THE RAMBLE WATERFRONT ENVIRONMENTAL + ENGINEERING STUDIES

LAUREL, DE

LAUREL REDEVELOPMENT CORPORATION
P.O. Box 333, Laurel, DE 19956
Invest in Laurel

This report was prepared on behalf of the Laurel Redevelopment Corporation by ForeSite Associates Inc. using Federal funds under award NA14 NOS 419 0123 from the Delaware Coastal Programs and the Office for Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the OCM, NOAA or the U.S. Department of Commerce

ABBREVIATIONS IN THIS DOCUMENT INCLUDE:

LRC - Laurel Redevelopment Corporation : the client

FA - ForeSite Associates : the consultant

SWM - stormwater management

BMP - best management practices

GTBMP - green technology best management practices : used interchangeably with BMP

DNREC - Delaware Department of Natural Resources and Environmental Control

NOAA - National Oceanic and Atmospheric Administration (US Department of Commerce Division)

USACE - United States Army Corps of Engineers

USDA - Unite States Department of Agriculture

NRCS - Natural Resource Conservation Service (US Department of Agriculture Division)

GIS - Geographical Information Systems : FirstMap is the Delaware website for this information

EIA - Environmental Impact Assessment : prepared by Brightfields Inc. for this project

UST - Underground storage tank

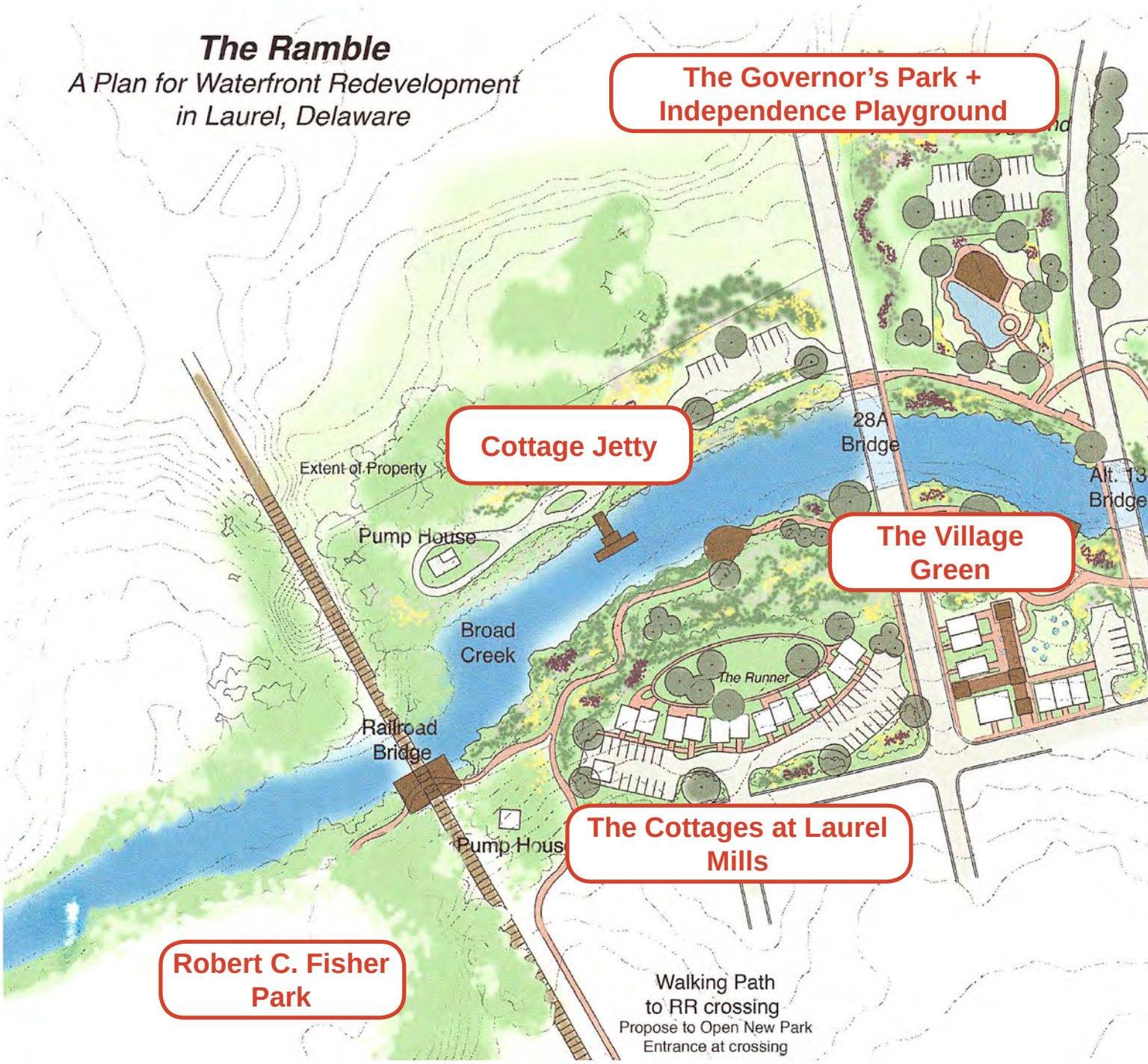
CDA - Contributing drainage area

MHHW - Mean High High Water

CONTENTS

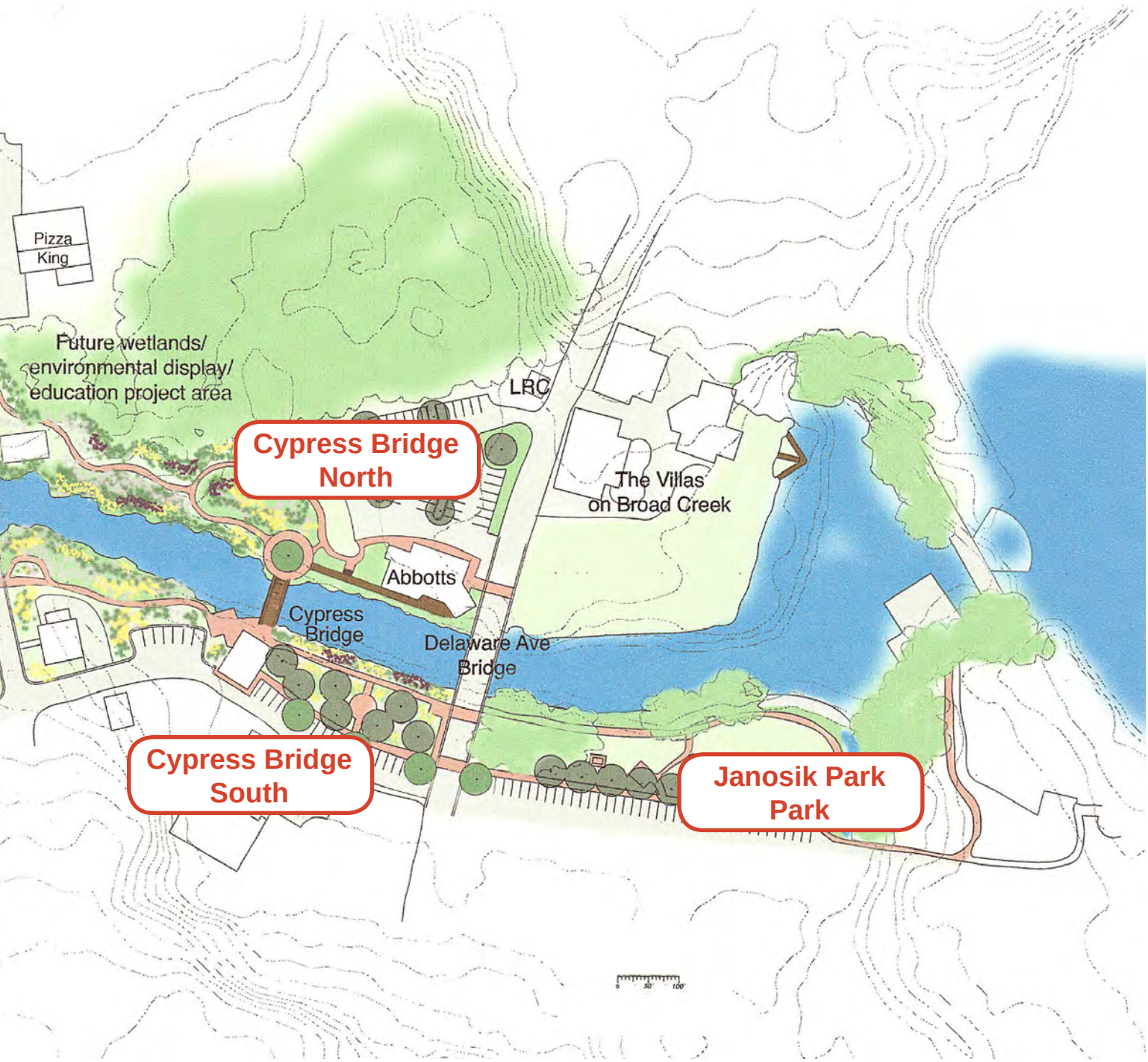
In January 2014, Dr. Jules Bruck, PLA worked on behalf of the Laurel Redevelopment Corporation (LRC) with a team of educators and planners from the University of Delaware (UD) to develop a master plan centered along Laurel's main cultural and economic amenity, the Broad Creek. The mission of the LRC, a nonprofit corporation founded in 1992, is to enhance the quality of life in the Town of Laurel by obtaining, rehabilitating and revitalizing properties which will increase economic development for the Town.

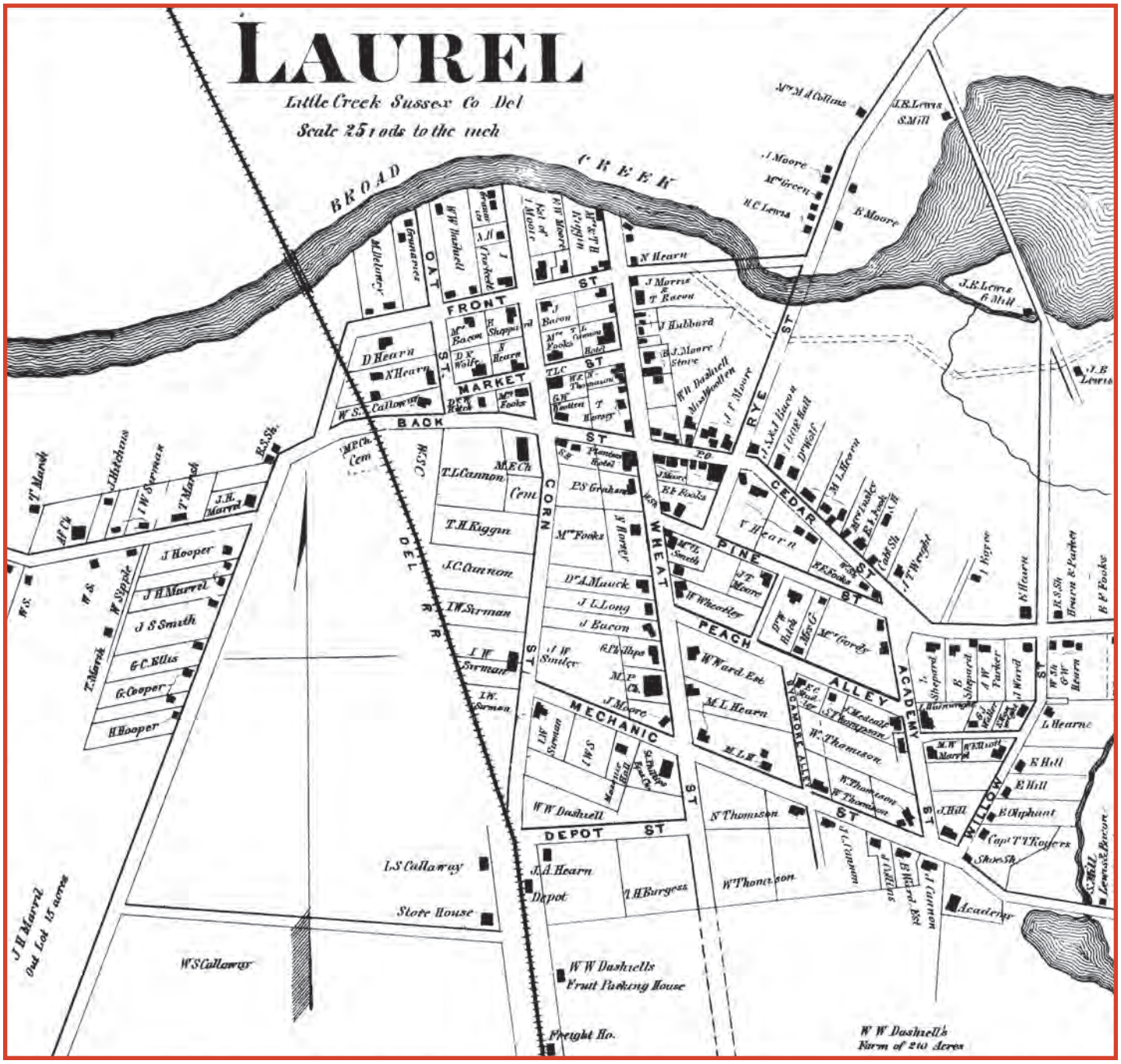
The final project, presented in September 2014 with the given moniker The Ramble, represents a comprehensive revitalization project supported by the LRC and the Town of Laurel and consistent with the 2011 Greater Laurel Comprehensive Plan. The Ramble highlights the Broad Creek as it flows



through Laurel from the Mill Dam to the Railroad Bridge (see The Ramble Plan below). The plan promotes green infrastructure along the banks of the creek to potentially protect the town from sea level rise induced flooding and aid in managing water quality and quantity.

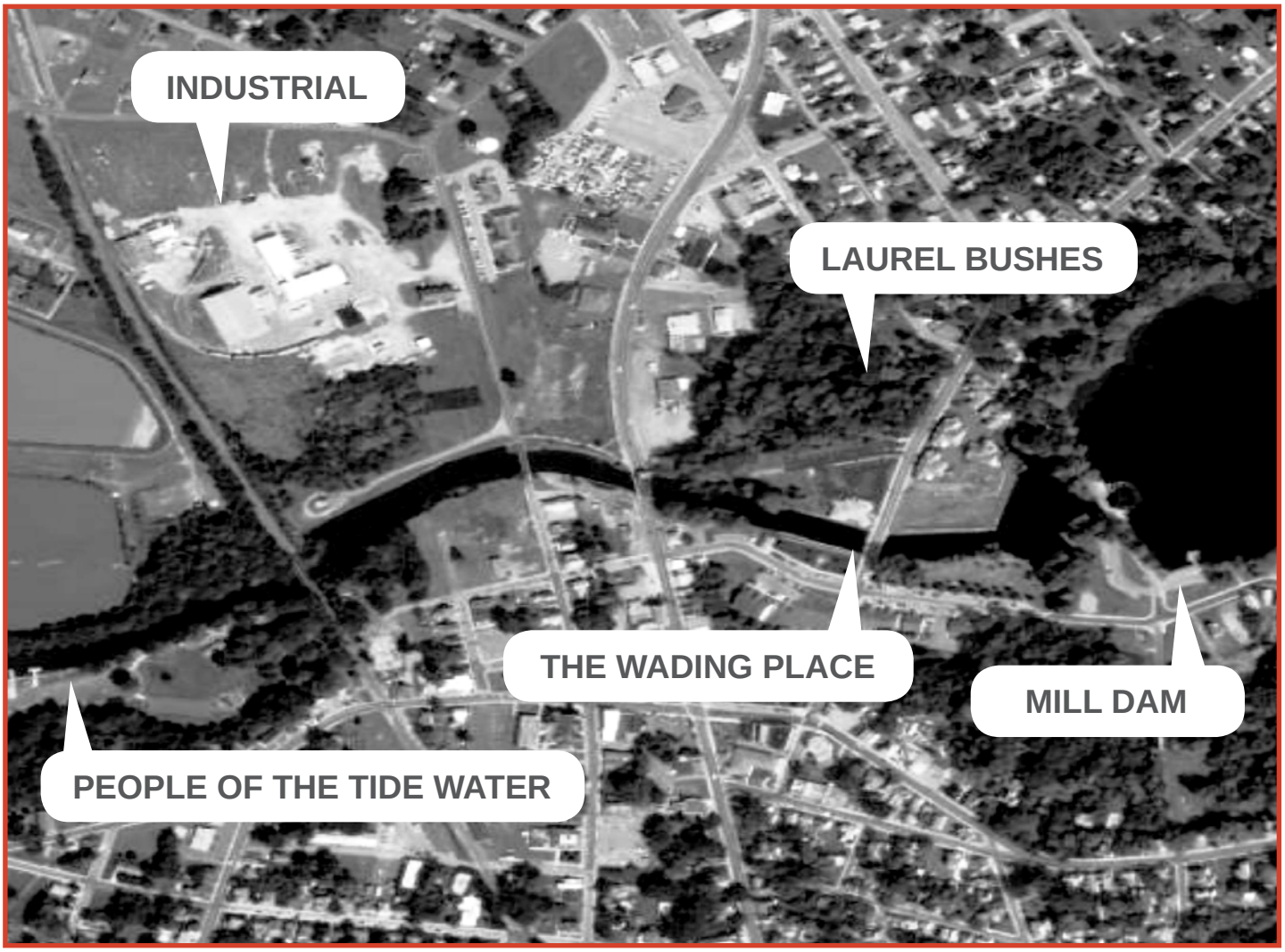
To begin implementing this plan the LRC applied for the Delaware Coastal Management Grant, and the professional firms of ForeSite Associates and Brightfields Inc. were added to the project team. Brightfields conducted an Environmental Impact Assessment (EIA) of the project site and ForeSite provided ecological and engineering studies. The following report is authored by ForeSite, the EIA report is a separate document that should be understood in-conjunction with this report.





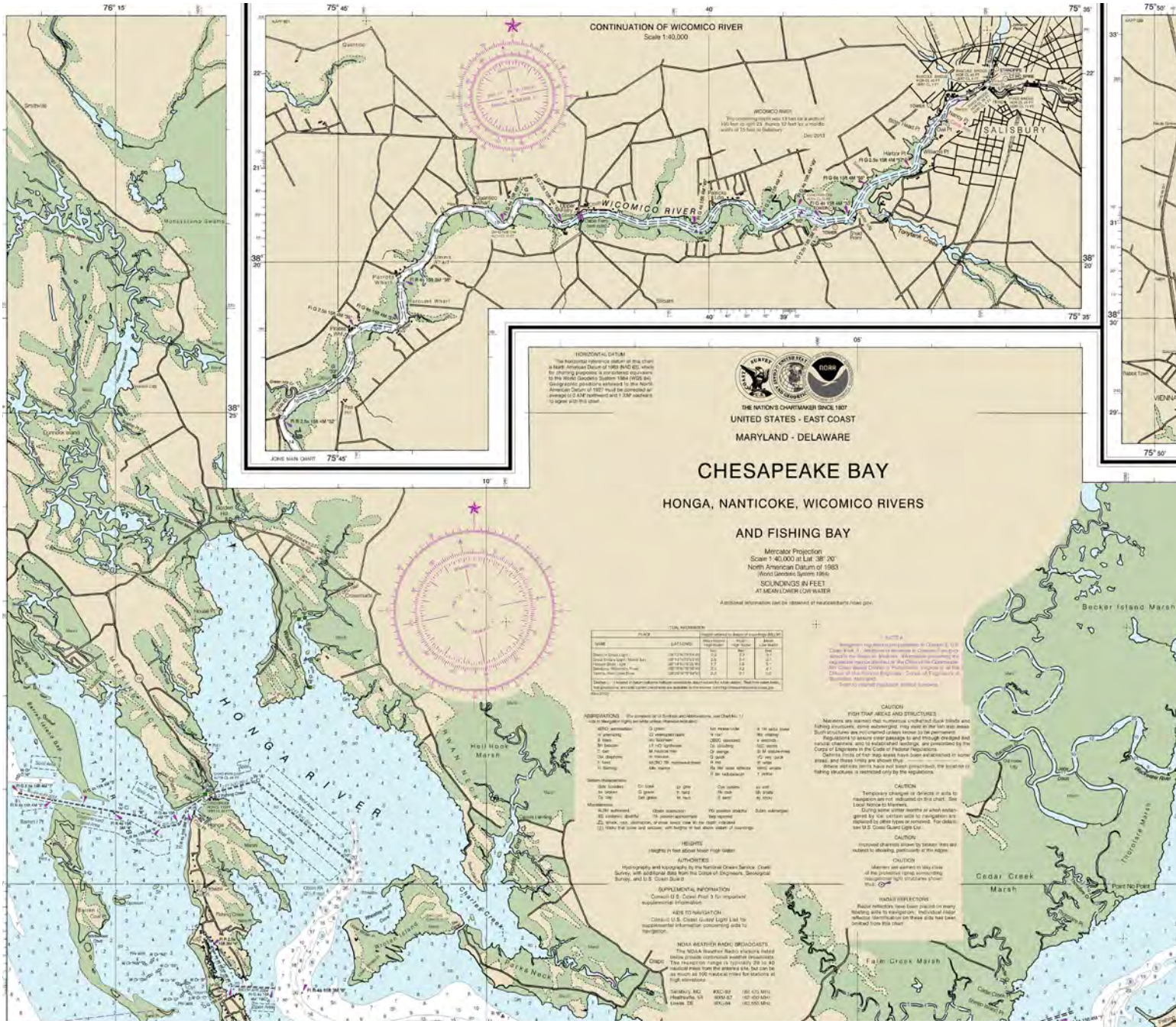
source: The Delaware Geologic Survey; retrieved from http://www.dgs.udel.edu/sites/data/1868hundreds/pdf/broadck.pdf

The 1968 Beers' Atlas of Delaware illustrates the primary role Broad Creek had in shaping the history of Laurel; the town literally stopped at the river. The river was a point of commerce for the town with many industries using it to send and receive goods. The EIA report identifies the varied history of the parcels in the study area and adjacent to the river. This map also illustrates how early in the history of Laurel the river was damned. Best practices in stormwater design require a historical review of the landscape to access the natural flow patterns and hydrology of the area. For this report and SWM concept plan, the lengthy history of Broad Creek in Laurel being damed and dredged, precluded any design strategies to restore pre-settlement site hydrology. The SWM design concepts set forth in this document reflect SWM practices that shift the current systems, toward ones that restore the site's hydrology to one typical of a river system such as Broad Creek.

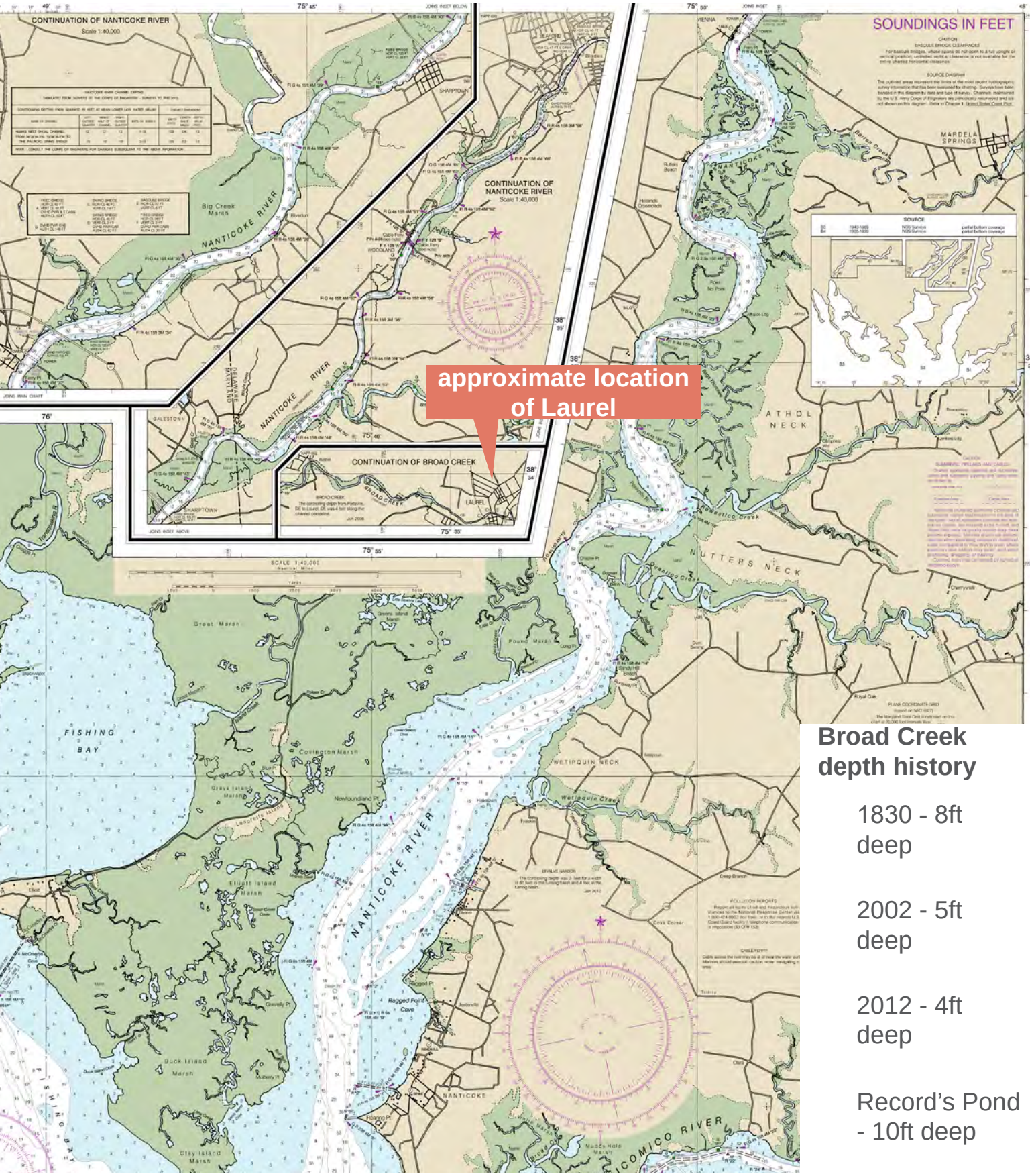


source: Google Maps

The 2011 Greater Laurel Comprehensive Plan provides a narrative on the history of Laurel. The graphic above represents five elements of Laurel that the authors considered important commentary on the hydrology of the area and could influence stormwater design. Only one record was found to illustrate the history of the river prior to the construction of the Mill dam in 1760. The Wading Place identifies a ford, or low spot, in the topography that provided a crossing area for Native Americans and colonial settlers. There is a plaque in Janosik Park informing visitors of this important topographic relic that gives a slight insight to the river topography before the dam. Stormwater designs strategies sought to balance the natural process of a river system with the constriction of the dam. Native Americans of the area are said to have been called People of the Tide Water, this name speaks the tidal influence of Broad Creek, an element of fluctuating hydrology that needs to be considered in SWM design strategies. The large industrial parcel in the landscape is emblematic of the strong industrial history of the area. The various industries that used the river to send and receive goods have potentially left unknown obstacles below the soil, such as those identified in the EIA report, that need to be evaluated prior to implementing stormwater strategies. Although no laurel bushes were found during the site visit, it is evident in the name of the town and the presence of the state champion tree, that the natural plant communities in the area include laurel bushes and cypress trees. Native plants are often most applicable to natural stormwater design strategies and should be considered during the design phase.



When designing stormwater strategies along a river course, whether it is currently dredged or has a significant dredge history, can influence the design and feasibility of shoreline treatments and BMP interaction with the waterway. During the height of the Town's industrial era, Broad Creek was dredged to allow cargo ships to transport goods to and from the Naticoke River. The 2011 Laurel Comprehensive Plan provides and overview of the dredge history along the river. Nautical maps of today show an approximate depth of 3-4ft. Due to the high siltation rate of the river and the introduction of rail lines, that lead to cessation of commercial river traffic, there is no longer dredging in Broad Creek in the area of Laurel DE.



Broad Creek depth history

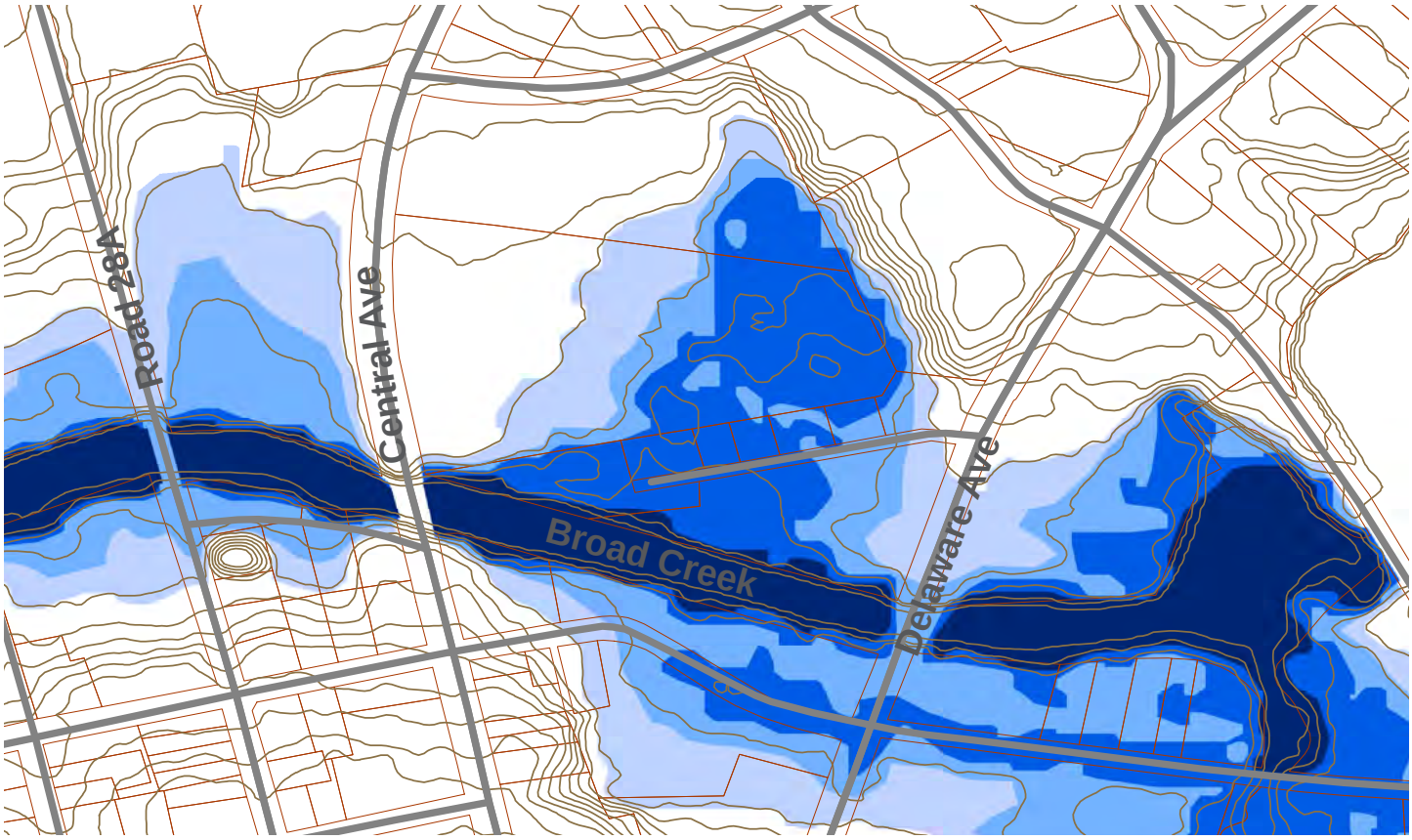
1830 - 8ft deep

2002 - 5ft deep

2012 - 4ft deep

Record's Pond - 10ft deep

source: National Oceanic and Atmospheric Association; retrieved from http://www.charts.noaa.gov/PDFs/12261.pdf



source: Delaware First Map Open Data, ForeSite Associates

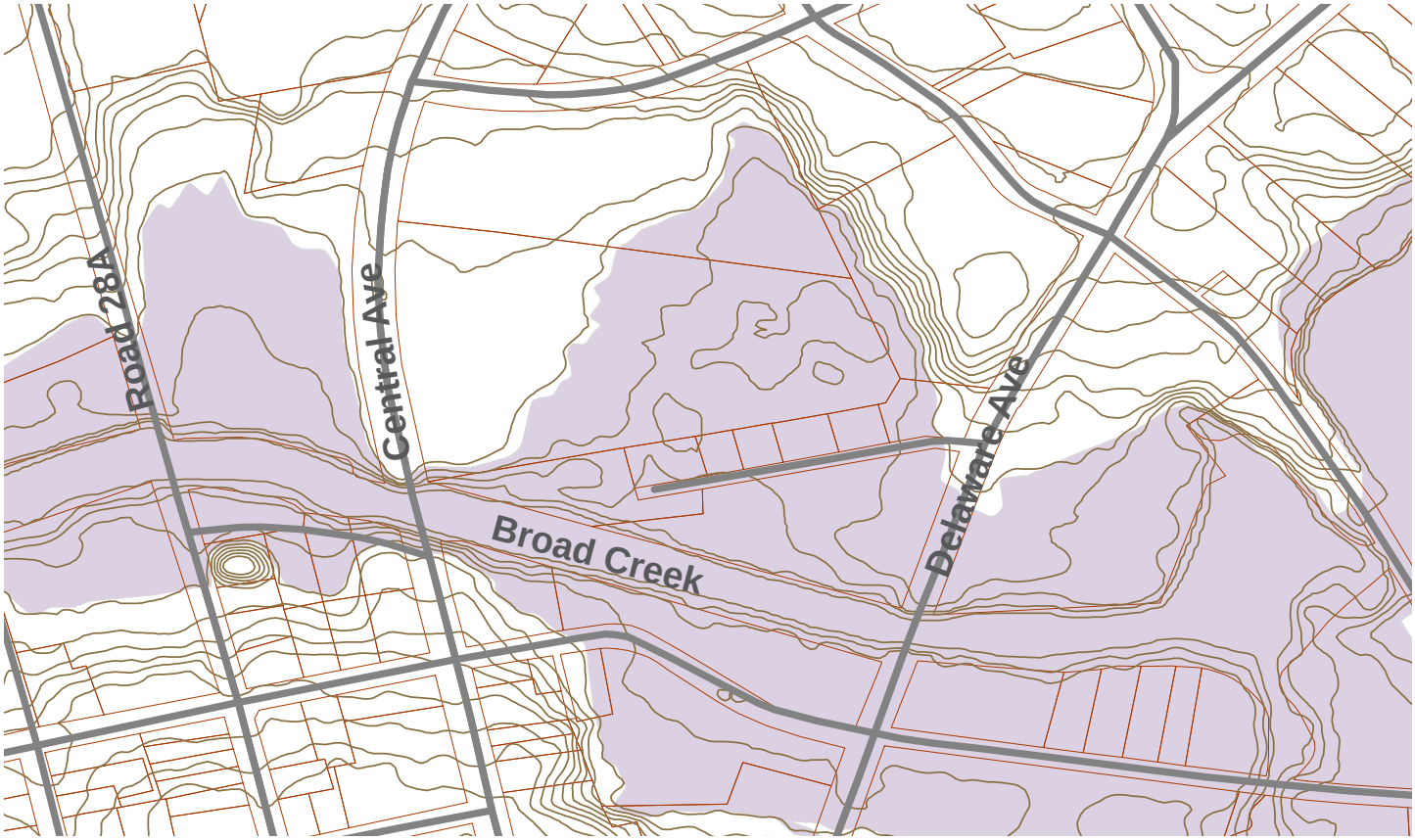
SEA LEVEL RISE

legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

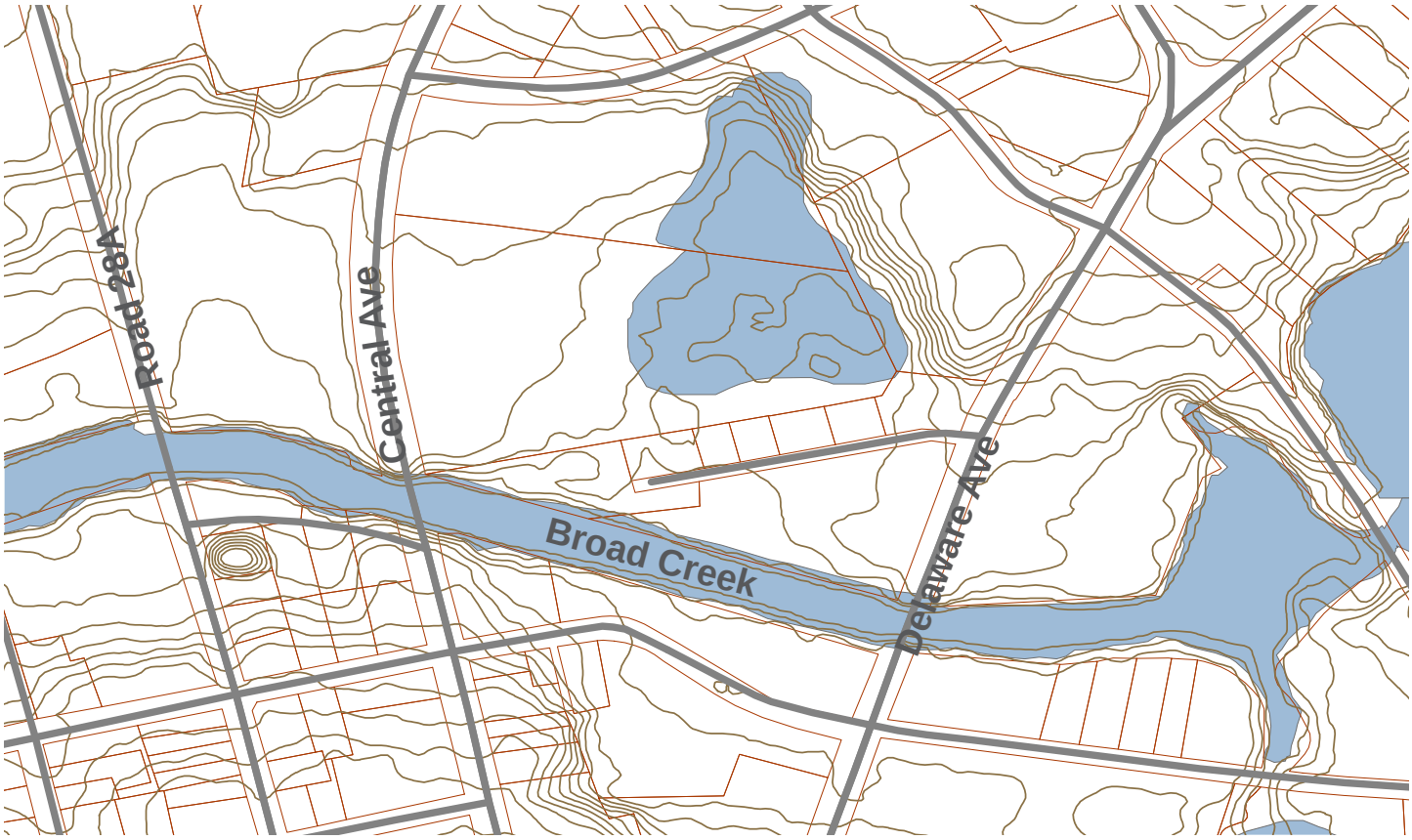
In 2009 DNREC held a Sea Level Rise Technical Workgroup session, in which they identified four sea level rise planning scenarios: stable, low, intermediate, and high. The graphic above reflects the high sea level rise scenario and was retrieved from the DE GIS site FirstMap. This map is repeated in the concept plan sections of this report and further identifies how each SWM strategy will be effected by sea level rise.



source: Delaware First Map Open Data, ForeSite Associates

100 YR FLOODPLAIN

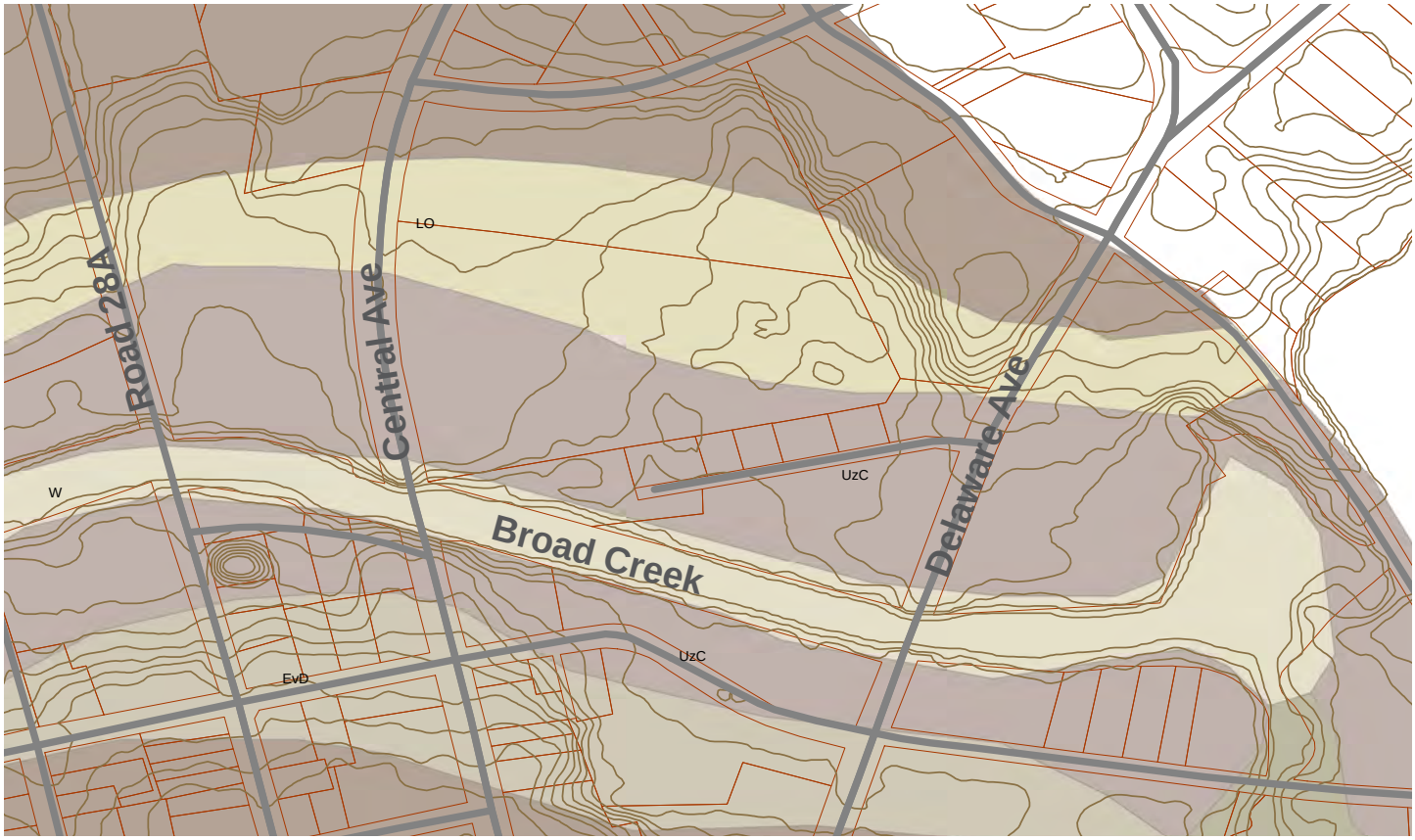
The feasibility of certain BMPs often requires the system to be installed outside of the 100 year floodplain. This requirement aides in ensuring optimal functionality of the system under worse case storm scenarios. Due to the proximity of the design areas to the river, most BMP strategies set forth in this document fall within the limits of the 100 year floodplain. The BMPs will require careful planning during the construction design phase, to adapt the concept ideas to the most resilient implementation strategies.



source: Delaware First Map Open Data, ForeSite Associates

DE WETLANDS

The feasibility of BMPs often requires the systems not impact any DE state identified wetland areas. Certain concept ideas set forth in this document will most likely require permitting due to the close proximity of the design areas to Broad Creek. Permitting is a method for regulatory agencies to ensure wetlands are not negatively impacted by any proposed construction. Besides Broad Creek, the other area identified on the FirstMap site as a DE wetland is not within the project limits.

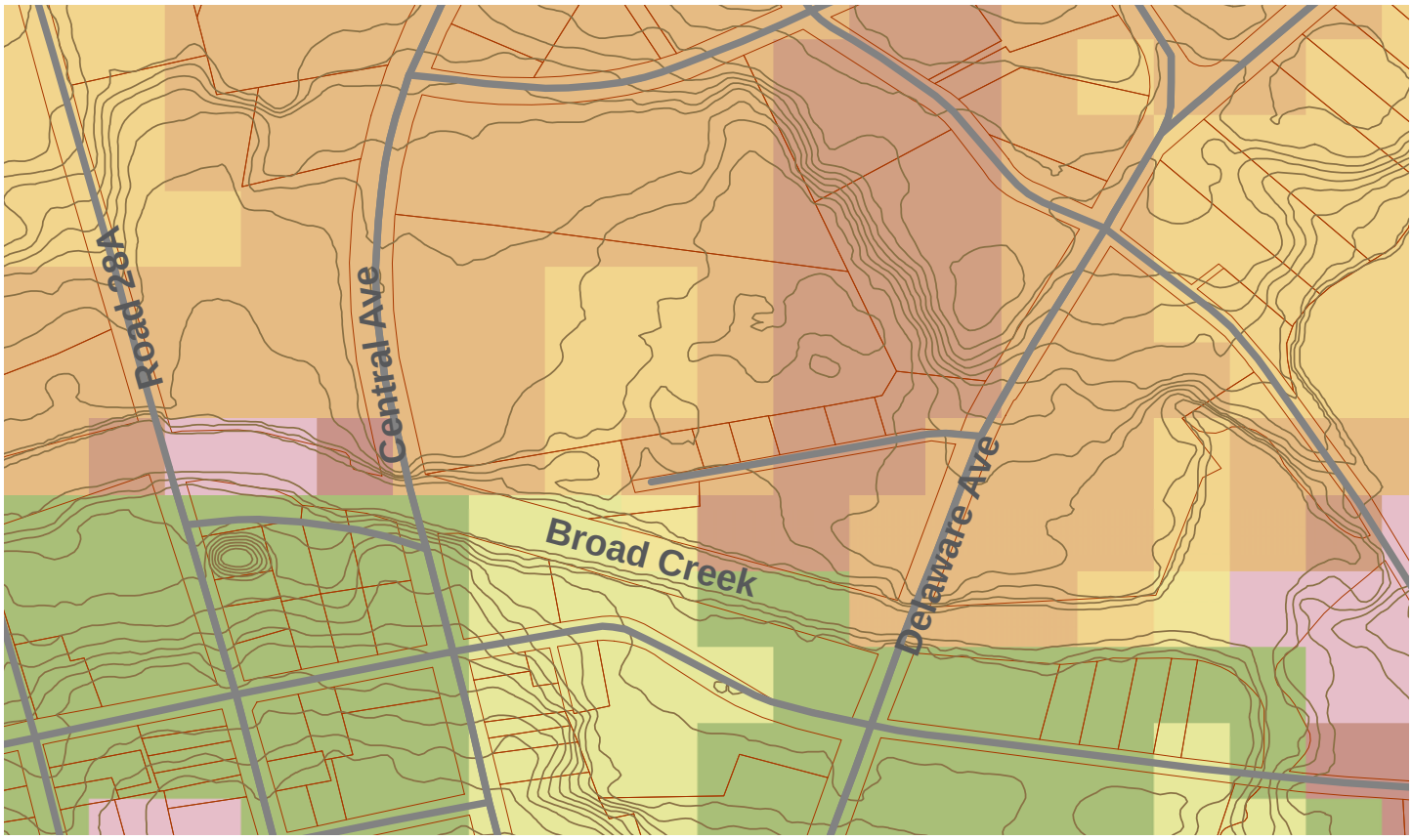


source: Delaware First Map Open Data, ForeSite Associates

SOILS

- Udorthents (UzC)
- Longmarsh and Indiantown (LO)
- Evensboro (EvD)
- Henlopen-Rosedale-Urban (HsA)

The native undisturbed soils most prominent in the design areas are Udorthents. These soils are a sandy loam created by fluviomarine deposits, well drained, and hyrologic soil group A. Hydrologic soil group A is categorized by the USDA as having good infiltration rates. Good infiltration rates are beneficial to stormwater design as it helps move runoff down through the soil profile and aides in preventing a system exceeding maximum capacity. The EIA report illustrates the varied history of the area with industrial uses that may have compacted the soils, introduced filled areas, and made portions of the design areas less appropriate for SWM initiatives without soil restoration. Prior to any construction, areas should be tested to confirm the actual soil profiles present in the locations of the proposed BMPs.



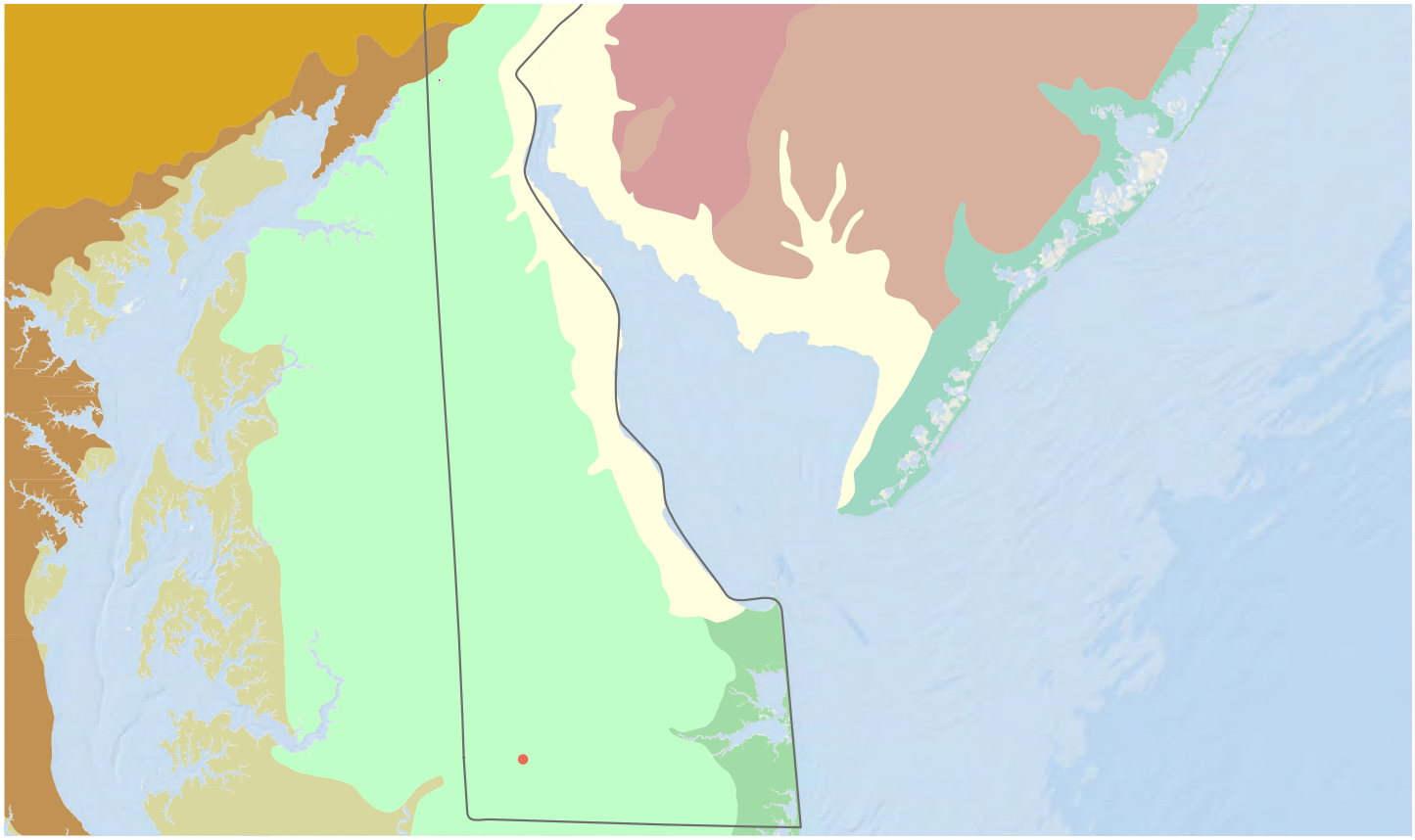
source: Delaware First Map Open Data, ForeSite Associates

SOLAR ASPECT

legend

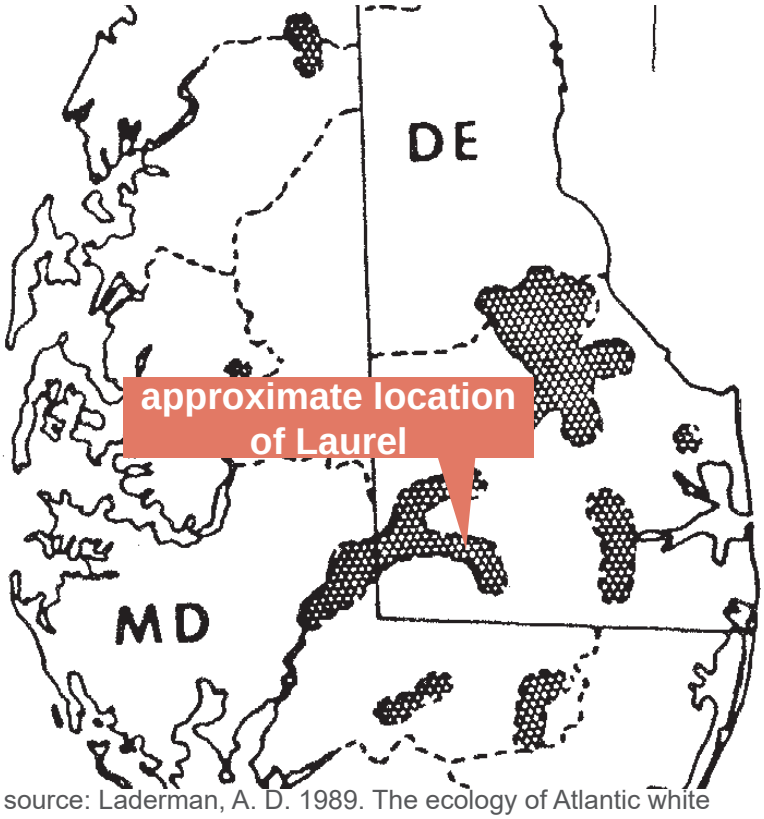
- north
- northeast
- east
- southeast
- south
- southwest
- west
- northwest

Solar aspect has been minimally utilized in the feasibility study of BMPs strategies in this concept document. During the construction phase, when plant palettes are determined for each BMP, it will be important to understand the solar exposure of the BMP location and select appropriate plant materials for the solar aspect direction. The linear low point of the river creates a prominent divide line for topography that faces north and northeast on the south banks, to the south and southwest facing banks on the north side of the river.



source: Delaware First Map Open Data, ForeSite Associates

CYPRESS SWAMPS



source: Laderman, A. D. 1989. The ecology of Atlantic white cedar wetland: a community profile. Biological Report 85(7.21). Washington, DC, USDI, Fish and Wildlife Service, National Wetlands Research Center

ECOREGIONS

Similar to the solar aspect, ecoregion limits have been minimally utilized in the feasibility study of BMP strategies in this concept document. While the ecoregion had minimal impacts on BMP selection, the surrounding ecology and opportunities to connect BMPs with surrounding ecology was considered. During the construction phase, when plant palettes are determined for each BMP, it will be important to select native plant palettes appropriate to the Delmarva Uplands Ecoregion (level 4) or Mid-Atlantic Coastal Plain Ecoregion (level 3) shown in pale green on the map above. The red dot identifies the approximate location of Laurel DE.

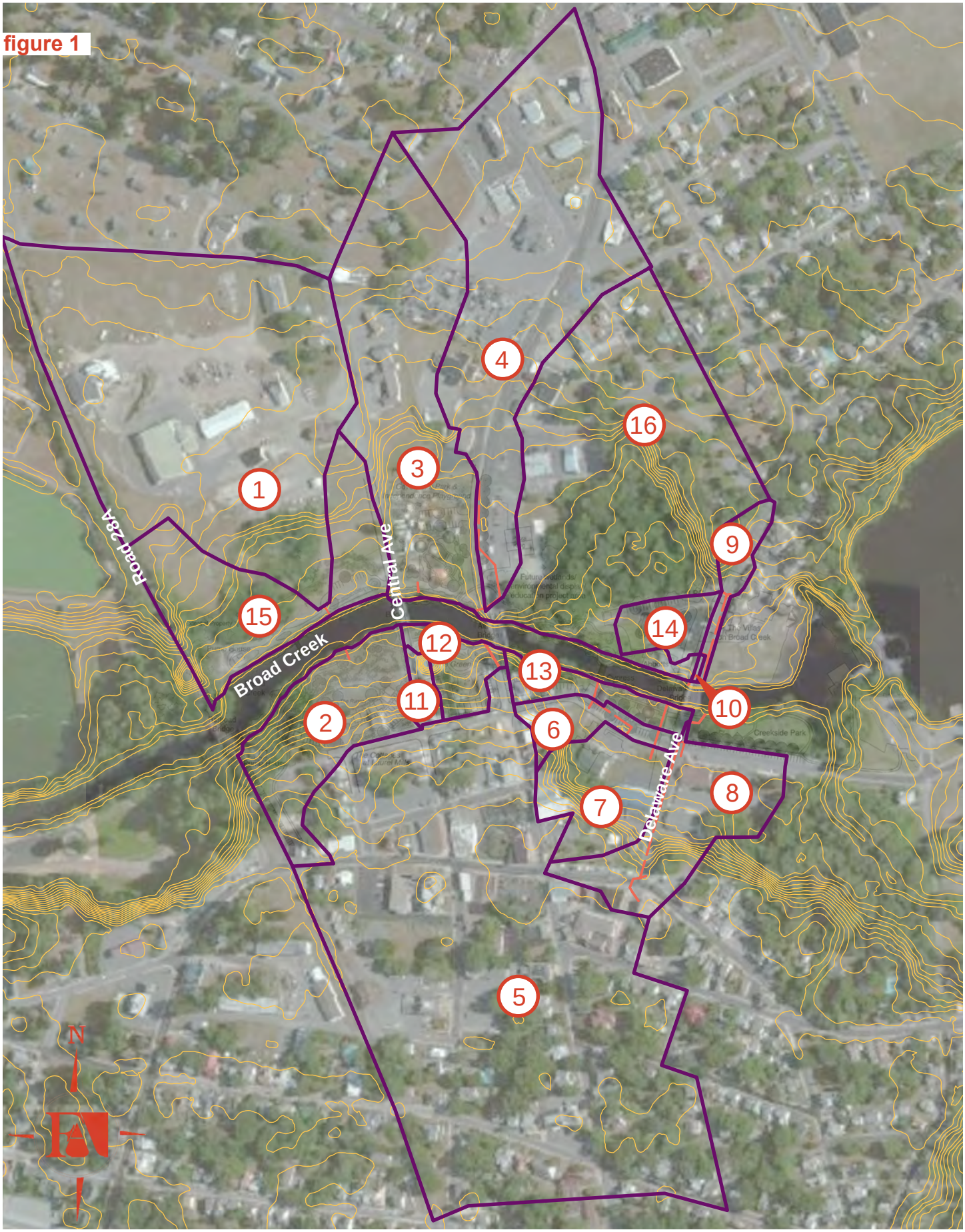
Historic maps show Cypress swamp communities existed in the region of Laurel DE. The DE state cypress tree in the design area is most likely a relic of this unique habitat. SWM design plant palettes should consider natural plant community restoration.

Prior to any design concepts being considered, FA visited the site and took inventory of the landscape typologies. Specifics as they relate to the site hydrology were inventoried in the design areas. Outfalls visible in the riverbanks were inventoried as to size, material, and approximate drainage area; pictures were taken to identify site character; and a second site visit surveyed the area to confirm specific locations in relation to publicly available topographic information. Further synopsis of the outfalls and watersheds can be found later in this document. The above image is a representation of the different bank stabilization methods in the design area. Existing treatments are relevant in accessing the feasibility of certain BMPs and their potential connection to the river system. In the Cottage Jetty design location the bank is stabilized with a concrete bulkhead;

aerial source : Google Maps ; inset images : ForeSite Associates

prior to construction the stability of this bulkhead should be confirmed. The Governor's Park and Independence Playground design location, as well as, The Village Green, and portions of Cypress Bridge North, Cypress Bridge South, Janosik Park and the Cottages at Laurel Mills, have rip rap stone installed to prevent erosion and aide in stabilizing the bank. There is metal sheet piling stabilizing the banks in the area of Cypress Bridge South near the memorial park. Along the banks in the design area there are also a few locations where vegetation is the stabilizing structure; in some ares there is evidence of past restoration efforts, but little remains and it is unlikely they are still functioning in accordance with their design intent. Some of these existing bank treatments may need to be repaired or replaced for the proposed BMPs to function properly.

figure 1


1
2
3
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7
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11
12
13
14
15
16
Road 284
Central Ave
Broad Creek
Delaware Ave
Creekside Park
N

DRAINAGE AREA SYNOPSIS

To effectively develop stormwater strategies most suited for the parcels adjacent to Broad Creek and included in The Ramble Plan, a preliminary drainage study of the area was conducted by ForeSite Associates (ForeSite). The study focused on the surface landscape and ten (10) pipes with outfalls into Broad Creek between the railroad tracks and Delaware Ave (also known as Rd. 466). This study was conducted for feasibility design parameters only and limitations and assumptions of the study are as noted in the discussion. Unless otherwise noted, all roads were assumed to be crowned and storm drain networks assumed to generally follow landscape topography. Site information was gathered on June 25, 2015 and August 13, 2015. The gathered data for the study area was analyzed within the context of publicly available site information, such as GIS contour data, and mapping provided by the Town of Laurel, such as proposed drainage plans. Information pertaining to most of the existing storm drain infrastructure (pipe and structure locations, pipe size and material, and structure inverts) was not available. Such information can be critical to accurately delineate watershed boundaries and conduct an accurate hydraulic assessment of existing conditions beyond the feasibility stage. Consequently, assumptions were made regarding the locations and connections of existing storm drain infrastructure based on limited field visits and desktop review of Google Street View imagery in order to estimate watershed boundaries. The following is a narrative of this analysis with reference to the map image on the previous page (figure 1). To more accurately evaluate existing drainage infrastructure, ForeSite recommends that the Town consider developing an overall stormwater (drainage) assessment inventory. It is possible that funding for such an additional study could be obtained from DNREC, with assistance from DelDOT.

There were found to be five watershed areas with direct surface drainage to Broad Creek, drainage areas 12, 13, 14, 15, and 16 (see table 1). The remainder of the watersheds, with the exception of watershed 11 appeared to be connected to the creek by a pipe network; many of these outfalls drain significant areas upstream of the parcels of focus in The Ramble Plan. Watershed 11 has a low point at a storm drain along Rd 28A, it is assumed this connects to a pipe which daylights under the bridge however, no evidence of this was found and the outfall location of this watershed is unknown. There was one unknown pipe near the Sportz Tees shop, at 109 E Front St, and adjacent to the pipe draining watershed 6; for the purposes of this study it was determined this pipe was most likely abandoned and was not considered in the discussed interventions. Pipe sizing and material construction can be found in table 1, their location can be determined from figure 1. Pipe information as it relates to individual watersheds can be found later in the analysis by design area. In this report, pipe materials are noted as RCP, reinforced concrete pipe, CMP, corrugated metal pipe, PVCP, polyvinyl chloride pipe, or HDPEP, high density polyethylene pipe. Pipe names denote the individual network and pipe section, e.g. SD9-P1 denotes storm drain network 9, pipe 1 (outflow pipe).

Watershed characteristics such as size, soil drainage capacity, and an approximation of impervious acreage were used to perform a hydrologic analysis to estimate probable storm runoff volumes during the water quality or resource protection rainfall event of 2.7”. The curve number method, also known as the SCS method or TR-55 methodology, was used in the analysis to estimate runoff discharge volume. Based on municipal zoning and aerial photos, assumptions were made to determine composite runoff curve numbers (CNs) for each watershed. Composite curve numbers were then used to estimate resource protection runoff volumes (RpV).

table 1

Drainage Area				Outfall Pipe		
I.D.	*Area (ac.)*	*Imperviousness (%)*	*Imp. Area*	*Pipe I.D.*	*Size (in.)*	*Material*
1	18.8	50%	9.40	SD1-P1	12	PVC
2	4.4	30%	1.32	SD2-P1	18	CMP
3	10.0	40%	4.00	SD3-P1	18	HDPE
4	13.4	85%	11.39	SD4-P1	18	HDPE
5	30.2	85%	25.67	SD5-P1	36	CMP
6	1.1	65%	0.72	SD6-P1	15	CMP
7	2.8	50%	1.40	SD8-P1	24	CMP
8	4.0	70%	2.80	SD9-P1	24	RCP
9	0.9	65%	0.59	SD10-P1	18	RCP
10	0.04	100%	0.04	SD11-P1	18	DIP
11	0.4	85%	0.34	unknown	unknown	unknown
12	1.2	40%	0.48	n/a	n/a	n/a
13	1.2	35%	0.42	n/a	n/a	n/a
14	1.1	85%	0.94	n/a	n/a	n/a
15	5.5	10%	0.55	n/a	n/a	n/a
16	15.7	25%	3.93	n/a	n/a	n/a

The RpV volumes in the table below signify the probable runoff volume required for regulatory compliance under the current Delaware Sediment and Stormwater Regulations; however, it does not appear feasible to provide full water quality treatment for all watersheds within the urban framework along Broad Creek. A summary of the input data for runoff estimation within the hydrologic model is provided below in Table 2.

table 2

Drainage Area				Hydrologic Analysis		
I.D.	*Area (ac.)*	*Imperviousness (%)*	*Imp. Area*	*CN*	*RpV (cf)*	*RpV (ac-ft)*
1	18.8	50%	9.40	69	33,908	0.78
2	4.4	30%	1.32	57	2,493	0.06
3	10.0	40%	4.00	63	10,994	0.25
4	13.4	85%	11.39	89	79,906	1.83
5	30.2	85%	25.67	89	180,087	4.13
6	1.1	65%	0.72	78	3,595	0.08
7	2.8	50%	1.40	69	5,050	0.12
8	4.0	70%	2.80	80	15,201	0.35
9	0.9	65%	0.59	78	2,952	0.07
10	0.04	100%	0.04	98	359	0.01
11	0.4	85%	0.34	89	2,385	0.05
12	1.2	40%	0.48	63	1,319	0.03
13	1.2	35%	0.42	60	975	0.02
14	1.1	85%	0.94	89	6,644	0.15
15	5.5	10%	0.55	45	96	0.00
16	15.7	25%	3.93	54	5,719	0.13

All areas were assumed to be hydrologic soil group A, having high infiltration potential, based on information retrieved from the USDA soil survey; a small portion of the study area does contain B/D soils, having moderate to low infiltration potential, but due to the small percentage (5.3%) this was removed from the modeling, see figure 2. Overtime urbanization may have altered the soil profiles in the study areas, as areas are carried further in the design process to construction, additional testing should be completed to more fully characterize them.

figure 2

Sussex County, Delaware (DE005)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
EvD	Evesboro loamy sand, 5 to 15 percent slopes	3.4	4.3%
HsA	Henlopen-Rosedale-Urban land complex, 0 to 2 percent slopes	61.2	77.5%
LO	Longmarsh and Indiantown soils, frequently flooded	4.2	5.3%
UzC	Udorthents, 0 to 10 percent slopes	7.9	10.0%
W	Water	2.3	2.9%
Totals for Area of Interest		**79.0**	**100.0%**

source : Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/.

TIDAL STUDY

A tidal study was completed by ForeSite Associates to determine tidal influence and probable ground saturation in the design areas along Broad Creek. Instrumentation was installed by ForeSite along the wooden crib wall in front of the memorial garden on the south side of Broad Creek; the instrumentation was installed on August 13, 2015. The instrumentation was protected and encased in a piece of PVC casing and recorded data for a full lunar cycle from August 13, 2015 to September 21,2015. The top of casing elevation was surveyed to facilitate conversion of water depth data into the site vertical datum (NAVD88, ft). Table 3 indicates the approximate tide levels using the following abbreviations: Mean High High Water (MHHW), Mean High Water (MHW), Mean Tide Level (MTL), Mean Low Water (MLW), Mean Low Low Water (MLLW). There were no available NOAA or other agency tide gages in the local area to reference the recorded data. Figure 3 is a graph of the tidal information collected over the lunar cycle. As no extreme events were observed during the observation period, the computed tidal elevations are assumed as normal values for the purpose of this study.

table 3

MHHW	1.54	ft, NAVD88
MHW	1.47	ft, NAVD88
MTL	0.01	ft, NAVD88
MLW	-1.45	ft, NAVD88
MLLW	-1.57	ft, NAVD88

Analysis of rain events in correlation to the tide events provides a useful analysis in understanding the degree to which the pipes may be inundated during a normal rain event. River outfall pipes can be affected by the tide flux, as well as post storm creek levels, and overtime, due to changes in the larger watershed context, pipes that when originally built were above tide and creek water levels, may now be affected by higher water levels. If a pipe is inundated with creek water at the outfall location, the capacity of the pipe to contain stormwater is reduced, which could negatively impact the adjacent landscapes and present limitations to introducing GTBMPs. Table 4 below provides a synopsis of the pipe in relation to high and low tides. Further details for each watershed is discussed later within the individual design areas.

From the study it can be understood that of the ten pipes included in the study area, nine of them have an invert (bottom inside) that falls below MHHW and three of them have a crown (top inside) that falls below MHHW. The extent to how far back the storm drain system was inundated by the tides was beyond the scope of this initial feasibility phase. Should one of the pipes influenced by tidal flux be in a targeted watershed for GTBMP installation, further research is suggested. Two rain events, one on September 1, 2015 with rainfall accumulation of 1.16” and one on September 12, 2015 with rainfall accumulation of 1.31”, coincided with lunar cycle high tides. Although still below the standard 2.7” rainfall event, also known as the resource protection event and used for water quality design, the rain events were in the range of the 90th percentile storm event, which accounts for about 50% of the rain events in the Delmarva region (Delaware DNREC Runoff Reduction Guidance Document, 2013).

figure 3

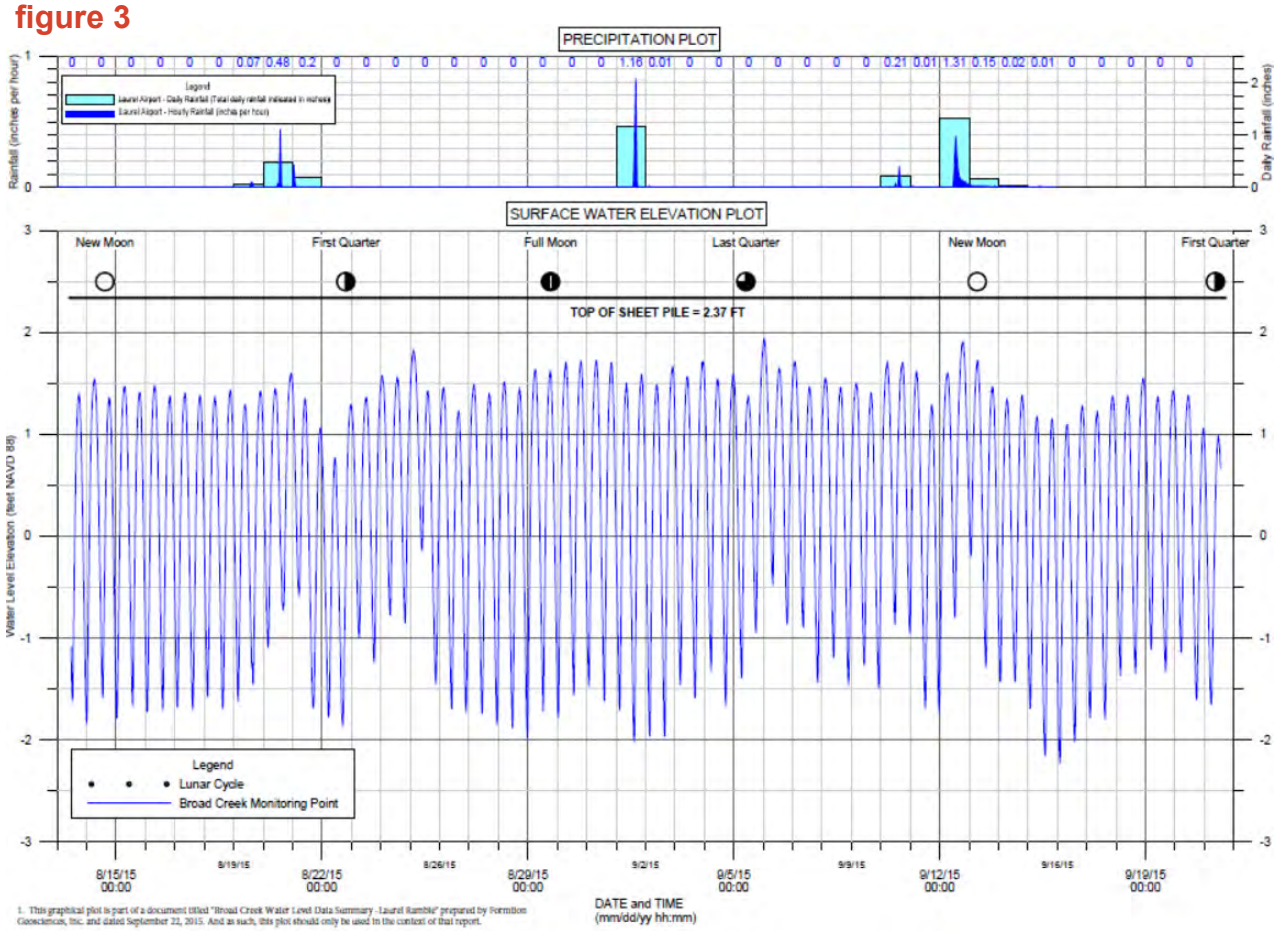


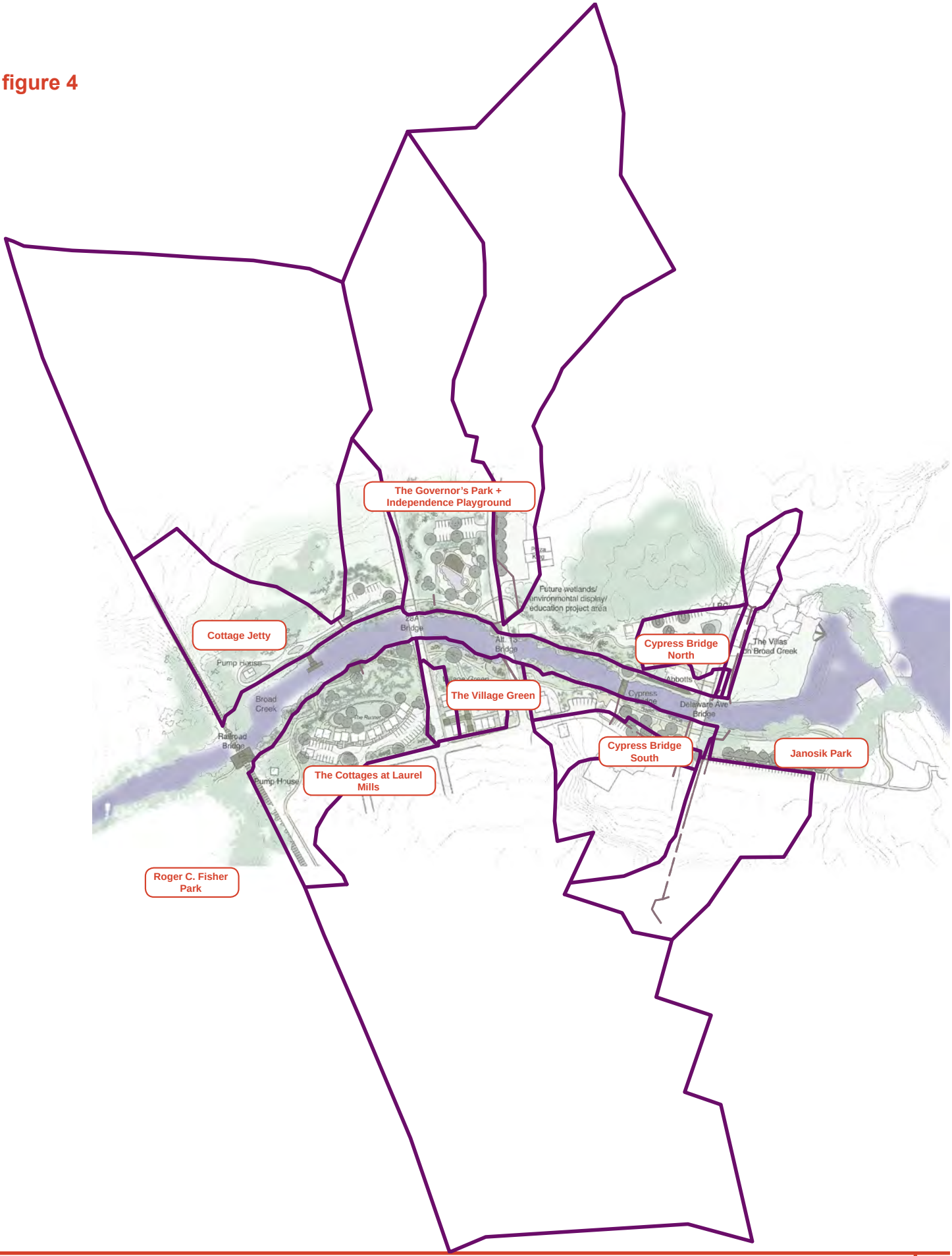
table 4

	Outfall Pipe		Downstream Elevations		Tidal Study Elevations		Is MHHW >	
I.D.	*Pipe I.D.*	*Size (in.)*	*Invert*	*Crown*	*MLLW*	*MHHW*	*Inv.?*	*Crown?*
1	SD1-P1	12	2.08	3.08	-1.57	1.54	No	No
2	SD2-P1	18	0.46	1.96	-1.57	1.54	Yes	No
3	SD3-P1	18	0.38	1.88	-1.57	1.54	Yes	No
4	SD4-P1	18	1.35	2.85	-1.57	1.54	Yes	No
5	SD5-P1	36	1.00	4.00	-1.57	1.54	Yes	No
6	SD6-P1	15	-0.22	1.03	-1.57	1.54	Yes	Yes
7	SD8-P1	24	0.62	2.62	-1.57	1.54	Yes	No
8	SD9-P1	24	-1.15	0.85	-1.57	1.54	Yes	Yes
9	SD10-P1	18	-0.33	1.17	-1.57	1.54	Yes	Yes
10	SD11-P1	18	0.27	1.77	-1.57	1.54	Yes	No
11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

HYDROLOGIC SYNOPSIS BY DESIGN AREA

As per the concept plan prepared by Jules Bruck PhD. and the University of Delaware, the following narratives identify specific drainage and tidal nuances by design areas; figure 4 illustrates the shared boundaries between the concept design and the watershed delineation. All stormwater and drainage analyses are by design area but do not include recommendations based on proposed impervious, assumptions are noted but in general this was outside the scope of this study.

figure 4


The Governor's Park + Independence Playground
Future wetlands/ environmental display/ education project area
Cottage Jetty
Pump House
Broad Creek
Railroad Bridge
Pump House
The Village Green
Cypress Bridge North
The Villas on Broad Creek
Abbotts
Delaware Ave Bridge
Cypress Bridge South
Janosik Park
The Cottages at Laurel Mills
Roger C. Fisher Park

Cottage Jetty

This design area is located on the north bank on the far west of the study area, between the railroad and Poplar Street. The area is proposed to be used as a kayak launch, the concept design proposes this area to remain a kayak launch with additional amenities such as a parking lot and paths to make access to the launch easier. This design area has two watersheds,1 and 15, draining through it and one pipe outfall, SD1-P1.

Watershed 15 is 5.5 +/- acres in size and lies directly adjacent to the creek. The land cover is primarily open lawn and old fields with approximately 10% of the area impervious cover. The shoreline appears to be retained by a concrete bulkhead.

Watershed 1 is 18.8 +/- acres and lies just north of watershed 15, it appears to drain to a low point approximately midway through the design area and then travel through pipe SD1-P1 to daylight into the creek; there appears to be no direct surface land connection from this watershed to the creek. The watershed is approximately 50% covered by impervious surfaces with one large industrial parcel, that includes a fertilizer plant, making up the majority of the impervious cover. SD1-P1, which appears to be the outfall source for watershed 1 into the creek, is made of PVC piping and is 12” in diameter. The pipe appears to be in good condition based on a visual inspection of the outfall. During tidal surges neither the invert nor the pipe crown appears to be inundated by creek flows. Flows across watershed 1 appear to be largely overland flows, as the pipe is only 45 +/- feet in length and was most likely installed to bring the water through the parcels contained in watershed 15 without impacting that parcel’s land use. Water moving across watershed 1 to the pipe outfall appears to pass through a section of early successional woodlands before reaching the grass swale to the pipe inlet.

outfall conditions

SD1-P1 outfall along north bank of Broad Creek

site images + shoreline conditions

Shoreline conditions; image taken from south bank looking north east at Road 28A

Shoreline conditions; image taken from south bank looking northwest, SD1-P1 visible along the shoreline

The Governor's Park + Independence Playground

This design area is located on the north bank and bordered by N. Central Ave. and Poplar St. The area adjacent to the creek is currently an open mowed grass field used for seasonal town festivals; the concept design proposes the area adjacent to the creek remain open lawn for seasonal events and the northern portion of the lawn area become a community playground. The design area has two watersheds draining through it, 3 and 4, and two pipe outfalls, SD3-P1 and SD4-P1.

Watershed 3 is 10 +/- acres in size with a small portion appearing to directly drain to the creek. The shoreline adjacent to the creek is rip rap stone. The watershed has approximately 40% of its area covered by impervious surfaces; the impervious coverage is primarily from commercial buildings and parking lots on the northern end, with the large lawn area in the southern portion. The lawn area has a gradual slope down to the creek however, the recreational walkway along the edge appears to form a berm preventing direct sheet flow; stormwater is believed to flow to a low point just prior to the walk and enter pipe SD3-P1 to flow under the walk and outfall to the creek. The origins of SP3-P1 are unknown, no upstream inlet was found and the limits of the watershed are based on topographic conditions. SD3-P1 is an 18" pipe made of high density polyethylene material and appears to be in good condition based on a visual inspection of the outfall. During tidal surges the invert of SD3-P1 appears to be inundated by creek flows, the pipe crown does not. There is a sanitary sewer system with elevated manholes within the park area.

Watershed 4 is 13.4 +/- acres in size and appears to connect to SD4-P1 to outfall into the creek, there appears to be no direct surface flow connection to the creek. The watershed is approximately 85% impervious and contains a section of N. Central Ave. and several commercial business. The surface flows are believed to collect in storm drains along the curb lines of N. Central Ave., at the last storm drain on the northwest corner of the drawbridge, the water appears to enter SD4-P1 to outfall directly into the creek. SD4-P1 is an 18" pipe made of high density polyethylene material and appears to be in good condition based on a visual inspection of the outfall. During tidal surges the invert of SD4-P1 appears to be inundated by creek flows, the crown does not.

outfall + shoreline conditions

SD4-P1

SD3-P1

site images

Governor's Park; image taken from path along creek looking northwest

Governor's Park; image taken from path along creek looking northeast towards Pizza King and other retail establishments along N. Central Ave.

Cypress Bridge North

The primary design area for the north bank of Broad Creek is the location of Cypress Bridge, a proposed pedestrian crossing, which contains watersheds 16, 10, and 14. Apart from the introduction of a pedestrian bridge over Broad Creek west of Abbott's restaurant, the concept plan proposes educational enhancements to the area, such as walking paths and restored wetlands. Adjacent to the design area and included in the study to further confirm what flows were contributing to this design area is watershed 9. This watershed appears to contain the majority of the surface run off from Delaware Ave. up to the intersection of Maryland Ave and Willow Street. It is believed this watershed connects to storm drains that outfall to the east side of the Delaware Ave. Bridge, outside the limits of the study.

Watershed 14 is 1.1 +/- acres in size, with approximately 85% of its area covered by impervious surface. Much of the parking lot of Abbott's is captured in this watershed and directed to what appears to be a stormwater wetland with overland discharges to Broad Creek. Overflows from this area appear enter watershed 16.

Watershed 16 is 15.7 +/- acres in size with all of it believed to have a direct surface flow connection to the creek. The watershed has approximately 25% of its area covered by impervious surface, some from residential properties and some from a few commercial parcels along N. Central Ave. The land slope in watershed 16 becomes very mild as it approaches the creek bank's floodplain. The shoreline has some deteriorated wooden bulkeading but for the most part appears to be naturally vegetated along the western edge of the design area, with a small section showing evidence of recent shoreline restoration. The area does have a large Bald Cypress tree at the shoreline. This tree is the state's largest cypress tree, as recorded in the fourth edition of "Big Trees of Delaware, Guidebook to the First State's Largest Trees," published in 2012 by the Delaware Forest Service. There are elevated sanitary sewer manholes one located in a paved part of the Abbott's parking lot and one in the lawn near the cypress tree.

Watershed 10 is 0.04 +/- acres in size and 100% impervious cover. The watershed consists of a small section of Delaware Ave in front of Abbott's restaurant and right before the bridge. The road appears to grade to a storm drain that is believed to direct the water through a pipe, SD11-P1, and outfall directly into the creek. SD11-P1 is an 18" ductile iron pipe that projects approximately 2' from the shoreline. The outfall appears to be in fair condition based on a visual inspection. During tidal surges the invert of SD11-P1 appears to be inundated by creek flows, the pipe crown does not and no check valve was observed to help prevent tidal backflow into the storm drain system.

outfall conditions

SD11-P1; image taken from Delaware Avenue Bridge, Abbott's restaurant is in the background of the image

site images + shoreline conditions

shoreline conditions along northwest creek bank in front of Abbott's

shoreline conditions along northeast bank of design area; Delaware's larges bald cypress shown in image

sign posting along shoreline

image of recent shoreline restoration

Cypress Bridge South

The primary design area for the south bank of Broad Creek in the location of Cypress Bridge, a proposed pedestrian crossing, contains three watersheds, 13, 6, and 7. Apart from the introduction of a pedestrian bridge, the concept plan proposes the area to remain in its current condition.

Watershed 13 is 1.2 +/- acres in size with all of it believed to have a direct surface flow connection to the creek. The watershed has approximately 35% of its area covered by impervious surface, mostly coming from small commercial parcels on the north side of Front Street. The shoreline along the eastern half across from Abbott's restaurant appears to be retained by wooden bulkheads. The western half has evidence of deteriorated wooden and concrete bulk heading and includes more vegetative cover with both trees and herbaceous plants.

Watershed 6 is 1.1 +/- acres in size and has approximately 65% of its area covered by impervious surface. The area appears to primarily collects flows from Front St. with a few adjacent residential parcels on N. Central Ave. contributing to the flows. The surface flows are believed to collect into storm drains along Front St. and travel through SD6-P1 to outfall into Broad Creek. SD6-P1 is a 15" CMP pipe and appears to be in good condition based on a visual inspection of the outfall. During tidal surges both the invert and the pipe crown of SD6-P1 appear to be inundated by creek flows.

Watershed 7 is 2.8 +/- acres in size and has approximately 50% of its area covered by impervious surface. The area primarily collects flows from two large parcels, the Broad Creek Liquor store and the Dr. Pierce Ellis Medical Center. The surface flows are believed to collect in a stormwater BMP to the north of the liquor store, overflows from that BMP travel through SD8-P1 to outfall into Broad Creek. SD8-P1 is a 24" pipe constructed of CMP materials and appears to be in fair condition based on a visual inspection of the outfall, with isolated lawn mower damage visible on the top of the pipe outfall. During tidal surges the invert of SD8-P1 appears to be inundated by creek flows, the pipe crown does not; a poorly fitting flap gate valve exists at the outfall.

outfall conditions

SD8-P1

SD6-P1

site images + shoreline conditions

shoreline conditions along south bank west of Sportz Tees

image close of shoreline in same general location

site context in design area; image facing east with Sportz Tees in the foreground

site context; image taken from north bank facing design area

site context in design area; image facing west

site context in design area; image facing east

The Village Green

The design area for the Village Green is located on the south bank of Broad Creek between Central Ave. and Poplar Street. The area is currently residential housing and open land. The concept plan proposes this area to remain similar to existing with additional paths and park elements added to the current open space. There appear to be three watersheds connected to the design area: 5, 11, and 12. The connection from watershed 11 to the creek was not found at the time of either site visit. Based on visual observations of surface topography, it is expected there may be an outfall below the 28A bridge that is only visible during low tides. Future stormwater design initiatives would need to investigate this watershed further if they proposes to integrate with this storm drain system.

Watershed 12 is 1.2 +/- acres in size with all of it appearing to have a direct surface flow connection to the creek. The watershed has approximately 40% of its area covered by impervious surface, mostly coming from small parcels of unknown use. The shoreline is covered by tree, shrub, and herbaceous vegetation growing on steep and nearly vertical banks.

Watershed 5 is 30.2 +/- acres in size, represents the core of downtown Laurel, and has approximately 85% of its area covered by impervious surface. Site visits attempted to confirm the limits of this watershed however the size, due to storm drain connections, is beyond the scope of this investigation. It was assumed the high point at 6th St. was most likely the limit of the storm drain network. The surface flows appear to collect into storm drains along Poplar St., Central Ave., and Front St., then travel through SD5-P1 to outfall into Broad Creek. SD5-P1 is a 36” CMP pipe which appears to be in poor condition based on a visual inspection of the outfall, which revealed a corroded invert section at the outfall as well as a broken/missing section of pipe. It is recommended that the Town of Laurel perform further investigations on this pipe and consider replacing it. During tidal surges the invert of SD5-P1 appears to be inundated by creek flows, the pipe crown does not.

outfall + shoreline conditions

SD5-P1

rip rap stone shoreline conditions

site images

image taken upslope looking northwest

image taken looking west along design area

image taken looking south toward Central Ave. with Broad Creek behind the photographer

The Cottages at Laurel Mills

The design area for the Cottages at Laurel Mills is located on the south bank of Broad Creek between Poplar St. and the Railroad Bridge. The area includes a small amount residential housing and the remainder is open land. The concept plan proposes this area to be further developed to include more residential housing. This area contains one watershed and one pipe outfall. The pipe, SD2-P1, is an 18" CMP. This pipe appears to be in poor condition with broken seams and visible chips at the outfall. It is recommended that the Town of Laurel perform further investigations on this pipe and consider replacing it. There does not appear to be any upstream connection and for the purposes of this study it is assumed this pipe is abandoned in place.

Watershed 2 is 4.4 +/- acres in size with all of it appearing to have a direct surface flow connection to the creek. The watershed has approximately 30% of its area covered by impervious surface, mostly coming from residential parcels. The shoreline is covered by tree, shrub, and herbaceous vegetation. A recently installed demonstration meadow lies within the watershed

site image + shoreline conditions + outfall conditions

image taken looking south; a demonstration meadow is currently being established

image taken from the north bank looking at the design area

Janosik Park

Janosik Park is located at the eastern most edge of the study area. It is currently an open lawn area with mature shade trees used for recreation. The concept plan proposes the area remain the same. The shoreline of the park is currently rip-rap stone. Local residents say there had been a living shoreline demonstration area in this design area at one time, as of this study, little remained of the demonstration but a few ornamental plants, primarily located near the headwater of Cooper Branch, a stream network that joins Broad Creek and forms the eastern boundary of the design area. The design area's hydrology is believed to be influenced by direct surface flows through the park and additional upland contributions through watershed 8.

Watershed 8 is 4.0 +/- acres in size with surface flows believed to travel into storm drains along Delaware Ave. and Market St. The storm drains most likely connect underground and outfall through pipe SD9-P1 into Broad Creek. SD9-P1 is a 24" RCP pipe and appears to be in fair condition based on a visual inspection of the outfall. The watershed is 70% covered by impervious surfaces, with primarily retail and commercial land cover. During tidal surges both the invert and the pipe crown of SD9-P1 appears to be inundated by creek flows, and there was no check valve observed to prevent tidal backflow within the storm drain system.

site image + shoreline conditions + outfall conditions

image taken looking west at design area; inset is of SD9-P1

The BMP matrices on the following pages have three primary reference sources for the comparative values applied for feasibility assessment. In order of importance they are as follows:

1. Delaware Department of Natural Resources and Environmental Control (DNREC). *Sediment and Stormwater Technical Document. Article 3.06.2: Post Construction Stormwater BMP Standards and Specifications*. October 2015

2. United States Environmental Protection Agency (EPA) Office of Wetlands, Oceans and Watersheds National Estuary Program. *Coastal Stormwater Management Through Green Infrastructure : A Handbook for Municipalities.* EPA 842-R-14-004 December 2014

3. The professional experience and opinion of the authors of this document: ForeSite Associates Inc., New Castle, DE.

All sixteen DNREC approved BMPs were considered:
3.06.2.1 Infiltration
3.06.2.2 Bioretention
3.06.2.3 Permeable Pavement Systems
3.06.2.4 Vegetated Roofs
3.06.2.5 Rainwater Harvesting
3.06.2.6 Restoration Practices
3.06.2.7 Rooftop Disconnection
3.06.2.8 Vegetated Channels
3.06.2.9 Sheet Flow to Filter Strip or Open Space
3.06.2.10 Detention Practices
3.06.2.11 Stormwater Filtering Systems
3.06.2.12 Constructed Wetlands
3.06.2.13 Wet Ponds
3.06.2.14 Soil Amendments
3.06.2.15 Proprietary Practices
3.06.2.16 Source Controls

The list of appropriate BMP strategies was reduced to the six BMPs in bold italic print based on the scope, limit of the project, and the information deemed most usable to the LRC on a master plan scale. An example would be Vegetated Roofs, although a usable BMP that should be considered for future construction, this level of detail was to fine for the scope of this report.

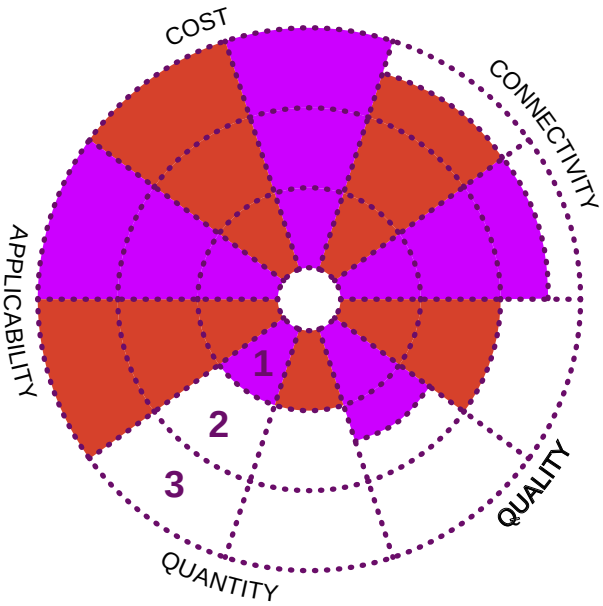
The BMPs were rated on their performance in response to stormwater quality and quantity as defined by regulatory standards; they were rated on applicability and cost based on reference data and site information; and they were rated on an additional category titled connectivity. This section includes values that can be most paralleled to ecosystem services, values that are still under research for their quantifiable contribution to stormwater systems but non the less should not be ignored, as they are proven to increase facility resiliency and support important adjacent ecosystems.

The values were scored: 1 - lowest value, 2- moderate value, 3-highest value. The systems were related to each other independent of project variables, the chart to the right, and then accessed per project area. The totals were multiplied to give an overall rating for the most applicable BMP for that design area.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3		3		2		1		2		2		1	
Pollutant Removal	3		3		2		2		1		2		1	
Bacteria Reduction	3		3		2		2		1		2		1	
STORMWATER QUANTITY														
Runoff Volume Reduction	3		3		1		1		1		1		1	
Peak Flow Reduction	2		3		1		1		3		2		3	
Groundwater Recharge	3		3		1		1		1		1		1	
APPLICABILITY														
Space Requirements	3		2		2		2		1		2		1	
Pretreatment	2		2		3		3		1		2		1	
Water Table Seperation	1		1		3		3		2		3		2	
COSTS														
Construction	2		1		3		3		2		1		1	
Operation + Maientenance	2		1		3		3		3		1		2	
CONNECTIVITY														
Habitat Value	1		2		1		1		1		3		2	
Sea Level Rise Adapatation	3		2		3		3		2		2		2	
Community Acceptance	2		3		3		3		1		2		2	
Educational Value	1		3		1		1		1		3		2	
Floral Diversity	1		2		1		1		1		3		1	
TOTAL SCORE	35	0	37	0	32	0	31	0	24	0	32	0	24	0
COMPOSITE SCORE	0		0		0		0		0		0		0	

BMP MATRIX BY DESIGN AREA - COTTAGE JETTY

- VEGETATED CHANNEL 1248
- SHEET FLOW FILTER STRIP 1178



A feasibility assessment, for the Cottage Jetty design area suggest that a vegetated channel BMP would be the most appropriate stormwater design strategy for this location. "Vegetated channels can provide a modest amount of runoff filtering and volume attenuation within the stormwater conveyance system resulting in the delivery of less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets and pipes" (DNREC, 2015). Regulatory feasibility elements as defined by 3.06.2 are as follows:

Contributing Drainage Area - Feasibility requirements suggest a maximum drainage area of 10 acres. Drainage area 15 has a direct connection to the Cottage Jetty design area and has a contributing drainage area of 5.5 acres, some of drainage area is from lands outside of the parcel boundary.

Available Space - The narrow and linear configuration of the parcel adapts itself well to the addition of a vegetated channel which requires less space compared to other BMP's. The addition of the design elements to the Cottage Jetty, such as the parking lot, will only decrease the available space for a BMP, making a vegetated channel applicable to both current and future design interventions.
Site Topography - Design standards suggest a maximum longitudinal slope of 4%. The grades adjacent to the river are mild and a vegetated channel designed parallel to the river to catch stormwater, should meet the less than 4% suggested longitudinal slope.
Land Use - One of the suggested land use types for a vegetated channel includes areas along the margins of small parking lots.
Hydraulic Head and Hydraulic Capacity - Fully vetting these feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.
Depth to Water Table - Feasibility requirements suggest a vegetated channel be above seasonal high ground water elevations. Specific site groundwater testing should be conducted prior to implementation of any design strategies. Given the pipe outfall in the design area is not impacted by regular tidal flux, it is expected that a vegetated channel in this location would not be affected by ground water.
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.
Floodplains - This design area is situated within the 100 yr floodplain and does not meet this feasibility criteria.

Beyond the regulatory feasibility requirements, vegetated channels rated high for the cottage jetty design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity. Regulatory design strategies provide a variable planting palette to meet the definition of vegetated. The high feasibility values rated for the connectivity section would require the use of an aesthetic, botanically diverse, and ecologically appropriate planting pallet.

Sheet flow filter strips also rated high in feasibility for this design area. The stormwater concept plan on the following pages outlines further the incorporation of such BMP's.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	1	3	1	2	2	1	1	2	2	2	2	1	1
Pollutant Removal	3	2	3	2	2	2	2	2	1	2	2	2	1	1
Bacteria Reduction	3	1	3	2	2	2	2	2	1	2	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	2	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	2	1	1	1	1	3	3	2	2	3	3
Groundwater Recharge	3	1	3	1	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	3	2	3	2	3	2	3	1	1	2	1	1	1
Pretreatment	2	1	2	1	3	3	3	3	1	1	2	1	1	1
Water Table Seperation	1	1	1	1	3	3	3	3	2	3	3	3	2	2
COSTS														
Construction	2	2	1	2	3	3	3	3	2	1	1	1	1	1
Operation + Maientenance	2	2	1	2	3	3	3	3	3	3	1	1	2	2
CONNECTIVITY														
Habitat Value	1	1	2	2	1	3	1	3	1	3	3	3	2	3
Sea Level Rise Adapatation	3	1	2	1	3	3	3	3	2	3	2	2	2	2
Community Acceptance	2	2	3	3	3	3	3	3	1	2	2	2	2	2
Educational Value	1	1	3	3	1	3	1	3	1	3	3	3	2	2
Floral Diversity	1	1	2	2	1	3	1	3	1	3	3	3	1	3
TOTAL SCORE	35	24	37	30	32	39	31	38	24	34	32	30	24	27
COMPOSITE SCORE	840		1110		1248		1178		816		960		648	


Road 28A
250 lf
VEGETATED CHANNEL
4300 sf
CONSTRUCTED WETLAND
FILTER STRIP
615 lf

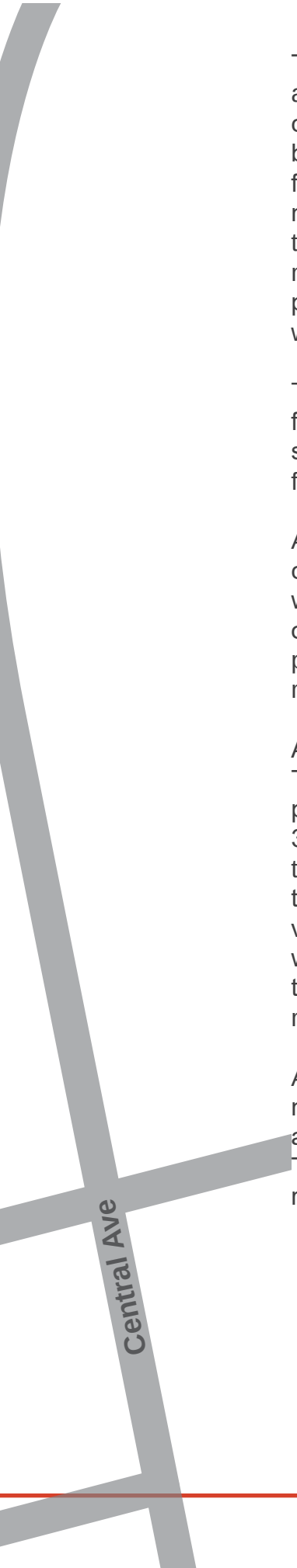
The Cottage Jetty design parcel is influenced by two watersheds, 1 and 15. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A bio-retention BMP to treat watershed 15 would need to be approximately 100 sq ft to meet regulatory standards. A bio-retention BMP to treat watershed 1 would need to be approximately 25,000 sq ft to meet regulatory standards. The size of the parcel and the lack of direct connectivity to watershed 1 make the potential to meet regulatory standards for this watershed unlikely. The stormwater concept plan proposed could potentially meet regulatory requirements for watershed 15, which includes the lands within the proposed design area.

The stormwater concept plan for the Cottage Jetty design area incorporates three features: a vegetated channel, ranking highest in feasibility, a sheet flow filter strip, ranking second in feasibility, and a constructed wetland, ranking third in feasibility.

A vegetated channel could be located along the northern parcel boundary. This channel could collect water from the proposed parking road and parking lot, as well as potentially filter any water within watershed 15 that comes from lands outside the parcel boundary. For the most effective result the channel should be planted with a ground-cover layer in the grass family and colorful forbs in the 2-3' mature height range.

A sheet flow filter strip could be installed along the bulkheaded edge of the river. The strip could be 4-6 ft wide depending on adjacent constraints, existing and proposed. It is recommended an ecologically appropriate, low maintenance, 3-4ft high, mono-culture planting be installed in this location. Keeping the palette to one or two plant species will create an attractive border that is appropriate to the context, should be less costly than a traditional floral garden, and provide a visual boundary to the river's edge. For maintenance purposes a minimum 5ft wide band along the river's edge should be left un-planted. This area, along with the planted strip, could be mulched with stone, either a garden type or recycled material.

A constructed wetland could be installed in the existing depression on the northern side of the SD1-P1, just prior to the wood edge. A site visit indicated a mass of varying vegetation in the area, some beneficial and some invasive. The placement and construction of this BMP should be placed in a location that removes invasive plants and conserves beneficial trees and shrubs.

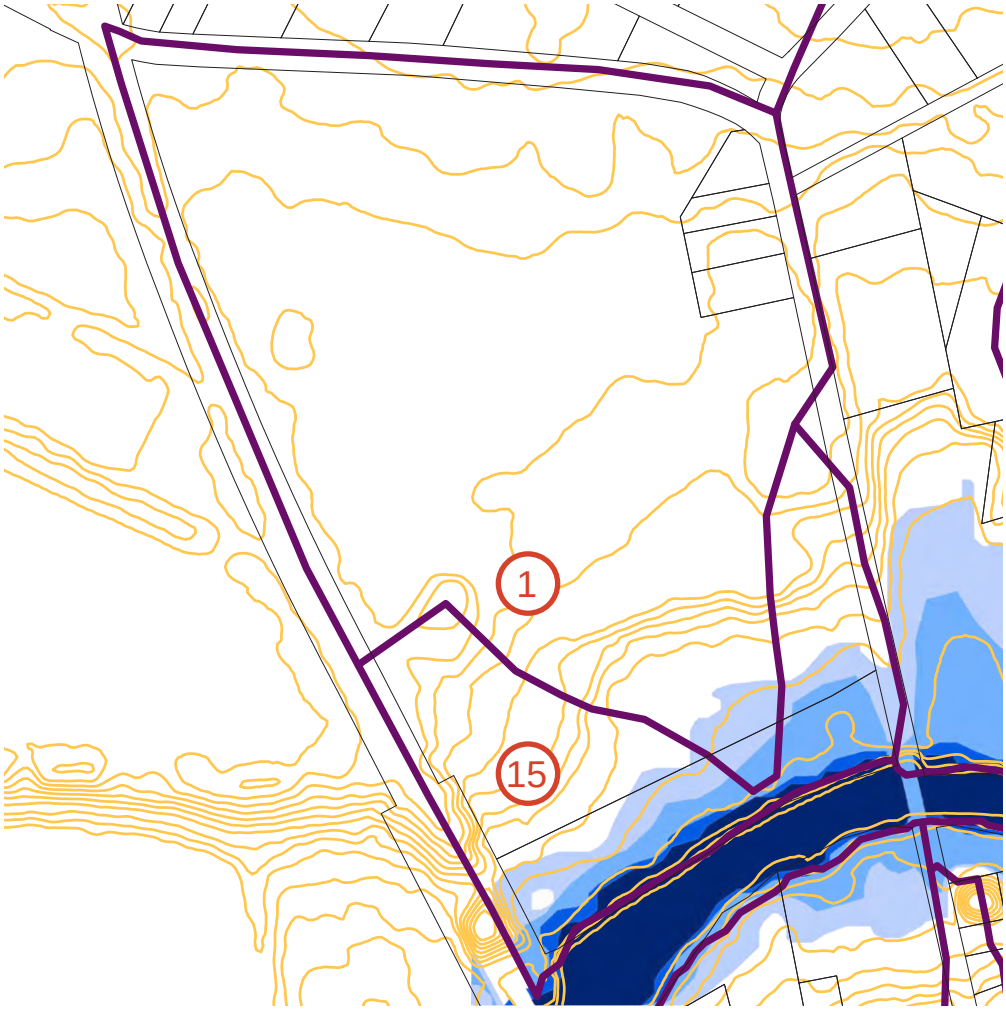


legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

- watershed



SEA LEVEL RISE RESPONSE

In response to sea level rise approximately half of the Cottage Jetty design area would be effected in the 1.0 meter rise scenario. With mean high high water being estimated at elevation 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the vegetated channel to be between elevations 4 and 6. These elevations would most likely not be effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would effect the BMP. The low installation costs and potential for seed dispersal allow for easier adaptability to higher ground, should it be decided to relocate the facility in the future.

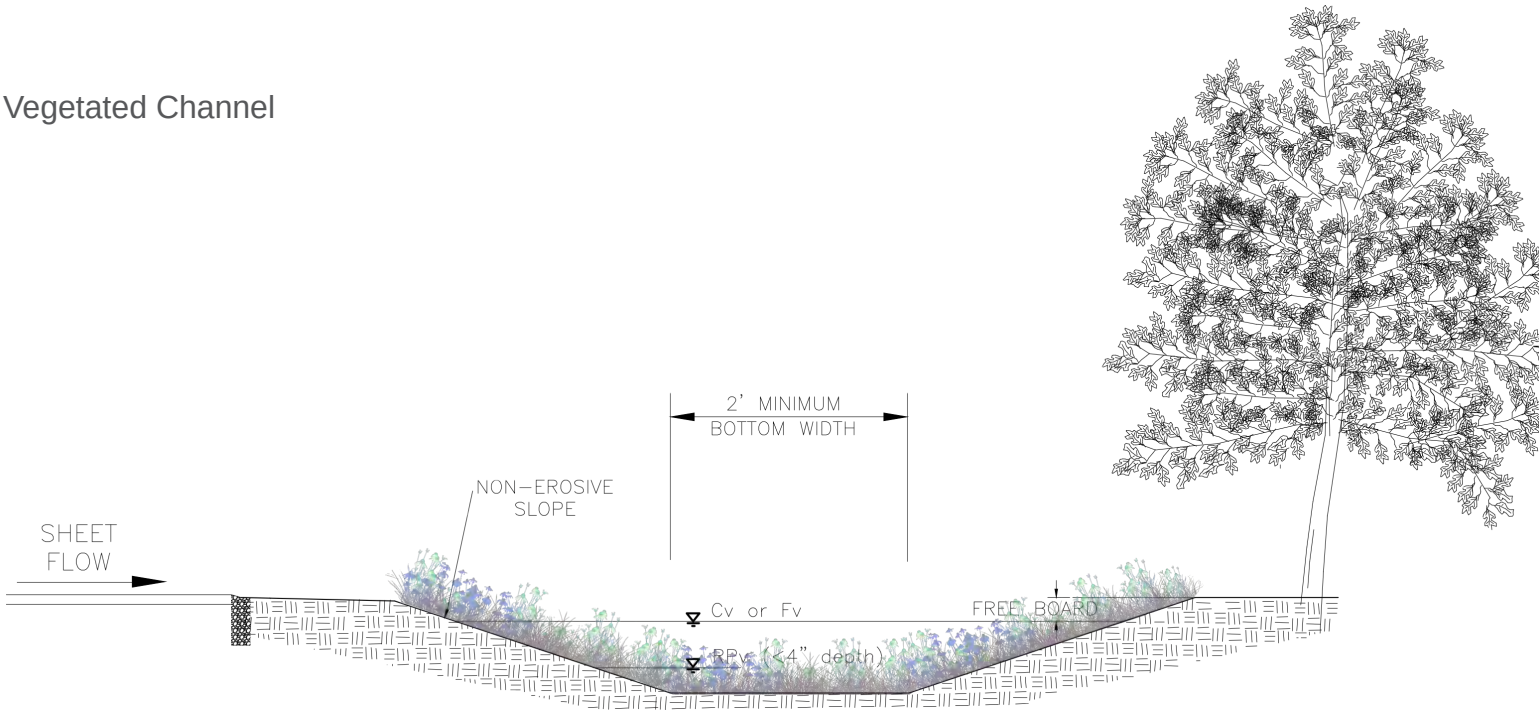
The sheet flow filter strip installed at the edge of the bulkhead would range in elevation from 2-3 ft. A 0.5 meter change in elevation would begin to effect portions of the filter strip and higher rise scenarios would most likely effect the functionality of the BMP. This is a low cost element of the concept plan and primarily proposed for existing and near future conditions. Should this BMP be effected, it is expected the bulkhead itself would most likely be re-evaluated and any SLR response techniques would incorporate appropriate stormwater BMP's.

The constructed wetland is proposed roughly between elevations 4 and 6. This systems response to SLR scenarios would vary depending on final design depths. It is expected a 0.5 meter change would

not effect it however, depending on the depth of the bottom of the facility some additional inundation may occur. A 1.0 scenario would most likely effect some portion of the facility. Re-locating the facility would be a more costly effort. Utilizing more salt tolerant plants at installation could potentially allow the system to function as a wet pond as SLR scenarios increase inundation.

CONCEPT SECTIONS

Vegetated Channel



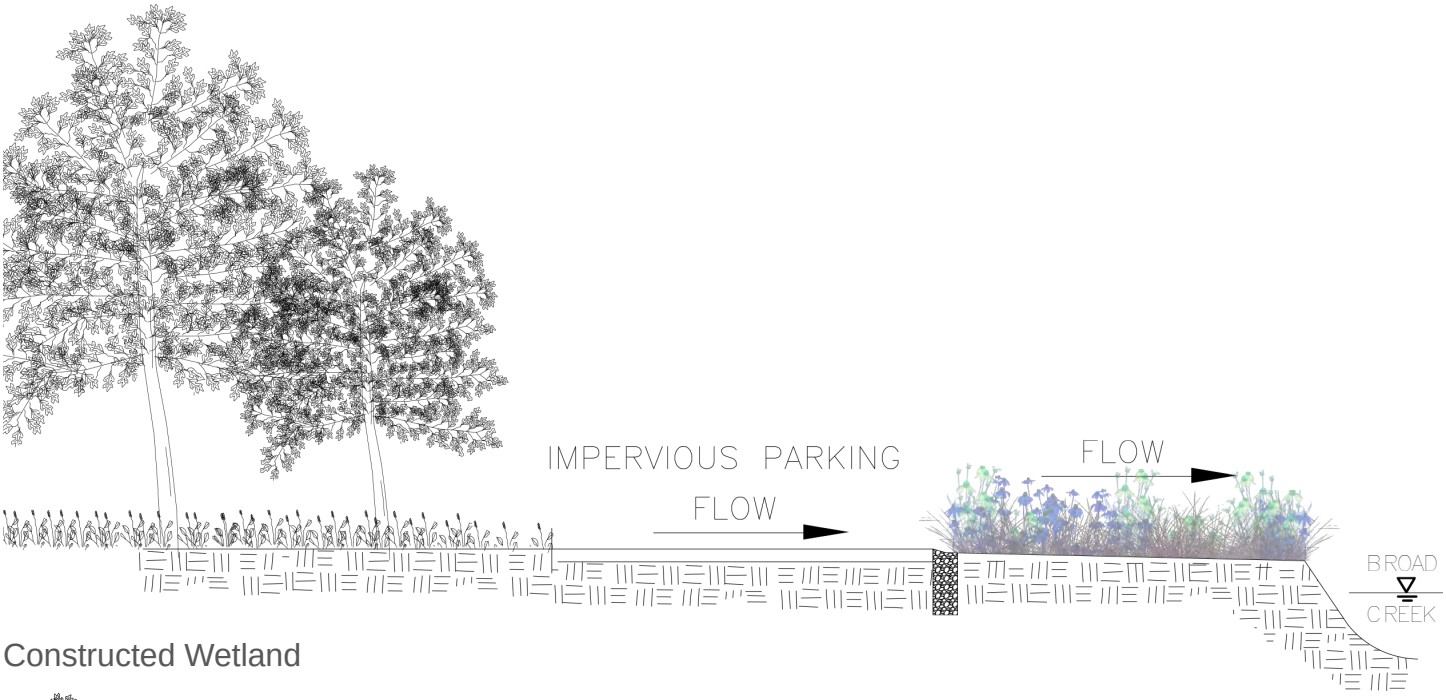
The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. In the EIA assessment of the project, this parcel was indicated as potentially having fill soils. BMP effectiveness and appropriateness to a location could be impacted by soil conditions. Specific design details should be prepared for each proposed BMP intervention.

The above section represents a cross section of a vegetated channel. The system is designed to capture the resource protection volume storm event and allow for additional capacity for the conveyance volume or retention volume; there is also an additional area of free board above these limits for extreme storm events. The functionality of the system is dependent on the design for conveyance of the runoff, longitudinal slope of the system, and the vegetation stem density to reduce flow velocities and promote soil infiltration.

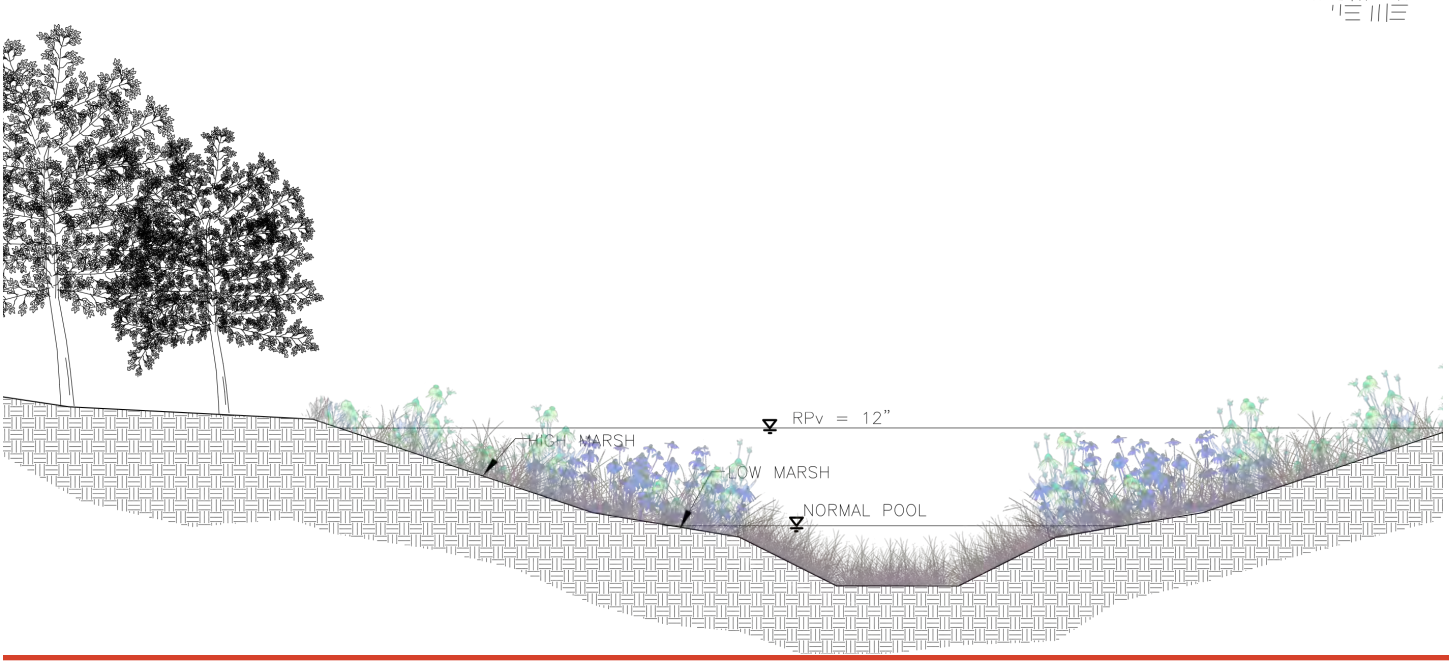
The sheet flow filter strip also relies on vegetation stem density to reduce flow velocities and promote soil infiltration. This system is generally designed with little to no retention volume, with the plants being installed at grade. This is the design intent for the filter strip along the bulkhead, a level planting strip for surface water to pass through, before entering the river.

The constructed wetlands section illustrates the unique vegetation diversity utilized in these systems. They are designed to hold a specific amount of water, much like a very shallow wet pond, and then have two levels, or vegetation shelves, above the normal pool, one the high marsh zone and one the low marsh zone. The three zones of water inundation create unique plant communities that serve a variety of wildlife. These plant communities can dramatically increase the floral diversity of the Cottage Jetty design area while significantly enhancing the aesthetics through the use of flowering species. These areas also serve as key food sources for the local bird populations. An additional connection benefit to this BMP is through its adjacency to the river system, this area would provide opportunities for some species migration during sea level rise scenarios. Plant and wildlife species that may no longer be able to live along the banks of Broad Creek, could establish themselves in this constructed wetland, thus continuing the rich ecology of the area.

Sheet Flow Filter Strip



Constructed Wetland



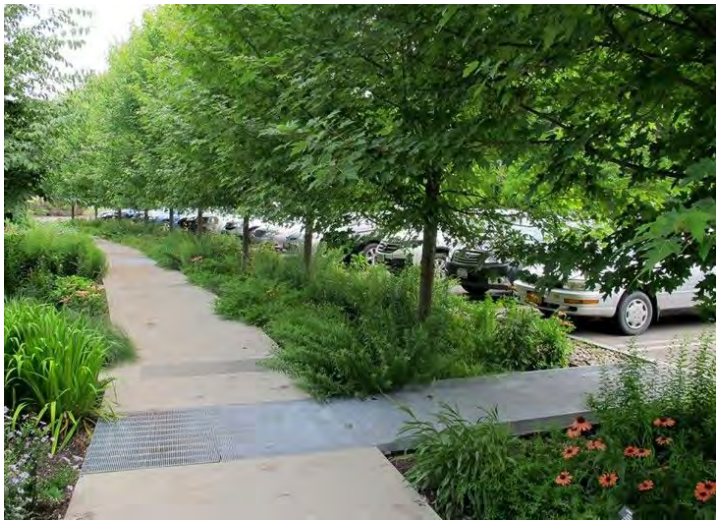
PRECEDENT IMAGERY

(image credit see reference number in reference section)

vegetated channel (1)

(2)

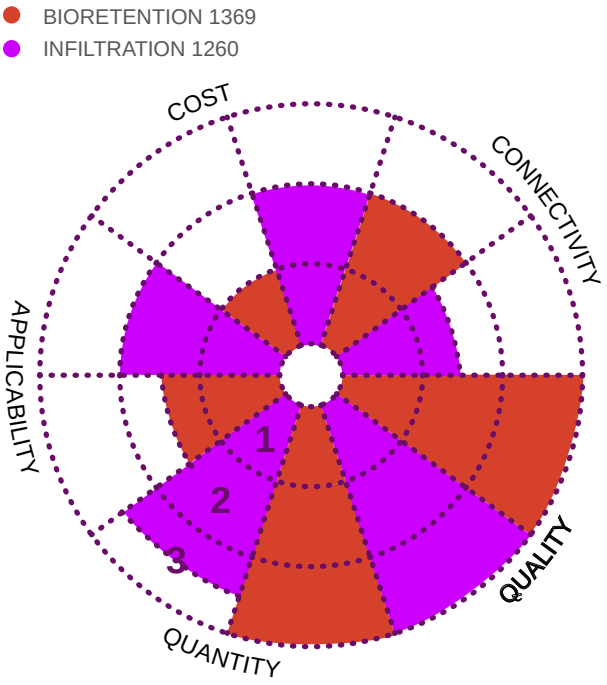
filter strip (3)



(4)

constructed wetland (5)

(6)



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with the Governor's Park and Independence Playground (Park) design location, suggests that a bioretention BMP would be the most appropriate stormwater design strategy for this location. "Bioretention systems are typically designed to manage stormwater runoff from frequent, small magnitude storm events. Pollutant reduction occurs through a combination of runoff reduction and treatment by the filtering media" (DNREC, 2015). Regulatory feasibility elements as defined by 3.06.2 are as follows:

DNREC Technical Document - Bioretention with infiltration requires a 2 foot separation from seasonal high groundwater without an underdrain and when utilized, the invert of an underdrain must be above the seasonal high groundwater. It is expected this criteria could be met however, being close to the river, groundwater depths are likely high and should be confirmed for final design.

Required Space - "The bioretention surface area will usually be between 3% to 6% of the contributing drainage area (CDA), depending on the imperviousness of the CDA and the desired bioretention ponding depth." As illustrated in the SWM concept plan, the combined proposed surface area does not meet the minimum 3% CDA. As designed, it does meet the minimum 3% CDA for the Park parcels. The parcel is approximately 3.75 +/- ac., prior to construction the Town should review the Park parcels and discuss if they would like to increase the bioretention footprints.

Site Topography - Design standards suggest a maximum slope of 5%. The grades adjacent to the river are mild and the designed bioretention should meet the less than 5% suggested slope.

Available Hydraulic Head -Fully vetting this feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.

Water Table - It is expected the proposed facilities will meet this criteria however, final design should confirm available depth to water table prior to implementation.

Soils and Underdrains - Geo-technical and/or geologic analyses should be completed prior to final design implementation. It is expected the bioretention facilities for the Park should be designed with an underdrain to effectively meet the infiltration and groundwater separation criteria.

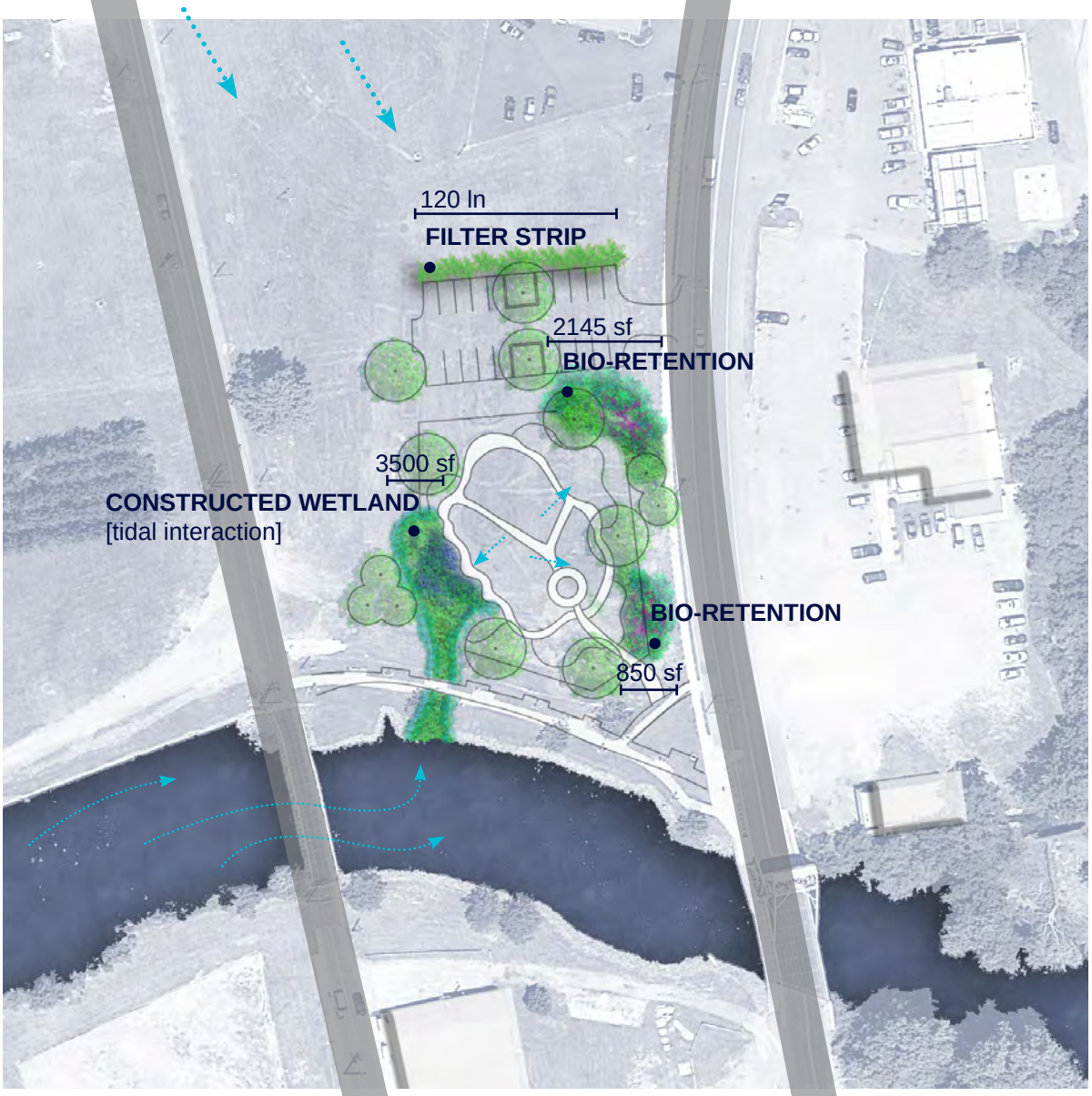
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.

Floodplains - This parcel is situated within the 100 yr floodplain and does not meet this feasibility criteria.

Beyond the regulatory feasibility requirements, bioretention rated moderate to high for the Park's design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity.

Infiltration practices ranked second on the feasibility matrix. Due to the proximity of the river and future planning efforts to mitigate SLR, this practice was not chosen. The next highest scoring criteria, constructed wetlands, was deemed a suitable practice in this location and the stormwater concept plan on the following pages outlines further the incorporation of this BMP.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	3	3	3	2	2	1	1	2	2	2	2	1	1
Pollutant Removal	3	3	3	3	2	2	2	1	1	1	2	2	1	1
Bacteria Reduction	3	3	3	3	2	2	2	1	1	1	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	3	3	3	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	3	1	1	1	1	3	3	2	2	3	3
Groundwater Recharge	3	3	3	3	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	3	2	3	2	2	2	1	1	2	2	3	1	2
Pretreatment	2	2	2	2	3	3	3	1	1	2	2	3	1	2
Water Table Seperation	1	2	1	1	3	2	3	1	2	2	3	3	2	2
COSTS														
Construction	2	2	1	1	3	3	3	1	2	2	1	2	1	1
Operation + Maientenance	2	2	1	1	3	3	3	1	3	2	1	2	2	2
CONNECTIVITY														
Habitat Value	1	1	2	2	1	1	1	1	1	1	3	3	2	2
Sea Level Rise Adapatation	3	3	2	2	3	3	3	1	2	2	2	2	2	2
Community Acceptance	2	2	3	2	3	3	3	1	1	1	2	2	2	1
Educational Value	1	1	3	3	1	1	1	1	1	1	3	3	2	2
Floral Diversity	1	1	2	2	1	1	1	1	1	1	3	3	1	1
TOTAL SCORE	35	36	37	37	32	31	31	16	24	25	32	36	24	25
COMPOSITE SCORE	1260		1369		992		496		600		1152		600	


Road 28A
120 ln
FILTER STRIP
2145 sf
BIO-RETENTION
3500 sf
CONSTRUCTED WETLAND
[tidal interaction]
BIO-RETENTION
850 sf
Central Ave

The Governor's Park and Independence Playground (Park) design area is influenced by one watersheds directly, 3, and has one adjacent to it, 4, which outfalls along the river very near the Park's parcel limits. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A bioretention to treat watershed 3 would need to be approximately 9,000 sq ft to meet regulatory standards. A bioretention to treat watershed 4 would need to be approximately 61,000 sq ft to meet regulatory standards, bioretention facilities of these scales can become impractical to successfully implement. Although the outfall for watershed 4 is near the Park's parcel, the CDA is not, in addition the location of the outfall would make incorporating this drainage area into a BMP on Park property costly. Given the large impervious area on the downstream end of this watershed, the Town might consider beginning a conversation with local property owners to initiate BMP's higher up in this watershed, to reduce the burden on downstream properties such as Governor's Park. The stormwater concept plan proposed could meet regulatory requirements for watershed 3 with additional square footage, as noted on the previous page under feasibility criteria.

The stormwater concept plan for the Park design area incorporates four features: two bioretentions, ranking highest in feasibility, a sheet flow filter strip, and a constructed wetland, ranking third in feasibility.

The two bioretentions would be designed to capture runoff from the proposed park. They should be planted with a colorful palette similar to traditional residential flower gardens, so they appear more as a park amenity than a stormwater facility. Final design of the facilities should incorporate areas for the Park visitors to learn about the function of bioretention facilities and their contribution to the larger watershed.

A sheet flow filter strip could be installed along the edge of the proposed parking lot. The strip could be 4-6 ft wide depending on adjacent constraints, existing and proposed. It is recommended an ecologically appropriate, low maintenance, 3-4ft high, mono-culture planting be installed. Keeping the palette to one or two plants will create an attractive border that is appropriate to the context and should be less costly than a traditional floral garden.

A constructed wetland could be installed in the southwest corner of the park. This location is down slope and closer to the river from the proposed bioretention areas; a constructed wetland that allows for more interaction with the groundwater table was deemed more appropriate in this area. This location could also capitalize on the existing outfall structure and use the pipe for a direct tidal connection to lower portions of the constructed wetland. Tidal interactions can improve water quality, by providing increased interaction with filtering vegetation, and provide spawning locations for migrating fish.

SEA LEVEL RISE RESPONSE

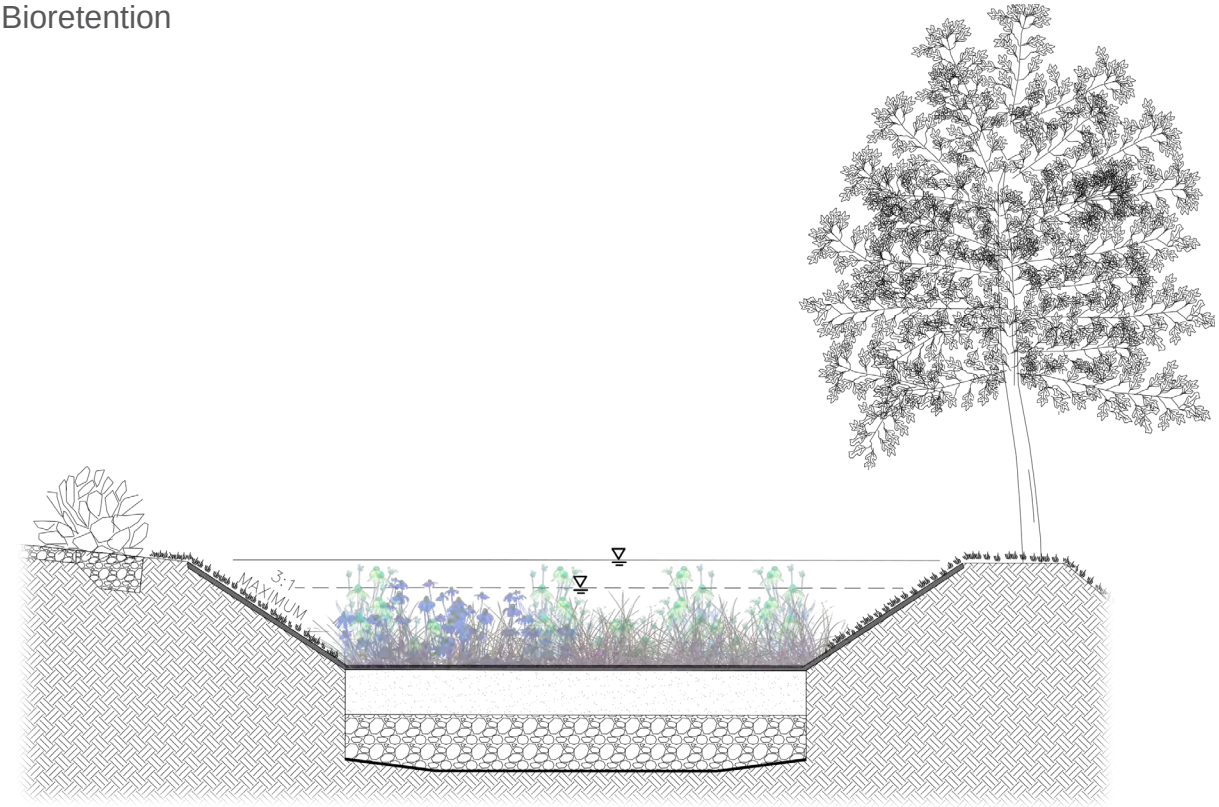
In response to sea level rise most of the Park would be effected in the 1.0 meter rise scenario. With mean high high water being estimated at elevation 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the bioretention gardens to be between elevations 4 and 6. These elevations would most likely not be effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would partially effect the BMPs. Where increased inundation due to sea level rise is likely, NOAA suggests leaving the media area the same but increasing the ponding area to allow more time for the runoff to navigate the system. Increased saturation from SLR may fill void spaces in the media area, thus reducing the effectiveness. Layout design changes should be made during the construction design phase to incorporate increased ponding areas.

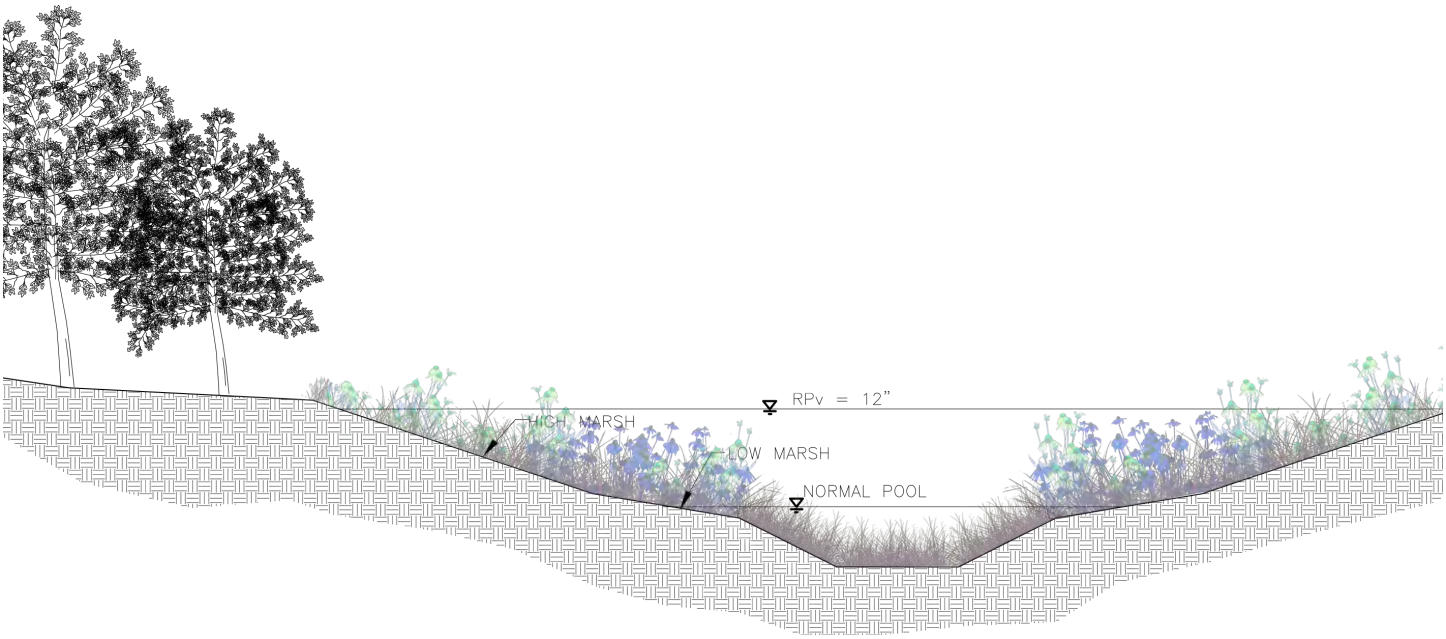
The stormwater concept plan estimates the constructed wetland to be between elevations 2 and 4. These elevations would be minimally effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would effect the BMPs. Similar to the design strategies noted in the DNREC manual, a constructed wetland with various "cells" could allow for some areas to still function if inundation of down slope areas occurs. Even if inundated by SLR, the habitat value of these systems would most likely remain high, for example they would still be accessible as spawning areas for anadromous fish, areas that are critically limited in this portion of Broad Creek.

CONCEPT SECTIONS

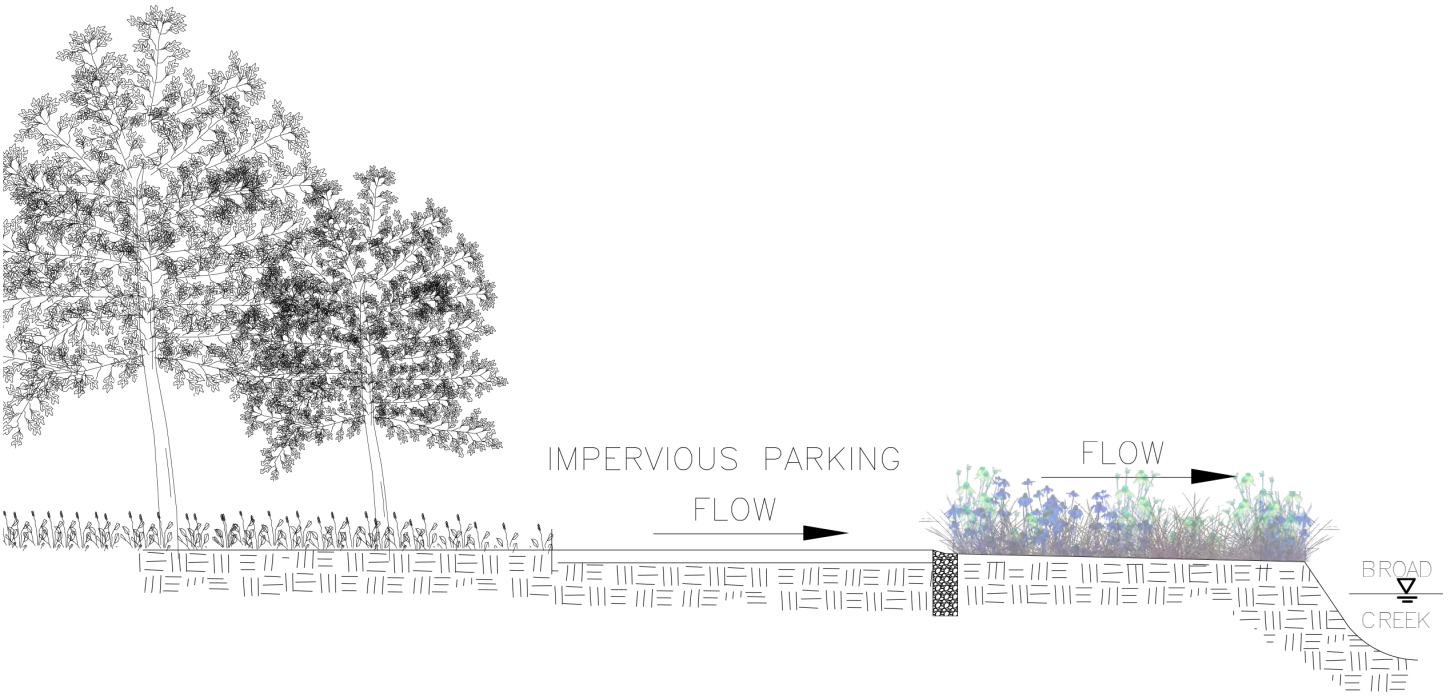
Bioretention



Constructed Wetland



Sheet Flow Filter Strip



The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

The constructed wetlands section illustrates the unique vegetation diversity utilized in these systems. They are designed to hold a specific amount of water, much like a very shallow wet pond, and then have two levels, or vegetation shelves, above the normal pool, one the high marsh zone and one the low marsh zone. The three zones of water inundation create unique plant communities that serve a variety of wildlife. Constructed wetlands typically have multiple “cells” within the footprint, each containing the three water inundation zones. An additional connection benefit to this BMP is through its adjacency to the river system, this area would provide opportunities for some species migration during sea level rise scenarios. Plant and wildlife species that may no longer be able to live along the banks of Broad Creek due to submergence of important habitat, could establish themselves in this constructed wetland, thus continuing the rich ecology of the area. The constructed wetland in this location does propose a direct tidal interaction and will require micro-topographic grading during the construction design phase.

The sheet flow filter strip relies on vegetation stem density to reduce flow velocities and promote soil infiltration. This system is generally designed with little to no retention volume, with the plants being installed at grade. This is the design intent for the filter strip along the parking lot, a level planting strip for surface runoff to pass through as it leaves the impervious parking surface and enters the surrounding landscape.

The bioretention section illustrates a common practice in SWM design. The system is adaptable to both urban and rural conditions. The system relies on a designed depth of engineered media to filter stormwater as it infiltrates down through the system. Below the media is an area of stone to allow a sump area for water storage to release either into the surrounding soils (in-situ infiltration), or an underdrain. An underdrain system can either daylight to surrounding grades or a specific outfall location, such as a storm pipe leading to the constructed wetland. The bioretention systems for the Park will most likely contain an underdrain and discharge excess flows away from the playground surfaces via a newly installed storm drain system.

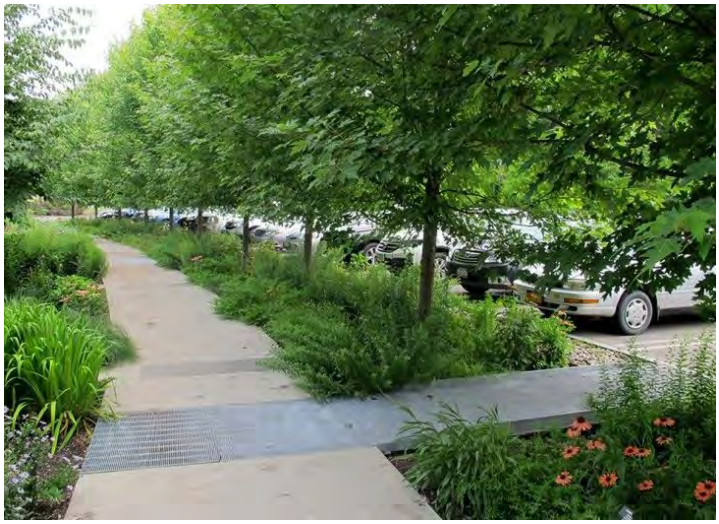
PRECEDENT IMAGERY

(image credit see reference number in reference section)

bioretention garden (7)

(8)

filter strip (3)



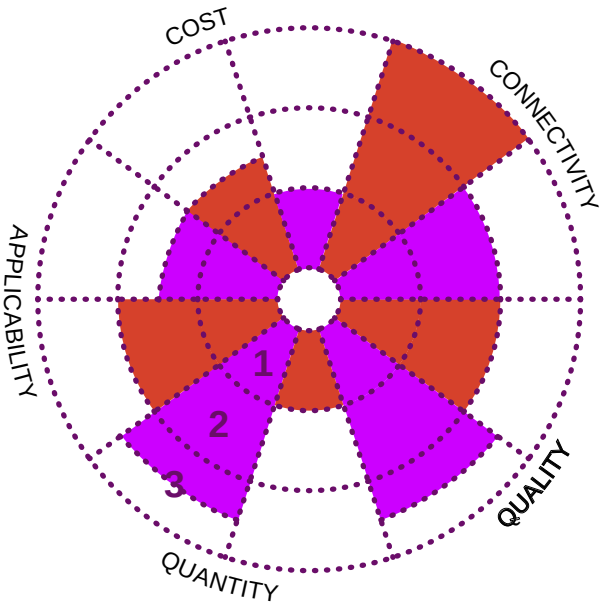
(4)

constructed wetland (5)

(6)

BMP MATRIX BY DESIGN AREA - CYPRESS BRIDGE NORTH

- CONSTRUCTED WETLANDS 1088
- BIORETENTION 1036



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with the Cypress Bridge North design location, suggest a constructed wetland BMP would be the most appropriate stormwater design strategy for this location. “Constructed Wetlands are shallow depressions that receive stormwater inputs for water quality treatment. The majority of the wetland surface area is covered by shallow (<1’ deep) wetland area, with greater depths in the forebay and pools within the wetland.” (DNREC, 2015). Regulatory feasibility elements as defined by 3.06.2 are as follows:

Adequate Water Balance - Feasibility requirements suggest the system should not go dry after a 30-day summer drought. Based on a visual assessment of the area, it is expected the proposed facility would meet this requirement, re-grading would most likely be needed.

Contributing Drainage Area (CDA)- Design standards suggest a minimum of 2-3 acres to maintain wetland hydrology if the only source of water is from stormwater. The proposed facility is connected to a drainage area 16 +/- ac in size; not all of this drainage area has been designed to flow through this facility, however, it has been proposed with a direct river/tidal connection to portions of the facility increase hydrology.

Available Hydraulic Head - Fully vetting this feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.

Minimum Setbacks - As noted in 3.06.2, this feasibility criteria should be fully vetted during final construction drawings per local ordinances. To accommodate tidal interaction this facility is located near the property line; variances should be applied for if needed.

Depth to Water Table - Design standards don’t significantly apply to depth to water table constraints, as these facilities need continued inundation. Although this design detail can be limiting for the quantity and quality criteria, the connectivity criteria offsets the low scoring for quantity and quality.

Soils - As noted previously, the USDA NRCS soil maps rate the areas next to the river as having A soils, with good infiltration rates. Given the history of the parcels noted in the EIA report, this rating may not be accurate. A visual assessment of the area also suggests this rating may not be accurate. Geo-technical and/or geologic analyses should be completed prior to final design, however, it is expected the site contains appropriate soils for a constructed wetland.

Use of, or Discharges to, Natural Wetlands - As noted in the Appendices appropriate input has been requested from some agencies. Additional agencies should be contacted as appropriate during the construction drawing phase.

Community and Environmental Concerns - The proposed BMP is expected to meet all community and environmental concerns.

Beyond the regulatory feasibility requirements, constructed wetlands rated high for the Cypress Bridge N. design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity. It is expected that the incorporation of a constructed wetland will mimic the landscape typology similar to the natural conditions which the existing cypress tree would be typically found in and that a constructed wetland system would integrate well with surrounding ecosystems

Bioretentions and sheet flow filter strips also rated high in feasibility for this design area. The stormwater concept plan outlines further the incorporation of such BMP’s in this location.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	2	3	2	2	1	1	1	2	1	2	2	1	1
Pollutant Removal	3	2	3	2	2	1	2	2	1	1	2	2	1	1
Bacteria Reduction	3	2	3	2	2	1	2	2	1	1	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	2	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	2	1	1	1	1	3	1	2	2	3	2
Groundwater Recharge	3	2	3	2	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	2	2	1	2	2	2	3	1	1	2	2	1	1
Pretreatment	2	2	2	2	3	2	3	3	1	1	2	2	1	1
Water Table Seperation	1	1	1	1	3	1	3	1	2	1	3	1	2	1
COSTS														
Construction	2	1	1	1	3	2	3	3	2	1	1	2	1	1
Operation + Maientenance	2	1	1	1	3	2	3	3	3	1	1	2	2	2
CONNECTIVITY														
Habitat Value	1	1	2	2	1	1	1	2	1	1	3	3	2	2
Sea Level Rise Adapatation	3	2	2	1	3	3	3	3	2	1	2	3	2	2
Community Acceptance	2	2	3	2	3	2	3	3	1	1	2	3	2	2
Educational Value	1	2	3	3	1	1	1	2	1	1	3	3	2	2
Floral Diversity	1	2	2	2	1	1	1	2	1	1	3	3	1	1
TOTAL SCORE	35	28	37	28	32	23	31	33	24	16	32	34	24	22
COMPOSITE SCORE	980		1036		736		1023		384		1088		528	


CONSTRUCTED WETLAND
[tidal interaction]
BIO-RETENTION
FILTER STRIP
850 sf
1200 lf
4600 sf
WHARF PLANTER
1200 sf
Central Ave
Delaware Ave

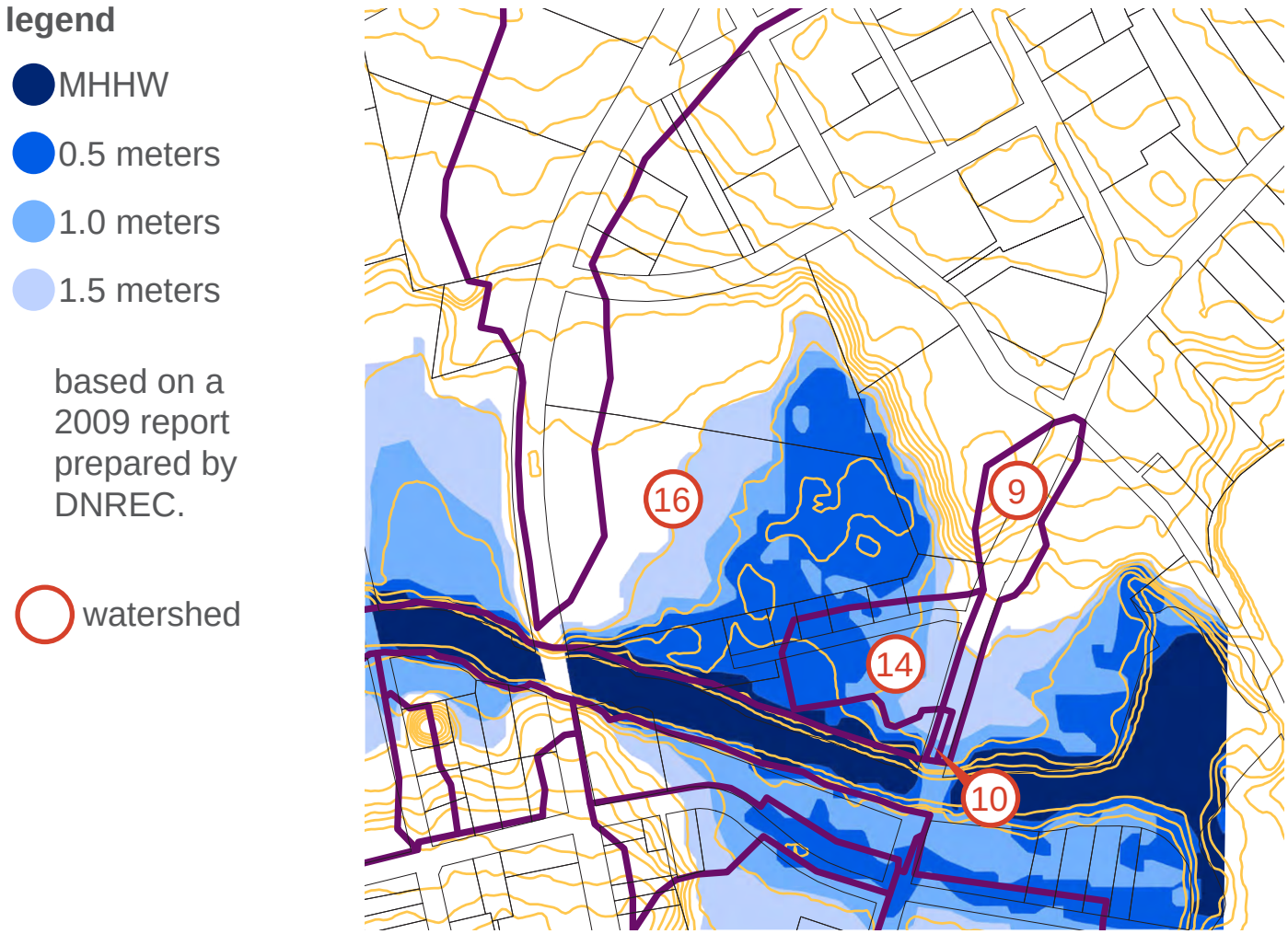
The Cypress Bridge N. design area includes three watersheds, 10,14,16. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A bioretention BMP to treat watershed 10 would need to be approximately 300 sq ft to meet regulatory standards. A bioretention BMP to treat watershed 14 would need to be approximately 5000 sq ft to meet regulatory standards. A bioretention BMP to treat watershed 16 would need to be approximately 4500 sq ft to meet regulatory standards. The stormwater concept plan proposed could meet regulatory requirements for watershed 10 and 16. As designed it most likely would not meet requirements for watershed 14 however, opportunities to reduce impervious cover in the parking lot of Abbott's and increase bioretention facilities do exist and could allow for a combined system to meet regulatory standards.

The stormwater concept plan for the Cypress Bridge N. design area incorporates four features: a constructed wetland, ranking highest in feasibility, a bioretention area, ranking second in feasibility, a sheet flow filter strip, ranking third in feasibility, and a wharf planter, a river side adaptation of a bio-retention garden.

A constructed wetland could be located in the low areas in the southwest corner of watershed 16. This area is adjacent to the home of the largest Taxodium distichum (bald cypress) tree in Delaware, a plant native to wet moist environments. The construction of a wetland in this area would most likely restore the landscape typology that naturally wants to be in that location. The constructed wetland could have a direct tidal connection to the river. Tidal interactions can improve water quality, by providing increased interaction with filtering vegetation, and provide spawning locations for migrating fish. Increased opportunities for wetland and shallow water habitat adjacent to Broad Creek are critical for adaptation to potential sea level rise.

A sheet flow filter strip could be installed along the edge of the existing parking lot. The strip could be 4-6 ft wide depending on adjacent constraints, existing and proposed. It is recommended an ecologically appropriate, low maintenance, 3-4ft high, mono-culture planting be installed. Keeping the palette to one or two plants will create an attractive border that is appropriate to the context, should be less costly than a traditional floral garden.

A wharf planter has been proposed to filter roof run off from the restaurant, and potentially watershed 10. The wharf planters would have design standards similar to a traditional bioretention facility, more specifically a stormwater planter however, unlike a stromwater planter, these systems treat various water sources and have a riverine component to them. "Stormwater Planters are a useful option to disconnect and treat rooftop runoff, particularly in ultra-urban areas. They consist of confined planters that store and/or infiltrate runoff in a soil bed to reduce runoff volumes and pollutant loads" (DNREC, 2015).These facilities would be incorporated into a box like structure,"planter", that would make it more feasible to install over the rip rap stone shoreline at the edge of the restaurant decking. These planters should be planted with colorful flora that tolerates bioretention hydrology. The use of bright colors can make these facilities an attractive garden element for the restaurant landscape.



SEA LEVEL RISE RESPONSE

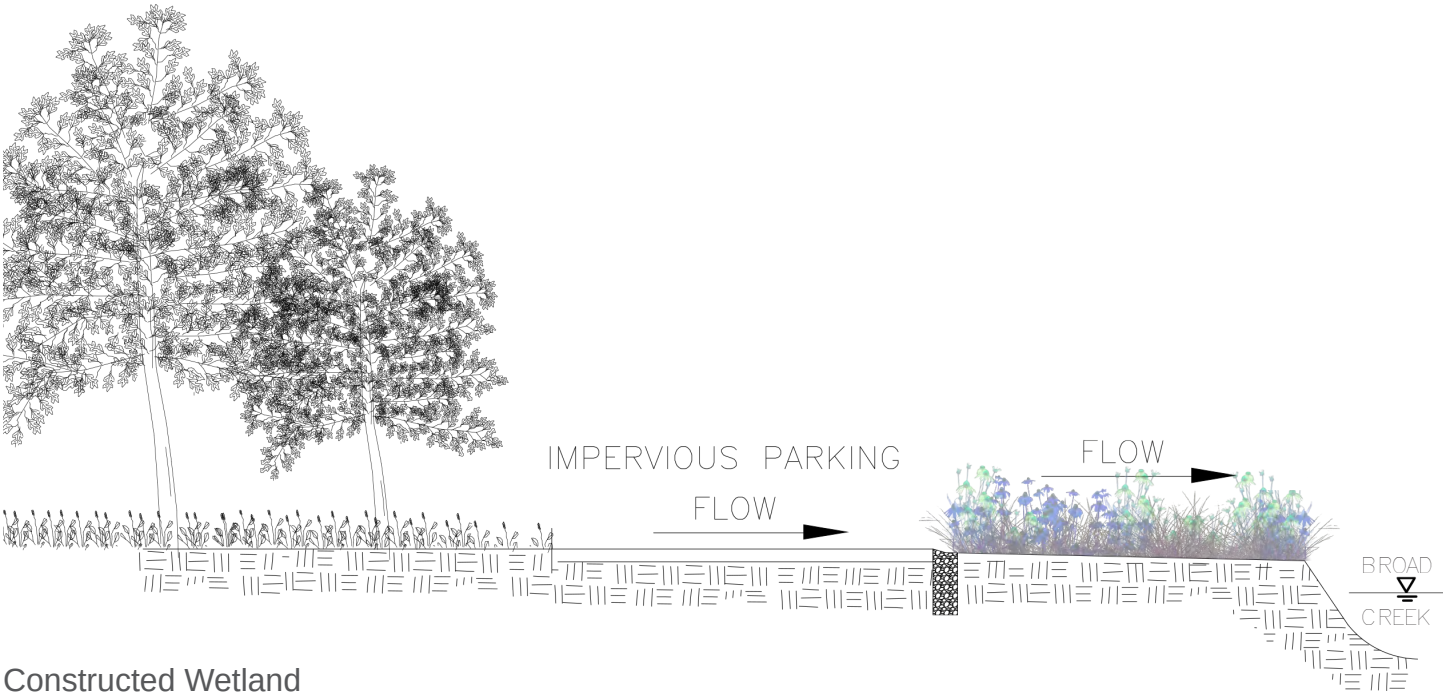
In response to sea level rise most of the Cypress Bridge N. area would be effected in the 1.0 meter rise scenario. With mean high high water approximated at elevation 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the bioretention gardens to be between elevations 1 and 2. These elevations would most likely be effected by a 0.5 meter and 1.0 meter change in elevation. Where increased inundation due to sea level rise is likely, NOAA suggests leaving the media area the same but increasing the ponding area to allow more time for the runoff to navigate the system. Increased saturation from SLR may fill void spaces in the media area, thus reducing the effectiveness. Layout design changes should be made during the construction design phase to incorporate increased ponding areas.

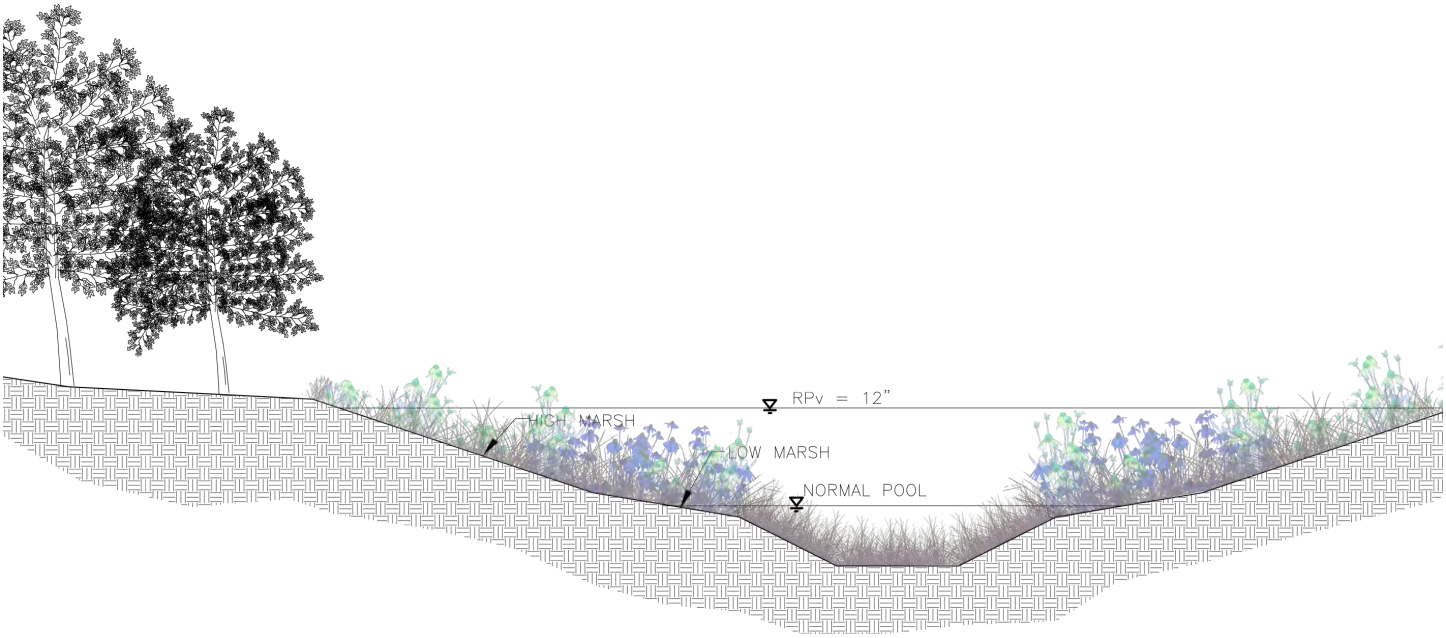
The stormwater concept plan estimates the constructed wetland to be between elevations 1 and 2. These elevations would be effected by a 0.5 meter and 1.0 meter change in elevation. Similar to the design strategies noted in the DNREC manual, a constructed wetland with various "cells" could allow for some areas to still function if inundation of down slope areas occurs. Even if inundated by SLR, the habitat value of these systems would most likely remain high, for example they would still be accessible as spawning areas for anadromous fish. Research suggests a variable response of Taxodium distichum to increased hydrology; seedlings may be stunted but stands may persist, increased salinity and storm surges may require human intervention to restore the cypress swamp.

CONCEPT SECTIONS

Sheet Flow Filter Strip



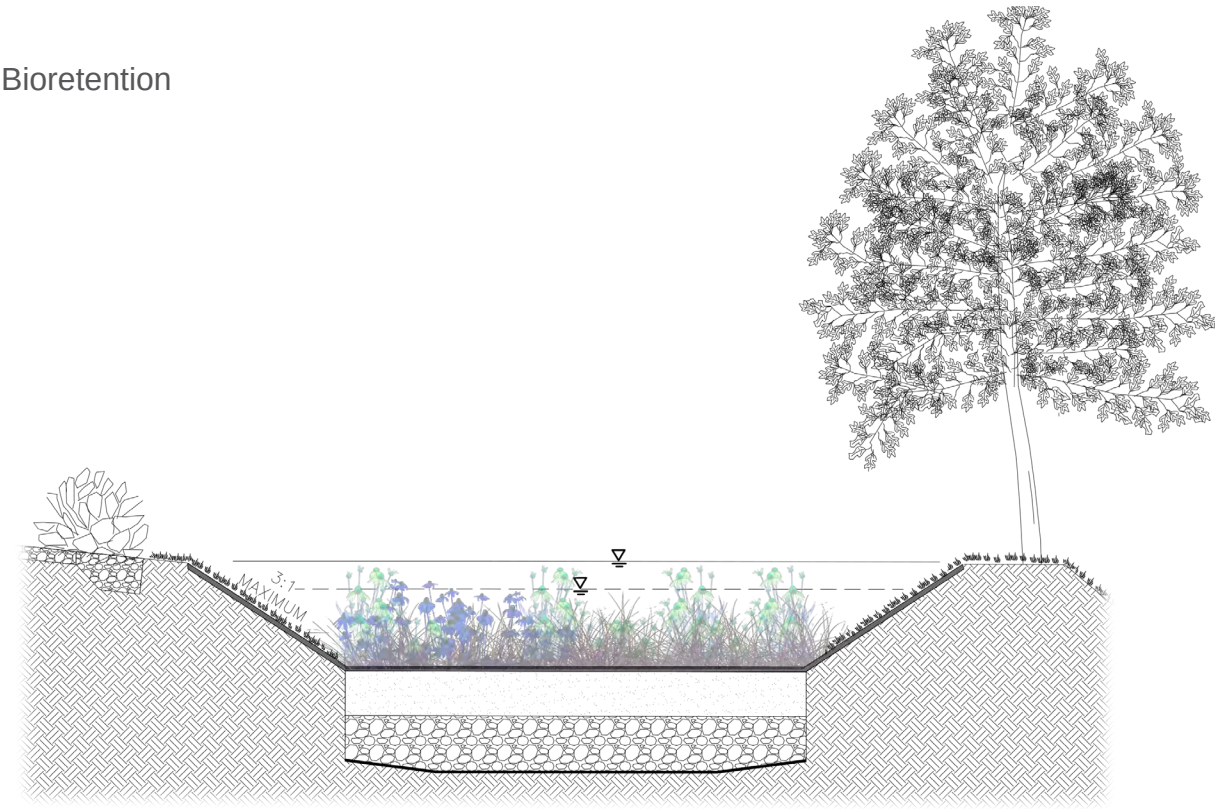
Constructed Wetland



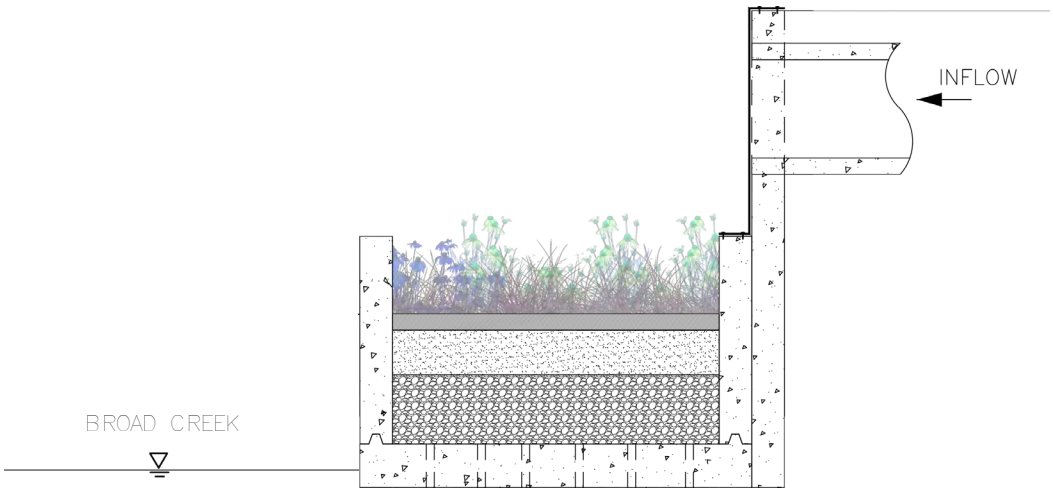
The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

The constructed wetlands section illustrates the unique vegetation diversity utilized in these systems. They are designed to hold a specific amount of water, much like a very shallow wet pond, and then have two levels, or vegetation shelves above the normal pool, one the high marsh zone and one the low marsh zone. The three zones of water inundation create unique plant communities that serve a variety of wildlife. Constructed wetlands typically have multiple “cells” within the footprint, each containing the three water inundation zones. An additional connection benefit to this BMP is through its adjacency to the river system, this area would provide opportunities for some species migration

Bioretention



Wharf Planter



during sea level rise scenarios. Plant and wildlife species that may no longer be able to live along the banks of Broad Creek could establish themselves in this constructed wetland, thus continuing the rich ecology of the area. The constructed wetland in this location does propose a direct tidal interaction and will require micro-topographic grading during the construction design phase and careful protection of the historic cypress tree.

The sheet flow filter strip relies on vegetation stem density to reduce flow velocities and promote soil infiltration. This system is generally designed with little to no retention volume, with the plants being installed at grade. This is the design intent for the filter strip along the parking lot, a level planting strip for surface runoff to pass through as it leaves the impervious parking surface and enters the surrounding landscape.

The bioretention section illustrates a common practice in SWM design. The system is adaptable to both urban and rural conditions. The system relies on a designed depth of engineered media to filter stormwater as it infiltrates down through the system. Below the media is an area of stone to allow a sump area for water storage to release either into the surrounding soils (in-situ infiltration), or an underdrain. An underdrain system can either daylight to surrounding grades or a specific outfall location, such as a storm pipe. The bioretention systems for the Cypress Bridge N. will most likely contain an underdrain and discharge excess flows in an appropriate location.

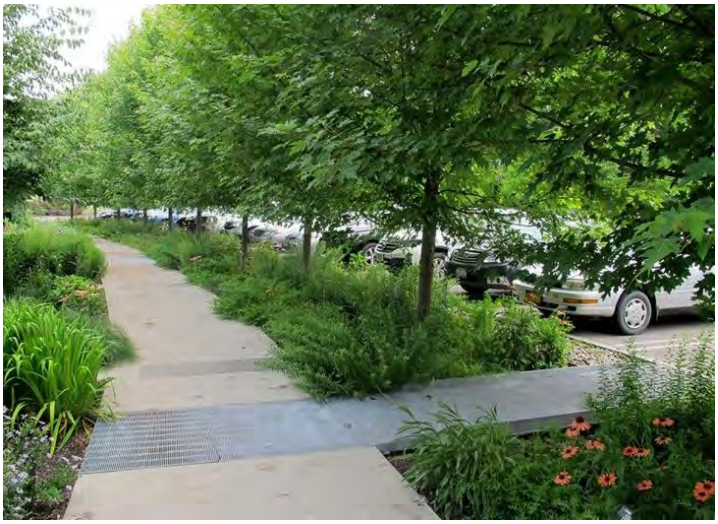
A wharf planter relies on the same filtering concepts as a bioretention garden but is installed in a container structure adjacent to the river. Within the structure, which could be concrete or other stable material, would be a level of stone for storage, a level of media for filtration, an overflow location, and vegetation. In this design area the water would enter the planter from downspout pipes and overflow through a weir cut, or spillway, in the planter wall.

PRECEDENT IMAGERY

(image credit see reference number in reference section)

bioretention garden (7)

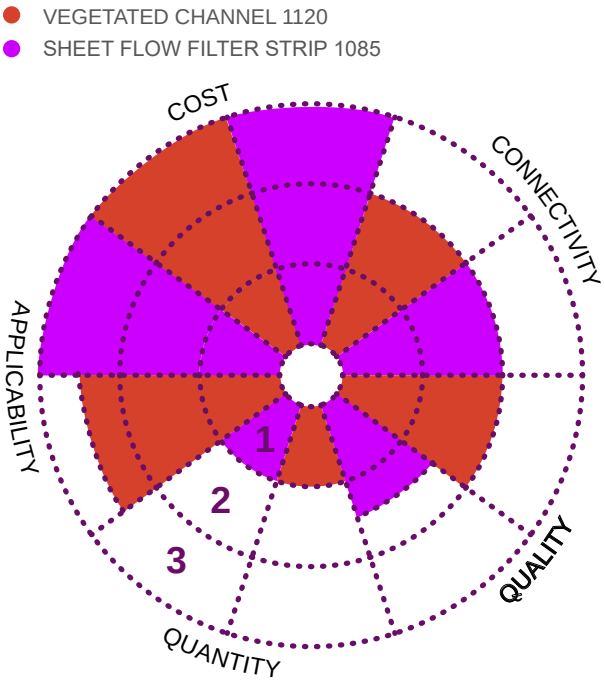
constructed wetland (5)



filter strip (4)

wharf planter (functional concept) (9)

BMP MATRIX BY DESIGN AREA - CYPRESS BRIDGE SOUTH



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with the Cypress Bridge South design location, suggest that a vegetated channel BMP would be the most appropriate stormwater design strategy for this location. "Vegetated channels can provide a modest amount of runoff filtering and volume attenuation within the stormwater conveyance system resulting in the delivery of less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets and pipes" (DNREC, 2015). Although a vegetated channel was determined most applicable to the site by the BMP matrix methodology, the SWM concept proposes a linear wharf planter as described on the following pages. The surface grades in this area and limited space make a vegetated channel difficult to implement. The linear wharf planter utilizes some of the characteristics of a vegetated channel. Visually the wharf planter is very similar to a vegetated channel, structurally it is more similar in design details to a bioretention system, thus feasibility criteria are noted below for a bioretention system. Regulatory feasibility elements, as defined by 3.06.2, are as follows:

DNREC Technical Document - Bioretention with infiltration requires a 2 foot separation from seasonal high groundwater without an underdrain and when utilized, the invert of an underdrain must be above the seasonal high groundwater. It is expected, being close to the river this criteria could be met, however groundwater depths are likely high and should be confirmed for final design.
Required Space - "The bioretention surface area will usually be between 3% to 6% of the contributing drainage area (CDA), depending on the imperviousness of the CDA and the desired bioretention ponding depth." As illustrated the SWM concept plan does not meet the minimum 3% CDA. Watershed 7 would be entering the proposed system from an existing bioretention BMP, thus capability to meet this requirement may be possible.
Site Topography - Design standards suggest a maximum slope of 5%. The grades adjacent to the river are mild and the designed bioretention should meet the less than 5% suggested slope.
Available Hydraulic Head -Fully vetting this feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.
Water Table - The proposed system will have some tidal interaction and it is expected to be occasionally influenced by the water table. As defined the system will likely not meet this feasibility criteria.
Soils and Underdrains - Geo-technical and/or geologic analyses should be completed prior to final design implementation. This proposed system is likely to utilize engineered soils and not utilize an underdrain.
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.
Floodplains - This parcel is situated within the 100 yr floodplain and does not meet this feasibility criteria.

A bioretention facility scored low in the BMP matrix methodology, however the modifications proposed to the traditional design would better meet some of the criteria. Two criteria receiving low values were applicability and costs. The modified design would increase the applicability values to the highest score. The costs would still receive a low score, bioretention facilities in general are more expensive than a vegetated channel.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	2	3	2	2	2	1	1	2	1	2	2	1	1
Pollutant Removal	3	2	3	2	2	2	2	2	1	1	2	2	1	1
Bacteria Reduction	3	2	3	2	2	2	2	2	1	1	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	2	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	2	1	1	1	1	3	1	2	2	3	1
Groundwater Recharge	3	1	3	2	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	3	2	1	2	2	2	3	1	1	2	2	1	1
Pretreatment	2	2	2	1	3	3	3	3	1	1	2	2	1	1
Water Table Seperation	1	1	1	1	3	3	3	3	2	1	3	2	2	1
COSTS														
Construction	2	2	1	1	3	3	3	3	2	1	1	2	1	1
Operation + Maientenance	2	2	1	1	3	3	3	3	3	1	1	2	2	1
CONNECTIVITY														
Habitat Value	1	1	2	1	1	2	1	2	1	1	3	2	2	1
Sea Level Rise Adapatation	3	3	2	1	3	3	3	3	2	1	2	2	2	1
Community Acceptance	2	2	3	2	3	3	3	3	1	1	2	2	2	1
Educational Value	1	1	3	2	1	2	1	2	1	1	3	2	2	1
Floral Diversity	1	1	2	2	1	2	1	2	1	1	3	2	1	1
TOTAL SCORE	35	29	37	25	32	35	31	35	24	16	32	30	24	16
COMPOSITE SCORE	1015		925		1120		1085		384		960		384	


160 sf
1400 sf
BIORETENTION PLANTER
WHARF PLANTER
Delaware Ave
Central Ave

The Cypress Bridge S. design area is influenced by three watersheds, 6,7 and 13. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A bioretention BMP to treat watershed 6 would need to be approximately 2500 sq ft to meet regulatory standards. A bioretention BMP to treat watershed 7 would need to be approximately 3500 sq ft to meet regulatory standards; note there is already a BMP in this watershed, the actual treated area is unknown and not within the scope of this report. A bioretention BMP to treat watershed 13 would need to be approximately 1000 sq ft to meet regulatory standards.

The stormwater concept plan for the Cypress Bridge S. design area incorporates two features: a wharf planter, a riverine adaptation of a bio-retention garden, and a bioretention planter.

The bioretention planter has been proposed for the downspouts adjacent to the t-shirt shop, at 109 E. Front St. “Stormwater Planters are a useful option to disconnect and treat rooftop runoff, particularly in ultra-urban areas. They consist of confined planters that store and/or infiltrate runoff in a soil bed to reduce runoff volumes and pollutant loads. Stormwater Planters combine an aesthetic landscaping feature with a functional form of stormwater treatment. Stormwater Planters generally receive runoff from adjacent rooftop downspouts and are landscaped with plants that are tolerant to periods of both drought and inundation.”

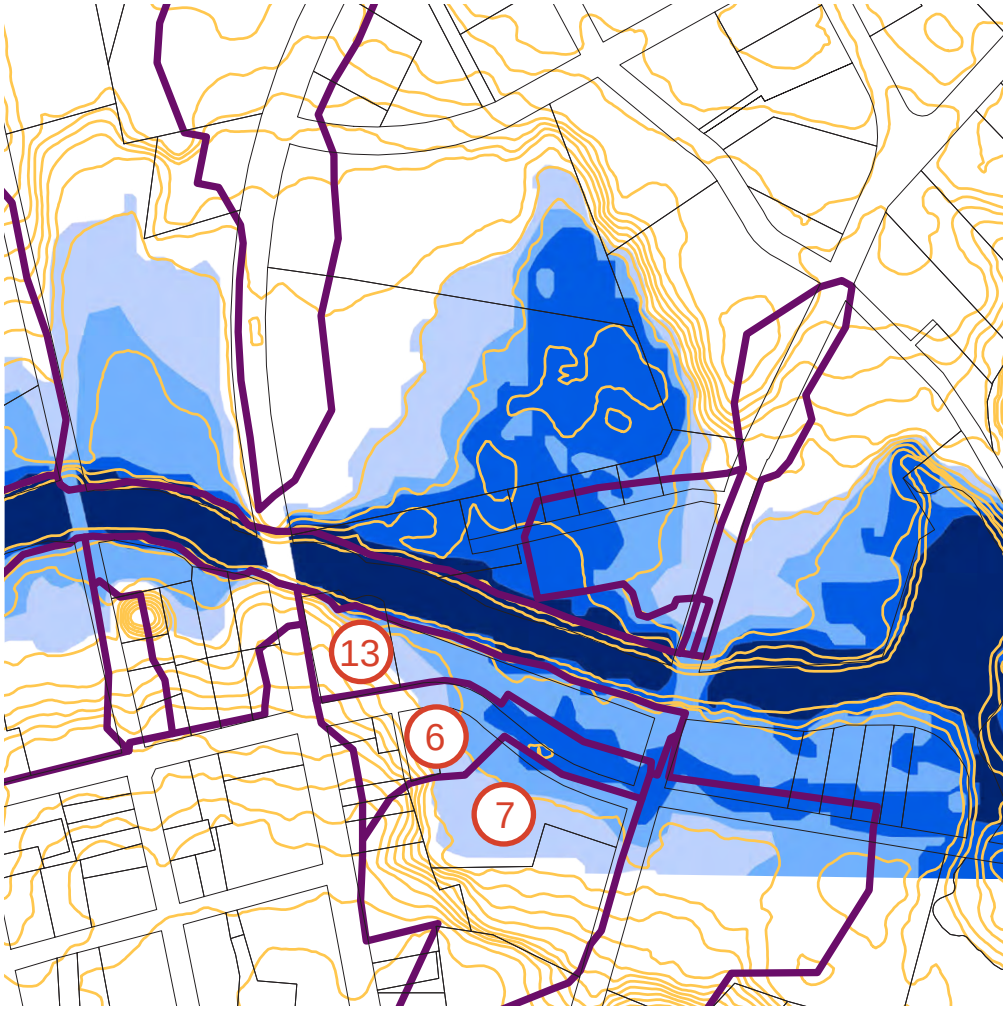
The wharf planter has been proposed as a final filtering element for the water exiting the outfall of SD8-P1. As noted previously the planter is most similar in design details to a bioretention facility. The shape is more defined than a traditional bioretention, more like a stormwater planter, however, unlike a stromwater planter, these systems treat various water sources and have a riverine component to them. These planters should be planted with colorful flora that tolerates bioretention hydrology. The use of bright colors is suggested to make these facilities an attractive garden element next to the memorial park.

legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

- watershed



SEA LEVEL RISE RESPONSE

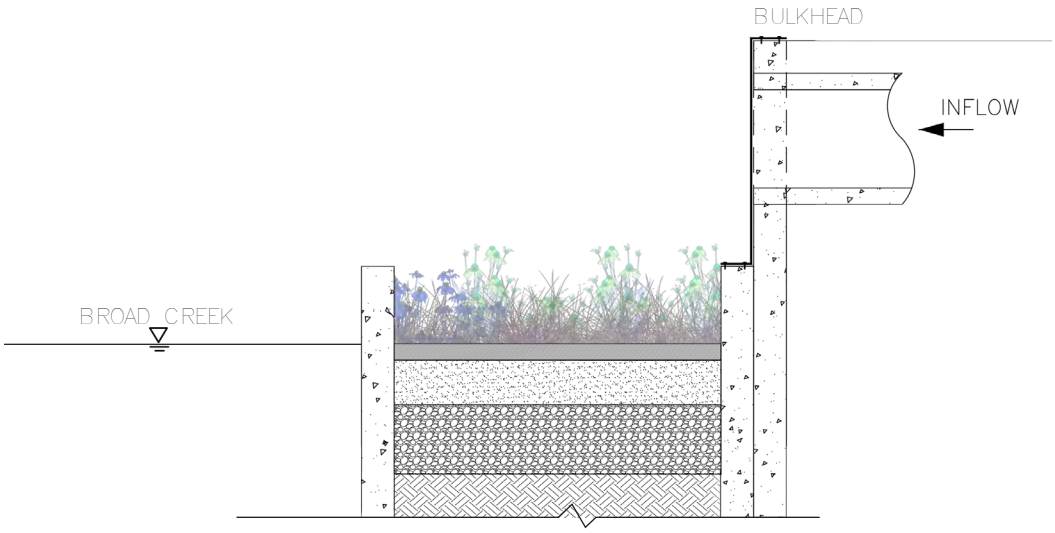
In response to sea level rise, nearly all of the design area would be effected in the 1.0 meter rise scenario. With mean high high water estimated at 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the wharf planter and the bioretention planter between elevations 2 and 4. These elevations would most likely not be effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would effect the BMPs. The bioretention planters are designed to receive run off from the roof of the t-shirt shop and would be designed to be movable for maintenance purposes. Relocation up slope would be the most appropriate response to SLR for these structures.

The wharf planter in this concept, unlike the north side, would be less mobile and relocation a less feasible response. The planter on this side could be designed similar to a constructed wetland with interior "cells" at varied elevations. This design strategy would allow for some of the areas to retain function as hydrology increases. Due to the topography, the design location of this wharf planter is higher than areas further away from the river, as illustrated in the image above. The parking areas south of the wharf will be inundated by a 0.5 meter change in elevation. It will most likely be possible for the wharf planter to continue to treat the low areas in watershed 6 at the 0.5 meter scenario.

CONCEPT SECTIONS

Wharf Planter



The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

A wharf planter relies on the same filtering concepts as a bioretention garden but installed in a container structure adjacent to the river. Within the structure, which could be concrete or other stable material, would be a level of stone for storage, a level of media for filtration, an overflow location, and vegetation. In this design area the wharf planter would have different sections installed at different levels. Some sections would only receive surface water, others would receive water from the pipe outfalls of watershed 6 and 7, and if feasible there could even be a level that intercepts river water and increased storm surges. The water would exit the system through weir cuts, or spillways, in the planter wall.

A bioretention planter would have the same components and a similar cross section as a wharf planter with the exception of a direct connection to Broad Creek. As noted in the SWM concept plan this planter would filter roof runoff from the adjacent t-shirt shop. The structure of a bioretention planter would also differ in that it would be four sided, and appear similar to an elevated planter box or large rectangular planter unlike the proposed wharf planter in this section which would utilize a bulk head connection.

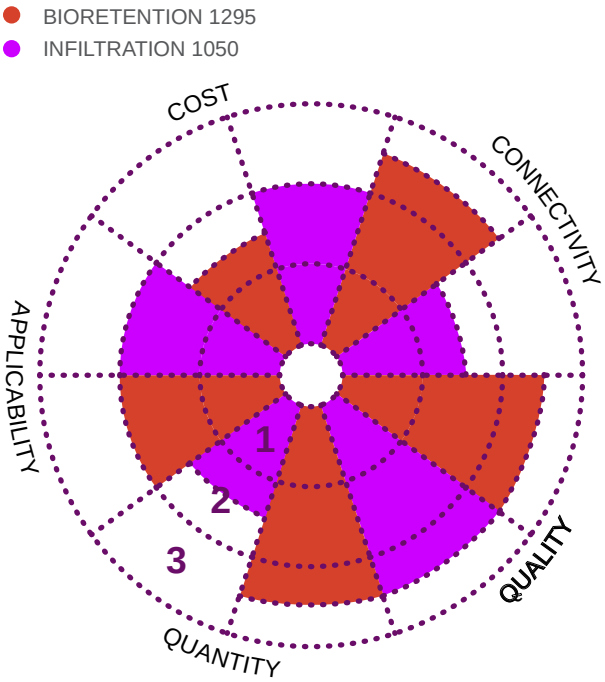
PRECEDENT IMAGERY

(image credit see reference number in reference section)

bioretention planter (10)

wharf planter (functional concept image) (9)

BMP MATRIX BY DESIGN AREA - THE VILLAGE GREEN



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with the Village Green (Green) design location, suggests that a bioretention BMP would be the most appropriate stormwater design strategy for this location. "Bioretention systems are typically designed to manage stormwater runoff from frequent, small magnitude storm events. Pollutant reduction occurs through a combination of runoff reduction and treatment by the filtering media" (DNREC, 2015). Regulatory feasibility elements as defined by 3.06.2, are as follows:

DNREC Technical Document - Bioretention with infiltration requires a 2 foot separation from seasonal high groundwater without an underdrain and when utilized, the invert of an underdrain must be above the seasonal high groundwater. It is expected this criteria could be met however, being close to the river, groundwater depths are likely high and should be confirmed for final design.

Required Space - "The bioretention surface area will usually be between 3% to 6% of the contributing drainage area (CDA), depending on the imperviousness of the CDA and the desired bioretention ponding depth." As illustrated in the SWM concept plan, the combined proposed surface area does not meet the minimum 3% CDA. As designed, it does meet the minimum 3% CDA for the watersheds 11 and 12; watershed 12 should be further researched for the potential to disconnect from the direct river outfall and be redirected to one of the proposed facilities.

Site Topography - Design standards suggest a maximum slope of 5%. The grades adjacent to the river are mild and the designed bioretention should meet the less than 5% suggested slope.

Available Hydraulic Head -Fully vetting this feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.

Water Table - It is expected the proposed facilities will meet this criteria however, final design should confirm available depth to water table prior to implementation. Due to its proximity to Broad Creek and proposed direct interaction with the waterway, the standard water table separation may not be appropriate for the this application.

Soils and Underdrains - Geo-technical and/or geologic analyses should be completed prior to final design implementation. It was identified in the EIA report that this design area is adjacent to a known brownfield site, thus soils should be fully vetted prior to implementing any SWM BMP's. It is expected the bioretention facilities for the Green should be designed with an underdrain to effectively meet the infiltration and groundwater separation criteria.

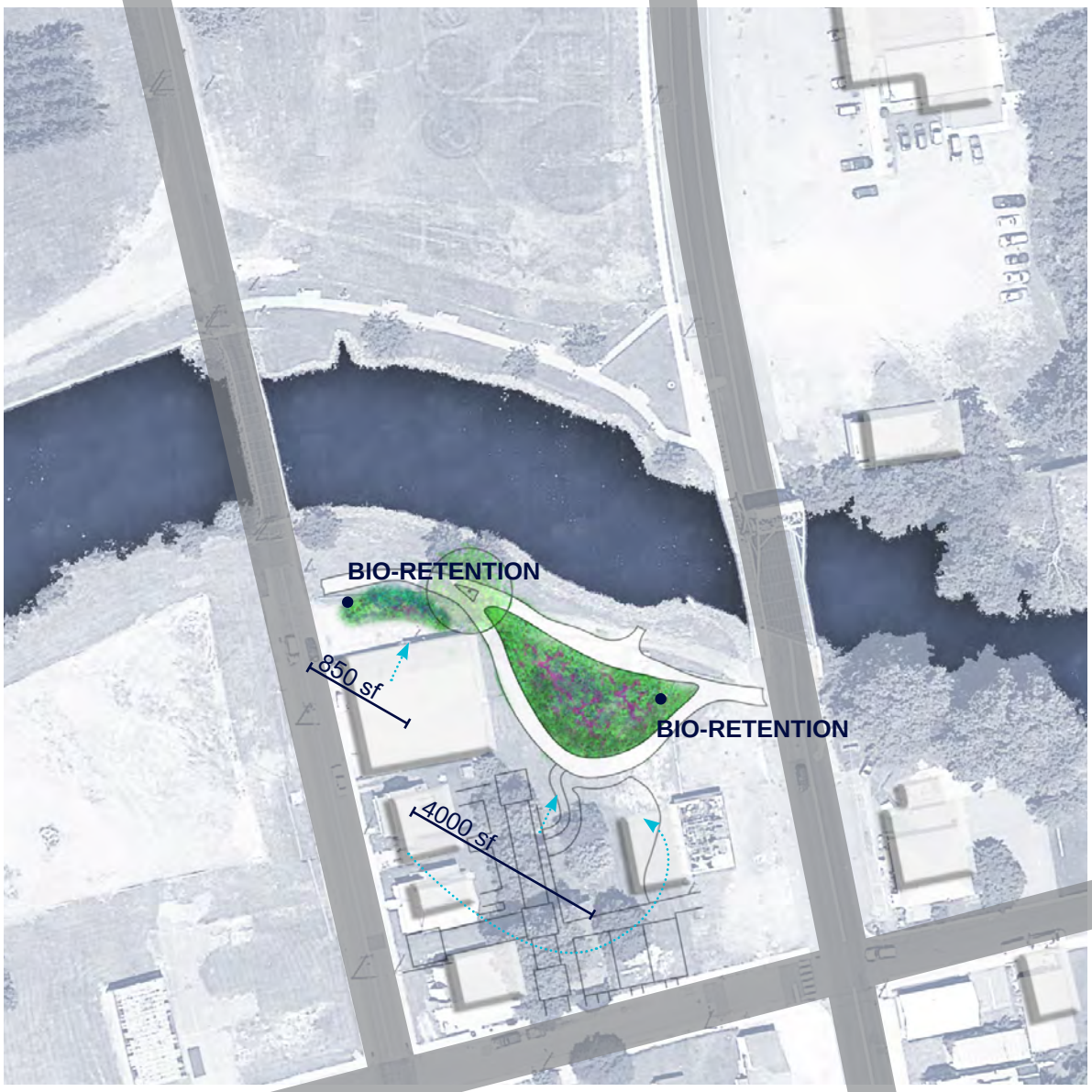
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.

Floodplains - This parcel is situated within the 100 yr floodplain and does not meet this feasibility criteria.

Beyond the regulatory feasibility requirements, bioretention gardens rated moderate to high for the Green design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity.

Infiltration practices ranked second on the feasibility matrix. Due to the proximity of the river, future planning efforts to mitigate SLR, and the adjacent properties industrial past, this practice would most likely not be applicable in this location.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	2	3	2	2	1	1	1	2	1	2	2	1	1
Pollutant Removal	3	2	3	2	2	1	2	2	1	1	2	2	1	1
Bacteria Reduction	3	2	3	2	2	1	2	2	1	1	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	2	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	2	1	1	1	1	3	1	2	1	3	1
Groundwater Recharge	3	1	3	2	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	3	2	3	2	1	2	3	1	1	2	2	1	1
Pretreatment	2	2	2	3	3	2	3	3	1	1	2	1	1	1
Water Table Seperation	1	1	1	1	3	1	3	1	2	1	3	1	2	1
COSTS														
Construction	2	3	1	2	3	3	3	3	2	1	1	1	1	1
Operation + Maientenance	2	2	1	2	3	3	3	3	3	1	1	1	2	1
CONNECTIVITY														
Habitat Value	1	1	2	2	1	1	1	2	1	1	3	3	2	1
Sea Level Rise Adapatation	3	3	2	2	3	2	3	3	2	1	2	2	2	1
Community Acceptance	2	2	3	2	3	2	3	2	1	1	2	2	2	1
Educational Value	1	1	3	3	1	1	1	2	1	1	3	3	2	1
Floral Diversity	1	1	2	3	1	1	1	2	1	1	3	3	1	1
TOTAL SCORE	35	30	37	35	32	23	31	32	24	16	32	28	24	16
COMPOSITE SCORE	1050		1295		736		992		384		896		384	



Road 28A

Central Ave

The Green design area is influenced by three watersheds, 5,11, and 12. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A BMP to treat watershed 5 would need to be approximately 140,000 sq ft to meet regulatory standards. A BMP to treat watershed 11 would need to be approximately 2,000 sq ft to meet regulatory standards. A BMP to treat watershed 12 would need to be approximately 1,000 sq ft to meet regulatory standards. The extent of watershed 5 makes treating the entire watershed prior to inflow into the river, less feasible than watersheds 11 and 12. However, the current and future proposed Town features in this area may allow for an increased BMP footprint than illustrated in the SWM concept plan. As this design area moves to the construction design phase, further research should be completed on soil structure and available space to increase the BMP size depicted.

The stormwater concept plan for the Green design area incorporates one stormwater BMP, bioretention gardens.

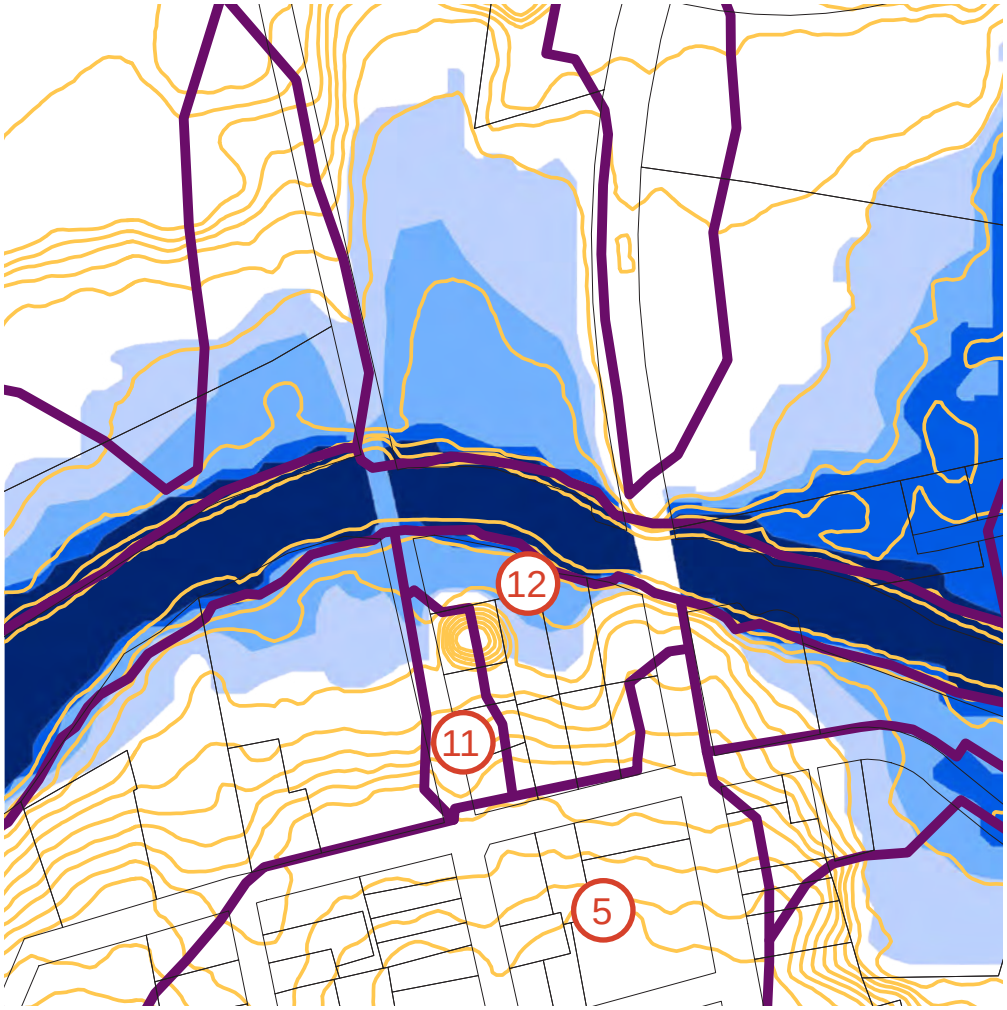
The two bioretentions facilites would be designed to capture runoff from the proposed structures and adjacent landscapes within the watershed. They should be planted with a colorful palette similar to traditional residential flower gardens, so they appear more as a landscape amenity, than a stormwater facility. Final design of the facilities should incorporate areas for visitors along the river walk to learn about the function of bioretention facilities and their contribution to the larger watershed.

legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

- watershed



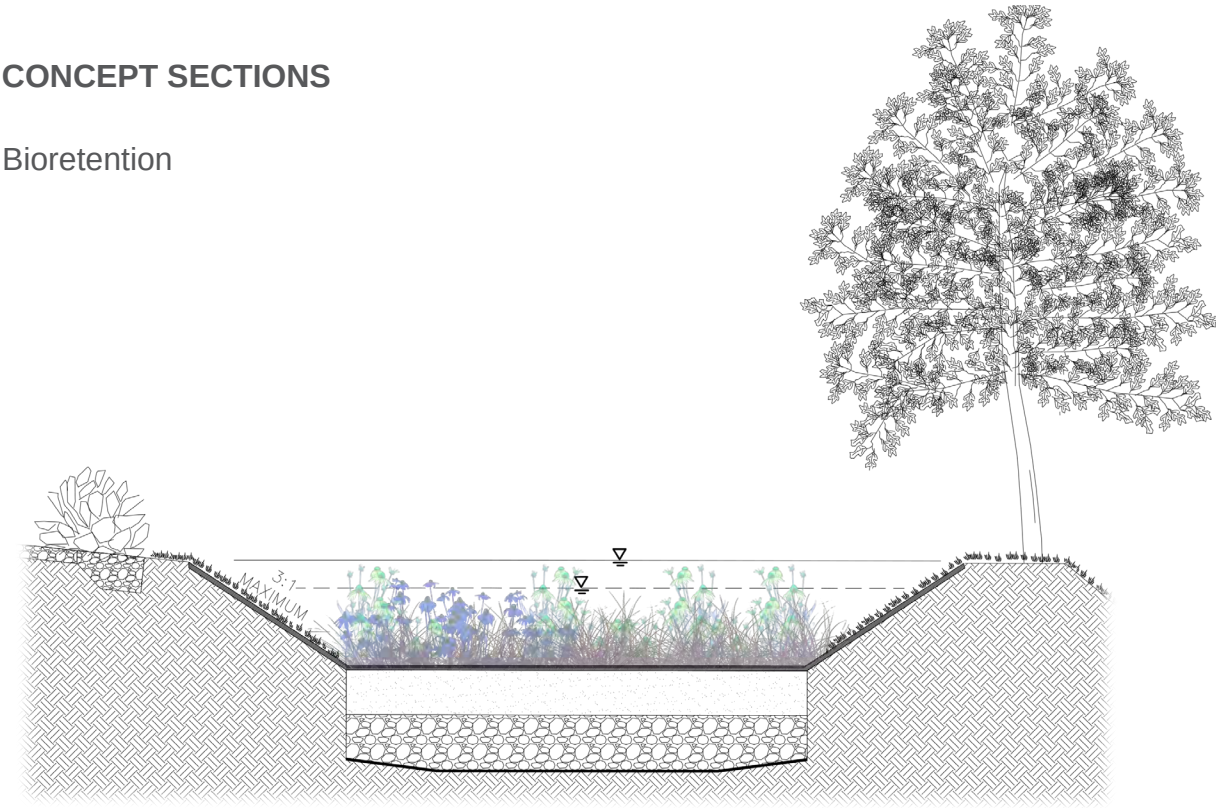
SEA LEVEL RISE RESPONSE

In response to sea level rise the lower elevations of the Green would be effected in the 1.0 meter rise scenario. With mean high high water being approximated at elevation 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the bioretention gardens to be between elevations 2 and 4. These elevations would most likely not be effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would effect the BMPs. Where increased inundation due to sea level rise is likely, NOAA suggests leaving the media area the same but increasing the ponding area to allow more time for the runoff to navigate the system. Increased saturation from SLR may fill void spaces in the media area thus reducing the effectiveness. Layout design changes should be made during the construction design phase to incorporate increased ponding areas.

CONCEPT SECTIONS

Bioretention



The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

The bioretention section illustrates a common practice in SWM design. The system is adaptable to both urban and rural conditions. The system relies on a designed depth of engineered media to filter stormwater as it infiltrates down through the system. Below the media is an area of stone to allow a sump area for water storage to release either into the surrounding soils (in-situ infiltration), or an underdrain. An underdrain system can either daylight to surrounding grades or a specific outfall location, such as a storm pipe. The bioretention systems for the Green will most likely contain an underdrain and discharge excess flows to an appropriate location.

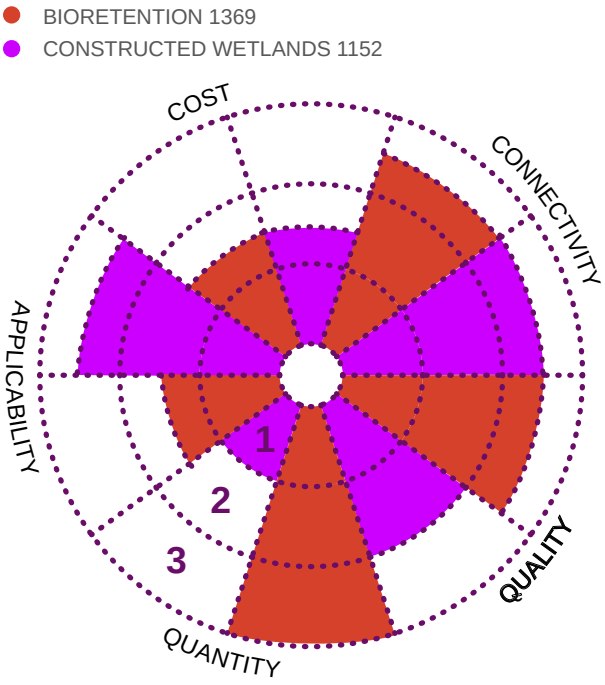
PRECEDENT IMAGERY

(image credit see reference number in reference section)

bioretention garden (7)

(8)

BMP MATRIX BY DESIGN AREA - THE COTTAGES AT LAUREL MILLS



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with The Cottages at Laurel Mills (Cottages) design location, suggests that a bioretention BMP would be the most appropriate stormwater design strategy for this location. "Bioretention systems are typically designed to manage stormwater runoff from frequent, small magnitude storm events. Pollutant reduction occurs through a combination of runoff reduction and treatment by the filtering media" (DNREC, 2015). Regulatory feasibility elements as defined by 3.06.2, are as follows:

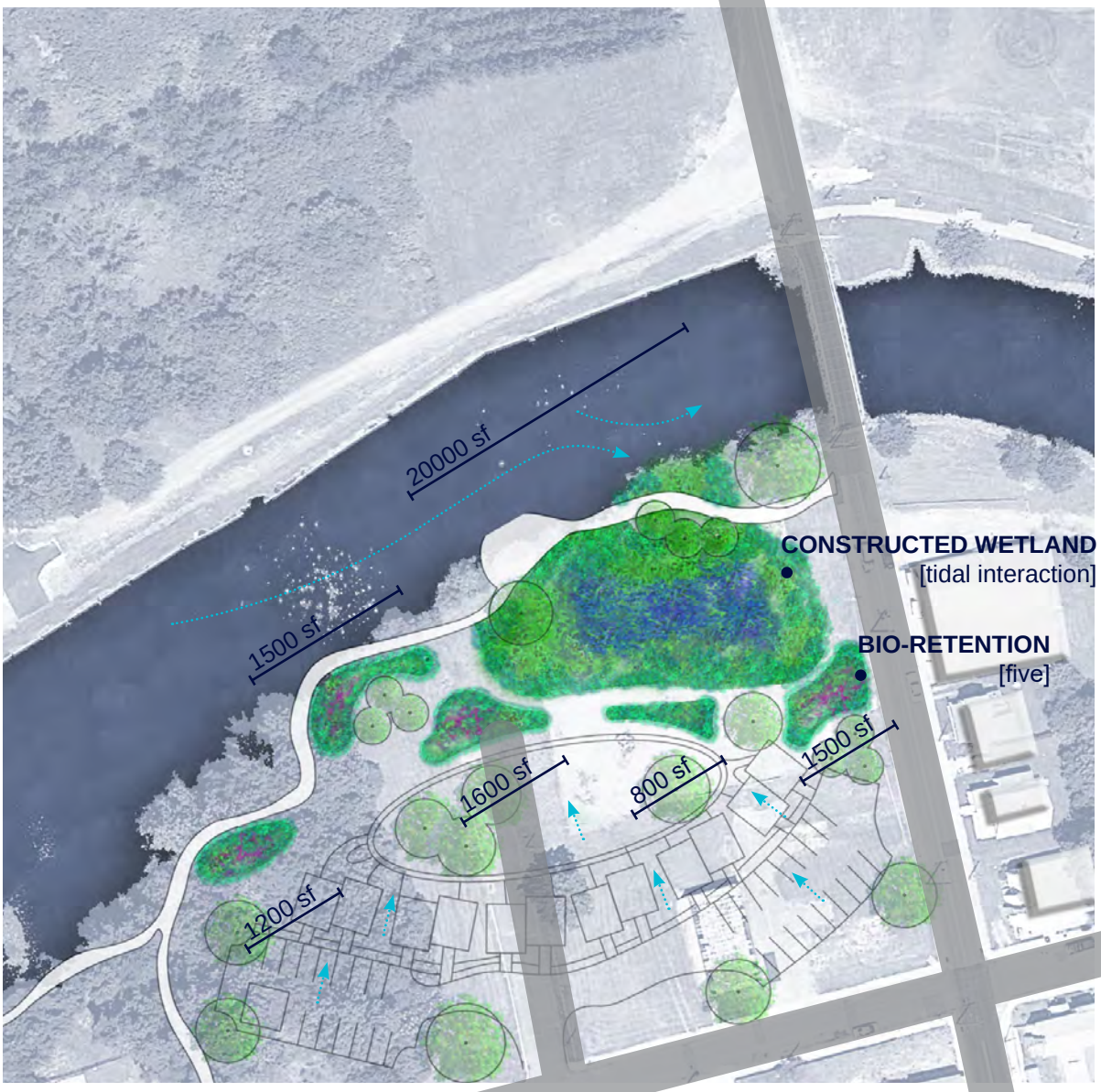
DNREC Technical Document - Bioretention with infiltration requires a 2 foot separation from seasonal high groundwater without an underdrain and when utilized, the invert of an underdrain must be above the seasonal high groundwater. It is expected this criteria could be met however, being close to the river, groundwater depths are likely high and should be confirmed for final design.

Required Space - "The bioretention surface area will usually be between 3% to 6% of the contributing drainage area (CDA), depending on the imperviousness of the CDA and the desired bioretention ponding depth." As illustrated in the SWM concept plan, the combined proposed surface area will meet the minimum 3% CDA. The area is currently primarily an open field with proposed amenities as a residential community. Depending on final site design details, there may be excess capacity in the proposed systems.
Site Topography - Design standards suggest a maximum slope of 5%. The grades adjacent to the river are mild and the designed bioretention should meet the less than 5% suggested slope.
Available Hydraulic Head -Fully vetting this feasibility criteria was outside the scope of this report. Should this BMP be implemented for final design it is expected that DNREC thresholds would be met.
Water Table - It is expected the proposed facilities will meet this criteria however, final design should confirm available depth to water table prior to implementation.
Soils and Underdrains - Geo-technical and/or geologic analyses should be completed prior to final design implementation. It is expected the bioretention facilities for the Cottages should be designed with an underdrain to effectively meet the infiltration and groundwater separation criteria.
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.
Floodplains - This parcel is situated within the 100 yr floodplain and does not meet this feasibility criteria.

Beyond the regulatory feasibility requirements, bioretention facilities rated moderate to high for the Cottages design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity.

Constructed wetlands ranked second on the feasibility matrix. As illustrated in the SWM concept a tidally influenced constructed wetland has been incorporated into the plan. The bioretention gardens rate higher than constructed wetlands in both stormwater quantity and quality and thus have been incorporated closest to the proposed structures. The constructed wetlands will increase the habitat value of the landscape and potentially adapt better to SLR.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	2	3	2	2	2	1	1	2	2	2	2	1	1
Pollutant Removal	3	2	3	3	2	2	2	2	1	1	2	2	1	1
Bacteria Reduction	3	2	3	2	2	2	2	2	1	1	2	2	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	3	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	3	1	1	1	1	3	2	2	2	3	3
Groundwater Recharge	3	2	3	2	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	1	2	2	2	2	2	2	1	2	2	3	1	2
Pretreatment	2	1	2	2	3	2	3	3	1	2	2	2	1	2
Water Table Seperation	1	1	1	1	3	2	3	3	2	1	3	3	2	1
COSTS														
Construction	2	1	1	2	3	2	3	3	2	2	1	2	1	2
Operation + Maientenance	2	1	1	2	3	2	3	3	3	3	1	2	2	2
CONNECTIVITY														
Habitat Value	1	1	2	2	1	1	1	2	1	1	3	3	2	2
Sea Level Rise Adapatation	3	2	2	2	3	2	3	2	2	1	2	2	2	2
Community Acceptance	2	1	3	3	3	2	3	2	1	1	2	3	2	2
Educational Value	1	1	3	3	1	1	1	2	1	1	3	3	2	2
Floral Diversity	1	1	2	3	1	1	1	2	1	1	3	3	1	2
TOTAL SCORE	35	23	37	37	32	26	31	32	24	23	32	36	24	27
COMPOSITE SCORE	805		1369		832		992		552		1152		648	


20000 sf
1500 sf
CONSTRUCTED WETLAND
[tidal interaction]
BIO-RETENTION
[five]
1500 sf
1600 sf
800 sf
1200 sf
Central Ave
Road 28A

The Cottages design area is influenced by watershed 2. For a better understanding of scale and comparison across the entire master plan concept, treatment for each watershed was estimated as a bioretention BMP. A BMP to treat watershed 2 would need to be approximately 2,000 sq ft to meet regulatory standards. This footprint is based on current site conditions and would be expected to increase due to the proposed residential structures. There is potential there may be additional capacity in this design area to treat additional run off. If strategies to incorporate watershed 11 into the Village Green parcels are not successful, there may be potential to redirect watershed 11 to outfall into the constructed wetlands of the Cottages, prior to entering the river. If the system is designed with excess capacity and no other drainage areas are incorporated into the system, the additional space will increase its adaptability to SLR.

The stormwater concept plan for the Cottages design area incorporates two stormwater BMP, bioretention gardens and a constructed wetland.

The five bioretentions would be designed to capture runoff from the proposed structures and adjacent landscapes within the watershed. They should be planted with a colorful palette similar to traditional residential flower gardens, so they appear more as a landscape amenity, than a stormwater facility.

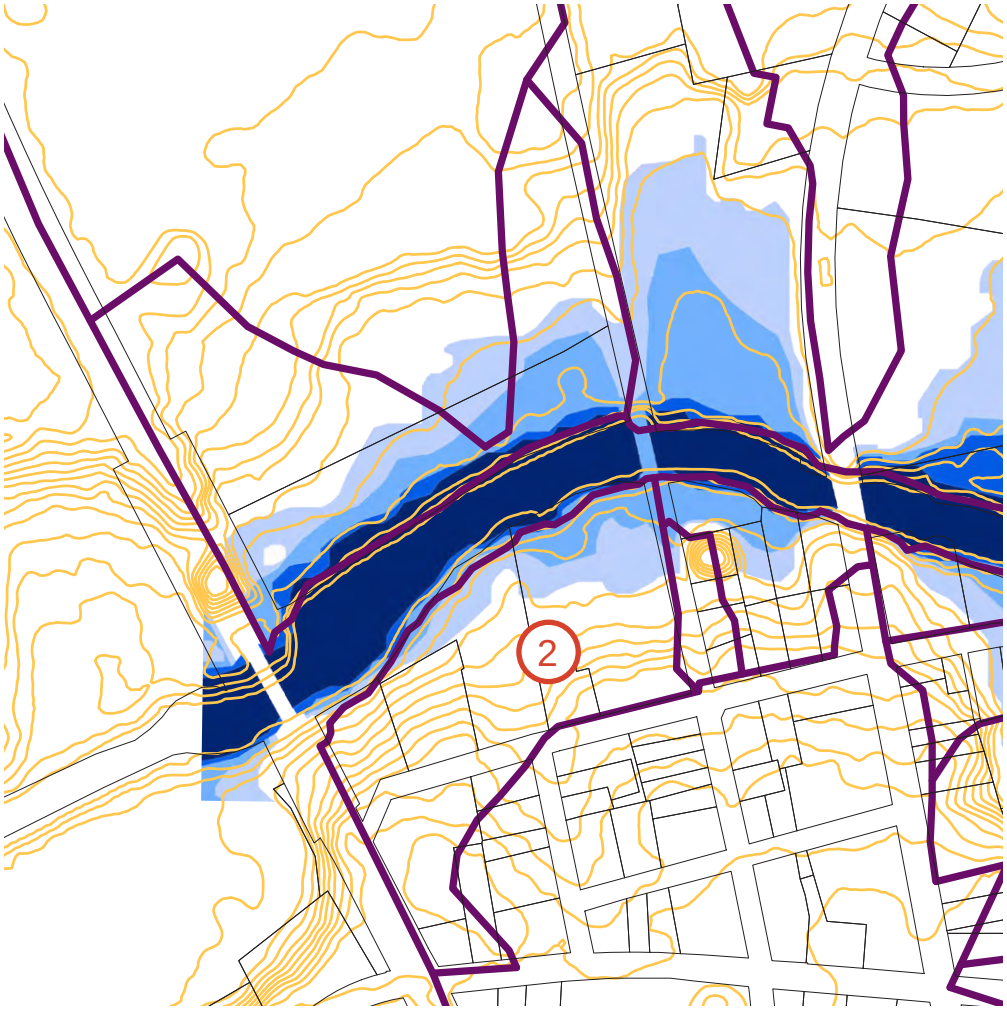
A constructed wetland could be located in the low areas in the northeast corner of watershed 2. This location is down slope from the proposed bioretention areas, thus a constructed wetland that allows for more interaction with the groundwater table was deemed more appropriate. The constructed wetland could have a direct tidal connection to the river. Tidal interactions can improve water quality, by providing increased interaction with filtering vegetation, and provide spawning locations for migrating fish. Increased opportunities for wetland and shallow water habitat adjacent to Broad Creek are critical for adaptation to potential sea level rise.

legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

- watershed



SEA LEVEL RISE RESPONSE

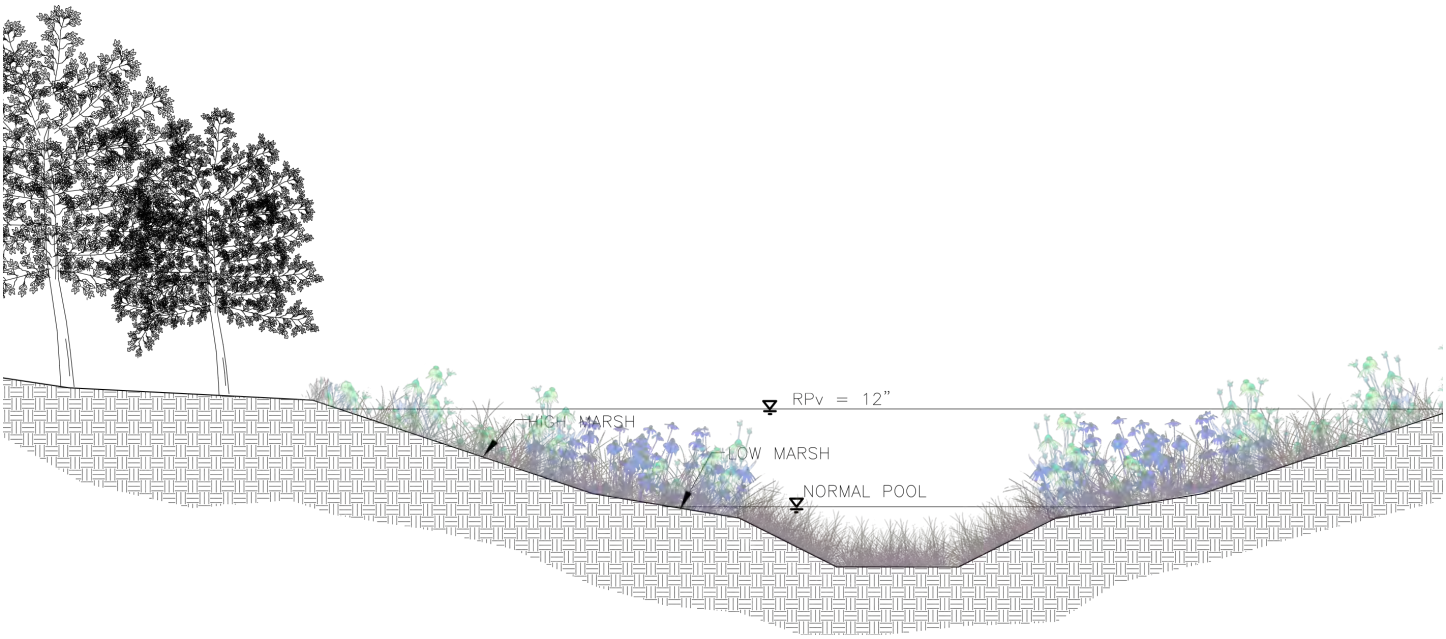
In response to sea level rise a small portion of the Cottages would be effected by a 0.5 meter rise scenario and a slightly larger area effected by the1.0 meter rise scenario, with minimal inundation by SLR compared to the other study areas. With mean high high water being estimated at elevation 1.54, the proposed BMP's would be variably effected by the sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the bioretention gardens to be between elevations 4 and 6. These elevations would be minimally effected by a 0.5 meter change in elevation. At a 1.0 meter SLR scenario some of the bioretention gardens would experience increased hydrology. Where increased inundation due to sea level rise is likely, NOAA suggests leaving the media area the same but increasing the ponding area to allow more time for the runoff to navigate the system. Increased saturation from SLR may fill void spaces in the media area thus reducing the effectiveness. Layout design changes should be made during the construction design phase to incorporate increased ponding areas.

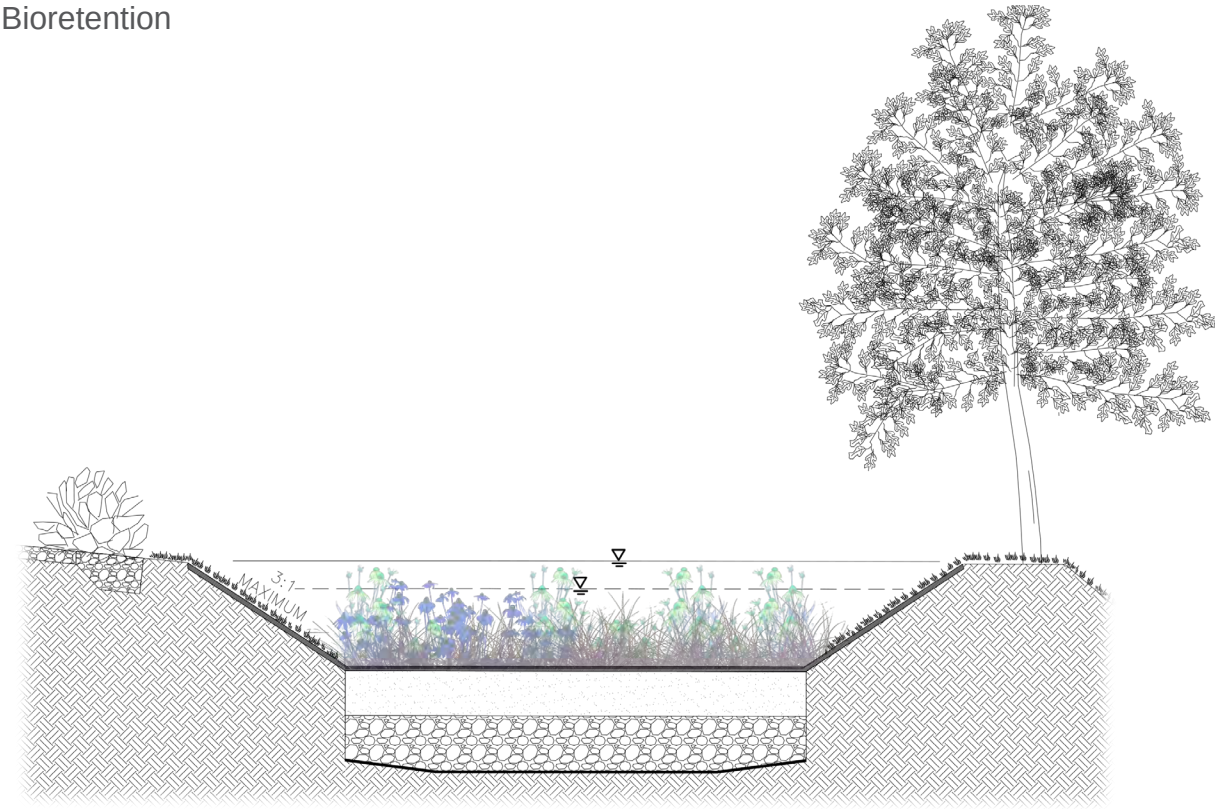
The stormwater concept plan estimates the constructed wetland to be between elevations 1 and 3. These elevations would be slightly effected by a 0.5 meter change in elevation. A 1.0 meter SLR scenario would effect the BMPs. Similar to the design strategies noted in the DNREC manual, a constructed wetland with various "cells", could allow for some areas to still function if inundation of down slope areas occurs. Even if inundated by SLR, the habitat value of these systems would most likely remain high, for example they would still be accessible as spawning areas for anadromous fish, areas that are critically limited in this portion of Broad Creek

CONCEPT SECTIONS

Constructed Wetland



Bioretention



The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

The constructed wetlands section illustrates the unique vegetation diversity utilized in these systems. They are designed to hold a specific amount of water, much like a very shallow wet pond, and then have two levels, or vegetation shelves above the normal pool, one the high marsh zone and one the low marsh zone. The three zones of water inundation create unique plant communities that serve a variety of wildlife. Constructed wetlands typically have multiple “cells” within the footprint each containing the three water inundation zones. An additional connection benefit to this BMP is through its adjacency to the river system, this area would provide opportunities for some species migration during sea level rise scenarios. Plant and wildlife species that may no longer be able to live along the banks of Broad Creek could establish themselves in this constructed wetland, thus continuing the rich ecology of the area. The constructed wetland in this location does propose a direct tidal interaction and will require micro-topographic grading during the construction design phase.

The bioretention section illustrates a common practice in SWM design. The system is adaptable to both urban and rural conditions. The system relies on a designed depth of engineered media to filter stormwater as it infiltrates down through the system. Below the media is an area of stone to allow a sump area for water storage to release either into the surrounding soils (in-situ infiltration), or an underdrain. An underdrain system can either daylight to surrounding grades, or a specific outfall location, such as a storm pipe. The bioretention systems for the Cottages will most likely contain an underdrain and discharge excess flows to an appropriate location such as the adjacent constructed wetland.

PRECEDENT IMAGERY

(image credit see reference number in reference section)

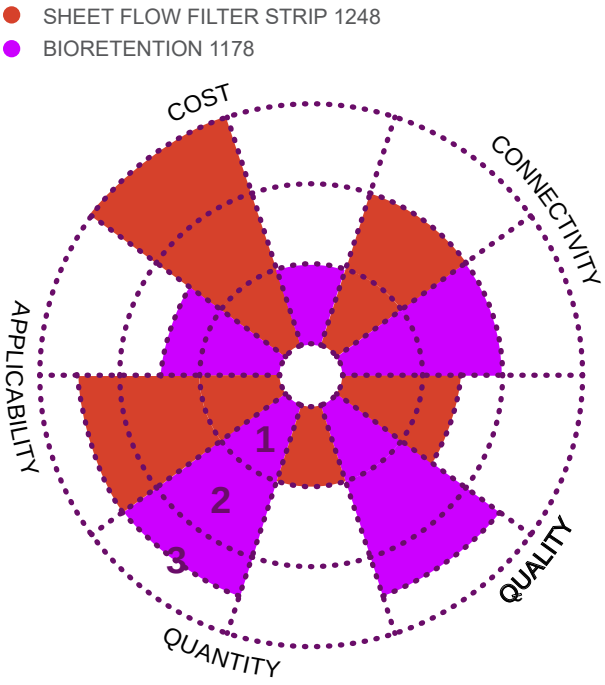
bioretention garden (7)

(8)

constructed wetland (5)

(6)

BMP MATRIX BY DESIGN AREA - JANOSIK PARK



A feasibility assessment, for the landscapes that contribute to the drainage areas associated with Janosik Park (Park) design location, suggest that a sheet flow filter strip would be the most appropriate stormwater design strategy for this location. "Filter strips are vegetated areas that treat sheet flow delivered from adjacent impervious and managed turf areas by slowing runoff velocities and allowing sediment and attached pollutants to settle and/or be filtered by the vegetation." (DNREC, 2015). Sheet flow filter strips are further categorized into vegetated filter strips and conserved open space. The SWM concept for the Park suggests implementing a living shoreline. Although a living shoreline is not a regulated BMP, for the purposes of this study it has been paralleled in standards most similar to those related to a vegetated filter strip. A living shoreline practice is noted in the DNREC manual under Restoration Practices, but no regulations are provided for run-off reduction standards and thus it was not utilized in the BMP Matrix. It is possible to have certain areas near the stream graded as filter strips during the repair work associated with a failing brick walkway. Regulatory feasibility elements as defined by 3.06.2 for a vegetated filter strip are as follows:

Slopes - Feasibility requirements suggest a maximum landscape slope of 8 percent for a vegetated filter strip. The grades adjacent to the river are mild and the designed filter strip should meet the maximum 8% suggested slope

Soils - Design standards note a vegetated filter strip is appropriate for all soil types but not fill. The EIA report did not specifically call out fill in this location but did note the varied industrial history of the landscape with many unknown locations of underground storage tanks (UST). Historic aerials of the Park indicate there were houses present on the landscape in the past, thus the design location should be evaluated for fill materials.

Hot Spot Land Uses - The design location is not expected to be influenced by any hot spot land uses and thus should meet this feasibility requirement.

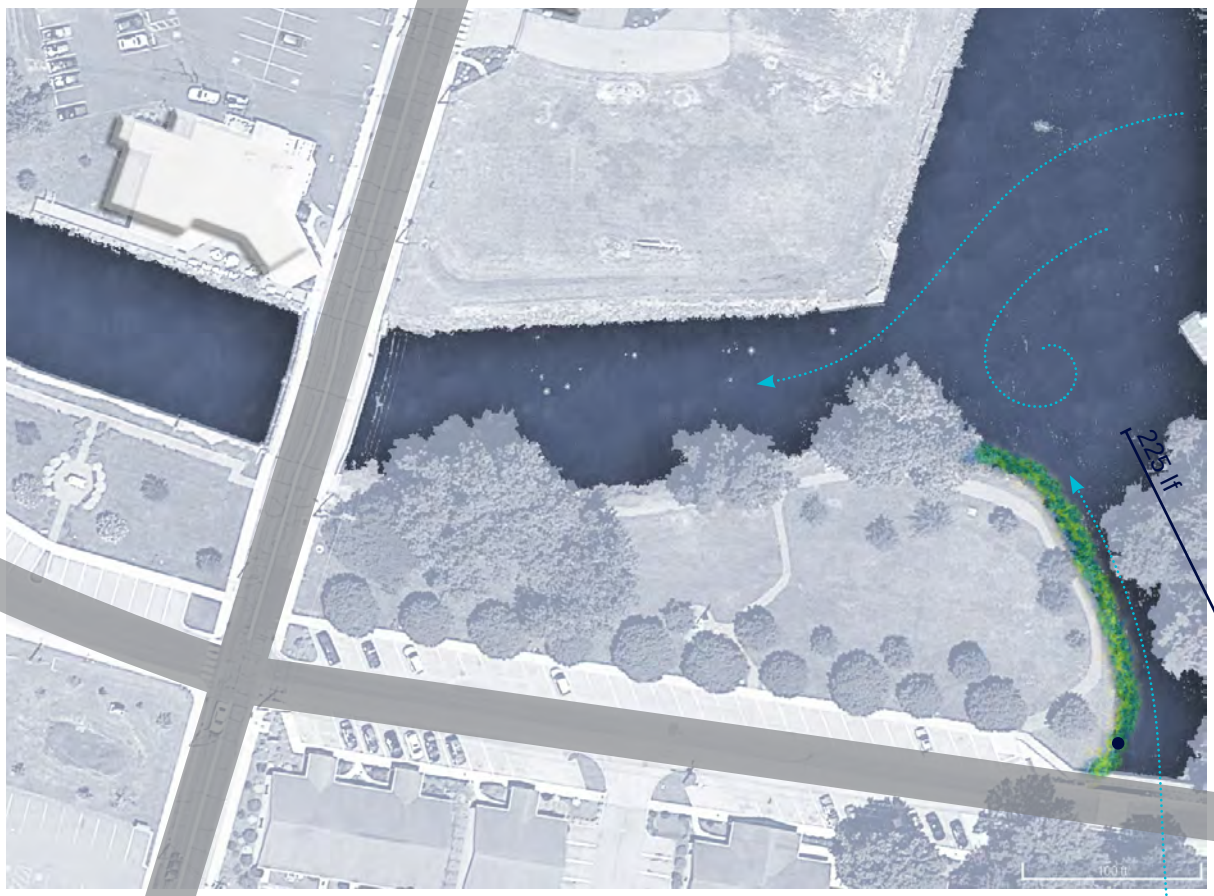
Utilities - Prior to final design and again during construction, the location of all utilities present in the area should be confirmed.

Jurisdictional Wetlands - Permitting requirements should be reviewed and discussed with appropriate authorities prior to implementation. It is likely the proposed living shoreline would require further discussions with the US Army Corps of Engineers, and potentially additional permits.

Beyond the regulatory feasibility requirements, vegetated channels rated moderate to high for the Park design area for habitat value, sea level rise, community acceptance, educational value, and floral diversity. The connectivity values in some categories were higher than the base values as they reflect a living shoreline and not an actual vegetated filter strip.

Infiltration practices and bioretention gardens also rated high in feasibility for this design area. Due to the proximity of the river and future planning efforts to mitigate SLR, an infiltration practice would most likely not be applicable in this location. Current conditions and proposed conditions for this area to remain an open green make a bioretention garden not applicable either, given it would reduce the usability of the park green. If the portions of the Park are developed in the future, a bioretention garden might be considered a suitable stormwater treatment.

SELECTION ATTRIBUTE	BEST MANAGEMENT PRACTICE													
	INFILTRATION - PERFORMANCE	INFILTRATION - CONTEXT	BIORETENTION - PERFORMANCE	BIORETENTION - CONTEXT	VEGETATED CHANNELS - PERFORMANCE	VEGETATED CHANNELS - CONTEXT	SHEET FLOW FILTER STRIP - PERFORMANCE	SHEET FLOW FILTER STRIP - CONTEXT	DETENTION PRACTICE - PERFORMACE	DETENTION PRACTICE - CONTEXT	CONSTRUCTED WETLANDS - PERFORMANCE	CONSTRUCTED WETLANDS - CONTEXT	WET PONDS - PERFORMANCE	WET PONDS - CONTEXT
STORMWATER QUALITY														
Sediment Control	3	2	3	2	2	2	1	1	2	1	2	1	1	1
Pollutant Removal	3	2	3	2	2	2	2	2	1	1	2	1	1	1
Bacteria Reduction	3	2	3	2	2	2	2	2	1	1	2	1	1	1
STORMWATER QUANTITY														
Runoff Volume Reduction	3	2	3	2	1	1	1	1	1	1	1	1	1	1
Peak Flow Reduction	2	2	3	2	1	1	1	1	3	1	2	1	3	1
Groundwater Recharge	3	2	3	2	1	1	1	1	1	1	1	1	1	1
APPLICABILITY														
Space Requirements	3	3	2	1	2	1	2	3	1	1	2	1	1	1
Pretreatment	2	2	2	1	3	1	3	3	1	1	2	1	1	1
Water Table Seperation	1	1	1	1	3	1	3	2	2	1	3	1	2	1
COSTS														
Construction	2	3	1	1	3	2	3	3	2	1	1	1	1	1
Operation + Maientenance	2	3	1	1	3	2	3	3	3	1	1	1	2	1
CONNECTIVITY														
Habitat Value	1	1	2	2	1	1	1	2	1	1	3	2	2	2
Sea Level Rise Adapatation	3	2	2	2	3	2	3	3	2	1	2	2	2	2
Community Acceptance	2	2	3	1	3	1	3	3	1	1	2	2	2	2
Educational Value	1	1	3	2	1	1	1	3	1	1	3	2	2	2
Floral Diversity	1	1	2	2	1	1	1	2	1	1	3	2	1	1
TOTAL SCORE	35	31	37	26	32	22	31	35	24	16	32	21	24	20
COMPOSITE SCORE	1085		962		704		1085		384		672		480	


225 lf
LIVING
SHORELINE
Delaware Ave

The Park design area is influenced by two watersheds, watershed 8 and an unknown watershed. The limits of the study precluded any further research into the contributing drainage area for landscapes not connected to SD9-P1. For a better understanding of scale and comparison across the entire master plan concept, treatment for the watershed was estimated as a bioretention BMP. A BMP to treat watershed 8 would need to be approximately 12,000 sq ft to meet regulatory standards. The SWM concept plan proposes implementing a living shoreline along the east bank near the Cooper's Run tributary. Watershed 8 outfalls into the river further upstream. It is unlikely the runoff from watershed 8 would interact with the living shoreline as proposed in the concept plan. The Town might consider increasing the length of this shoreline, or potentially implementing a SWM BMP in a location upstream of the pipe and the Park landscape.

The proposed living shoreline has been designed to provide a vegetative system that strengthens the shoreline between the river the eastern edge of the Park. The shoreline concept stops at the confluence of Broad Creek and Cooper's Run. It is suggested implementing a living shoreline or hybrid living shoreline, the length of the shoreline along Janosik Park, as it would be beneficial to the river ecology. Rare habitat studies indicate Broad Creek is frequented by anadromous fish populations searching for a place to spawn. The living shoreline could provide niche spaces for fish and insects to habitat and thus creating potential spawning and feeding areas for the various fish species that might visit the area. The Records Pond dam forms an impenetrable barrier for these species that are critical to the broader food chain. Shallow water vegetated areas, such as those created by living shorelines, can provide critical nursery habitat for juveniles and provide protection while they grow, before entering deeper water and eventually returning to the sea.

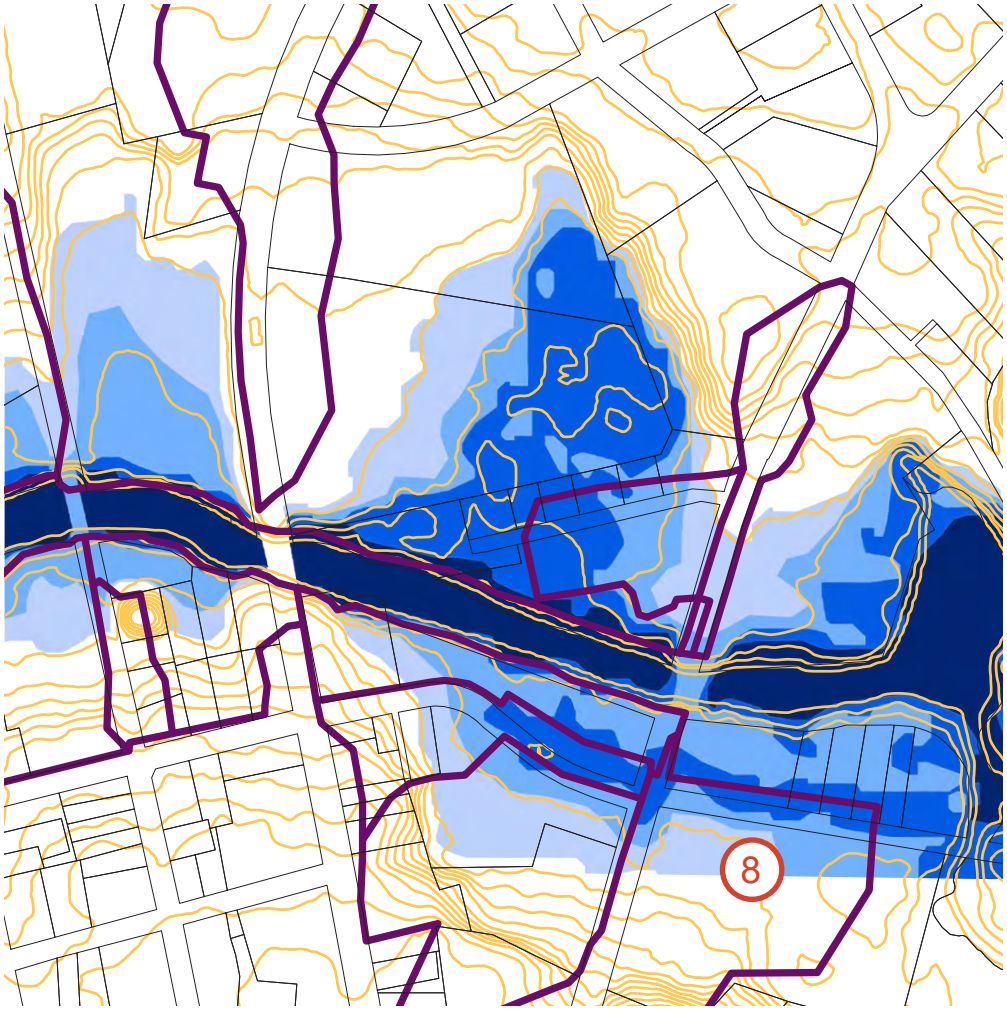
Prior to implementation the slopes in the proposed locations should be evaluated for stability. A visual inspection of the site indicates the slopes are most likely not stable and thus will need to be re-graded prior to implementation. Regrading the Park's edge for a more stable slope will most likely encroach on the Park's green space. The existing brick path shows signs of subgrade failure, possibly due to lateral shifting of soils due to bank erosion. A potential solution to the failure of the brick path is relocation further from the existing streambank. This relocation could provide the opportunity to create a living shoreline that aids both the shoreline condition and the condition of park infrastructure.

legend

- MHHW
- 0.5 meters
- 1.0 meters
- 1.5 meters

based on a 2009 report prepared by DNREC.

- watershed



SEA LEVEL RISE RESPONSE

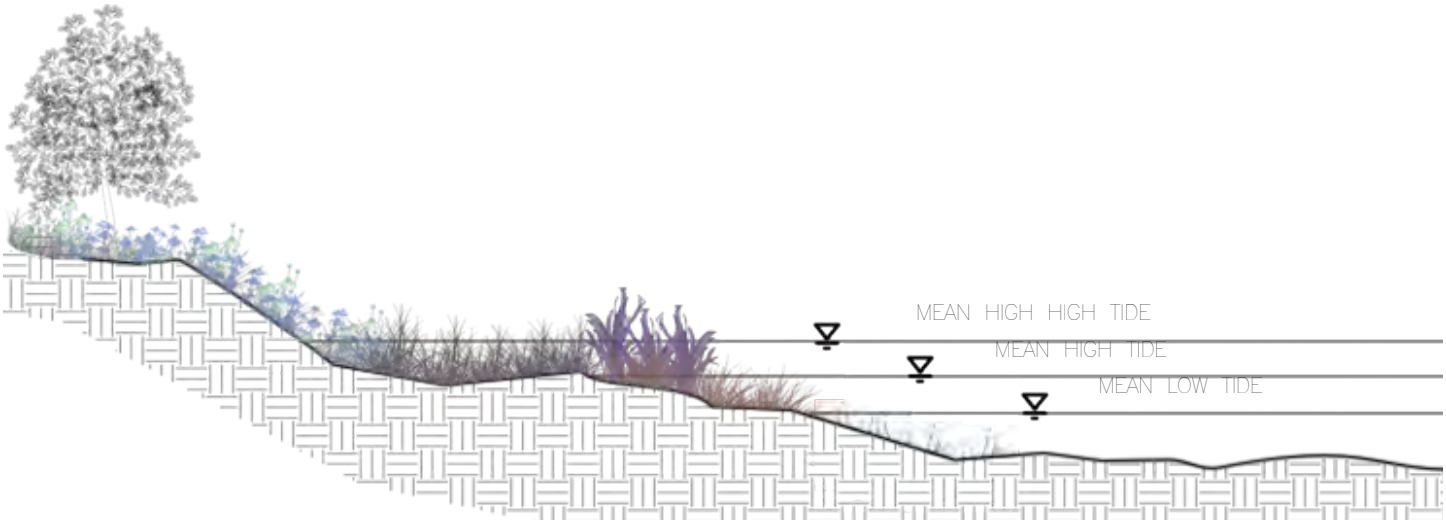
In response to sea level rise most of the Park would be effected in the 1.0 meter rise scenario. With mean high high water being estimated at elevation 1.54, the proposed BMP's would be effected by the 0.5 and 1.0 sea level rise scenarios noted in the graphic above.

The stormwater concept plan estimates the living shoreline between elevations 1 and 2. These elevations would most likely be effected by a 0.5 meter change in elevation. The longevity and resiliency of living shorelines to sea level rise is currently still being studied. Some research suggests natural marsh accretion can occur and marsh communities migrate up slope naturally. DNREC is currently studying the use of dredge sediments to aid marsh communities in adapting to SLR. The Town's responses to future SLR scenario's in this design location should consider the Park landscape and any proposed SWM strategies.

The BMP sections presented are of typical design details based on 3.06.2 and intended for illustrative explanation only. Specific design details should be prepared for each proposed BMP intervention.

As discussed previously a living shoreline is considered a restoration practice under DNREC guidelines and do not have any run off reduction standards. Even if the benefits of these systems cannot be calculated or credited for stormwater purposes, the inclusion in the manual as a restoration

CONCEPT SECTIONS



practice recognizes the many benefits these systems provide to the environment. Additionally, these systems can reduce streambank erosion rates and therefore reduce the potential for sedimentation of the adjacent waterway, as well as reducing the release of pollutants and nutrients contained within the stream bank sediments. It is this reduction in soil nutrient release into the waterway that is likely to provide a significant improvement in water quality adjacent to the existing eroding banks. Living shoreline design relies upon a thorough evaluation of tide levels through a minimum of one cycle, analysis of the impacting wave and wind action, and an understanding of the land cover and slopes of adjacent landscapes. Depending on the wave and wind analysis, a living shoreline may require a sill or breakwater system. In the proposed location this would most likely not be necessary. There would be three planting zones depending on tide inundation, a submerged aquatic vegetation zone, effected by low tide, a low marsh zone, effected by mean high tide, and a high marsh zone, effected by high high tide, with a fourth upland zone above that. As noted previously, to establish these zones and better stabilize the river edge, the depth of the shoreline would most likely encroach on the existing walkway and the walkway would need to be relocated further inland.

PRECEDENT IMAGERY

(image credit see reference number in reference section)

living shoreline (11)

(12)

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APPENDICES

Environmental Investigations Progress Letter

DNREC Species Conservation and Research Program Report

Construction Costs Estimate

www.WatershedEco.com
Creating Value

January 9, 2016

Foresite Associates, Inc.
208 Delaware Street
New Castle, Delaware 19720

Attention: Andrew C. Hayes, P.E.

Subject: Progress Report for Laurel Waterfront Project
Through January 9, 2016

Drew:

This letter is written to address the progress of the environmental investigations on the above referenced project.

The following tasks have been completed:

- Meet with U.S. Army Corps of Engineers to discuss possible permitting requirements and study parameters. Also discussed other projects in the area and data that may assist this project. It was learned that DelDOT submitted for improvements to two crossings in the project area and the Corps walked the project area, reviewed plans and determined that no permits were required from their office.

- The study area was walked in order to determine site conditions related to Waters of the United States, Wetlands and Rare Species and Habitat types. Wetlands were flagged and the flagging numbered and located with handheld GPS for plotting for planning purposes.

- A potentially rare habitat type was discovered in the project area. This area was being impacted by invasive species and possibly from an adjacent landfill and potential long term hydrology modifications. This area was mapped and conditions discussed with your office.

- Coordination was conducted with the U.S. Fish and Wildlife Service related to Federally listed species within the project area. Preliminary findings are that no species are present, we are waiting on a final determination that could take 30 to 45 days.

- Coordination was conducted with DNREC Natural Heritage to determine if any State listed species are present in the project area. Preliminary discussions with the State Botanist indicated that there was concern for the rare habitat identified above and that DNREC would expect to coordinate on any plans that might impact this area. No additional information has been received although we expect to get a formal response within 30 to 45 days.

302-464-0831
Jim@WatershedEco.com

I have attached the Preliminary Federal findings, along with the wetlands mapping described above.

If you need any additional information, please contact me.

I will forward the expected correspondence when it is received. When you have a concept plan for development, we can meet and discuss permitting requirement and agency submissions.

Sincerely,

James C. McCulley IV, PWS (#000471)
Environmental Scientist

302-464-0831
Jim@WatershedEco.com

302-464-0831
Jim@WatershedEco.com

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chesapeake Bay Ecological Services Field Office
177 ADMIRAL COCHRANE DRIVE
ANNAPOLIS, MD 21401
PHONE: (410)573-4599 FAX: (410)266-9127

Consultation Code: 05E2CB00-2016-SLI-0435 January 09, 2016
Event Code: 05E2CB00-2016-E-00426
Project Name: Laurel Waterfront

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having

similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq.*), and projects affecting these species may require development of an eagle conservation plan (http://www.fws.gov/windenergy/eagle_guidance.html). Additionally, wind energy projects should follow the wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm; http://www.towerkill.com; and http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment

United States Department of Interior
Fish and Wildlife Service

Project name: Laurel Waterfront

Preliminary Species list

Provided by:

Chesapeake Bay Ecological Services Field Office
177 ADMIRAL COCHRANE DRIVE
ANNAPOLIS, MD 21401
(410) 573-4599

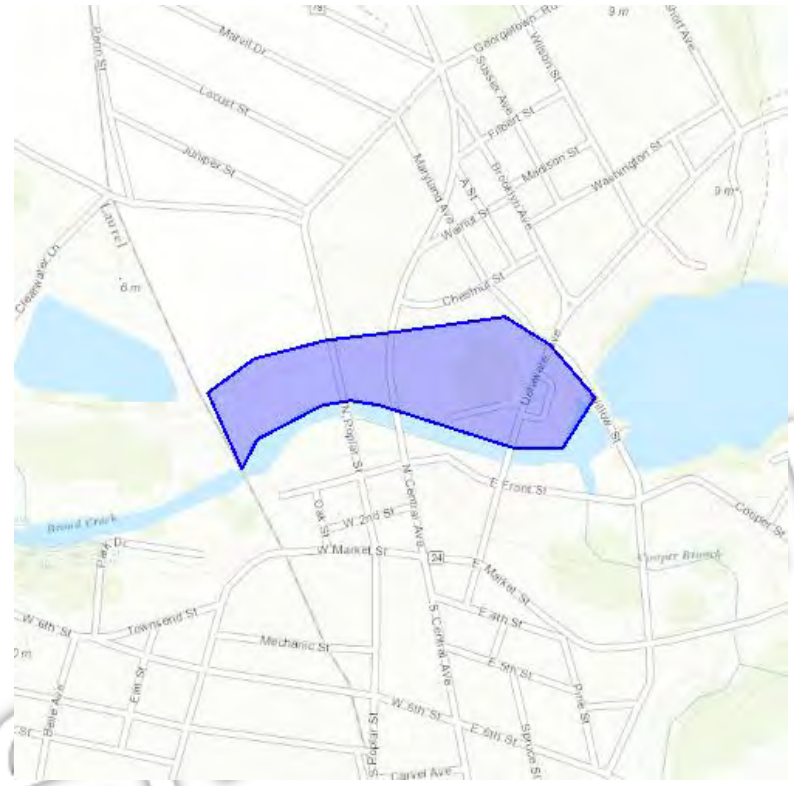
Consultation Code: 05E2CB00-2016-SLI-0435
Event Code: 05E2CB00-2016-E-00426

Project Type: LAND - RESTORATION / ENHANCEMENT

Project Name: Laurel Waterfront
Project Description: Walking Trail, Amenities and Habitat Restoration

Please Note: The FWS office may have modified the Project Name and/or Project Description, so it may be different from what was submitted in your previous request. If the Consultation Code matches, the FWS considers this to be the same project. Contact the office in the 'Provided by' section of your previous Official Species list if you have any questions or concerns.

Project Location Map:



Project Coordinates: MULTIPOLYGON (((-75.57482242584229 38.55811629091986, -75.5755090713501 38.55925728049183, -75.57458639144897 38.55979421049396, -75.57317018508911 38.5600794529262, -75.57190418243408 38.56018012645554, -75.56969404220581 38.56043180966199, -75.56881427764893 38.56001233716164, -75.56795597076416 38.55919016395955, -75.56857824325562 38.55841831933387, -75.56947946548462 38.55841831933387, -75.57214021682739 38.55908948904362, -75.57271957397461 38.559139826519214, -75.57325601577757 38.55907270987725, -75.57452201843262 38.55855255377718, -75.57482242584229 38.55811629091986)))

Project Counties: Sussex, DE

Endangered Species Act Species List

There are a total of 0 threatened or endangered species on your species list. Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Critical habitats listed under the **Has Critical Habitat** column may or may not lie within your project area. See the **Critical habitats within your project area** section further below for critical habitat that lies within your project. Please contact the designated FWS office if you have questions.

There are no listed species identified for the vicinity of your project.

Critical habitats that lie within your project area

There are no critical habitats within your project area.

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
& ENVIRONMENTAL CONTROL
DIVISION OF FISH & WILDLIFE
89 Kings Highway
Dover, Delaware 19901

OFFICE OF THE DIRECTOR

Phone: (302) 739-9910
Fax: (302) 739-6157

February 11, 2016

Jim McCulley
158 Coopers Drive
Newark, Delaware 19702

Dear Mr. McCulley,

Re: WAEC 2016 Laurel Waterfront Trail and Restoration

Thank you for contacting the Species Conservation and Research Program (SCRP) about information on rare, threatened and endangered species, unique natural communities, and other significant natural resources as they relate to the above referenced project. Although a picture of the general project area was provided, it was not labeled and a scope of work for this project has not been provided. As such, comments are general in nature, and consider information we have received from others associated with the project. Please contact us again once a scope of work has been formulated.

In general, care should be taken in regards to the placement of shoreline structures so that they don't create erosion problems that will later require rip-rap. We typically do not recommend the use of rip-rap whenever practicable, but it is especially important in this system which provides habitat to numerous state rare species and anadromous species. It would be beneficial to reduce the components of this project that alter the shoreline to the greatest extent practicable.

In early planning stages of this project, it has been indicated that a kayak launch has been proposed along the northern shoreline within the project area. This structure appears to be included in the picture of the site that was provided with the review request. DFW has previously indicated that a state boat launch is located just to the west of the railroad tracks, approximately 2/10 of a mile from the proposed kayak launch, and has already addressed parking and access issues. As such, it appears that this kayak launch may be a duplicative use of resources.

If a housing development is included as part of this project, as it appears to be based on the picture of the site provided, it will be imperative that best management practices are followed to mitigate water quality impacts to broad creek (e.g. adequate buffers, minimization of fertilizers, effective stormwater management including measures to deter nuisance waterfowl). In general, vegetative buffers (not comprised of lawn) should be utilized throughout the project area where impervious surfaces are proposed to limit water quality impacts to Broad Creek.

Next, we understand that restoration activities may be a component of this project. Note that plants associated with restoration activities should be native and certainly not invasive. Please contact our program botanist, Bill McAvoy at William.McAvoy@state.de.us or 302-735-8668 for suggestions on appropriate plants for this site.

Species Considerations:

Bald Cypress
There is a bald cypress (*Taxodium distichum*) community near or within the future wetlands/environmental display/education project area that is included within the picture of the site that was provided with the review request. This unique wetland community is especially important in terms of defining Delaware's natural heritage as it is a southern species at the extreme northern limit of its range. It is important to preserve species that are at the edge of their range because they are adapted to living in a different environment than those in the center. This helps maintain the genetic diversity of the species. Environmental interpretation and wetlands restoration efforts in this area are encouraged, as long as project activities do not disturb the existing trees.

Atlantic Sturgeon
The occurrence of Atlantic Sturgeon *Acipenser oxyrhynchus* in the Nanticoke River watershed, including Broad Creek has been confirmed. This species is listed as endangered under the U.S. Endangered Species Act. Atlantic Sturgeon are likely inhabiting the river system from approximately August 15th through November 1st based on sampling efforts in conjunction with acoustic telemetry data. Note that this is an evolving project in the first few years of study and the dates may change in the future. Depending on the proposed work, a time of year restriction to avoid impacts to this federally listed species may be necessary, and Section 7 consultation may be required.

Other Anadromous Species
Broad Creek is utilized during upstream migration by several fish species of concern. American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*) collectively known as alosines, utilize the river during spawning and then as a nursery habitat for young-of-the-year. Habitat degradation is one factor leading to a decline in the populations of these species. American shad numbers have indicated serious declines along the East Coast and is a species currently undergoing restoration efforts on the Nanticoke River. Alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), often collectively referred to as 'river herring', are listed by the National Marine Fisheries Service as a Species of Concern[1]. In addition, these species are important to both commercial and recreational fisheries and form an important forage base for other fish and animal species.

In Delaware, these species spawn between late March and mid-May. Note that Records Pond, which is just upstream of the project site, forms an impediment to upstream migration and as a result there is great potential for these species to be concentrated in the study area during the spring spawning run. Depending on the scope of work, it may be necessary to avoid completing certain project activities prior to March 15 or after June 1 to avoid affecting these species. Additionally, alosines are very sensitive to changes in their natural environment and if in-water or shoreline work is proposed, efforts should be

[1] **Species of Concern** are those species about which NOAA's National Marine Fisheries Service (NMFS) has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act (ESA).

made to: 1) minimize noise transmitted into the water column (i.e. driving piles) as not to interrupt their migration upstream, 2) minimize sedimentation, 3) maintain adequate shoreline buffers to protect water quality and 4) minimize the replacement of natural shoreline with hard materials (i.e. rip-rap, bulkheads, etc.) when feasible.

In addition, there is a viable resident Largemouth Bass population in Broad Creek that supports the states most popular freshwater fishery. Bass are a nest building species and in tidal rivers they spawn in shallow areas out of the current in coves, marina basins, and backwaters found near spillpools, such as that by Records Pond. The timing of their movement into spawning areas somewhat overlaps with anadromous fish species, so the time of year restriction requested above should also minimize impacts to Largemouth Bass.

Overall, woody debris such as root wads and deadfalls should not be cleared from the shoreline of the creek. Leaving structure along the shoreline is essential for Largemouth Bass and other resident fish species that utilize this type of habitat for shelter and foraging. A few areas upstream and a fairly large section downstream of the project area has relatively natural shoreline. If the woody debris was removed, shoreline erosion would likely occur prompting the need for shoreline stabilization which can be costly and degrade the ecosystem services this habitat provides for fish and wildlife. Fairly large areas of the shoreline upstream from the project area have already been replaced with man-made materials (i.e. rip-rap). Cumulative impacts of converting natural habitat and hardening the shoreline such as this should be considered as project activities are determined.

Mussels
The Nanticoke River watershed is the most diverse in the State with regard to freshwater mussels. Because freshwater mussels are filter feeders, and have a long lifespan and complex life cycle, they often serve as excellent indicators of water quality. Impacts to this population of freshwater mussels should be minimized by taking measures to decrease downstream sedimentation during construction activities.

Education
Please consider providing educational materials (e.g. interpretive signs) regarding the important and interesting species found in the project area, including Broad Creek. For technical assistance in developing content, please contact me and I can connect you with the appropriate biologist.

We are continually updating our records on Delaware's rare, threatened and endangered species, unique natural communities and other significant natural resources. If the start of the project is delayed more than a year past the date of this letter, please contact us again for the latest information.

Please feel free to contact me with any questions or if you require additional information.

Sincerely,

Katherine M Fleming

Kate Fleming
Wildlife Biologist/Environmental Review Coordinator
(302) 735-8658; fax: (302) 653-3431; Kate.Fleming@state.de.us

(See invoice on next page)

INVOICE - PAYMENT DUE

It is our policy to charge a fee for this environmental review service. This letter constitutes an invoice for $70.00 ($35.00/hour for a minimum of one hour). Please make your check payable to "Delaware Division of Fish and Wildlife" and submit to:

DE Division of Fish and Wildlife
89 Kings Hwy.
Dover, DE 19901
ATTN: Pamela Severson

In order for us to properly process your payment, you must reference "WAEC 2016 Laurel Waterfront Trail and Restoration**" on your check.**

cc: Pamela Severson, Fish and Wildlife Coordination/Accounting; Code to 72900

BrightFields, Inc.
Environmental Services

March 14, 2016

Brian Shannon
Property Manager
Laurel Redevelopment Corporation
P.O. Box 333
Laurel, DE 19956

bgshannon@msn.com
(302) 875 - 0601

RE: Cost Estimates for Green Stormwater Conceptual Designs
The Ramble Waterfront Redevelopment Area, Laurel, DE
BrightFields File # 3299.01.51

Dear Mr. Shannon:

BrightFields, Inc. has prepared the following cost estimates based on conceptual designs for green stormwater management as a part The Ramble Waterfront Redevelopment Area project. The redevelopment area is located along Broad Creek in Laurel, Delaware. Currently, there are eight stormwater outfalls into Broad Creek in the redevelopment area. In an effort to reduce the impacts of the outfalls to Broad Creek, green infrastructure designs are being considered to filter out the sediments and other potential pollutants in stormwater runoff.

The cost estimates for the proposed infrastructure features are approximate as the final construction designs and further environmental assessment, recommended in the *Phase I Environmental Site Assessment for The Ramble Waterfront Redevelopment Area, Laurel, Delaware,* have not been completed. As the recommended work is completed and more site specific information is available, BrightFields will be able to refine the cost estimates. The cost estimates included below are based on the infrastructure features designed by ForeSite Associates, provided to BrightFields, Inc. on February 22, 2016.

Costs:

The construction cost for the Green Stormwater Conceptual Designs for the Ramble Waterfront Development Area collectively are estimated to be between $651,000 and $994,000.

Assumptions:

1. All of the redevelopment areas will be performed at the same time; therefore, one mobilization will be required.
2. Bioretention areas will be installed 3 feet below current grade.
3. Final grades are assumed to remain the same as the current grades.
4. Dewatering and/or groundwater treatment is not included in the cost estimate.
5. Limited contaminated soil disposal is included in the cost estimate.
6. The length of the 15" hope pipes are estimated.

7. Costs from removal or repairs to the sidewalks is included in the contingency costs.
8. Seeding and stabilization activities include one application.

BrightFields, Inc. looks forward to continuing to work with the Laurel Redevelopment Corporation, ForeSite Associates and the University of Delaware to implement the proposed redevelopment of The Ramble Waterfront Redevelopment. If you have any questions concerning the cost estimates please contact me.

Sincerely,

BrightFields, Inc.

Kathy Stiller
Program Manager

cc: Andrew Hayes, P.E. – ForeSite Associates, Inc.