APPENDIX II

HENSON CREEK VILLAGE AREA STUDY

ENVIRONMENTAL PRESERVATION AND FLOOD CONTROL

KCI

PRINCE GEORGE'S COUNTY
Planning Department

December 2021

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Henson Creek Trail
PHOTO BY JANTOS/CC BY 2.0

PHOTO BY KCI, MAY 2019

Henson Creek floodplain

Executive Summary

The Prince George's County Planning Department of The Maryland-National Capital Park and Planning Commission (M-NCPPC), hereinafter referred to as "the Commission," hired KCI Technologies (KCI) to prepare an environmental assessment with recommendations, as part of a larger effort, for an approximately 159-acre area of Prince George's County in Planning Area 80, located west of MD 210 (Indian Head Highway), north of Old Fort Road and Oxon Hill Road, and east of the Tor Bryant Estate subdivision (hereafter referred to as "Henson Creek Village"). The goal of the environmental study is to provide the community and planning staff with research and implementation recommendations that respond to environmental sensitive revitalization and redevelopment of the study area.

Henson Creek Village contains many valuable ecological and environmental assets including wetlands, rivers, floodplains, and forests. Henson Creek and Hunters Mill Branch Tributary flow through Henson Creek Village to the Chesapeake Bay. These natural areas are regulated to limit disturbance and promote preservation. Other regulations in place that dictate what and how development occurs within the corridor, this includes zoning, floodplain, and stormwater management for both water quality and quantity.

Flooding, identified as a major concern by stakeholders, is primarily caused by over-development and development without adequate stormwater management within the watershed; destruction or alteration of natural functions including wetlands, forests, and floodplains; and an increase in the frequency and magnitude of severe storms.

To revitalize the community, while also addressing flooding, recommendations for redevelopment of Henson Creek Village take a comprehensive approach including preserving, protecting, and restoring natural areas and functions; expanding the park and trail network; redevelopment of existing impervious areas (developed lands where water cannot absorb into the ground) in accordance with the floodplain and stormwater regulations; and working to implement solutions upstream of Henson Creek Village to reduce flooding. Preservation, restoration, and enhancement of natural areas both within and upstream of Henson Creek Village will fulfill goals

outlined in the Prince George's County 2017 Resource Conservation Plan, improve water quality, and reduce flooding. Recommendations also include restoration of impaired natural areas including expanding wetlands and forest plantings and reconnecting the streams to the floodplains. While counterintuitive, expanding the floodplain in areas will help alleviate flooding downstream by giving the water a place to go. This means restoring and enhancing the areas within the historical Henson Creek floodplain, including those that were filled in the past, and regrading them so they are lower. This gives the water a designated area to spread out. These opportunities could be realized through public-private partnerships, voluntary buyouts, or other property acquisition strategies.

Expansion of the Henson Creek Trail network has health and wealth benefits and supports the goals and objectives as defined in the 2017 Resource Conservation Plan, as well as those expressed by stakeholders. The trail network can be extended through created or preserved natural areas and connected to existing amenities.

Redevelopment within Henson Creek Village will require several factors of responsible development (e.g., natural resource preservation or mitigation, floodplain mitigation, proper stormwater management [SWM] practices, erosion control, etc.) to ensure that Henson Creek Village is brought up to current standards and meets regulations. Given that widespread flooding is a major cause for concern in this area, various quantity control BMP measures, such as underground storage structures and underground sand filter structures, will be required. In addition, reducing flooding will require stormwater measures to be taken upstream of this drainage area, such as a possible retention pond or storm drain upgrades, to reduce the discharge within Henson Creek Village. Stormwater facilities should be designed based on updated NOAA precipitation (100-year rainfall event) to ensure adequate quantity management in current and future climate scenarios.

Building partnerships provides opportunities to share funding for the design and implementation of projects that benefit Henson Creek Village and meet MS4 Permit or mitigation requirements. Department of the Environment (DoE) and CWP implementation projects upstream of Henson Creek Village will result in improved water quality and reduced flooding. Private Investors, Grantors, and DoE fund stream,

To revitalize the community, while also addressing flooding, recommendations for redevelopment of Henson Creek Village take a comprehensive approach ...

wetland, and floodplain restoration projects that reduce flooding, enhance natural areas, improve water quality, and increase property values and recreation opportunities. Washington Suburban Sanity Commission's (WSSC) infrastructure upgrade or protection projects are often in areas requiring stream stabilization.

Redevelopment of Henson Creek Village to provide economic growth and revitalize the region is possible. The need to add higher quality sit-down restaurants and plaza settings will need to be integrated with green infrastructure and improved SWM. Responsible development within this environmentally sensitive corridor will require detailed environmental surveys and sound engineering with strict adherence to the current standards and regulations. Recommendations to preserve, protect, and restore natural areas within Henson Creek Village will require funding partnerships and voluntary buyouts or property acquisitions. To address flooding within Henson Creek Village requires a comprehensive approach including partnerships to implement upstream stormwater quantity or levee projects, preservation of functioning natural areas, and restoration of floodplains and natural features to allow a temporary area for flood flows to be retained and eventually released downstream.

Introduction and Background

Project Background

A portion of the study area was identified in the 2006 Approved Master Plan and Sectional Map Amendment for the Henson Creek-South Potomac Planning Area as the "Henson Creek Transit Village" and includes the current Livingston Square Shopping Center. This master plan envisioned the Henson Creek Transit Village as a "pedestrian-oriented village setting focused on a two to three block section of Livingston Road between Palmer and Old Fort Road." Livingston Road is predominately occupied by auto-oriented and vehicular service businesses on the west and a near-vacant strip mall anchored by a grocery store. The environmental study, in addition to addressing flooding and stormwater issues, explores the potential to preserve and restore natural areas and energize the Henson Creek Stream Valley Park as a regional recreational feature.

Goals and Objectives

Along with the economic/market study contained in Appendix I, the goal of the environmental study is to provide the research, design options, and implementation recommendations that inform the redevelopment strategies and address flooding and stormwater issues in the general area. To meet these needs, this section provides recommendations for stormwater and flood management, along with opportunities for recreational activities in the floodplain area. Development opportunities were evaluated in context with the County's floodplain management ordinance, existing environmental and infrastructure conditions, and green infrastructure opportunities as defined in the 2017 Resource Conservation Plan.

The 2017 Approved Prince George's County Resource Conservation Plan: A Countywide Functional Master Plan (Resource Conservation Plan) amends the related policies and strategies of previously approved plans, in particular the 2014 Plan Prince George's 2035 Approved General Plan (Plan 2035), 2005 Green Infrastructure Plan, and 2010 Water Resources Plan. Plan 2035 identifies policies to address potential climate change impacts, preserve and enhance environmental features, improve water quality, and integrate historical resources and sites. Pertinent policies include:

- Integrate the priority status of the designated green infrastructure network as the County's highest priority areas for preservation, restoration, and enhancement of natural resources into the work programs of all County agencies.
- Link historical resources and sites with the County's trails and sidewalk system, where appropriate.
- Integrate environmental settings of historical sites with proposed parks and open space plans.
- Fund improvements to the trail network that serves the people.
- Explore alternative trails, such as water trails, and fill gaps in the trail network.

The environmental study focuses on:

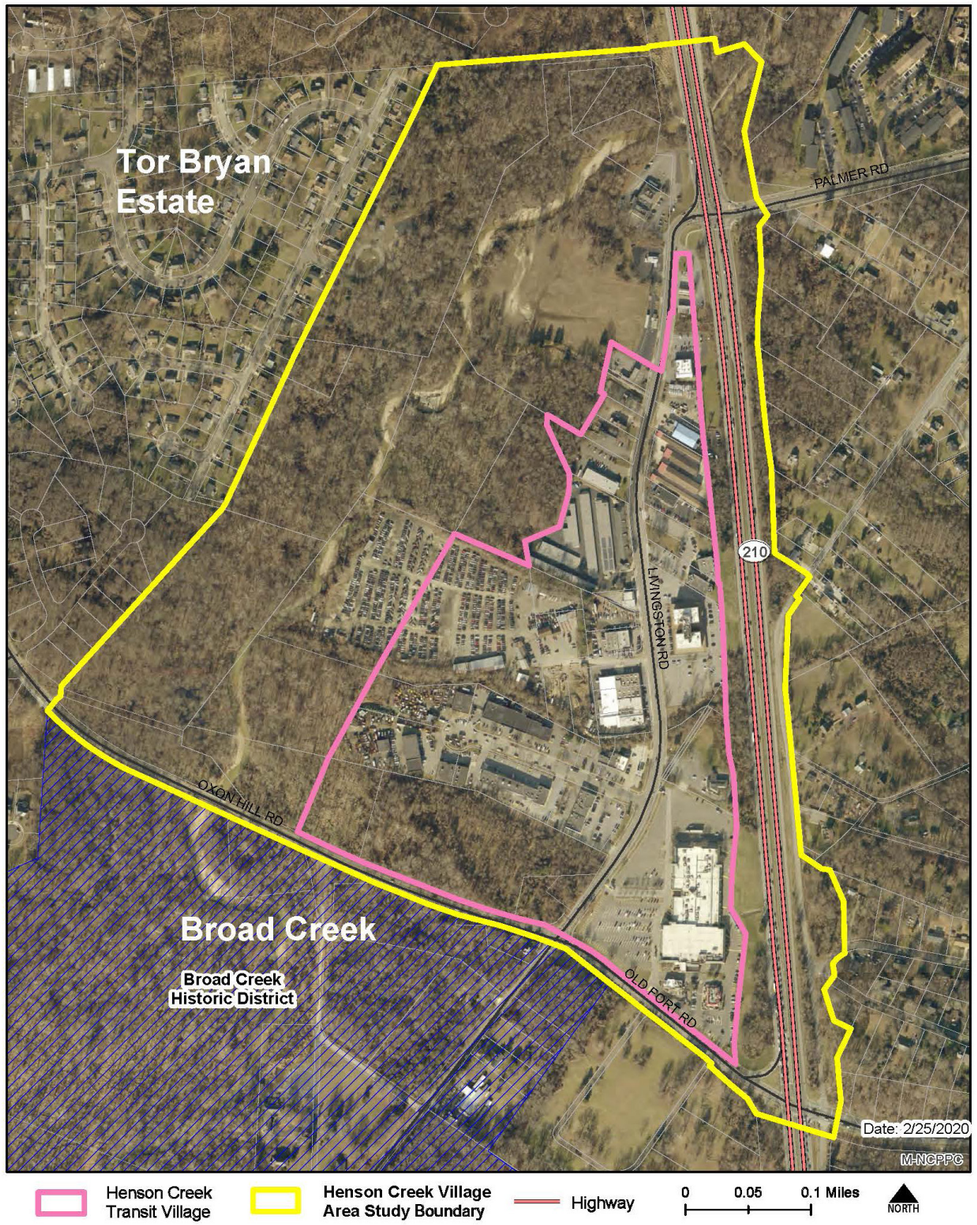
- How can economic growth occur in Henson Creek Village with minimal impact to the environment and subwatershed.
- What mitigation techniques could be appropriate to control flooding in Henson Creek Village and the subwatershed.
- How can environmentally sensitive parkland be energized for public use in accordance with the plans and goals of the Prince George's County Department of Parks and Recreation.
- How will potential development scenarios impact SWM and opportunities to improve SWM with the County Code.

Existing Conditions

LAND USE

Henson Creek Village is primarily comprised of retail and office buildings located along Livingston Road from the boundaries of Oxon Hill Road and Palmer Road. The approximate 0.6 miles along Livingston Road is comprised of retail shops, automobile-oriented businesses, consumer restaurants, strip retail, and a golf driving range. Cady Drive, which intersects with Livingston Road, provides access to another row of retail business along both sides of the roadway. Henson Creek Village primarily contains impervious surfaces that vary from the office/retail buildings, roadway pavements, concrete sidewalks, and parking lots that help support the overall function of this community.

Figure 1. Figure 1. Henson Creek Village Study Area



WATERSHED

Henson Creek Village is located within the Chesapeake Bay watershed, which requires a reduction in sediment and nutrient loads (Total Maximum Daily Load [TMDL]). Henson Creek Village is also within the Potomac River Upper Tidal Drainage Basin (HUC 02140201), which is listed under section 303(d) of the Clean Water Act (CWA), as impaired for the following pollutants: polychlorinated biphenyls (PCBs) in fish tissue in tidal waters, nutrients, and sediments (Tetra Tech, Prince George's County Countywide Watershed Assessment for MS4 Permit [2014-2019], 2018).

Figure 2. Chesapeake Bay Watershed (MDE)

WETLANDS, WATERS OF THE U.S. AND REGULATED FLOODPLAIN

Henson Creek Village contains many ecological and environmental assets that, according to the 2005 Approved Countywide Green Infrastructure Plan (Green Infrastructure Plan), are either regulated or evaluated lands in the green infrastructure network because of the streams, wetlands, buffers, floodplains, steep slopes, or potential for sensitive species and habitat. Wetlands are areas where water covers the soil and is present at or near the surface of the soil all year or part of the year. Wetlands provide values that include natural water quality improvement and flood protection. The Green Infrastructure Plan identifies the tidal wetlands downstream of Henson Creek Village at the mouth of Broad Creek as a Special Conservation Area given its importance to the overall ecology of the Lower Potomac River Basin.

Henson Creek and Hunters Mill Branch are perineal channels (where waters always flow) that are classified as Waters of the U.S. and flow through Henson Creek Village. Henson Creek runs parallel to Livingston Road and plays a key role in the overall ecosystem of Henson Creek Village. Henson Creek is situated within a reserved open space series of parcels to allow space for natural river functions. Hunters Mill Branch runs tangential to Livingston Road and MD 210 (Indian Head Highway) and joins Henson Creek within Henson Creek Village. Henson Creek and Hunters Mill Branch are part of the Potomac River Watershed Upper Tidal Basin (number 02140201). Henson Creek and Hunters Mill Branch both are designated by the Maryland Department of the Environment (MDE) as Use Class I for Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life. Based on the designated use class, MDE also identifies Henson Creek and Hunters Mill Branch as impaired by chloride, habitat alterations, and sulfate. MDE attributes these impairments to channelization and urban runoff/storm sewers.

Henson Creek receives stormwater runoff from throughout its 24-square-mile drainage area (DA) and joins with Broad Creek downstream of Henson Creek Village. Hunters Mill Branch drainage area is approximately 2.5 square miles. The figures below reflect the estimated drainage areas (U.S. Geological Survey, StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications StreamStat, March 2020).

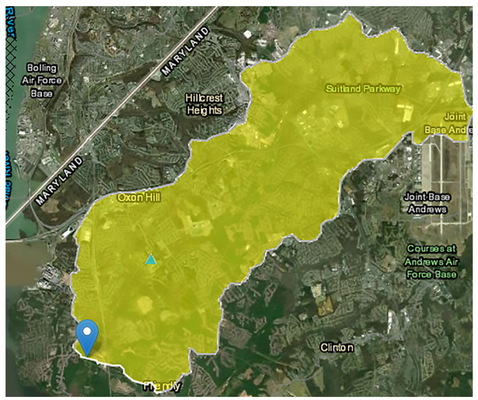


Figure 3. Henson Creek DA 24 sq. mi. DA (USGS)

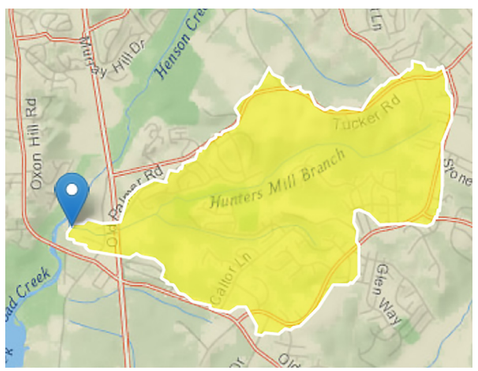


Figure 4. Hunters Mill Branch 2.5 sq. mi. DA (USGS)

Existing wetlands and floodplain

PHOTO BY KOI

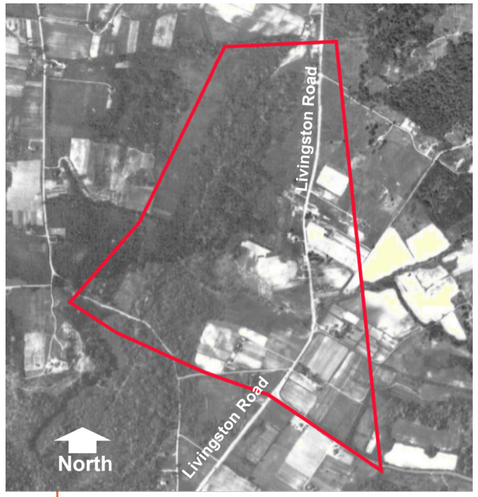
SIGNIFICANT LOCATIONS OF INTEREST NEAR HENSON CREEK VILLAGE

There are many significant locations of interest within the vicinity of Henson Creek Village as shown in the map.

Figure 6. South County Historic Sites (from Potomac River Heritage Tourism Alliance)

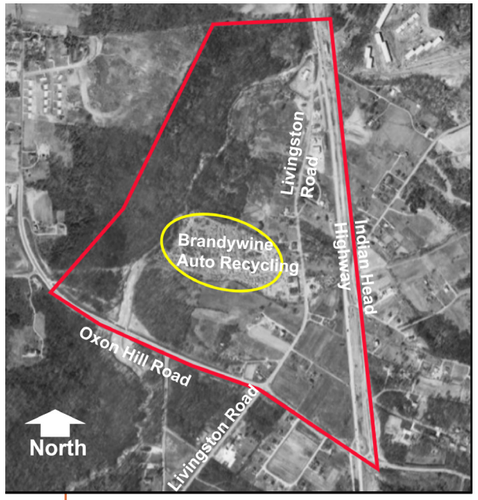
Historical Conditions

TIME LAPSE AND HISTORY OVER THE YEARS



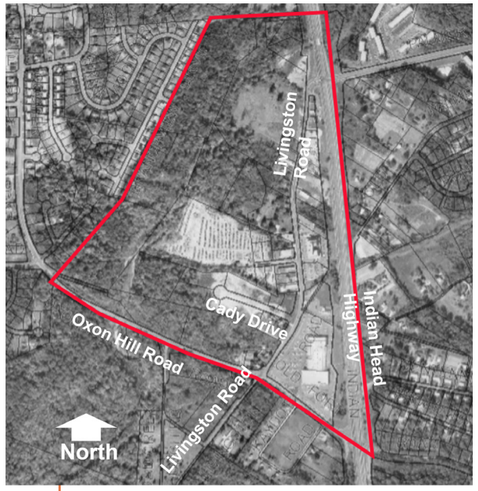
1938

Henson Creek Village comprised relatively large parcels of undisturbed forests and natural vegetation except for a few buildings. Only Livingston Road existed in the north/south direction of travel. There are large plots of cleared, open fields, with significant altering and clearing around Hunters Mill Branch Tributary, but Henson Creek is still surrounded by forests. Neither MD 210 nor Oxon Hill Road existed during the period as indicated by the historical pictures.



1965

During this time, the addition of Oxon Hill Road and MD 210 encouraged development within the Henson Creek Village corridor. As seen within the figure, the parking lot (Brandywine Automotive Center today) is already constructed and operational. The northwest corner of Livingston and Oxon Hill Roads, which is forested in present day, included single-family homes with an access roadway as shown in the historical pictures. Henson Creek, near the crossing of Oxon Hill Road, appears to have widened significantly, which could be because of increased silt deposits, increased flow volumes, or planned widening due to the bridge along Oxon Hill Road.



1980

As indicated by the historical photos, a lot of the development you see today was completed during this period. The Livingston Square Shopping Plaza, complete with the building and parking areas, was constructed and operational at its present-day location. At the northwest corner of Livingston and Oxon Hill Roads, several homes were removed and replaced with forest cover; two parcels within this area still contain structures and an access road remains. Present-day Cady Drive is cleared of forest cover and contains a few structures. The driving range (presently known as Fort Washington Golf Range) is constructed and operational. A large portion of the impervious surfaces within Henson Creek Village were completed during this period.

2020

Today, additional structures are present including the storage space structures on either side of Livingston Road and the development of Cady Drive and retail businesses that were added circa 1990. The northwest corner parcel of Livingston and Oxon Hill Roads went through some significant development changes between 1980 and 2020. A large portion of the forest area was cleared but eventually all structures were razed and new forest cover was planted circa 2000. Cady Drive was completed as a cul-de-sac roadway with the retail business structures on both sides constructed in the early 1990s. Henson Creek, while in relatively the same drainage path throughout the years, appears to be experiencing lateral migration and growth of depositional features.

Regulations and Guidance

Henson Creek Village has seen significant development that predates current regulations established to protect natural features from destruction and the community from devastating flooding. These regulations include the Prince George's County 2018 Zoning Ordinance, Floodplain Ordinance, and SWM regulations.

Zoning Regulations

The zoning map for Henson Creek Village, as of 2020, shows a diverse assembly of zoning and land uses to support the environmental features and commercial properties within the village. Additional information about the specific uses permitted, and the detailed description for each zone, can be found within the Prince George's County Code, Subtitle 27 Zoning.

Henson Creek is a significant environmental asset to this region, the area surrounding the stream is typically categorized as Reserved Open Space (R-O-S). The primary goal of this zone is to preserve in perpetuity large areas of vegetation and open space. These areas are environmentally sensitive and should primarily be retained as land for nonintensive active or passive recreational use. There are also areas classified as Open Space (O-S), where the primary goal is to provide land conservation for agriculture and natural resource use. Any development within this zoning district should be extremely limited to avoid disturbance to environmentally sensitive areas. Within Henson Creek Village, the function of these two zones is to provide a place for the water to go during runoff events. It is especially important that any development at or near these zones have minimal impact in order to prevent further damage to the functioning of the stream and environment.

The auto salvage lot (Tax Account # 1347848, Parcel 106) located within the O-S is a key example of disturbance near an environmentally sensitive area that should be avoided. Auto salvage yards typically produce pollutants such as motor oil, diesel fuel, gasoline, and other toxic carcinogens that can leach into the soil subsurface before entering the groundwater and eventually into Henson Creek. Other harmful pollutants such as heavy metals, vehicle battery acid, and other suspended solids can have a harmful impact to the chemistry of the soil and the surrounding environmental features. This salvage yard has been in operation since well before the 1940s, no studies have been completed to determine

Figure 7. Parcel 106 (Source - PGATLAS)

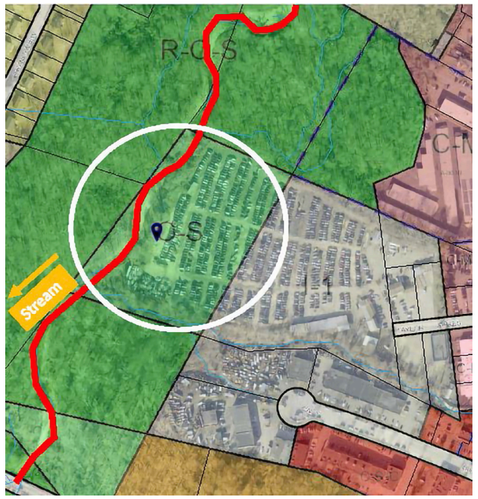
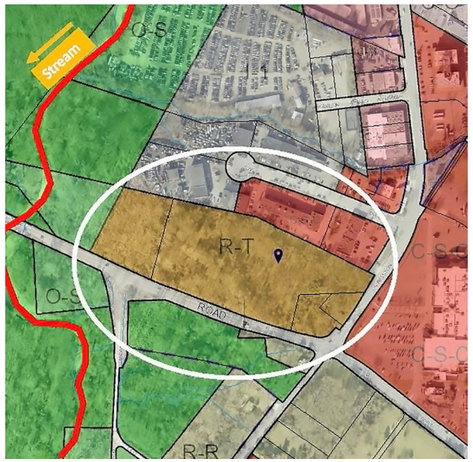


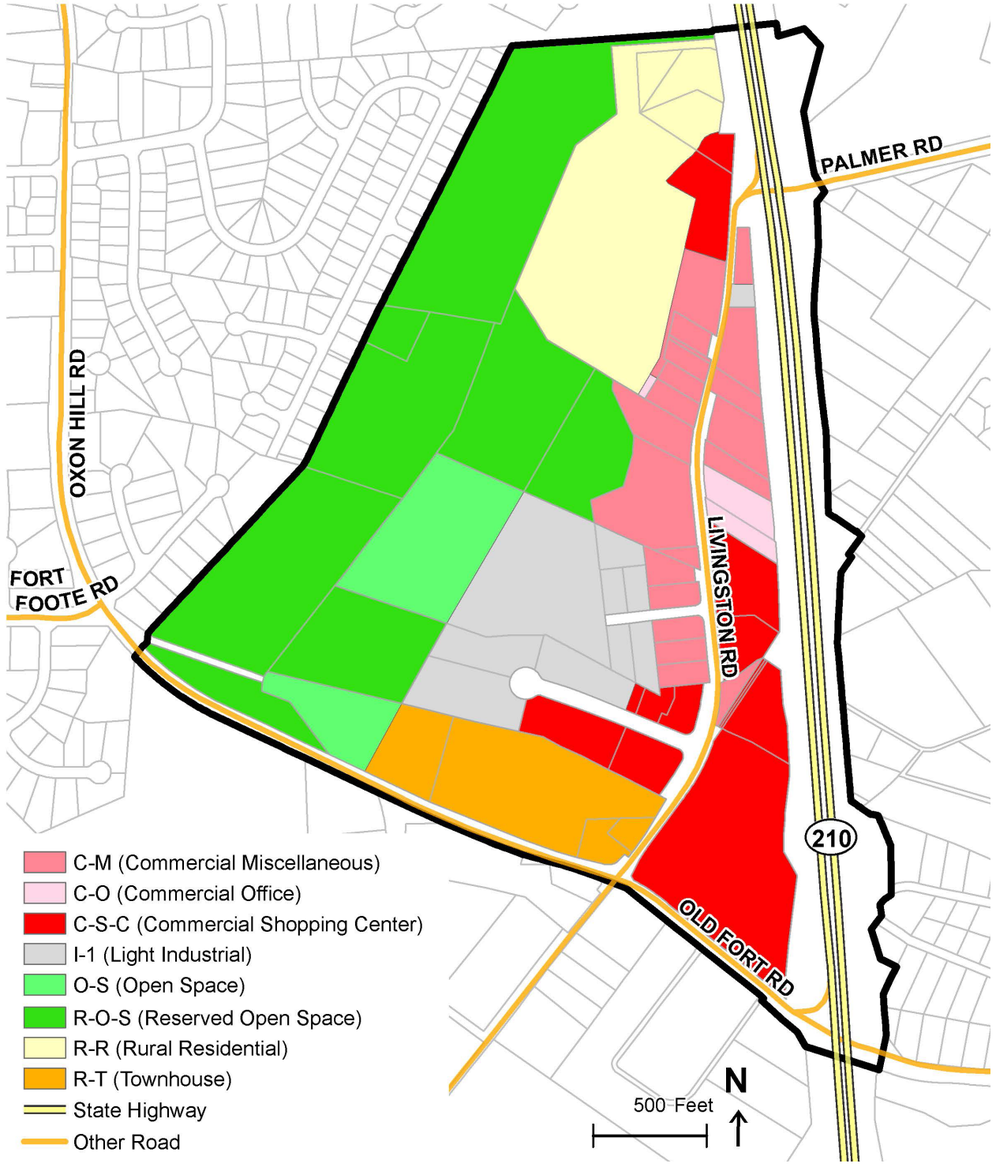
Figure 8. Parcel 144, Tax Account #0384990



the impact of this operation to the adjacent Henson Creek waterway nor any auxiliary effects downstream of Henson Creek Village. The figure shows the proximity of the salvage yard to Henson Creek, which is approximately 70 feet in distance measured using aerial topography on PGAtlas.

Another parcel that can be closely analyzed for possible development is Parcel 144 (Tax Account

Figure 9. Zoning Map (Source - Prince George's ArcGIS)



#0384990), which is zoned Townhouse (R-T). The zoning regulations allow for this parcel to provide three to six attached dwelling/townhouse type developments that would efficiently use available land, public utilities, and public facilities.

Sec 27-433(d)(2) states, *"There shall not be not more than six (6) nor less than three (3) dwelling units in any horizontal, continuous, attached group, except where accepted by the Planning Board or District Council, as applicable, determines that more than six (6) dwelling units (but not more than eight (8) dwelling units) or that one-family semidetached dwellings would create a more attractive living environment, would be more environmentally sensitive, or would otherwise achieve the purposes of this Division…"*

If developed in accordance with the zoning code, it is recommended that only the portion outside the 100-year floodplain be developed and that tree removal be minimized. Increased tree canopy coverage in residential zones offers numerous benefits—promotes clean air while combating air pollution, reduces summer peak temperatures, provides wildlife habitat, reduces stormwater run-off and enhances property values. Depending on the amount of forest that is preserved and removed, Prince George's County requires that woodland conservation be completed through an off-site tree bank within the same watershed to obtain credits for removed trees. This tree bank would be within the same watershed and calculations would need to be provided to show the exact amount of forest mitigation required. In addition, a Natural Resources Inventory and Forest Stand Delineation (NRI/FSD) would need to be completed to determine the extent and type of forests, wetlands, streams, or other natural resources located within the parcel. A tree conservation plan would then be completed by a qualified professional to detail what is being removed, preserved, and how forest conservation requirements would be met.

Even though this parcel is heavily forested and undeveloped, future development may occur within this area per the County zoning code. If this parcel is developed, strict adherence to environmental requirements and adequate stormwater management and sediment control measures during the design and implementation will be necessary to mitigate impact to the nearby environmental features.

NOAA Rainfall Event Precipitation

NOAA Atlas 14 contains the precipitation frequency estimates for different locations within the United States. This information helps provide temporal distribution of heavy precipitation, analysis of seasons within the area, and overall trends of annual maximum precipitations for any given area. The current NOAA Atlas 14 Precipitation Frequency Estimate for Central Prince George's County is 8.5 inches for a 24-hour rainfall intensity. This intensity, along with a rainfall distribution type of NOAA "C," identified in NRCS-SCS methodology, should be used during the design of stormwater management ponds for computing the 100-year discharge and 100-year flood control attenuation. The 100-year storm refers to the estimated probability of a storm event happening in any given year. A 100-year event has a 1 percent chance of occurring in any given year.

Table 1. NOAA Atlas 14 Point Precipitation Rainfall Event Frequency (in inches) in Prince George's County

Duration	24-hour rainfall
2 year	3.19
10 year	4.93
100 year	8.5

Similarly, SWM ponds designed in Prince George's County should use a 24-hour rainfall intensity of 4.93 inches (10-year storm) and 3.19 inches (2-year storm) as based on NOAA Atlas 14 and NOAA "C" rainfall distribution.

Prince George's County Development Within a 100-year Floodplain

As shown in the figure, a large portion of Henson Creek Village is located within the 100-year floodplain. Any development would have to follow the guidelines within the Prince George's County Floodplain Ordinance as discussed below.

Establishment of the County Floodplain

Prince George's County Department of Permitting, Inspection and Enforcement (DPIE) has established the County floodplain areas as those locations that are at a high risk of inundation by the 100-year flood. These areas are delineated on official floodplain maps and maintained through County regulations. All County floodplains are available through public access of the County's GIS-based floodplain maps, which is operated by M-NCPPC's Prince George's County Planning. Much of Henson Creek Village is within the County floodplain.

Sec. 32-204(b) of the Prince George's County Code of Ordinance states that all of the following are to be included as part of the County floodplain:

100-year floodplain as determined by the Federal Emergency Management Agency (FEMA), including:

1. "Delineated floodplains – areas that have a detailed study to determine the 100-year floodplain
2. Special flood hazard areas, as identified by the County
3. Wetland floodplains – areas of wetland subject to inundation by the 100-year flood
4. Area delineated by approved County Comprehensive Watershed Management Plans, supporting data, or other County floodplain studies to be subject to the 100-year flood
5. Areas delineated by any other floodplain studies prepared using the County's GIS based floodplain models."

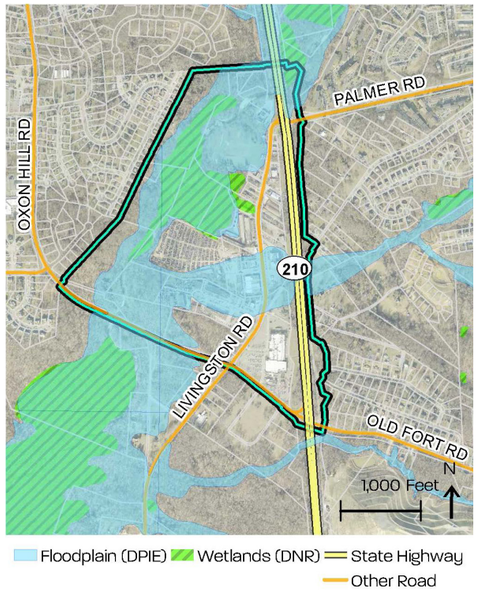
Development Regulations

FLOODPLAIN ORDINANCE

Within a County floodplain, the following development is permitted in accordance with Sec. 32-205(b) of the Prince George's County Floodplain Ordinance:

1. "The modification, alteration, repair, reconstruction, or improvement of a structure which does not constitute substantial improvement to the structure (including improvements to historic structures that do not affect the exterior dimensions). The improvements shall be elevated and/or flood proofed to the greatest extent possible. The elevation of the lowest floor shall be at least one (1) foot above the elevation of the 100-year flood or those parts of the improvement below the elevation of one (1) foot above the 100-year flood shall be dry flood proofed in accordance with the U.S. Army Corps of Engineers flood proofing regulations.
2. Private and public utilities and facilities which conform to the construction, design, and flood proofing requirements of this Division.
3. Private or public streets crossing the floodplain.
4. Stormwater management facilities.
5. Small projections leading off of the floodplain which would be enclosed by storm drainage pipes.
6. Lowest Floor and Setback Requirements: Any new or substantially improved residential or nonresidential structures, including manufactured homes, shall be located outside the floodplain and have the lowest floor and the surrounding ground elevated, by fill, to or above the flood protection elevation. Basements are not permitted. The elevation of the lowest floor shall be certified by a registered surveyor or professional engineer on the as-built plan or after the lowest floor is in place. All new structures in any subdivision shall be located outside the 1-percent annual chance (100-year) floodplain boundary. All residential structures shall be set back at least twenty-five (25) feet from the 1-percent annual chance (100-year) floodplain."

Figure 10. 100-year floodplain within Henson Creek Village



Any fences or enclosures that may restrict or change the direction of water, collect debris carried by the water, or that are placed within the natural flow of the floodwater to carry sediments downstream to cause damage to public or private project will not be allowed without the appropriate waivers by the County.

Any new development or substantially improved residential or nonresidential structure should be located outside of the floodplain and have their lowest floor and surrounding ground elevation up to or above the flood protection elevation. These

elevations will need to be certified by a professional land surveyor during the as-built plan or once the first floor has been erected. All residential structures should be a minimum of 25 feet from the 100-year floodplain delineated by the County.

Within Henson Creek Village, most of the proposed developments would be considered redevelopment since existing structures would be demolished and new buildings would be erected. The design of these buildings would have to be brought up to current County Code standards and proper SWM would have to be provided.

COMPENSATORY STORAGE REQUIREMENTS

Any filling or construction within the 100-year floodplain is generally discouraged by Prince George's County. DPIE has regulations in place for these circumstances to assist with the permit and development process. In cases where filling is required within the floodplain, the following regulations have been enacted by the County per Sec. 32-205 (g) of the Prince George's County Floodplain Ordinance: *"Cut and Fill: If floodplain storage is reduced because of the project, an equal amount of compensatory storage within the floodplain shall be provided. A site grading plan prepared by a professional engineer, showing a balance of cut-and-fill, shall also be submitted. The limits of the floodplain before and after development shall be clearly shown on the site plan."*

Sec. 32-205 (h): *"Changes in Base Flood Elevation: A detailed floodplain analysis shall be conducted to indicate that the new floodplain can carry the discharge of the 100-year flood without increasing the water surface elevation at any point on other private or public property either upstream or downstream from the tract to be developed, unless such lands affected by an increase in water surface elevation are either acquired by the applicant or reserved through acquisition of suitable floodplain easements, provided such increases will not, in the determination by DPIE, cause or aggravate damage to such properties. However, development shall not increase water surface elevation of the base flood more than one (1) foot at any point. The floodplain analysis shall consider backwater conditions, local obstructions and, where required by DPIE, partial or complete failure or obstruction of any culvert or enclosed storm drainage system. The new floodplain shall be designed to prevent detrimental erosion, overflow, or nuisance of any kind and shall ultimately discharge into a storm drain facility or a watercourse in accordance with County standards and procedures."*

REQUIRED FLOODPLAIN STUDIES FOR DEVELOPMENT

Any development within the floodplain of Henson Creek Village will require a thorough and detailed engineering study prepared by a professional engineering who will evaluate the entire effects of the development/construction. Sec. 32-205(i) of the Prince George's County Floodplain Ordinance states: *"…. The report shall use the 1-percent annual chance (100-year) flood and floodplain data prepared by FEMA, if applicable, and other County-approved watershed and floodplain studies. For permits that result in changes to the FEMA floodplain, evidence shall be provided that all adjacent communities and the Maryland Department of the Environment have been notified by certified mail regarding the proposed modification, as required for processing of a State of Maryland Waterway Construction permit. Copies of these notifications shall then be forwarded to FEMA's Federal Insurance Administration. The applicant or developer must conduct a study to assure that the 1-percent annual chance (100-year) flood carrying capacity within the altered or relocated portion of the watercourse in question will be maintained. If the development involves stormwater management facilities, the owner shall execute a declaration of covenants for stormwater management maintenance with the County, which shall be recorded in the Land Records."*

All plans and studies that are submitted to the DPIE would be subject to review and may be used by the County for reviewing other development or for other purposes (such as adjoining properties or surrounding properties within the area). By completing the floodplain study, any new development within the study area will be able to determine the base flood elevation and the required elevations to set the first-floor elevation of the structure. Also, this floodplain study will help determine downstream effects to Broad Creek and the communities in the adjacent region of the village.

WAIVER REQUIREMENTS FOR DEVELOPMENT WITHIN A FLOODPLAIN

In order to complete development within a County floodplain other than what is permitted, an approved waiver will be required by the Prince George's County DPIE Director.

The request for the waiver would include the following:

1. The information required for a permit for development.
2. A statement explaining the need for the development, any benefit to the general public, and steps taken to mitigate any threat of potential flooding, flood damage, or other environmental consequences from the development.
3. Plans and studies required by the reviewing agency.

Sec. 32-206(e) of the Prince George's County Floodplain Ordinance states: *"Waivers will not be granted for any filling, or the construction or placement of any structures or obstructions which will ultimately be in the FEMA-designated Floodways,"* or in the County designated Special Flood Hazard Areas which will increase the water surface elevation of the base flood. *"Within the floodplain, waivers shall not be granted for any new structures, the lowest floors of which are below flood protection elevations."*

Sec. 32-206 (f) of the Prince George's County Floodplain Ordinance states, *"If a waiver is granted, then this should only involve the least modification necessary to provide relief. If it should become necessary to grant any variance, the applicant shall be required to comply with all applicable requirements of the National Flood Insurance Program regulations (60.3d) including the requirements for elevation, flood proofing and anchoring. The applicant must also comply with any other requirements considered necessary by the regulatory agency Department. Notwithstanding any of the provisions above, however, all structures shall be designed and constructed to have the capability of resisting the 100-year flood. Flood proofing is not an option in residential construction. All residential structures must be elevated."*

Prince George's County DPIE has passed several different legislations in the recent years to impose stricter floodplain regulations, especially in those areas, such as Henson Creek Village, that have a long history of flooding or are prone to high flooding events. Any development within this study area would likely not receive a floodplain waiver, but instead would be subject to full development standards to bring the property and proposed development up to current code and regulation.

DESIGN STANDARDS WITHIN A FLOODPLAIN

Prince George's County has set forth various design guidelines and construction standards required within a floodplain. The regulations are specified within the County Floodplain Ordinance.

Sec. 32-207(a)(1) of the County Floodplain Ordinance requires that all new construction and substantial improvements, which are permitted in the floodplain, shall be:

1. Designed (or modified) and adequately anchored to prevent flotation, collapse, or lateral movement of the structure.
2. Constructed and placed on the lots to offer the minimum obstruction to the flow and height of the floodwater.
3. Constructed with materials and utility equipment resistant to flood damage.
4. Constructed by methods and practices that minimize flood damage and adverse environmental impacts.

During the design of the structure, Section 32-207(a)(2) states, *"The elevation of the lowest floor of all new or substantially improved structures, except for garages, storage and accessory structures, which are less than 300 square feet and not used for human habitation, shall be at least one (1) foot above the 100-year flood. Basements in buildings within the floodplain are prohibited."*

In areas where fill is allowed within the floodplain, the regulations require adherence to compensatory storage requirements, as well as the following:

1. Appropriate fill material approved by the County will be required within this area.
2. Fill slopes shall be no steeper than one (1) vertical to two (2) horizontal, unless substantiating data justifying steeper slopes are submitted to and approved by the County.
3. Fill shall be used only to the extent to which it does not adversely affect adjacent properties.
4. Regarding the landscape design of the development, it will be highly important to maintain natural vegetation within the floodplain to limit disturbance. Adequate ground cover should be provided to promote soil stabilization and prevent the risk of soil erosion. During the grading design, contours should be directed to flow away from structures but not adversely increase surface runoff to neighboring properties. The selection of plant materials should aim to reduce downstream runoff while also limiting runoff to nearby structures. The western perimeter of the Henson Creek Village study area, which fronts the Henson Creek stream, has green infrastructure already in place that should be maintained and further enhanced. The natural vegetation provides a buffer between the

development and the Henson Creek stream that will prevent further environmental damage or adverse effects to the local ecosystem.

For new public and private utilities that will be designed and installed within Henson Creek Village, this infrastructure should be flood proofed to adequately handle 100-year flood events. From Sec. 32-207(a)(9) of the Prince George's County Floodplain Ordinance, the following guidelines for public and private utilities should be maintained:

1. New or replacement water supply systems and/or sanitary sewage systems shall be designed, and flood proofed to eliminate or minimize infiltration of flood waters into the systems and discharges from the systems into the flood waters, and to avoid impairment during flooding and to minimize flood damage
    a. Cesspools and seepage pits are prohibited.
    b. Septic tanks are permitted provided they are securely anchored to resist buoyant forces during inundation.
    c. All pipes connected to sewage systems shall be sealed to prevent leakage.
2. All gas, electrical and other facility and utility systems shall be located, constructed and flood proofed to eliminate or minimize flood damage
3. All new storm drainage facilities within and leading to or from the County floodplain shall be adequately designed, flood proofed and installed to eliminate or minimize property damage resulting from the flood waters of the 100-year flood and to minimize adverse environmental impacts of their installation and use.

PERMIT REQUIREMENTS WITHIN A FLOODPLAIN

Prince George's County requires all development, construction, fill, or structures within a floodplain to have the proper permits through the regulatory agency. Construction is only allowed to begin once all local, state, and federal permits have been obtained by the applicant. The permit process includes an application submitted to DPIE to apply for either the building or grading permit application.

The following information is required as part of the permit package contained in Sec. 32-209:

1. "If the development includes any grading, new construction, or exterior modifications to existing structures, a site grading plan prepared by a professional engineer or architect showing: the size and location of the proposed development and any existing buildings or structures; the location, dimensions and elevation in mean sea level of the site in relation to the stream channel, shoreline and the floodplain; the elevations of the 1-percent annual chance (100-year) flood, the existing and proposed final grading and the lowest floor elevations of all structures; the method of elevating the proposed structure, including proposed fill, retaining walls, foundations, erosion protection measures; and such other information as may be required by the Department.
2. For substantial improvement to existing structures, a summary description of the proposed work and estimated cost.
3. New construction or substantial improvements of nonresidential structures within the floodplain shall be certified by a professional engineer or a licensed architect, through the execution of a Flood Proofing Certificate that states that the design and methods of construction meet the requirements of this section. A Flood Proofing Certificate shall be submitted with the construction drawings.
4. A plan showing the location of all existing and proposed public and private utilities, facilities, drainage structures and road access. If the 1-percent annual chance (100-year) flood elevation has been determined, it shall be delineated on the proposed plan. For all proposals associated with a watercourse having a drainage area of fifty (50) acres or more, the Department shall approve the 1-percent annual chance (100-year) flood elevation using floodplain models and the applicant shall delineate it on the proposed plan. Private consultant engineering studies and studies using the County's GIS-based floodplain models will be accepted by the Department. In addition, field survey information of structures, within the floodplain, as may be required by the County to complete the study, shall be supplied by the applicant. For all proposals associated with a watercourse having a drainage area of fifty (50) acres or less, the delineation of the 1-percent annual chance (100-year) flood may be excluded upon the approval of the Department. All plans shall be certified by a professional engineer."

According to Sec. 32-209(d), the following is reviewed by DPIE once the application has been received:

1. "The proposed development is consistent with the construction and design requirements of this Division
2. Adequate drainage is provided to reduce exposure to flood hazards
3. The plans provide at least one access which will permit safe vehicular ingress and egress from the subdivision and/or new development during a 100-year flood
4. Adequate measures have been taken to minimize any potential adverse environmental impacts of the proposed development
5. The development complies with the requirements of this Division and all other applicable codes and ordinances."

During the construction of a project, Prince George's County DPIE will closely monitor the progress to ensure that it adheres to the approved plans and permit. The premise will also be subject to inspection by MDE to ensure compliance with the permit and local regulation (i.e., proper sediment control and adherence to the proposed limit of disturbance). A use and occupancy permit will only be approved by the DPIE after a complete elevation certificate is provided by a registered land surveyor or engineer certifying the "as-built" elevation of the proposed construction.

Any applicant who fails to comply with the standards or requirements set by the Prince George's County regulatory agency will be subject to stop work notices, fines, or imprisonment depending on the nature of the offense. Further information on this matter can be found in greater detail within the County Floodplain Ordinance.

Figure 11. Site Development Concept Permit Process (DPIE)

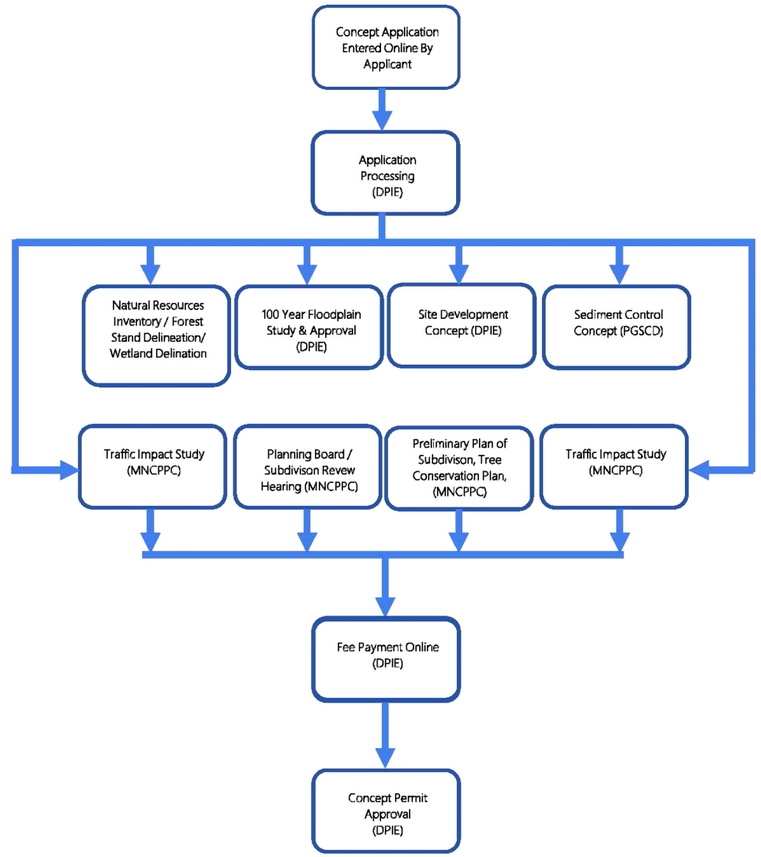
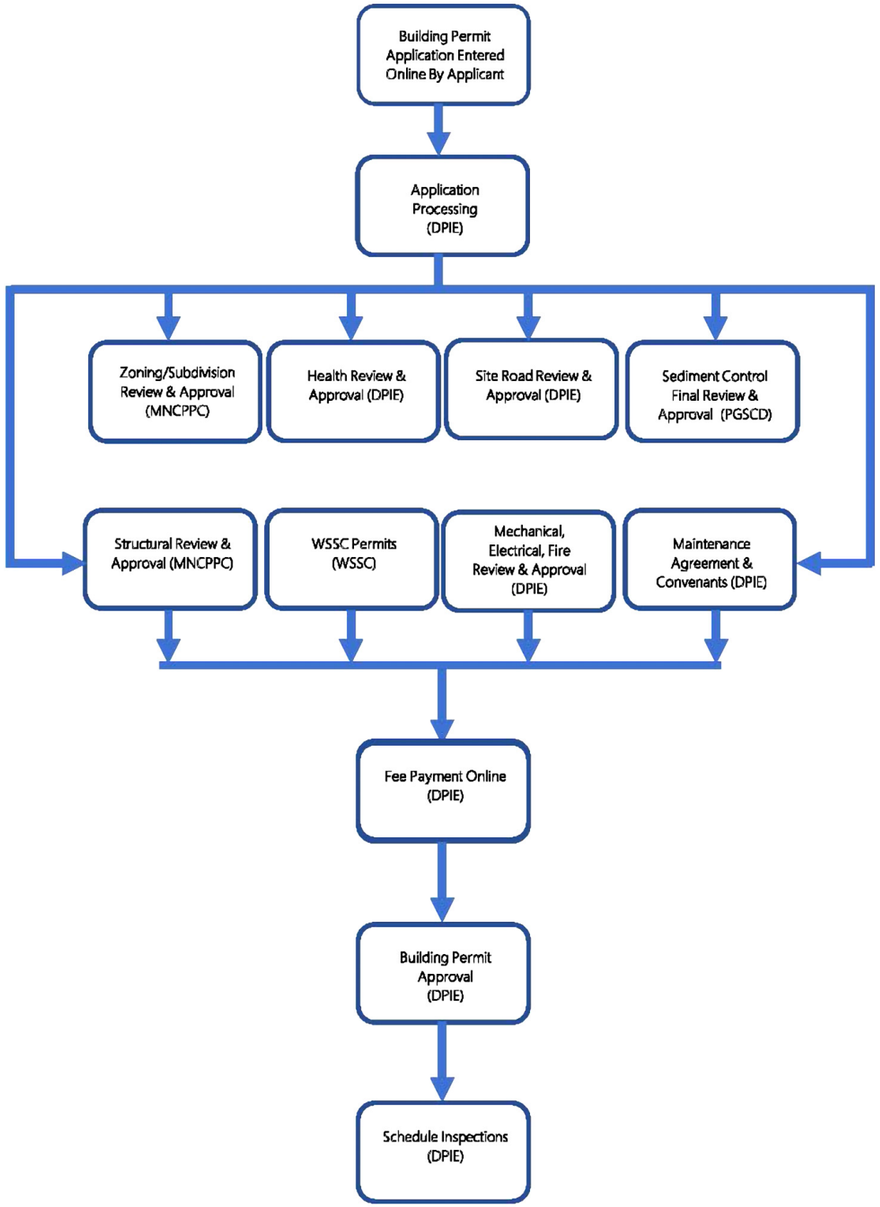


Figure 12. Building Permit Process (DPIE)



Stormwater Management (SWM)

Prince George's County Goal and Purpose

MDE's Stormwater Management Act of 2007 established a comprehensive process for SWM approval by implementing environmental site design (ESD) using practices in Chapter 5 of the Maryland Design Manual to the maximum extent practicable (MEP), and supplemented by structural practices as described in Chapter 3 of the Maryland Design Manual used as necessary to meet stormwater requirements (Maryland Department of the Environment, Stormwater Design Manual, Volume I and II. (2009), April 2021). Prince George's County has also provided guidance in the design of SWM systems through the County's Water Quality Resources and Grading Code (County Code Sec. 32 – Division 3).

According to Chapter 5 of the Maryland Design Manual, design engineers are to complete a stormwater management plan that achieves the following goals:

1. "Prevent soil erosion from development projects.
2. Prevent increases in nonpoint pollution.
3. Minimize pollutants in stormwater runoff from both new development and redevelopment.
4. Restore, enhance, and maintain chemical, physical, and biological integrity of receiving waters to protect public health and enhance domestic, municipal, recreational, industrial, and other water uses as specified by MDE.
5. Maintain 100 percent of the average annual predevelopment groundwater recharge volumes.
6. Capture and treat stormwater runoff to remove pollutants.
7. Implement a channel protection strategy to protect receiving streams.
8. Prevent increases in the frequency and magnitude of out-of-bank flooding from large, less frequent storms.
9. Protect public safety through the proper design and operation of SWM facilities."

The purpose of the County Code and MDE's Maryland Design Manual is to work in conjunction to ensure that all new land development, redevelopment projects, or other land impacts are properly permitted by DPIE to ensure they meet SWM systems that:

1. "For new land development, replicate, as much as practicable, woods in good condition for the disturbed area.
2. For redevelopment, water quality measures would have to be provided to the full extent as a new development.
3. Prevent loss of life and significant property damage that would otherwise be caused by major storms.
4. Provide an acceptable degree of access and use of property during and following less severe storms.
5. Preserve, to the extent possible, desirable natural watercourses and natural habitats.
6. Adequately convey stormwater flows from upstream sources.
7. Mitigate the adverse effects of stormwater flow on downstream properties."

National Pollutant Discharge Elimination System (NPDES) Phase I MS4 Permit

The NPDES Municipal Separate Storm Sewer System Discharge Permit (MS4) covers all stormwater discharges owned and operated by Prince George's County, Maryland. This includes all conveyance systems including roads with catch basins, curbs, gutters, ditches, manmade channels, or any storm drains owned by the County that discharge stormwater to waters of the state and the United States. The County has the responsibility to manage and enforce a stormwater management program (SWMP) in accordance with the CWA and corresponding stormwater NPDES regulation to meet the following:

1. "Effectively prohibit pollutants in stormwater discharges or other unauthorized discharges through the County's Illicit Discharge Detection and Elimination inspection program as necessary to comply with the State's receiving water quality standards;
2. Attain applicable Waste Load Allocations for each established or approved TMDL for each receiving water body; and
3. Comply with all other provisions and

requirements contained in the permit, plans, and schedules developed in fulfillment of the permit."

Total Maximum Daily Load and Phase II Watershed Implementation Plan (WIP)

In the most recent reissuance of the MS4 Permit to Prince George's County, the permit required a plan to include a schedule and cost estimate for implementing water quality improvement practices, methods to track restoration plan progress, and an interactive process to evaluate restoration progress and create alternative strategies when necessary. To address efforts to clean up the Chesapeake Bay, the EPA established regulatory mandates, or TMDLs, with timelines for the state to develop a Phase I Watershed Implementation Plan that proposes load reduction strategies (nitrogen, phosphorous, and sediments) at a statewide scale to meet the Chesapeake Bay TMDL reduction goals. Prince George's County developed a Phase II Watershed Implementation Plan (WIP-II) outlining a strategy to reduce the nutrient and sediment load quantities delivered to the Bay, which includes the following sectors as part of the target plan:

1. "Wastewater treatment plans
2. Septic systems
3. Agriculture
4. Urban stormwater runoff."

Within Henson Creek Village, the primary focus will be the urban stormwater runoff as part of this initiative; WIP-II focuses on retrofitting existing developments that do not have current SWM controls in place. As per the County SWM design manual, the County will need to retrofit 7,000 impervious acres by 2025 to complete their TMDL load reduction goals.

Environmental Site Design to the Maximum Extent Practicable

In accordance with Chapter 5 of the Prince George's County SWM design manual, the design process requires the developer to achieve ESD to the MEP:

1. "Develop a map that identifies natural resource areas and drainage patterns and devise strategies for protection and enhancement.
2. Minimize total site imperviousness by implementing clustered development and other better site design techniques.

Table 2. Outfall Considerations

On-Site Considerations	Off-Site Considerations
Underground Utilities	Backwater conditions
Public (water, gas, sewer, etc.)	Downstream culvert
Private (septic systems, well heads, etc.)	Nearby stream
Steep or very flat slopes	Tidal influences
Existing and proposed sump points	Ditch or channel restrictions
Verify existing storm sewers	Large amounts of debris in channels
Soils (bedrock versus sand/ clay)	Future development

3. Demonstrate that all reasonable opportunities for meeting stormwater requirements using ESD have been exhausted by using natural areas and landscape features to manage runoff from impervious surfaces and that structural BMPs have been used only where absolutely necessary.
4. Participate in the comprehensive review process for interim plans review and approval at the concept, site development, and final phases of project design.
5. Integrate strategies for erosion and sediment control and SWM into a comprehensive development plan."

On-site and Off-site Outfall Considerations

Any new development within Henson Creek Village would need to implement outfall consideration to capture and release all the incoming stormwater and runoff. Below are some outfall considerations to be contemplated when designing and implementing these structures depending on the site conditions and intended outfall location.

Prince George's County 100-year SWM Control Legislation

In 2019, DPIE released Techno-Gram 002-2019), which identifies and clarifies the method of calculating 100-year flow rates.

The map from Techno-Gram 002-2019 identifies the locations of watersheds that are prone to high flooding. The areas in yellow identify the watersheds where high flooding is known to occur, and therefore require 100-year stormwater management to be provided for any proposed development.

In the cases where a 100-year SWM control is required, the design engineer is required to complete further downstream analysis to identify any potential flooding risks. This would typically require DA and peak flow analysis in pre and post development conditions, as well as identification of potential impacts to any downstream structures. Attenuation of the 100-year storm is required if the post development 100-year flow rate exceeds predevelopment rates, or if there is a potential for flooding.

The areas in white define watersheds where flooding to existing homes and structures are not known to occur. However, DPIE still reviews development and evaluates whether 100-year control is required on a case-by-case basis.

As shown in the figure, the area circled in red delineates Henson Creek Village, which is shown in the yellow. This means that full 100-year management would be required for all new development projects.

Predevelopment Flow Requirements

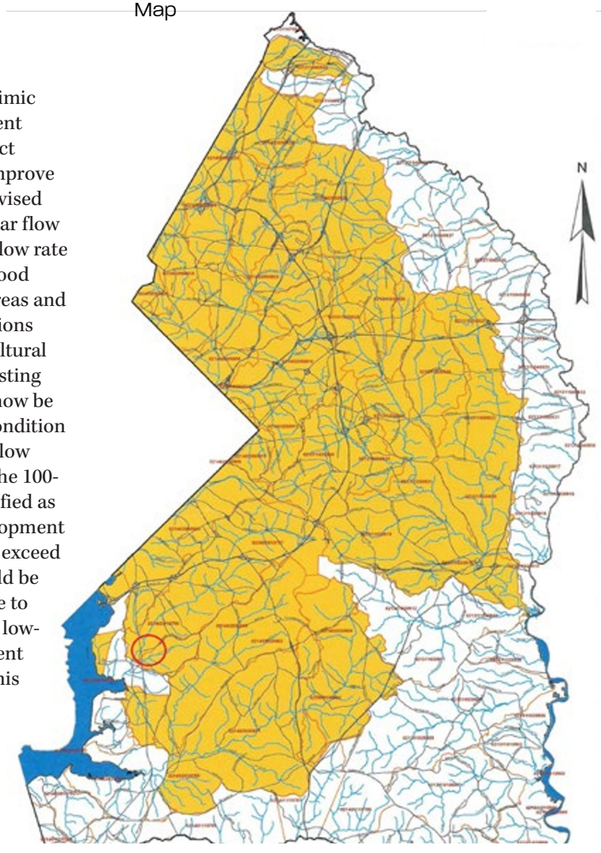
The goal of stormwater management is to mimic the runoff characteristics prior to development or predevelopment to reduce flooding, protect downstream waterways from erosion, and improve water quality. The Techno-Gram 002-2019 revised the requirements for predevelopment 100-year flow calculations. The predevelopment 100-year flow rate shall now be calculated based on woods in good hydrologic conditions for existing wooded areas and based on meadow in good hydrologic conditions for existing pervious, impervious, and agricultural areas. An example of this would be for an existing parking lot—these impervious areas would now be considered as meadow in good hydrologic condition when calculating predevelopment 100-year flow rates. The intent of this would be to reduce the 100-year flow rates in areas that have been identified as high flood prone watersheds. The post development conditions would be required to meet or not exceed these predevelopment runoff rates. This could be achieved by providing on-site storage volume to retain runoff and slowly discharge through a low-flow orifice. Different stormwater management techniques and structures are identified in this report to note how this can be achieved (See Stormwater Best Management Practices section).

Required Stormwater Management for Redevelopment Projects

In accordance with Techno-Gram 001-2019 (Prince George's County DPIE), the regulations for redevelopment projects have been revised. The new regulations require that applicants for redevelopment projects approved after May 4, 2019 need provide stormwater management water quality treatment for 100 percent of the impervious area. This was updated from the 2016 legislation, which required 75 percent of the existing impervious area to be treated.

Henson Creek Village is primarily impervious surfaces within the developed area. Through this legislation, any structures to be demolished and redesigned will need to implement ESD to the MEP to provide water quality treatment for 100 percent of the existing impervious area within the limit of disturbance.

Figure 13. Required 100 Year Management Control Map



Stormwater Management Control Requirements

In accordance with the Maryland Stormwater Manual Sec. 5.2.4, there are several quality control requirements when providing on-site SWM for a proposed development. They can be broken up within the following major categories:

- "ESD Control (Treatment of Target Rainfall Amount using MDE Table 5.3 for new development and 1 inch for redevelopment). Use 2.7 inches for maximum allowable volume to be treated at any device.
- Quantity Control (attenuation of 10-year storm increases).
- Flood Control (attenuation of 100-year storm increases).
- Conveyance (Storm Drain System)."

The criteria for sizing the ESD practices required is established based on capturing and storing enough rainfall so that the runoff leaving the site is reduced to a level that is equivalent to a wooded site in good condition as determined using United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) methods (e.g., TR-55, TR-20). The goal is to provide enough treatment through ESD practices (nonstructural BMPs found in MDE SWM Manual Chapter 5) to replicate the postdevelopment in good condition for the 1-year rainfall event, and to treat runoff from one inch of rainfall wherever stormwater management is required. When the target rainfall is not met, the remaining can be treated using the structural BMP practices (MDE SWM Manual Chapter 3). Within Henson Creek Village, the site conditions would most likely require treatment through structural practices given the rainfall intensity (see Table 1) and need to provide additional quantity control SWM.

The ESD volume requirements for the proposed development is derived with the following:

ESDV = PE x RV x A/12

PE = Rainfall target from Table 5.3, Maryland Design Manual, Chapter 5

RV = the dimensionless volumetric runoff coefficient

= 0.05 + 0.09(I) where I is percent impervious cover

A = drainage area (in square feet or acres)

ESDV = Runoff volume (in cubic feet or acre-feet) used in the design of specific ESD practices

For all structural BMP's that are utilized to supplement ESD devices, these structural BMPs would be designed to provide the additional required SWM volume, after the nonstructural BMPs have been accounted for. The method of calculating this volume can be found within the Prince George's County SWM manual, Chapter 9. *"To attenuate the extreme flood protection (100-year) sizing, the design engineer will have to calculate the predevelopment Q100, post-development Q100, and post-development Q100 with the controls in place. With this information, the design engineer would be able to evaluate the peak flows to certify that the post development with controls do not exceed the pre-scenario."*

DOWNSTREAM HYDRAULIC ANALYSIS

During the design permit process of a new development within the 100-year floodplain, the engineer will perform a downstream analysis to verify if off-site areas would be adversely impacted by stormwater flows for the 10- or 100-year storm event. The level of analysis would depend on the development's potential for adverse impacts such as size and type of development, size and type of BMP provided, and land use through which drainage passes downstream. In cases where there is a high likelihood of adverse downstream impacts to other properties, an analysis will be required regardless of the flow increase percentage.

In some cases, DPIE may require the applicant to provide off-site SWM improvements if they find that it would be more beneficial than on-site facilities. Applicants who are required to provide off-site improvements would be entitled to a reduction in the SWM fee or level of on-site SWM control required for the project. The cost of the off-site SWM improvement would be based on an amount that is comparable to the on-site controls for the site to be developed.

As per the DPIE SWM manual, quantity control of the 100-year storm may be required at the discretion of DPIE if the downstream analysis indicates the following:

1. "Previous flooding has occurred; or
2. Houses would be within 25 feet of the 100-year floodplain; or
3. Buildings other than houses would be within the 100-year floodplain.

The applicant can submit a request to DPIE to consider off-site mitigation for flood control rather than on-site attenuation if it can be demonstrated that it would be more beneficial to the affected community. This off-site mitigation option is considered in cases where on-site SWM construction is infeasible and no adverse effects downstream would occur if the on-site controls were waived from the development. The determination will be made by DPIE once the request and supporting documents have been provided."

STORMWATER BEST MANAGEMENT PRACTICES (BMPS)

During the design and development process, the engineer would need to provide adequate stormwater practices that would effectively provide the required quantity and quality control within the project site. The water quality control refers to the ESD practice utilized to treat runoff from one inch of rainfall (e.g., PE = one inch) on all development where stormwater management is required. The water quantity control refers to the storage volume to control the 10 year or 100-year storm, while also providing attenuation of the overbank protection (Qp) and Extreme flood (QF). The following examples describe several BMPs that would effectively meet the desired goals for treatment and SWM.

As always, for each of these practices, it is essential that the landowner provides regular maintenance and inspection to ensure proper functionality. Inspections should be done on a yearly basis by trained professionals experienced with BMP inspections, following the guidance from the 2000 Maryland Stormwater Design Manual Volume I and II. This inspection report would be sent to the County to ensure they have detailed records of the BMP site conditions to identify potential issues that would require correction. A logbook should be retained to collect all important field information regarding the BMP, including pictures for each site visit completed. The Prince George's County Department of Environmental Resources also has a BMP inspection form that can be used when completing the BMP inspection to ensure consistency and recordation of important results.

The subcategories for some examples of BMP facilities include the following, which are noted in greater detail within the Prince George's County Department of Environmental Resources—NPDES Program:

1. SWM Ponds
    a. Wet Pond
    b. Forebay
    c. Dry Pond
2. Infiltration Facilities
    a. Dry Well
    b. Infiltration Basin
3. Wetland Facilities
    a. Artificial Wetlands
    b. Shallow Marsh
4. Filtering Devices
    a. Bioretention
    b. Sand Filter
    c. Grass Swale
5. Hydrodynamic Structures
    a. Underground Storage

SOURCE: ISTOCK

Figure 14. Eco friendly bank of a wet pond with gentle slope to stimulate growth of wildflowers and swamp vegetation in a recreational ecological park

WET POND

This stormwater practice is a large basin filled with stormwater runoff to enhance water quality and retain a large quantity of stormwater runoff in both a design volume and additional capacity (if properly designed).

Wet ponds are able to retain large quantities of stormwater and release them over time through a riser and outfall structure, slowly returning depth to normal levels after release. Wet ponds are able to treat the incoming runoff by settling any debris, pollution, and other chemical components. Biological activity within the pond will decompose organic matter and provide required nutrients for the upkeep of the pond.

Wet ponds require regular maintenance after any large storm event in order to ensure that the functionality of the outfall and riser structures are operational and undamaged. In addition, regular maintenance such as mowing and removal of overgrown vegetation will be required throughout the life of the pond.

The use of wet ponds would be most advantageous upstream of Henson Creek Village to control stormwater at the higher point collection source.

Advantages

- Retention for large quantity of stormwater runoff.
- Soil erosion can be minimized.
- Control of algae growth/sustainability for marine ecosystem.
- Capable of treating runoff that contains high pollutant loads.

Disadvantages

- Requires large areas of open space to contain the wet pond, embankment, and the emergency spillway.
- May cause a safety concern for nearby community.
- If improperly located, the construction of the wet pond can demolish existing wetlands or forest.
- High maintenance cost required for maintenance and inspection.

PHOTO BY JEFFREY BEALL/CC BY-SA 2.0

Figure 15. Dry pond in Denver, Colorado.

DRY POND

Dry ponds, or "detention ponds," are designed to retain stormwater temporarily for several days and then discharge it slowly through an outlet release. This allows water to collect substantially while the pollutants settle to the bottom of the detention pond. Dry ponds typically do not have a permanent pool of water that is retained, and in many cases will not have any water if maintained properly. A dry detention basin is designed to empty all stormwater in less than 24 hours, resulting in the limited removal of sediment and potential resuspension of sediments.

Dry ponds allow for the removal of pollutants and the settlement of particulate matter, which can likely recollect during the next major runoff event. For this reason, dry ponds are typically utilized to reduce peak runoff velocity from stormwater to limit downstream flooding and provide channel and erosion protection. Thus, dry detention ponds are used solely for quantity management to attenuate the peak flow discharge rates to reduce downstream flood potential.

Dry ponds should be utilized upstream of Henson Creek Village to provide quantity management before runoff reaches the Henson Creek River. The retention of the runoff will help provide protection against downstream flooding or flooding within Henson Creek Village.

Advantages

- Can limit downstream scour, improve aquatic habitats, and provide erosion protection by reducing the peak flow discharge rates before entering stream body.
- Overall low cost for construction and maintenance.
- Can be utilized as a recreational field (athletic field) if properly designed.

Disadvantages

- Can frequently clog within the outlet pipes and inlets, affecting retention time and pollutant removal.
- Requires large area of land.
- Cannot be used to control multiple major storms as ground saturation would not provide enough storage to avoid unintended runoff.
- Ineffectively maintained dry ponds can collect trash and create odor issues.

PHOTO BY DRYWELLGUY/CC BY-NC-SA 2.0

Figure 16. Dry Well construction to take roof discharge and redirect it from the pavement to a dry well.

DRY WELL

Dry wells are small, excavated pits that are backfilled with aggregate and used to infiltrate runoff from roof downspouts or paved areas. The stone pit captures the water to filter through any large sediment or debris before it is infiltrated to the underlying stone and soil layers.

Dry wells can be constructed consecutively along the perimeter of a building to provide both quantity and quality management as a stormwater BMP. Runoff would be channeled through pipes and outfalls to direct the stormwater into the stone pit basin.

Within Henson Creek Village, new development or retrofitted developments can incorporate dry wells near their building structures as necessary to provide quantity stormwater management. Given that these are small in nature and there is limited area within Henson Creek Village, these facilities would provide enough storage for a reduced amount of space.

Advantages

- Small scale practices that can be installed in multiple locations within a proposed development to provide required quantity and quality management.
- Can reduce the size and cost of downstream BMPs and storm drains.
- Design is feasible for either new development or redevelopment scenarios.
- Provides groundwater recharge.

Disadvantages

- Clogging is likely when runoff is coming from areas other than rooftop structures.
- Applicable in smaller DAs of 1 acre or less.
- When located near buildings, it may cause unintended issues with water leaking to basements or causing heaving within building slabs.
- Not suitable for treating large impervious surfaces such as parking lots.

PHOTO BY MISSISSIPPI WATERSHED MANAGEMENT ORGANIZATION/CC BY-NC 2.0

Figure 17. Infiltration Basin at a golf course.

INFILTRATION BASIN

An infiltration basin is a stormwater runoff impoundment facility that is constructed over permeable soils to allow stormwater to percolate into ground soils. The stormwater is allowed to collect within this basin to let physical, chemical, and biological processes occur and provide proper pollutant filtration. These basins are effective in removing soluble pollutants from stormwater before entering the underlying groundwater system.

Infiltration basins also help attenuate peak discharges within the DA, as it can serve DAs from 5 to 50 acres. Runoff from stormwater is stored within the basin until it infiltrates through the soil of the basin floor. Pollution prevention and pretreatment is important for sites where infiltration basins are located to separate the contaminated and uncontaminated runoff. The uncontaminated runoff can filter directly into the soil layers, while the contaminated runoff would need to be collected and pretreated using various BMP options and then routed into the infiltration basin.

Appropriate vegetation is important to an infiltration basin as deep-rooted vegetation will enhance the infiltration of the water while also providing erosion control to the surrounding basin. A large amount of open space is required to maintain a shallow pool within the basin to allow for infiltration, typically within 72 hours or less depending on the ground saturation.

Infiltration basins would best be suitable upstream of Henson Creek Village in well-draining soils, and away from the main corridor of Livingston Road. This SWM practice can retain a large quantity of stormwater runoff to allow for the necessary treatment before underground infiltration is completed.

Advantages

- Reduces local flooding.
- Can be used within large development sites.
- Helps preserve the natural water balance of a site.
- Helps maintain the flow velocity of the local stream by reducing peaking flow velocity and discharge rates, which can thereby reduce erosion and scour.

Disadvantages

- Frequent maintenance is required to keep functionality.
- Soil requirements can make this problematic as good infiltration is required.
- Requires a large open space for performance and maintenance.
- Clogging of the basin from the settling of sediment may cause issues to the overall functionality.

PHOTO BY AARON VOLKENING/CC BY 2.0

Figure 18. Bioretention in median of Grange Avenue in Greendale, Wisconsin.

BIORETENTION FACILITY

A bioretention facility is a BMP that can be distinguished as a smaller scale infiltration basin practice that treats stormwater runoff through infiltration within the soil and stone layers. The bioretention filter media can remove large varieties of pollutants including suspended solids, nutrients, bacteria, phosphorus, nitrogen, metals, and different sizes of debris.

The use of specific vegetation within the facility helps to allow a natural ecosystem to develop within the facility that will grow plant and animal habitats, while also filtering out particulates that come from stormwater runoff. The runoff is collected and stored within the facility prior to filtration through the media, until it reaches the underdrain within the bottom layer. The underdrain would be located to collect the runoff before it reaches the water table so that it can eventually be conveyed to a discharge pipe, other larger SWM practice, or a municipal storm drain system.

The use of bioretention facilities located within Henson Creek Village would be most beneficial within large parking lots as multiple bioretention facilities can serve multiple drainage areas or points of runoff collection.

Advantages

- Typical for areas with small drainage areas.
- Easily designed and constructed within new developments.
- Can be used on small lots with space constraints.
- Will provide groundwater recharge and preserve the natural water balance of the site.

Disadvantages

- Not suitable for large drainage areas.
- Frequent landscaping maintenance within the facility is required.
- Clogging can occur within the soil layers if not properly maintained.

SAND FILTER

A sand filtration system consists of a sedimentation chamber, filtration section, flow spreader, and underdrain pipe to serve the functionality of providing stormwater treatment before final discharge. The overall purpose is a flow through system that collects water from impervious drainage areas to slowly filter through the sand layer and remove pollutants through straining and sedimentation. The treated stormwater will be collected and discharged to outlet pipes to an outfall or municipal storm sewer system.

Sand filters can be above ground or underground. Underground sand filters can be used where above ground space is limited, yet a large amount of runoff is still required to be treated from the impervious area. The underground sand filter would be ideal for Henson Creek Village as it can be placed within parking lots and other asphalt roadways. Given that this area is a highly urban environment where land costs remain high, it will be ideal to place this system out of sight so that other development above ground may occur.

Sand filters can also be used in areas with poor soil conditions where the rate of infiltration is low, or where groundwater concerns limit the use of infiltration. Sand filters are typically intended for quality control and not quantity control, as a flow splitter will typically route a portion of the runoff into the sand filter, while the remaining amount would go to a separate quantity control BMP.

Advantages

- Useful in location with high urban developed areas and steep slopes.
- Requires less space than most typical BMPs, and can be easily constructed in locations such as parking lots.
- Long design life if properly maintained and operated.
- Can easily handle drainage areas of 1 to 10 acres but can be designed to handle 5 times that amount.

Disadvantages

- Pretreatment is required to prevent clogging within the filter media chamber.
- Not the most effective in controlling the peak discharge flow.
- Expensive to build and install.
- May not be beneficial in sites that contain a high groundwater level.

PHOTOS BY ADVANCED DRAINAGE SYSTEM (STORMTECH CATALOG)

Figure 19. Underground Storage Chambers

UNDERGROUND STORAGE

The subsurface structure is designed to capture large quantities of stormwater runoff within large pipes or other structures. The large volume of stormwater runoff is retained within the pipes until after the storm event has passed. It is then released directly into surface water through outlet pipes at desired intervals. The captured runoff can also be designed to infiltrate with the surrounding soils to help recharge the groundwater table.

Underground structures can be constructed of plastic, concrete, or steel depending on the desired goals for containment. The owner of the facility will have to perform periodic inspections to ensure that trash and debris is removed to avoid clogged pipes and repair drain lines or parts of the structure as necessary.

This system provides minimal quality stormwater management treatment; however, it can provide sufficient quantity management for the immediate development area. Large areas of impervious area runoff can be captured and retained within these structures to assist with downstream flooding and reduce the overall peak flow discharge.

The underground storage system is an ideal BMP candidate to assist with compensatory storage requirements as this would be an effective, cost-efficient method to store the volume of water that would be displaced by fill material.

For Henson Creek Village, this BMP could be used frequently to provide quantity control management for the proposed development. Given that a large portion of development would occur within the floodplain, this BMP practice could be utilized within the asphalt areas to effectively store and maintain runoff for the 100-year discharges.

Advantages

- Underground storage allows for above ground space to be used for other purposes.
- Ideal for compensatory storage requirements.
- Reduces downstream flooding.
- Useful in stormwater retrofit applications.

Disadvantages

- The pipes can easily clog if not properly maintained and inspected.
- High up-front cost for excavation and installation of the system.
- Does not provide water quality treatment.

Flooding and Flood Control Techniques

Causes of Flooding

The 2017 updated Prince George's County Hazard Mitigation Plan identifies riverine flooding as a significant hazard (Hazard Mitigation Plan, 2010). In Henson Creek there is $7.4 million in flood-prone property within the 100-year floodplain. Flooding in the general area can be attributed to several factors including watershed management, development upstream prior to environmental regulations, and manipulation (e.g., straightening, clearing, fill, roadways) of the stream and floodplain.

Development Upstream

Henson Creek Village is located within the Henson Creek watershed, which drains 24 square miles, about one-third the size of Washington, D.C. Of this 24 square miles, 44 percent is impervious (developed lands where water cannot absorb into the ground).

Floodplain Constrictions and Stream Altering

In addition to development and added impervious surfaces without proper stormwater management, modifications to the streams, wetlands, and floodplains can also cause flooding. Stream straightening, ditching, and armoring to protect streamside investments at one location can lead to increased riverine erosion downstream (Glick et al., The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction, 2020). Construction of levees and the placement of fill materials into areas such as wetlands to allow for development in one part of a floodplain can lead to increased flooding downstream (Glick et al., 2020). Anthropogenic floodplain constrictions result in the water being concentrated into a more confined area, which creates higher velocities and erosive forces. Constricted floodplains can act

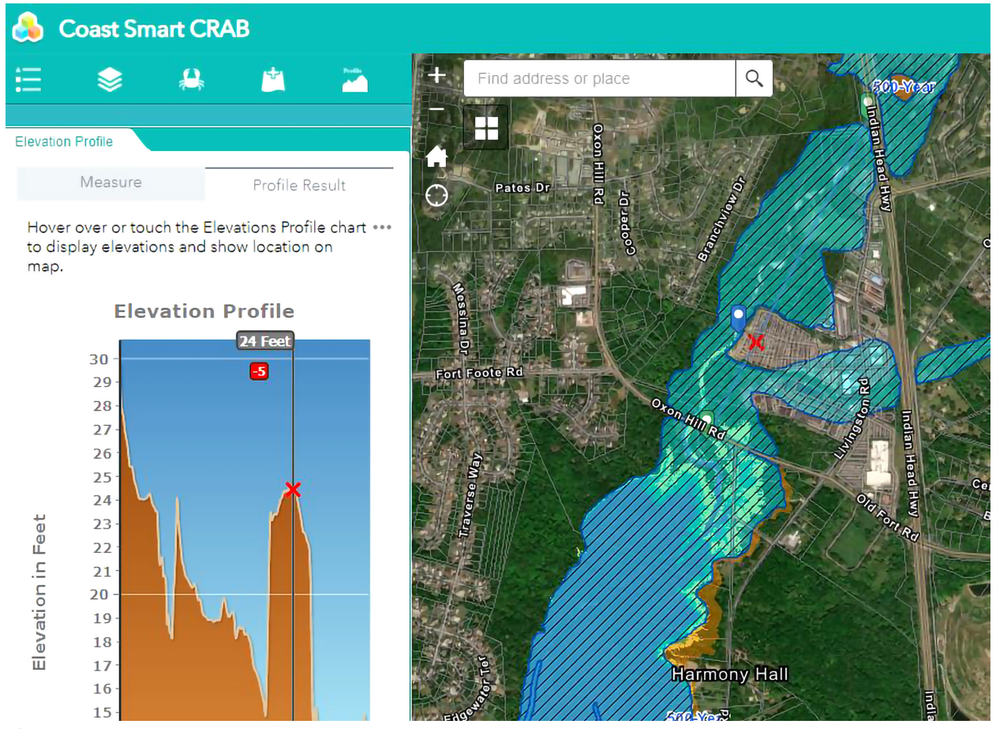


Figure 20. Henson Creek East Floodplain (https://mdfloodmaps.net/crab/)

as pinch points and cause backwater upstream. Roadways with bridges or culverts, and fill areas within the historical floodplain (the regularly flooded area prior to development), constrict peak flows leading to increased flooding upstream and downstream.

Using the Coast Smart CRAB tool created by MDE to assess the elevations along the east side of the Henson Creek historical floodplain, indicates that up to 9 feet of vertical fill is interrupting floodplain functions. The figure shows the elevations from upstream to downstream (north to south) along the east side of Henson Creek through the historical floodplain.

The figure also illustrates the large areas that are currently outside of the regulated FEMA floodplain due to significant fill placed long ago (see red 'X').

Techniques to Control Flooding

Techniques to control flooding include looking for and promoting opportunities upstream, and within Henson Creek Village, to implement SWM, stream restoration, and floodplain and wetland restoration. Techniques focus on attenuating and slowing down runoff (i.e., increasing time of concentration) to reduce peak discharges. Controlling flooding requires a countywide approach in regulation, stream and floodplain restoration, targeted stormwater quantity management facilities upstream, repair of compromised ecosystem and waterways, and quality SWM techniques during development. Flood control requires a collaborative effort by state and local government agencies, the Army Corps of Engineers, other nongovernmental environmental entities including the private sector, and communities.

SWM and stream, wetland, and floodplain restoration techniques to control flooding are discussed in the next sections. Additionally, flooding can be addressed through recently passed legislation and property acquisition.

Stormwater Management Within Henson Creek Village

Stormwater management opportunities within Henson Creek Village to control flooding are limited due to site constraints, namely the regulated environmental resources, existing infrastructure, and scale and location of the site relative to the larger DA network.

After completing a Freedom of Information Act request through DPIE to determine what SWM facilities are recorded in Henson Creek Village, the results showed that only one recorded SWM structure at 9119 Livingston Road within the 225-acre Henson Creek Village. This structure was an oil grit separator (Structure ID 0311-001) with an as-built completion date of March 13, 2000. The oil grit separator provides water quality but does not provide quantity management to effectively attenuate flows and reduce discharges.

Future development within Henson Creek Village will require the installation of more BMPs to provide both quality and quantity management for storm events. Underground storage or sand filters, as discussed in previous sections of this study, are the most suitable structural BMPs to provide quantity control within Henson Creek Village and should be integrated into the redevelopment design. The specific type, volume required, and BMP utilized to meet this requirement will be determined through the design phase.

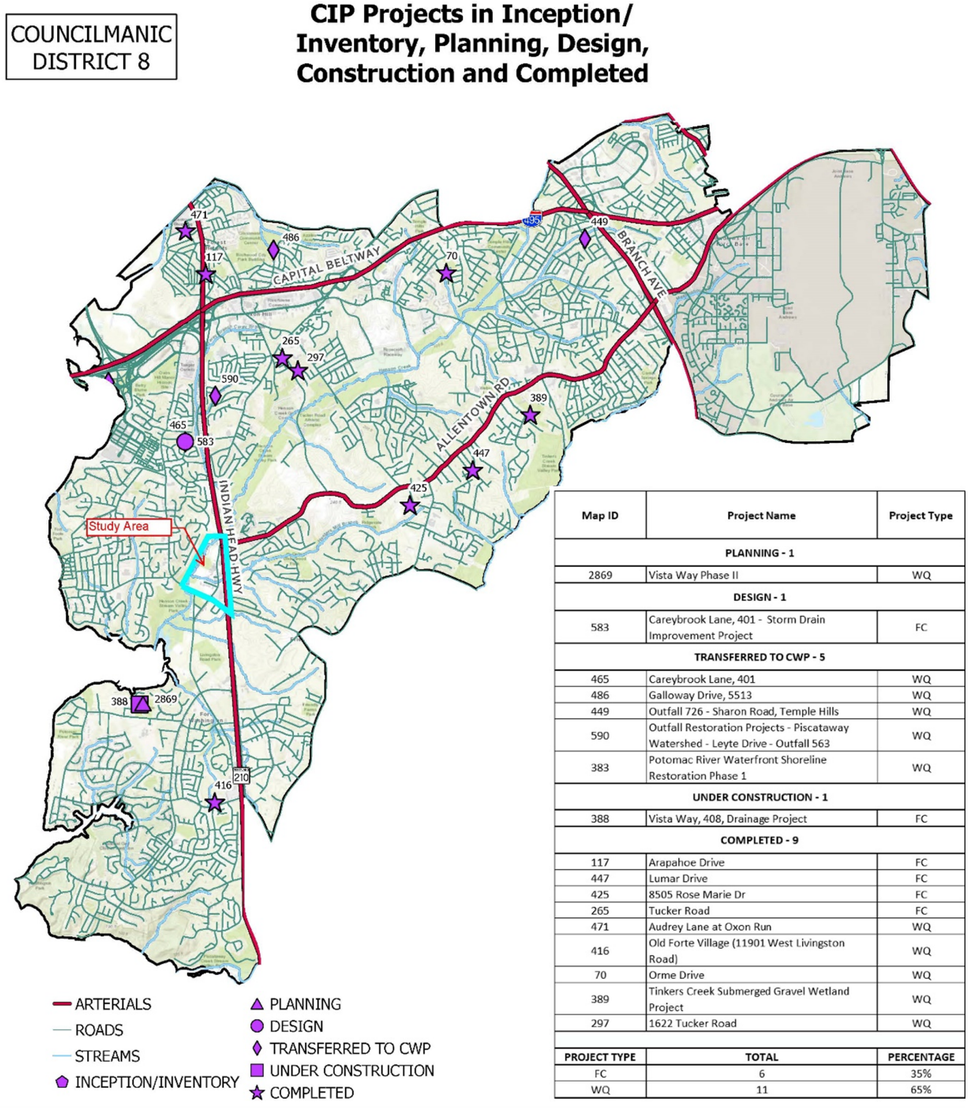
SWM Techniques Upstream of Henson Creek Village

Upstream of Henson Creek Village, stormwater BMPs, including regional wet ponds and infiltration basins, can provide attenuation, increase times of concentrations, and result in reduced flood flows being delivered into Henson Creek Village. Projects to improve water quality are being implemented by the Department of Environment and the Clean Water Partnership.

Prince George's County Capital Improvement Projects (CIP)

As shown in Figure 25, there are no Prince George's County CIP projects that have been completed or planned for Henson Creek Village. The projects that have been completed upstream of Henson Creek Village range from either flood control (FC) or water quality (WQ). From the list of projects that are FC and completed, all these projects involve storm drain improvements that upsize the pipes to retain more of the incoming runoff and capacity.

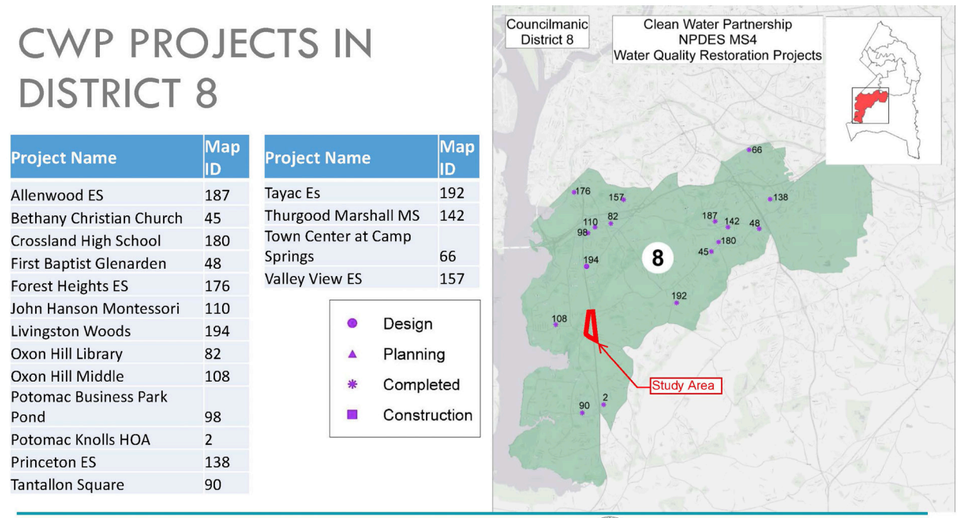
Figure 21. Prince George's County Capital Improvement Projects (Source - Prince George's County



Map ID	Project Name	Project Type
PLANNING - 1		
2869	Vista Way Phase II	WQ
DESIGN - 1		
583	Careybrook Lane, 401 - Storm Drain Improvement Project	FC
TRANSFERRED TO CWP - 5		
465	Careybrook Lane, 401	WQ
486	Galloway Drive, 5513	WQ
449	Outfall 726 - Sharon Road, Temple Hills	WQ
590	Outfall Restoration Projects - Piscataway Watershed - Leyte Drive - Outfall 563	WQ
383	Potomac River Waterfront Shoreline Restoration Phase 1	WQ
UNDER CONSTRUCTION - 1		
388	Vista Way, 408, Drainage Project	FC
COMPLETED - 9		
117	Arapahoe Drive	FC
447	Lumar Drive	FC
425	8505 Rose Marie Dr	FC
265	Tucker Road	FC
471	Audrey Lane at Oxon Run	WQ
416	Old Forte Village (11901 West Livingston Road)	WQ
70	Orme Drive	WQ
389	Tinkers Creek Submerged Gravel Wetland Project	WQ
297	1622 Tucker Road	WQ

PROJECT TYPE	TOTAL	PERCENTAGE
FC	6	35%
WQ	11	65%

Figure 22. Clean Water Project within District 8 (Prince George's County Department of the Environment)



Project Name	Map ID
Allenwood ES	187
Bethany Christian Church	45
Crossland High School	180
First Baptist Glenarden	48
Forest Heights ES	176
John Hanson Montessori	110
Livingston Woods	194
Oxon Hill Library	82
Oxon Hill Middle	108
Potomac Business Park Pond	98
Potomac Knolls HOA	2
Princeton ES	138
Tantallon Square	90

Project Name	Map ID
Tayac Es	192
Thurgood Marshall MS	142
Town Center at Camp Springs	66
Valley View ES	157

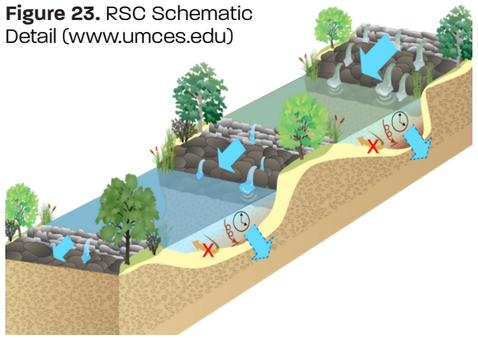
Clean Water Partnership (CWP) Projects

As shown in Figure 26, no CWP projects have been completed, or are currently in progress, within Henson Creek Village. Additionally, the projects within the DA focus primarily on water quality, rather than quantity, management.

Stream Restoration Techniques

While perhaps counterintuitive, reconnecting streams and rivers to their floodplain can reduce flooding downstream. This is accomplished by lowering the floodplain, raising the channel invert, or a combination of both, allowing for flood flows to access the floodplain, where it is then stored and filtered. Within Henson Creek Village, there are opportunities to re-establish natural functions by allowing the floodplain to store overbank flow from rivers and streams in adjacent forests and wetlands. This means restoring and enhancing the areas within the historical Henson Creek floodplain, including those that were filled in the past, and regrading them so they are lower. This gives the water a designated area to spread out. These opportunities could be realized through public private partnerships, voluntary buyouts, or other property acquisition strategies.

Figure 23. RSC Schematic Detail (www.umces.edu)



Regenerative Stormwater Conveyance (RSC)

RSC systems are a restoration technique to restore gullies. These are most applicable in coastal plain headwater channels such as the Hunters Mill Branch Tributary upstream of Henson Creek Village and involve filling the incised channel with a mix of sand and woodchips and creating a series of pools, riffles, and boulder weirs. RSCs are especially good at capturing nutrients and sediment and increasing denitrification. These systems effectively store, slow, and filter runoff to improve water quality and reduce flooding downstream.

PHOTOS BY KCI

Figure 25. Log Roll Bioengineering Technique

Bioengineering Techniques

Where feasible, stream restoration aims to use on-site harvested materials and relies on vegetation and coconut fiber matting rather than rock or other hard structures. This reduces the carbon footprint of the restoration by avoiding importation of large quantities of rock, and allows the stream to remain more flexible and resilient over a range of storms. Based on performance monitoring for various projects, one bioengineering technique, woody toe protection, appears to remain stable over time and over a range of flows, including 500-year-plus events. Adding wood into a restored channel provides habitat and organics. Hard structures often transfer the erosive energies somewhere else. For example, if rock is placed along one stream bank, the opposite bank will often begin eroding.

The log roll is another example of a bioengineering technique used. Log rolls are a way to manage elevation change in as short a distance as possible, while maintaining a controlled flow pattern and stable bed. The logs introduce organic material into the channel, create flow diversity (e.g. deep and slow, shallow and fast), and encourage downwelling and upwelling of flow into and out of the hyporheos.

Figure 24. Woody Toe Protection

"The hyporheic zone is defined as the region below and alongside a stream, occupied by a porous medium where there is an exchange and mixing of shallow groundwater and the surface water in the channel." (Wood, 2020).

Wetland Creation and Enhancement

Wetlands act as natural sponges, storing and slowly releasing floodwaters after peak flood flows have passed (Glick et al., 2020). Research suggests that a single acre of wetland can store up to 1.5 million gallons of floodwater. An assessment of flood reduction potential of wetlands in the Eagle Creek watershed of central Indiana found that they reduce peak flows from rainfall by up to 42 percent, flood area by 55 percent, and maximum stream velocities by 15 percent. (Glick et al., 2020). Address Climate Change Resiliency by restoring natural systems such as wetlands, floodplains, and forests. The wetlands and trees hold carbon rather than releasing it into the environment. Floodplain connection also allows for improved water quality. Wetland creation and enhancement within Henson Creek Village is already occurring through an MDOT SHA mitigation project and is estimated to create up to five acres of wetlands. Preliminary modeling indicates that the work may slightly reduce the limits of the 100-year floodplain.

Land Acquisition and Floodplain Restoration

One of the objectives identified in Plan 2035 is to "develop a program to utilize vacant land (both publicly and privately owned) for stormwater management, [and to] acquire land to serve the dual purpose of green infrastructure/stormwater infiltration and recreational/open space." (Prince George's County Planning Department, 2014).

Acquisition of specific parcels within Henson Creek Village, that were filled in the past and have constricted the floodplain, should be a priority. This will allow restoration by regrading and reconnecting to the stream. These areas provide opportunities to create wetlands, forest buffers, and reduce flooding. Policy 2 of Plan 2035 strives to improve and maintain water quality through stormwater management and water resource protection and implement state and federal pollution reduction requirements of the local Phase II Watershed Implementation Plan for the Chesapeake Bay TMDL and County MS4 requirements in coordination with County efforts (Prince George's County Planning Department, Plan Prince George's 2035 Approved General Plan, 2014). "Although the cost of purchasing land may outweigh the potential flood mitigation benefits in some areas, targeting investments based on preservation costs and expected flood damages could yield significant net benefits" (Glick et al., 2020).

Legislation

County and state legislation aims to provide further scrutiny and requirements to reduce flood risks. During the 2021 legislative session, the state passed bills to establish the Office of Resilience and a Chief Resiliency Officer in the Maryland Emergency Management Agency. This bill includes a requirement to develop a flood risk assessment tool for use by statewide programs and projects. That requirement applies to private construction or reconstruction projects that disturb one acre or more of land and are in an area designated as a Special Flood Hazard Area by FEMA; are in or within three vertical feet of the 100-year floodplain as mapped and updated; or are in an area that, as of 2019, is subject to nuisance flooding. Other legislation in 2021 includes the SB 319 Clean Energy Loan Program - Remediation and Resiliency, and HB512 Coast Smart Siting. SB 319 expands the types of projects that may be financed under a clean energy loan program enacted by a County or municipality by adding water efficiency projects, environmental remediation projects, and resiliency projects. HB 512 expands existing provisions that require specified state or local capital projects to be constructed or reconstructed in compliance with Coast Smart siting and design criteria, beginning July 1, 2020—to also apply to specified private construction or reconstruction projects, beginning July 1, 2022. (Maryland General Assembly website).

Case Studies

Figure 26. Carroll Creek Linear Park – vibrant and accommodating for all pedestrians; (City of Frederick – Department of Economic Development)

City of Frederick, MD

During the early 1970s, the City of Frederick's downtown region experienced several devastating floods that caused widespread property damage and posed a risk to residents' lives within the community. Carroll Creek met with the Monocacy River creating a confluence. As the water traveled within the Carroll Creek drainage basin, it was a 100-year storm. As it met with the Monocacy River, the water levels were of a 200-year storm (much worse given the combining). Records showed the 100-year storm within the Carroll Creek drainage basin and passed as a 200-year storm within the Monocacy River drainage basin. There were unprecedented levels of rainfall—nearly 7 inches within a 16-hour period. Nearby homes would experience five feet of flooding within the basement levels and records showed approximately eight feet of flooding within their historical performing arts theater (Weinberg Center of the Arts).

A project was undertaken by the local and state government to engineer a solution that would reshape the stormwater management system within this area. Drawing inspiration from the River Walk in San Antonio, Texas, the designers implemented a large concrete canal designed to implement a flood control measure and carry the floodwater 1.3 miles along the length of the city. In addition, there would be four 20-foot by 20-foot conduits that make up the flood control system, with each conduit able to hold 1.4 million cubic feet of water. There were stormwater pump stations installed along the flood control system for low lying areas to divert runoff into the conduits and the installation of a flood warning system for the area residents.

The stormwater would outfall at a designated location away from the downtown area, into a natural preserve that was composed of existing forests, meadows, and wetlands, until reaching the Monocacy River itself. This open space land was designed to handle

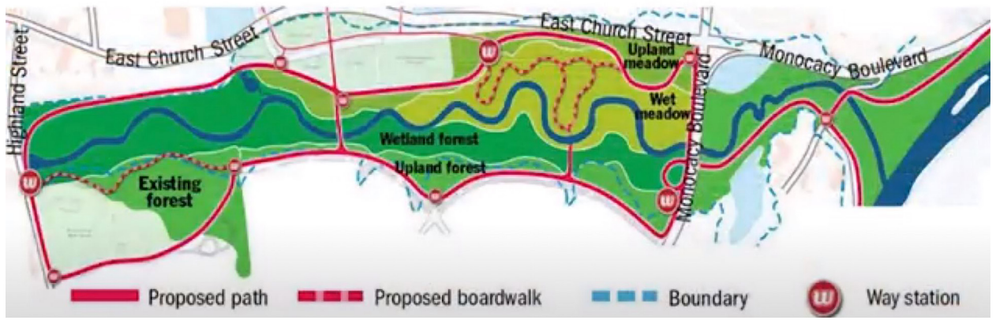


Figure 28. Implementation of Wetlands/Forests along receiving outfalls (City of Frederick – Department of Economic Development)

the flood waters unimpeded from any development within the area. There are boardwalks and bike trails located within this area to allow residents to enjoy the natural amenities.

This project revitalized transportation and recreational facilities in downtown Frederick, creating an immediate development of $30 million and an estimated future planned development of $100 million. This project also led to the removal of approximately 130 acres of downtown Frederick from the 100-year floodplain, relieving property owners of mandatory FEMA flood insurance. The mitigated floodwaters allow for the potential for new assets and further development to occur because the threat of environmental impacts from severe storms are reduced.

A similar goal can be used at Henson Creek Village, where the use of stormwater management can be designed and implemented as part of the redevelopment within the village. By implementing innovative structural practices to retain the 100-year flood, the environmental threats that are posed within this village would be greatly reduced.

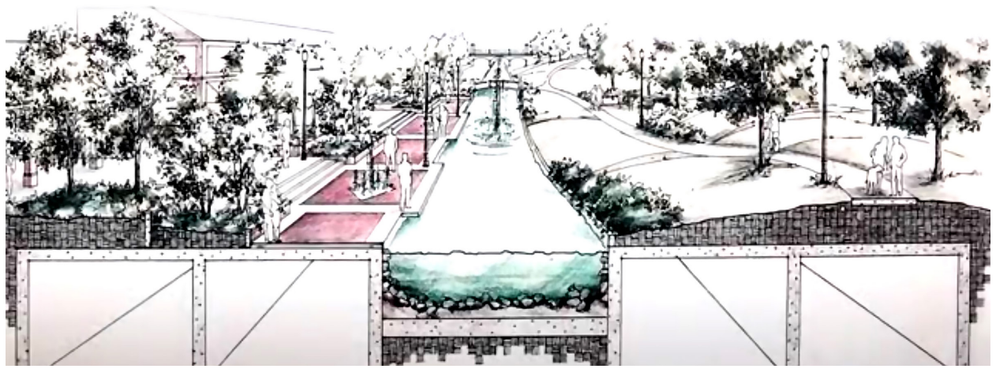
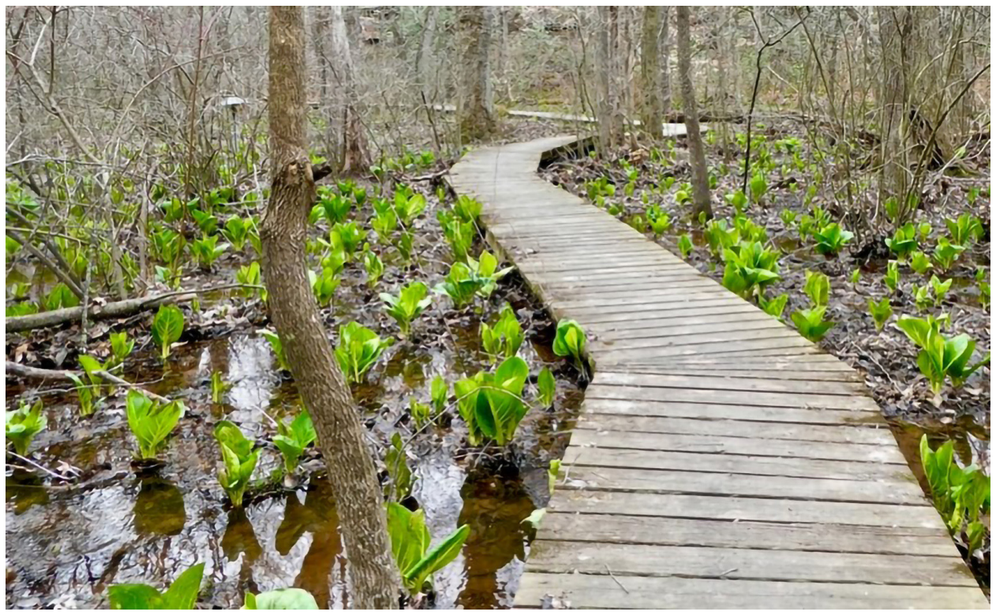


Figure 29. Carroll Creek Linear Park (Profile) (City of Frederick – Department of Economic Development)



PHOTOS BY M-NCPPC AND DNR

Figure 30. Jug Bay Natural Area and Wetlands (M-NCPPC, DNR)

Jug Bay Trail/Wetland

The Jug Bay Natural Area in Upper Marlboro exemplifies how a recreational trail network through ecologically rich wetlands and forests. "M-NCPPC works cooperatively with federal, state, and local agencies, and conservation organizations to ensure the Patuxent River remains one of Maryland's premier river greenways. Jug Bay Natural Area provides over 14 miles of scenic woodland trails for hikers, bicyclists, and horseback riders, and provides facilities for camping and picnics, fishing, and boating. There is also a Nature Exploration Area that includes a giant rope spider web to climb on, a wooden tree house, a canoe sandbox (with a stone "river"), tree stump jump, loose parts area, a bamboo shoot sound spindle, and many other evolving features. (M-NCPPC Department of Natural Resources, Jug Bay Natural Area, 2021)

Figure 32. After with reconnected floodplain and improved habitat

Jones Falls Stream Restoration

The Jones Falls Stream Restoration is located on the Baltimore County/City border and has a DA of 25 square miles, with 19 percent impervious surface. The DA is a similar size to Henson Creek within Henson Creek Village. Jones Falls had been heavily altered in the past through straightening, concrete lining, and floodplain fill. The restoration aimed to improve trout habitat and water quality and provide recreational fishing access. Funding of the restoration was provided through partnerships with Maryland Trout Unlimited and grants through Maryland Department of Natural resources. The restoration involved reestablishing plan form and providing floodplain reconnection using a combination of bioengineering and hard rock stabilization. Volunteers continue to monitor the site following construction and have observed trout within the restored reach, which was previously uninhabited.

Figure 31. Before with Concrete Lined Channel

Partners and Funding Opportunities

There are many shared challenges and shared opportunities when working to redevelop an area with sensitive environmental features. Prince George's County DPIE and DoE, and the Prince George's County Department of Parks and Recreation will be key partners for any redevelopment or recommended enhancement projects. By enhancing the stream corridor, multiple objectives can be addressed, which also helps to build partnerships and funding sources.

Funding Opportunities (Incentives and Partners)

Environmental restoration projects that go beyond what is required for the redevelopment have many potential options for funding. The 2005 Green Infrastructure Plan prioritizes use of public funds to preserve, enhance, connect, restore, and protect critical ecological systems. There are many stakeholders that would benefit from, and may help fund, stream and wetland restoration and stormwater improvement projects within Henson Creek Village.

MS4 PERMIT REQUIREMENTS

The Chesapeake Bay TMDL requires MS4 Permit holders, including Prince George's County, to reduce nutrients and sediments, which are impairing the Chesapeake Bay.The Prince George's County Department of Environment, and the CWP, each fund and implement stream restoration and stormwater projects to help meet the County's permit requirements, specifically the urban stormwater sector of the required MS4 load reductions. The nutrient and sediment load reductions generated by stream, wetland, and stormwater can also be traded. Policy 2 of Plan 2035 is to "improve and maintain water quality through stormwater management and water resource protection. Including implementing state and federal pollution reduction requirements of the local Phase II Watershed Implementation Plan for the Chesapeake Bay TMDL and County MS4 requirements in coordination with County efforts." This can be accomplished in part by "utilizing the local Clean Water Act fees to fund projects and programs to meet the stormwater pollutant load reductions mandated under federal and state law and to improve the water quality of local streams and the Chesapeake Bay." (Prince George's County Planning Department, 2014).

Based on the Prince George's County website, and 3-tiered priority system, Henson Creek Village would likely qualify as a Priority II or III to receive funding and resources through the County's DoE CIP. According to the recent Drainage and Flooding in Prince George's County report issued by DPIE, DoE, and DPW&T, the FY22 Capital budget for vendor contracts who construct remedies for SWM issues is $35M or which $15M is dedicated to DoE to address private properties and $20M is dedicated to DPW&T for public right of ways (Prince George's County, Drainage and Flooding in Prince George's County, 2021).

CLEAN WATER PARTNERSHIP

The CWP is a partnership between Corvias and Prince George's County to implement stormwater management infrastructure in selected locations across the County to improve and supplement the areas that lack these BMP measures. The goal is to improve the local economy by working with local disadvantaged subcontractors, consultants, and suppliers to boost economic growth, while supporting small businesses. The long-term goal of this partnership is to incorporate the following core guiding principles: efficiency, social value creation, long-term sustainability, and site flexibility. By implementing green infrastructure projects through a planning and design approach, the CWP can select projects that would benefit the long-term future within a community.

MITIGATION FOR STREAM AND WETLAND IMPACTS

Stream and floodplain restoration and wetland creation and enhancement can also be performed to generate mitigation credits for unavoidable impacts to resources from development. Private investors and consultants look for opportunities to fund and implement projects that can be used to establish mitigation banks. Flood risk mitigation will also be a future need based on potential and pending legislation and regulations. Projects funded by the private sector can also be sold for TMDL or Impervious Acre Treatment credits.

GRANTS

Grant funding for watershed restoration that address the Chesapeake Bay TMDL, including stream restoration and stormwater projects, are available from the Department of Natural Resources, the National Fish and Wildlife Foundation, and the

Table 3. Table 4. Potential Funding Partners and Project Types

Organization	Type of Project	Benefit to Henson Creek Village	Partner Funds / Incentive
CWP (P3)	Stormwater Quality BMPs Upstream of Henson Creek Village	Improves water quality	MS4
DoE, Grantors	Stormwater Quantity/ Quality BMPs Upstream of Henson Creek Village	Reduce flooding, improves water quality	MS4/TMDL
DoE, Grantors	Stream Restoration	Reduce flooding, enhance natural areas, improves water quality, improves property value, recreation opportunities	MS4/TMDL
Private Investors	Stream, Floodplain, Wetland Restoration/Creation		Mitigation Banks, Full Delivery Projects for TMDL, flood mitigation
WSSC	Infrastructure upgrade / protection + stream stabilization	Enhance natural areas, improves water quality, improved property value	Protects infrastructure

Chesapeake Bay Trust (CBT). CBT cooperates with Prince George's County to administer two grant programs. The Prince George's County Stormwater Stewardship Grant Program funds on-the-ground restoration activities that improve neighborhoods, improve water quality, and engage Prince George's County residents in the restoration and protection of the local rivers and streams of Prince George's County. The CBT also administers the Prince George's County Rain Check Rebate grant for citizens to install water quality improvements at their homes. Seven types of stormwater practices are eligible for rebates: rain barrels, cisterns, rain gardens, urban tree canopy, pavement removal, permeable pavement, and green roofs (CBT).

The USDA's NRCS works with local groups to help prevent floods, protect watersheds, improve agricultural water management, and enhance wildlife habitat through this program. Eligible project sponsors are County agencies, soil and water conservation districts, flood prevention/flood control districts, or other subunits of state government with the authority and capacity to carry out, operate, and maintain installed works of improvement (NRCS).

Other Partners

REVIEWING AGENCIES

There are many regulating agencies that review plans and issue approvals or permits to ensure regulations are met and resources are protected. These include, but are not limited to, the U.S. Army Corps of Engineers, MDE, Maryland Department of Natural Resources, U.S. Fish and Wildlife Services, Maryland Historic Trust, Prince George's County Soil Conservation District, and DPIE. Involving the agencies early in the process allows better cooperation and communication throughout the process and helps streamline the permit process. For example, conducting pre-application meetings prior to permit submissions.

WSSC

WSSC is responsible for maintaining the aging water and sewer infrastructure within Henson Creek Village. WSSC recently completed the Broad Creek Waste Water Pumping Station Augmentation Project. Sanitary sewer lines run throughout Henson Creek Village. Henson Creek Water Main Replacement is another project that involves the replacement and relocation of the existing water main within the Henson Creek Corridor to Palmer, Tucker, and Allentown Roads, spanning from Indian Head Highway to Temple Hill Road. Coordinating with WSSC before and during redevelopment is required. With enough planning the stream and floodplain projects can also work in tandem with WSSC to address infrastructure upgrades. Infrastructure protection projects conducted by WSSC often involve local stream stabilization to address bed or bank erosion. These could be looked at more systemically to result in additional natural area functional uplift.

Energizing the Parkland

Environmentally sensitive parkland can be energized for public use in accordance with the plans and goals of the Department of Parks and Recreation as outlined in the Resource Conservation Plan (M-NCPPC, 2017). This can be achieved by preserving and enhancing natural areas including forests, wetlands, streams, and floodplains, and expanding the trail network. Henson Creek Village contains portions of the Henson Creek River Valley Park, as well as the potential to expand and connect to nearby park and recreation facilities.

The 2040 Functional Master Plan indicates "the greatest recreation facility need in Prince George's County is for trails to connect not only places of recreation, but also places of work, school, and shopping" (Prince George's County Department of Parks and Recreation, Formula 2040: Functional Master Plan for Parks, Recreation and Open Space, 2013). Studies also show that building personal connections with the environment can benefit public health and conservation and stewardship efforts (Glick et al., 2020). The Economic Benefits of Protecting Healthy Watersheds, released by the EPA in 2012, reports there "are social and health benefits related to the proximity of people to nature, parks, walking trails and biking trails—both in the form of physical exercise and mental stress relief. Forests outside of urban areas significantly contribute to human health in urban areas. These health benefits have the potential to provide significant cost savings in health expenditures. People who exercise regularly and seek stress relief are generally healthier, have fewer insurance claims and spend less time in hospitals, thus their societal health care costs are lower" (EPA, 2012).

Studies show that proximity to parks increases property value and increases revenue from property taxes (Glick et al., 2020). "Ohio and Virginia have shown increased property values and tax revenues from properties near open space, green space, walking/biking trails, or riparian areas. Preserving healthy watersheds and protecting open space while providing access to people has the potential to boost local revenues while providing attractive amenities" (EPA, 2012).

Henson Creek Stream Valley Park

"This 54-acre segment of the Henson Creek River Valley Park is owned by the Maryland-National Capital Park and Planning Commission and comprises the western edge of Henson Creek Village. The natural features and main points of interest in this park include woodlands, nontidal wetland areas and Henson Creek. There is a paved asphalt trail that traverses the west side of Henson Creek. The natural features identified are areas of particular interest for conservation in the 2017 Resource Conservation Plan and its predecessor the Green Infrastructure Plan" (M-NCPPC correspondence with Councilwoman, 2021).

Nearby Park and Recreation Facilities

"The existing park facilities specific to athletic fields in Service Area 8 which includes Henson Creek Village Area Study consist of one Level II field at Riverview Park located 2.5 miles southwest, one Level II field located at Tantallon North Park located 2.8 miles southwest, and a Level II field located at Fort Foote Neighborhood Recreation Center located 2.5 miles north. Additionally, the Tucker Road Athletic Complex located 3 miles to the northeast contains several Level III playfields. Level I fields are less structured, neighborhood serving fields, ideal for informal, walk up play. Level II and Level III fields are competition fields that contain varying levels of amenities such as lighting, restrooms, and bleacher seating. Level III fields are our highest rated fields for play." (M-NCPPC correspondence with Councilwoman, 2021).

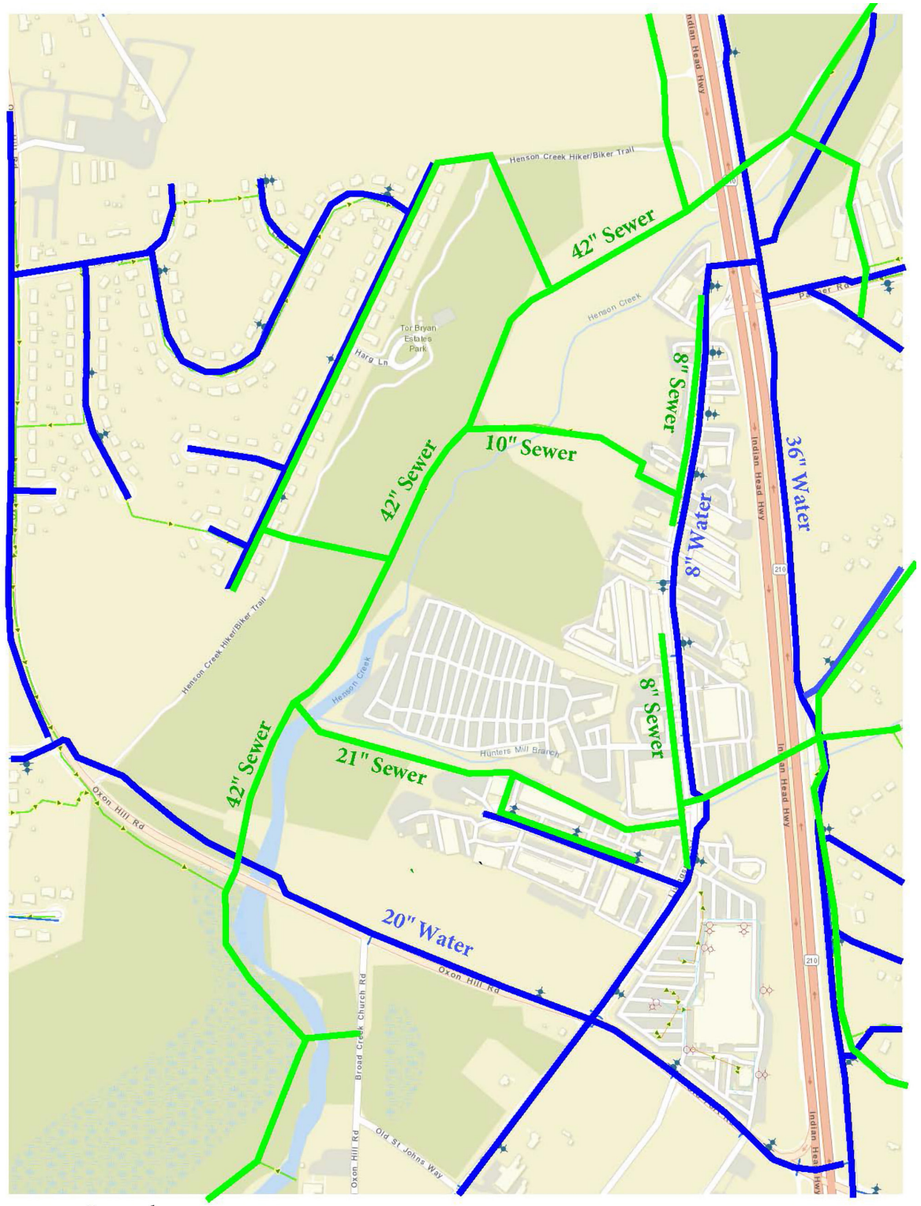
Fulfilling Approved Plans and Objectives

The expanded trail network and preservation and restoration of natural areas supports the goals and objectives as defined in Section II of the *Green Infrastructure Plan: A Countywide Functional Master Plan* of the 2017 *Prince George's County Resource Conservation Plan* (M-NCPPC, 2017).

The Green Infrastructure Plan articulates the following intentions:

- "Preserving, enhancing, and/or restoring an interconnected network of significant countywide environmental features that retains ecological functions and improves water quality.
- Increasing connectivity of built and natural green spaces.
- Improving wildlife habitat.
- Addressing energy efficiency and the need for

Figure 33. Existing Henson Creek Village Water and Sewer Pipeline (WSSC)



green buildings and jobs.

- Improving overall human health by providing equitable access to connected open and green spaces throughout the County.
- Achieving 52 percent forest and tree canopy coverage countywide by 2035.
- Protecting existing resources when constructing stormwater management features and when providing mitigation for impacts.
- Recognizing the ecosystem services provided by diverse land uses, such as woodlands, wetlands, meadows, urban forests, farms and grasslands within the green infrastructure network and work toward maintaining or restoring connections between these landscapes.
- Preserving, enhancing, connecting, restoring, and protecting special conservation areas, and the critical ecological systems supporting them.
- Identifying critical ecological systems and ensure they are preserved and/or protected during the site design and development review processes.
- Ensuring equitable and accessible green and open spaces.
- Ensuring that the public has physical and/or visual access to the green and open spaces where appropriate through the provision of access and views from an existing or proposed sidewalk, trail, or roadway.
- Continuing to require mitigation during the development review process for impacts to regulated environmental features, with preference given to locations on-site, within the same watershed as the development creating the impact, and within the green infrastructure network.
- Improving water quality through stream restoration, stormwater management, water resource protection, and strategic conservation of natural lands."

The expanded trail network also supports Council Bill CB 2-2012—Adequate Public Pedestrian and Bikeway Facilities in Centers and Corridors—that requires adequate sidewalk and bike facilities to both serve the subdivision internally and connect to surrounding areas.

The *2040 Functional Master* plan outlined a vision to "balance environmental, social, and economic concerns to meet current needs without sacrificing the ability to meet the needs of future generations. The *2040 Plan* identified introduction of multifunctional landscapes in urban settings to fulfill multiple needs simultaneously (e.g., providing healthy recreational opportunities, flood protection, climate change adaptation, habitat creation, and on-site stormwater management) as an action item to integrate parks into Prince George's County's Urban Environment.

Conclusions and Recommendations

Redevelopment of Henson Creek Village to provide economic growth and revitalize the region is possible. The need to add higher quality sit-down restaurants and plaza settings will need to be integrated with green infrastructure and improved stormwater management. Responsible development within this environmentally sensitive corridor will require topographic and detailed environmental surveys, and sound engineering with strict adherence to the current standards and regulations. Recommendations to preserve, protect, and restore natural areas within Henson Creek Village will require funding partnerships and voluntary buyouts or property acquisitions. To address flooding within the Henson Creek Village study area, a comprehensive approach including County funding for CIP projects, partnerships to implement upstream stormwater quantity or levee projects, preservation of functioning natural areas, and restoration of floodplains and natural features to allow flood flows a place to go, will be required.

The recommended redevelopment concept within Henson Creek Village area involves:

1. PRESERVING AND PROTECTING NATURAL AREAS AND FUNCTIONS

The existing wetlands, forests, streams, and rivers within Henson Creek Village should be protected and preserved through zoning and property acquisition. This supports many objectives articulated in the Green Infrastructure Plan including the goal toward 52 percent forests by 2035. Within Henson Creek Village, acquisition of privately owned forested land—Parcel 144, Tax Account #0384990—would protect these resources from future development potential.

2. RESTORING, ENHANCING, AND CREATING NATURAL AREAS AND FUNCTIONS

While there are many valuable and functioning natural areas within Henson Creek Village, there are others that should be restored or enhanced to improve water quality and help control flooding.

Stream restoration of Hunters Mill Branch Tributary upstream of Henson Creek Village using bioengineering or RSC techniques will help slow and filter runoff and reduce flooding within Henson Creek Village.

Recommendations for stream restoration, floodplain enhancement, and wetland creation throughout the contributing DA upstream of Henson Creek Village will also reduce flooding within Henson Creek Village and fulfill goals established in the County's Green Infrastructure Plan.

Within Henson Creek Village, restoration of the floodplain through excavation and replanting to create forested wetlands and reconnection of the river to the floodplain to allow the water a place to spread and be stored when it rains will be necessary. To fully implement this recommendation requires acquisition or voluntary buy out of Tax Account # 1347848, Parcel 106, currently zoned as Open Space.

This parcel, historically in the floodplain, was filled in long ago and is now technically outside of the regulated FEMA floodplain. Now the filled parcel is causing a pinch point in the floodplain, which exacerbates flooding both upstream and downstream. The recommendation is to excavate and dispose of the filled material, reconnecting Henson Creek to allow for frequent inundation. The area would be planted with native vegetation to create forested wetlands.

3. EXPANDING THE PARK AND TRAIL NETWORK

The trail network can be expanded to traverse through the existing and proposed natural areas and connect to the existing amenities. The Jug Bay Natural Area exemplifies how a trail network through a rich ecosystem can be a transformative, central feature of a community. The expanded trail network could include the creation of victory gardens, educational signage, and natural play areas.

4. MEETING STORMWATER MANAGEMENT AND FLOODPLAIN REGULATIONS

Redevelopment within Henson Creek Village will require several factors of responsible development (e.g., floodplain mitigation, proper SWM practices, erosion control, etc.) to ensure that Henson Creek Village is brought up to current standards and regulations. Given that widespread flooding a major cause for concern in this area, various quantity control BMP measures, such as underground storage structures and underground sand filter structures, will be required. In addition, there can be additional measures taken upstream of this DA including possible retention pond or storm drain upgrades to reduce the discharge within Henson Creek Village. Stormwater facilities should be designed based on updated NOAA precipitation (100-year rainfall events) to ensure adequate quantity management in current and future climate scenarios.

During the design stage, engineers will need to ensure that the redevelopment scenarios do not add an increased demand on stormwater capacity beyond the amount that can be provided. In addition, any additional risk to the floodplain and watershed should be mitigated through green infrastructure and buffers where necessary.

It is entirely possible to create strong economic growth safely within Henson Creek Village, while also minimizing the impact to the environment and subwatershed, by implementing the design criteria from the Floodplain Ordinance (Prince George's County Code, Division 4) and MDE SWM manual. The required natural resource inventory conducted prior to development, provides the engineer data to consider during the redevelopment phase. Proper mitigation and site design will ensure that the environmental features and watershed remain protected during development.

The proposed development will also provide Henson Creek Village a renewed opportunity to bring all features up to current Prince George's County standards (e.g., SWM requirements, building construction requirements, zoning regulations, etc.). Developers and engineers will have the opportunity to provide an in-depth analysis of Henson Creek Village through field topographic surveys and natural resource inventories in a manner that has not been done in past decades. Given that much of this development was completed by the 1960s, most of the developed area is not up to current County standards. The issues with flooding within this area can be improved in part through responsible development and upgrades to meet current regulations. Further studies can be completed to determine if and how additional stormwater quantity management can be completed outside of Henson Creek Village.

5. BUILDING PARTNERSHIPS

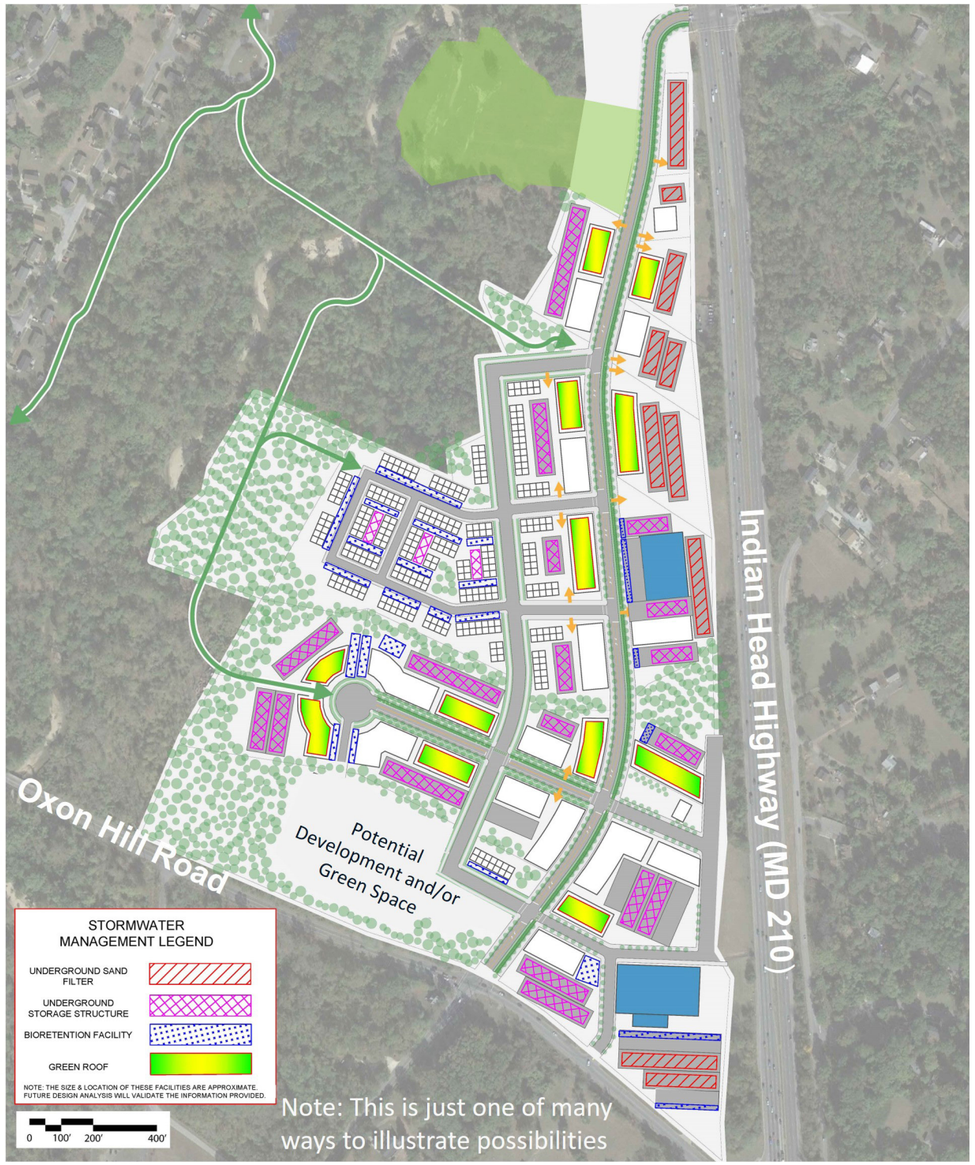
Partnerships with DoE, CWP, the private sector, and grantors will be important to fully realize the objectives of revitalizing the community and addressing flooding. CWP and DoE can implement large regional ponds and other stormwater quantity projects upstream of Henson Creek Village. Grantors can play a role in stormwater quality, stream restoration, and small-scale water quality improvement and educational efforts for residents. The private sector, including engineering consultants, mitigation bankers, and other investors, fund and implement restoration projects such as the wetland and stream mitigation project for MDOT SHA that is in progress to restore floodplain functions and create wetlands within Henson Creek Village. Projects may be implemented to meet MS4 requirements (Bay TMDL), for mitigation or for flood mitigation.

Conceptual Site Plan Example

With the coordination of M-NCPPC; HR&A Advisors, Inc; and KCI Technologies, Inc, the concept site plan below, which illustrates one of many different possibilities, provides a potential development effort that considers long-term infrastructure growth as well as environmental improvements within Henson Creek Village. Planners, developers, architects, and engineers have the potential to revitalize Henson Creek Village with new retail, commercial, and multifamily residential buildings. The new development would include restoration of the natural areas including streams, floodplains, and forests.

The figure reflects the proposed structures and roadway networks in relation to various stormwater management structural BMPs that could be implemented for this village. Given that there is currently only one BMP within this study, it will be imperative to find locations for other potential structural BMPs such as sand filters and underground storage structures that will be able to provide quantity management. Through climate change and increased developments, rain events will continue to intensify, which will further exacerbate the need to provide proper flood control and management to avoid any imminent risk to life within the village or further downstream.

Figure 34. Example Henson Creek Village Conceptual Site Development Plan



References

U.S. Environmental Protection Agency. The Economic Benefits of Protecting Healthy Watersheds. April 2012. EPA 841-N-12-004

City of Frederick, Maryland. Carroll Creek Linear Park. Accessed October 15, 2020. https://www.businessinfrederick.com/220/Carroll-Creek-Linear-Park

Chesapeake Bay Trust. Grants. Accessed 3/30/2021. https://cbtrust.org/grants/

Glick, P., E. Powell, S. Schlesinger, J. Ritter, B.A. Stein, and A. Fuller. The Protective Value of Nature: A Review of the Effectiveness of Natural Infrastructure for Hazard Risk Reduction. 2020. Washington, DC: National Wildlife Federation.

Maryland Department of the Environment. What is the Bay. Accessed March 30, 2021. https://mde.maryland.gov/programs/Water/TMDL/TMDLImplementation/Pages/what-is-the-bay.aspx

Maryland General Assembly. Accessed April 16, 2020. https://mgaleg.maryland.gov/. Legislation SB319; HB512; HB542.

Maryland Department of the Environment. Stormwater Design Manual, Volume I and II. (2009). Accessed April 10, 2021. https://mde.maryland.gov/programs/water/stormwatermanagementprogram/pages/stormwater_design.aspx

Prince George's County Planning Department. PGAtlas. 2014. Accessed September 9, 2020. https://www.pgatlas.com/

Prince George's County Department of Parks and Recreation. Formula 2040: Functional Master Plan for Parks, Recreation and Open Space. 2013. Riverdale, MD.

Prince George's County Planning Department. Approved Prince George's County Resource Conservation Plan: A Countywide Functional Master Plan. 2017. Upper Marlboro, MD.

Prince George's County Planning Department. Plan Prince George's 2035 Approved General Plan. 2014. Upper Marlboro, MD.

Maryland Department of Natural Resources. Patuxent River Park Nature Exploration Area. Accessed March 30, 2021. https://dnr.maryland.gov/pgc/Pages/NPS/Patuxent-River-Park.aspx;

Prince George's Count Department of Parks and Recreation, Jug Bay Natural Area. Access March 30, 2021. http://www.M-NCPPC.org/3186/Jug-Bay-Natural-Area

Sea Grant Maryland, Watershed Protection and Flood Prevention Program. Accessed March 30, 2021. https://www.mdsg.umd.edu/wra/programs/watershed-protection-and-flood-prevention-program

NOAA. NOAA Atlas 14: Precipitation – Frequency Atlas of the United States. 2016. Accessed April 10, 2021. https://www.weather.gov/media/owp/oh/hdsc/docs/Atlas14_Volume11.pdf

Prince George's County and The City of Laurel, Maryland. Hazard Mitigation Plan. 2017 Accessed September 7, 2021. https://www.princegeorgescountymd.gov/DocumentCenter/View/29942/2017-PGC-Hazard-Mitigation-Plan-Update_ADOPTED

Prince George's County Stormwater Management Division. Clean Water Program. Accessed March 30, 2021. https://www.princegeorgesCountymd.gov/261/Stormwater-Management

Prince George's County. Stormwater Design Manual (2014). Accessed April 10, 2021. https://www.princegeorgescountymd.gov/DocumentCenter/View/4782/Stormwater-Management-Design-Manual-PDF?bidId=

Prince George's County. Drainage and Flooding in Prince George's County (2021). Accessed April 10, 2021. (https://www.princegeorgesCountymd.gov/DocumentCenter/View/35172/Drainage-and-Flooding-in-Prince-George's-County--County-Council-Presentation-Binder).

Prince George's County Department of Environmental Resources. Stormwater Best Management Practices Inspection Manual (2009). Accessed April 10, 2021. https://www.princegeorgescountymd.gov/DocumentCenter/View/4788/DepartmentoftheEnvironment-Stormwater-Best-Management-Practices-Inspection-Manual-PDF

Prince George's County Code, Division 4. Floodplain Ordinance. 2014. Accessed January 11, 2021. https://library.municode.com/md/prince_george's_county/codes/code_of_ordinances/229965?nodeId=PTIIITI17PULOLAPRGECOMA_SUBTITLE_32WAREPRGRCO_DIV4FLOR

Prince George's County Department of Permitting, Inspections, and Enforcement. Techno-Gram. Accessed October 13, 2020. https://www.princegeorgescountymd.gov/2362/Techno-grams

Tetra Tech. Prince George's County Countywide Watershed Assessment for MS4 Permit (2014-2019). 2018. Accessed online March 30, 2021. http://pgcdoe.net/pgCountyfactsheet/Areas/Factsheet/Documents/Reports/PGC_MS4_Watershed%20Assessment_20180221.pdf

Montgomery County Department of Environmental Protection. Underground Sand Filter – Structural Maintenance. 2013. Accessed April 10, 2021. https://www.montgomerycountymd.gov/DEP/Resources/Files/PostersPamphlets/Structural-Underground-Sand-Filters.pdf

The Maryland-National Capital Park and Planning Commission, March 2017. Approved Prince George's County Resource Conservation Plan: A Countywide Functional Master Plan.

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Watershed and Flood Prevention Operations Program (2021). Accessed September 3, 2021 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/

U.S. Environmental Protection Agency. The Economic Benefits of Protecting Healthy Watersheds. 2012. EPA 841-N-12-004

U.S. Environmental Protection Agency. How's My Waterway. Accessed March 30, 2021. https://mywaterway.epa.gov/waterbody-report/MDE_EASP/MD-02140201/2018).

U.S. Geologic Survey, StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications. Accessed March 30, 2021. https://streamstats.usgs.gov/ss/.

Prince George's County. Flood Protection & Drainage Improvement (2021). Accessed September 3, 2021. https://www.princegeorgescountymd.gov/296/Flood-Protection-Drainage-Improvement

Prince George's County Department of the Environment. Watershed Existing Condition Report for the Potomac River Watershed. 2014. Accessed April 10, 2021. http://pgcdoe.net/pgcountyfactsheet/Areas/Factsheet/Documents/Reports/WECR_Potomac_20141231.pdf

Williams, M., J. Hawkey, S. Costanzo, 2013. Stormwater Management Reducing Water Quantity and Improving Water Quality. Chesapeake and Atlantic Coastal Bays Trust Fund. Accessed September 3, 2021. https://ian.umces.edu/publications/stormwater-management/

Washington Suburban Sanitary Commission (WSSC), Engineering Records and Information. Accessed April 18, 2021.

https://www.wsscwater.com/work-with-us/codes-standards-policies-and-procedures/engineering-recordsinformation-weri

Wood, D., and Tom Schueler, Chesapeake Stormwater Network, October 27, 2020. Prepared by:. Consensus Recommendations to Improve Floodplain Restoration Protocols in the Chesapeake Bay Watershed (Accessed 9/15/2021, https://www.chesapeakebay.net/documents/FINAL_Approved_Group_4_Memo_10.27.20.pdf)

www.pgplanning.org