Coping with Severe Weather in Harrisburg

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PENN STATE HARRISBURG
Coping with Severe Weather in Harrisburg

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¹ The opinions and arguments put forth in this report are not endorsed or representative of the Pennsylvania State University. They are the product of student and faculty research. Any errors are our own.
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Executive Summary

The City of Harrisburg already copes with significant severe weather problems, from snow removal to flooding, that will only be exacerbated by a changing climate. This report includes two chapters with fifteen recommendations surrounding road quality, energy efficiency, and stormwater runoff.

Road Quality

Upgrading road surfacing materials would prolong the road surface and require less maintenance over time. “Perpetual Pavement” is a high-quality road surfacing material made of two distinct layers of asphalt designed to last longer than 50 years. While there is a higher up-front cost for materials, the material saves money in maintenance over time. Also replacing road salt with biodegradable deicers such as beet juice will improve environmental and human health.

Recommendations:

1. Invest in long lasting surfacing materials like “Perpetual Pavement.”
2. Survey the Karst-limestone topography. PennDOT Municipal Services will estimate options to repair limestone-related problems free of charge, as well as create a narrative to aid in applying for a grant funds.
3. Utilize the PennDOT Traffic Counting Safety and Assistance Program (TCSAP) to conduct an additional traffic study of the impacts that could result from tolling the I-83 South Bridge.
4. Apply for federal grant money from the Bipartisan Infrastructure Law to fund repairs and upgrades.
5. Replace road salt with biodegradable alternatives to prolong road surfaces and minimize environmental contamination and impacts to human health.

Energy Solutions

Temperature impacts are expected to increase over time because of climate change. 26.2% of the Harrisburg population falls under the poverty line, which strains budgets and creates safety concerns for vulnerable populations. One contributor to high energy costs is the aging, energy inefficient nature of the Harrisburg’s resident housing. We considered a coordinated outreach effort in partnership with local citizen action organizations to encourage low-income residents to voluntarily apply for home weatherization improvements through Pennsylvania’s Weatherization Assistance Program. Upon review, we found that applicants must meet strict eligibility requirements to qualify.

A broader solution is to reduce energy usage in highly trafficked public areas such as downtown and outside of government buildings. Cool pavements are paving materials that reflect solar energy, enhance water evaporation, or have been otherwise modified to remain cooler than conventional pavements outside of municipal buildings and city-subsidized housing. Investment in the material returns in the form energy cost savings.

Another solution is adding vegetation to rooftops, aka. “Green Roofs.” “Green Rooftops” reduce energy usage and improves storm water runoff. Planted vegetation stores rainwater and releases
it into the air, reducing water runoff. The roofs are easy to maintain and can be adapted for use on almost any rooftop surface.

Finally, we considered partnering with community groups to paint building roofs and/or large buildings white to cool buildings naturally. Based on barium sulfate, a compound used to whiten photo paper and cosmetics, this specially made paint has a molecular structure that can make it highly reflective to solar wavelengths of light. The paint reflects up to 98.1 percent of sunlight and sends infrared heat away from the surface, lessening energy use by an estimated 25%.

Recommendations:

1. We recommend working with community groups to enroll low-income residents in *Pennsylvania’s Weatherization Assistance Program*. Suggested partners include the Tri County Community Action / Community Action Commission, Harrisburg Habitat for Humanity, Central PA Red Cross, and the Boys & Girls Club of Harrisburg. We suggest a combined strategy a targeted social media campaign to residents, as well as distribution of printed, multi-language materials at strategic locations used by the residents who would benefit from the program.

2. Next, partner with non-profit community groups to implement innovative small-scale projects such as painting smaller buildings with white energy-reducing paint and installing “green” rooftops or balconies, beginning with identifying groups and locations most at-risk from the dangers posed by extreme temperatures.

3. After determining which buildings and neighborhoods would be most suitable, we recommend working with one of the referenced non-profits to apply for the next round of grant funding, opening in 2023, made available to Dauphin County qualifying non-profits organizations by revenue earned at the Hollywood Casino in Grantville, PA via the *Local Share Account (LSA)* fund.

4. We also recommend applying for funding through the *Keystone Communities Program (KCP)*. The program allows communities to tailor the assistance to meet the needs of its specific revitalization effort.

5. In Fall of 2022, the *Energy Efficiency and Conservation Block Grants* through the Department of Energy (DEP) block grant program will provide $550 million to states, local governments, and tribes for projects that reduce energy use, increase energy efficiency, and cut pollution. We recommend working with government officials to identify buildings to be coated with the higher content barium-sulfate paint as a trial and applying for DEP block grants to cover the cost. We also recommend a second grant application for the purchase and installation of the *Cool Pavement* material outside of the selected painted buildings to measure how effective the two elements are together.

**Storm water Runoff**

Higher oceans, altered weather patterns, and heavier storms are all signs of a changing environment. Storm water runoff results when an excess of water does not immediately soak into the ground, polluting the environment and increasing flooding risks. To address these issues our plan considers the use of *rain gardens* and *green alleyways*, cultivated areas of vegetation that help absorb water into the soil. They effectively collect and reallocation of water and aid in the absorption of pollutants. Plantings are hardy and easy to maintain. *Permeable Pavement* is a
material that allows water to seep into the ground through the pavement, slowing down runoff and replenishing underground reservoir. The maintenance cost of permeable pavement is less than the cost of conventional asphalt and underground storm drains.

Another option is to create an alternative diversion channel to move water flow away from midtown while adding vegetation to the channel to slow the flow of the Paxton Creek Watershed and Spring creek. The use of overflow water storage facilities would alleviate excess water from Paxton River, provide clean water from filtration systems, and help the prevent overflow from waste treatment plants.

Next we considered an item in the 2020 Comprehensive plan for the City of Harrisburg. Civil engineers proposed a plan for a floodgate to be erected near the mouth of Paxton Creek. This would greatly limit one of the greatest sources of flooding to the city of Harrisburg. This would also allow the regulation of water levels. Another existing plan is The Paxton Creek Master Plan, designed to remove 133 acres from the FEMA 100-year flood plan.

The land in and around Paxton and Spring Creeks is flood prone and will continue to remain so indefinitely. We propose creating Wildwood South, converting the most flood-prone sections of the city to a wetland similar to Wildwood Park in North Harrisburg. While this would force the relocation of a few businesses along that stretch, it would be a long-term solution to a persistent community problem.

Finally, public engagement is vital to the success of these measures. We considered creating a holiday or a festival to engage the community in the water runoff issues affecting the city. “Awareness Day” would be a community event to empower businesses, residents and community service centers to participate in runoff solutions.

Recommendations:

1. Integrate Permeable Pavement and Green Alleyways into the city’s landscape architecture.
2. Remove all the cement lining in Paxton Creek, restoring it to a more natural state, and planting different varieties of native vegetation in and alongside the Creek to regulate the flow of water and trap more waste, chemicals, and garbage.
3. Establish a community Awareness Day. Partner with advocacy groups to organize and execute the event.
4. Build Wildwood South. Lands around Paxton and Spring Creeks, below Cameron Street between Sycamore and Elliot Streets, are flood prone and will continue to remain so indefinitely. We recommend converting this area into a second active wetland similar to the current Wildwood Park in North Harrisburg to accommodate and slow the rate of water that enters Paxton Creek. This includes adding water control structures along Paxton Creek.
   a. Creating Wildwood South would require the relocation of at PennDOT and the Ames True Temper warehouse. We recommend a combination giving them land available in another part of the city and offering tax incentives to relocate.
   b. To further protect the city, we recommend a combination of swales and a flood wall be erected along Cameron Street from Gibson Street to Sycamore Street.
5. Establish an additional grant writing position to seek funding from both the Federal government through funds available from the *Federal Infrastructure Bill* and private entities.

While ambitious in scope, this generational plan serves as a blueprint for Harrisburg City to move forward in the years ahead and honors the needs of all who work, play and live in Harrisburg City.
Introduction

Global climate change has significant implications for Central Pennsylvania. Already a highly flood-prone state, cities and boroughs across the Commonwealth can expect increasing flooding by the end of the century (Sharma et al. 2021). Figure 1 shows the 100 and 500-year floodplains in Harrisburg. It is little surprise that they fall close to the Susquehanna River and Paxton Creek. Paxton Creek will receive much attention in this report. While they are referred to as 100- and 500-year events, such flooding is occurring more frequently. 100-year floods could occur as often as 1-30 years in New England and the mid-Atlantic states by the end of the century (Marsooli et al. 2019). Pennsylvania will see not only more rainfall, but it will be concentrated in fewer events, meaning a greater potential for flooding (PA DEP 2021). But climate change does not just bring warming and water, it brings a greater severity in weather. Those already vulnerable to the effects of severe weather – low income, persons of color, and those with medical conditions – will be the most impacted. Coping with rain, heat, and snow are current challenges for the city of Harrisburg that will only become more significant over time. The primary aim of this report is to present solutions to addressing the impacts of severe weather that can be implemented now to lessen the effects of a changing climate on the city.
Figure 1. Harrisburg City Floodplains

ArcGIS Web Map
This white paper was developed as part of the course requirements for PUBPL 304 Public Policy Analysis at Penn State Harrisburg. It is the third in a series of collaborative research projects with the City of Harrisburg (Mallinson 2020, 2021). Students in the course learn about the policy process, policy analysis, and policy writing and this report is the culmination of an entire semester’s work. In collaboration with Councilman Dave Madsen, the topic of coping with severe weather was chosen for our spring 2022 research. The aim is to leverage academic research and policy learning from other cities to offer recommendations for the city on stormwater management, snow removal, and coping with heat.

The following report presents each group’s findings and recommendations. Each section has a similar structure. Following a brief introduction of the problem(s) that the section addresses, the students evaluate specific social, economic, political, and structural environments in the city that cause and are affected by those problems (Birkland 2020). After this evaluation, possible solutions to the problem(s) are presented, evaluated, and specific recommendations are made. Students were strongly encouraged to provide creative sources of funding for their recommendations, as well as a timeline for implementation. Each section has been lightly edited by the professor, but they largely appear as the students wrote them. This is being presented as the work of the students and the professor. Nothing herein is the official opinion of the Pennsylvania State University.
Severe Weather

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Severe weather preparation is an essential focus for cities to ensure that commuters can travel to work efficiently and safely. The city of Harrisburg, as a commuter town, struggles with persistent potholes caused by using salt on the roads following snowstorms. The use of road salt and snowplows damages road surfaces through the city and impacts nearby watersheds. Roadway runoff leads into streams, contaminating pipes that carry drinking water. This negatively affects the community’s health since elevated levels of chloride can lead to health issues by triggering the mobilization of harmful substances such as mercury and lead in drinking water supplies (Hintz, Fay, and Relyea 2022). Harrisburg also faces a large budget burden due to overdue and unpaid resident energy utility bills, and therefore cannot address severe weather damage as promptly. This chapter will address the challenges of road surface repair, snow removal, and energy costs.

Road Surface Repair

As a result of salt usage, pothole infrastructure upgrades are needed. A long-wearing crack-resistant material called “Perpetual Pavement” shows promising results with a three-layer design that distributes stress and weight to prolong the life of the road surface. In wintry weather, road salt can also be substituted with biodegradable beet juice or other natural alternatives before an expected snowstorm, a technique called anti-icing. With anti-icing, liquid deicers, or brines, are applied on roads before snowstorms and help reduce the overall amount of ice on the roads. To ensure that the anti-icing agent is evenly distributed to reduce wear and minimize environmental impacts, the use a closed loop spreader added to snowplows will help ensure that salt is spread efficiently on the roads to prevent buildup. Another option to lessen the
environmental impacts of road salt is through using specific plants that can withstand a larger salt intake and cold weather. These plants can also be installed alongside roads, as discussed more in this report.

Next, we consider how the combination of road salt, snowplows and winter weather are affecting road quality and longevity. We focus on two areas of concern where road wear and damage from wintry weather pose a persistent problem - South Cameron Street and the Paxton Street corridor. This region of Harrisburg is a popular commuter route for residents from neighboring communities. As a commuter town, Harrisburg’s population size tends to double congestion throughout the region. 62.4% of the population drives a car, truck, or van alone with an average commute of 15 to 19 minutes from surrounding communities (City of Harrisburg 2020). According to the Traffic Volume Map from the Pennsylvania Department of Transportation (Figure 2), the Annual Average Daily Traffic volume, defined as the typical daily traffic on a road segment for all the days in a week over a one-year period, for South Cameron Street and Paxton Street is between 14,000 to 18,000 cars per day.
This portion of south Harrisburg features a range of disparate land use patterns—residential areas in the central and eastern portions, flanked by industrial areas to the west and south, with auto-centric commercial development to the north. Karst limestone geology underlays the entire area, which manifests through sinkholes and depressions that make development more expensive and compromise long-term viability. The majority of property west of Cameron Street is in floodplain formed from the confluence of the Susquehanna River, Paxton Creek, and Spring Creek (City of Harrisburg 2020).

A proposed plan to toll the I-83 South Bridge would add an additional traffic burden and stress on road infrastructure. If a toll is placed on the I-83 South Bridge Project, an estimated 22% of daily traffic, predominantly passenger vehicles and small trucks (PennDOT Traffic Diversion Analysis), is expected to choose to divert off the interstate to avoid paying the toll. The primary diversion routes the study identified are the I-81 Bridge, I-76 Bridge, Harvey Taylor Bridge and Market Street Bridge. Harvey Taylor Bridge will see increases in the range of 350-670 vehicles per hour, and the Market Street Bridge will see up to 280 vehicles per hour increase in the westbound direction during the PM peak hour. Peak times were used to evaluate the operations at intersections during the busiest times of the day.
Given the amount of traffic flowing through South Cameron Street to Paxton Street, reducing plowing or de-icing methods in not a viable option. However, the damage to roads from snowplows prompts an examination of the Harrisburg current snow removal process. Harrisburg is divided into eight snow-removal zones with two trucks assigned to work in each zone (Vendel 2016). According to PennDOT Press Secretary Alexis Campbell, the agency uses rock salt, made of sodium chloride, as a deicer and crushed natural aggregate (such as limestone and sandstone depending on geology of the region) as an anti-skid or abrasive material (Zaktansky 2022).

Potholes form when water seeps into pavement and cracks the asphalt. This water expands inside of the pavement as it freezes, creating a weak patch. A pothole begins to form when cars drive over this weak patch, or when freeze-thaw cycles extend the damage. Salt can exacerbate the problem because it keeps water in liquid form at a lower temperature. With salt mixed in, water does not freeze until around 15 degrees (F). Water infused with salt will continue to go through the freeze-thaw cycle at lower temperatures than pure water, which increases the number of total freeze-thaw cycles. As a result, road salt can lead to pothole formation under extreme cold and in already damaged roads (Unique Paving 2018).

The water shed from salty roads harms aquatic species in nearby water sources. As salinity from road salt run-off into the watershed increases, sensitive species suffer:

“The more sensitive species are affected first, while the more tolerant species persist. Over time, this causes decreasing diversity within our aquatic communities where you have the highest levels of road salt (contamination). Salt can have a varying impact on different life cycles within the same species, as eggs and fry can be more susceptible than adults, so species that spawn earlier in the spring can see more of an immediate impact. Increased salinity can also suppress feeding and growth and can be more detrimental if mixed with other external ions or contaminants” (Zaktansky 2022).

These immediate impacts tend to be the greatest after a storm where salt has been spread and there is some type of runoff event, whether it be a follow up rain or rapid melting where an
increased concentration of salt enters the waterways. The greatest impacts are along roadways that run parallel to a waterway, so there is a long distance where that water runs straight off the road and into a stream (Zaktansky 2022). The portion that remains on roadways eats away at pavement and bridges. It does the same to pipes that carry drinking water and can result in lead contamination, creating health concerns.

**Energy Usage**

Wintry weather does more than just affect road quality. Cold temperatures in winter, as well as high temperatures in summer cause energy demand to increase. Roughly 26% of Harrisburg’s population falls under the poverty line, which places strain on Harrisburg's budget and affects the City’s ability to address infrastructure concerns. Low-income residents, especially those from minoritized communities, are more likely to be rent-burdened and pay more money toward their utility bills. They are also more likely to experience utility insecurity when energy usage soars during peak periods of heat and cold (Micek 2021).

This mirrors a national trend. Mark Wolfe, executive director for the National Energy Assistance Directors Association, estimates that the total amount of unpaid utility bills has soared from $10.5 billion, owed by nearly 20 million U.S. households at the end of 2019, to more than $23 billion in 2022 (Wolfe 2022). A study of electricity bills in thirteen states and the District of Columbia by Arcadia, which helps households find renewable energy sources to lower their utility costs, also found that one-quarter of the families belonging to Arcadia's network in those states had past-due balances on their electricity bills as of January. The average amount owed is nearly $850 - a 67% increase from the end of 2019 (Liedtke and Bussewitz 2021).

One contributor to high energy costs for residents is the aging nature of Harrisburg’s housing stock. Construction of approximately 82% of the city’s housing occurred before 1970,
with the highest percentage constructed in 1939 or earlier (City of Harrisburg 2020). Older homes may be energy inefficient and in need of repairs and energy upgrades.

The *Home Rule Charter* allows Pennsylvania city governments to choose the structure of their own government. In Harrisburg, the City Council collaborates with the mayor to identify legislative concerns through various committees. In response to severe weather, council members may oversee the effectiveness of public assistance programs, respond to citizens’ complaints caused by heavy snow or rain, or borrow funds to repair storm damage to public infrastructure (National League of Cities). The Public Works committee in particular works to address severe weather issues that arise. City council members are motivated to serve their constituents since they are elected officials. They require public support and accurate information about the city’s needs.

**Tax Revenue**

On the revenue side, the city expects general fund revenue of $72.5 million in 2022, including the use of $8.86 million in federal American Rescue Plan Act (ARPA) funds as reimbursement for COVID-related expenses and revenue losses (Gittens 2022). Property taxes represent about 28 percent of Harrisburg’s overall revenue stream, but the future for real estate revenues appears dim. The city’s property tax revenue has fallen flat with property owners regularly challenging and lowering their assessments. Coupled with lower-priced housing in the region, Harrisburg does not have a significant number of tax-generating properties. Harrisburg’s revenue trend has remained flat at about 23% growth from 2003 to 2016 (Vendel 2017). Harrisburg’s revenue forecast is an important factor shaping our recommendations to offer effective solutions while having little impact on the city’s budget.
Solutions

Potholes and Infrastructure Upgrades

We considered a variety of solutions to address the problems of poor road surface performance, damage from snow removal, and the problem of high energy bills. To address road deterioration and the formation of potholes, the first solution we evaluate is investment in longer-lasting road surface materials made of asphalt, rather than the asphalt/concrete mixture currently in use. Upgrading road surfacing materials would prolong the road surface and require less maintenance over time. “Perpetual Pavement” is a high-quality road surfacing material made of two distinct layers of asphalt: (1) a foundational flexible layer that resists tensile strain caused by traffic and prevents cracks from forming at the base and (2) an intermediate layer below the trafficked surface. A layer of rut-resistant asphalt mix is placed on top (Tensar International 2020). If properly maintained and rehabilitated, a perpetual pavement can be designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction and needing only periodic surface renewal in response to distresses confined to the top of the pavement. Less expensive options include mixtures such as the Ravel Check Rejuvenation & Preservation Liquid which is sprayed annually on the roads to seal and protect road surfaces (PavementInteractive.org).

The underlying Karst-limestone geology presents a significant challenge. To fully understand the issue, Harrisburg should conduct a survey, or partner with an engineering firm, to gather accurate information on geological, residential, and commercial activities to aid in the creation of a response plan to fix the Karst-limestone issue and prevent future damage. Road engineering projects of the magnitude to repair the Cameron Street/Paxton Street corridor are
price-prohibitive, lengthy, and involve multiple agencies and levels of government. However, federal infrastructure funds currently available offer an opportunity for necessary improvements.

*Damage from Plowing and Road Salt*

There are several solutions Harrisburg can consider to minimize the hazards of winter storms while also preventing long-term negative consequences of using road salt. One solution is to replace road salt with an alternative deicer that can effectively melt snow and ice without damaging the environment, water supply, or vehicles. Substitutes are biodegradable deicers, such as beet juice, which can be sprayed on the roads before an expected winter storm while leaving little environmental impact. Beet juice or brine as an alternative to road salt has already been implemented in several cities and states across the U.S and Canada including Washington D.C., Toronto, Maine, and New Jersey. A mixture of sugar beet molasses, a waste by-product of beet sugar refining, and salt called beet brine is a common approach.

Other practical solutions include upgrading the snowplows that the Harrisburg Department of Public Works uses with ones that have electronic closed loop salt spreaders. A closed loop spreader is a valuable innovative technology that measures just the right amount of road salt to be applied on roads, lessening not only the cost of winter maintenance but also the damage that oversalting roads can cause. This automated process is controlled by an electronic device aptly named a spread controller. They are designed with capabilities such as remote control, data downloads, and GPS. The spread controller gathers information from various sensors that relay vehicle-speed, engine RPM, and pavement temperature. It then adjusts the amount of salt dispersed on the road accordingly. These technologically advanced spread controllers can be programmed to configure the spread rate and material output of deicers. Moreover, spread controllers are equipped with safety features like automatic override and a built-in ground speed.
sensor that counteracts technical breakdowns. Similarly, the purchase of new snowplows with
camera systems is another plausible solution. Just as modern-day cars are equipped with cameras
so drivers can have a wider field of view, snowplows with cameras can provide a wealth of
information to operators, road maintenance supervisors, and the public.

Replacing road salt with an alternative would help prolong road life. Liquid deicers, a
method of anti-icing, consist of solid granular deicers dissolved into a solution and are an
effective alternative to rock salt. Liquid deicers, or brines, are often applied before or at the
beginning of a storm. They are primarily used to prevent snow and ice from bonding to the
pavement, but they can also be used as deicers to burn through packed snow and ice. Use of
liquid deicers can reduce the number of deicing materials used, aid in quicker recovery of the
road surface, and reduce person and equipment hours. Data has shown that the use of liquids can
reduce solid materials usage by up to 50%.

Energy-bill Relief

Temperature impacts are expected to increase over time because of climate change (PA
DEP 2021). To assist with rising energy costs, we considered a coordinated outreach effort in
partnership with local citizen action organizations to encourage low-income residents to
voluntarily apply for home weatherization improvements through Pennsylvania’s Weatherization
Assistance Program (WAP). Energy experts conduct on-site energy audits to assess conditions in
homes and identify the most cost-effective energy saving measures, which are then installed at
no cost to the owner. Improvements lessen energy usage during periods of extreme heat and
cold, reducing costs and improving energy efficiency and resident comfort. Raising public
awareness of the program would encourage more residents to apply for it. A targeted social
media campaign in combination with multi-language print materials distributed in areas qualified residents frequent would help generate more awareness of WAP.

A broader solution is to reduce energy usage in highly trafficked public areas such as downtown and outside of government buildings. “Cool pavements” are paving materials that reflect solar energy, enhance water evaporation, or have been otherwise modified to remain cooler than conventional pavements outside of municipal buildings and city-subsidized housing (US EPA 2021a). Cool pavements also reduce stormwater runoff and improve water quality. These permeable pavements lessen impacts from road salt by allowing stormwater to soak into the pavement and soil, reducing runoff and filtering pollutants. Both permeable and non-permeable cool pavements can help lower the temperature of runoff, resulting in less thermal shock to aquatic life in the waterways into which stormwater drains (US EPA 2021a).

Another solution is adding vegetation to rooftops, i.e., “green roofs.” At Chicago City Hall, 53% of the roof is green. The City of Chicago reported a year-round average rooftop temperature reduction of nearly 4°C (78F) with a peak reduction of approximately 22°C (408F) in the summer, as well as energy savings. The EPA found that “green roofs can reduce building energy use by 0.7% compared to conventional roofs, reducing peak electricity demand and leading to an annual savings of $0.23 per square foot of the roof’s surface” (US EPA 2021b). This level of cooling helps to minimize the negative effects of the urban heat island, including heat stress and increased heat-related mortality, leading to improved air quality and reduced energy consumption from air conditioning (Smith and Roebber 2011).

Finally, we analyzed partnering with community groups to paint building roofs and/or large buildings white to cool buildings naturally. Based on barium sulfate, a compound used to whiten photo paper and cosmetics, this specially made paint has a molecular structure that can
make it highly reflective to solar wavelengths of light. The paint reflects up to 98.1 percent of sunlight and sends infrared heat away from the surface, making it cooler than the surrounding air (Morrison 2021).

**Assessment**

**Potholes and Infrastructure Upgrades**

Our assessment of Perpetual Pavement found that while the materials and installation are initially more expensive, use of the material can add up to significant savings over time as maintenance and replacement costs will be much less. In 2016, the Iowa Department of Transportation conducted an innovative asphalt project using these materials. Their “LCCA [life-cycle assessment analysis] shows that the road’s longer life offsets higher initial costs. In terms of life-cycle costs, the perpetual pavement shows cost savings ranging from 17 to 28 percent, depending on the economic indicator (NPV or EUAC) and selected discount rate” (Flintsch and Meijer 2020). Life-cycle costs include the full range of construction and maintenance costs during the life of the pavement as well as costs associated with the maintenance of traffic in work zones.

Other costs include those incurred by passenger and freight transportation on the section being reconstructed. These are delay costs due to construction activities, lane blockages, and lower speeds, and costs associated with the higher incidence of accidents involving road users and highway construction personnel in work zones. Although life-cycle costs are a compelling argument for using long-lasting, lower maintenance pavement, higher initial costs can meet with resistance from the highway construction industry and the public (Research and Technology Coordinating Committee 1998).
**Damage from Plowing and Road Salt**

Replacing road salt is a difficult decision as it is the least expensive deicer in the market and adopting alternative deicers will result in initial higher costs. Though eliminating the use of road salt is not economical, weaning from dependence on salt is feasible and will lead to a more sustainable Harrisburg.

Maintaining the status quo might seem to be a reasonable solution considering how road salt is the least expensive deicer at $0.16 per kilogram and the salt level in the Susquehanna River and Swatara creek is 25ppm, a level considered safe (for comparison, Pennypack creek in Philadelphia—one of the cities most affected by salt pollution in the US—has 423.6 ppm) (Izaak Walton League of America 2022). Although rivers and streams in the Harrisburg area are healthy now, it does not mean that they will stay that way for the future. Changing the city’s deicing methods now would prevent having to address an even larger problem in the future. Maintaining the status quo is a myopic policy and is not one that we recommend. Salt also has the disadvantage of corroding bridges, parking garages, and vehicles, which costs Harrisburg a great deal in maintenance.

A major advantage of beet brine is that it is more effective at clearing roads than road salt. A 2018 experiment where PennDOT tested various deicers on snow-covered parking lots including salt brine and a beet brine called Beet Heet reports that Beet Heet performed 51.3% better than salt brine (Zhang et al. 2018). Furthermore, road salt is less effective at temperatures lower than 25 degrees, but beet brine can melt snow and ice at temperatures down to 15 degrees (Parker and Tatum 2021). The stickiness of the molasses helps the salt bond to roads and enhances its ability to melt snow and ice. Beet brine also does not corrode metal like salt does, thus the application of beet brine on roads will not damage vehicles and roadways and decrease the costs of expensive road, vehicle, and bridge repairs. Unlike road salt, beet juice will not harm
water quality and can reverse the rising trend of salinization of freshwater streams, creeks, and rivers due to the road salt contaminating groundwater.

The most significant disadvantage of beet brine is that it is 10.4 times more expensive than salt (Zhang et al. 2018). The adoption of beet brine could put a strong burden on Harrisburg’s finances. Therefore, beet brine, if adopted, should be used sparingly. Beet brine also poses some environmental concerns. The deicer can leak into streams and bacteria attracted to the sugary molasses suck up the dissolved oxygen in water that other aquatic organisms rely on to survive (Silverman 2014). Additionally, it can have an impact on insects. A study from the American Physiological Society (2018) exposed mayflies, an insect that is particularly sensitive to runoff contaminants, to beet brine deicer and discovered that the potassium in beet brine can compromise the mayflies’ organ function. It should be taken into consideration that research on the environmental impact of beet brine is limited, and more research should be done before reaching definitive conclusions on beet brine’s effects on the environment.

The use of a closed loop spreading system is vastly superior to that of an open loop because the closed loop spread controller can self-correct and change the amount of salt that is spread on roads based on the amount of snow, ice, and temperature. An open loop system does not have a feedback loop and thus the salt being spread is a predetermined amount, which leads to oversalting. Another benefit is that the automated spreading system means that the snowplow operator will not have to closely monitor the amount of salt that is used on the roads, making their tasks easier and efficient. This is a useful innovation as the snow and ice management industry is facing a labor shortage and more automation can fill the gap when there are not enough workers to operate snowplows. Several manufacturers produce commercially available closed loop spread controllers like Force America 5100EX Spreader Controller, Bosch Rexroth
CS550, AEBI Schmidt WinterCare. We contacted the respective manufactures and Force America replied stating cost of the 5100EX as $2,000 and an additional $1,000 for closed loop feedback sensors and harnessing.

The primary challenge to closed-loop spreaders is the accuracy of the amount of salt which is being dispersed. The purpose of a spread controller is to assess what the “right amount” of salt needs to be spread yet this can be a tough balancing act since too much salt leads to the problems discussed earlier. However, too little salt would not melt ice and snow, placing drivers and pedestrians in great danger due to the higher chance of accidents. A study of the responsiveness and accuracy of closed-loop spreaders in comparison to spreading salt manually concluded that spreading salt with automated closed-loop spreaders gives about the same result as the driver adjusting the salt spreader but has a positive effect on road safety and work environment for the driver as he/she can focus on driving instead of adjusting the salt spreader.

In addition to adopting the use of automated closed-loop salt spreaders on snowplows, City Council should purchase new snowplows with a camera system. PennDOT has already invested in this solution by purchasing a J & J horizontal ejector snowplow for Somerset County in 2017 (Rock 2017). This snowplow comes equipped with the J & J Aware camera system that allows the operator to see behind the truck and monitor the salt spreader. The cost of this truck was $200,025, including the plow and spreader, which is comparable with other trucks (Rock 2017). In addition to the cameras, the snowplow incorporated an innovative horizontal ejector, so operators do not have to physically lift the truck bed to spread salt. This technology is useful when the snowplow operator is driving on bridges or overpasses where there is a possibility that the truck becomes too tall and can collide with them. Disadvantages of adopting the camera system include the degraded image quality due to dirt or snow falling on the camera lens. This
issue can be prevented by investing in a camera washing system for each camera and heated lenses to prevent damage from wintry weather.

Energy-bill Relief

In reviewing the Pennsylvania Weatherization Assistance Program, we found that applicants must meet strict eligibility requirements to qualify. The program is open to low-income individuals (at or below 200% of the federal poverty level), with priority given to higher risk residents such as the elderly, disabled, families with children, and high energy users. Once accepted into the program, the average expenditure per household is $7,669 depending on the home audit results (PA DCED 2022).

Social equity must be considered as there are often correlations between hotter neighborhoods and the demographic characteristics of residents. Factors such as race, language barriers, and income play a role in the strength of the effects felt by extreme heat, especially for the following groups:

- Older adults (65+ years)
- People with existing medical conditions
- Children, infants, and pregnant women
- People who live alone
- People who are homeless
- People with limited personal resources (US EPA 2022).

Our assessment of “green rooftops” (rooftop gardens and green spaces) found that vegetation planted on rooftops not only significantly reduces energy usage, but it also improves storm water runoff (the topic of the next chapter). The planted vegetation stores rainwater and then releases it into the air and water runoff from the rooftop is reduced. Rooftop gardens and green roofs have been a staple in Europe for three decades. They are easy to maintain and can be adapted for use on almost any rooftop surface.
There are two types of green roofs: extensive green roofs that require less than 6" of soil medium and support mostly herbaceous plants and complex green roofs that include shrubs and small trees. For Harrisburg’s needs, the most suitable vegetation would consist of low growing, fire resistant, hardy plants that can withstand heat, cold and wind. Once a building is inspected and approved, material needs for the green roof are low, consisting of a barrier/membrane between the roof surface and the soil (to function as a water-proof base to prevent leaks), soil, and plants. A basic rooftop garden is estimated to cost in the range of $100 - $3,000 (N.A. 2022).

A review of heat-reflecting white paint found that a high concentration of barium sulfate particles added to the paint created reflective results that made surfaces 19 degrees Fahrenheit cooler than the air at night. Even during the midday heat, the paint was effective at cooling, reducing surface temperatures to eight degrees below the air temperature (Morrison 2021). The newness of the high-barium-sulfate content product may present a price-barrier. However, there are other slightly less effective bright white paints designed to improve energy efficiency already on the market. This product reflects 80 to 90 percent of sunlight, but the building surface materials get warmer, not cooler, by absorbing ultraviolet light. Cities such as New York and Chicago have programs to paint roofs white to combat urban heat. The heat-reflecting paints currently on the market lessen energy use by an estimated 25%. Costs range from $15,000 - $35,000 per building depending on square footage (TexCote).

Recommendations

Encourage citizen engagement and empowerment in energy-usage to build a more sustainable community through partnerships with community groups. We recommend harnessing the power of community organizing to educate and empower community members on energy
improvements to empower them to make the changes on their own and to increase public awareness of the effects of extreme temperatures. Suggested community groups include the Tri County Community Action / Community Action Commission, Harrisburg Habitat for Humanity, Central PA Red Cross, and the Boys & Girls Club of Harrisburg. We recommend a combined strategy of a targeted social media campaign to residents, and the distribution of printed, multi-language materials at strategic locations used by the residents who would benefit from WAP.

Next, the city should partner with non-profit community groups to implement innovative small-scale projects such as painting smaller buildings with the less-expensive white energy-reducing paint materials that are already on the market and installing “green” rooftops or balconies. This work should begin by identifying groups and locations most at-risk from the dangers posed by extreme temperatures to address social equity concerns. After determining which buildings and neighborhoods would be most suitable, we recommend working with one of the referenced non-profits to apply for the next round of grant funding, opening in 2023, made available to qualifying non-profits in Dauphin County by revenue earned at the Hollywood Casino in Grantville, PA. In 2022, the Dauphin County Commissioners approved projects for over one hundred groups through this grant fund (Howard 2022). A second grant available through The Keystone Communities Program (KCP) is designed to encourage the creation of partnerships between the public and private sectors that jointly support local initiatives such as the growth and stability of neighborhoods and communities; social and economic diversity; and a strong and secure quality of life. The program allows communities to tailor the assistance to meet the needs of its specific revitalization effort. Approval of one of these grants would cover the cost of materials needed to paint and plant green rooftop spaces. The city should work with groups to enlist volunteers to conduct project implementation.
In fall of 2022, the *Energy Efficiency and Conservation Block Grants* through the U.S. Department of Energy will provide $550 million to states, local governments, and tribes for projects that reduce energy use, increase energy efficiency, and cut pollution. We recommend working with government officials to identify buildings to be coated with the higher content barium-sulfate paint as a trial and applying for one of these Department of Energy block grants to cover the cost. We also recommend a second grant application for the purchase and installation of the Cool Pavement material outside of the selected painted buildings to measure how effective the two elements are together. The results of this evaluation could then be used for future grant applications that can expand application in the city.

The city should prioritize reducing reliance on road salt during winter weather to increase road longevity and reduce impacts on water shed and human health. This includes choosing alternative road salt materials and exploring alternative methods of snow removal such as investing in snowplows with automated closed-loop salt spreaders and camera systems.

We recommend conducting two impact surveys that, combined, will make a compelling case for approval in grant applications. The first is an impact survey to determine the level of additional stress the proposed I-83 South Bridge toll would place on the Market Street Bridge, Front Street, and the portion of South Cameron Street leading up to the I-83 on ramp to Hershey, PA. PennDOT’s Traffic Counting Safety and Assistance Program (TCSAP) will work with municipalities to ensure the collection of accurate traffic data.

The second survey we recommend is to assess the Karst-limestone issue affecting road quality in the South Cameron Street/Paxton Street portion of Harrisburg. The federal *Infrastructure Investment and Jobs Act of 2021* provides a unique opportunity to address the issues caused by the Karst-limestone geology. We suggest using PennDOT Municipal Services.
where representatives will help municipal managers estimate options to repair the Karst-limestone issue free of charge, as well as help to create a narrative to aid in the grant process. A survey of the region may reveal that the Paxton Street to South Cameron Street portion of Harrisburg qualifies for a *FEMA Hazard Mitigation Assistance Grant*, which has been updated to include preventative measures for sinkholes and geological factors in grant approvals. In 2014, FEMA provided the city with $1.65 million for the sinkhole mitigation project that repaired 14th Street (Benscoter 2019). An impact survey identifying potential traffic increases caused by the South Bridge toll would further stress the importance of the needed infrastructure upgrade. One other free PennDOT service is the *Local Technical Assistance Program* (LTAP), designed to help Pennsylvania’s municipalities make the best use of their roadway maintenance dollars.

**Conclusion**

Rising temperatures and winter weather have a significant impact on the Harrisburg’s infrastructure. Resulting increased energy demands place an additional burden on residents, business owners, and the city government, while impacting their quality of life. Available Federal, state, and county funds present a unique opportunity to improve road quality and prioritize smart energy improvements that will help build a more sustainable future for Harrisburg.
Stormwater Management

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Significant stormwater runoff is a prevalent issue in the city of Harrisburg. Stormwater runoff is a result of rainfall or snowmelt, which produces an excess of water that does not immediately soak into the ground. The excess water has been a problem in Harrisburg for quite some time and is getting worse every year left untreated. Around 31% of all properties in the city of Harrisburg currently have a chance of greater than 26% of being severely affected by flooding (Flood Factor). In addition to the more than 6,148 properties that could be affected (Flood Factor), if the issue is not addressed there could be several environmental and infrastructure impacts that the city and its residents could face as well. The issues that can result from this could be detrimental to both the city and its residents. With thousands being impacted by this problem every year, it is important to explore viable solutions to either eliminate or lessen the amount of stormwater runoff that impacts the city.

To determine how to fix the current problem of stormwater runoff, we first investigated Harrisburg’s environment and established a clear definition of the problem. While several problems can be identified, we argue that flooding is the most pressing. The flooding is a direct result of the excess stormwater runoff that the city is currently experiencing. After identifying flooding as the main problem, we next identify potential alternatives to fix the problem. We then analyze each alternative to determine which best meets the needs of the city. We use criteria such as availability of land, effectiveness, and overall cost. While many of the alternatives would help fix the problem of flooding caused by stormwater runoff, only some are effective within the parameters that are important to the city. Finally, the best alternatives that meet our criteria are
recommended. In fact, we argue for a combination of solutions for most effectively solving the problem of excessive stormwater runoff in the city.

**Evaluation of Harrisburg’s Environment and the Problem**

In Harrisburg, there are 6,148 properties listed that have a greater than a 26 percent chance of being badly flooded in the next 30 years. This accounts for 31% of the city’s total real estate. In addition to property damage, flooding can block off access to utilities, emergency services, and transportation, as well as have an influence on an area’s general economic well-being. Overall, Harrisburg has a substantial risk of flooding in the next 30 years (see Figure 3), which means flooding will certainly disrupt daily life in the city. Property, companies, road infrastructure, and social risk are all factors in determining an area’s overall flood risk. Each parameter is assessed on a 6-point scale, and the total risk is calculated by the overall risk level.

Some demographics for Harrisburg are below (**Flood Factor**):

- 5,046/14,600 homes in Harrisburg have some flood risk.
- 126/227 miles of roads within Harrisburg are at risk of becoming impassable due to flooding.
- 1,099/1,472 businesses and other properties in Harrisburg have some flood risk.
- 9/15 infrastructure facilities are at risk, being any of the following: hospitals, police stations, fire stations, airports, seaports, power stations, wastewater station plants, superfund / hazardous waste sites, water outfalls and wastewater treatment facilities.
Flood Risks Are Increasing Because of the Environment

Higher oceans, altered weather patterns, and heavier storms are all signs of a changing environment. Evaporation increases when the atmosphere warms, resulting in more water accessible when it rains. Warmer oceans, because of a warmer atmosphere, can exacerbate flooding from hurricanes and offshore storms. “If current trends continue, an additional 1.7 million homes in the United States will be at risk, and the damage and cost of floods will continue to rise. A river flood across central Pennsylvania in September 2011 impacted 1578 properties in Harrisburg, according to a rebuilt model of the disaster” (Flood Factor).

Existing Conditions

The Paxton Creek Watershed, which drains a 27.3 square mile region to the Susquehanna River and provides half of the Chesapeake Bay’s freshwater input, includes the lower part of Paxton Creek. Paxton Creek has multiple tributaries, the largest of which is Asylum Run, which covers 3.7 square miles. The majority of Paxton Creek (92 percent or 253,220 linear feet) is an extensively modified concrete-lined channel built by the City’s fast urban and industrial development beginning in the early 1800s. Paxton Creek has suffered considerable ecological
damage as a result of this growth and development, and it now suffers from Urban Streams Syndrome (USS). Flash floods, heightened nutrient and pollutant concentrations, changes channel shape, and reduced biotic rightness with an increased dominance of non-native species are all symptoms of USS (PennDOT 2018). Paxton Creek has a Warm Water Fishes (WWF) and Migratory Fishes (MF) designation and is listed as impaired due to Combined Sewer Overflow-Dissolved Oxygen/ Biochemical Oxygen Demand, Urban Runoff/Storm Sewers-Suspended Solids, Urban Runoff/Storm Sewers-Water/Flow Variability, and Urban Runoff/Storm Sewers-Other Habitat Alterations, according to PA Code Chapter 93 Water Quality.

**Combined Sewer System Primary Culprit**

The city’s intricate system of pipes, sewers, and pumps must work in concert with the city’s natural infrastructure, which includes Paxton Creek and the Susquehanna River, to clear stormwater from the city. Approximately 80% of the collecting system was installed prior to 1940, indicating that most of the city’s stormwater infrastructure is more than 80 years old. The infrastructure’s age, combined with decades of neglect, has resulted in a slew of structural difficulties, operating flaws, and debris buildup. Although inspecting the subterranean infrastructure is difficult and time-consuming, preliminary findings show that roughly 40% of Harrisburg’s sewer and stormwater infrastructure needs to be repaired or rebuilt (2022). More importantly, Harrisburg, like communities across the country, is facing the task of maintaining and updating decades-old water and sewer systems.

Moreover, a combined sewer system, where stormwater and sewage are carried in the same pipes, serves approximately 60% of Harrisburg’s sewer lines. Harrisburg is one of over 800 cities using a combined system across the country. The sewage is carried to the Advanced Wastewater Treatment Facility during dry weather to be treated before entering the Susquehanna...
River. Stormwater flows exceed the sewer system’s capacity during wet weather periods, causing a mixture of sewage and stormwater to overflow into the Susquehanna River and Paxton Creek.

*Stormwater and Pollution*

Stormwater is water that does not soak into the ground due to rain, snow, or ice melting. In a natural setting, most of the rain, snow, and ice melt falls on pervious surfaces such as grass and filters into the earth, replenishing groundwater and maintaining stable water tables. When water falls on an impervious surface, however, it travels until the ground can absorb it. In cities, pervious surfaces are rarely sufficient to absorb most of the rainfall before it reaches a storm drain or pools in a low-lying area. Stormwater can pick up trash and contaminants such as oil, chemicals, fertilizers, pesticides, and more as it travels to the nearest storm drain or pervious surface.

These contaminants and debris end up in waterways, putting the health of water used for drinking, recreation, and habitat in Harrisburg and downstream cities in jeopardy. Runoff pollutants can contaminate drinking water, endangering human health, and harming aquatic life. Raw adds to the pollution and damage in a combined stormwater system. Furthermore, more than half of Harrisburg’s sewer pipes transport dirty stormwater runoff and sewage to be treated in the same pipes. This toxic water can overflow into Paxton Creek and the Susquehanna River during severe storms. Capital Region Water is also in charge of separate stormwater and sanitary flow pipelines, in addition to the combined sewer system. The health of the Paxton Creek, the Susquehanna River, and the Chesapeake Bay rely on guaranteeing that both systems meet regulatory standards, minimize pollution, and improve water quality.
EPA Resolution

In 2015, the EPA announced “a partial settlement with the Pennsylvania Department of Environmental Protection (PADEP), the City of Harrisburg, and Capital Region Water to resolve alleged Clean Water Act violations involving sewer overflows and polluted stormwater discharges to the Susquehanna River and Paxton Creek” (Sternberg 2015). The settlement was meant to not only benefit the Susquehanna, but also the Chesapeake Bay. Long before Capital Region Water privatized the system in 2013, Harrisburg battled with a mixed sewer and stormwater infrastructure. Every time the city receives heavy rainfall, the city’s aging sewage system is overloaded, dumping millions of gallons of untreated sewage, a mix of everything flushed down the toilet and rainwater streaming into storm drains into the river. Water backs up into basements and into city streets on occasion.

Untreated wastewater discharge has a negative impact on downstream water quality, affecting numerous fisheries and requiring other water utilities to be extra cautious when sourcing their community drinking water from the river. Moreover, the runoff eventually drains into the Chesapeake Bay, contributing to algal blooms, poisoned fish, and other repercussions (Harrisburg and Capital Region Water are among the most significant, but far from the main culprits). Finally, because sewage overflows, and storm water discharges from municipal sewer systems pose a substantial threat to water quality and public health, one of the EPA’s National Enforcement Initiatives is to keep raw sewage and contaminated stormwater out of US seas. The EPA is aiming to reduce sewer overflow discharges by gaining city commitments adopt timely, cost-effective fixes.
Potential Alternatives

As we can see, the problem of stormwater management is an ever-escalating situation, as well as one with several alternative solutions that all provide some form of positive impact on stormwater management. These alternative solutions consist of erecting dams at the mouth of Spring and Paxton creeks, build an alternative channel to compensate for heavy rains, build underground storage facilities for overflow of rainwater from the Susquehanna, build raingardens, and the last alternative solution would be to design a festival or holiday to fundraise money for any improvements on storm water management in Harrisburg. However, to move forward in finding the best solution, we must critically evaluate the alternatives.

Analyze the Alternatives

Maintain the status quo

While it may seem like the most cost-effective solution, maintaining the status quo and delaying the response to flooding in Harrisburg would prove to be a greater cost in the long run for the city of Harrisburg.

Paxton Creek Master Plan

In the 2020 Comprehensive plan for the City of Harrisburg, it is mentioned that civil engineers proposed a plan for a floodgate\(^2\) to be erected near the mouth of Paxton Creek. This would limit one of the greatest sources of flooding to the city of Harrisburg. This would also allow the regulation of water levels that would provide methods to better suit boating activities.

The Paxton Creek Master Plan is an existing project with the goal of “transforming Paxton Creek into an Urban Green Space (UGS) to restore the creek’s ecosystem and services.”

\(^2\) A gate that can be opened or closed to admit or exclude water
This plan is a multifaceted approach with several major objectives. The plan would “create a natural stream channel with the appropriate dimension, pattern and profile”; “provide adequate channel size and flood conveyance to reduce 100-year flood elevation to 314”; and “establish a riparian ecosystem that is supportive of natural biota” (PennDOT 2018). The plan also would “improve water quality by reduction of nutrients and chemical pollutants”; “provide balance sediment transport” and “stormwater retention and treatment”; and “create instream habitat and flow diversity.” Lastly this plan would “achieve bank stability and riparian buffers”; “create increased opportunities for passive recreation and aesthetics”; and “provide a multi-use pathway for bicycle and pedestrian access through the corridor” (PennDOT 2018). This Paxton Creek Master Plan intends to remove 133 acres from the FEMA 100-year flood plain, with an additional 275 acres being partially removed. The total cost for this project would be roughly $60 to 90 million.

**Rain gardens and green alleyways**

This solution is one that the city of Harrisburg has actively been participating in implementing and should continue to do so. Rain gardens and green alleyways are areas of vegetation that help absorb water into the soil. Not only do they help with the collection and reallocation of water in the city of Harrisburg, but they also aid in the absorption of pollutants. To aid this, the city of Harrisburg could potentially match what the city of Philadelphia does. They have a Green Roof Tax Credit that provides a fifty percent rebate, up to $100,000, for businesses who install a green roof.

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3 Relating to or situated on the banks of a river.
4 a garden that lies below the level of its surroundings, designed to absorb rainwater that runs off a surface such as a patio or roof.
**Permeable Pavement**

The implementation of a permeable pavement is a potential solution that would help mitigate some of the flooding in the streets of Harrisburg. Permeable pavement is a unique type of pavement that can absorb water and redistribute it. Lancaster implemented a similar solution to help with stormwater management. Permeable pavement can handle roughly 60 feet of water per hour, which would greatly aid in the distribution of flood water (N.A. 2014). The maintenance cost of permeable pavement is also less than the cost of conventional asphalt and underground storm drains (N.A. 2014). Because of this, it would be a great investment for Harrisburg when replacement of road structures is needed.

**Raise buildings**

Raising all buildings along the flood corridor a minimum of two feet would be a monumental task that would require a significant amount of effort as well as cost. While this solution is something that is done in storm prevalent areas, this solution is not viable for the city of Harrisburg.

**Create awareness day/holiday**

This simple idea would be a great way to bring attention to this critical issue. Creating a holiday maximizes cost efficiency as there are no expenses necessary in the implementation of a city holiday. While this idea would not directly solve the problem, creating awareness and promoting ideas would benefit the problem-solving process. Camp Hill Borough’s [StormFest](#) could be a model. In addition to creating a holiday, community planning events could also be created to encourage the implementation of rain gardens and the planting of indigenous plant species that would help mediate the problem. There are several organizations that could be utilized to aid in this such as the Green Urban Initiative.
Recommendations

The reality is that no single solution presented above will be enough to fully address the issue being faced. We must therefore look for a holistic approach that combines several alternatives into a single plan of action. Therefore, our recommendation will include multiple actions that work together to mitigate the amount of flooding that Harrisburg experiences, as well as the amount of stormwater runoff they are required to process during times of heavy rains.

Grant Office

First and foremost, the city of Harrisburg needs to establish an office that will seek grants for these efforts. Our proposal will require the city to seek funding from multiple different streams including both the Federal government and private entities. We have provided examples in Appendix 2 of some grants that are available to fund these activities. Some of the grants that are available include the Department of Transportation RAISE Discretionary Grants as well as a FEMA Flood Mitigation Assistance Grant. The Department of the Interior also has a Coastal Wetlands Conservation Grant Program that could be applied to activities involved with restoration of essential wetlands.

Build A Wildwood South

What is clear is that the land in and around Paxton and Spring Creeks is flood prone and will continue to remain so indefinitely. Any land that sits below Cameron Street between Sycamore and Elliot Streets is at significant risk of future flooding and damage. Ideally, the city could take this land and convert it into active wetlands, like how Wildwood Park works in North Harrisburg. Thus, we recommend converting that area into a second wetlands park that will be able to accommodate and slow the rate of water that enters Paxton Creek.
This would require the relocation of at least PennDOT building (parcel 01-049-032) and the Ames True Temper warehouse (parcel 01-049-037). While this seems like it would be highly problematic and troubling, there are other potential sites for these facilities, and they could be offered to each of them. For example, Harrisburg School District owns 42 acres of undeveloped land in Susquehanna Township that is located directly off Route 22 (parcel 62-026-033, see Figure 4). This would make an ideal location for both a new PennDOT as it exceeds the 11 acres they currently utilize on the river front, as well as the Ames True Temper warehouse. Alternatively, parcel 02-008-018 could be purchased by the city and offered to Ames as a suitable relocation site, perhaps with an offer to extend them tax credits for multiple years.

**Figure 4. - Parcel 62-026-033 – A 42 acre plot of land currently owned by Harrisburg School District that sits directly off Route 22 in Northern Harrisburg**

Once that land has been cleared, it will be restored back to a typical wetlands environment that mirrors what exists at other locations along the Susquehanna that have been left undeveloped. Rather than place a floodgate the mouth of Paxton Creek where it meets the
Susquehanna River, the city will extend out the banks of the creek to create a more natural environment where the two connect (Figure 5). The banks on either side will be planted with native grasses and plants that tolerate wet conditions, trap solid waste, and slow the flow of water in both directions.

**Figure 5. Proposed Site for Wildwood South**

Next, a diversion channel will be built that connects Paxton Creek to Spring Creek near the City incinerator (parcel 01-066-002, Figures 6-8). The diversion channel will require the erecting of a floodgate at the location where Ames True Temper currently sits, along with the addition of a broad catch basin that is connected to Spring Creek via a series of culverts\(^5\) that go under Cameron Street and 13\(^{th}\) Street.

\(^5\) A tunnel carrying a stream or open drain under a road or railroad.
Figure 6. Parcel 01-066-002, the location of the city incinerator, where Spring Creek travels northeast away from the Susquehanna River
Figure 7. Location of the culverts connecting the retention pond to Spring Creek

Figure 8. Conversion site of the Ames True Temper site into a retention pond and rain garden
To further protect the city, a combination of swales[^6] and a flood wall[^7] could be erected along Cameron Street from Gibson Street to Sycamore Street. A secondary lower swale could be built along the river-facing edge of the train tracks that will slow the rate of rising water when flooding does occur. Both sets of swales can be fronted with a combination of native vegetation and rock to prevent erosion and to preserve the structural integrity of both the swales and the flood wall (see Appendix 1 for examples of native plants). To further protect the city, a second floodgate can be placed just to the East of Shanois Street where the current concrete channel for Paxton Creek begins. This will protect against severe flooding events that could potentially overrun the wetlands area the city has built.

Finally, the Greenbelt trail that runs through this space will be elevated and replaced with a wooden style walkway that mimics the walkways used at Wildwood Park. The goal is to allow for the walkways to be usable even during times of changing water levels, and to protect and preserve the natural wetlands habitat created.

Taken together these steps enhance the attractiveness of the city, improve the Greenbelt trail, and provide a natural flood control system at the Southern end of the city.

**Restoration of the Paxton Creek Watershed**

While the creation of a new wetlands and diversion channel at the mouth of Paxton Creek will aid in preventing much of the flooding seen now, there is additional work to complete regarding Paxton Creek itself. Much of the current run of Paxton Creek through the City of Harrisburg happens in a cement basin. While a cement streambed permits a faster flow of water, once water is in the cement basin, it has nowhere to go except up, causing destructive flash flooding.

[^6]: A low or hollow place, especially a marshy depression between ridges.
[^7]: A primarily vertical artificial barrier designed to temporarily contain the waters of a river or other waterway which may rise to usual levels during seasonal or extreme weather events.
flooding. Removing the concrete in favor of a natural dirt and stone creek bed permits more of the water that flows through Paxton Creek to infiltrate the surrounding environment. Adding in native vegetation will aid with this and will help naturally regulate not just the flow of water, but also trap more waste, chemicals, and garbage that could eventually flow into the Susquehanna River. Plants such as swamp milkweed and common switchgrass are two examples of vegetation that does this well.

Taken together, these steps also fit into the Pollutant Reduction Plans (PRPS) framework as part of the MS4s regulations set forth by the Commonwealth. Specifically, all four of the impairments listed on the MS4 site as affecting Paxton Creek: solid waste, pathogens, water flow variability, and water habitat alterations are remediated by this step. Therefore, we recommend the city remove all the cement lining in Paxton Creek, restoring it to a more natural state, and planting different varieties of native vegetation in and alongside the Creek. See Appendix 1 for types and varieties of vegetation to use.

**Addition of Water Control Structures Along Paxton Creek**

In addition to the work listed above, there are some locations along Paxton Creek within the City of Harrisburg that could have rain gardens added to them while minimizing the impact to the community or businesses. These would be integrated into Paxton Creek itself and would provide space for additional water to flow into and slowly infiltrate, as well as for the entrapment of debris and solid waste. For example, Capitol Building Supply has left a large band of Parcel 07-058-001 undeveloped along Paxton Creek (Figure 9).
We therefore recommend that Capitol Building Supply be asked to donate a portion of their parcel to the city for conversion into an integrated rain garden (Figures 9 and 11). In addition, on the opposite bank of Paxton Creek at the same location, there are two undeveloped plots of land, parcels 08-034-006 and 07-058-003 that could be converted for the same use (Figure 10, Figure 12).
Figure 10. Parcels 08-034-006 and 07-058-003 – Both of these lots currently sit empty and positioned directly between Cameron Street and Paxton Creek
Figure 11. The strip of land that Capitol Building Supply leaves empty and could be donated to the city in order to build a rain garden.
Figure 12. The two locations for the rain gardens in North Harrisburg near Cameron Street

In both locations, the banks of Paxton creek would be expanded and graded out further to establish small wetlands. The edges facing Capitol Building Supply and Cameron Street would both again be converted into swales which would help hold the creek should it flood. The creek side of the bank would be planted with rain gardens that would help trap pollutants, solid waste, and pathogens. They would also provide homes for habitats and encourage the return of helpful pollinators like honeybees, bumble bees, butterflies, etc. The introduction of plants into the banks and along the outside of the swale also helps to preserve them and prevent flooding. Finally, introducing native vegetation including trees in this space helps to trap carbon, lower the average temperature in the area, and promotes the return of wildlife beneficial to the environment. One additional benefit that should be noted is that many of the plants that thrive in
a rain garden are excellent pollinators, especially for bumble bees, who are going extinct. Implementing this portion of the plan provides them with areas in the city where they too can thrive.

**Improvements to the Spring Creek Watershed**

As the intended destination of any expected overflow from the Susquehanna River, steps need to be taken to improve the ability of Spring Creek and the land that surrounds it to accept any stormwater runoff. The use of rain gardens, mixing in native vegetation and swales will allow the banks of Spring Creek to accept and process diverted runoff from the Susquehanna River and Paxton Creek. Therefore, we recommend that along both banks of Spring Creek from Cameron Street to just past Route 83 where the creek abuts Parcel 63-024-019 belonging to United Water, swales and native vegetation are also deployed. This basin should be integrated with Spring Creek and engineered to accept any overflow that may reach it (Figure 13).

**Figure 13.** Parcel 63-024-019, a quarry pond that borders Spring Creek and could be used as an additional retention pond in times of flooding
Furthermore, we recommend a second catch basin be built in Parcel 63-024-081 currently owned by the County of Dauphin. If the city builds a 350 foot by 350 foot by 4 foot deep catchment basin (approximately 2.6 of the 4.6 acres available) it would be able to hold approximately 3.6 million gallons of storm water runoff. If additional space is desired, Parcel 63-024-070 is the neighboring parcel and is 8 acres, which would allow for an additional 10 million gallons of storm water runoff retention (Figure 14).

**Figure 14. Parcels 63-024-070 and 63-024-081 are two empty lots currently adjacent to Spring Creek and the Harrisburg Greenbelt**

By placing retention ponds at these locations (Figure 15), the city prevents the water from impacting others further upstream and allows the water to infiltrate into the ground. Furthermore, both parcels are near the Greenbelt Trail, and could be integrated with it as an extension, expanding the park and recreation space in and around Harrisburg.
Integration of Permeable Pavement and Green Alleyways

Another area that can have some improvement on the amount of stormwater runoff that enters the city is the use of permeable pavement and so-called “green alleyways.” The intention with this is to allow stormwater to infiltrate into the ground naturally instead of ponding or entering the stormwater system in the first place. Permeable pavement is an integral part of building green alleyways. Green alleyways can work in one of two ways.

First, the regular pavement for an alleyway is replaced with a mix of permeable pavement and concrete lattice pavers that is still usable for vehicular transportation if necessary (see Figure 16). Not only does this allow water to enter the ground, but the concrete lattice pavers also permit the growth of grass and other local vegetation which not only traps carbon, but it also keeps the pavement cooler and facilitates the capture of water.
Second, alleyways that use permeable pavement that then routes the water into a series of dry wells via trenches. The dry wells help to capture pollutants like oil and antifreeze. The water is then injected into the local aquifer underground, helping to replenish the local water supply naturally. These typically are blocked off from normal motor vehicle traffic, and instead are intended for pedestrian and bike traffic only.

We recommend that both be deployed in Harrisburg. In areas in the south of the city, closer to the River and the Capitol building, we recommend the use of type 1. This would include Dubbs Alley, Oliver Alley, Academy Alley, but also Prince Street, Penn Street, and
others. This would permit for the normal flow of traffic and usage by emergency vehicles, and trash collection, while working to reduce the amount of stormwater overall.

In northern Harrisburg, we recommend converting alleyways such as Clover, Wharton, and portions of Brensinger into type 2 green alleyways. We would recommend the use of type 2 green alleyways in locations around Allison Hill, for example Crooked Street, Haehnlen Street, Nectarine Street, Reese Street, etc., trapping stormwater runoff in dry wells and then injecting into the aquifer there is a reduction in the overall load on the city stormwater runoff system in total.

It is important to note that while there is a perception that permeable pavement is a good solution in some places, but it is not practical in the Northeast because of concerns around the freeze thaw cycle. Fortunately, that is not true. Locations including Lake Owasso in Minnesota and Lancaster, PA have successfully used permeable pavement (N.A. 2014), and Lake Owasso has used less road salt after installation (Janzer 2020).

The key thing to do with the implementation of green alleyways, especially type 2, is to involve the community in their planning and building. When the community members feel like they have ownership over the project, they are more likely to maintain it, and utilize it.

One other consideration is to avoid green gentrification, which can have the unfortunate effect of pricing people out of their own community. By varying the types of green alleyways in use, and more carefully integrating them into neighborhoods as they have done in places like Detroit, MI (Freehill-Maye 2017), and working with neighborhoods to develop and maintain them, we hope to minimize this from happening.
**Awareness Day**

Community ownership and buy-in is why for our final recommendation we are encouraging you to establish an Awareness Day that will be a city holiday, and whose purpose is to help all citizens understand the need for the changes that are being made, the benefits of them, and how residents are part of the solution. Coordinating an awareness day event with the community as well as advocacy groups like the Susquehanna River Basin Commission and the Chesapeake Bay Foundation will help people understand that stormwater runoff is not just a problem for their street, but also a citywide issue, and a regional one as well. Community service groups like the Scouts could participate, even by doing some of the work listed above in other sections. Neighboring Camp Hill has such a day focused on stormwater.

Another feature of Awareness Day is to encourage property owners in the city to replace some or all their grass with more native vegetation, especially along sidewalks and curbs. The goal is to catch any fertilizer or pesticide that could run off from lawns onto sidewalks and eventually into waterways. Property owners could also be encouraged to replace asphalt driveways and parking lots with permeable pavement and/or concrete lattice pavers that allow for more infiltration into the ground. Seminars and educational events could happen throughout the city as well as at locations like Harrisburg University, Penn State Harrisburg, Widener, and at public schools and fire stations. While likely not feasible at this point, the city should consider in the future implementing an additional property tax that can be reduced by property owners if they take the above steps. For example, the tax rate increase could be an addition to the millage rate by square footage of asphalt parking lot, or an addition to the millage rate for property abutting sidewalk that is not a rain garden.
An Awareness Day celebration is also important in helping to ensure that routine maintenance is done on all the different rain gardens and systems that have been established. By having a day where people learn more about the benefits of the solutions put in place, it is also possible to educate them on what maintenance is required, and even set up schedules by community where people will work together to maintain the gardens established in their neighborhood. As noted above, it is important that people feel a sense of joint ownership over whatever is placed in their community.

Another key element of an event like an Awareness Day is to encourage businesses and community service centers to participate and to convert portions of their own properties into rain gardens, especially those areas that butt up against sidewalks and streets. To that end, an Awareness Day event should include both tours of rain gardens and alleyways that have been established (which will also encourage communities to maintain their systems) and a competition to see who has built the nicest, the largest, the most diverse, etc. Encouraging healthy competition among businesses and community centers in the city can help speed adoption. Furthermore, by having tours that wind through the city and let people see how it is integrating green systems throughout, people can see that there is more to Harrisburg and its neighborhoods than just the Riverfront, and that many areas have wonderful things to offer.

Conclusion

As made evident from this report, stormwater runoff is a pressing issue for the City of Harrisburg, and it needs to be solved. The runoff water is one of the major causes of flooding in the city, which as previously stated causes damage every year for both the city and its residents. While the issue might not be able to be solved by one method, it is possible to resolve through a combination of alternatives. As laid out in this report, a combination of alternatives such as the
addition of water control structures along Paxton Creek and improvements to the Spring Creek Watershed. When utilizing a combination of alternative approaches, it is possible to fix or greatly limit the issue of stormwater runoff in the City of Harrisburg, while staying within the scope of the city’s resources.
# Appendix 1 – Examples of Native Plants for Rain Gardens

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Ideal Zone</th>
<th>Drought Tolerant</th>
<th>Key Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swamp Milkweed</td>
<td>Wet</td>
<td>No</td>
<td>Can survive in standing water; essential food for Monarch Butterflies; minimal maintenance required</td>
</tr>
<tr>
<td>Mountain Mint</td>
<td>Wet</td>
<td>No</td>
<td>Very tolerant of different soil types; beloved by all manner of pollinators including Bumble Bees</td>
</tr>
<tr>
<td>Switchgrass</td>
<td>Wet</td>
<td>Yes</td>
<td>Grasses help trap debris and waste; low maintenance; pest tolerant</td>
</tr>
<tr>
<td>Bald Cypress</td>
<td>Wet/Medium</td>
<td>Yes</td>
<td>A conifer tree that can tolerate wet conditions, it can grow up to 120 feet at maturity; excellent habitat for birds; great carbon sink.</td>
</tr>
<tr>
<td>Swamp Oak</td>
<td>Wet/Medium</td>
<td>Yes</td>
<td>A deciduous tree tolerates wet conditions; grows up to 80 feet tall; excellent shade tree reducing local temperatures; acorns are preferred by rabbits and squirrels, etc.; minimal maintenance</td>
</tr>
<tr>
<td>Black Chokeberry</td>
<td>Wet/Medium</td>
<td>Yes</td>
<td>Very tolerant of both wet and dry soil, requires little maintenance. Good for native wildlife</td>
</tr>
<tr>
<td>Inkberry Bush</td>
<td>Medium</td>
<td>No</td>
<td>An evergreen shrub that requires little maintenance and is deer resistant.</td>
</tr>
<tr>
<td>Joe Pye Weed</td>
<td>Medium</td>
<td>Yes</td>
<td>Sun-tolerant; its flowers attract a multitude of pollinators including Bumble Bees and Butterflies</td>
</tr>
<tr>
<td>Bottlebrush Grass</td>
<td>Medium</td>
<td>Yes</td>
<td>Grasses help to trap debris and waste; seeds are favorite food for birds</td>
</tr>
<tr>
<td>American Cranberry</td>
<td>Transition zone away from rain garden</td>
<td>Yes</td>
<td>Produces edible fruit; can tolerate both dry soils and wet, pest tolerant, supports native wildlife. Catches waste.</td>
</tr>
<tr>
<td>Fragrant Sumac</td>
<td>Transition zone</td>
<td>Yes</td>
<td>Low growing ground cover; provides good habitat to local wildlife; beautiful fall colors; traps garbage and debris</td>
</tr>
<tr>
<td>Butterfly Weed</td>
<td>Transition zone</td>
<td>Yes</td>
<td>Another variety of milkweed; fabulous source of pollen and nectar; supports Butterflies, Bumble Bees, etc</td>
</tr>
<tr>
<td>Threadleaf coreopsis</td>
<td>Transition zone</td>
<td>Yes</td>
<td>Perennial flowering plant boasting golden-yellow flowers from mid-summer to early fall. Limited maintenance; deer resistant; attracts beneficial insects and butterflies</td>
</tr>
<tr>
<td>American Buckeye Tree</td>
<td>Transition zone</td>
<td>Yes</td>
<td>A deciduous tree that grows to 75’ high; beautiful flowers are popular with butterflies</td>
</tr>
</tbody>
</table>
More examples and a complete list of recommended plants for rain gardens can be found at the Penn State Extension website [https://extension.psu.edu/rain-gardens-the-plants](https://extension.psu.edu/rain-gardens-the-plants)
## Appendix 2 – Examples of Grants

<table>
<thead>
<tr>
<th>Grant Source</th>
<th>Link</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Fish and Wildlife Foundation</td>
<td>[Appalachian Mountains Joint Venture (amjv.org)]</td>
<td></td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>[ENGAGING WITH COMMUNITIES IN PUBLIC LAND STEWARDSHIP</td>
<td>A Toolkit for Building and Sustaining Effective BLM Partnerships with Friends Groups</td>
</tr>
<tr>
<td>USDA Urban Forestry</td>
<td>[NATIONAL-UCF-NFA-RFP.pdf (urbanandcommunityforests.org)]</td>
<td></td>
</tr>
<tr>
<td>Partners for Fish and Wildlife</td>
<td>[<a href="https://www.grants.gov/web/grants/view-opportunity.html?oppId=336921">https://www.grants.gov/web/grants/view-opportunity.html?oppId=336921</a>]</td>
<td></td>
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<tr>
<td>Department of the Interior</td>
<td>[View Opportunity</td>
<td>GRANTS.GOV](<a href="https://grants.gov/">https://grants.gov/</a>)</td>
</tr>
<tr>
<td>Department of Transportation</td>
<td>[RAISE Discretionary Grants</td>
<td>US Department of Transportation](<a href="https://www.dot.gov/raise">https://www.dot.gov/raise</a>)</td>
</tr>
<tr>
<td>Flood Mitigation Assistance Grant Program</td>
<td>[Resources for the Flood Mitigation Assistance Grant Program</td>
<td>FEMA.gov](<a href="https://www.fema.gov/">https://www.fema.gov/</a>)</td>
</tr>
</tbody>
</table>
Acknowledgements

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https://www.plantgardener.com/how-much-rooftop-garden-cost/

https://dced.pa.gov/programs/weatherization-assistance-program-wap/


