Workshop Summary and Concept Design Memorandum for City of Martinsburg, West Virginia

WEST VIRGINIA GREEN INFRASTRUCTURE PLANNING AND IMPLEMENTATION

August 11, 2020

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INTRODUCTION

In partnership with the U.S. Environmental Protection Agency's (EPA's) Chesapeake Bay Program, West Virginia's Department of Environmental Protection (DEP) Chesapeake Bay Tributary Team is providing stormwater management technical assistance to West Virginia communities in the Chesapeake Bay watershed, with a focus on developing green infrastructure (GI) solutions to improve water quality and provide ancillary community benefits. Communities requested this technical assistance by submitting an expression of interest form and detailing the community needs and stormwater concerns.

The technical assistance is designed to help educate local elected officials and stakeholders about the benefits of GI and move a community through a process of assessment and planning with the ultimate objective of creating a concept design plan for one or more GI opportunities within the community that can be used to seek funding for implementation. The assistance incorporates a workshop that helps a community identify potential challenges, as well as realize opportunities that already exist to make progress. It includes a series of pre-and post-workshop conference calls and an on-site convening of stakeholders to discuss issues, next steps, and actions related to advancing the community's specific goals.

STAGES OF TECHNICAL ASSISTANCE

This memo documents the key outcomes of the technical assistance for the city of Martinsburg, West Virginia and identifies key community issues, prioritized goals, and specific actions to achieve the following goals:

- Engage with the city of Martinsburg and other stakeholders to identify concerns and priorities related to stormwater.
- Identify opportunities for implementing GI concepts in a context sensitive manner.
- Develop concept designs for the highest priority opportunity areas.

COMMUNITY CONTEXT

Martinsburg is the county seat of Berkeley County, West Virginia, having been settled in 1732 and chartered in 1778[1]. Martinsburg is approximately 6.67 square miles in the eastern panhandle and has just over 18,000 residents[2].

Martinsburg is served by Interstate 81and U.S. Route 11 as major north-south throughways, and state highways Route 9 and Route 45 as major east-west throughways. It is located approximately 21 miles southwest of Hagerstown, 25 miles northeast of Winchester, 78 miles northwest of the District of Columbia, and 90 miles west of Baltimore. Martinsburg is also home to many historic sites including the Adam Stephen House, Childhood Home of Belle Boyd and the B & O Roundhouse. The median household income in Martinsburg is just over $40,450, with

[1] https://www.britannica.com/place/Martinsburg

[2] http://cityofmartinsburg.org/

about 27% of the population below the poverty level [3]. In comparison, the median household income in West Virginia is over $44,000.

Martinsburg has experienced significant stormwater management concerns and recurring flooding issues throughout the city, which was the motivating factor in requesting technical assistance through this project. The focus area of the project is the downtown drainage area to a pump station at the intersection of West Addition Street and South Raleigh Avenue (Figure 1). Flooding occurs in the drainage area during significant rainfall events at the inlets along S. Raleigh Street prior to the pump activating and conveying stormwater farther through the system. Although a detailed drainage study has not been completed for this area, city of Martinsburg Stormwater staff have preliminarily identified lack of conveyance capacity and pump station limitations as the primary cause of the flooding issues. Localized flooding has also occurred upstream in the drainage area at the intersection of Buxton Street and West Virginia Avenue when the inlets are overwhelmed by the volume of runoff. Additional inlets were added in these areas in recent years, which has mitigated this issue to some degree. However, the City is interested in using GI strategies to make incremental improvement in stormwater management and flooding throughout the area.

Prior to beginning this project, the city of Martinsburg identified several locations in the drainage area to the pump station that could be potential candidates for GI. These sites provided the basis for the GI evaluation and workshop described in detail below. The sites were selected by the city of Martinsburg Stormwater team based on initial assessments of localized flooding, available green space and amount of impervious area draining to them.

[3] https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml

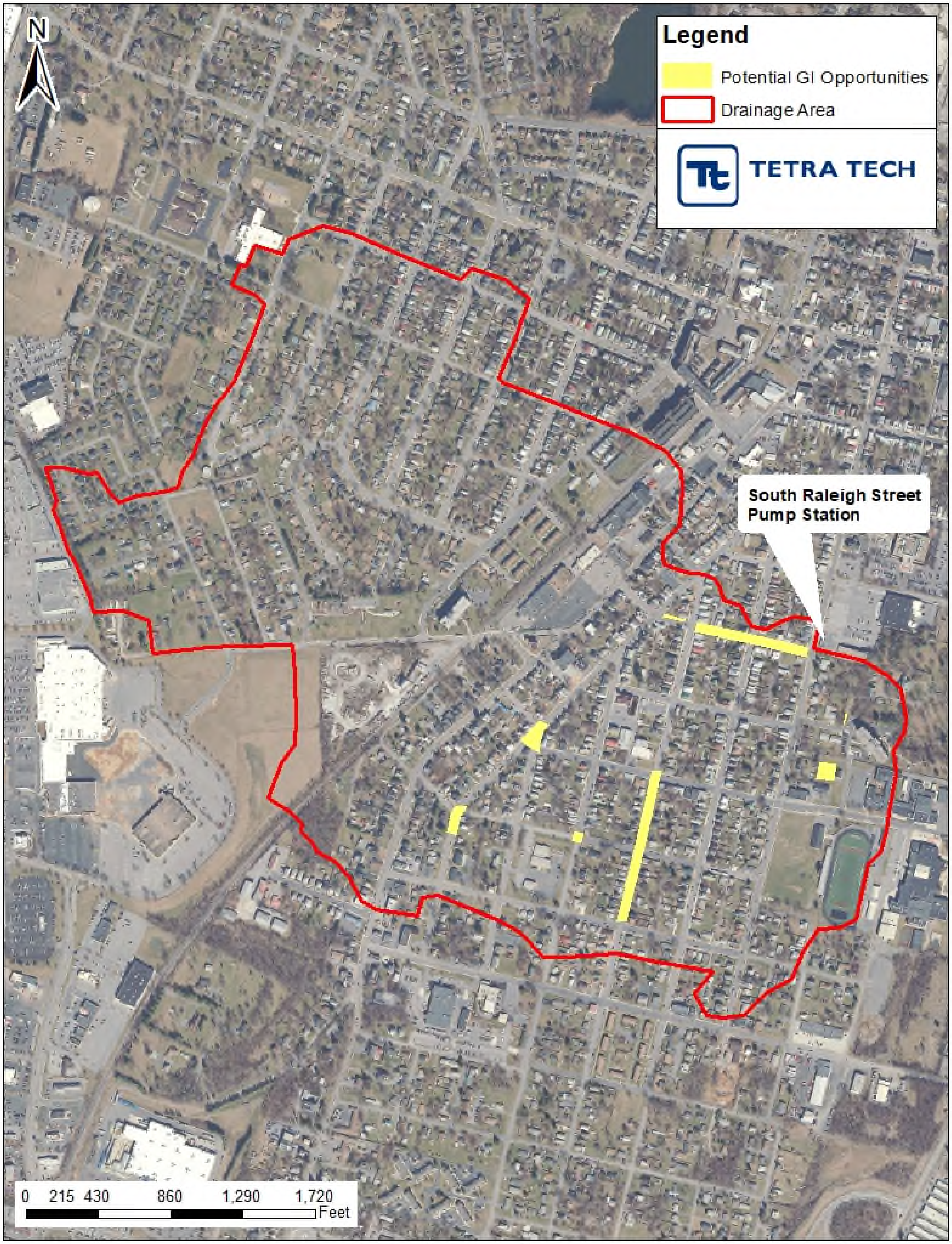


Figure 1. General drainage area to the pump station and potential GI practice locations identified by the City

Since Martinsburg is an older city, a significant portion of the stormwater infrastructure was developed 50 – 100 years ago and few records exist to document the exact layout and location of the pipe network. The City of Martinsburg Public Works Department has identified the pipe network where it is able. Frequently, information about the pipes and network is not known until a repair is required. Much of the storm drainage system is undersized relative to modern stormwater drainage design criteria and desired level of service. Catch basins and the pipes are insufficiently sized to convey flows from larger storms. The City also has a substantial amount of impervious area and inadequate or complete absence of catch basins along many of its streets, causing nuisance street flooding.

This project seeks to involve the Martinsburg community and stakeholders in the identification of stormwater concerns and priority action areas; identification of significant areas of imperviousness that can be managed with GI practices to help alleviate localized street flooding as well as mitigate the flooding conditions further downstream, while improving water quality to help meet the state's Chesapeake Bay TMDL implementation objectives; and development of concept designs for the highest priority opportunity areas.

STAKEHOLDER WORKSHOP

Representatives from the City of Martinsburg City Council, Planning Department and Public Works, West Virginia DEP, Eastern Panhandle Regional Planning and Development Council, community stakeholders, residents, and Tetra Tech gathered at Martinsburg's City Hall for a two-day workshop on January 22 and 23, 2020. The workshop included a background presentation on stormwater management and an introduction to GI practices, a tour focused on potential sites for the design and installation of GI practices and a working session where participants prioritized sites and then provided input into potential GI practices at the highest priority sites.

Day 1, January 22, 2020:

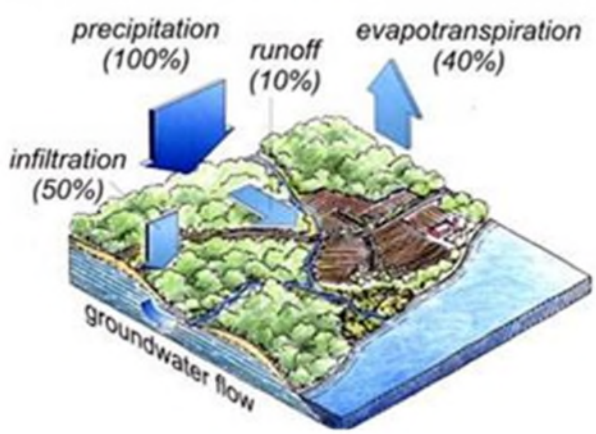
Day One of the workshop was a two-hour evening public meeting. During introductions the attendees were given the opportunity to share with the group why they were participating and what issues they hoped to address through GI. Responses included wanting to learn about GI, addressing stormwater issues, having an actionable GI plan, learning about GI strategies that could be applied more broadly and translated to other locations, and understanding whether there needs to be a zoning ordinance tie-in for GI.

After an opening statement and introductions from the Director of the Public Works Department, Jeff Wilkerson, Martinsburg's Stormwater Program team presented background information on stormwater management in the city of Martinsburg. The team highlighted the areas of concern, flooding issues, the purpose of the workshop, and the role of Tetra Tech. The project facilitator, Tetra Tech's Jonathan Smith, then presented background information on the concept of stormwater management, impacts of stormwater, and the importance of working to restore pre-development hydrology by developing stormwater management systems that function more like forested areas (Figure 2).

Differences in Pre-Development and Post-Development Hydrology

In pre-development conditions, most precipitation infiltrates into the ground or is taken up by vegetation and is lost to evapotranspiration. Only a small amount ends up as runoff. In post-development conditions, infiltration and evapotranspiration are reduced and the majority of precipitation turns into runoff. Typical post-development hydrology alters stream flow, creates flashy runoff with higher peak flows, and more volume is carried down in the stream channel more quickly. Higher flow volumes and velocities can result in stream widening and erosion, decreased channel stability, loss of in-stream pool and riffle structures, lower summer base flows and loss of riparian canopy. Development also results in an increase in pollutants carried from the watershed into receiving streams.

Pre-Development



Post-Development

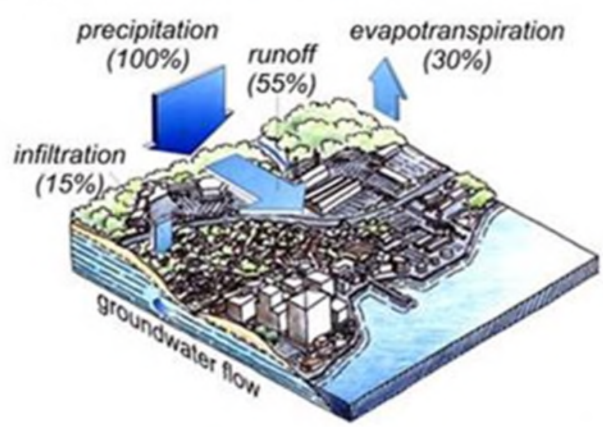


Figure 2. Illustration of the differences in pre-development and post-development hydrology.

The facilitator highlighted the guiding principles of GI stormwater management, which include 1) managing stormwater runoff both at the source and at the surface, 2) using plants and soil to slow, filter, cleanse, and infiltrate runoff and 3) designing facilities that are simple, low-cost, and aesthetically enhance the community. He also provided an overview of appropriate locations for GI and described a variety of the GI practices applicable in urban environments. Bioretention, street trees and permeable pavement practices were identified as the most applicable for the project areas in Martinsburg. When applied in street/right of way settings the resulting street section is commonly referred to as a green street. A green street is a stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks)[4]. These practices are described on page 13.

[4] https://www.epa.gov/G3/learn-about-green-streets

Following the presentation, the group discussed concerns regarding localized flooding; the need for traffic calming measures; safe pedestrian corridors; and co-benefits of GI in adding value to the community through beautification, enhancing ecology and providing sense of place.

Day 2, January 23, 2020:

Day Two of the workshop was an all-day meeting that included presentations, a site tour and hands-on visioning of potential GI in areas of Martinsburg selected by the group. After attendee introductions, Mr. Wilkerson provided an opening statement emphasizing the localized flooding at the 600 block of South Raleigh Street. Mr. Smith then continued the meeting by presenting an overview of the workshop process and the concept of GI and green streets to the participants. He continued with a deeper technical review of different types of GI practices, including the appropriate locations for each practice and how they might be used. Examples of the various GI options presented include street trees, bioretention, street trees, grass swales and permeable pavement.

Site Tour

Following the in-depth discussion of various GI practices, the group participated in a site tour to view the two priority potential project sites. The focus was on opportunities within the right of way at various locations throughout the project drainage area. Since the project sites were located away from the City Hall meeting location, the Department of Public Works arranged for bus transportation to the project sites. The group started the site walk at the intersection of South Raleigh Street and West Addition Street by the pump station, to discuss the flooding issues, and then headed west along West Addition Street (Figure 3).

Two blocks of West Addition Street from South Raleigh Street to Virginia Avenue and from Virginia Avenue to West Virginia Avenue had previously been identified by the Stormwater Management Team as a potential GI candidate site.

Figure 3. Overview of the area of West Addition Street evaluated during the site tour.

The group noticed West Addition Street is a wide through road with mixed commercial and residential uses that serves as a pedestrian corridor. There are no existing street trees on West Addition Street between South Raleigh Street and Virginia Avenue (Figure 4). West Addition Street at Virginia Avenue is the high point of the site, with drainage to the east and west from the intersection. Some of the street trees on West Addition Street between Virginia Avenue and West Virginia Avenue seemed to be in good condition. However, there are several tree planters without trees. The overhead electric lines are located on the southern side of the street. Manhole and valve covers were observed at the intersections indicating the water, storm and sanitary mains along the street. However, there was no indication of a gas line. Because West Addition Street and its sidewalks are very wide, many opportunities exist for GI between South Raleigh Street and West Virginia Avenue that can help improve the pedestrian user experience and manage stormwater.

Figure 4. View of West Addition Street from South Raleigh Street. Note wide street and few street trees.

The group then walked from the intersection of West Virginia Avenue and West Addition Street south to the intersection of West Virginia Avenue and Buxton Street (Figure 5). The intersection was noted as a low point with a history of significant flooding. In recent years, the City has installed additional inlets to increase the conveyance of the stormwater from this intersection, but past actions did not reduce the overall volume of stormwater draining to this point.

Figure 5. Overview of the area of West Virginia Avenue evaluated during the site tour.

The group continued walking south along West Virginia Avenue to the intersection of West Virginia Avenue and Berry Street. The group noted the wide street with the overhead utilities on the western side of West Virginia Avenue and few street trees on the both sides of the street. Manhole and valve covers were noticed at the intersections indicating the gas, water, storm, and sanitary mains along the street. Given the wide right of way and the significant contributing drainage area, this project site is also a good candidate for the implementation of GI.

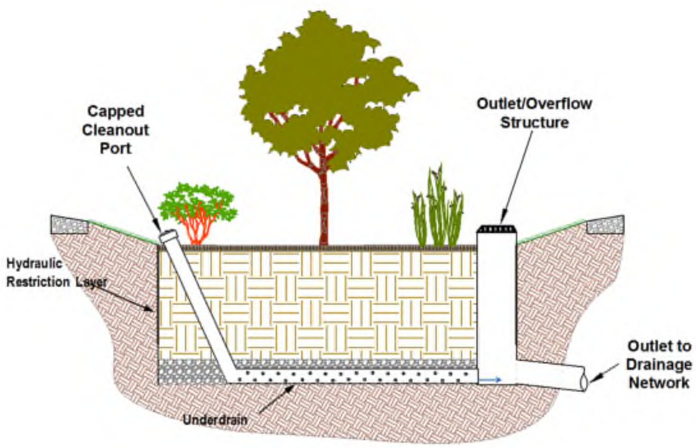
Figure 6. Participants discussing the drainage at West New York Avenue and Berry Street.

Outside the project area, the group walked west to the intersection of Berry Street and New York Avenue (Figure 6). This area is outside the primary project area but was viewed because it was initially highlighted by the City as a potential project area and representative of conditions throughout Martinsburg. The group noted a storm inlet that seemed to have eroded soil around it and could be forming a possible sink hole due to the karst geology of Martinsburg. A U.S. Army Reserves Training Center occupies the property on the southwest corner of the intersection and an open vegetated area exists along the south side of Berry Avenue providing a relatively large space for management practices. The presence of the federal facility could provide an opportunity for a cooperative effort with the City but may also require additional time and resources to secure approval. The group also noted that New York Avenue slopes to an unbermed west side such that the existing stormwater sheet flows to a grassed area on the south side of the armory property. The existing condition is already providing some infiltration benefit.

Throughout the site visit corridor, the group discussed opportunities for green streets, which include bioretention and permeable pavement with street trees and sidewalks incorporated to improve pedestrian access and aesthetic appeal. Each of these types of GI are discussed in the following boxes. Grass swales were also discussed. These are vegetated open channels designed to manage the runoff by reducing the depth of flow and velocity through the channel.

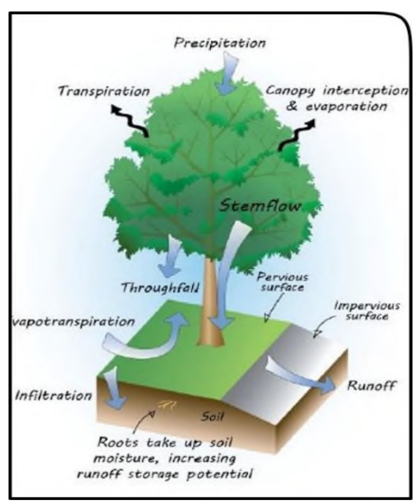
Bioretention

Bioretention best management practices are small-scale, shallow, vegetated, depressed areas with a soil (often engineered soil) media and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes.



Street Trees

Street trees are trees planted within the street right of way to provide a variety of functions such as shade, aesthetics, interception of rainfall, or other benefits. Street trees can be planted into vegetated strips or incorporated into green infrastructure practices such as bioretention.



Permeable Pavement

Permeable pavement is an alternative pavement system that allows precipitation and stormwater runoff to infiltrate through voids in the pavement surface and into an underlying aggregate reservoir. When used in parking lots, streets and sidewalks, permeable pavement can reduce stormwater runoff volumes and pollutants discharged to stormwater collection systems. Impermeable liners are required under permeable pavements in some areas to protect groundwater and prevent sinkholes. In such cases, permeable pavements can still be designed to reduce stormwater peak flows. The left photo is an example of permeable concrete, and the photo on the right is an example of permeable pavers.

Green Streets

A green street is a stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks). Green streets are designed to capture rainwater at its source, where rain falls. Whereas, a traditional street is designed to direct stormwater runoff from impervious surfaces into storm sewer systems (gutters, drains, pipes) that discharge directly into surface waters, rivers and streams. (source: EPA).

KEY COMMUNITY ISSUES

After the site tour, the workshop participants were led through an exercise to evaluate the challenges and opportunities specific to the city of Martinsburg as they relate to GI implementation. These provide context when determining appropriate GI solutions.

Challenges

The city of Martinsburg faces several challenges in implementing GI projects. Some of these challenges stem from structural limitations or a lack of local resources and experience, while others can be traced to the need for stakeholder engagement and support.

- **Limited Funding for Construction and Maintenance**: The City has limited budgets for stormwater infrastructure, in general, and GI more specifically, including construction of GI and long-term maintenance of installed practices. The efforts of the Maintenance Department are already spread thin.
- **Aged Infrastructure**: Most of the stormwater and other utility infrastructure in the city is more than 50 years old, and routinely fails. This places a significant burden on the town's maintenance staff.
- **Parking**: The City feels strongly that GI practices should not limit on-street parking throughout the project area.
- **Utility Conflicts**: The City noted that there are significant utility conflicts within the street rights of way. This can present design challenges to implementing GI and make some locations infeasible or not cost-effective.
- **Karst Geology:** The Karst geology of the city adds additional challenges in the implementation of effective GI practices. Karst geology significantly limits the use of infiltration techniques, which are important for reducing the impacts of flooding and enhancing water quality.
- **Lack of Public Awareness**: The City faces the need to build momentum to educate relevant stakeholders and move past any perceptions that cause resistance to change. However, the relatively robust participation in the workshop by city officials does indicate that there is interest in, and potential acceptance of, GI in Martinsburg.

The roots of many of these challenges are shared by many other similar communities striving to incorporate GI into their portfolio of stormwater management opportunities. The goal of this technical assistance is to help identify key opportunities for GI and fund the initial concept design, which can be used to seek funding for implementation, and can help overcome some of these challenges.

Opportunities

Despite the challenges described above, workshop participants were optimistic about several opportunities to advance GI in Martinsburg. Many felt that there are key organizations and characteristics that can be leveraged to overcome the challenges identified during the workshop.

- **Funding Sources**: Leveraging the partnership with DEP, the City is well positioned to apply for grants both from state agencies and regional entities, such as the

Chesapeake Bay Trust and the Chesapeake Bay Program. The City already has an EPA Green Streets, Green Jobs, Green Towns (G3) grant that can partially fund the engineering design of GI practices identified during this workshop process.

- **Improved Street Functionality:** The inclusion of the green infrastructure such as bioretention between the curb and sidewalk provides improved pedestrian user experience. Inclusion of permeable pavement in parking lanes provides dual functions of parking and stormwater management. These street enhancements will likely increase functional use of the streets.
- **Existing Infrastructure conditions:** The City has wide streets and ample parking lanes within the right of way, leaving plenty of room for GI practices without encroaching on private property. In addition, sidewalks throughout the project site are in various conditions, ranging from well-maintained to severely neglected. Since property owners are responsible for sidewalk maintenance and repair, any city GI project that results in a new or replacement sidewalk is an added amenity and can save the adjoining landowner the costs of repair and replacement of any degraded sidewalk areas.
- **Public Awareness:** The residents and landowners within the project area are already impacted by flooding and are aware of the need to improve conditions. This should provide some support for GI implementation. GI implementation also provides an opportunity to raise the public awareness on stormwater management.
- **Job Opportunities**: GI implementation will create job opportunities for installation and maintenance.
- **Reduction in Economic Loses:** The implementation of GI will help reduce the localized flooding. This will reduce the chances of economic loss due the flooding.
- **Tree Inventory:** The City has completed an inventory of existing street trees and street tree opportunity areas that can inform any tree planting as part of GI for this project and moving forward with other activities in the project area and the city more generally.
- **Active Watershed group:** There is an active watershed group in Martinsburg that can help build community support for GI and highlight the benefits to the Tuscarora Creek. The Tuscarora Creek Project Team membership is made up of agencies, non-profits, MS4 staff and volunteers. Tuscarora Creek is a tributary to Opequon Creek, so the group is part of the larger Opequon Watershed, Inc. nonprofit watershed group and can leverage the resources of that group as well.

In addition to these opportunities, the City has a motivated Stormwater Management team that can help build on these opportunities to inspire revitalization and improve stormwater management through the implementation of GI.

Concept Design Stakeholder Planning

In the afternoon of the second day, attendees participated in a planning-level design exercise using area maps to identify potential GI options. To prepare for the planning exercise, the facilitator discussed the various street "typologies", which included a discussion about how parking can be arranged on a street, possible street widths, and two-way versus one-way traffic to provide the stakeholders some options as they moved through the street-level GI planning process (Figure 7).

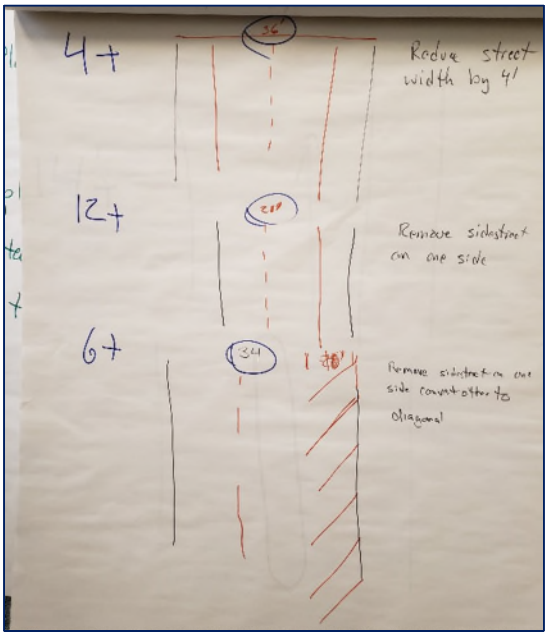


Figure 7. Examples of various street typologies for the stakeholders to consider.

Attendees were also advised of the need to limit the number of locations for concept design in this effort. Although there are numerous opportunity areas to manage stormwater in the pump station drainage, financial and other resource constaints mandate prioritization. Selected priorities can be viewed as first steps in Martinsburg's plans to expand retrofitting via GI and systemically incorpore GI into its stormwater management program.

Based on discussions between the local project team coordinators and Tetra Tech's team, two street corridors were selected to move forward during stakeholder planning: West Virginia Avenue from Buxton Street to Berry Street and West Addition Street from South Raleigh Street to West Virginia Avenue. Workshop participants were separated into two breakout groups, each assigned to one of the project sites and charged with developing a concept plan. Breakout groups were provided with GI game pieces, aerial images, and base maps of their site so they could develop and draw design strategies for each area (Figure 8).

The participants marked up the map to illustrate GI potential opportunity areas and the potential GI practices such as bioretention, permeable pavement, and street trees. The participants focused on increased community connection, aesthetics, traffic calming, safe pedestrian corridors, and poor stormwater drainage when siting the practices. The facilitators worked with the participants to select appropriate locations based on topography at the sites and potential constraints, such as maintaining pedestrian access, avoiding utility conflicts, and identifying appropriate locations where GI practices could

Figure 8. Participants discussing the concept design plans for each project location and illustrating the preferred GI options with game pieces and mark-ups.

be tied back into the existing stormwater infrastructure. In addition to marking up the aerial maps with GI practices, each group created a cross section of the street to better convey practice locations and widths.

One spokesperson from each group briefly summarized the findings and recommendations for their chosen area (Figure 9 and Figure 10). The group working on West Virginia Avenue decided to use a portion of the 40 foot wide roadway from Berry Street to Buxton Street to extend the curb line an additional four feet into the roadway on the eastern side of the road to gain space for bioretention behind the curb while still allowing sufficient space for two-way travel and parallel parking on both sides of the street. They also added permeable pavement to the western side parking lane. On the Bowers Street to Berry Street block, they proposed tree planting and permeable pavement in the parking lanes on both sides of the street. On the western side of the road, they chose to add low street trees to avoid conflicts with the overhead utilities. Taller trees can be planted on the eastern side because there are minimal overhead utility conflicts.

Figure 9. Stakeholder design concept for West Virginia Avenue.

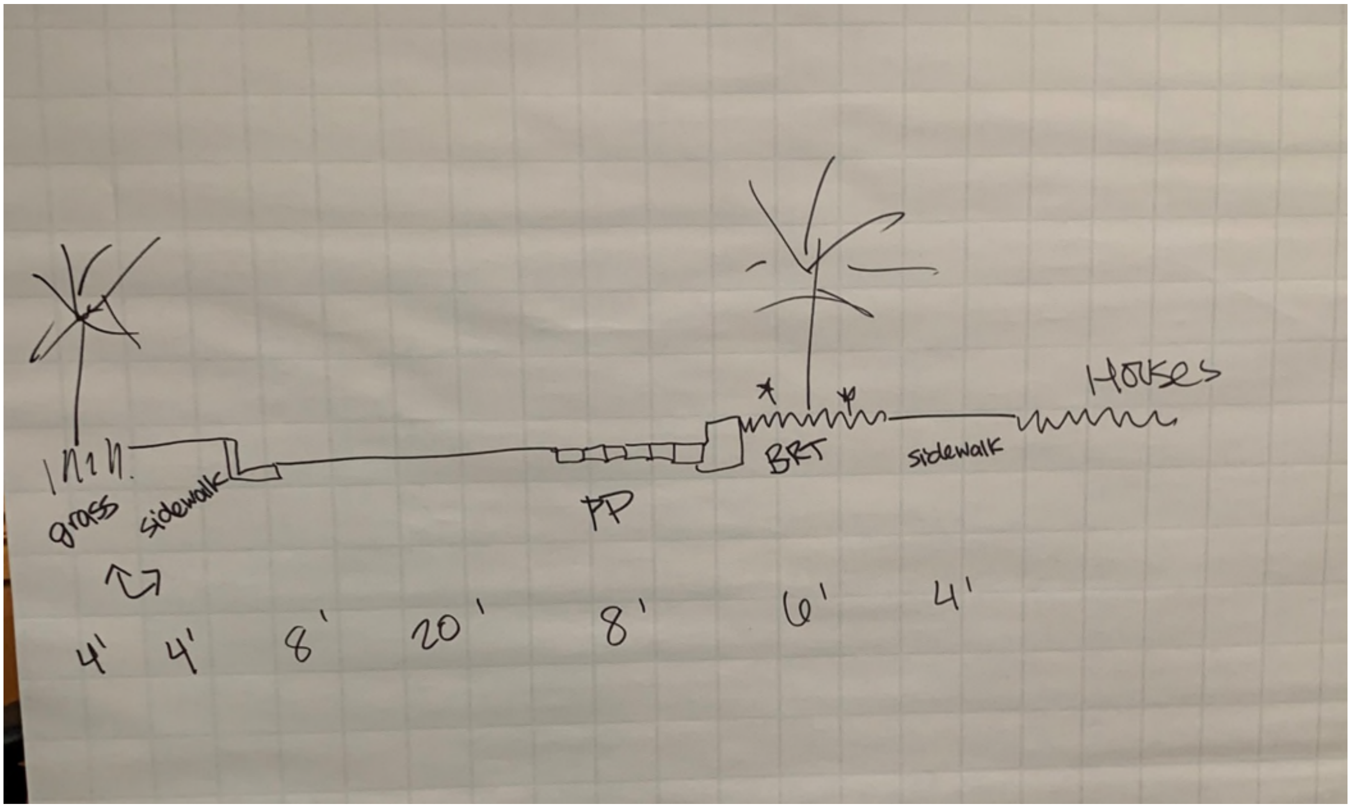


Figure 10. Stakeholder cross-section of design concept for West Virginia Avenue from Berry Street to Buxton Street.

The group working on the West Addition Street concept elected to maintain the original roadway width of 40 feet throughout the project area (Figure 11 and Figure 12). They placed permeable pavement on both sides of the South Raleigh Street to Virginia Avenue block and recommended tree planting on the southern side of the street. On the Virginia Avenue to West Virginia Avenue block, they proposed replacing trees in the right of way areas that are missing trees and placing bioretention at the far western end of the block on the north side of the street. They also recommended adding street trees along the West Addition to Silver Lane block of Virginia Avenue and permeable parking lanes on West Virginia Avenue, south of West Addition Street.

Figure 11. Stakeholder design concept for West Addition Street.

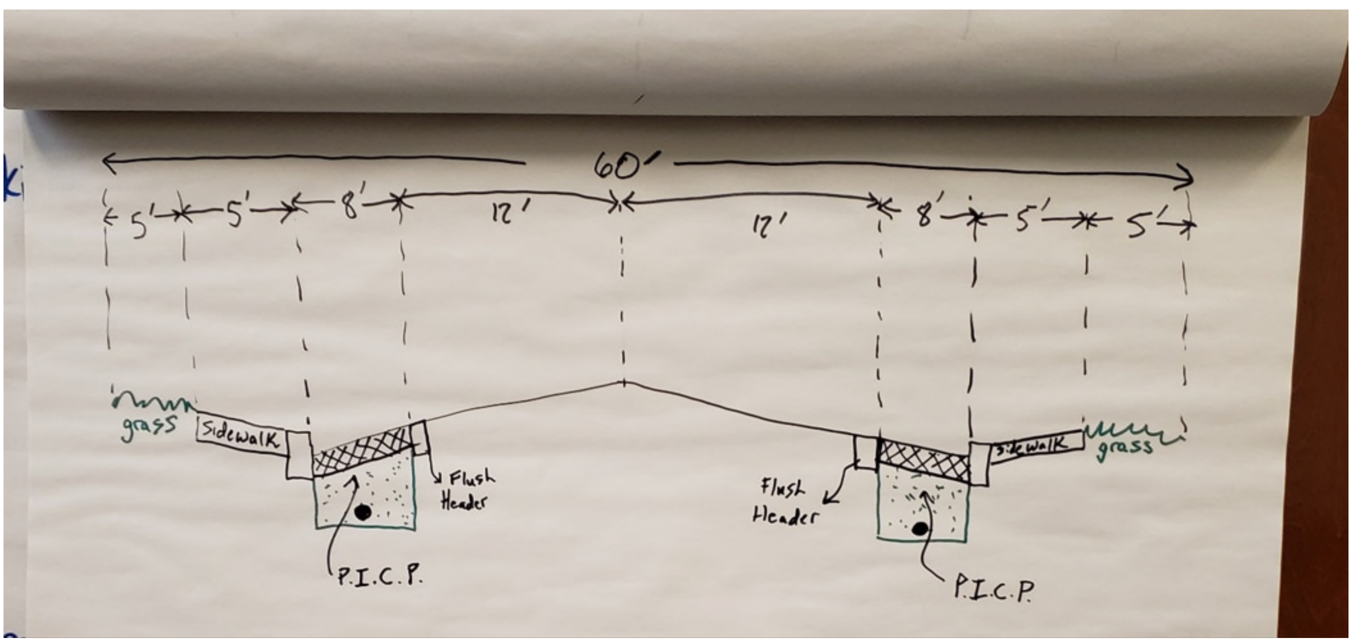


Figure 12. Stakeholder cross-section of design concept for West Addition Street.

Overall, the workshop was well received, and attendees were excited about how green street concepts might serve to increase green space and general community aesthetics, encourage economic growth and revitalization, and help alleviate stormwater issues.

Attendees felt they would be able to build upon the concept design planning to move projects forward to full design.

During the workshop all opportunities identified by the participants were considered. During the concept design phase, the potential projects are modified based on any additional constraints identified by the design engineers at Tetra Tech. Constraints can include utility conflicts, insufficient right of way space for practices, challenges with neighboring landowners, property ownership limitations, topography, and existing stormwater infrastructure. It is important to note that the concept designs were developed in the absence of updated topographic survey or geotechnical investigations of the project site. As a result, they do not consider conflicts of utilities not currently mapped or recognized.

CONCEPT DESIGNS

Full concept designs were developed for both the West Virginia Avenue project area and the West Addition Street project area. The karst geology of the city of Martinsburg means that any GI practices that are implemented will need to incorporate impermeable liner and underdrain components. The concept designs detailed below include impermeable liners, underdrains and other infrastructure necessary to support these features to the extent possible.

Concept Design Summary

Using the input provided by the workshop participants a green street concept plan was developed for the project areas. Narrative information is provided below for each project area with overview illustrations. The full concept design renderings are provided in Appendix C.

Along West Addition Street the green street concept incorporates permeable pavement, street trees and a curbside bioretention (Figure 13 and Figure 14). The permeable pavement proposed on the northern side of West Addition Street between South Raleigh Street and Virginia Avenue will receive runoff from approximately 0.10 acre of drainage area. This contributing drainage area includes both the permeable pavement parking lane and the westbound travel lane. Runoff from adjacent lots on the northern side of the street, which currently enters the street via overland flow, will be intercepted by a conventional standing curb and gutter system along the length of the block. This will route this runoff to a proposed stormwater inlet. The permeable pavement proposed on the southern side of West Addition Street between South Raleigh Street and Virginia Avenue will receive runoff from approximately 0.17 acre of drainage area. This contributing drainage area includes the remaining portion of the street area. Similarly, a stormwater inlet is proposed for the southern side of the street. The bioretention proposed on the northern side of West Addition Street between Virginia Avenue and West Virginia Avenue will receive runoff from approximately 1.30 acres of drainage area. This contributing drainage area includes a portion of the street area and a portion of the adjacent lots located on the northern side of the street. Street trees are also proposed along the northern side of West Addition Street on both blocks. Street trees can improve shade conditions and reduce heat stress during the warmer months.

Figure 13. Plan view of proposed green street concept along West Addition Street

Figure 14. Drainage areas for the bioretention (left) and permeable pavement (right) on West Addition Street.

Along West Virginia Avenue the green street concept incorporates permeable pavement, bioretention, street trees and a grass swale (Figure 15 and Figure 16). The concept includes a shift in the curbline to extend two feet into the roadway to accommodate additional storage volume in the bioretention and grass swale. The permeable pavement proposed on the western side of West Virginia Avenue between Buxton Street and Berry Street will receive runoff from approximately 0.20 acre of drainage area. This contributing drainage area includes the permeable area as well as the southbound travel lane. Runoff from adjacent lots on the western side of the street, which currently enters the street via overland flow, will be intercepted by a conventional standing curb and gutter system along the length of the block, which will route this runoff to the existing grate inlet. The bioretention proposed on the eastern side of West Virginia Avenue between Buxton Street and Berry Street will receive runoff from approximately 3.71 acres of drainage area. This contributing drainage area includes portions of the northbound travel lane on West Virginia Avenue and runoff from Virginia Avenue and Berry Street, in addition to portions of the adjacent lots located on the eastern side of West Virginia Avenue. The permeable pavement proposed on the western side of West Virginia Avenue between Berry Street and Bowers Street will receive runoff from approximately 0.18 acre of drainage area. This contributing drainage area includes the southbound travel lane. Runoff from adjacent lots located on the western side of the street, which currently enters the street via overland flow, will be intercepted by a conventional standing curb and gutter system along the length of the block, which will route this runoff to a proposed stormwater inlet. Street trees are also proposed along West Virginia Avenue on the western side of the street between Berry Street and Bowers Street. The grass swale proposed on the eastern side of West Virginia Avenue between Berry Street and Bowers Street will receive runoff from approximately 2.41 acres of drainage area. This contributing drainage area includes the northbound travel lane and adjacent lots on the eastern side of the street.

Figure 15. Plan view of proposed green street concept along West Virginia Avenue.

Figure 16. Drainage areas for the northern bioretention and permeable pavement (left) and southern grass swale and permeable pavement (right) on West Virginia Avenue.

Designs

The conceptual designs for the bioretention and permeable pavement areas were developed using the design guidance provided by DEP's Stormwater Management and Design Guidance Manual (WVDEP 2012). This manual provides design criteria for a range of stormwater management practices that provide treatment of stormwater runoff as well as management of runoff volumes and flows. A principle design criterion for bioretention and permeable pavement systems is the footprint of the practice, which directly relates to the storage available for the capture and treatment of stormwater runoff. At the conceptual stage the commonly used criteria are to size bioretention areas so that the practice footprint is approximately 3% to 6% of the contributing drainage area, and permeable pavement areas have a 2:1 ratio of run-on areas to permeable pavement. Since the design criteria provided in the manual are developed for the purposes of meeting specific regulatory management objectives, when applied to retrofit scenarios such as the Martinsburg GI concept designs, some variation from these criteria may be acceptable. A summary of bioretention and permeable pavement sizing ratios for the concept designs is provided in Table 1. It should be noted that the bioretention practices in the concept design capture contributing areas that include off-street residential areas exhibiting disconnected impervious areas and soils of moderate permeability. While the proposed practice sizing is less than the recommendation from DEP's guidance, the bioretention areas can be configured in an offline scenario such that volumes in excess of the storage capacity of each bioretention area can be bypassed. Actual drainage area and sizing should be further evaluated as part of future full design efforts. A topographic survey conducted as part of a full design will further clarify the drainage area to each of the proposed practices and confirm appropriate sizing. Drainage area estimates for the concept designs were developed using 3-foot contours and actual drainage areas may vary significantly.

Table 1. Summary of practice drainage areas and estimated sizing.

Bioretention/Permeable Paver	Drainage Area (acres)	Practice Area (square feet)	Sizing ratio*
W. Addition St. Bioretention	1.30	420	0.74%
W. Addition St. Northern Permeable Pavement	0.10	2,400	0.8:1
W. Addition St. Southern Permeable Pavement	0.17	2,400	2:1
West Virginia Ave. Bioretention	3.71	3,200	1.98%
West Virginia Ave. Grass Swale	2.41	3,200	3.05%
West Virginia Ave. Northwestern Permeable Pavement	0.20	3,200	1.7:1
West Virginia Ave. Southwestern Permeable Pavement	0.18	3,200	1.5:1

*sizing ratio represents ratio of GI practice footprint to drainage area. DEP guidance recommends sizing ratios of 3-6% for bioretention and maximum 2:1 ratio of run-on areas to permeable pavement

Uncertainties and Design Assumptions

The concept designs incorporate GI practices that will provide water quality treatment of stormwater runoff while providing other street enhancement services such as traffic calming, shading, and generally creating a sense of place along each street. The designs may also mitigate localized and downstream flooding, incrementally, through detention of street runoff and a minor amount of evaporative loss. However, an evaluation to quantify flood reduction has not been included for this report.

The project area is known to exhibit karst geology, therefore, infiltration-based GI practices (permeable pavement and bioretention) are assumed to incorporate an impermeable liner in accordance with typical application of these practices in karst areas. During future design phases geotechnical investigations should evaluate subsurface conditions to determine if the liner is necessary. In the event that an impermeable liner can be omitted from the designs, GI performance for both water quality treatment and flood reduction may be enhanced.

The selection of GI practices (permeable pavement, street side bioretention, grass swale, and street trees) was made by workshop participants after consideration of site conditions such as soil characteristics, available right of way space, maintenance requirements, and expected performance among others. Specific practice type, placement, and configuration of each practice generally reflects the explicit preferences expressed by local stakeholders during the workshop with limited modifications by the workshop facilitators to account for obvious conflicts.

Available site information at the time of concept design development was limited to topography, right of way boundaries, and incomplete information on subsurface utilities. This was supplemented by on-site observations to inform placement selection of individual practices. During future design phases additional site information obtained through site surveys and other investigations will undoubtedly require modification of these concepts.

The drainage area contributing to each street side GI practice often contains some off-site contributing area, including residential lots with pervious vegetated areas. The concept design proposes the installation of an interceptor curb/gutter to bypass off-site drainage where the selected GI practice is permeable pavement, in accordance with design guidance to avoid pervious run-on and to limit the ratio of contributing drainage area to permeable area at 2:1. An evaluation of the offsite flow rates or capacity of interceptor curb system has not been made. It is possible, if not likely, that during larger events offsite flow will enter the permeable system. An evaluation of the risk this poses to the practice should be made during future design phases.

Design storage (primary sizing value) for bioretention assumes vertical sidewalls at sidewalk and curb edge and a 1 foot storage depth. The use of side slopes within the planting bed will reduce overall design volume. Practice dimensions and configurations were assumed to be compliant with standard design criteria. Reported practice performance is based on published pollutant removal performance values and may not be reflective of performance of the final design. Further evaluation should be conducted during future design phases.

Most street sections exhibit longitudinal slope. As a result, permeable pavement systems will need to incorporate internal storage layer berms perpendicular to the street integrated with an underdrain system to prevent uninterrupted longitudinal flow at the bottom of the permeable pavement system in the downslope direction at the end of the practice. This will both enhance the detention period of runoff captured by the permeable system and mitigate the potential for up flow out of the permeable pavement back onto the roadway at the downslope end.

Volume Treated and Pollutant Reductions

Preliminary treated volumes were calculated for each of the proposed practices using the Simple Method[5]. The preliminary sizing and depth of reservoir/filter media were set to treat the runoff volume from the first one inch of rainfall. In the case of the bioretention system at West Addition Street the preliminary sizing was unable to meet the one inch treatment target due to limited space for the practice. However, the practice can be designed in an off-line configuration to prevent scour or damage to the bioretention system. On the other bioretention system the concept design provides treatment that exceeds the target one inch treatment volume. However, it is expected that practice sizing may be reduced during future design phases to accommodate utilities or other conflicts.

The Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST) was used to estimate the potential pollutant reductions from the proposed practices (Table 2). The pollutant reductions were estimated using the Chesapeake Bay 2019 Progress Scenario and applying each practice to the scenario individually and determining the resulting change in the load. More generally, the pollutant reduction efficiencies for the practices are 10%/20%/55% reduction in total nitrogen/total phosphorus/sediment for permeable pavement, 25%/45%/55% reduction in total nitrogen/total phosphorus/sediment for bioretention, and 45%/45%/70% reduction in total nitrogen/total phosphorus/sediment for a grass swale.

Table 2. Summary of estimated volume treatment and pollutant reductions from the proposed practices.

Bioretention/Permeable Paver	Volume Treated (cubic feet)	Total Nitrogen (pounds)	Total Phosphorus (pounds)	Sediment (pounds)
W. Addition St. Bioretention	691	1.13	0.14	221.84
W. Addition St. Northern Permeable Pavement	740	0.04	0.01	24.43
W. Addition St. Southern Permeable Pavement	1,311	0.06	0.01	41.56
West Virginia Ave. Bioretention	5,530	3.23	0.40	633.08
West Virginia Ave. Grass Swale	5,530	3.77	0.26	523.40
West Virginia Ave. Northwestern Permeable Pavement	1,501	0.07	0.01	48.85
West Virginia Ave. Southwestern Permeable Pavement	1,292	0.06	0.01	44.02

[5] Schueler, T. 1987. Controlling urban runoff: a practical manual for planning and designing urban BMPs. Metropolitan Washington Council of Governments. Washington, DC.

Costing

Opinion of probable construction costs for the concept designs are presented in Table 3. These costs were developed using approximate quantities derived from the concept plans and assumptions regarding GI practice dimensions, configurations and material type. Unit costs for construction items were based on a combination of sources including published construction costs databases, bid summaries from recently constructed projects with similar features and size, and the engineers estimates of unit cost from similar cost items and previous experiences in similar projects. Unit costs may not be reflective of local material and construction cost factors. Site specific characteristics which might further impact actual construction costs, such as extended disposal distances or the presence of shallow bedrock, are similarly not reflected. Since costs are reflective of the concept designs as presented, they represent GI practice implementation which likely exceeds target treatment volumes. As noted previously in this report, it is expected that conflicts with utilities, citizen input, and other factors will reduce total footprint of proposed GI practices which may be implemented in future design phases. This may result in lower construction costs than are reflected here. Additional, although not comprehensive, assumptions and uncertainties are provided below:

- It is assumed that the bioretention areas will exhibit vertical sidewalls to maximize treatment. Adjustment to a sloped sidewall may significantly reduce construction costs but will similarly reduce volume of water treated by these systems.
- Permeable pavement surface is assumed to be interlocking concrete pavers. The selection of an alternative permeable surface may affect construction costs.
- It is assumed that an impermeable liner will be required for all permeable pavement and bioretention practices due to the presence of karst soils. If geotechnical testing reveals the absence of karst geology or provides for the omission of the impermeable liner, GI practice function may be enhanced and construction costs reduced.
- Where sidewalks adjoin proposed GI practices, it is assumed they will not be removed. Subsurface conditions may require removal of some or all sidewalk in these areas.
- Construction costs include all practices described above. While several costs categories are split evenly between the West Addition Street and West Virginia Avenue project sites, the actual costs will be different by site, and the estimate assumes cost efficiencies gained by completing work on both projects simultaneously.

A complete itemized cost breakout is provided in Appendix D.

Table 3. Summary of Opinion of Probable Construction Costs.

	West Addition Street	**West Virginia Avenue**
Construction	$183,762	$346,657
Construction Mobilization/Bonds/Contingency	$95,556	$180,262
Total Construction Cost	**$279,319**	**$526,919**
Survey	$4,250	$4,250
Geotechnical Investigation	$10,000	$10,000
Design and Construction Management	$50,000	$50,000
Total Implementation Cost	**$343,569**	**$591,169**

NEXT STEPS

Using the concept designs provided in this report, the city of Martinsburg can move forward with the full design of one of more of the project sites. The City has already applied for, and received, a Chesapeake Bay Trust G3 grant, funded by U.S. EPA Region 3 and other partners. The grant funding along with the City's matching funds can be used to develop the full engineering design plans.

APPENDIX A: ADDITIONAL RESOURCES

EPA's Green Infrastructure Website

http://www.epa.gov/green-infrastructure

National Association of City Transportation Officials (NACTO) Urban Street Stormwater Guide

https://nacto.org/publication/urban-street-stormwater-guide/

EPA's Green Infrastructure Funding Sources

https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

Implementing Stormwater Infiltration Practices at Vacant Parcels & Brownfields

http://www.epa.state.il.us/water/watershed/publications/implementing-stormwater-infiltration-practices.pdf

EPA Reference Documents on Incorporating Green Infrastructure into Brownfields Projects

https://www.epa.gov/sites/production/files/2015-07/documents/green_infrastructure-9-16-14.pdf

http://www.epa.gov/green-infrastructure

West Virginia Stormwater Management and Design Guidance Manual, 2012

https://dep.wv.gov/WWE/Programs/stormwater/MS4/Pages/StormwaterManagementDesignandGuidanceManual.aspx

APPENDIX B: WORKSHOP ATTENDEES

West Virginia Green Infrastructure Planning and Implementation Sign-In Sheet January 22-23, 2020

Feel free to add your email so we can keep you informed on projects, volunteer activities and other events!

Name: (please print)	Email: (Please Print)
Janice & Allan Lower	
David Haarberg	davidhaarberg@gmail.com
Ken Collinson	k.collinson@cityofmartinsburg.org
Dave Montali, Tetra Tech	dave.montali@tetratech.com
Tony Petrucci	petrucciengr@gmail.com
Kim Petrucci	kpetrucci@cityofmartinsburg.org
Dana Keith	dkeith@cityofmartinsburg.org
Kimberly Nelson	knelson@cityofmartinsburg.org
Al Gaige	
Jeff Wilkerson	
Harriet Johnson	hjohnson@cityofmartinsburg.org
Zack Walburn	zwalburn@bcpssd.com
Ken Collinson	kcollinson@cityofmartinsburg.org
Kim Petrucci	kpetrucci@cityofmartinsburg.org
Dana Keith	dkeith@cityofmartinsburg.org
Monica Whyte	monica.a.whyte@wv.gov
Matthew Pennington	mpennington@region9wv.com
Mark Baldwin	City
Alana Hartman	alana.c.hartman@wv.gov

Chesapeake Bay Program
Science. Restoration. Partnership.

dep

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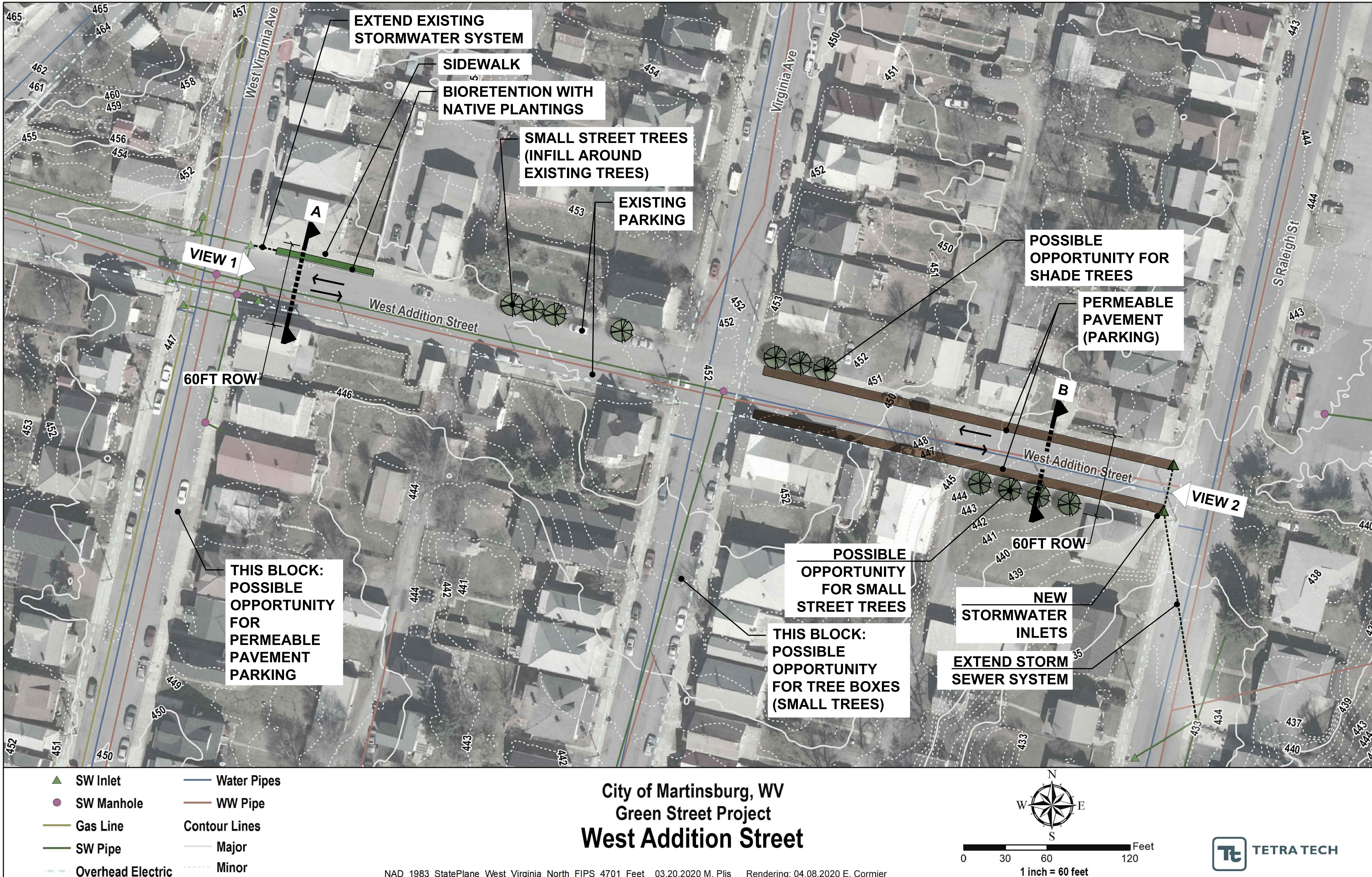
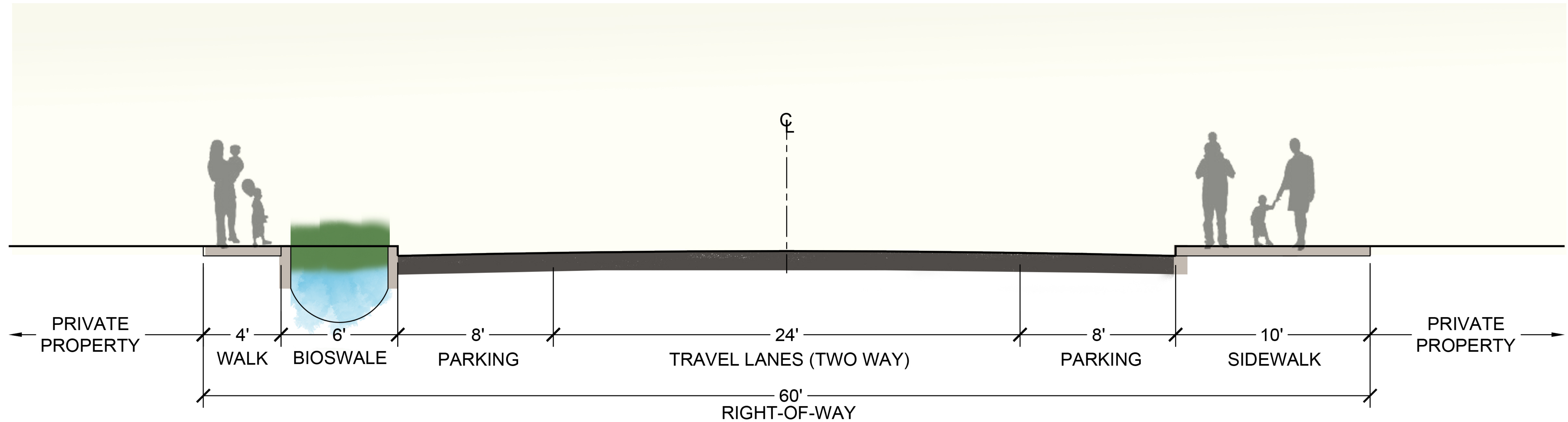
APPENDIX C: CONCEPT DESIGNS

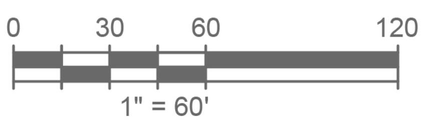


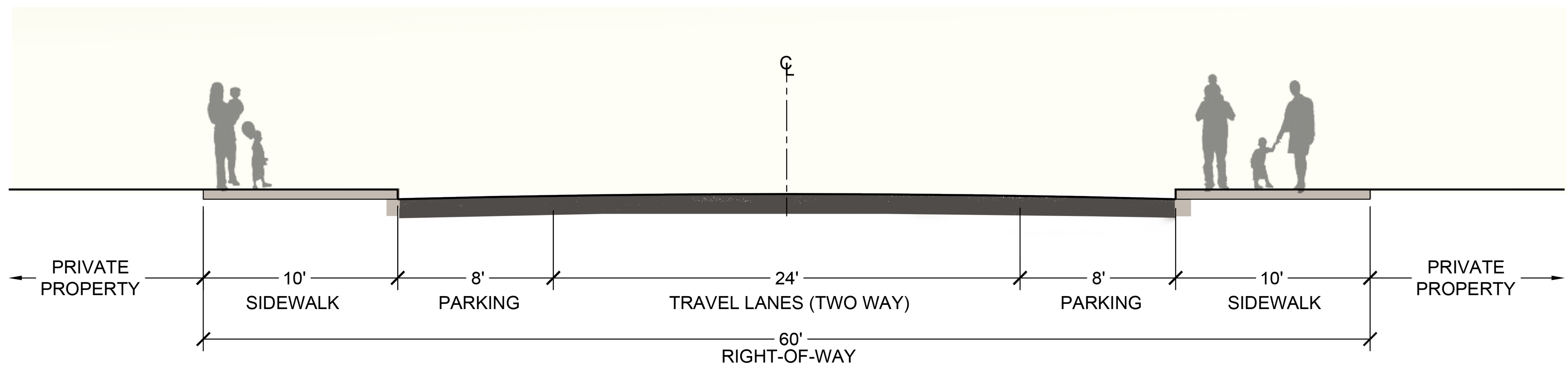
City of Martinsburg, WV
Green Street Project
West Addition Street

NAD_1983_StatePlane_West_Virginia_North_FIPS_4701_Feet 03.20.2020 M. Plis Rendering: 04.08.2020 E. Cormier



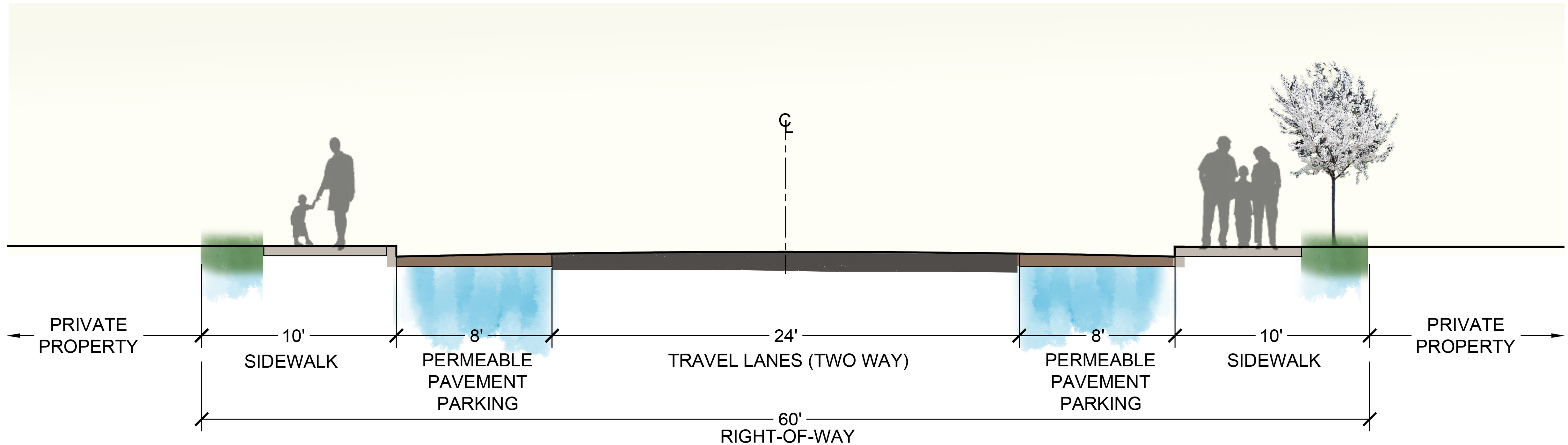
SECTION A - WEST ADDITION STREET - PROPOSED



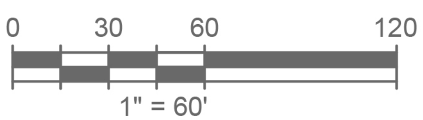


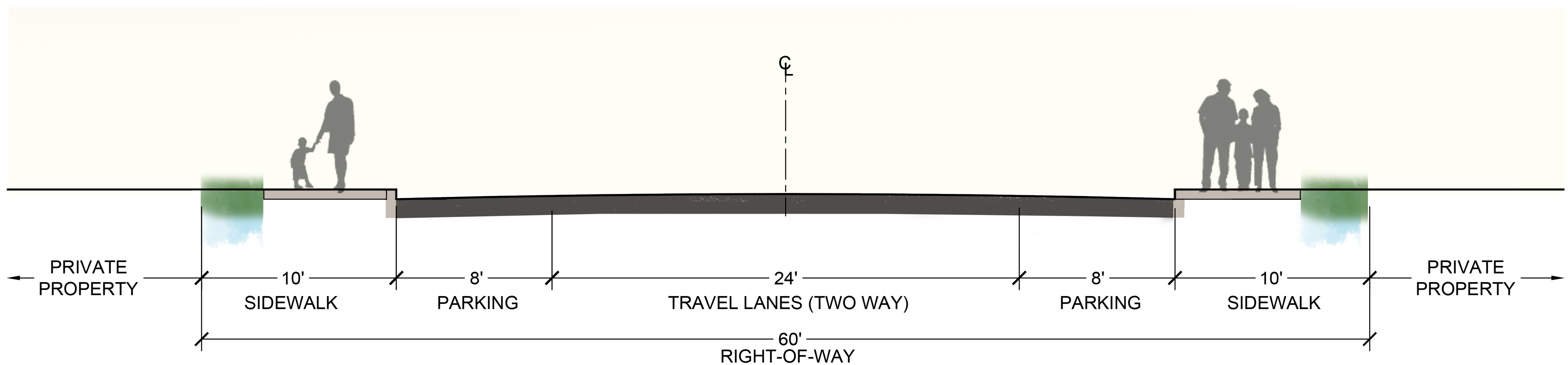
SECTION A - WEST ADDITION STREET - EXISTING


SIDEWALK
CURB CUT FOR
STORMWATER ENTRY
NATIVE PLANTINGS IN
BIORETENTION AREA
PROPOSED - WEST ADDITION STREET AT WEST VIRGINIA AVENUE (VIEW 1)



SECTION B - WEST ADDITION STREET - PROPOSED





SECTION B - WEST ADDITION STREET - EXISTING

PROPOSED - WEST ADDITION STREET AT S. RALEIGH STREET (VIEW 2)

▲ SW Inlet	Water Pipes
● SW Manhole	WW Pipe
Gas Line	Contour Lines
SW Pipe	Major
Overhead Electric	Minor

City of Martinsburg, WV
Green Street Project
West Virginia Avenue

0 30 60 120 Feet
1 inch = 60 feet

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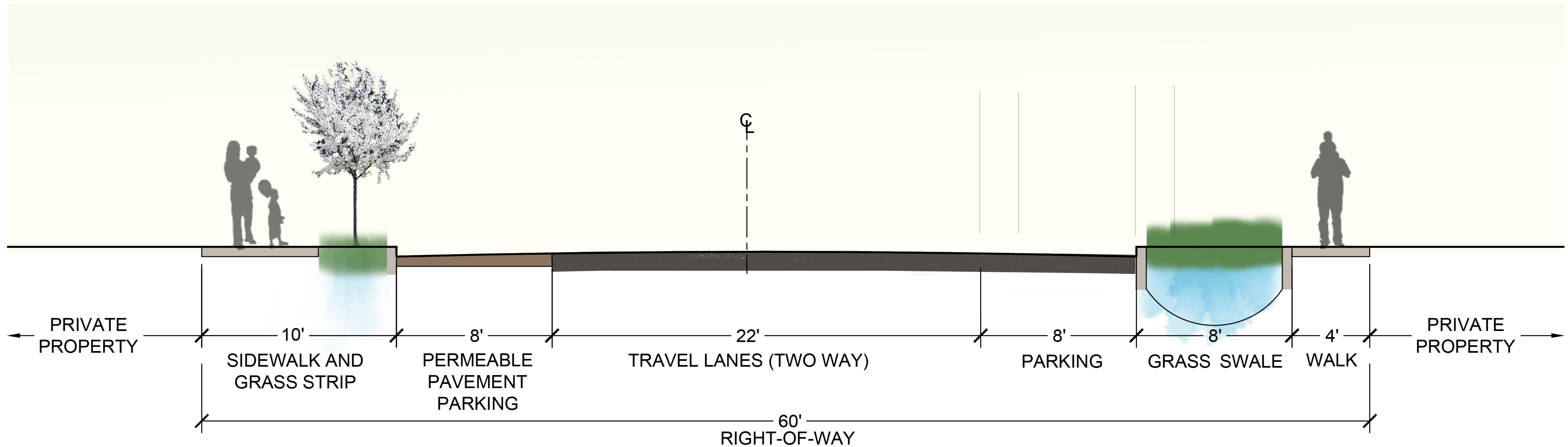
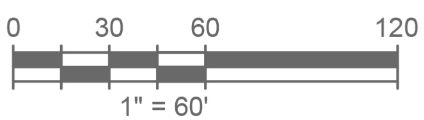
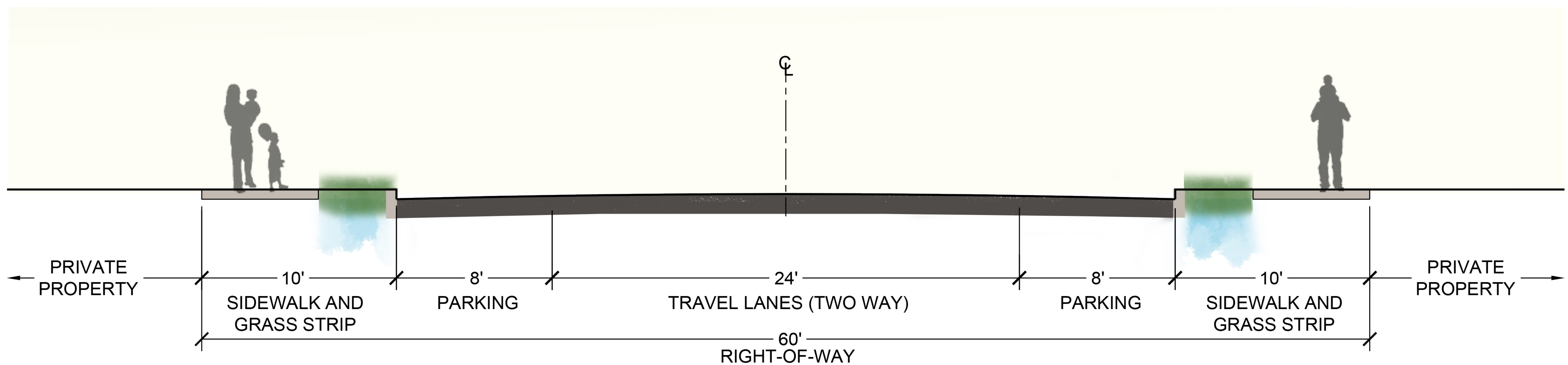
NAD_1983_StatePlane_West_Virginia_North_FIPS_4701_Feet 03.20.2020 M. Plis Rendering: 04.16.2020 E. Cormier



SECTION C - WEST VIRGINIA AVENUE - PROPOSED





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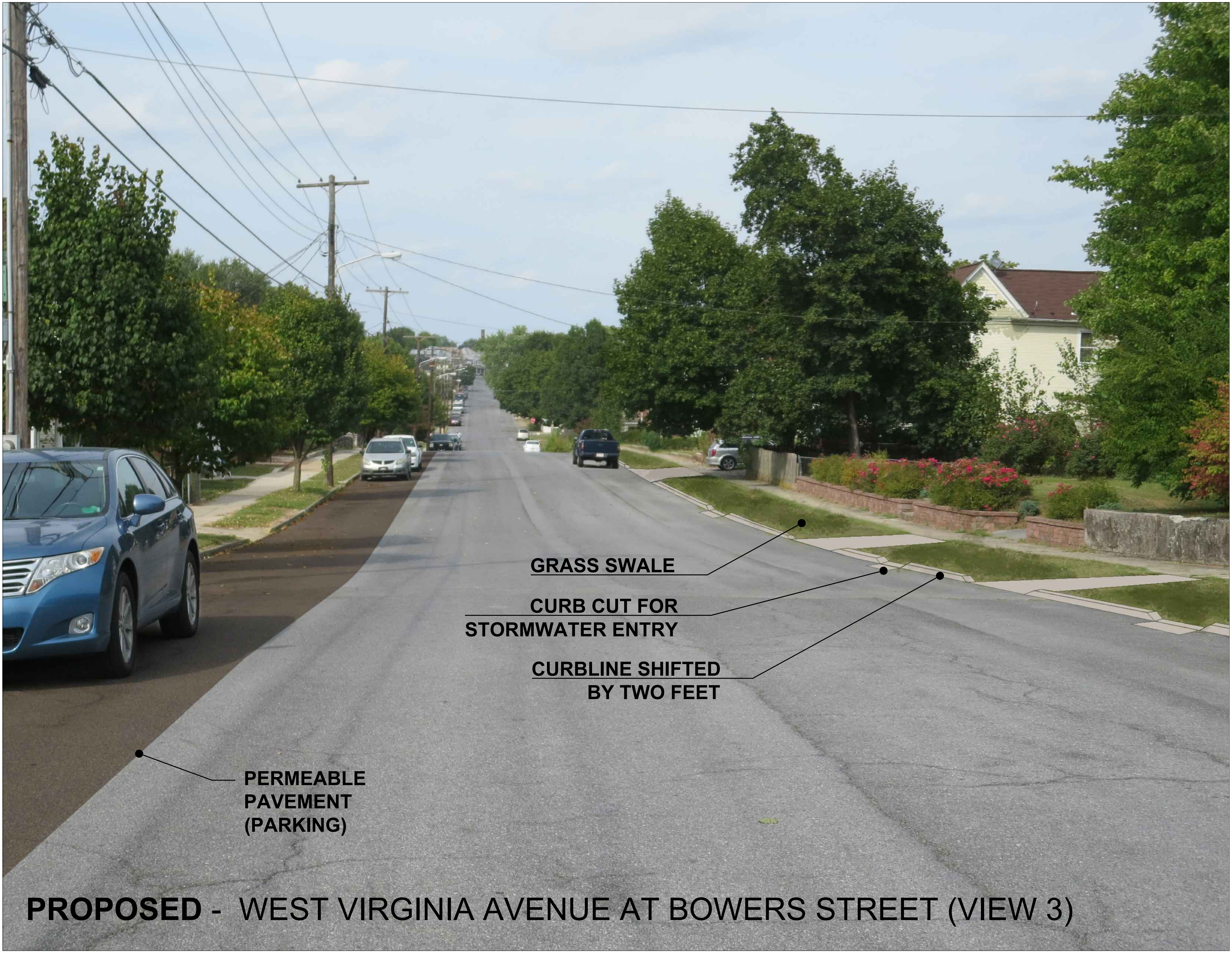
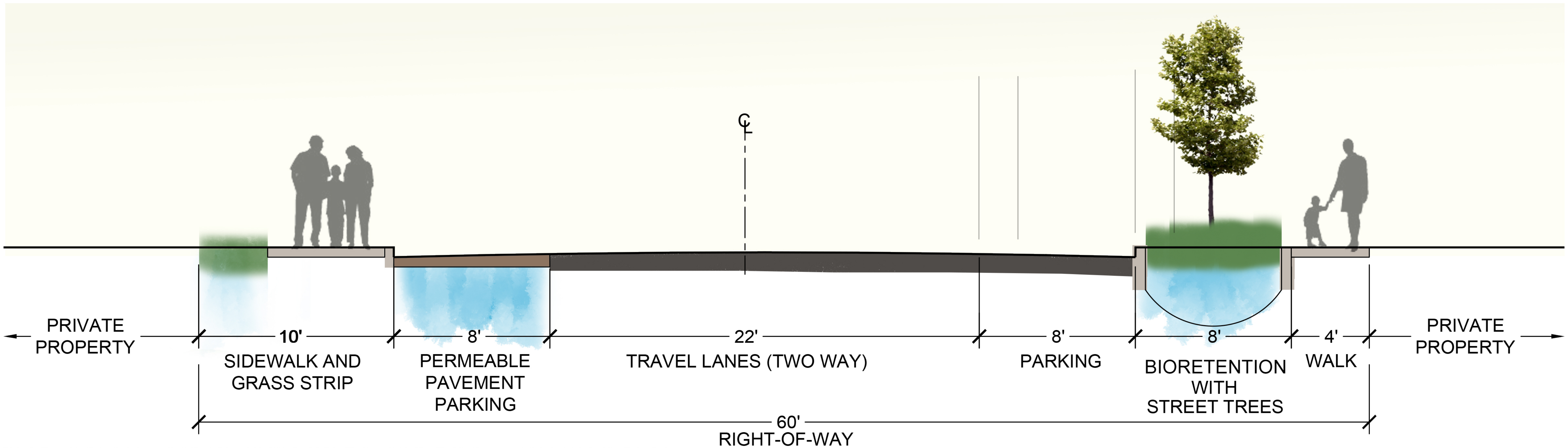
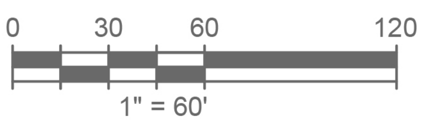
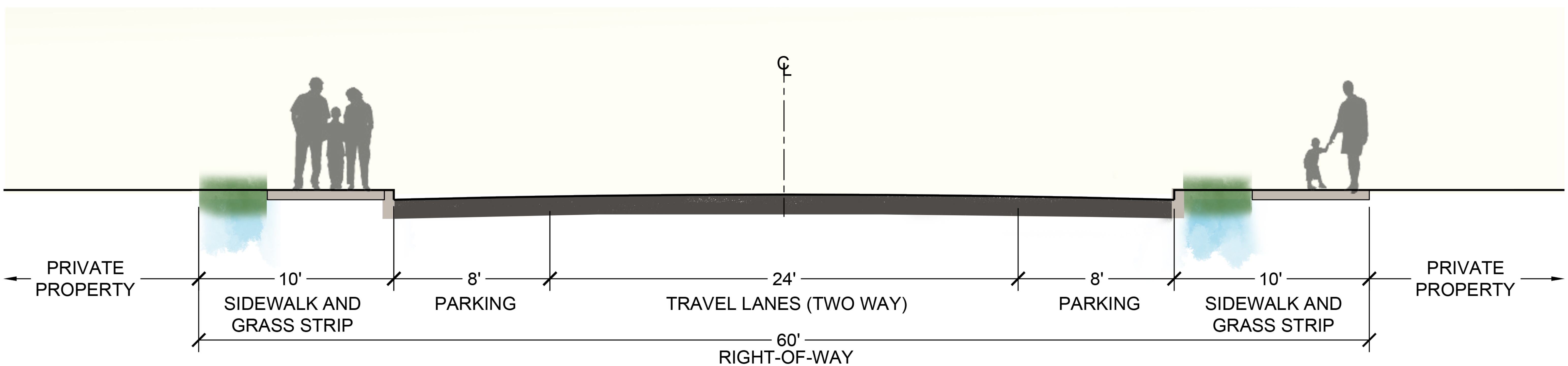


PROPOSED - WEST VIRGINIA AVENUE AT BOWERS STREET (VIEW 3)



SECTION D - WEST VIRGINIA AVENUE - PROPOSED





SECTION D - WEST VIRGINIA AVENUE - EXISTING

PROPOSED - WEST VIRGINIA AVENUE AT BERRY STREET (VIEW 4)

APPENDIX D: COST ESTIMATES

Title	Preliminary Opinion of Probable Cost: W. Addition Street Project Area
Project #	100-IWM-T94503
Project Name	WV GI Support
Location	Martinsburg, WV

	Name	Date
Quantities	E. Cormier	4/9/2020
Costs	J. Smith	4/24/2020
Checked By		
Approved By		

TETRA TECH, Inc.

Comments:	This sheet provides an opinion of probable construction cost based on the Preliminary concept designs. These costs should be used for planning purposes only and should be revised and updated with any further development or refinement of the concepts.
Project Site/Scenario:	Construction of an select GI improvements and associated other infrastructure necessary for their construction for **West Addition St** in Martinsburg, WV.

Item No	Description	Quant.	Unit	Unit Cost	Total
	Site Preparation				
1	Traffic control	1	LS	$1,000.00	$1,000
	Demolition				
2	Sawcut and remove existing asphalt pavement	767	SY	$11.00	$8,433
3	Curb and gutter removal	670	LF	$7.50	$5,025
	Earthwork				
4	Excavation (bioretention)	418	CY	$12.00	$5,013
5	Offsite Haul and Dispose	518	CY	$16.00	$8,289
6	Impermeable Liner	7830	SF	$2.00	$15,660
7	Washed 57	348	TN	$45.00	$15,660
8	Bedding Layer	29	TN	$50.00	$1,450
9	Underdrain (includes cleanouts)	660	LF	$10.00	$6,600
10	Engineered Media	32	TN	$65.00	$2,048
	Structures and Infrastructure				
11	Grate Inlet	2	LS	$4,500.00	$9,000
12	24" RCP	200	LF	$60.00	$12,000
13	Curb and gutter	600	LF	$21.00	$12,600
14	edge curb	600	LF	$15.00	$9,000
15	vertical curb (36" high)	120	LF	$25.00	$3,000
16	Interlocking Concrete Pavers	4800	SF	$10.00	$48,000
17	Concrete (sidewalk and Driveway apron)	240	SF	$10.00	$2,400
18	Asphalt concrete paving (repair)	1435	SF	$10.00	$14,350
	Landscaping				
19	Mulch	4	CY	$50.00	$194
20	sod	0	SY	$10.00	$0
21	Misc Landscaping, shrubs and containerized plantings	420	SF	$7.00	$2,940
22	Specimen Trees	11	EA	$100.00	$1,100
	Construction Subtotal				**$183,762**
23	Mobilization and stakeout 8%				$14,701
24	Bonds and Insurance 4%				$7,350
25	Estimating Contingency 10%				$18,376
26	Construction contingency 30%				$55,129
	Total Construction Cost				**$279,319**
27	Survey	1.00	LS	$ 4,250	$ 4,250
28	Geotechnical Investigation	1.00	LS	$ 10,000	$ 10,000
29	Design and Construction Management	1.00	LS	$ 50,000	$ 50,000
	Total Implementation Cost				**$343,569**

Title	Preliminary Opinion of Probable Cost: W. Virginia Avenue Project Area
Project #	100-IWM-T94503
Project Name	WV GI Support
Location	Martinsburg, WV

	Name	Date
Quantities	E. Cormier	4/9/2020
Costs	J. Smith	4/24/2020
Checked By		
Approved By		

TETRA TECH, Inc.

Comments:	This sheet provides an opinion of probable construction cost based on the Preliminary concept designs. These costs should be used for planning purposes only and should be revised and updated with any further development or refinement of the concepts.
Project Site/Scenario:	Construction of an select GI improvements and associated other infrastructure necessary for their construction for **West Virginia Avenue** in Martinsburg, WV.

Item No	Description	Quant.	Unit	Unit Cost	Total
	Site Preparation				
1	Traffic control	1	LS	$1,000.00	$1,000
	Demolition				
2	Sawcut and remove existing asphalt pavement	742	SY	$11.00	$8,164
3	Curb and gutter removal	1600	LF	$7.50	$12,000
	Earthwork				
4	Excavation (bioretention)	948	CY	$12.00	$11,378
5	Offsite Haul and Dispose	1176	CY	$16.00	$18,811
6	Impermeable Liner	14400	SF	$2.00	$28,800
7	Washed 57	640	TN	$45.00	$28,800
8	Bedding Layer	53	TN	$50.00	$2,667
9	Underdrain (includes cleanouts)	1200	LF	$10.00	$12,000
10	Engineered Media	240	TN	$65.00	$15,600
	Structures and Infrastructure				
11	Grate Inlet	2	LS	$4,500.00	$9,000
12	24" RCP	225	LF	$60.00	$13,500
13	Curb and gutter	800	LF	$21.00	$16,800
14	edge curb	800	LF	$15.00	$12,000
15	vertical curb (36" high)	1000	LF	$25.00	$25,000
16	Interlocking Concrete Pavers	6400	SF	$10.00	$64,000
17	Concrete (sidewalk and Driveway apron)	960	SF	$10.00	$9,600
18	Asphalt concrete paving (repair)	2720	SF	$10.00	$27,200
	Landscaping				
19	Mulch	30	CY	$50.00	$1,481
20	sod	356	SY	$10.00	$3,556
21	Misc Landscaping, shrubs and containerized plantings	3200	SF	$7.00	$22,400
22	Specimen Trees	29	EA	$100.00	$2,900
	Construction Subtotal				**$346,657**
23	Mobilization and stakeout 8%				$27,733
24	Bonds and Insurance 4%				$13,866
25	Estimating Contingency 10%				$34,666
26	Construction contingency 30%				$103,997
	Total Construction Cost				**$526,919**
27	Survey	1.00	LS	$ 4,250	$ 4,250
28	Geotechnical Investigation	1.00	LS	$ 10,000	$ 10,000
29	Design and Construction Management	1.00	LS	$ 50,000	$ 50,000
	Total Implementation Cost				**$591,169**