Flood Mitigation in the Chesapeake Beach SeaGate Community

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ABOUT PALS

The Partnership for Action Learning in Sustainability (PALS) is administered by the National Center for Smart Growth at the University of Maryland, College Park (UMD). It is a campus-wide initiative that harnesses the expertise of UMD faculty and the energy and ingenuity of UMD students to help Maryland communities become more environmentally, economically, and socially sustainable. PALS is designed to provide innovative, low-cost assistance to local governments while creating real-world problem-solving experiences for University of Maryland graduate and undergraduate students.

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Executive Summary

The town of Chesapeake Beach is on the Chesapeake Bay's western shore and is directly connected to the Bay by creeks that feed tidal marshes. Marshland within Chesapeake Beach's South Creek Estuary was filled in to enable community development, including the SeaGate townhouse community and Maryland Route 261. At less than four feet above mean sea level, Route 261 and the SeaGate's parking lots flood during high tide events, storm swells, and intense storm events. In addition to being inconvenient for community members, it is also a safety concern as Route 261 provides access to the SeaGate community, the local fire department, and wastewater treatment plant.

The historical practice of filling in wetlands for development and the increasing pressures of climate change have resulted in worsening flooding in the SeaGate community. Chesapeake Beach's 2021 Comprehensive Plan discusses the area's future of coastal resiliency and mentions the need to create a coordinated and consistent plan for addressing sea level rise.

There have been previous attempts by the community to control flooding resulting from rising tides and stormwater. The Army Corps of Engineers installed revetments and a gate to control tidal fluctuations, and the Maryland State Highway Administration raised Route 261 to prevent the road from flooding. However, the floodgate is no longer operational and mounting pressures from sea level rise combined with more intense storms have flooded the road with increasing frequency.

This report's proposed solutions address both tidal and stormwater flooding. Because the primary source of flooding is from the Chesapeake Bay, the floodgate must be replaced. The new floodgate will be automated to be in sync with tidal cycles and local weather conditions. The gate will automatically close at high tide and open at low tide to allow for the migration of wildlife between the tidal marshes and the Chesapeake Bay. There will also be an option to manually open and close the gate at the SeaGate community's discretion.

As well, three different technologies will address stormwater flooding—cisterns, permeable pavers, and bioretention cells. Cisterns will be fitted to the townhouse units to store runoff from rooftops. They will be sized to capture a five-year, 24-hour storm (4.18 inches), but can be adjusted to capture the runoff from various storms. The captured water will be automatically released during dry periods and at low tides, as controlled by a smart system, however there will also be a manual option to give community members more control.

Permeable pavers will reduce the volume of runoff and allow more water to infiltrate into the soil. They will be placed in low-traffic areas, such as parking lots and sidewalks, to reduce the wear on the pavers and extend their lifetime.

Bioretention cells will be implemented alongside roads and parking lots to help manage runoff volume and quality. There are a few existing bioretention cells in the SeaGate community, but they aren’t maintained and don’t appear to function well. The proposed design improves the existing systems and adds new bioretention cells.

To increase the feasibility of the proposed solutions and minimize the burden on the community, the report recommends applying to grant programs intended to help fund climate resiliency and sustainability projects in Maryland. Some of these include the Chesapeake and Coastal Grants Gateway, the Maryland G3 Grant Program, and the Watershed Assistance Grant Program. These grants will help fund the proposed solutions and create a safer, more climate resilient Seagate community.

Introduction

Climate Change in Chesapeake Beach

The waterfront town of Chesapeake Beach is on the Chesapeake Bay's western shore. The town has two estuaries, the 92-acre Fishing Creek Estuary and 12.5-acre South CreekE, both of which experience tidal action from the Bay. Significant development has occurred on the land around these estuaries (Town of Chesapeake Beach Steering Committee, 2023). As sea levels rise and stormwater volume increases, these low-lying areas have become vulnerable to flooding.

Chesapeake Beach and towns like it, which are along the shore of the Chesapeake Bay, are at accelerated flooding risk due to the combined impacts of land subsidence and higher than average rates of sea level rise in the region (Beckett et al., 2016; Ezer & Corlett, 2012). Outdated stormwater infrastructure, filled-in wetlands, and hard shorelines have limited the community's resilience to climate change (Town of Chesapeake Beach Steering Committee, 2023).

The South Creek Estuary runs along the northern edge of Chesapeake Beach (Figure 1). The 12.5-acre estuary is bisected by MD Route 261, leaving a three-acre wetland, known locally as Stinint's Marsh, between the road and the Bay and 9.5 acres of wetland on the inland side of the road. The two areas are connected via a small culvert underneath Route 261. The area is connected to the Bay by a 10-foot-wide concrete inlet; a floodgate is in this inlet, however it is broken and fixed in the open position. The remainder of the marsh's 500-foot intersection with the Chesapeake Bay is disconnected by a revetment shoreline that is characteristic of the town's waterfront. (Town of Chesapeake Beach Steering Committee, 2023)

Figure 1. Aerial view, South Creek Estuary, Chesapeake Beach
Source: (Town of Chesapeake Beach Steering Committee, 2023)

The Chesapeake Beach Water Reclamation Plant, North Beach Volunteer Fire Company, SeaGate residential community, and Route 261 were built on top of South Creek Estuary's natural wetlands. Route 261 is now regularly inundated during storm events as the South Creek Estuary seeks to reconnect itself, which limits access to key public services and threatens to flood neighboring communities. (Town of Chesapeake Beach Steering Committee, 2023)

Coastal Resiliency

In April 2022, Chesapeake Beach adopted a new Comprehensive Plan. In addition to prompting the creation of the town's Coastal Resiliency Plan, the Comprehensive Plan established guiding principles for the community to ensure a sustainable future. Two of these principles are particularly relevant to flood mitigation solutions.

The first principle states that “Lands that were ‘made’ through filling in wetlands, are the most quickly threatened by sea level rise. Allowing space for water to reclaim part of these areas and for wetlands to migrate within them can help recreate nature’s role in holding back flood waters and buffering storm surges.”

The flooding challenges in the South Creek Estuary are the result of unsustainable development. Figure 2 shows the landscape changes in Chesapeake Beach between 1938 and 1993; the images show the development on the estuary’s wetlands and the hardening of the shoreline. This report’s recommendations are designed to help mitigate flooding in these most vulnerable areas, increasing the quality of life for residents and businesses in these transitional zones.

Figure 2. South Creek Estuary before (1938) and after (1993) development

Source: Calvert County Maryland, 2024

The second principle states “Unplanned and uncoordinated efforts to raise the elevation of the land or build structural flood defenses including seawalls, raised bulkheads, shoreline revetments, etc. are counterproductive to ongoing efforts to coordinate an effective strategy to address sea level rise. Such measures must only be undertaken in a coordinated way consistent with an adopted plan.”

Previous efforts to address flooding in this area have included the installation of revetments, the installation of a floodgate, and raising the elevation of Route 261. This report's recommendations aim to provide Chesapeake Beach with more sustainable flood mitigation options that align with the town's guiding principles. (Town of Chesapeake Beach Planning and Zoning Commission, 2021)

Project Objectives

Project Objectives

This project's primary objectives are to mitigate flooding on Route 261 during intense storms and high tide events and improve the quality of life for those living around Stinint's Marsh. The project prioritizes sustainability and ensures that Chesapeake Beach's stormwater discharge into the Chesapeake Bay continues to meet Maryland Department of the Environment water quality criteria.

During spring 2024, students from the University of Maryland's ENST481 course gathered data, engaged with the community, and developed an array of flood mitigation solutions that highlight green infrastructure and mitigate flooding while minimizing the use of resources and the impact on the local environment. In addition, information was gathered regarding federal and state grants that can be used to implement these sustainable technologies.

Green New Deal and Improving Resiliency

Proposed in 2019, the Green New Deal was designed to minimize the impacts of climate change over a ten-year period. This project's recommendations align with its key goals including increasing resiliency against extreme climate events, improving infrastructure, switching to 100% renewable energy sources, and developing increasingly efficient technologies (Ocasio-Cortez, 2019). This project helps meet these goals by addressing sea level rise and storm surges and their detrimental impacts on Chesapeake Beach's infrastructure.

Water levels in the Chesapeake Bay are projected to rise 2.4 feet by 2050. In combination with increasingly severe storm events, flooding will become increasingly common in Chesapeake Beach (Town of Chesapeake Beach Steering Committee, 2023). If implemented, the design solutions are expected to slow water accumulation in Stinint's Marsh during high tides and high rainfall events.

The project is also aligned with the Green New Deal's emphasis on climate-resilient infrastructure, as the road bisecting the two wetlands is a major route connecting the North Beach Fire Department to the majority of North Beach. By reducing flooding on Route 261 and renovating with further climate change and sea level rise in mind, the project will improve an integral piece of infrastructure for both Chesapeake Beach and North Beach. The methods of achieving these goals are discussed below.

Data Collection Methods

Community Engagement

As this is a new project, an important first step was meeting with community members, an important element of ecological engineering: “Everyone is a designer.” Zoom meetings were held with community members and town officials to gain a better understanding of the issues and their ideas for potential solutions. Following the meetings, site visits revealed the physical layout of the site and water level fluctuations.

The first site visit showed that the primary source of flooding is tidal fluctuations. There was evidence of nuisance flooding from high tide in low portions of the roads and parking lots in the SeaGate community (Figure 3). As the tide receded and the water level in Stinint’s Marsh lowered, so did the flood waters. Viewing these tidal fluctuations, it was evident that the volume of water in the South Creek Estuary rapidly equilibrates with the elevation of the Chesapeake Bay. Thus, even during intense storm events, the runoff generated by Chesapeake Beach will have a minimal impact on the water elevation in the estuary compared to the impact of the Chesapeake Bay's fluctuations.

Among SeaGate community members, it is a common perception that stormwater runoff produced within the community during intense storm events is the driving force behind flooding. As sustainable solutions are developed that address the core source of the flooding, engaging and educating the community to change this perception will be important.

Figure 3. Seagate stormwater drainage system inundated during high tide (April 5th, 2024)

GIS Analysis

A variety of GIS programs were used to better understand the existing conditions. Chesapeake Beach community members shared their GIS database of ground elevation and slopes, soil types, property boundaries, and more.

Additional soil maps were accessed on the USDA Web Soil Survey (USDA NRCS, 2019). Community risks associated with sea level rise were assessed using NOAA's Sea Level Rise Viewer and from information and GIS maps in the community's Coastal Resiliency Plan (NOAA, 2023; Town of Chesapeake Beach, 2023). Finally, Calvert County's GIS Historic Imagery Map was used to evaluate landscape changes over time (Calvert County Maryland, 2024).

GIS and 2023 satellite imagery were used to calculate SeaGate's total impervious area: 6,625 square meters. The average rainfall depths associated with 24-hour storms of various recurrence intervals were determined using NOAA's 14-point precipitation frequency calculator (NOAA NWS, 2024). Those rainfall depths and the total impervious area were used to estimate stormwater volumes in the SeaGate community (Figure 4).

Figure 4. Stormwater volume falling on impervious surfaces in the SeaGate Community

Storm Return Period	1 year	2 year	5 year	10 year	100 year
Volume (gallons)	117,800	143138	185,813	222,708	383,628
Volume (ft^3)	15,749	19,136	24,841	29,774	51,287

GIS was also used to evaluate the potential benefits of flood mitigation technologies, for example, permeable pavers. To quantify the potential benefit of installing permeable pavers, GIS was used to estimate the area of impervious surfaces available for conversion. Similarly, to quantify the benefit of installing rain barrels to gather rooftop runoff, GIS was used to determine the roof area available for gathering rainwater.

Project Design: Tidal Flooding Solution

Existing Gate and Hydrologic Conditions

In 1988 the U.S. Army Corps of Engineers installed a floodgate at the Chesapeake Bay inlet of Stinint's Marsh to mitigate flooding in the South Creek Estuary (Calvert County Department of Planning & Zoning, 2020). A large concrete inlet surrounds a metal gate (Figure 5). The gate was designed to be closed during high tides, however the Chesapeake Bay Critical Area Commission eventually decided that the gate must be open to allow for natural tidal flow (Calvert County Department of Planning & Zoning, 2020). The metal gate, shown on the right, has since become inoperable, either due to rusting or a misalignment of the rails.

Figure 5. Current floodgate connecting Stinint's Marsh to Chesapeake Bay, shown fixed in the open position

With the gate fixed in open, water in the South Creek Estuary can equilibrate with water in the Chesapeake Bay. As shown in Figure 6, using data from a tidal gauge in Solomon's Island, water elevations in the Bay are significantly elevated during storm events, with a 1.7-inch storm event yielding an approximate two-foot rise in water level (NOAA, 2024). Knowing this, it's clear that as long as the gate is open, stormwater produced within the community would have minimal impact on the water level in Stinint's Marsh compared to the impact of changing water levels in the Bay.

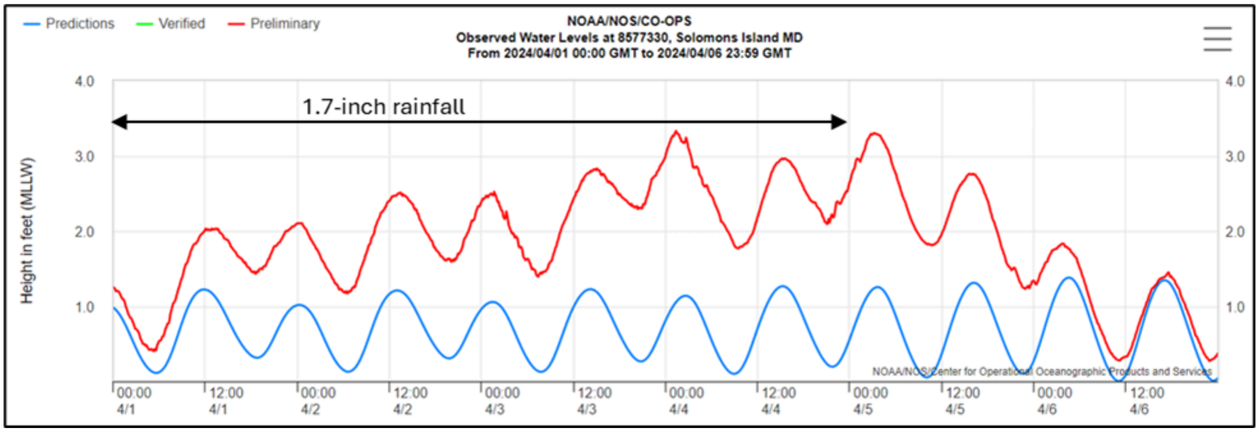

Figure 6. Solomon's Island NOAA tidal gauge data, during and after a storm event
source: NOAA, 2024

Smart System Gate

Fixing or replacing the floodgate is a key part of flood mitigation solutions in Stinint's Marsh, the SeaGate community, and across Route 261. The previous floodgate system relied on a human to both decide when the gate should be open or closed and to physically open and close the gate.

The new floodgate would be controlled by a system using "smart" technology to determine when to close the gate, based on known tidal fluctuations, current water levels, and predicted future weather conditions. To promote the important estuary-wetlands interactions advocated for by the Chesapeake Bay Critical Area Commission, the gate's default position would be open, ensuring maximum fish passage while also protecting the community from flooding. Depending on the available budget and community desires of the community, the smart system gate could range from a fully automated system to a simple smartphone app that tells a town official when to operate the gate. Along with automatic closing and opening, all designs would provide an option for manually opening and closing the gate in scenarios such as power outages and system malfunctions.

Automated flood gate systems have been successfully implemented in Australia, where similar technology is used to control the hydrology of coastal wetlands. In Australia, the system creates the best ecological conditions and aids wetlands in their transition from freshwater to saltwater (AWMA, n.d.).

Additionally, simpler smart technologies using a variety of hydrologic and weather data to function, such as smart irrigation systems, are available. Smart irrigation systems consider the soil's moisture content as well as expected weather conditions to determine when to water (Rachio, 2024). A similar system could be developed for a smart gate, replacing soil moisture content with existing water levels and adding on an additional variable of tidal fluctuations.

Project Design: Stormwater Flooding Solutions

Stormwater and Stinint's Marsh

As illustrated in Figure 6's tidal gauge data, high water level events in the Chesapeake Bay that may prompt closing the floodgate occur during and after storm events. Currently, stormwater from SeaGate and surrounding communities is discharged via a stormwater pump into Stinint's Marsh. With a closed floodgate, this stormwater will quickly build up in the marsh. To avoid this, additional stormwater management measures must be implemented along with repairing or replacing the tidal gate.

Permeable Pavers

As water floods the community, either as stormwater runoff or flooding from the marsh, it runs over impervious surfaces that prevent infiltration. Permeable pavers can decrease the amount of floodwater by allowing it to infiltrate into the ground and can prevent water ponding in low-lying areas as floodwaters recede. SeaGate's total impervious asphalt area is 3,615 square meters, and its total sidewalk area is 427.5 square meters. Any or all of this area could be converted into permeable paving.

Permeable paving would offer surface area and a few inches of depth for water storage during stormwater events and eliminate any stormwater that infiltrates through the pavers. The potential volumes of stormwater was estimated based on a 24-hour storm at different recurrence intervals (Figure 7).

Figure 7. Stormwater volume expected to fall on impervious surfaces in the SeaGate community

	1 year	2 year	5 year	10 year	100 year
Volume (gallons)	71,884	87,346	113,387	135,901	234,098
Volume (cubic feet)	9,610	11,677	15,159	18,169	31,297

Rain Barrels/Cisterns

Rain barrels or cisterns can reduce rainfall runoff coming from SeaGate's townhouses, which will reduce the volume of water entering Stinint's Marsh and reduce flooding in the community's parking lots.

While rains barrels and cisterns typically don't have filtration systems or pollutant removal methods, the collected rooftop runoff usually has a much lower concentration of pollutants than runoff from pavement. Also, the collected water can be released at low tides and dry periods in the marsh, coordinated with the floodgate's smart system, using a smart hose (Rachio, 2024).

A GIS analysis of the rooftops shows their total area in SeaGate, (28 identical housing units) is approximately 2,580 square meters. Figure 8 shows the estimated stormwater runoff volumes per housing unit for a 24-hour storm at various recurrence intervals.

Figure 8. Stormwater rooftop runoff estimated volumes for the SeaGate community

	1 year	2 year	5 year	10 year	100 year
Volume (Gallons)	1,640	1,993	2,587	3,100	5,340
Volume (Cubic Feet)	219	266	346	415	714

It’s standard to install cisterns or barrels that capture water generated by a 5-year, 24-hour storm (2,587 gallons/housing unit), however their size can be adjusted so they can capture water from storms of varying duration and intensity, as desired by the community. Adding a cistern to each set of units’ downspouts is recommended, with the specific size of each dependent on the number of housing units connected to a given downspout. Because all the units are raised, the cisterns or barrels can be placed underneath the front or back porches.

The SeaGate community is raised approximately five feet above Stinint’s Marsh, thus discharge from cisterns into the marsh could be accomplished via gravity (Calvert County Maryland, 2024).

Bioretention Cells and Rain Gardens

Bioretention cells, also called rain gardens and landscaped depressions designed to capture and hold stormwater. Filterra is a bioretention system developed for urban areas or areas with large impervious surfaces, like parking lots and streets. Water enters the system through a grate or pipe and meets a pretreatment layer (Contech Engineered Solutions, 2023). Under this layer is the Filterra media, which can reduce more than 50% of pollutants in stormwater (Contech Engineered Solutions, 2023). Replacing underused areas in the SeaGate community or malfunctioning stormwater drains with tree trenches or Filterra bioretention systems could be a more realistic and effective way to reduce both the runoff and stormwater flooding in the community.

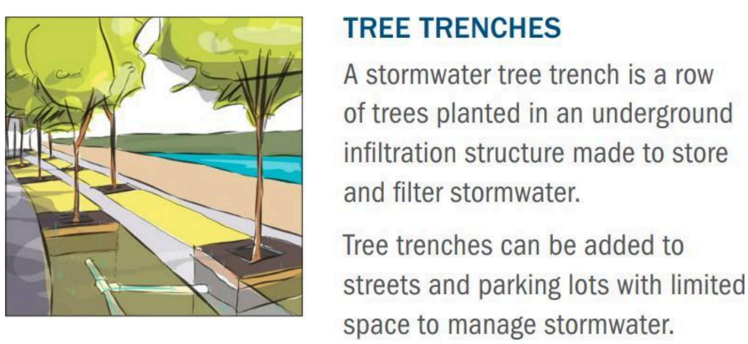

Figure 9. Tree trench technology (FEMA, 2021)

In addition to options such as Filterra, traditional bioretention cells could be installed. Figure 10 shows two of SeaGate’s current retention areas that could be more effective. The current cells are mulched depressions with only sparse vegetative cover and no filtering features. These cells could be renovated to increase retention time and filtration, and new cells could be added to increase the capacity to slow and filter runoff into Stinint’s Marsh. Increasing plant cover would protect the topsoil from erosion and loss of structure, currently evidenced by the incised, muddy flow path leading to the stormwater pipe. Cobbles around the pipe would slow water and filter large contaminants such as trash.

Figure 10. Potential sites for enhanced bioretention cells in the SeaGate community

Raising the Road

Although the Maryland State Highway Administration raised a section of Route 261 more than a foot after Hurricane Isabel, the roadway's highest elevation as it passes over the South Creek Estuary is just 3.7 feet above mean sea level (Figure 12) (Calvert County Maryland, 2024). SHA has rejected the community's recent requests to raise the road again.

Raising the road would reduce road flooding, which has prevented vehicles from passing through the section located near the South Creek marsh, and blocked access to the town's wastewater treatment facility and North Beach's fire department (Town of Chesapeake Beach Steering Committee, 2023). Figure 11 shows Route 261 inundated during a tidal flooding event.

Figure 11. October 2020 high tide event, flooding Route 261 in front of the SeaGate community

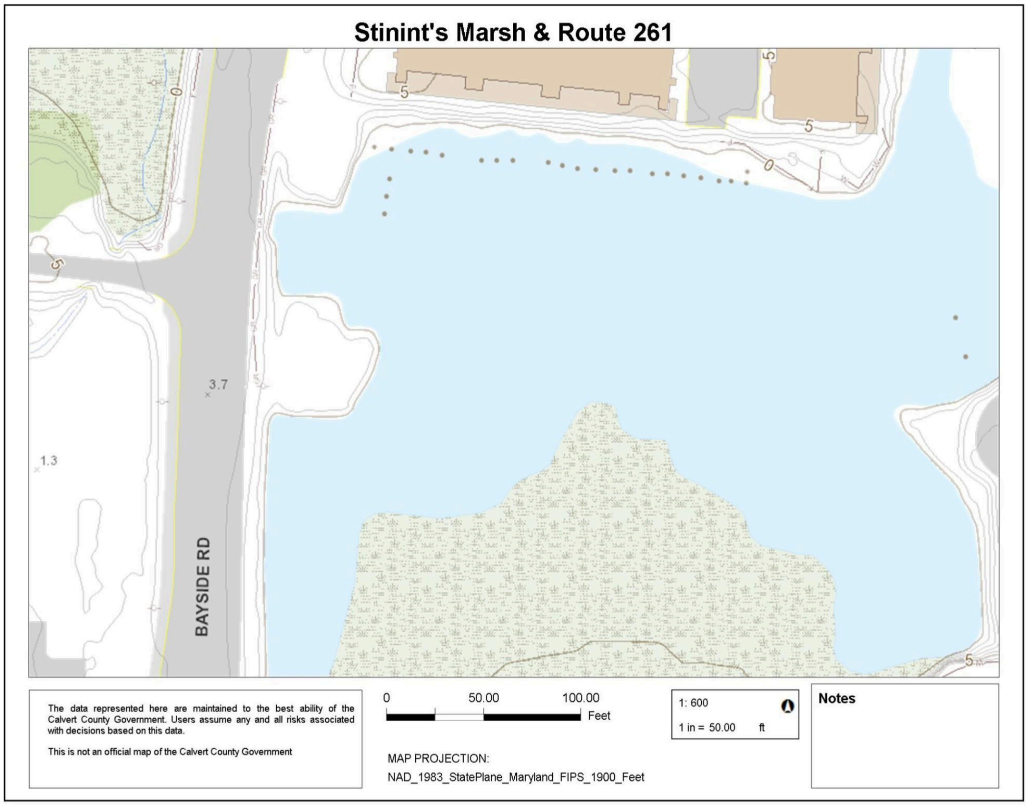

Figure 12. Topographic map illustrating the low elevation of Route 261
source: Calvert County Maryland, 2024

Budget and Budget Justification

Cost Determination

Costs for the proposed solutions were determined from sources including the Chesapeake Bay Program's Chesapeake Assessment and Scenario Tool (CAST) cost model data and publicly available project information from Maryland Department of Transportation.

Using the CAST cost model, permeable pavers were estimated at $6/square foot of treated area (CBP, 2020). GIS analysis shows that the SeaGate community has 38,910 square feet (3,615 square meters) of impervious asphalt area and 4,596 square feet (427 square meters) of impervious sidewalk. Replacing all asphalt and sidewalks with permeable pavers would cost an estimated $233,460 and $27,600, respectively.

The cost of rain barrels and cisterns was obtained from an online merchant, where a 50-gallon rain barrel cost $200 and a 2,500-gallon cistern cost $5,000 (TankAndBarrel.com, 2024). SeaGate has six sections, with each section containing multiple townhouses with shared roofs.

The joint roofs allow for the larger and more cost effective 2,500-gallon cisterns to be used. To capture the rainfall of the modeled two-inch storm event, the community would need 23 cisterns, at a cost of $115,000.

Filterra systems vary in cost due to the range of sizes. A single tree, 4-foot by 6-foot unit, which can treat stormwater from up to 0.21 acres of impervious surface, costs approximately $8,500 (City of Durham, 2011). A multi-tree, 7-foot by 13-foot tree box, which can treat stormwater from up to 0.82 acres, costs approximately $21,000 per unit (City of

Durham, 2011). To treat the SeaGate community's approximate 1.63 acres of impervious surface, two 7-foot by 13-foot tree boxes would be needed, for a total cost of $42,000.

The CAST cost model was used to estimate the cost of bioretention cells at $45,000/acre treated (CBP, 2020). The two potential locations for bioretention cells shown in Figure 9 have areas of 1,020 square feet and 1,130 square feet. Converting both these areas would cost an estimated $2,250. There is also a 0.71-acre area that would be ideal for conversion to a bioretention cell, although it is owned by a developer who would like to develop more townhomes. Converting this area to a bioretention cell would cost an estimated $32,000.

In the summer of 2021, Chesapeake Beach's neighboring community of North Beach reconstructed a portion of Route 261, elevating approximately 1,760 linear feet of roadway by two feet and constructing a new bridge with ADA compliant sidewalks at a total cost of $6.3 million (MDOT, 2021). Although the total cost of this project is available, the details of cost breakdowns are not publicly available. Assuming 50% of the project's total $6.3 million cost was related to raising the road, this project cost approximately $1,780 per linear foot of road raised by two feet.

Another relevant road raising project in an environmentally sensitive wetland is Broomes Island. This project was estimated to cost $775,000 to raise 1,558-feet of roadway by two feet (Calvert County Department of Community Planning and Building, 2016). This is a much lower cost per linear foot, just under $500 per linear foot.

Considering these two projects and estimating that 1,250 linear feet of Route 261 would need to be elevated to address flooding, this project is estimated to cost between $625,000 (2016) and $2,225,000 (2021). Adjusting for the time value of money using a 5% interest rate, the project is estimated to cost between $923,400 and $2,575,700.

Grants Available

Although there are significant costs associated with the tidal and stormwater flooding solutions detailed above, there at local, state, and federal, grants available to help communities adapt and mitigate the impacts of climate change. By pairing flooding solutions with available grants, the solutions can become reality in Chesapeake Beach. Figure 13 summarizes three grants, outlining project costs and available grants.

The Chesapeake and Coastal Grants Gateway aims to help Maryland communities impacted by high-intensity storms, flooding, and rising sea levels. One program outcome specifically addresses planning for the impacts of both coastal and stormwater flooding events, which can include implementing green infrastructure that addresses flooding hazards or planning for areas with a high flood risk. (MDNR, 2024)

The Green Streets, Green Jobs, Green Towns (G3) program created by Chesapeake Bay Trust can fund multiple solutions. It aims to reduce stormwater runoff, improve the health of the Chesapeake Bay, and improve community livability. This grant directly supports the EPA's G3 Partnership, which aims to support local efforts to reduce stormwater runoff in more urbanized areas. (CBT, 2024; US EPA, 2024)

The Watershed Assistance Grant program was created through a partnership of the CBT, MDNR, and MDE to support watershed planning and restoration to improve Maryland's water quality. This grant can fund project designs up to $100,000 for different stormwater solutions including bioretention cells, green infrastructure, and low-impact development techniques (CBT, 2023).

Figure 13. Projects costs and available grants for various stormwater flooding solutions

Solution	Cost	Grants Available
Permeable Pavers	\$6/ft^2 treated (CBP, 2020)	Chesapeake and Coastal Grants Gateway G3 grant program
Cisterns	\$200/rain barrel \$5,000/cistern (TankAndBarrel.com, 2024)	G3 grant program
Filterra	\$8,500 for a 4'x6' unit to \$21,000 for a (7'x13') unit (City of Durham, 2011)	G3 grant program Watershed Assistance Grant Program (up to \$100,000)
Bioretention Cells	,000/acre treated (CBP, 2020)	Watershed Assistance Grant Program (up to \$100,000) G3 grant program
Raising the Road	\$923,400 - \$2,575,700 (Calvert County Department of Community Planning and Building, 2016; MDOT, 2021)	

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