is a result of collaboration between HRSD's operations, engineering, and finance departments. The overarching goals are as follows:

- Analyze the impacts of climate change on HRSD wastewater infrastructure, including treatment plants and pumping facilities
- Identify capital improvement program (CIP) projects to prepare HRSD for climate resilience

The Flood Exposure of HRSD's Facilities

A climate change risk assessment is a process that identifies what is at risk, when it is at risk, and how severe the risk is for a given location. It can be thought of as a series of screening steps that help to prioritize locations and facilities that are more at risk, as shown in the figure below.



1

The first step in a risk assessment is a screening process that identifies the number of locations to include in the assessment.

HRSD is responsible for over 150 facilities that collect, convey, and treat wastewater generated by the region, most of which are critical to maintaining HRSD's mission. A total of 136 facilities were included in the flood exposure evaluation (13 treatment plants, 18 pressure reducing stations, 1 storage facility, 101 pump stations, and 3 administration facilities or Operations Centers).

The remaining facilities were excluded because they were either without equipment critical to HRSD's mission or designated to be replaced, relocated, or otherwise further evaluated by HRSD at the time of the study. The map shows the location of these HRSD treatment, pumping, and administration facilities.

Location of the HRSD Treatment, Pumping, and Administration Facilities Included in the Flood Water Level Evaluation

2 **The second step in the risk assessment is understanding the exposure of each selected facility to a climate hazard—in this case, exposure to current and future flooding.** This step "screens out" facilities that are unlikely to be impacted by flooding and identifies a list of vulnerable facilities for further evaluation.

Example of storm surge flooding – photo from the Boat Harbor Treatment Plant during Hurricane Isabel in September 2003.

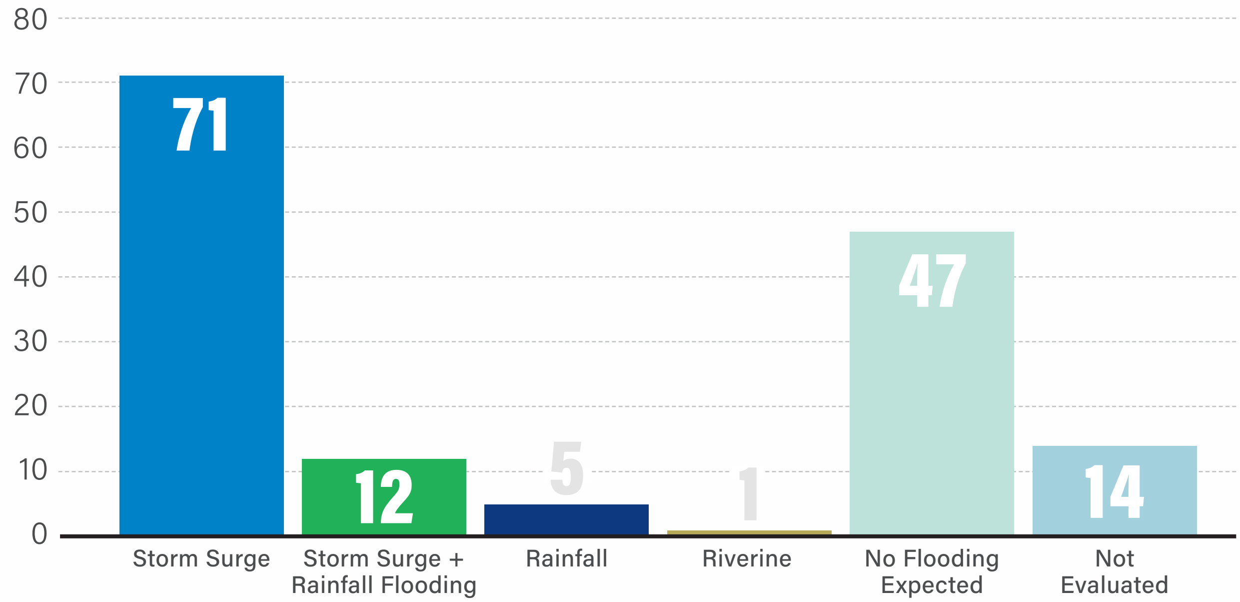
Flood waters in the region can be caused by three conditions:

1. Storm surge (coastal) flooding due to storm surge produced by atmosphere pressure changes and wind
2. Riverine (fluvial) flooding due to hydrology and floodplain conveyance capacity throughout a watershed
3. Rainfall runoff (pluvial) flooding due to hydrology and drainage system capacity in a localized area

Example of rainfall runoff flooding – photo from the South Shore Administration Building on November 12, 2020.

All three of these flooding sources were considered as part of this study for both current and future conditions through 2100, including whether more than one of these kinds of events happened simultaneously. The future conditions include changes to intensity and frequency based on Global Climate Models (Coupled Model Intercomparison Project Phase 5, or CMIP5), sea level rise estimates from the National Oceanic and Atmospheric Administration (2017), and the U.S. Army Corps of Engineers North Atlantic Coast Comprehensive Study (2014). The number of facilities impacted by different types of flooding are shown in the figure below.

Dominant Flooding Source for HRSD Treatment, Pumping, and Administration Facilities



HRSD's facilities are spread over a 3,000-square-mile service area (excluding the Eastern Shore). Determining flood water levels for specific HRSD facilities either requires (1) detailed information from the stormwater utilities in the city where the HRSD facilities are located or (2) HRSD to conduct large-scale analyses. HRSD met with representatives of the stormwater utilities at the onset of this study and determined that flooding information was not consistently or readily available to quantify the current and future flooding exposure of HRSD facilities. This posed a significant challenge to accurately determine flood water levels and required HRSD to perform its own flood water modeling for this plan, called hydrologic and hydraulic (H&H) analyses. A process to evaluate flooding exposure accurately and practicably for a given site was adopted to account for storm surge, riverine, and/or rainfall flooding at the HRSD facilities evaluated.

Different magnitudes of flooding are referred to as "annual chance flooding events," which means the chance in any given year of a flood of a certain size occurring.

One example is the 1 percent (%) annual chance flooding event, which is commonly known as the "100-year storm." This can be misleading because it is often thought of as a flood that will only happen every 100 years, but it actually means that in any year there is a 1% chance of this flood condition occurring. When thought of over a timespan of a typical 30-year mortgage, the home's location has a 26% chance of flooding—a very different feeling of risk than once every 100 years!

The potential magnitude of anticipated flood water levels from storm surge, riverine, or rainfall runoff was evaluated for current (2020) and three future conditions for 10% (10-year storm), 4% (25-year storm), 2% (50-year storm), 1% (100-year storm), and 0.2% (500-year storm) annual chance events at the HRSD sites selected for further evaluation. The future conditions, called "planning horizons," considered the modeled flooding conditions by 2050, 2080, and 2100.

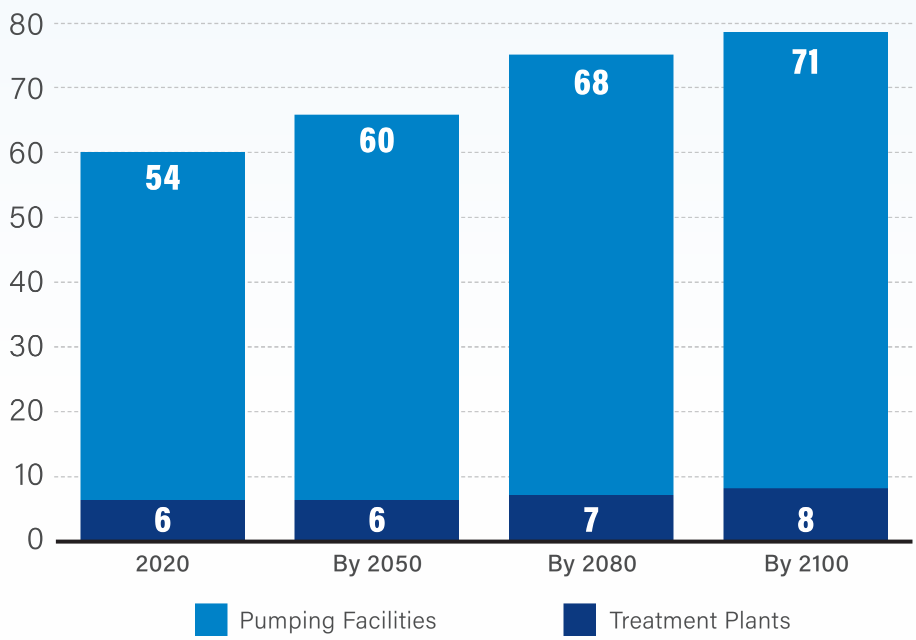
Flooding near the Monroe Place Pump Station.

A 10% annual chance event causes the lowest flood water levels and least amount of flooding for each of these planning horizons and a 0.2% annual chance event causes the highest flood water levels and most amount of flooding under these evaluated scenarios. Over time, because of climate change, the magnitude of these flood events becomes greater. These different event types can also be thought of as the “likelihood” or probability of a flooding event to occur at one of the HRSD facilities.

3

The third step of the risk assessment compared the exposure of the 136 facilities to the anticipated flood water levels at the respective site. “Flood Pathways” for each facility were compared to the flood water level predicted at that facility for a 1% annual chance event in 2100, as shown in the figure below.

Number of HRSD Facilities with 1 Percent Annual Chance of Flooding for Existing and Future Conditions



Arctic Avenue Pump Station.

A flood pathway is a location where water can enter a building or structure. Each access route, or opening, in the walls of a structure is a potential flood pathway. The most common examples at a treatment plant or pumping facility are the following:

- Personnel doors
- Roll-up doors
- Vents or louvers
- Penetrations for electrical wiring or pipes
- Connections to the sanitary, storm drain, floor drains, or plant drain system
- Cracks or water seepage through building walls

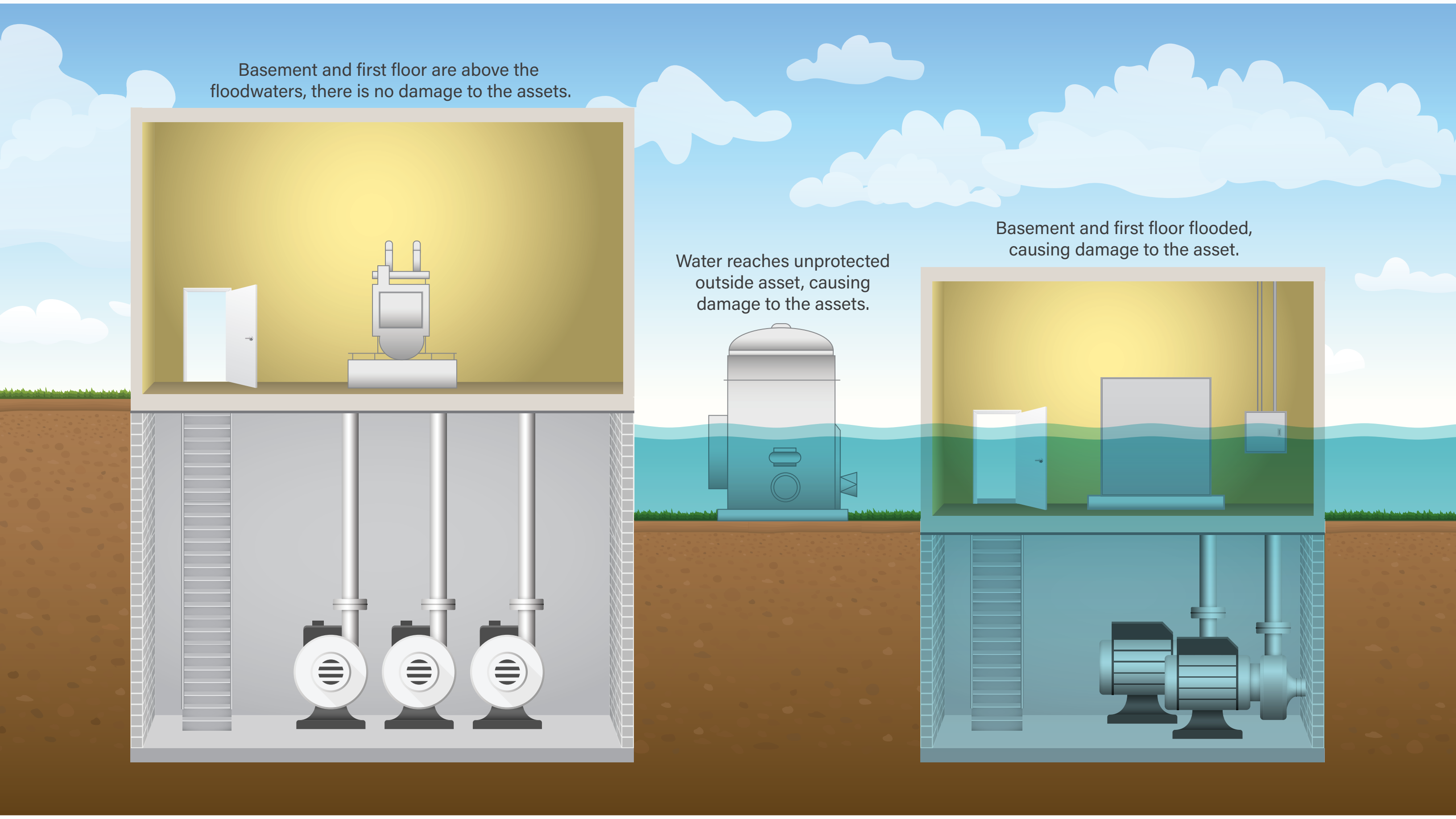
HRSD Facilities Identified by Their 1 Percent Annual Chance of a Current or Future Flooding Event

This study included collecting information on specific buildings, structures, and assets, such as their flood pathways. For assets, additional information was collected about their criticality, location within buildings, and height above the floor (elevation). The collected information allowed for comparison of flood pathways, flood water levels, and asset elevations to understand what is potentially exposed to current and future flooding. The figure below visually explains why this information is important for the study.

Many HRSD facilities were excluded from further analysis because the flood water level at that facility is not expected to be above a flood pathway that could cause damage. The future 1% annual chance event either before 2100 or before the date the facility is expected to continue operating[1] was the basis for this decision.

This left 6 treatment plants and 66 pumping facilities (8 pressure reducing stations and 58 pump stations), a total of 72 facilities, to be further evaluated for current and future flood risk based on the ground levels[2] compared to the current and future flood pathway levels. **These are considered HRSD's "at risk" facilities.**

Visual of Flood Pathways, Flood Water Levels, and Asset Elevations to Assess Flood Exposure



[1] The date a facility is expected to stop operating is referred as the "end of useful life" and assumed to be 100 years after the initial construction date.

[2] Ground surface elevations were derived either from HRSD benchmark elevations, record drawings, or publicly available mapping information that used LiDAR, a remote sensing method from the National Oceanic and Atmospheric Administration to estimate ground surface elevations.

The Flood Risk of HRSD's Facilities

The word "risk" is commonly used to express the probability of something negative occurring to something of value. It can be used qualitatively and quantitatively depending on the context. Any estimate of risk is rooted in the following equation:

In this study, risk is flood risk. The flood risk methodology provides an estimate of risk as a dollar value, which takes into account both the *consequences* and the *likelihood* of flooding at a facility. It allows HRSD to directly compare risk at different facilities.

Aeration basin at the Nansemond Treatment Plant.

Estimating consequences helps to answer the question *"what would the impact be if there was a flood of a certain level here?"* Consequences are the costs that result from HRSD's wastewater facilities becoming inoperable because of a flooding event and include two different components called "damages":

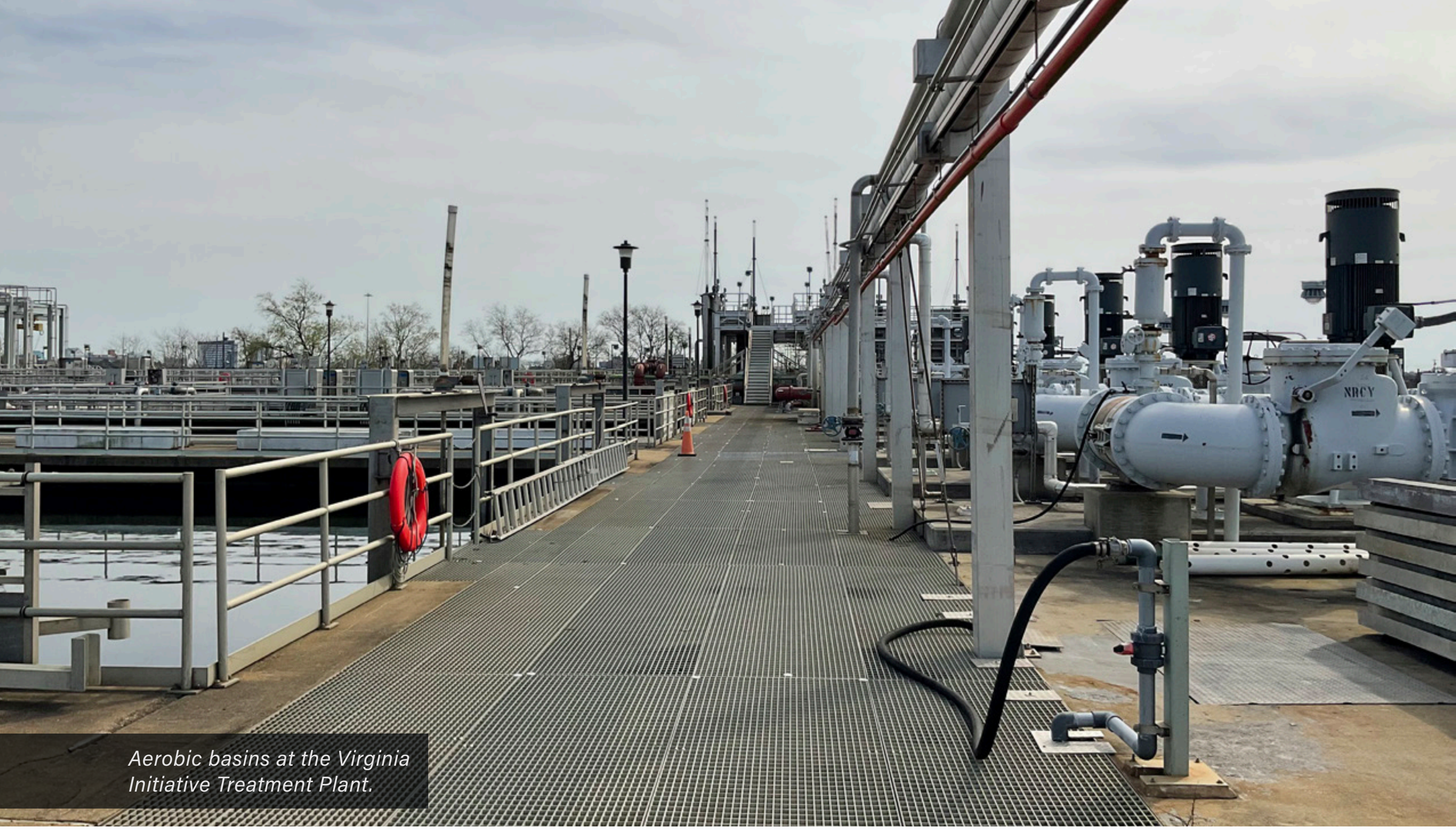
- Physical damages are the costs to replace a damaged asset such as a motor or electrical panel. Physical damages also include the costs for renting or buying temporary equipment that can help in getting essential facilities back into operation before full repairs can be made. As water levels get higher, the cumulative damages increase.
- Downtime damages is the number of days it might take to get a facility back into operation using temporary equipment. These days are translated into dollars on a per resident, per day basis, which is used to acknowledge the benefits of a functioning wastewater facility to the community and environment.

Likelihood is the probability of a flooding event occurring at a given location based on the annual chance of flooding events modeled as described in the previous section. Estimating this information answers the question *"how often does a flood of a certain depth occur here?"*

Multiplying consequences and likelihood values creates a dollar value called "annualized losses," which is how flood risk is quantified in this study. Calculating risk in this way considers the likelihood and consequences of all possible flood events, not just one or two. The metric of annualized losses allows HRSD to understand the flood risk in any given year, no matter what kind of event it is. This helps HRSD decide when to take action to reduce flood risk and by how much at any given facility.

Current flood risk is estimated to be $6 million[3] (expressed as annualized losses), and this increases because of climate change by more than a factor of three by 2060 and by nearly a factor of 20 by 2100. HRSD's pumping facilities, which are located throughout HRSD's service area to collect and convey wastewater from locality neighborhoods, carry approximately 75% of the total flood risk.

[3] Costs and risk values in this summary are presented in constant 2020 dollars so that they can be compared without an advanced financial analysis that accounts for inflation and the time value of money.



Aerobic basins at the Virginia Initiative Treatment Plant.

Improving Resilience through Flood Mitigation Concepts

After evaluating HRSD's risk for each facility exposed to flooding, the next task was to assess and decide how flooding can be mitigated.

The actions that can reduce flood risk are called "flood mitigation concepts" in this study. FEMA defines mitigation as "the effort to reduce the loss of life and property by lessening the impact of disasters[4]." Flood mitigation concepts for HRSD are the actions that can be taken to reduce potential damages to treatment plants and pumping facilities so that they are able to function as intended.

Different types of flood mitigation concepts have different advantages and disadvantages. **HRSD's facilities are best suited to dry floodproofing, floodwalls, and levees (with floodgates, stormwater pumping, and in some cases, stormwater storage), concepts that elevate a facility, or in some cases, relocation of a facility.**

Example of a floodwall.

[4] Source: FEMA Disaster Mitigation Resources webpage, October 9, 2019.

The next step after identifying and costing of a suitable mitigation concept for each facility was to understand how much the flood mitigation concept reduced flood risk at any given HRSD treatment plant or pumping facility.

Going back to the calculation of risk, a flood mitigation concept with a certain height of flood protection reduces the *consequences* of a given flood event (if implemented) because the mitigation concept reduces the physical damages and the downtime damages. The question is, by how much? Is the cost of the flood mitigation concept worth the benefit?

Consequences × Likelihood = Risk

Comparing pre- and post-mitigation flood risk also helps HRSD understand how much risk would remain—because it cannot be eliminated entirely—and plan accordingly. For all at-risk facilities considered, HRSD now has an understanding of the pre- and post-mitigation conditions, which provide insight into the following questions:

- How does pre-mitigation flood risk compare with the post-mitigation flood risk?
- How does the flood risk at a facility change over time?
- Is the proposed flood mitigation concept cost effective?
- When should the flood mitigation concept be implemented so that the benefits offered by the flood mitigation concept are realized in balance with HRSD's ability to afford the investment?

At any given location, HRSD may decide that the best path forward is not to implement the flood mitigation concept in this study to lower HRSD's overall flood risk; rather, a community-based flood resilience project implemented by the local government may protect the facility.

Example of a levee.

Why a mitigation concept?

Flood mitigation:

- Reduces consequences from the events it protects against.
- Implemented sooner provides more benefits because it reduces flood risk sooner.
- Implemented later gives more flexibility—defer the cost to later and see what happens.
- Can be expensive, so balancing these competing objectives of reducing risk and cost is important when deciding when to implement a mitigation concept.

A total of 57 out of the 72 evaluated at-risk facilities (6 treatment plants and 51 pumping facilities) were assigned a flood mitigation concept and a cost was estimated for each facility. Developing a flood mitigation concept and cost for every at-risk facility helps HRSD decide when to take action to reduce flood risk and by how much at any given facility. Questions asked to help determine the appropriate flood mitigation concept included the following:

- What is the source of the current and future flooding?
- How deep is the water expected to be under certain flooding scenarios?
- What flood mitigation concept could work under such flooding circumstances for a given facility?
- What are the site's layout and physical constraints that may impact a mitigation concept?
- Does the flood mitigation concept allow for the day-to-day operation of the facility? Or would it somehow impede HRSD's ability to serve its missions?
- What are the estimated construction and maintenance cost of these concepts?
- Would the flood mitigation concept be accepted by the community and meet HRSD's and the community's aesthetic standards?
- What effort and how much time are required to deploy the mitigation concept? Is the effort labor intensive?

[5] Fifteen facilities were not assigned a flood mitigation concept because accepting the flood risk seemed more beneficial than an on-site flood mitigation concept. HRSD can use the flood exposure information provided for these facilities to guide design with the future in mind.

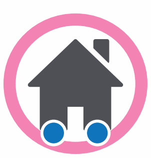
There are many options for flood mitigation that include larger watershed solutions that can reduce flood risk for a community as a whole. These solutions include planning, conservation, zoning changes, and floodplain management plans. In other cases, the best option at an HRSD facility may be no mitigation at all—and HRSD would accept the risk. Flood mitigation concepts for HRSD's facilities are described below.

Dry floodproofing is designed to keep flood waters out—in other words, keeping the assets inside of a facility dry by waterproofing the outside of the facility. To do this, all pathways where water could get or seep into the structure must be sealed, including windows, doorways, or vents. These can be permanent structures and sealants (e.g., waterproof paint and caulk) or temporary structures with seals that are deployed ahead of an event that may cause flooding. This includes **waterproof hatches**, which are submarine-type doors that create a waterproof seal and prevent flood waters from reaching underground equipment.

Floodwalls and Berms (Levees) protect a building or cluster of buildings and other equipment associated with a facility from flood waters and allow for continued operation of the building or facility. These can also protect adjacent peripheral structures and infrastructure. This is similar to dry floodproofing because it is designed to keep the water out, but they provide an advantage for use if dry floodproofing is not practicable given the height of protection or number of structures or openings needing protection. Floodwalls and berms (levees) can be designed with doors or gates so access is available when there is no flooding, but these must be closed before the event occurs. Floodwalls and berms (levees) include **stormwater pump stations and underground storage** to manage precipitation-driven flood waters for an enclosed location, such as one created from a floodwall or berm (levee). Underground stormwater storage tanks and aboveground ponds (where space is available) temporarily store peak precipitation to reduce the size of pump stations needed to remove the precipitation-driven flood waters from the enclosed location.

Floodgates are part of a either a dry floodproofing system or a floodwall and berm (levee) system that controls water flow at common entry and exit points.

Elevate means designing a structure or moving equipment so it is above an expected flood water level. This is a good option for facilities with high flood risk because the structure or equipment can be designed higher than other flood mitigation concepts to provide the most reduction in flood risk and because it is passive, meaning the structure is ready for a flooding event whenever that may occur.



Retreat and relocation are about moving people and properties out of areas that are expected to flood and into areas that have a lower flood risk because they are on higher ground. This approach depends on there being suitable and available land for such relocation.

Wet floodproofing is designed to allow flood waters to come into the structure while minimizing the damage and reducing the need for cleanup. This has the advantage of reducing pressure caused by water pushing against structures and avoids causing structural damage because the water is allowed to move through freely. A disadvantage is that the potential for water damage and need for cleanup remains after every event that caused flood waters to enter the structure. *Therefore, wet floodproofing was not recommended for HRSD.*

Process to Select a Mitigation Concept for Treatment Plants and Pumping Facilities

1. Start with a menu of flood mitigation options

2. Eliminate options that are technically infeasible

Technical Factors

- Structural needs to withstand waves
- Minimum and Maximum height thresholds
- Space for construction and storage
- Neighborhood aesthetic needs

3. Consider operational and financial factors for technically feasible options

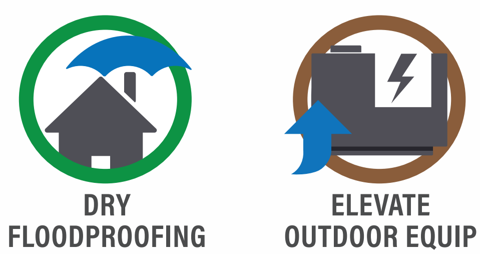
Operational Factors

- Can staff easily perform day-to-day responsibilities and routine maintenance with mitigation options in place?
- Will staff be available to deploy and/or operate the mitigation options?

Financial Factors

- Prefer more cost-effective options where minimal impacts to operations exist.
- Potentially choose a less cost-effective option to maintain operational flexibility.

4. Select a mitigation concept



Arctic Avenue Pump Station with flood mitigation enhancements.

HRSD's Path Forward

HRSD has identified solutions to protect its facilities over the next 80 years. Prioritizing and scheduling 57 flood mitigation projects to address the complex multimillion-dollar risk posed by current and future flood exposure is a big undertaking, and it requires thoughtful planning and prioritization. Implementation must be planned over time; HRSD does not have the resources to reduce all risk immediately. **HRSD will implement flood mitigation solutions as necessary or needed to protect the at-risk facilities identified in this study. In addition, HRSD will take future flood levels into consideration for new facilities.** In many cases, HRSD may choose to instead work with local governments on regional solutions to achieve similar benefits to reducing flood risk rather than implement flood mitigation for individual facilities. In addition, HRSD will review regional and local solutions on an annual basis and assess the impacts to HRSD facilities prior to implementing any given solution. HRSD will also review the climate change scenarios as climate change science progresses and re-assess vulnerability, at a minimum of every five years.

This process allows HRSD to save and invest for the future, make informed decisions, and work with the region on common climate resilience solutions.

At the core of the study is a vulnerability assessment that estimates current flood exposure for specific facilities and estimates the increase in flood exposure over time as climate change occurs. The vulnerability assessment also quantifies flood risk for each facility from an economic perspective. **By monetizing the risk of current and future flooding compared to the cost of implementing resilient flood mitigation concepts, on a facility-by-facility basis, HRSD can make informed risk-based decisions for prioritizing capital improvement expenditures.** This integrates climate resilience into HRSD's planning efforts and decision making as a utility, allowing them to plan ahead and budget for climate change risk.

Climate change science is continuously being refined. It is HRSD's intention is to use the latest science to refine this plan, while working toward reducing flood risk with its mission in mind: to convey and treat wastewater to protect public health and the environment.

Regional Call to Action for a Resilient Future in Hampton Roads

The Hampton Roads region is among the most vulnerable in the United States to the impacts of flooding-related climate change. **Over time, flooding exposure in the region and at HRSD's facilities will increase.** This climate change planning study outlines how HRSD will address climate risk for its critical infrastructure to improve resilience and guide HRSD toward actions and collaboration with the region.

Climate change planning is an ongoing process to be refined as additional science becomes available and resilience actions are taken. **In the coming decades, substantial flood mitigation planning will occur throughout the region to increase resilience. In many cases, working with localities or facility neighbors for a common solution—instead of HRSD implementing a stand-alone flood mitigation at a facility—makes more practical and financial sense for all parties involved.** HRSD will use this analysis to provide insight into whether implementing a mitigation concept makes sense at a given facility, either now or in the future, or if working with regional partners is the better path. The analysis also identified locations where a community-based flood mitigation project may be likely in the foreseeable future that could benefit the HRSD facilities and surrounding area.

HRSD recognizes there are key partners that would all benefit from collective action by regional, local, and federal entities that serve the public. HRSD plans to work collaboratively with these key partners for common flood mitigation solutions. HRSD will work with HRPDC to share knowledge, engage key partners, and support regional resource allocations for a resilient future in the Hampton Roads region.

Inset: Hurricane damage to the Claremont Avenue Pump Station (left) and rebuilding of the pump station property (right).

Below: Claremont Avenue Pump Station (underground) adjacent to a residences.

West Point Treatment Plant.

Prepared for

HRSD

Prepared by

CDM Smith

Historic Fort Monroe National Park landmark near Hampton, Virginia.