West Windsor Redevelopment Area Regional Stormwater Management Analysis and Build-out Report

Township of West Windsor

Mercer County, NJ

Prepared for:

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Princeton Hydro, LLC Project No. 0020.004

Princeton Hydro

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1.0 Background

1.1 Project Overview

The Township of West Windsor contracted Princeton Hydro and SWM Consulting to perform a preliminary engineering study relating to the analysis of regional stormwater management within the area designated under the *Redevelopment Plan for Princeton Junction* (herein referred to as the Redevelopment Plan) adopted March 23, 2009. To complete the analysis, the following specific tasks were undertaken as identified in the proposal prepared by the Project Team, last revised June 6, 2013:

- Completion of aerial topographic survey;
- GIS Layer Overlays (including GIS parcel maps, aerial photography, known environmental restrictions, preliminary geotechnical information, Redevelopment Area layout, boundaries, and roadway configuration);
- Preliminary stormwater management calculations for existing and full build-out conditions; and
- Identification of conceptual basin locations.

1.2 Study Area

The study area is identified on the USGS Map included in this section of the report. In general terms, the study area is bound to the northwest by the Little Bear Brook, to the northeast by Alexander Road, southwest of Washington Road (with the exception of the Sarnoff Woods area), and northwest of the New Jersey Transit rail line. The overall study area encompasses 180.83 acres and portions of 42 parcels within the Township of West Windsor, Mercer County, New Jersey. This represents a portion of the 350-acre Redevelopment Area. The area was selected based on existing redevelopment plans already approved and areas that lie in a separate drainage area. The focus for this study was on areas draining to the Little Bear Brook and known properties where potential regional stormwater Best Management Practices[1] (BMPs) could be located.

The Redevelopment Plan "proposes a compact mixed use community center offering place-making civic features, improved circulation and increased commuter parking, expanded housing options for empty nesters and young professionals, additional retail goods and services fronting on vibrant pedestrian-friendly streetscapes and high quality office uses drawn by a polished sense of place." A total of "as of right" up to 496 residential units, up to 275,410 square feet of retail, up to 871,909 square feet of office space and a 200,000 square feet hotel/conference center are possible within the overall Redevelopment Area. The following section will detail the characteristics of the study area evaluated for the stormwater analysis.

[1] Stormwater BMPs are techniques, measures or structural controls used to manage the quantity and/or improve the overall water quality of stormwater runoff.

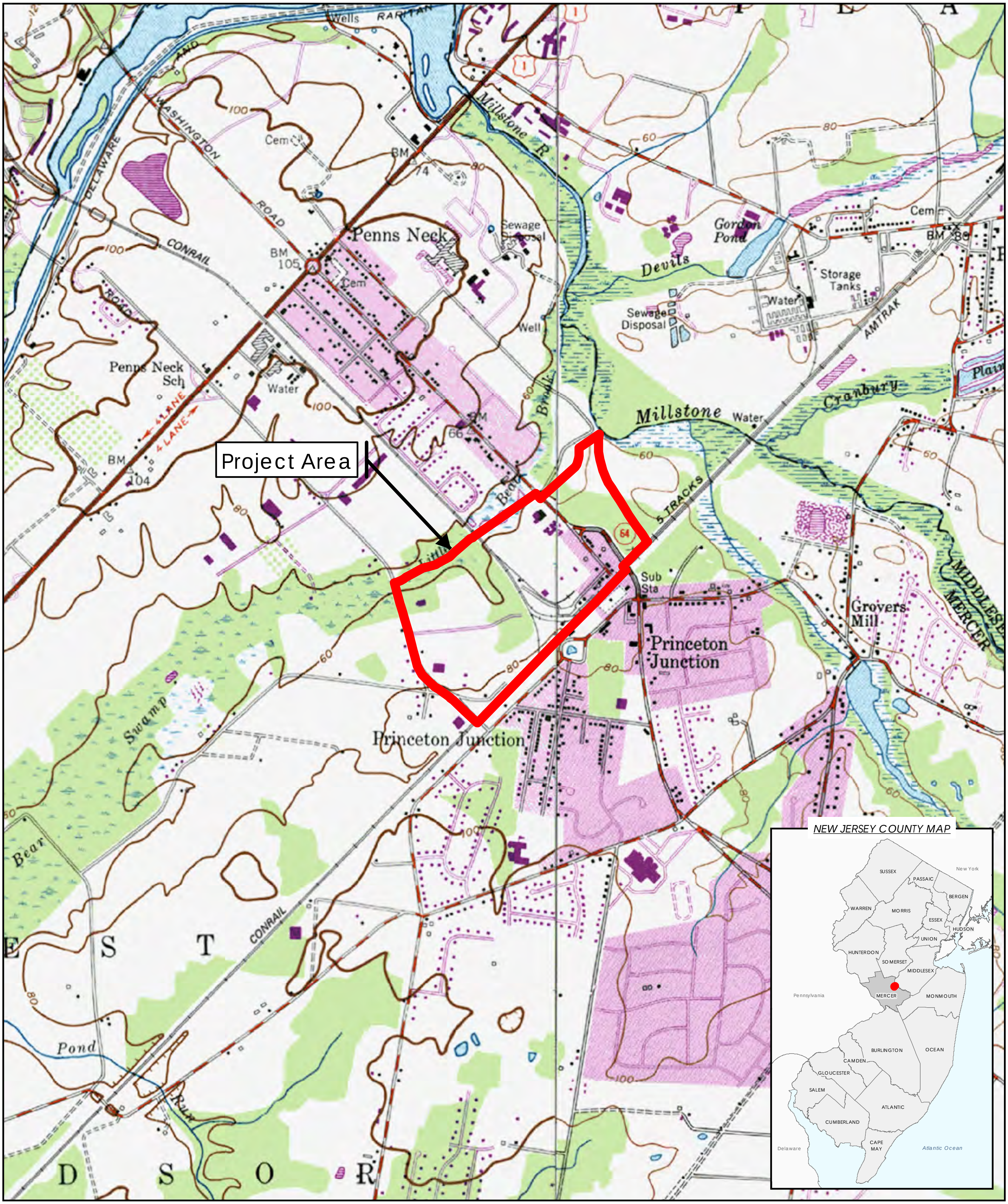

FIGURE1: SITE LOCATION

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

pH
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
*with offices in NJ, PA and CT

NOTES:
1. Project area is approximate.
2. USGS topographic digital raster graphic obtained from Terrain Navigator Pro, Hightstown & Princeton, NJ quadrangles.

0 1,000 2,000 Feet

Map Projection: NAD 1983 StatePlane New Jersey FIPS 2900 Feet

2.0 Study Area Characteristics

2.1 Aerial topography

The Redevelopment Area is bounded by the Little Bear Brook and the Millstone River. The limits of the Little Bear Brook watershed drains to the Millstone River approximately 0.8 miles upstream of the US Route 1 Bridge over the River. The Redevelopment Area is located within the Stony Book-Millstone Watershed. The Stony Brook-Millstone Watershed is a 265 square mile area of Central New Jersey that drains to the Millstone River. The Millstone River flows to the Raritan River, which empties into the Raritan Bay.

Detailed topographic information was obtained for the entire area and the detailed topography was generated using aerial imagery survey. The aerial imagery was completed on April 3rd, 2012 by Promaps of Moorestown, New Jersey. The topography in the Redevelopment Area identified average slopes. This survey also included the areas necessary to perform the Little Bear Brook Flood Analysis. The detailed topography generated for the entire study area is provided in Attachment A of this report.

2.2 Parcels

There are portions of 42 parcels within the study area as identified on the Parcel Tax Map on Page 4 of this report. Redevelopment Plan Districts 1 through 6 and 10 are found within the study area boundary. The township's parcel coverage with block and lot denoted for each area are shown; this will assist in identifying parcel(s) and property owner(s) for redevelopment.

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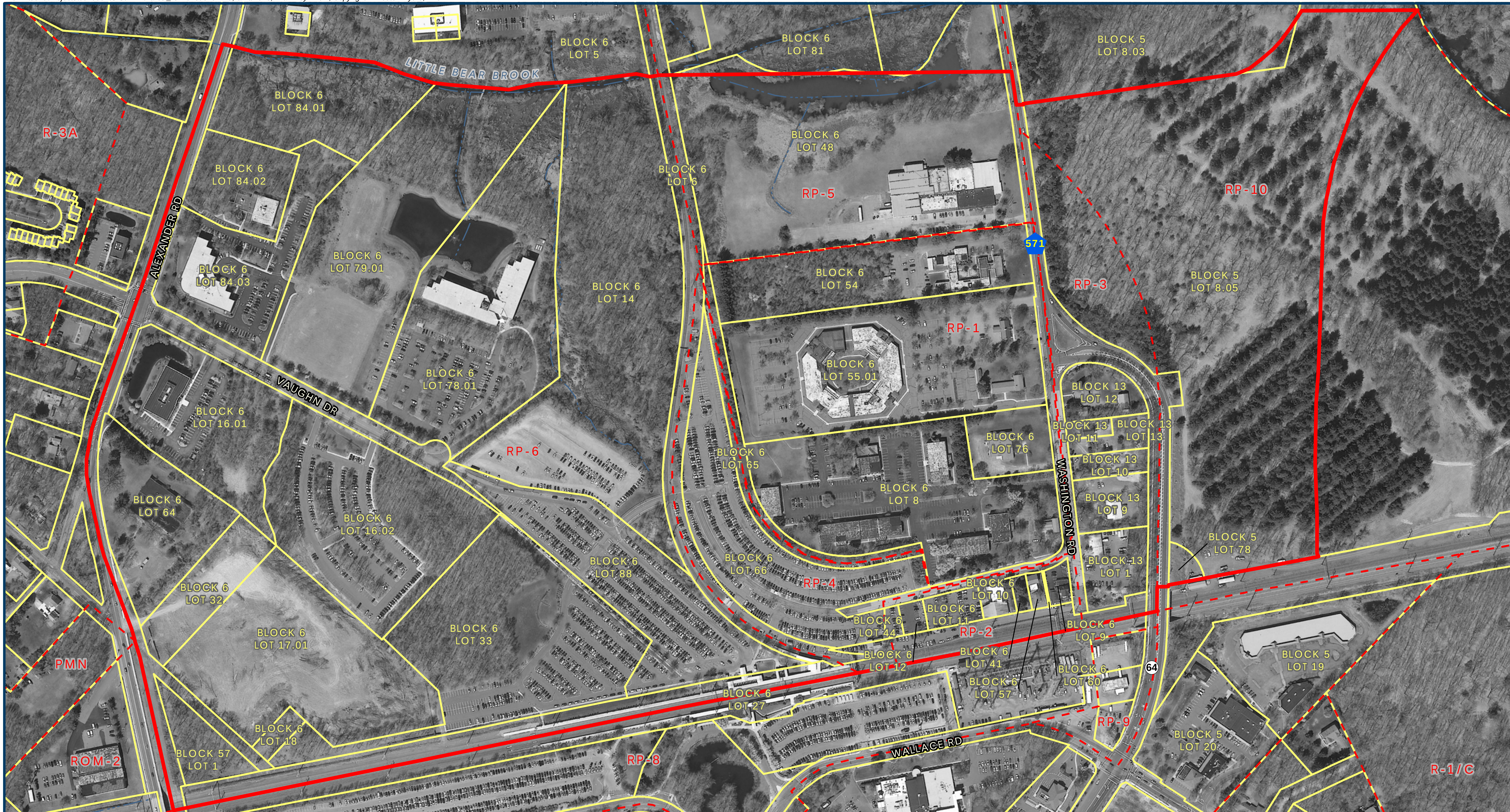

FIGURE 2:

PARCEL TAX MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit

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NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams obtained from NJDEP GIS website.
3. 2012 orthoimagery obtained from NJGIN Information Warehouse

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

2.3 Redevelopment Area Layout, Zone Boundaries, and Roadway Configurations

Based on the Redevelopment Plan, the overall Redevelopment Area is 350 acres in size. Of this area a study area was defined for this project scope of 180.83 acres. This area is organized into individual zoning districts as identified on the following page. The following is a brief summary of the districts within the study area:

- **District 1 (RP-1):** 25.91 Acres; mix of residential, retail, office and civic space can be designed as a distinctive walkable center with a sense of place for Princeton Junction. Maximum improvement coverage: 95%.
- **District 2 (RP-2):** 3.23 Acres; is envisioned as a place for public or private structured parking with retail and professional office service on the first floor. Maximum improvement coverage: 80% for retail and office uses and 95% for parking. 95% impervious cover was used for RP-2 to be conservative in the analysis.
- **District 3 (RP-3):** 9.8 Acres; is intended to be a retail and office development serving as a visual connection and facilitating pedestrian and bicycle linkage between the retail developments in Districts 7 and 1. Maximum improvement coverage: 60% for buildings up to three stories and 90% for four story buildings. 90% impervious cover was used in the modeling to be conservative.
- **District 4 (RP-4):** 7.86 Acres; which is owned entirely by New Jersey Transit, is intended as a location for commuter parking with supplementary retail uses to maintain an active street life. Maximum improvement coverage: 90%.
- **District 5 (RP-5):** 14.43 Acres; which has substantial environmental constraints, is intended to serve as an area of public park land, wetlands mitigation, and storm water management, with the goal of the eventual demolition of the existing light industrial building. Maximum improvement coverage: 0%. The existing impervious surfaces in RP-5 are grandfathered in under the current ordinances, so the impervious cover is 2.54% for Hydrologic Soil Group A and 42.06% for Hydrologic Soil Group D in the proposed build out analysis described later in this report.
- **District 6 (RP-6):** 94.05 Acres; is to accommodate existing office development in the Vaughn Drive and Alexander Road area, to provide for office development to be used as a means of facilitating the development of public parking structures for commuters, to provide for retail and restaurant uses along Vaughn Drive in order to create a more active street life, to accommodate a future BRT, to serve as the location for a hotel conference center and to serve as a receiving area for transfer of development rights from the Sarnoff Woods portion of District RP-10. Maximum improvement coverage: 90%, except that areas with environmental constraints shall be excluded from the MIC calculation.
- **District 10 (RP-10):** 25.85 Acres; is intended to both recognize the existing R&D zoning and the general development plan that was approved as part of the broader R&D District while at the same time encouraging a transfer of development potential from District 10 to District 6 in order to preserve the Sarnoff Woods. According to Chapter 200 of the township ordinances, specifically 200-219.2H, the maximum improvement coverage shall be 45%.

Discussions with the Township during the progression of this project regarding the Redevelopment Plan guided the placement of proposed conceptual BMPs. The location of the BMPs was selected in order to avoid impacts to environmentally sensitive areas. It is our understanding properties within the

Redevelopment Area have already received municipal approval. As such, stormwater management facilities were not identified for those properties.

File: P:\0020\Projects\0020004\GIS\MXD\RedvelopmentArea_rev20150310.mxd, 3/16/2015, Drawn by kklein, Copyright Princeton Hydro, LLC.

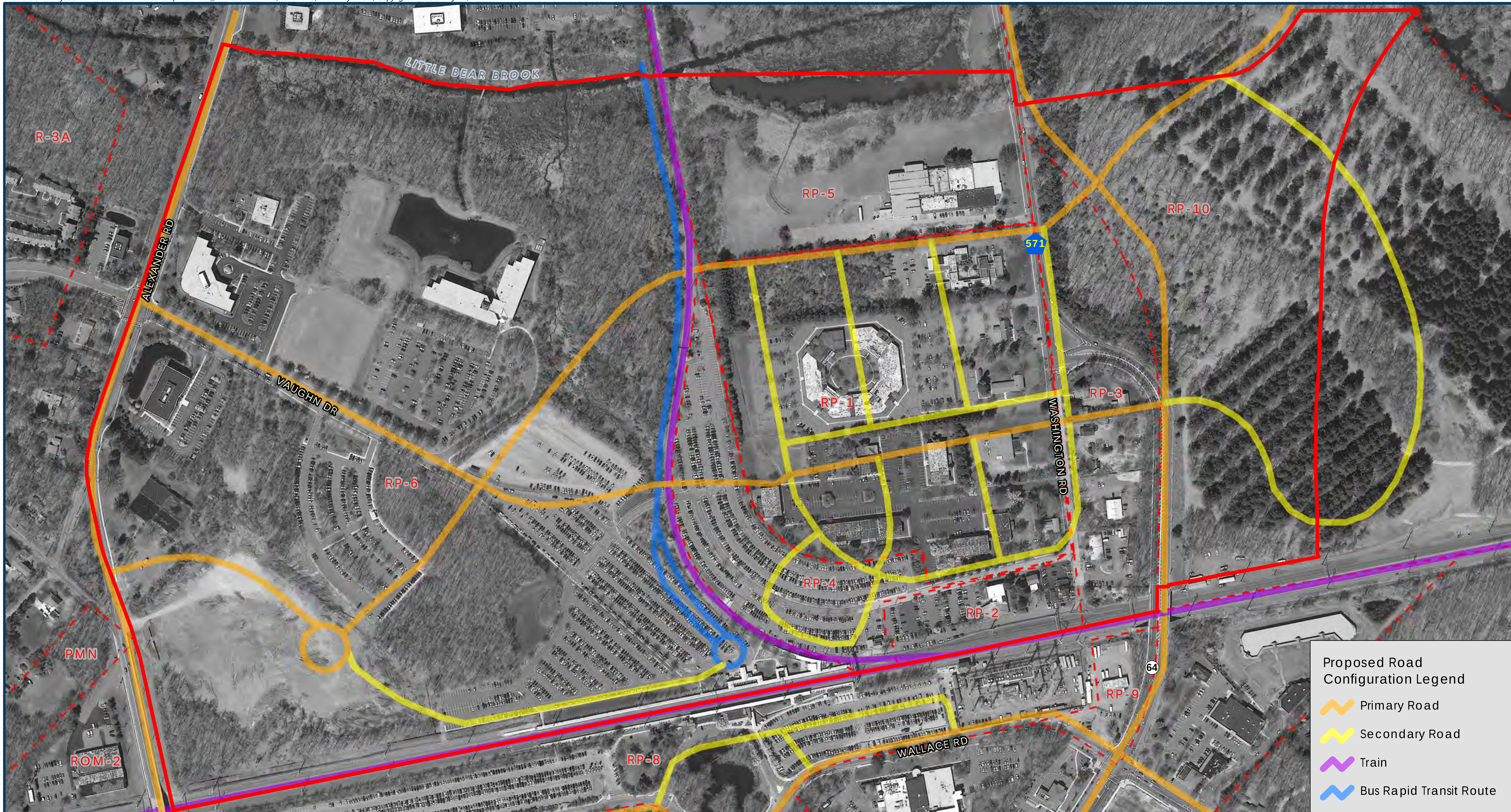

FIGURE 3:
REDEVELOPMENT AREA LAYOUT

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Stream
Project Area
Water Body

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

2.4 Environmental Constraints

In addition to the existing development and known planned development within the study area it was necessary to assess other limitations to the implementation of regional stormwater management features. To that end, Princeton Hydro evaluated environmental constraints within the study area. The environmental constraints located in the study area consist of freshwater wetlands[2], their associated transition areas (or buffers), limits of State Open Waters, regulated floodplains[3] of the Millstone River and Little Bear Brook, the Delaware and Raritan Canal Commission (DRCC) stream corridor, Well Head Protection Areas (WHPAs) and known contaminated sites as illustrated by the map entitled Environmental Constraints as provided on page 8 of this report.

The majority of the wetlands are located along the northern and western boundaries of the study area. The mapped floodplains, the DRCC stream corridor and the mapped wetlands are associated with the Little Bear Brook and the Millstone River along these boundaries. Other mapped wetland areas may exist south of Vaughn Drive and between Wallace Road and Washington Road and Princeton-Hightstown Road.

A WHPA is an area calculated around a Public Community Water Supply (PCWS) well in New Jersey that delineates the horizontal extent of groundwater captured by a well pumping at a specific rate over two-, five-, and twelve-year periods of time for unconfined wells. The well head protection area(s) are to be controlled by the water purveyor in accordance with Safe Drinking Water Regulations (see NJAC 7:10-11.7(b)1). Tier 3 well head protection areas are located in the northeastern portion of the study area. Typically, there are few limitations with the installation of stormwater management systems in Tier 3 WHPAs, however, the location of the WHPAs are noted for reference.

There are two (2) known contaminated areas within the study area: one is the Princeton Windsor News Service located off of Washington Road and the other is the West Windsor Landfill located off of Alexander Road. The West Windsor Landfill is identified by PI number G000011100 and is in active closure and remediation. The Princeton Windsor News Service is identified by PI number 004810 and is pending resolution. Depending on the nature of the contamination at these sites and the status of the pending remediation work, stormwater management (particularly infiltration) should be sited outside these properties.

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[2] The wetlands shown in the Environmental Constraints figure are those available from NJDEP Bureau of Geographic Information Systems. Wetlands within the study area would need to be formally delineated to verify the presence of wetlands prior to implementation of any stormwater management facility design.

[3] Regulated floodplains discussed in this report include floodplains mapped as part of the Flood Insurance Rate Maps available from the Federal Emergency Management Agency. Mapping prepared for this report is from the Digital FIRM data available from the FEMA website.

File: P:\0020\Projects\0020004\GIS\MXD\Env_Constraints_BMPs_rev20150310.mxd, 3/16/2015, Drawn by kklein, Copyright Princeton Hydro, LLC.

FIGURE: 4

ENVIRONMENTAL CONSTRAINTS MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Project Area
Stream
Water Body

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams, water bodies, NJDEP wetlands (2007 land use/land cover), known contaminated sites, landscape project v3.1 and well head protection zones obtained from NJDEP GIS website.
3. FEMA Q3 data obtained from FEMA Map Service Center.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

FEMA Floodplains and Flood Insurance Study (FIS):

The Federal Emergency Management Agency (FEMA) issues floodplain maps that describe flood events in the 100-year (1% exceedance probability) and 500-year (0.2% exceedance probability) flood zones. The Flood Insurance Rate Map (FIRM) and associated flood profiles for the Little Bear Brook and Millstone River can be found in Appendix A of this report. These areas are based upon exceedance probabilities and not frequency of flood events. The 100-year floodplain is split into two designations. Zone A followed by a number represents the 100-year floodplain for which Base Flood Elevations (BFE) have been established using detailed methods; the BFE is based on detailed area-specific hydraulic analyses and is tied to a vertical datum (National Geodetic Vertical Datum of 1929 (NGVD)). Zone A, which has no BFE, is based on area topographic models of flooding. Additionally, for studied streams there is often a Zone B which is the area between the 100-year flood and the 500-year flood or certain areas subject to 100-year flooding with average depths less than one foot, or areas protected by levees from the base flood.

Little Bear Brook flows through both single and multi-family residential neighborhoods as well as a large office complex between Alexander Road and the NJ Transit Tracks and commercial and industrial buildings on Washington Road. The 500-Year floodplain limits illustrate the current flood hazard risk to roadways, residences, offices and commercial buildings along the Brook from extreme flood events.

According to the FEMA Flood Insurance Study (FIS) the drainage area of the Little Bear Brook at its confluence with the Millstone is 2.39 square miles. The flow rates at the confluence are as follows:

10-year event - 120 cfs
50-year event - 205 cfs
100-year event - 250 cfs
500-year event - 385 cfs.

The portion of the project area along the Little Bear Brook is partially within the FEMA Zone A5. Due to backwater influence from the Millstone the 100-year flood elevation is 62.0 feet NGVD29 (60.92 NAVD88) and the 500-year flood elevation is 64.5 feet NGVD29 (63.42 NAVD88) for the entire project area.

The Millstone River has a much larger watershed with a higher percentage of urban land and flatter average slope when compared to the Little Bear Brook watershed. This results in the Millstone River watershed having a greater river peak discharge, higher peak river water surface elevation and slow response times at the river's confluence with Little Bear Brook than those generated by the Brook itself as reported by SWM Consulting.

Based on the Little Bear Brook Flood Hazard Assessment Phase I – Little Bear Brook and Millstone River prepared by SWM Consulting dated March 3, 2015, it was determined that the primary source of the frequent, chronic flooding of both Washington and Alexander Roads was neither Little Bear Brook nor the Millstone River but, instead, inadequate capacity of the storm sewer systems draining the roadways.

Therefore, the original scope of the Little Bear Brook Flood Hazard Assessment and the Regional Stormwater Management Plan was revised to include both an analysis of these existing storm sewer systems and the development of preliminary system improvements to reduce the frequency and severity of this chronic roadway flooding. The data, analyses, and results of this storm sewer system analysis, including the potential use of stormwater management facilities both within and outside the

Redevelopment Area will be presented in the separate Phase II Report on the Little Bear Brook Flood Hazard Assessment.

The Landscape Project:

In 1994, NJDEP Division of Fish and Wildlife's (NJDFW) Endangered & Non-game species program adopted the Landscape Project approach for the protection of imperiled species. The current Landscape Project Version 3.1 utilizes 2007 land cover data, an extensive database of rare species' locations, and their conservation status to delineate critical habitat patches. These Landscape Project maps were most recently updated in 2012 to assist with revised occurrences of rare, threatened, or endangered species, and changes to the endangered species list at NJAC 7:25-4.13 and the nongame wildlife list at NJAC 7:25-4.17. Landscape Project Version 3.1 maps also include species not represented in previous statewide versions, such as freshwater mussels, marine mammals, and marine turtles.

The Landscape Project delineates critical habitat patches based on the species present and their conservation status which are ranked from common to most rare. Areas with federally threatened or endangered species receive the highest ranking (5), followed by state endangered (4), state threatened (3), state species of priority concern (2), and finally suitable habitat for more common species (1). This ranking system is described in Table 4 below. Ultimately, this information can assist state, local and private agencies in prioritizing areas that could be preserved to protect habitat for rare species. This information also serves to alert officials to ensure that any future development minimizes disturbances to these critical habitat areas.

The NJDFW defines *Endangered Species* as those species whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance, or contamination. The NJDEP defines *Threatened Species* as those who may become endangered if conditions surrounding them begin to or continue to deteriorate. These threatened and endangered species are identified and protected in accordance with the Nongame Species Conservation Act. (N.J.S.A. 23:2A-1 et seq.) **www.nj.gov/dep/fgw/spclspp.htm**.

Rank	Title	Description
0	Non-suitable Habitat	Patches that do not contain any species occurrences and do not meet any habitat-specific suitability requirements
1	Suitable Habitat	Patches that meet habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species
2	Priority Concern	Patches containing one or more occurrences of at least one non-listed State priority species
3	State Threatened Species observed	Patches containing one or more occurrences of at least one State threatened species
4	State Endangered Species observed	Patches with one or more occurrences of at least one State endangered species
5	Federally Listed Species observed	Patches containing one or more occurrences of at least one wildlife species listed as endangered or threatened on the Federal list of endangered and threatened species

Table 1: Landscape Ranks and Description

For this project, two (2) species occurrences are documented within the study area and are located east of Washington Road. The observed species include the State Threatened Long-eared Owl (*Asio otus*) and State Endangered Bald Eagle (*Haliaeetus leucocephalus*) as identified on the Environmental Constraints Map as provided on Page 8 of this report. The Long-eared owl habitat is directly adjacent to Washington Road and is comprised of forested land. The Bald Eagle habitat is also east of Washington Road and is located within proximity to known water bodies and water courses. The remainder of the study area does not have any documented occurrences of State Endangered or Threatened species. It is anticipated that the presence of threatened and endangered species may impact placement of stormwater management features in that limitations exist regarding disturbances to habitat for these species.

2.5 Preliminary Geotechnical Information

Soils:

Soils are derived largely from the weathering of underlying geologic formations. A hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Hydrologic soil groups are determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable or depth to a water table. Soil characteristics such as particle size (e.g., sand, silt, and clay), water-holding capacity, and nutrient content are factors determined by the underlying bedrock, topography, and hydrology. In turn, microorganisms, plants and other biotic communities, and climate, collectively referred to as soil forming factors, affect and contribute to soil formation. The Soil Survey Geographic Database (SSURGO) is maintained by the Natural Resources Conservation Service (NRCS), an office within the US Department of Agriculture (USDA). The soil characterization process is directed by nationwide uniform procedures that account for particulate composition and size (clay, silt, and sand), stratification, and topography. These soil units are also characterized by crop suitability, compaction, strength, shrink-swell potential, available water capacity, erodibility, and permeability.

The soils within the study area belong to ten soil series as described below:

- **Downer (DohgB):** Fine sandy loam with gravelly clay loam substratum with 0 to 5 percent slopes. The Downer series consist of well drained soils used for agriculture. Typically, these soils have 10 inch thick dark grayish brown loamy sand surface layer. The subsoil between 10-18 inches is typically a yellowish brown loamy sand which is very strongly acid. The substratum from 18-80 inches is characterized as loose, very strongly acid, yellowish brown, loamy sand changing to a loamy sand, at a depth of approximately 30 inches. Depth to seasonal high water table is greater than 6 feet. They are included within Hydrologic Group A.

- **Eversboro (EvgB):** The Evesboro series consists of very deep excessively drained soils on uplands. They formed in acid sandy coastal plain sediments. Typically, these soils have a grayish brown sand surface layer 3 inches thick and a yellowish brown sand layer from 3 to 16 inches. The subsoil between 16 to 30 inches is yellowish brown sand. The substratum from 30 to 72 inches is loose yellowish brown sand. Slopes range from 0 to 5 percent. Depth to seasonal high water table averages between 4 to 6 feet. These are not considered to be hydric soils. They are included within Hydrologic Group A.

- **Fluvaquents (FmhAv):** Fluvaquents, frequently flooded consist of deep, poorly drained to very poorly drained soils adjacent to perennial streams in the coastal plain province that are subject to frequent stream overflow. These soils formed in sediments that are quite variable in texture. Slopes range from 0 to 3 percent. Depth to seasonal high water table averages approximately 6 inches. These are considered to be hydric soils. They are included within Hydrologic Group B/D.

- **Galestown (GadB):** The Galestown series consists of very deep, somewhat excessively drained soils on uplands. They formed in marine, eolian, and alluvial sediments. Typically these soils have a dark brown loamy sand surface layer 11 inches thick. The subsoil, from 11 to 29 inches, is yellowish brown loamy sand, and from 29 to 40 inches, is strong brown loamy sand. The substratum, from 40 to 65 inches, is brownish yellow sand. Slopes range from 0 to 5 percent. Depth to seasonal high water table averages greater than 5 feet. These are not considered to be hydric soils. They are included within Hydrologic Group A.

- **Galloway (GASB):** The Galloway series consist of very deep, moderately well drained soils which is often cultivated. They formed from sandy, unconsolidated marine sediments. Typically these soils have a dark grayish brown loamy sand surface layer 9 inches thick. The subsoil, from 9 to 28 inches, is light yellowish brown moderately acid loamy sand with few fine faint brownish yellow iron accumulations. The substratum, from 28 to 72 inches, is white gravelly sand changing to sand. Slopes range from 0 to 5 percent. Depth to seasonal high water table averages 2 to 4 feet. These are not considered to be hydric soils. They are included within Hydrologic Group A.

- **Glassboro and Woodstown (GKAWOB):** The Glassboro series consists of deep, somewhat poorly drained soils that formed in loamy fluvial or marine sediments on stream terraces and on the lower coastal plain. Typically, they have a dark grayish brown fine sandy loam surface about 9 inches thick. The subsoil from 9 to 17 inches is mottled light olive brown fine sandy loam. Below 17 inches, it is mottled grayish brown fine sandy loam to 37 inches. The substratum from 37to 66 inches is mottled brownish yellow fine sand. Slopes range from 0 to 5 percent. Depth to seasonal high water table averages approximately 1 foot. The Woodstown series consists of deep, moderately well-drained soils on uplands and terraces. They formed in marine and alluvial coastal plain sediments. Typically, these soils have a dark grayish-brown sandy loam surface layer, 7 inches thick, and a subsurface layer, from 7 to 11 inches, of light yellowish brown sandy loam. The light olive brown sandy clay loam subsoil, from 11 to 29 inches, is mottled in the lower part. The substratum layers, from 29 to 70 inches, are sandy loam and loamy sand. Slopes range from 0 to 5 percent. Depth to seasonal high water table averages between 2 to 3 feet. These are considered to be hydric soils. They are included within Hydrologic Group A/D.

- **Manahawkin Muck (MakAt):** The Manahawkin series consists of very deep, very poorly drained soils formed in organic deposits, over sand and gravel. Typically, they have a black surface and subsurface layer of highly decomposed organic material, 39 inches thick. The substratum to a depth of 60 inches is gray sand. Manahawkin soils are in low positions in back swamps, lake basins, and along fresh water channels as they open to tide water. Slopes range from 0 to 2 percent. Depth to seasonal high water table averages approximately 0 feet. These are considered to be hydric soils. They are included within Hydrologic Group A/D.

- **Plummer (PmmA):** The Plummer series consists of very deep, poorly to very poorly drained soils formed from marine or fluviomarine deposits. Typically, they have a dark grey, very acid surface layer from 0 to 9 inches. The subsurface layers from 9 to 50 inches below grade are typically gray to light grey, loose, single grain, very strongly acid sand. The substratum to a depth of approximately 80 inches is light grey sandy load with common medium and fine, prominent yellowish brown masses of oxidized iron, and is very strongly acid. Slopes range from 0 to 5 percent but typically less than 1 percent. Depth to seasonal high water table averages approximately 0 to 10 inches. These are considered to be hydric soils. They are included within Hydrologic Group B/D.

- **Sassafras (SacB):** The Sassafras series consists of very deep, well-drained soils on uplands. They formed in marine or alluvial coastal plain sediments. Typically, these soils have a brown sandy loam surface layer, 9 inches thick. The subsoil, from 9 to 21 inches, is yellowish-brown loam, from 21 to 32 inches, is brown sandy clay loam, and from 32 to 40 inches, is strong brown sandy loam. The substratum, from 40 to 52 inches, is strong brown gravelly sandy loam and, from 52 to 70 inches, is brownish-yellow loamy sand. Slopes range from 0 to 10 percent. Depth to seasonal high water table averages 5 to 6 feet. These are considered to be hydric soils. They are included within Hydrologic Group B.

- **Udorthents (UdgB):** gravelly substratum with 0 to 8% slopes. The soil is well drained. Typically these soils vary greatly with depth and location. However, they are generally well suited to use as building sites, parks, recreation fields, lawns and landscaping. Depth to seasonal high water table is greater than 5 feet. These are considered to be hydric soils. They are included within Hydrologic Group D.

Fluvaquents, Glassboro & Woodstown, Manahawkin Mucks, Plummer, and Sassafras soil series are all classified as being hydric – which is an indication of wetlands and are areas where infiltration would be severely limited due to the presence of shallow groundwater. These are located within the immediate vicinity of the Little Bear Brook and an isolated feature located off of Alexander Road near the railroad crossing. A Soils Maps and Soils Drainage Map for the study area are included on pages 14 and 15 of this report.

FIGURE 5:
SOILS MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

Legend

1 inch = 300 feet
0 150 300 Feet

Zoning Boundary
Project Area
Stream
Soil Map Unit Limit

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams obtained from NJDEP GIS website.
3.SSURGO Soils obtained from NRCS, USDA, Soil Survey Geographic (SSURGO) Database for Mercer County, New Jersey.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

Princeton Hydro

FIGURE 6:
SOILS DRAINAGE MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Stream
Project Area
Water Body

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Drainage class and hydric soil rating (SSURGO soils) obtained from NRCS, USDA, Soil Survey Geographic (SSURGO) Database for Mercer County, New Jersey.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

Geology:

The study area in West Windsor Township is located along the margin of the Piedmont and Coastal Plain physiographic provinces. The Coastal Plain Physiographic Province is characterized by unconsolidated deposits from the Lower Cretaceous to the Miocene period. A majority of the formations and rock types in the Piedmont Province are a part of the Newark basin supergroup and include the Passaic formation, the Lockatong formation, the Stockton formation, and basalt and diabase.

The majority of the study area lies within the Piedmont Province and the Stockton Formation where formations of sandstone, mudstone, silty mudstone, argillaceous siltstone, and shale form the bedrock with overlying glacial deposits. The southeastern corner of the study has Gneiss granofels and Migmatite formation of the Coastal Plain province. This is described as heterogeneous felsic, intermediate and mafic rock, graphic schist and minor marble.

The Stockton Formation is the coarsest-grained formation in the section, consisting of medium to coarse-grained arkose sandstones, which can be purple, white, and red sandstone, siltstone and quartzite conglomerates of the Stockton formation. The Lockatong Formation consists of mostly gray and black shale and siltstone, with subordinate purple and red mudstone (shale + siltstone). The lower Stockton Formation is a mostly fluvial deposit (that is, it was deposited by rivers). The upper Stockton and lower Lockatong formations represent lacustrine strata in which the lake deposits got progressively deeper. Bedrock and surficial geology maps are provided herewith.

Geologic formation is important when planning for redevelopment as it relates to structure placement and its required flood protection and impacts from flooding.

Princeton Hydro

FIGURE 7:
BEDROCK GEOLOGY MAP
REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet
0 150 300 Feet

Legend
Zoning Boundary
Stream
Project Area

NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams obtained from NJDEP GIS website.
3. Geology data obtained from NJDEP Geological and Water Survey website.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).
Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

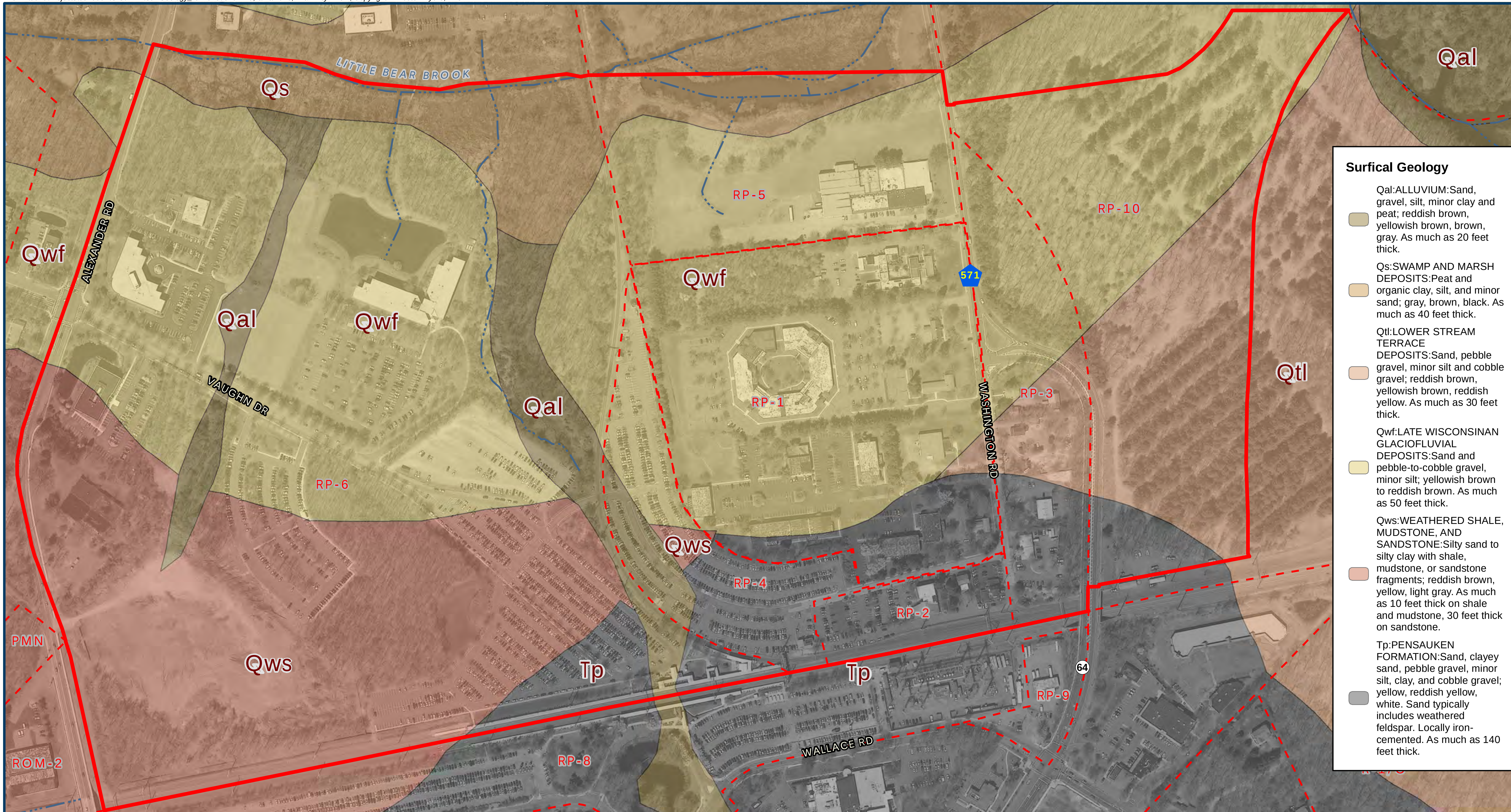

FIGURE 8:
SURFICIAL GEOLOGY MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Stream
Project Area

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
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3. Geology data obtained from NJDEP Geological and Water Survey website.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

Groundwater Recharge:

Groundwater recharge data was obtained from the New Jersey Geological Survey (NJGS) GSR-32 methodology. This methodology estimates groundwater recharge based upon modeling using land use, soil characteristics, and precipitation data to estimate of groundwater recharge in inches per year. A single soil unit may have several rates based on slope, proximity to wetlands, and land use. Hydrogeologists recognize that the volume of water that will actually recharge the deeper potable groundwater aquifers is considerably less than the volumes estimated using the GSR-32 method. Most infiltrated water in this area seeps or discharge as baseflow into streams and surface water features including wetlands. As such, the data presented in is not a reflection of the amount of bedrock aquifer recharge, but merely the potential shallow recharge through the upper soil horizons to a point below the root zone. Indeed, baseflow in streams, the normal discharge regime not fed by surface runoff during storm events, is entirely sustained by shallow groundwater flows thus necessarily reducing recharge to bedrock aquifers. General hydrology modeling in the area further indicates that most shallow groundwater is discharged to stream systems and that relatively little enters the aquifer.

New Jersey receives approximately 45 inches of precipitation each year and approximately 50% can return to the atmosphere through evaporation and through transpiration from plant leaves. Surface runoff also accounts for a large fraction of total precipitation leaving a small percentage that infiltrates.
Data provided by NJGS indicates groundwater recharge in the majority of the study area is variable (as identified on the Groundwater Recharge Map). In areas where wetlands and hydric soils prevail (approximately 58.4 acres) no recharge is noted; however the northeastern region of the project area can infiltrate 13.00 to 14.97 inches of recharge annually. Likewise, a small portion of the south western portion of the project area has potential to infiltrate 10.00 to 14.97 inches. The central portion of the site infiltrates approximately 0.01 to 5.00 inches annually. Recharge in the study area is shown on a map provided on Page 21.

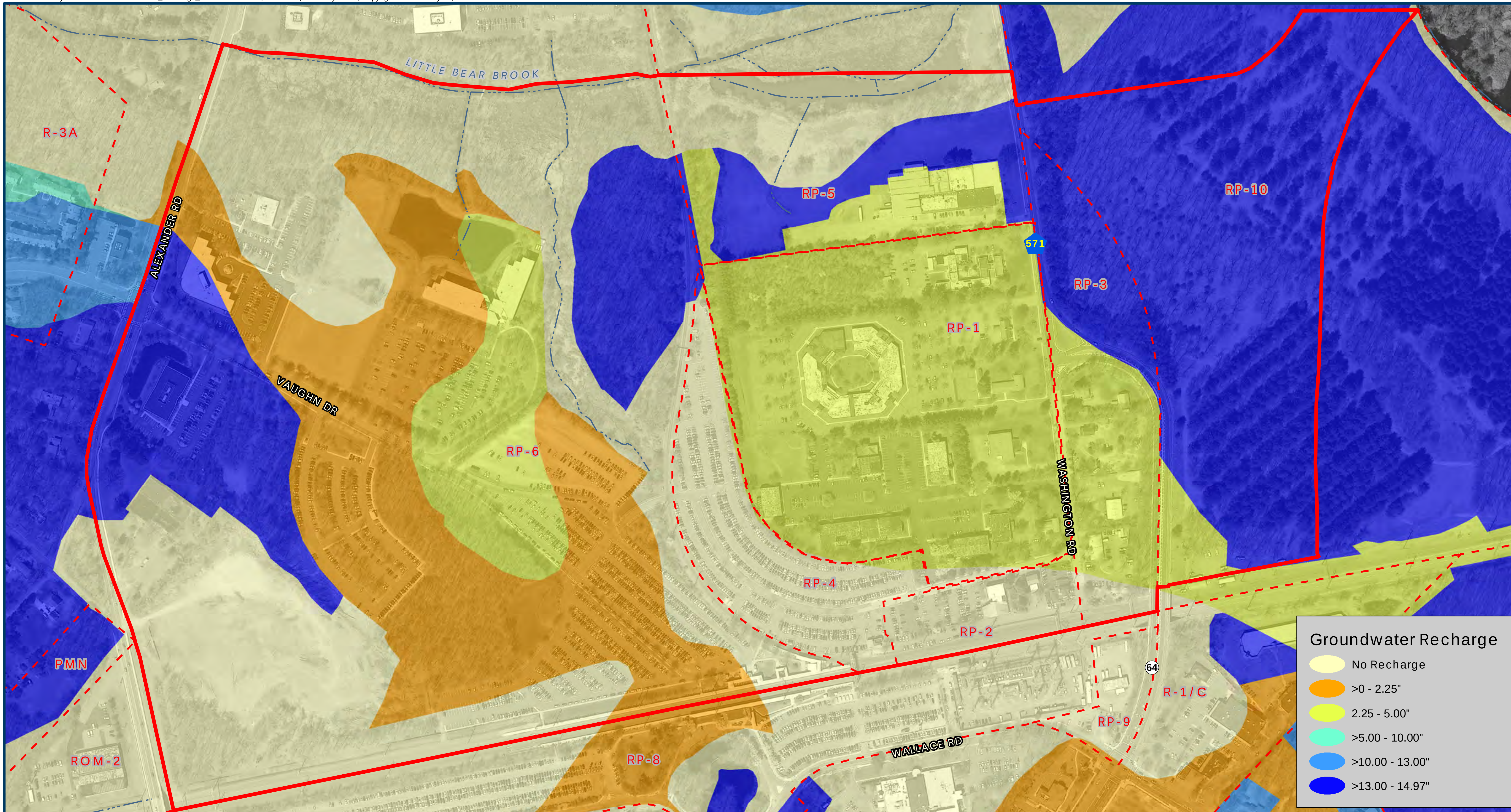

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FIGURE 9:
GROUNDWATER RECHARGE MAP

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet
0 150 300 Feet

Legend
Zoning Boundary
Stream
Project Area

NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams obtained from NJDEP GIS website.
3. Groundwater recharge obtained from NJDEP Geological and Water Survey website.
4. 2012 orthoimagery obtained from NJ Office of Information Technology (NJOIT), Office of Geographic Information Systems (OGIS).
Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

3.0 Stormwater Calculations

Princeton Hydro completed detailed stormwater management calculations for the study area. The calculations completed include a detailed stormwater quantity analysis. The quantity analysis calculated the changes between existing and proposed conditions as well as reducing stormwater quantity from existing conditions to the greatest extent practicable.

3.1 Existing Conditions Calculations

Hydrology:

Existing hydrology for the study area was established using the USDA Soil Conservation Service Technical Release 55 (TR-55) methodology. Based on the topography of the site, the project area was divided into four (4) drainage areas culminating in four separate Points of Analysis. The drainage areas are labeled from 1 through 4 starting from the west at Alexander Road to the east end at the Sarnoff property. Each drainage area has a Point of Analysis (POA) associated with it where it intersects the receiving waterbody, which is the Little Bear Brook for drainage areas 1 through 3 and the Millstone River in the case of the drainage area 4.

Land Use/Land Cover (LU/LC) data was used to establish the runoff Curve Numbers for analysis. LU/LC is a two-tiered classification system that systematically defines similar land areas according to land utilization and vegetative structure. The NJDEP uses a modified Anderson Classification schema (Anderson 1976). The dataset was created by combining existing information about land use and photo-interpretation of aerial photographs. Information presented in this report is based on the 2012 aerial and database. A copy of the Land use / Land Cover Map is provided in this section.

The Curve Numbers are closely associated with the level of development in a watershed and are specifically tied to the amount of pervious surface, disturbed soils, and vegetative cover. The combination of these factors along with the hydrologic soil group of the underlying soil, as identified, determines the quantity of runoff and/or infiltration from a particular area.

The existing land uses within the study area includes agriculture, barren lands, forest, urban, and wetlands. Each of these can be further broken down into more detailed categories based on how the area is used. For example, agriculture is broken down into farming method (e.g. row crop, pasture, cover crop, etc.), and urban land uses are further categorized into residential, commercial, and industrial development as well as supporting infrastructure such as roadways and utilities.

The aerial imagery and topography were used to calculate the Times of Concentration[4] (TC) for each POA.

[4] The Time of Concentration is a term used in hydrology to measure the response of a watershed to a rain event. It is defined as the time needed for water to flow from the most remote point in a watershed to the watershed outlet and is a function of the topography, geology and land use within the watershed.

The overall drainage areas were divided into pervious and impervious areas as per the regulations. Refer to the table below for a summary of the existing hydrology and additional information can be found in Appendix C.

Table 2: Time of Concentration				
Drainage Area ID	**POA ID**	**Area (acres)**	**CN**	**TC (minutes)**
DA-1	POA-1	41.83	71	37.4
DA-1 Imp.	POA-1	15.27	98	23.9
DA-2	POA-2	23.37	56	39.1
DA-2 Imp.	POA-2	15.16	98	17.2
DA-3	POA-3	35.046	56	31.5
DA-3 Imp.	POA-3	27.85	98	9.1
DA-4	POA-4	25.009	71	28.4
DA-4 Imp.	POA-4	1.01	98	5

The runoff volume and peak rate of discharge to each of the points of analysis were analyzed using Hydro CAD version 10.0. The Type III, NRCS 24 hour design storm rainfall distribution for Mercer County was utilized for the storm events: 2-year, 10-year and 100-year with rainfalls of 3.3 inches, 5.0 inches, and 8.3 inches respectively as identified in Table 3 below.

Table 3: Existing Runoff						
POA	**Existing 2-Year Event**		**Existing 10-Year Event**		**Existing 100-Year Event**	
	Vol. (af)	Q (cfs)	Vol. (af)	Q (cfs)	Vol. (af)	Q (cfs)
1	7.175	61.02	13.439	116.40	27.131	237.48
2	4.482	50.16	8.046	80.27	16.227	150.41
3	8.029	116.68	14.096	182.18	27.771	326.68
4	2.215	18.41	4.812	43.54	10.767	100.23

3.2 Build-Out Condition Calculations

Hydrology:

The drainage areas and points of analysis have remained the same from existing to proposed conditions for ease in comparing run off characteristics for the Redevelopment Area. The Redevelopment Plan stated a maximum allowable impervious area for each zoning area.

For the purposes of the proposed hydrologic analysis, each drainage area was divided by zone and then the resultant area was multiplied by the percent impervious and assigned a curve number of 98. The remaining area was divided by hydrologic soil group and assigned a CN value for grass cover in good condition which is 39 for Hydrologic Soils Group A or 80 for Hydrologic Soils Group D.

Table 4: Build-Out Condition – Time of Concentration				
Drainage Area ID	**POA ID**	**Area (acres)**	**CN**	**TC (minutes)**
DA-1	POA-1	5.71	58	18.6
DA-1 Imp.	POA-1	51.395	98	20.7
DA-2	POA-2	3.853	55	12.1
DA-2 Imp.	POA-2	34.677	98	17.2
DA-3	POA-3	14.476	63	23.8
DA-3 Imp.	POA-3	44.627	98	19
DA-4	POA-4	14.310	71	20.2
DA-4 Imp.	POA-4	11.709	98	12.6

This information was entered into HydroCAD version 10.0 and modeled for the same 2-, 10- and 100-year events as existing. Refer to the table below for a summary of the existing hydrology and additional information can be found in Appendix D.

Table 5: Build-out Condition - Runoff						
POA	**Proposed 2-Year Event**		**Proposed 10-Year Event**		**Proposed 100-Year Event**	
	Vol. (af)	Q (cfs)	Vol. (af)	Q (cfs)	Vol. (af)	Q (cfs)
1	13.316	155.39	20.956	241.91	36.105	413.60
2	8.953	114.67	14.079	178.36	25.252	304.81
3	12.088	144.45	19.534	231.16	34.686	407.37
4	4.112	54.14	7.172	93.99	13.637	177.40

3.3 Stormwater Management Discussion:

In order for the Redevelopment Plan to successfully address stormwater in accordance with current regulations both the increases in volume and flow need to be addressed through the incorporation of stormwater management measures. The runoff volumes and the peak rates of runoff can be reduced through the implementation of Best Management Practices (BMPs) throughout the site to capture, retain, and possibly infiltrate the additional water.

Table 6: Stormwater Volume									
POA	**2-Year Event**		**10-Year Event**		**100-Year Event**		**Vol. Difference (Prop-Ex)**		
	Ex. Vol. (af)	Prop. Vol. (af)	Ex. Vol. (af)	Prop. Vol. (af)	Ex. Vol. (af)	Prop. Vol. (af)	2-Yr. (af)	10-Yr. (af)	100-Yr. (af)
1	7.175	13.316	13.439	20.956	27.131	36.105	6.141	7.517	8.974
2	4.482	8.953	8.046	14.079	16.227	25.252	4.471	6.033	9.025
3	8.029	12.088	14.096	19.534	27.771	34.686	4.059	5.438	6.915
4	2.215	4.112	4.812	7.172	10.767	13.637	1.897	2.36	2.87

Table 7: Stormwater Peak Flow Summary									
POA	2- Year Event		10-Year Event		100-Year Event		Peak Rate Difference (Prop-Ex)		
	Ex. Q (cfs)	Prop. Q (cfs)	Ex. Q (cfs)	Prop. Q (cfs)	Ex. Q (cfs)	Prop. Q (cfs)	2-Yr. (cfs)	10-Yr. (cfs)	100-Yr. (cfs)
1	61.02	155.39	116.4	241.91	237.48	413.6	94.37	125.51	176.12
2	50.16	114.67	80.27	178.36	150.41	304.81	64.51	98.09	154.4
3	116.68	144.45	182.18	231.16	326.68	407.37	27.77	48.98	80.69
4	18.41	54.14	43.54	93.99	100.23	177.4	35.73	50.45	77.17

In order to comply with the Stormwater Management Rules, it is necessary to reduce the peak rates of runoff from existing conditions for the 2-year storm by 50%, and by 25% for the 10-year storm, and by 20% for the 100-year storm event. The below summary table provides the reductions in peak rate necessary for the various POAs under the regulated storm events.

Table 8: Build-out Condition – Reduction of Peak Rates									
POA	2- Year Event		10-Year Event		100-Year Event		Peak Rate Reductions* (cfs)		
	Ex. Q (cfs)	Required Q (cfs)	Ex. Q (cfs)	Required Q (cfs	Ex. Q (cfs)	Required Q (cfs	2-Yr. (cfs)	10-Yr. (cfs)	100-Yr. (cfs)
1	61.02	30.51	116.4	87.3	237.48	189.984	124.88	154.61	223.616
2	50.16	25.08	80.27	60.2025	150.41	120.328	89.59	118.1575	184.482
3	116.68	58.34	182.18	136.635	326.68	261.344	74.33	75.585	116.626
4	18.41	9.205	43.54	32.655	100.23	80.184	44.935	61.335	97.216

*The peak rate reductions included in the above table refer to the predicted peak rates of discharge from the Stormwater Flow Summary table for proposed conditions. In order to achieve these peak rate reductions, stormwater BMPs will be required to retain varying levels of stormwater runoff as discussed later in this report.

BMPs were evaluated for each of the various POAs. Discussion on the BMPs is included under Section 3.4 below.

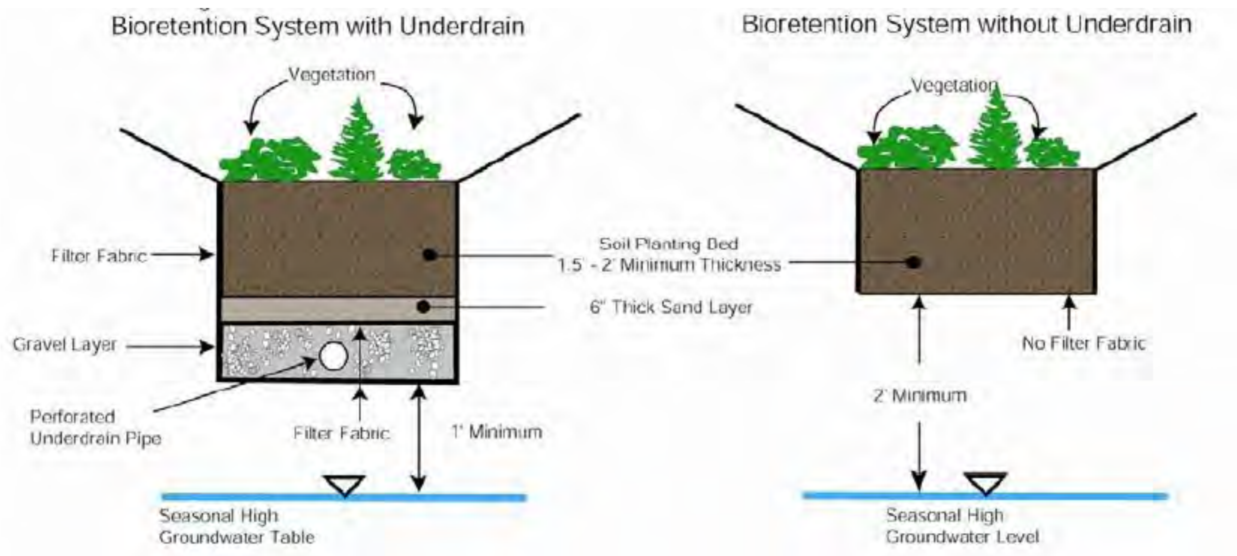
3.4 Concept Stormwater Management Practices

Potential Best Management Practices (BMPs) Available

NJDEP Division of Watershed Management published the *New Jersey Stormwater Best Management Practices Manual* listing design guidance for stormwater management. Chapter 9 of the manual focuses on thirteen (13) Structural Stormwater Management Measures. These will be summarized below and discussed in more specific detail later in this report.

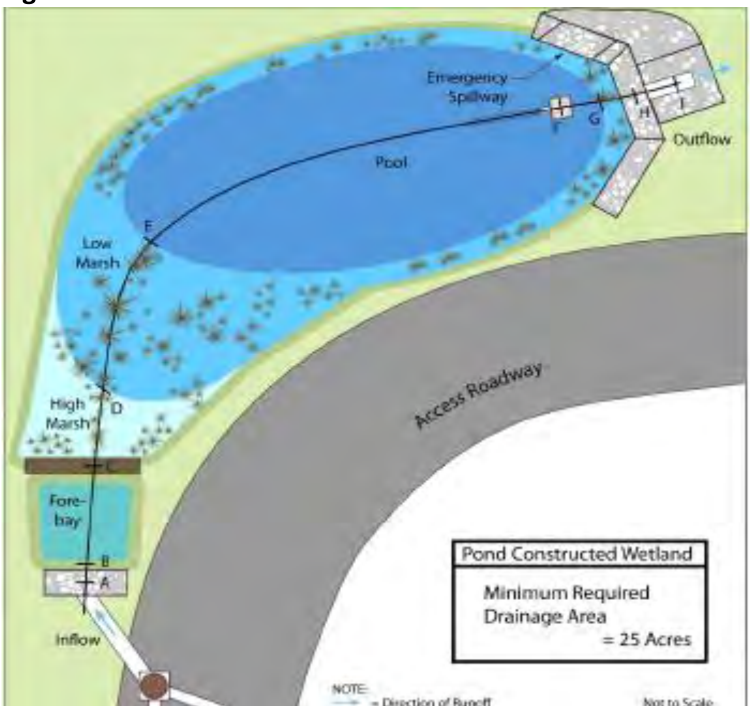
- **Bioretention Systems:** A bioretention system consists of a soil bed planted with suitable non-invasive (preferably native) vegetation. Stormwater runoff entering the bioretention system is filtered through the soil planting bed before being either conveyed downstream by an underdrain system or infiltrated into the existing subsoil below the soil bed. Vegetation in the soil planting bed provides uptake of pollutants and runoff and helps maintain the pores and associated infiltration rates of the soil in the bed. Bioretention systems are used to remove a wide range of pollutants, such as suspended solids, nutrients, metals, hydrocarbons, and bacteria from stormwater runoff. They can also be used to reduce peak runoff rates and increase stormwater infiltration when designed as a multi-stage, multi-function facility.

Figure 10: Bioretention Systems



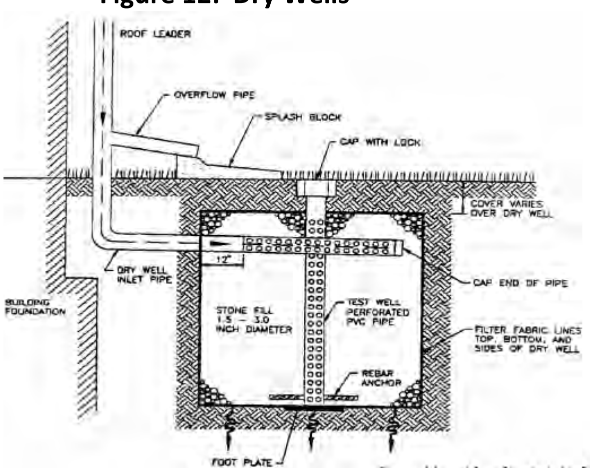
- **Constructed Wetlands:** Standard constructed wetlands are engineered wetland systems used to remove a wide range of pollutants from land development sites; stormwater runoff is directed through the open, marsh system where pollutants are removed through settling and both uptake and filtration by the vegetation. Standard constructed wetlands can also be used to reduce peak runoff rates when designed as an on-line system. On-line systems receive upstream runoff from all storm events; they provide treatment for the Water Quality Design Storm and convey the runoff from larger storms through an outlet or overflow. In off-line systems, most or all of the runoff from storms larger than the Water Quality Design Storm bypass the constructed wetland system through an upstream diversion.

Figure 11: Constructed Wetlands



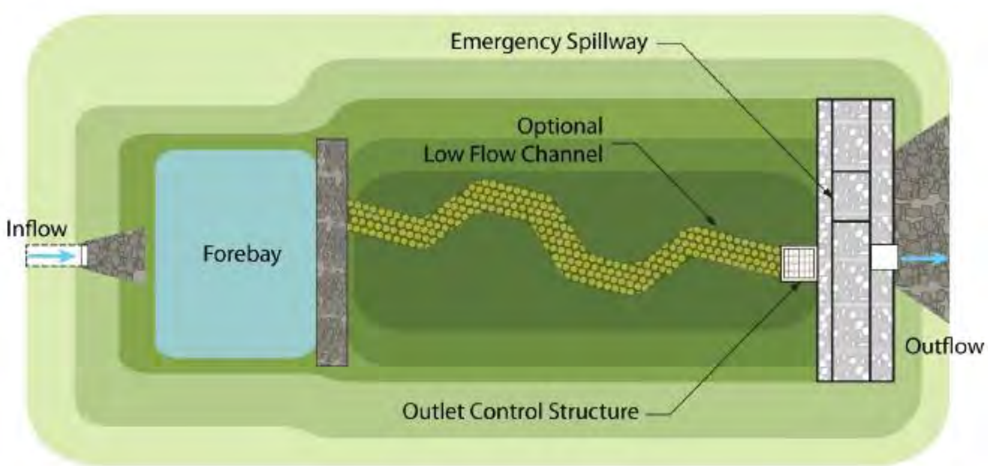
- **Drywell:** A dry well is a subsurface storage facility that receives and temporarily stores stormwater runoff from roofs of structures. Discharge of this stored runoff from a dry well occurs through infiltration into the surrounding soils. A dry well may be either a structural chamber and/or an excavated pit filled with aggregate. Dry wells can be used to reduce the increased volume of stormwater runoff caused by roofs of buildings. While generally not a significant source of runoff pollution, roofs are one of the most important sources of new or increased runoff volume from land development sites.

Figure 12: Dry Wells



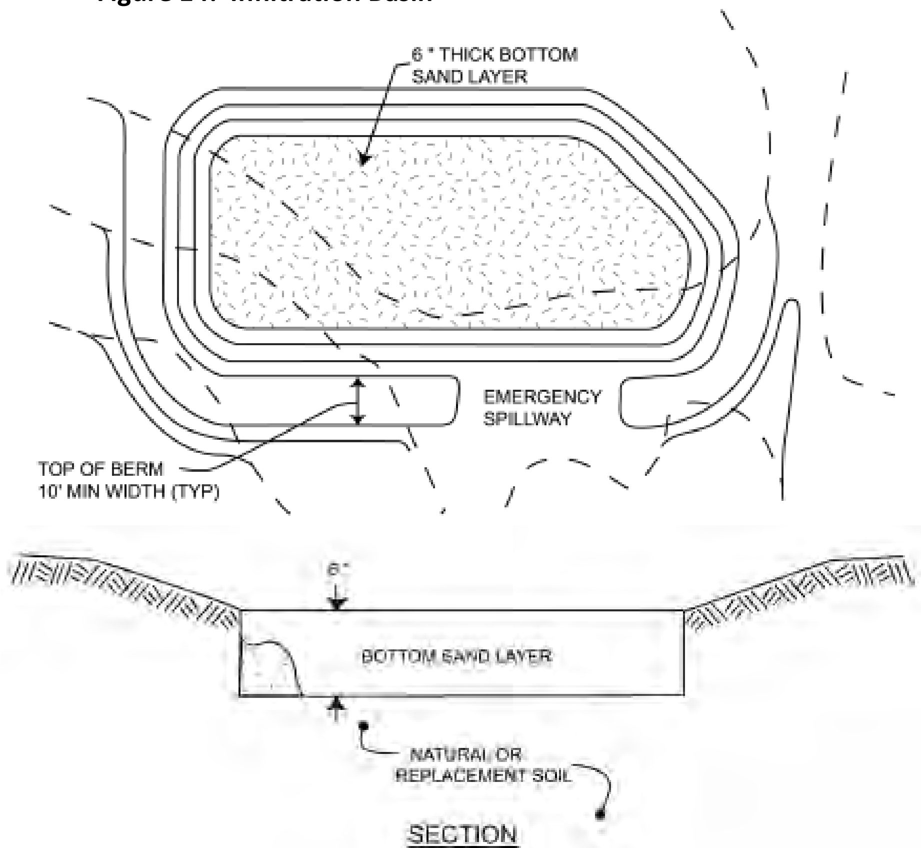
- **Extended Detention Basins:** Extended detention basins are used to address both the stormwater runoff quantity and quality impacts of land development. The lower stages of an extended detention basin detain runoff from the Water Quality Design Storm promoting pollutant removal through settling. The higher stages of the basin attenuate the peak rates of runoff from larger storm events. Extended detention basins may be used at sites where significant increases in runoff are expected as a result of site development; however, their limited efficacy in removing both particulate and soluble pollutants may limit their use for water quality.

Figure 13: Extended Detention Basins



- **Infiltration Basin:** An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of stormwater runoff. An infiltration basin does not normally have a structural outlet to discharge runoff from the stormwater quality design storm. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage for both stormwater quality and quantity management. Infiltration basins are used to remove pollutants and to infiltrate stormwater back into the ground. Such infiltration also helps to reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutant removal is achieved through filtration of the runoff through the soil as well as biological and chemical activity within the soil.

Figure 14: Infiltration Basin



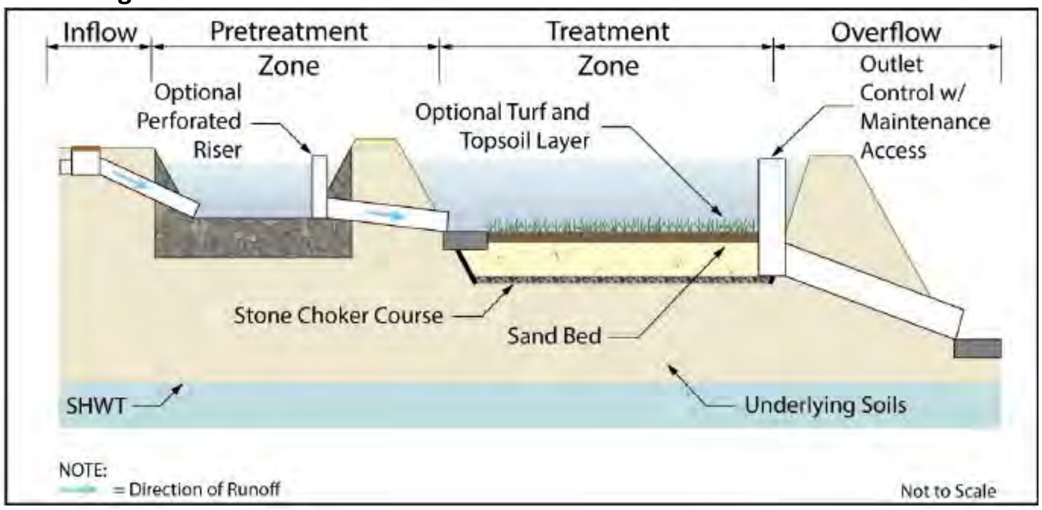
- **Manufactured Treatment Devices:** A manufactured treatment device is a pre-fabricated stormwater treatment structure utilizing settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to remove pollutants from stormwater runoff. Manufactured treatment devices are typically used to address water quality within small drainage areas.

- **Pervious Paving Systems:** Pervious paving systems are paved areas that produce less stormwater runoff than areas paved with conventional paving. This reduction is achieved primarily through the infiltration of a greater portion of the rain falling on the area than would occur with conventional paving. This increased infiltration occurs either through the paving material itself or through void spaces between individual paving blocks known as pavers. Pervious pavement is used to reduce runoff volumes from developed area surfaces, such as patios, walkways, driveways, fire lanes and parking spaces.

- **Rooftop Vegetated Cover:** Rooftop vegetated cover or green roofs are specially engineered structures which have vegetation planted on them to reduce the runoff volume. This reduction is achieved primarily through absorption by the plant material and by the soil for later used by the plants.

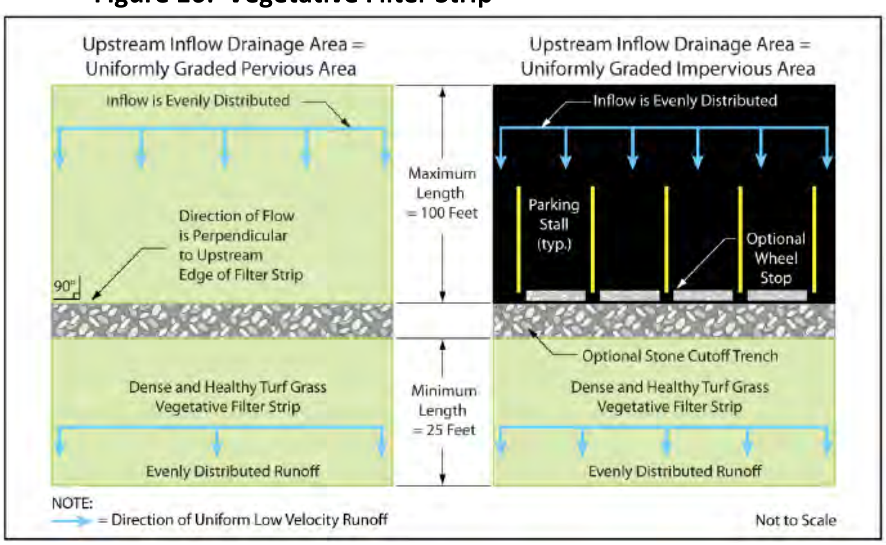
- **Sand Filters:** A sand filter is a stormwater management facility that uses sand to filter particles and particle-bound constituents from runoff. There are two types of sand filter systems: infiltration sand filters and underdrained sand filters. Stormwater entering the sand filter is first conveyed through the pretreatment zone where trash, debris and coarse sediment are removed. It then passes through the treatment zone and out of the system through either an outlet pipe, in an underdrained system, or through the subsoil via infiltration.

Figure 15: Sand Filters



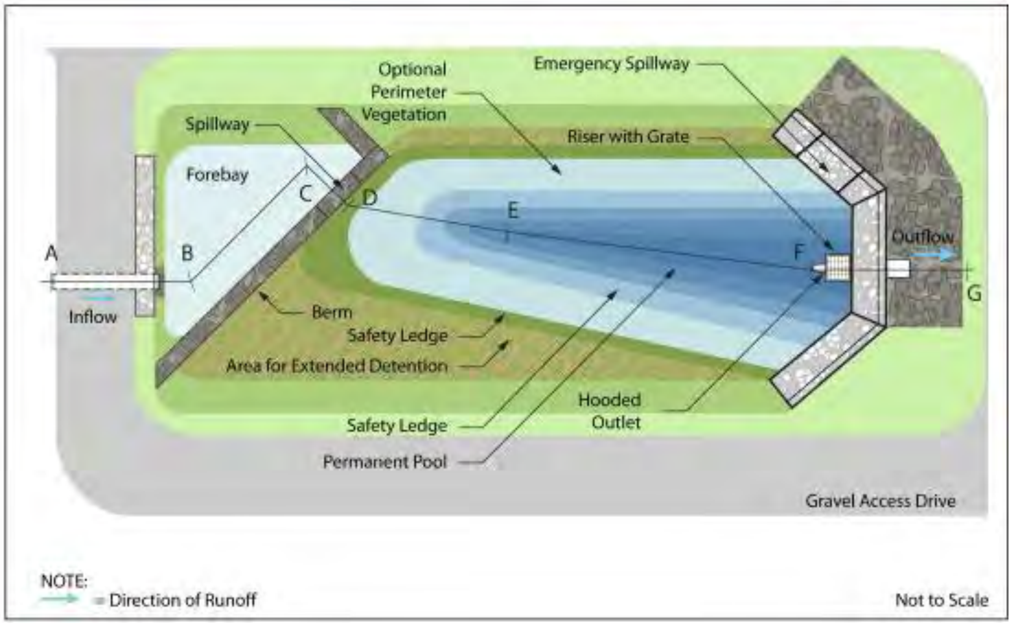
- **Vegetative Filter Strips:** A vegetative filter strip is a stable, evenly graded area that removes pollutants from stormwater runoff through filtration and biological uptake. In order to provide pollutant treatment, runoff must enter and move through the filter strip as sheet flow; therefore, vegetative filter strips must have shallow enough slopes to maintain sheet flow. Vegetative filter strips are intended to treat runoff generated from drainage areas that are uniformly graded, such as yards, parking lots and driveways, where runoff moves as sheet flow. Vegetative filter strips are intended for water quality treatment only.

Figure 16: Vegetative Filter Strip



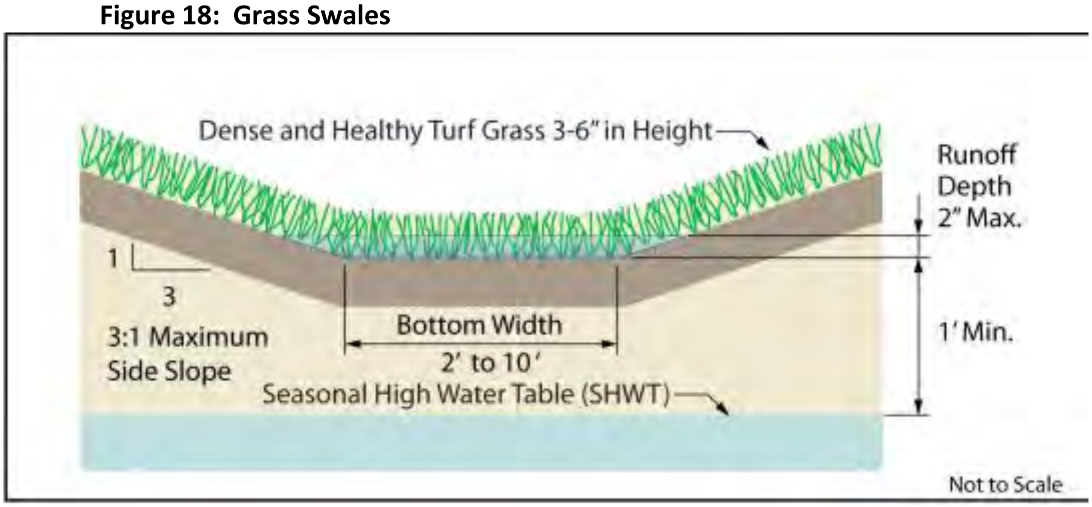
- **Wet Ponds:** Wet ponds, also known as retention basins, are used to address the stormwater quantity and quality impacts of land development. This type of stormwater facility has an elevated outlet structure that creates a permanent pool where stormwater runoff is detained and attenuated. Wet ponds can be designed as multi-stage, multi-function systems. Wet ponds can also be used to provide wildlife habitat, recreational benefits and water supply for fire protection; they can also be used to enhance the aesthetics of a site. However, these systems are designed primarily for stormwater treatment, so they should not be located within natural areas because they will not have the same range of ecological function.

Figure 17: Wet Ponds



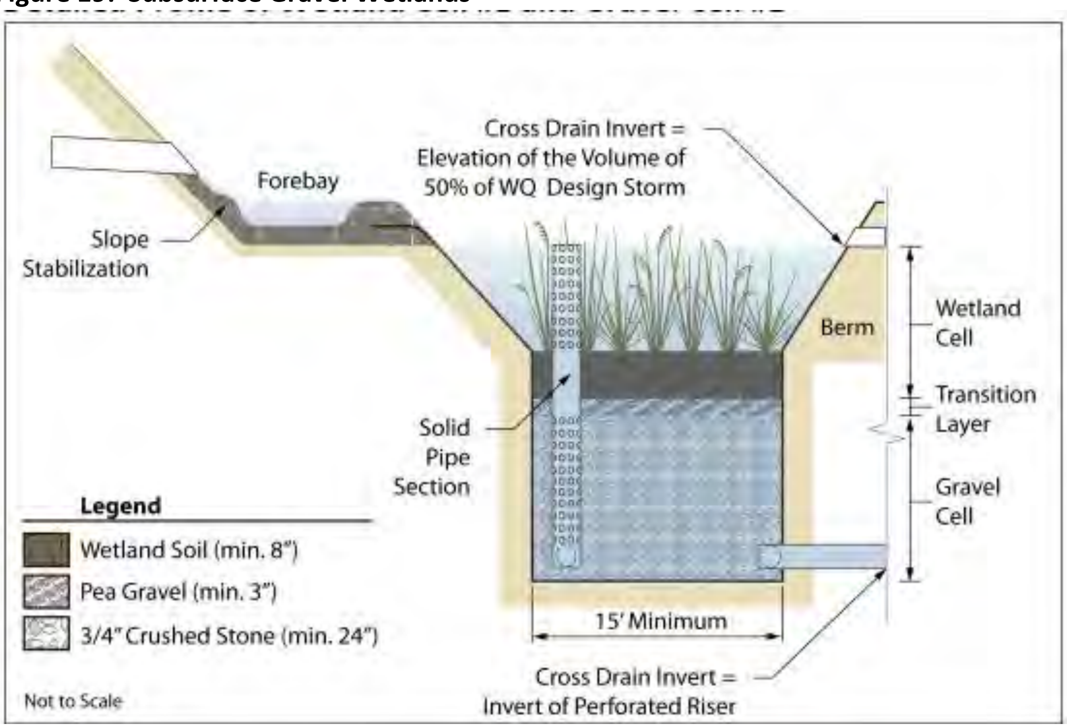
- **Grass Swales:** A grass swale is a stable, parabolic or trapezoidal channel that is lined with turf; it is used to improve water quality and convey stormwater runoff.

Figure 18: Grass Swales



Subsurface Gravel Wetlands: Subsurface gravel wetlands are stormwater management systems used to address the stormwater runoff quality impacts of land development. This type of stormwater facility is a combination of a surface marsh and a subsurface gravel bed. In the surface marsh, pollutants in runoff are treated through filtration and biological uptake by the marsh vegetation and through settling. Runoff flows vertically from the surface marsh through a perforated pipe into the saturated gravel bed, located directly below the surface marsh. Runoff then moves horizontally through the gravel where pollutants are treated by chemical transformation, specifically denitrification. Denitrification is a microbially-facilitated, multi-step process whereby nitrogen compounds in runoff are transformed to nitrogen gas. The nitrogen gas is then permanently removed from the system via the soil into the atmosphere.

Figure 19: Subsurface Gravel Wetlands



Being that the primary goal is to address water quantity for the entire site, focus shall be given to the BMPs which can handle water quantity for large areas (as the study area is approximately 185 acres in size). These include bioretention systems, constructed wetlands, extended detention basins, infiltration basins, and wet ponds. Other best management practices can be used throughout the developments area to convey water to the primary basin and/or to address water quality or recharge.

BMP Concepts for Redevelopment Area

To complete the stormwater analysis, Princeton Hydro reviewed the Redevelopment Area plans along with the all the GIS overlays discussed previously in this report. A total of eight (8) possible BMPs locations were identified in the four drainage areas and are identified by letter from A to H. A BMP Location Map is provided on Page 36 of this report.

Assessment of potential depth of the various BMPs was completed using HydroCAD Version 10.0. Assumed storage volumes and basic outlet control structures were input to determine potential depths of the BMPs. Depths were calculated assuming that the BMPs collected runoff from the drainage areas within which they were located only. Should multiple areas be directed to single BMPs, the depths listed in the Table 9 below would need to increase.

Table 9. Regional Stormwater BMP Analysis

Point of Analysis (POA)	BMP Site ID	Surface Area (ac)	Depth Needed[1] (ft.)	Resulting Storage[2] (af)	Minimum Volume Required[3] (af)	Volume Achieved[4] (Y/N)
2	A	3.78	5	18.9	9.025	Y
1	B	1.05	6	6.3	8.974	N
1	C	2.74	6	16.44	8.974	Y
3	D	2.26	3.5	7.91	6.915	Y
4	E	4.89	1.5	7.335	2.87	Y
3	F	1.31	3.5	4.585	6.915	N
3	G	1.18	3.5	4.13	6.915	N
4	H	4.89	1.5	7.335	2.87	Y

[1]The depths indicated assume that runoff from the individual drainage areas are all that is directed to the BMP. It also assumes that the BMPs will be installed together to accommodate the full volume of stormwater. Outlet structures used in the modeling efforts are simplistic and recharge is not included in the overall assessment.
[2] The resulting storage shown on the table assumes that the basin is constructed with vertical slopes for the full depth. It is assumed that this volume will be reduced when grading at the site is known. The resulting storage volume is higher in most cases than the minimum volume required to account for this simplification.
[3] The minimum volume required is taken for the 100-year design storm results shown in Table 6 above and is for the entire POA. As stated in note 1 above, the analysis was completed assuming that all BMPs would be installed together to ensure the minimum volumes are achieved.
[4]The volumes achieved assume that the entire increase in volume resulting from the redevelopment area can be stored in the BMP. This does not mean that the BMPs can achieve the storage independently for the BMP areas where "N" is denoted.

As part of this study, the Township requested that the potential overdesign of each BMP area be evaluated to determine whether reductions in runoff volume could be achieved from existing conditions. The results of this analysis are included in Table 10 below. It is important to note that the results are conceptual and do not take into consideration onsite soils limitations, depths to Seasonal High Groundwater and potential other constraints (utility lines, development plans, etc.).

Point of Analysis (POA)	BMP Site ID	Surface Area (ac)	Volume Required for 5% Reduction[1] (af)	Additional Depth Needed (ft.)	Volume Required for 10% Reduction (af)	Additional Depth Needed (ft.)	Volume Required for 15% Reduction (af)	Additional Depth Needed (ft.)
2	A	3.78	9.84	0	10.65	0	11.46	0.5
1	B	1.05	10.33	N/A[3]	11.69	N/A	13.04	N/A
1	C	2.74	10.33	0	11.69	0	13.04	0.25
3	D	2.26	8.30	1.3	9.69	2	11.08	2.5
3	E	4.89	8.30	1.3	9.69	1.5	11.08	1.9
3	F[2]	1.31	8.30	0	9.69	0	11.08	0
3	G	1.18	8.30	N/A	9.69	N/A	11.08	N/A
4	H	4.89	3.41	0.5	3.95	0.5	4.49	0.5

Table 10. Overdesign of BMPs Analysis for Volume Reduction

[1] The volumes identified include the volume from Table 6 for the 100-year design storm in addition to a five percent reduction in overall existing runoff volume for the corresponding POA. This same approach applies for the 10% and 15% reductions shown in the table.
[2] For the volumes and depths shown, BMP F must discharge and be connected to BMP D.
[3] It is not possible with the implementation of BMP B or G alone to achieve the required reduction.

There are other potential connections between BMP areas and sizing scenarios which could be evaluated, however, the above approach was determined to be most applicable for this study.

The general characteristics of each BMP location within the overall study area are summarized in the table below. Subsequent to the table is a discussion of each BMP including potential implementation limitations, costs, and maintenance for the various BMPs.

Table 11: BMP Location Summary

BMP Site ID	Size (ac)	Ownership	Environmental Constraints?	Soils constraints?	Avg. Elevation
A	3.78	NJT/Rail	Yes[1]	Yes	60
B	1.05	NJT/Rail	No	Yes	89
C	2.74	Public/NJT Rail	No	No	72
D	2.26	Private	Yes[2]	No	60
E	4.89	Private	Yes[3]	No	68
F	1.31	Private	Yes[4]	No	69
G	1.18	NJT/Rail	No	No	78
H	4.89	Private	Yes[5]	No	68.5

[1] BMP Site ID A is partially constrained by 1% Flood Hazard Limit and the Delaware & Raritan Canal Commission Buffer.
[2] BMP Site ID D is constrained by 1% Flood Hazard Limit, and the Delaware & Raritan Canal Commission Buffer.
[3] BMP Site ID E is partially constrained by 1% Flood Hazard Limit, Delaware & Raritan Canal Commission Buffer, State Threatened Species (Rank 3), and Well Head protection Public Community Tier 3 (12 years).
[4] BMP Site ID F is partially constrained by Well Head protection Public Community Tier 3 (12 years).
[5] BMP Site ID H is partially constrained by State Threatened Species (Rank 3), and Well Head protection Public Community Tier 3 (12 years).

Each BMP area was further reviewed for suitability for the various stormwater volume control BMP types identified in the NJ Stormwater BMP Manual. Table 12 below summarizes the ranking with 1 being the most suitable and 5 being the least suitable.

Table 12: BMP Suitability Ranking

	Bioretention System	Constructed Wetland	Extended Detention Basin	Infiltration Basin	Wet Pond
A	3	2	4	1	5
B	1	N/A	2	N/A	N/A
C	5	4	2	1	3
D	2	4	3	1	5
E	4	2	5	1	3
F	1	4	2	3	5
G	1	4	3	5	2
H	4	2	5	1	3

Several of the BMP locations have high probability for good infiltration rates. The infiltration capabilities of these sites should be fully explored as there exists the potential to further reduce existing runoff volumes from the study area. In addition, if the BMPs are constructed in series, there exists greater potential to incorporate water quality improvements and tie together compatible BMP types for construction. Where possible, extended detention should not be considered unless no other options are viable due to the limited water quality benefits associated with that type of BMP.

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FIGURE 20:
REDEVELOPMENT AREA LAYOUT

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

N W E S

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Project Area
Stream
Parcel Limit
Potential Stormwater BMP Location

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP A:

BMP A is located within drainage area 2 on Block 6, Lot 14 within zone RP-6. The property is currently owned by the NJ Transit and is partially within the 1% Flood Hazard Area Limit and the Delaware and Raritan Canal Commission (DRCC) stream corridor. The current land use is forest on Galloway soils which are well drained and has a high potential for groundwater recharge. Based on the soil series description, the depth to the seasonal high water table is 2 to 4 feet below grade. The existing elevation at this location could provide the water quantity benefits necessary for the Redevelopment Area with the appropriate drainage and piping network. Additionally, this BMP location could be connected to BMP D, discussed below, to provide further benefits for the Redevelopment Area.

Constructed Wetland:

BMP location A would be ideal for a constructed wetland of any type especially in combination with BMP D, as the two locations could be linked to maximize the treatment area and potential. The constructed wetland would likely need to be lined with an impermeable liner in order to maintain the design hydraulics of the system. The design depths of the various types of wetland and wetland components vary from six inches to six feet depending on the designed plant community and if a pool is part of the design. This system also requires a forebay or other pretreatment and a minimum of two control structures. The control structures would be located between the pretreatment forebay and the wetland and the final outlet structure.

Due to the need for the liner and particular design hydraulics for the system this practice would not be ideal to address groundwater recharge.

Bioretention System:

Should there be opposition to the constructed wetlands option, then the installation of a bioretention basin in this location is possible pending a detailed soils investigation. It is important to note that the sizing of the system may need to be adjusted due to the determination of the seasonal high groundwater table. The BMP may need to be lined, with clay or other impermeable material depending on the difference in elevation between the bottom of the bioretention system and seasonal high water table. If the system needs to be lined, the ability to recharge groundwater will be eliminated thereby requiring additional BMP considerations to address the necessary recharge. The required separation between the water table and bottom of the proposed basin may eliminate a bioretention system as potential BMP at this location.

Depending on the depth of planting bed media (typically 1.5 to 2 feet) and the types of vegetation to be planted, the water quality benefit of the basin varies from 80% to 90%.

Wet Ponds:

BMP A is an ideal location for a wet pond as it meets the minimum in flow drainage area and can meet the square footage requirements for permanent pool. The BMP would need to have an impermeable liner in order to maintain the permanent pool. A forebay or other pre-treatment practice is also required to reduce the accumulation of sediment and debris within the wet pond itself. Two control structures would be necessary: one between the forebay and the wet pond, and one as the discharge location of the wet pond. This type of system will not provide the necessary recharge.

Infiltration Basin:

BMP location A has the potential to be an ideal location for an infiltration basin as long as the depth to the groundwater table is sufficient and the soils have the required permeability rate. A forebay or other pre-treatment practice shall be installed as well to reduce maintenance and the clogging potential of infiltrative surface. The depth of the basin will be dependent on the volume necessary to infiltrate as well as retain to address water quantity and recharge. The New Jersey Stormwater Best Management Practices Manual (dated April 2004, last revised September 2014) specifies a minimum of 0.5 inches per hour design permeability rate for infiltration basins. As a result of this requirement, site specific soils investigation will be required, as part of the design stage.

Extended Detention Basin:

Depending on final elevations and water volumes, an above ground extended detention basin may not be feasible at this location. A typically basin will range from three to twelve feet deep with a minimum normal depth of three feet to minimize mosquito breeding and maximize effectiveness of the basin. The overall depth of the basin will be determined based on the volume needed to be retained, the inflow elevation (s) and the final discharge elevation. Based on the preliminary information that is known at this BMP site, it would be a challenge to balance all of these elevations and provide the necessary detention. In addition, this type of system will not provide the necessary recharge.

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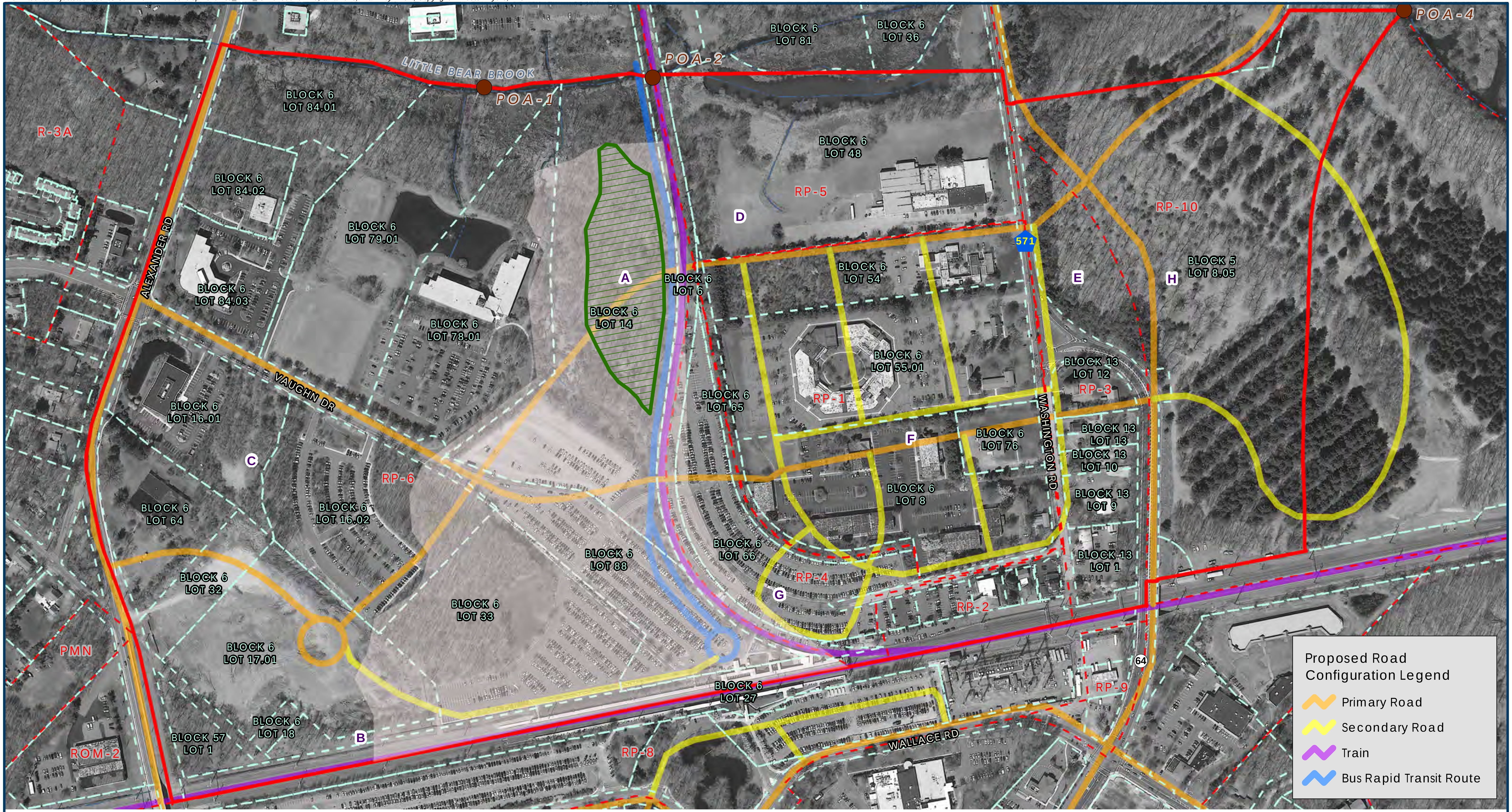

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FIGURE 21:

BMP A

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit
- BMP A Area
- BMP_A Drainage Area
- Point of Analysis

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP B:

BMP B is located adjacent to the Northeast Corridor New Jersey Transit rail line on the drainage divide for drainage areas 1 and 2. The property is currently owned by the railroad and is located on portions Block 6 Lots 33, 18, and 17.01. The current land use is part urban and part forest on Udorthents soils which are somewhat excessively drained with minimal recharge potential. This site is not the ideal location for a best management practice because:

- it is a small area making it difficult to create a BMP to maximize the treatment potential;
- located at the elevation top of the drainage area will make drainage into and out of the BMP difficult, and
- The close proximity to the transit line has the potential to have other utility conflicts.

For this reason BMP location B will not be discussed in any additional sections of this report. It is a possible location; however, it is not recommended.

BMP C:

BMP C is located within drainage area 1 just south of the Vaughn Drive on Block 6, Lots 16.01 and 16.02 and within zone RP-6. The property is currently publically and privately owned. The current land use is forest on Galestown soils which are somewhat excessively drained and has a high potential for groundwater recharge. Based on the soil series description, the depth to the seasonal high water table is approximately 72 inches below grade. The existing elevation of this location could provide the water quality and quantity benefits necessary for the Redevelopment Area within the immediate vicinity of the BMP location. The elevation and location would not be conducive to direct additional runoff to this location.

Bioretention System:

The installation of a bioretention basin in this location is a good possibility. However, pending a detailed soils investigation, the sizing of the system may need to be adjusted due to the determination of the seasonal high groundwater table. The BMP may need to be lined with clay or other impermeable material depending in the difference in elevation between the bottom of the bioretention system and seasonal high water table. If the system needs to be lined, the ability to recharge groundwater will be eliminated therefore requiring additional BMP considerations to address the necessary recharge. The depth to the groundwater table should not be an issue at this location as the inflow drainage area in small and the water table is anticipated to be six feet below grade.

Depending on the depth of planting bed media (typically 1.5 to 2 feet) and the types of vegetation to be planted, the water quality benefit of the basin varies from 80 to 90%.

Constructed Wetland:

The constructed wetland would likely need to be lined with an impermeable liner in order to maintain the design hydraulics of the system. The design depths of the various types of wetland and wetland components vary from six inches to six feet depending on the designed plant community and if a pool is part of the design. This system also requires a forebay or other pretreatment and a minimum of two control structures. The control structures would be located between the pretreatment forebay and the wetland and the final outlet structure.

Due to the need for the liner and particular design hydraulics for the system, this practice would not be ideal to address groundwater recharge.

A constructed wetland may not be a feasible BMP at this location due to the drainage area requirements of a minimum of 10 acres. The drainage area to this BMP location should be delineated prior to selection of this site and BMP type.

Extended Detention Basin:

Depending on final elevations and water volumes, an above ground extended detention basin should be feasible at this location. A typical basin will range from three to twelve feet deep with a minimum normal depth of three feet to minimize mosquito breeding and maximize effectiveness of the basin. The overall depth of the basin will be determined based on the volume needed to be retained, the inflow elevation(s) and the final discharge elevation. Based on the preliminary information that is known at this BMP site, it could be feasible to balance all of these elevations and provide the necessary detention. In addition, this type of system will not provide the necessary recharge.

Infiltration Basin:

BMP location C has the potential to be an ideal location for an infiltration basin as long as the depth to the groundwater table is sufficient and the soils have the required permeability rate. A forebay or other pre-treatment practice should be installed as well to reduce maintenance and the clogging potential of infiltrative surface. The depth of the basin will be dependent on the volume necessary to infiltrate as well as retain to address water quantity and recharge. The New Jersey BMP manual specifies a minimum of 0.5 inches per hour design permeability rate for an infiltration basin. A site specific soils investigation will be required, as part of the design stage.

Wet Ponds:

A wet pond is at BMP location C is not an ideal as it does not meets the minimum in flow drainage area but can meet the square footage requirements for permanent pool.

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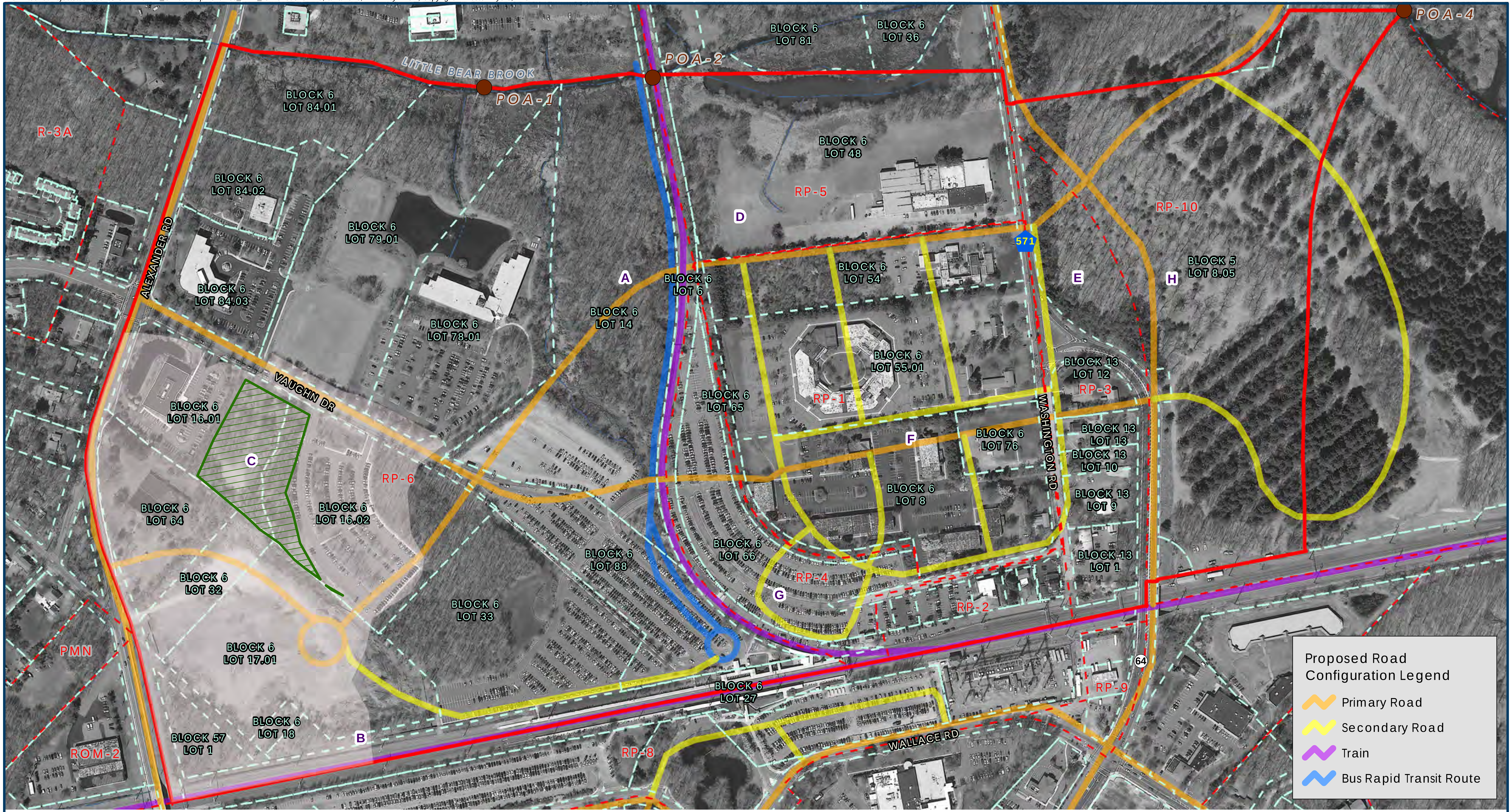

FIGURE 22:

BMP C

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Project Area
Stream
Parcel Limit
BMP C
Area
BMP_C Drainage Area
Point of Analysis

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP D:

BMP D is located within drainage area 3 on Block 6, Lot 48 and within zone RP-5. The property is currently privately owned and is partially within the 1% Flood Hazard Area Limit and the Delaware and Raritan Canal Commission Buffer. The current land use is forest and urban on Galestown soils which are somewhat excessively drained and have a high potential for groundwater recharge. Based on the soil series description, the depth to the seasonal high water table is approximately 72 inches below grade. The existing elevation of this location could provide the water quality and quantity benefits necessary for the Redevelopment Area with the appropriate drainage and piping network. Additionally, the benefits of this location could be increased via connection to BMP A as described above.

Constructed Wetland:

BMP location D would be ideal for a constructed wetland of any type especially in combination with BMP A, as the two locations could be linked to maximize the treatment area and potential. The constructed wetland would likely need to be lined with an impermeable liner in order to maintain the design hydraulics of the system. The design depths of the various types of wetland and wetland components vary from six inches to six feet depending on the designed plant community and if a pool is part of the design. This system also requires a forebay or other pretreatment and a minimum of two control structures. The control structures would be located between the pretreatment forebay and the wetland and the final outlet structure.

Due to the need for the liner and particular design hydraulics for the system this practice would not be ideal to address groundwater recharge.

Bioretention System:

Should there be opposition to the constructed wetlands option, then the installation of a bioretention basin in this location is a possibility. However, pending a detailed soils investigation, the sizing of the system may need to be adjusted due to the determination of the seasonal high groundwater table. The BMP may need to be lined with clay or other impermeable material depending on the difference in elevation between the bottom of the bioretention system and seasonal high water table. If the system needs to be lined, the ability to recharge groundwater will be eliminated therefore requiring additional BMP considerations to address the necessary recharge. The required separation between the water table and bottom of the proposed basin may eliminate a bioretention system as potential BMP at this location.

Depending on the depth of planting bed media (typically 1.5 to 2 feet) and the types of vegetation to be planted the water quality benefit of the basin varies from 80% to 90%.

Wet Ponds:

BMP location D is an ideal location for a wet pond as it meets the minimum in flow drainage area and can meet the square footage requirements for permanent pool. The BMP would need to have an impermeable liner in order to maintain the permanent pool. A forebay or other pre-treatment practice is also required to reduce the accumulation of sediment and debris within the wet pond itself. Two control structures would be necessary: one between the forebay and the wet pond, and one as the discharge location of the wet pond. This type of system will not provide the necessary recharge.

Infiltration Basin:

BMP location D has the potential to be an ideal location for an infiltration basin as long as the depth to the groundwater table is sufficient and the soils have the required permeability rate. A forebay or other pre-treatment practice should be installed as well to reduce maintenance and the clogging potential of infiltrative surface. The depth of the basin will be dependent on the volume necessary to infiltrate as well as the volume to be retained to address water quantity and recharge. The New Jersey BMP manual requires a minimum of 0.5 inches per hour design permeability rate for infiltration basins. Site specific soils investigation will be required, as part of the design stage.

Extended Detention Basin:

Depending on final elevations and water volumes, an above ground extended detention basin may not be feasible at this location. A typically basin will range from three to twelve feet deep with a minimum normal depth of three feet to minimize mosquito breeding and maximize effectiveness of the basin. The overall depth of the basin will be determined based on the volume needed to be retained, the inflow elevation(s) and the final discharge elevation. Based on the preliminary information that is known at this BMP site, it would be a challenge to balance all of these elevations and provide the necessary detention. In addition, this type of system will not provide the necessary recharge.

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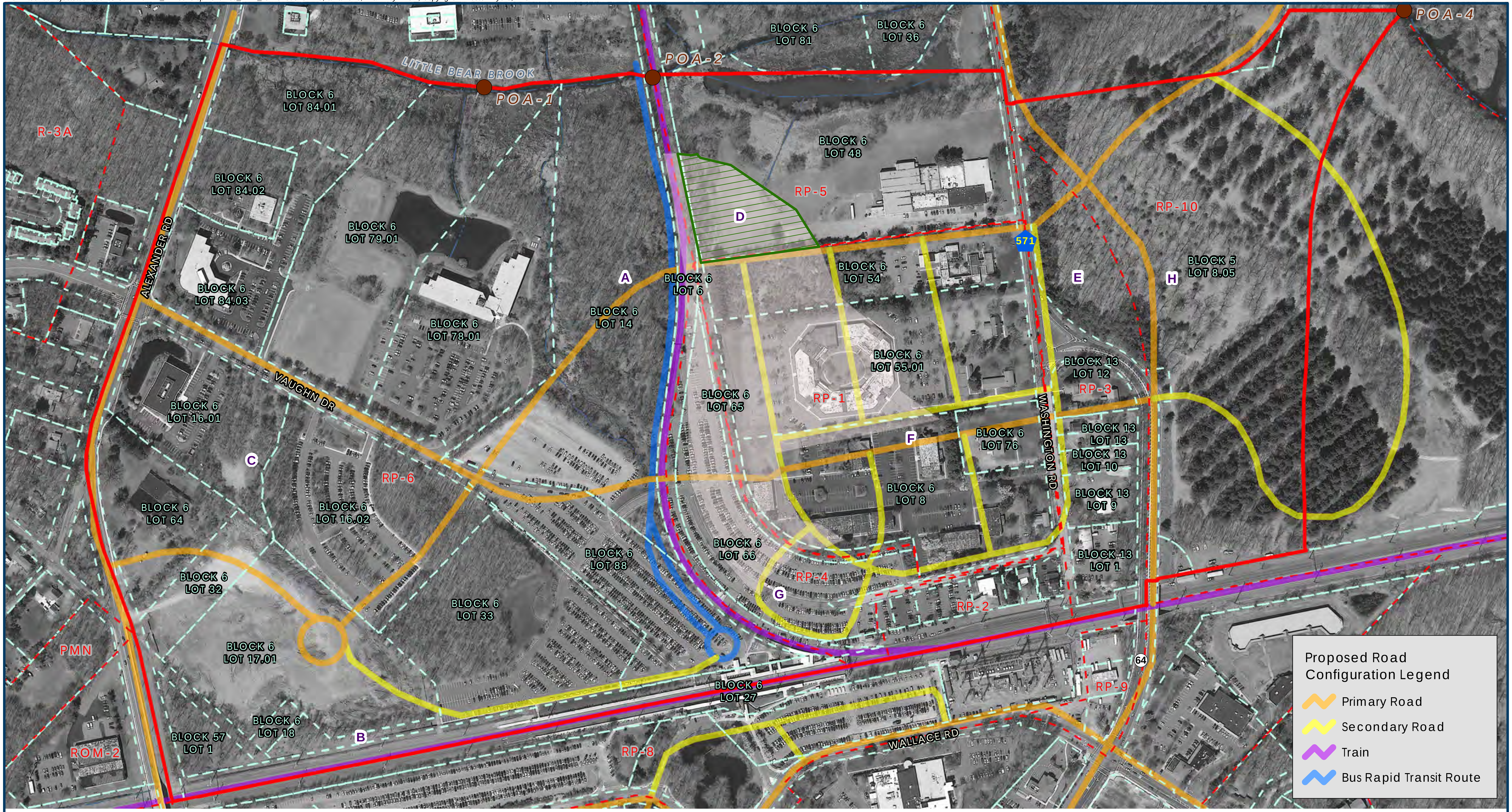

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FIGURE 23:
BMP D

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit
- BMP D Area
- BMP_D Drainage Area
- Point of Analysis

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP E:
BMP E is located within drainage area 3 to the east of the Washington Road (County Route 571) on Block 5, Lot 8.05 and within zone RP-3. The property is currently privately owned. The proposed BMP location is partially within the 1% Flood Hazard Area Limit, the Delaware and Raritan Canal Commission Buffer, as the presence of a Rank 3 State Endangered Species and is within the third tier of a well head protection area. The current land use is forest on Galestown soils which are somewhat excessively drained and have a high potential for groundwater recharge. Based on the soil series description the depth to the seasonal high water table is approximately 72 inches below grade. The existing elevation of this location could provide the water quality and quantity benefits necessary for a portion of the Redevelopment Area, likely drainage areas 3 and 4 and possibly portions of drainage area 2 with the appropriate drainage and piping network. The distance from and elevations of drainage area 1 would inhibit any runoff from this portion of the Redevelopment Area to be treated at this location.

Bioretention System:
The installation of a bioretention basin in this location is a possibility. However, pending a detailed soils investigation, the sizing of the system may need to be adjusted due to the determination of the seasonal high groundwater table. The BMP may need to be lined with clay or other impermeable material depending on the difference in elevation between the bottom of the bioretention system and seasonal high water table. If the system needs to be lined, the ability to recharge groundwater will be eliminated therefore requiring additional BMP considerations to address the necessary recharge. The depth to the groundwater table should not be an issue at this location as size of the BMP can be adjusted and the water table is anticipated to be six feet below grade.

Depending on the depth of planting bed media (typically 1.5 to 2 feet) and the types of vegetation to be planted the water quality benefit of the basin varies from 80% to 90%.

Constructed Wetland:
The constructed wetland would likely need to be lined with an impermeable liner in order to maintain the design hydraulics of the system. The design depths of the various types of wetland and wetland components vary from six inches to six feet depending on the designed plant community and if a pool is part of the design. This system also requires a forebay or other pretreatment and a minimum of two control structures. The control structures would be located between the pretreatment forebay and the wetland and the final outlet structure.

Due to the need for the liner and particular design hydraulics for the system, this practice would not be ideal to address groundwater recharge.

Extended Detention Basin:
Depending on final elevations and water volumes, an above ground extended detention basin should be feasible at this location. A typical basin will range from three to twelve feet deep with a minimum normal depth of three feet to minimize mosquito breeding and maximize effectiveness of the basin. The overall depth of the basin will be determined based on the volume needed to be retained, the inflow elevation(s) and the outflow elevation(s)/final discharge elevation. Based on the preliminary information that is known at this BMP site, it could be feasible to balance all of these elevations and provide the necessary detention. In addition, this type of system will not provide the necessary recharge.

Infiltration Basin:

BMP location E has the potential to be an ideal location for an infiltration basin as long as the depth to the groundwater table is sufficient and the soils have the required permeability rate. A forebay or other pre-treatment practice should be installed as well to reduce maintenance and the clogging potential of infiltrative surface. The depth of the basin will be dependent on the volume necessary to infiltrate as well as retain to address water quantity and recharge. The New Jersey BMP manual for infiltration basins requires a minimum of 0.5 inches per hour design permeability rate, this will require site specific soils investigation as part of the design stage.

0Wet Ponds:

BMP location E is an ideal location for a wet pond as it meets the minimum in flow drainage area and can meet the square footage requirements for permanent pool. The BMP would need to have an impermeable liner in order to maintain the permanent pool. A forebay or other pre-treatment practice is also required to reduce the accumulation of sediment and debris within the wet pond itself. Two control structures would be necessary: one between the forebay and the wet pond, and one as the discharge location of the wet pond. This type of system will not provide the necessary recharge.

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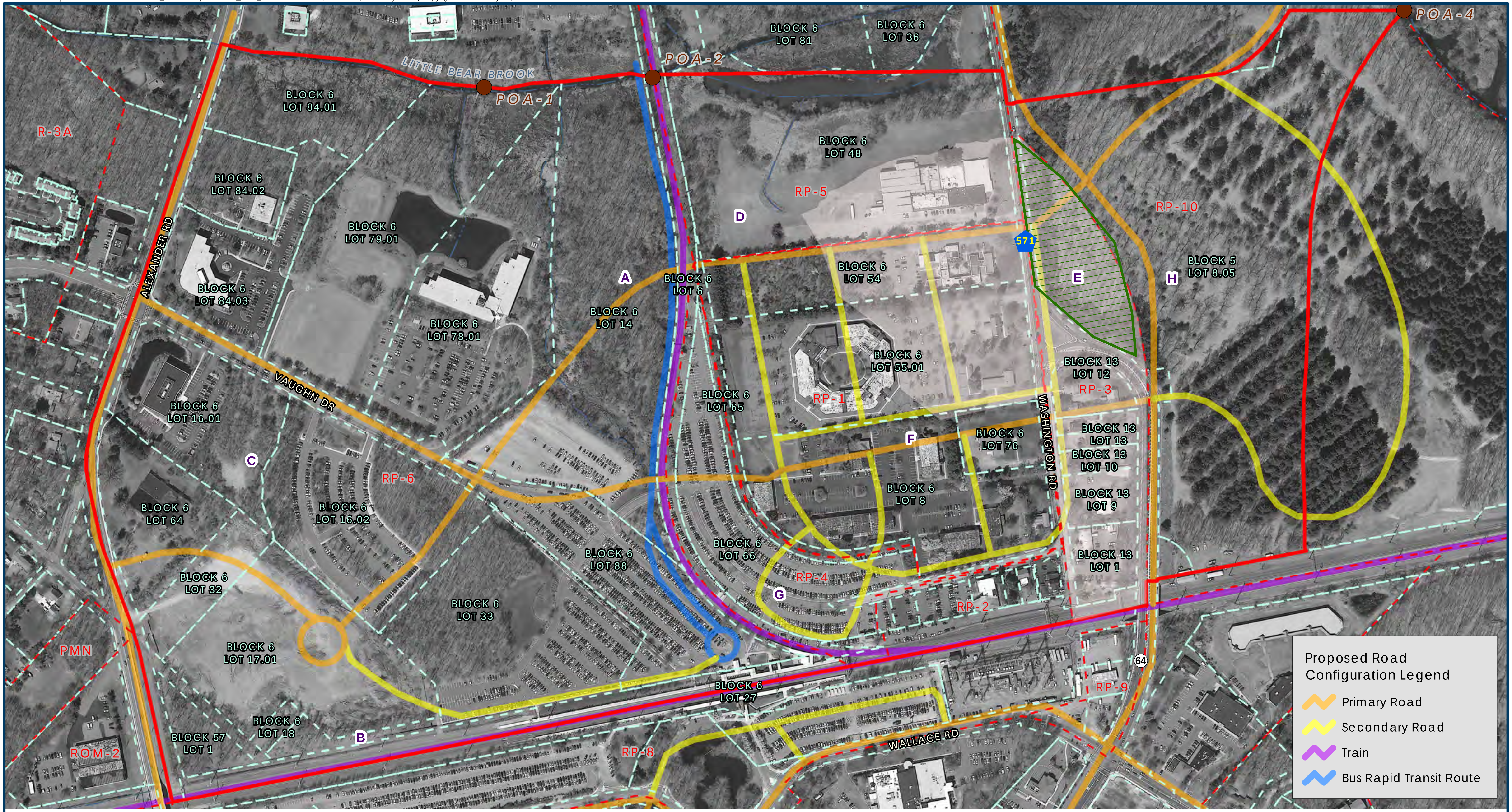

FIGURE 24:
BMP E

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet

0 150 300 Feet

Legend

Zoning Boundary
Project Area
Stream
Parcel Limit
BMP E
Area
BMP E Drainage Area
Point of Analysis

Princeton Hydro

NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP F:

BMP F is a linear section along a proposed roadway connecting Washington Road to the existing New Jersey Transit parking area. This BMP location is within drainage area 3, is privately owned, and on Block 6, Lots 55.01, 8 and 76. The current land use is part urban on Galestown soils which are somewhat excessively drained and have a high potential for groundwater recharge. Based on the soil series description, the depth to the seasonal high water table is approximately 72 inches below grade. This site is not the ideal location for a best management practice because:

- it is a small area making it difficult to create a BMP to maximize the treatment potential;
- located at the elevation top of the drainage area will make drainage into and out of the BMP difficult, and
- the redevelopment within this area is proposed to be downtown shopping with a park like setting between the traffic lanes. Small manufactured devices or below grade systems could be installed here. However these BMPs would serve a water quality treatment for a small a drainage area.

For these reasons, BMP location F will not be discussed in any additional sections of this report. It is a possible location; however, it is not recommended for any large scale water quantity BMP.

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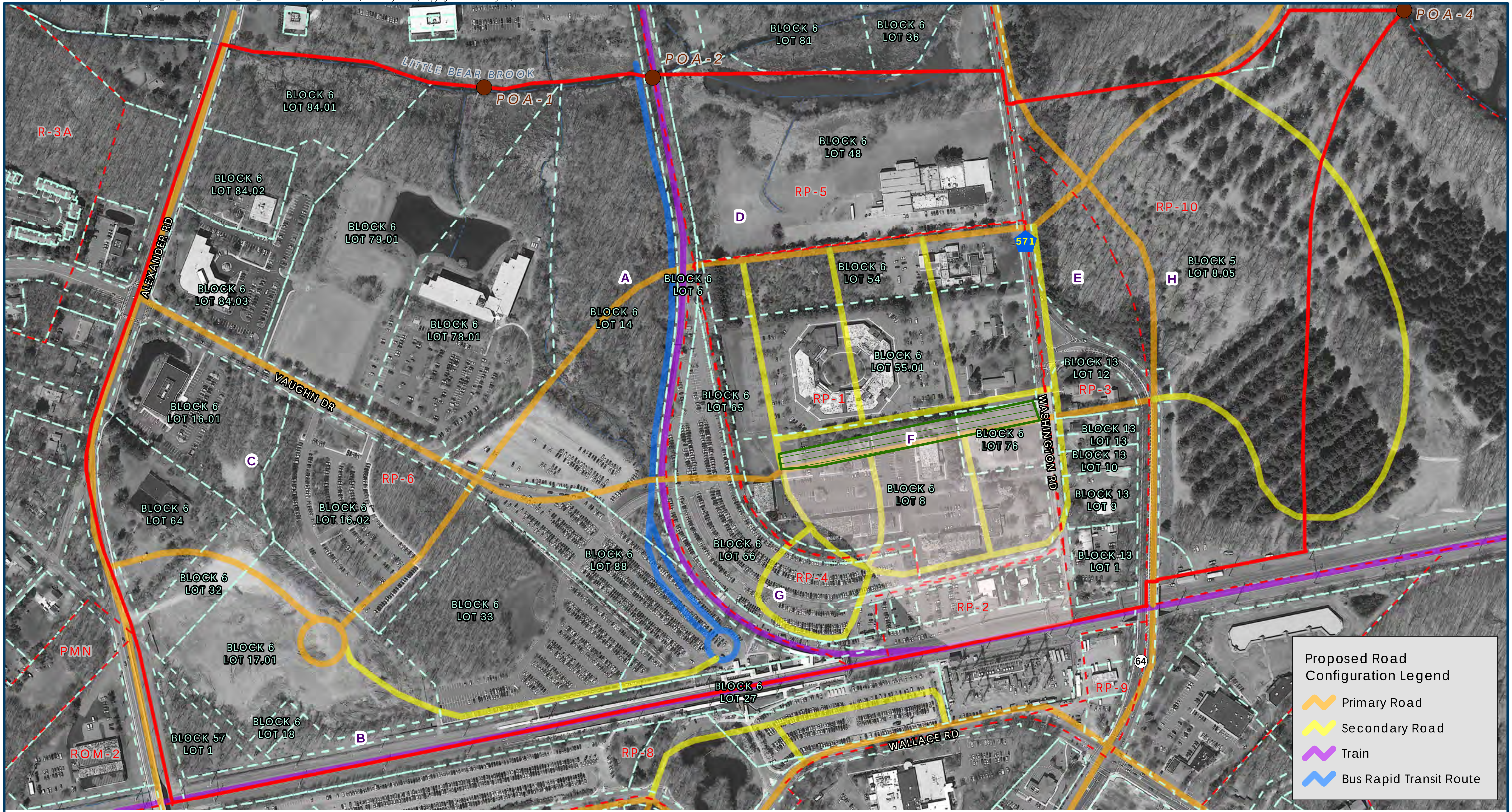


FIGURE 25:
BMP F

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet
0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit
- BMP F Area
- BMP_F Drainage Area
- Point of Analysis

Princeton Hydro

NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

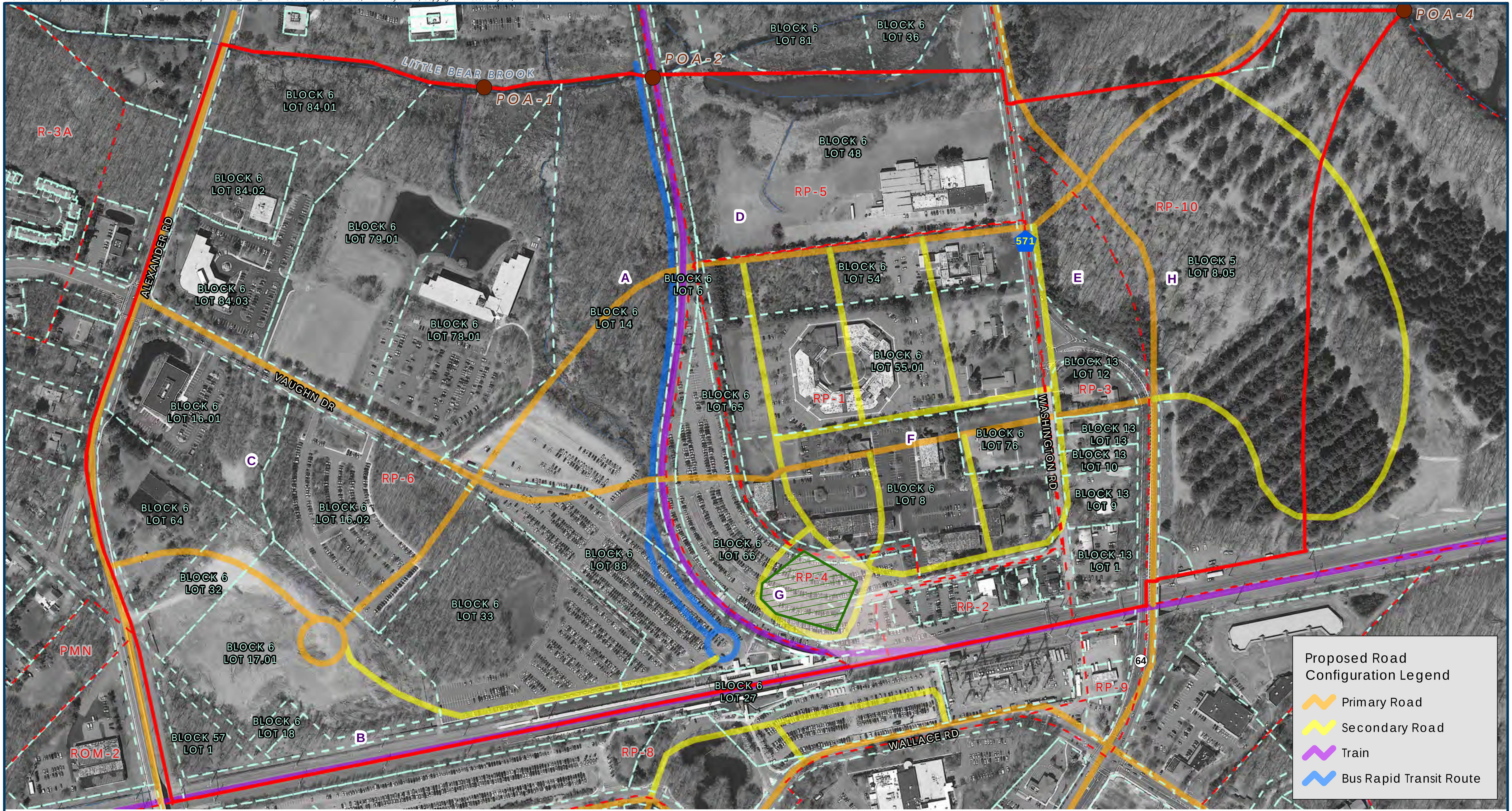
BMP G:

BMP G is located within drainage area 3 near the New Jersey Transit parking lot on Block 6, Lot 66 and within zone RP-4. The property is currently owned by New Jersey Transit. The current land use is urban on Udorthents soils which are somewhat excessively drained with minimal recharge potential. This site is not the ideal location for a best management practice because:

- it is a small area making it difficult to create a BMP to maximize the treatment potential;
- located at the elevation top of the drainage area will make drainage into and out of the BMP difficult, and
- the redevelopment within this area is proposed to be parking lots. A small BMP could be installed here to address the runoff from the immediate area. However, this would not provide the regional stormwater benefits for the entire Redevelopment Area.

For these reasons, BMP location G will not be discussed in any additional sections of this report. It is a possible location. However, it is not recommended for any large scale water quantity BMP.

File: P:\0020\Projects\0020004\GIS\MXD\BMP_G-RedvelopmentArea_BMP_rev20150310.mxd, 3/16/2015, Drawn by kklein, Copyright Princeton Hydro, LLC.



Princeton Hydro

FIGURE 26:
BMP G

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet
0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit
- BMP G Area
- BMP_G Drainage Area
- Point of Analysis

NOTES
1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
3. Proposed road configuration digitized from 'Township of West Windsor Redevelopment Plan for Princeton Junction' Figures I and L, March 23, 2009 (2009-04).
4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

BMP H:

BMP H is located within drainage area 4 to the east of Washington Road (County Route 571) on Block 5, Lot 8.05 and within zone RP-10. The property is currently privately owned. The proposed BMP location has the presence of a Rank 3 State Endangered Species and is within the third tier of a well head protection area. The current land use is forest on Galestown soils which are somewhat excessively drained and have a high potential for groundwater recharge. Based on the soil series description, the depth to the seasonal high water table is approximately 72 inches below grade. The existing elevation of this location could provide the water quality and quantity benefits necessary for a portion of the Redevelopment Area, likely drainage areas 3 and 4 and possibly portions of drainage area 2 with the appropriate drainage and piping network. The distance from and elevations of drainage area 1 would inhibit any runoff from this portion of the Redevelopment Area to be treated at this location.

Infiltration Basin:

BMP location H has the potential to be an ideal location for an infiltration basin as long as the depth to the groundwater table is sufficient and the soils have the required permeability rate. A forebay or other pre-treatment practice should be installed as well to reduce maintenance and the clogging potential of infiltrative surface. The depth of the basin will be dependent on the volume necessary to infiltrate as well as retain to address water quantity and recharge. The New Jersey BMP manual for infiltration basins requires a minimum of 0.5 inches per hour design permeability rate. This will require site specific soils investigation as part of the design stage.

Wet Ponds:

BMP location H is an ideal location for a wet pond as it meets the minimum in flow drainage area and can meet the square footage requirements for permanent pool. The BMP would need to have an impermeable liner in order to maintain the permanent pool. A forebay or other pre-treatment practice is also required to reduce the accumulation of sediment and debris within the wet pond itself. Two control structures would be necessary: one between the forebay and the wet pond, and one as the discharge location of the wet pond. This type of system will not provide the necessary recharge.

Bioretention System:

The installation of a bioretention basin in this location is a possibility. However pending a detailed soils investigation, sizing of the system may need to be adjusted due to the determination of the seasonal high groundwater table. The BMP may need to be lined with clay or other impermeable material depending on the difference in elevation between the bottom of the bioretention system and seasonal high water table. If the system needs to be lined, the ability to recharge groundwater will be eliminated therefore requiring additional BMP considerations to address the necessary recharge. The depth to the groundwater table should not be an issue at this location as size of the BMP can be adjusted and the water table is anticipated to be six feet below grade.

Depending on the depth of planting bed media (typically 1.5 to 2 feet) and the types of vegetation to be planted, the water quality benefit of the basin varies from 80% to 90%.

Constructed Wetland:

The constructed wetland would likely need to be lined with an impermeable liner in order to maintain the design hydraulics of the system. The design depths of the various types of wetland and wetland components vary from six inches to six feet depending on the designed plant community and if a pool is part of the design. This system also requires a forebay or other pretreatment and a minimum of two control structures. The control structures would be located between the pretreatment forebay and the wetland and the final outlet structure.

Due to the need for the liner and particular design hydraulics for the system this practice would not be ideal to address groundwater recharge.

Extended Detention Basin:

Depending on final elevations and water volumes, an above ground extended detention basin should be feasible at this location. A typical basin will range from three to twelve feet deep with a minimum normal depth of three feet to minimize mosquito breeding and maximize effectiveness of the basin. The overall depth of the basin will be determined based on the volume needed to be retained, the inflow elevation(s) and the final discharge elevation. Based on the preliminary information that is known at this BMP site, it could be feasible to balance all of these elevations and provide the necessary detention. In addition this type of system will not provide the necessary recharge.

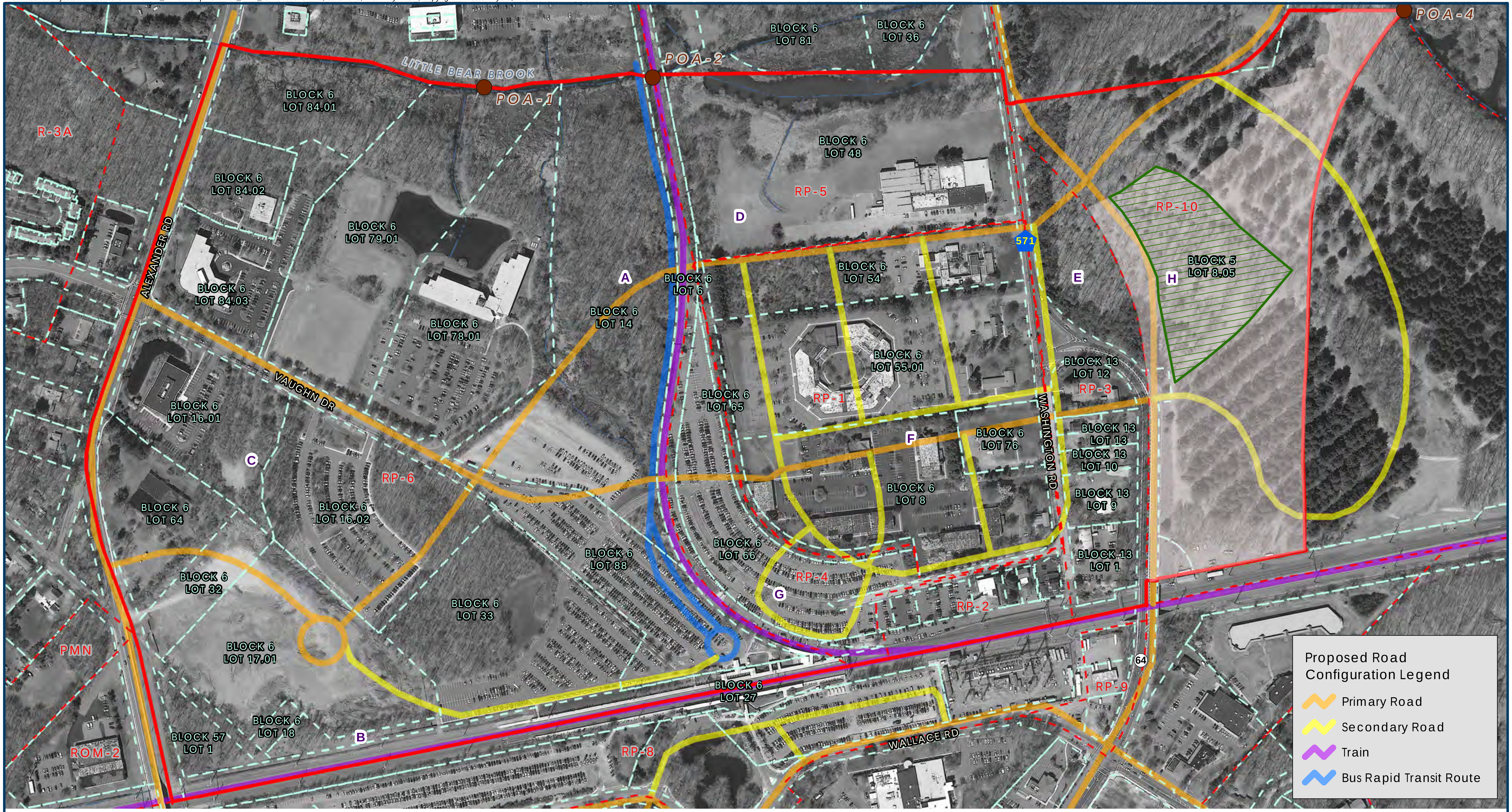


FIGURE 27:
BMP H

REGIONAL STORMWATER MANAGEMENT ANALYSIS
REDEVELOPMENT AREA
WEST WINDSOR TOWNSHIP
MERCER COUNTY, NEW JERSEY

1 inch = 300 feet
0 150 300 Feet

Legend

- Zoning Boundary
- Project Area
- Stream
- Parcel Limit
- BMP H Area
- BMP_H Drainage Area
- Point of Analysis

Princeton Hydro

NOTES

1. Zoning boundary, project area (RP zones 1 - 6; 10 partial), and parcel limits obtained from West Windsor Township.
2. Streams and water bodies obtained from NJDEP GIS website.
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4. 2012 orthoimagery obtained from NJGIN Information Warehouse.

Coordinate System: NAD 1983 StatePlane New Jersey FIPS 2900 Feet
Projection: Transverse Mercator

3.5 Regulations

A variety of ordinances, rules, and regulations currently exist to protect water quality in waterbodies throughout New Jersey originating from local municipalities to the federal government. The simple enforcement and implementation of these rules is going to be among the strongest tools in protecting the watershed in the future. Most of the existing regulatory framework regarding stream protection is focused on mitigating impacts related to future development and changes in land use.

The following section is a review of some of the more important regulatory measures related to environmental protection and redevelopment limitations which would apply to the Study Area during planning and/or implementation phases.

Stormwater Management Rules

The Stormwater Management Rules (N.J.A.C. 7:8) dictate a broad set of goals related to managing stormwater at a variety of governmental levels including municipalities, counties, regional and interstate commissions, and various state agencies. The basic goals of these rules are to: reduce flood damage, minimize increases in stormwater runoff, reduce soil erosion, maintain groundwater recharge, maintain stream channel integrity, reduce pollutant loading, and ensure proper design, performance, and maintenance of stormwater BMPs. It also encourages and provides guidance for the formulation of regional and municipal stormwater management plans and stormwater control ordinances. This set of rules, and the production of stormwater management plans, is primarily focused on stormwater management associated with major development, but may include stormwater management focused on upgrades and retrofits for existing land uses.

The Stormwater Management Rules provide special protection for C1 waters and mapped tributaries in the same HUC14 watersheds through the establishment of Special Water Resource Protection Areas (SWRPA). The SWRPA is a 300' buffer on both banks measured perpendicular to the top of bank or from the centerline of a stream with poorly defined banks applied to C1 waters. The purpose of the SWRPA is to limit encroachment in this buffer to preserve important ecological functions and any encroachment in the SWRPA shall be limited to areas of previous development or disturbance. Even when encroachment is allowed within the SWRPA the buffer shall not be reduced below 150'. This extends to the discharge of stormwater and no outfalls can be located within 150' of the stream.

Flood Hazard Area Rules

The Flood Hazard Area Rules (N.J.A.C. 7:13) are an expansive set of rules related to land uses, development, and other activities related to or located within flood hazard areas and riparian zones of regulated waters. The general intent of the rules is to minimize damage to life and property associated with flooding caused by development in flood hazard areas, preserve water quality, and protect wildlife and vegetation. The rules include a number of methodologies for determining flood hazard area and riparian zone and define regulated waters and regulated activities. Six methods are described for determining flood hazard areas in non-tidal waters; this is usually based on some derivation of the 100-year flood elevation with appropriate constraints. Riparian zones are also determined in various ways and vary in width from 50 feet to 150 feet or 300 feet.

Besides defining the limits of the flood hazard zones and regulated waters, it also defines regulated activities which range from in-stream activities to encroachment in the floodplain. A thorough understanding of regulated activities is important in assessing permitting requirements and the level of effort and detail needed to implement management alternatives for the watershed protection plan. It must be stressed that additional permits may be required to undertake regulated activities such as freshwater wetlands permits. Regulated activities are classified in four groups: permit-by-rule, general permit, individual permit and emergency permit.

Permit-by-rule is the least intensive class and requires no prior approval from the State, only a notification prior to initiating work. These activities are generally anticipated to have little to no impact to the riparian zone or increased chance of flooding when undertaken in compliance with the technical regulations by following specific instructions for each activity. Many of the proposed management activities considered as permit-by-rule include activities such as constructing an aquatic habitat enhancement device, conducting normal property maintenance, implementing soil conservation practices outside a floodway, and planting native vegetation.

General permits are required for the next class of activities. These types of activities are generally more intensive and may involve the use of heavy machinery or operating within the stream channel, and carry a higher burden of detail as well as prior approval from the State upon review. At a minimum these permits require submitting engineering or surveying plans sealed by the responsible party. These permits may also require obtaining additional permits and abiding by various other rules including the Standards for Soil Erosion and Sediment Control (N.J.A.C. 2:90). These activities include, but are not limited to, channel cleaning, constructing agricultural roadways and fords, wetlands restoration, outfall installation and maintenance, and repairing or relocating flood damaged structures. Each of the general permits is accompanied by a specific set of limitations to protect both the floodplain and the regulated activity.

Individual permits are issued for larger and more complex projects set within a regulated area or those that fall outside the purview of general permits. These activities include non-agricultural crossings, bank stabilization, stormwater discharges, construction activities, and utilities crossings. Permit submissions are also more complex and must include full engineering drawing sets, hydrology and hydraulic assessments, flood hazard area identification methodology, existing and final grading plans, construction methodology, and identifying and addressing potential impacts as well as many other requirements. Individual permits must satisfy not only all requirements related directly to the Flood Hazard Rules, but also satisfy Water Quality Management Planning Rules (N.J.A.C. 7:15). Individual permits will be required for in-stream restoration activities including bed and bank stabilization activities requiring grading or importing new materials or any activity related to disturbance of the channel or the riparian zone. Individual permits are enforced to protect flood storage capacity and other natural and constructed resources and functions, water supply, ecological functions, drainage, and navigation associated with waterbodies and flood hazard areas.

Emergency permits are issued to undertake regulated activities when immediate action is required to protect the environment and public safety, health, or welfare. Two basic conditions are linked to approval and the permit shall only be approved if severe environmental damage will occur or there is an immediate and high risk to public health and safety and there is a high probability that the impacts to the environment or public welfare will occur before a general or individual permit could be reasonably obtained. Again, these permits are related only to emergency activities and barring a catastrophic flood event.

Freshwater Wetlands Protection Act Rules

The Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A) are based in part on satisfying the Federal Water Pollution Control Act (Clean Water Act) regulations. In scope and function they are similar to the Flood Hazard Area rules and define identification methodology, regulated activities and permits. The end goal of these rules is to protect the integrity of freshwater wetland systems including habitat and hydrologic functions which are critical components of stream systems and watersheds. Some of the benefits associated with wetland systems include their habitat value to plant and wildlife communities, flood storage, mitigation of contaminated stormwater, stormwater storage (distinct from flood storage), and providing a buffer for streams in both the headwaters and lower in the basin.

Identification of freshwater wetlands is performed under the three-parameter approach that focuses on hydrology, soils, and plant communities. Wetland determination is subject to review by NJDEP and the findings published as a Letter of Interpretation (LOI) which defines presence or absence and the delineation of the wetland boundary. Wetlands are further defined as one of several classes, including Ordinary Resource Value, Intermediate Resource Value, and Exceptional Resource Value, which carry different regulatory weight with increasing protection for higher value resources. One of the variable protections associated with the different classes is the Transition Area width which increases with higher resource value wetlands to provide refuge and buffer the wetland.

Regulated activities associated with wetlands are similar to those defined for flood hazard areas and include disturbance from excavation, fill, dredge operations, drainage or disturbance of water stage or groundwater table, dumping, construction, or destruction of vegetation. These activities may be performed under several permit classes including general permits encompassing freshwater wetlands permits, open water fill, or transition area waivers, individual permits and emergency permits. There are a large number of general permits, nearly 30, that cover a variety of activities including maintenance of existing structures, utilities, channel cleaning, additions to existing structures, habitat creation and enhancement, trails, and bank stabilization among others. Individual permits may be granted for projects in which a combination of general permits is insufficient or have additional permit conditions that would not be sufficient to ensure compliance with the act. Emergency permits are granted on an emergency basis where there is an unacceptable threat to the environment, public safety, or property, and that there is not a reasonable expectation of receiving a general or individual permit before the anticipated threat.

New Jersey Pollution Discharge Elimination System Rules

The New Jersey Pollution Discharge Elimination System Rules (NJPDES, N.J.A.C. 7:14A) is similar to the federal National Pollution Discharge Elimination System, and is charged to protect potable water sources, the chemical, physical, and biological integrity of waterbodies, health and human safety, and ecological integrity from the discharge of pollutants. Regulated activities under the NJPDES rules include discharge to ground or surface waters, indirect discharge, land application of wastewater, animal feed operations, stormwater and storm sewers, site remediation, and wastewater treatment plants as well as other activities. Much of the enactment of the NJPDES rules is related to water quality based effluent limitations listed within the rules and related to other statutory vehicles such as the Surface Water Quality Standards. The effluent standards target a variety of pollutants and physicochemical parameters including nutrients, solids, floatables, petroleum hydrocarbons, microbes, temperature, and a large suite of additional parameters.

In addition to the broad categorization above, all municipalities and other agencies in the state are required to file for Municipal Separate Storm Sewer (MS4) permits related to storm sewers, draining roadways and public complexes. MS4 permits are granted on condition of satisfying the Statewide Basic Requirements (SBR) including public involvement and participation, reduction of pollutants, long-term operation and maintenance of BMPs, controlling solids and floatables, and implementing Municipal Stormwater Management Plans which are enacted through local ordinance, policy, or inclusion in the Master Plan.

The NJPDES rules are important for protecting both surface and groundwater resources from point and nonpoint source pollution. The NJPDES rules are directed mostly towards new development or redevelopment activities.

Soil Erosion and Sediment Control Act

Standards for Soil Erosion and Sediment Control (N.J.A.C. 2:90) are a set of engineering and construction management practices utilized to protect environmentally sensitive areas from the impacts of erosion. The management practices vary from vegetative swales to riprap protection to construction standards for dust and water control. Any disturbance greater than or equal to 5,000 square feet requires an approval from the county or multi-county based soil conservation district. Mercer County Soil Conservation District would have jurisdiction over any work completed within the Redevelopment Area.

Local Ordinances

Since the regional stormwater BMPs would likely be constructed at the specific request of the Township, it is not anticipated that any local approvals would be required for the BMP construction. Should the BMPs be constructed privately as part of the redevelopment, then the projects would be subject to review by any of the various existing West Windsor Township regulatory bodies. These include, but are not limited to: the Zoning Board of Adjustment, Planning Board, and Site Plan Advisory Board.

3.6 Concept Stormwater Management Practices Restrictions

Environmental Restrictions / Regulatory Approvals

BMP A

BMP A is located within the floodplain of the Little Bear Brook. Based on the FEMA FIRM, the 100 year storm elevation is 62 feet, which is higher than the ground elevation at the BMP location. As such, construction of the BMP in this location may require approval under the Flood Hazard Area Program. In addition, the BMP site will need to be evaluated for potential presence of freshwater wetlands and/or wetland transition areas. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP B

BMP B is located outside of regulated flood hazard areas, however, the potential exists that wetlands or wetland transition areas exist in the project site and a formal delineation would need to be undertaken to determine this. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan

Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP C

It is our opinion that no regulated flood hazard areas exist on the project site, so no Flood Hazard Area approval would be required for this BMP Area. The potential exists that wetlands or wetland transition areas exist in the project site and a formal delineation would need to be undertaken to determine this. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP D

BMP D is located within the floodplain of the Little Bear Brook. Based on the FEMA FIRM, the 100 year storm elevation is 62 feet, which is higher than the ground elevation at the BMP location. As such, construction of the BMP in this location may require approval under the Flood Hazard Area Program. In addition, the BMP site will need to be evaluated for potential presence of freshwater wetlands and/or wetland transition areas. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP E

BMP E is within the floodplain of both the Little Bear Brook and the Millstone River. Based on the FEMA FIRM the 100 Year storm elevation for the Little Bear Brook is 62 feet and the Millstone River is 61.5 feet. As such the NJ Flood Hazard Area Elevation is 63 and 62.5 feet respectively. Construction of the BMP in this location may require approval under the Flood Hazard Area Program. In addition, the BMP site will need to be evaluated for potential presence of freshwater wetlands and/or wetland transition areas. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP F

It is our opinion that no regulated flood hazard areas exist on the project site, so no Flood Hazard Area approval would be required. The potential exists that wetlands or wetland transition areas exist in the project site and a formal delineation would need to be undertaken to determine this. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP G

It is our opinion that no regulated flood hazard areas exist on the project site, so no Flood Hazard Area approval would be required for the BMP. The potential exists that wetlands or wetland transition areas exist in the project site and a formal delineation would need to be undertaken to determine this. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES –

Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

BMP H

BMP H may partially be located within the floodplain of the Millstone River. Based on the FEMA FIRM, the 100 year storm elevation is 61.5 feet. As such the NJ Flood Hazard Elevation is 62.5 feet. Construction of the BMP in this location may require approval under the Flood Hazard Area Program. In addition, the BMP site will need to be evaluated for potential presence of freshwater wetlands and/or wetland transition areas. This BMP is located in Zone B for DRCC regulations, so a permit may be required depending upon the final size of the BMP. In addition, a Soil Erosion and Sediment Control Plan Certification and NJPDES – Discharge of Stormwater during Construction Activities may be required depending upon the size of the final BMP in this area and the area of land disturbance.

Property Restrictions:

The property ownership of the possible BMP's locations is a possible concern for implementation. As shown in Table 10 above, the properties are either publically owned, privately owned or owned by NJ Transit/Amtrak. The ownership of the property could add extra layers of complication in order to implement/install the BMP at a particular location.

Public:

West Windsor Township currently owns and maintained the properties and they would not have an issue with the installation of a communal BMP or one that would provide the necessary treatment for multiple portions of the Redevelopment Area.

Private:

Private properties are currently owned by a developer, business, or individual. It will be complicated to enforce the installation of a communal best management practice on these privately owned properties. The Redevelopment Area zoning may work to the advantage of the township in acquiring these or portions of these properties for the BMP installation.

Rail Road:

The properties owned by the railroad (NJ Transit) will also result in added complications for the installation of a BMP; however, it is anticipated that they would cooperate with the Township. It is expected that the property would be acquired by the township via purchase or an easement or other access agreement would be obtained by the township in order to install the BMP(s) which would treat a large portion of the area.

Costs

Costs for Best Management Practices vary widely and depend upon many things. For general planning purposes, a cost discussion is included below for each of the BMPs evaluated in this report.

Bioretention System:

Engineered soil media is typically the largest expense associated with bioretention systems unless an underdrain system and liner is required. Smaller scale bioretention systems (e.g. rain gardens less than five acres in size) typically cost on the order of $15,000 to $650,000 to construct.

Constructed Wetlands:
Constructed wetlands systems have many elements that can add to the cost. In particular, the need for a liner, plantings, and complex outlet structures are all significant elements in terms of cost. Smaller scale constructed wetlands systems typically cost on the order of $50,000 to $750,000.

Extended Detention Basin:
These types of BMPs are fairly inexpensive to construct; however, the reduction in cost does not come without reduction in benefits. Extended detention systems do not provide any groundwater recharge or sufficient water quality benefits to comply with the current regulations. Smaller-scale extended detention basins (less than five acres in size) cost on the order of $10,000 to $400,000.

Infiltration Basin:
Infiltration basins are typically fairly inexpensive to construct. The most significant costs associated with infiltration basins are the placement of sand. Smaller-scale infiltration basins (less than five acres in size) cost on the order of $15,000 to $450,000.

Wet Ponds:
Wet ponds have several elements that add to the expense of these systems. Lining of the ponds and the complexity of the outlet structure add to the cost. Smaller-scale wet ponds (less than five acres in size) cost on the order of $50,000 to $500,000.

Maintenance

The long term effectiveness of all BMPs is regular and proper maintenance of each component of the improvement. This includes but is not limited to: the forebay or pre-treatment, headwalls, control structures, berms, vegetation, outlet structures, and open water areas. The maintenance for the possible BMPs are discussed below. Additionally, as part of the design a site and BMP specific maintenance manual shall be prepared.

Bioretention System:

General Maintenance:
All bioretention system components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, trash racks, low flow channels, outlet structures, riprap or gabion aprons, and cleanouts.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

Vegetated Areas:
Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass outside of the bioretention system should be mowed at least once a month during the growing season. Grasses within the bioretention system must be carefully maintained so as not to compact the soil, and through hand-held equipment, such as a hand held line trimmer. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should

also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health should not compromise the intended purpose of the bioretention system. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

Structural Components:

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

Other Maintenance Criteria:

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the ground surface in the bioretention system. This normal drain time should then be used to evaluate the system's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72 hour maximum is exceeded, the system's planting soil bed, underdrain system, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the system.

The planting soil bed at the bottom of the system should be inspected at least twice annually. The permeability rate of the soil bed material may also be retested. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken.

<u>Constructed Wetlands:</u>

General Maintenance:

All components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration. Components expected to receive and/or trap debris must be inspected for clogging at least twice annually. If a forebay is used in the pretreatment zone, it must be cleaned when it accumulates 6 inches of sediment, there is a 10% loss of forebay volume, or if it remains wet 9 hours after the end of a storm event. If using the optional bottom drain pipe, it must be sized to drain the permanent pool within 40 hours to allow excess sediments to be removed when necessary. Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations. All valves for maintenance must be clearly shown in the Operations and Maintenance Manual. Additionally, it must also be conspicuously stated that all valves are to remain closed except when necessary to perform specific activities, such as temporary drawdown or backflush.

Drains with lockable valves are required to allow the drawdown or backflush of wetland cells; these drains must be readily accessible.

Vegetated Areas:

Bi-weekly inspections are required when establishing/restoring vegetation. A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation. Vegetative cover must be maintained at 85%; damage in excess of 50% must be addressed through replanting in accordance with the original specifications. Pruning within the standard constructed wetlands must be performed on a regular schedule based on specific site conditions; perimeter grass should be mowed at least once a month during growing season. Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the remaining vegetation. The types and distribution of dominant plants must be assessed during the semi-annual wetland inspections, and an appropriate balance between original and volunteer species must be achieved in accordance with the intent of the system's original design. All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation health must not compromise the intended purpose of the standard constructed wetland.

Drain Time:

The approximate drain time for the various wetland pools to their normal standing water levels must be indicated in the maintenance manual. If the actual drain time is significantly different from the design drain time, the components that could provide hydraulic control must be evaluated and appropriate measures taken to return the wetland system to the design drain time.

<u>Extended Detention Basin:</u>

General Maintenance:

All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration. Components expected to receive and/or trap debris must be inspected for clogging at least twice annually. Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.

Vegetated Areas:

Bi-weekly inspections are required when establishing/restoring vegetation. A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation. Vegetative cover must be maintained at 85%; damage in excess of 50% must be addressed through replanting in accordance with the original specifications. Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the remaining vegetation. All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation health must not compromise the intended purpose of the extended detention basin.

Drain Time:

The approximate time it would normally take for the extended detention basin to drain the maximum design storm runoff volume and begin to dry must be indicated in the maintenance manual. If the actual drain time is significantly different than the design drain time, the basin's outlet structure, underdrain system and both groundwater and tailwater levels must be evaluated and appropriate measures taken to return the basin to minimum and maximum drain time requirements.

Infiltration Basin:

General Maintenance:

All infiltration basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding 1 inch of rainfall. Such components may include bottoms, riprap or gabion aprons, and inflow points. This applies to both surface and subsurface infiltration basins.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris, trash, sediment, and other waste material should be done at suitable disposal/recycling sites and in compliance with all applicable local, state, and federal waste regulations.

Studies have shown that readily visible stormwater management facilities like infiltration basins receive more frequent and thorough maintenance than those in less visible, more remote locations. Readily visible facilities can also be inspected faster and more easily by maintenance and mosquito control personnel.

Vegetated Areas:

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The structure must be inspected for unwanted tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established.

Once established, inspections of vegetation health, density, and diversity should be performed at least twice annually during both the growing and non-growing season. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides, and other means to assure optimum vegetation health must not compromise the intended purpose of the infiltration basin. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All vegetated areas should be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation and basin subsoil.

Structural Components:

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

Other Maintenance Criteria:

The maintenance plan must indicate the approximate time it would normally take to drain the maximum design storm runoff volume below the bottom of the basin. This normal drain or drawdown time should then be used to evaluate the basin's actual performance. If significant increases or decreases in the normal drain time are observed, the basin's bottom surface, subsoil, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the basin. This applies to both surface and subsurface infiltration basins.

The bottom sand layer in a surface infiltration basin should be inspected at least monthly as well as after every storm exceeding 1 inch of rainfall. The permeability rate of the soil below the basin may also be retested periodically. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken. Annual tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces.

Wet Ponds:

General Maintenance:

All wet pond components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive accumulation at least twice annually, or as needed; these components may include forebays, bottoms, trash racks, outlet structures, and riprap or gabion aprons. The forebay must be cleaned when it accumulates 6 inches of sediment, there is a 10% loss of forebay volume, or if it remains wet 9 hours after the end of a storm event. Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations. All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.

Vegetated Areas:

When establishing or restoring vegetation, inspections should be performed biweekly. Once established, inspections of health, density and diversity should be performed at least twice annually during both the growing and non-growing seasons. The vegetative cover must be maintained at 85%; if vegetation has greater than 50% damage, the area must be reestablished in accordance with the original specifications and the inspection requirement above. Mowing/trimming of vegetation must be performed on a regular schedule based on specific site conditions; perimeter grass should be mowed at least once a month during growing season. Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the remaining vegetation. All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation health must not compromise the intended purpose of the sand filter.

Drain Time:

The approximate time it would normally take to completely drain the Water Quality Design Storm volume above the permanent pool must be indicated in the maintenance manual. If the actual drain time is significantly different from the design drain time, the components that could provide hydraulic control must be evaluated and appropriate measures taken to return the wet pond to minimum and maximum drain time requirements. If the actual drain time is significantly different than the design drain time, the outlet structure and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements.

4.0 Recommendations

After analyzing the study area in preparation of this report, Princeton Hydro recommends the installation of a BMP combination at either locations A and D or E and H. The A and D combination has the ability to control runoff to the required regulatory standards due to the elevations of the proposed sites. It is suggested that a combination of a wet pond or constructed wetland be installed in combination with an infiltration basin at these sites. This combination will be able to address both groundwater recharge and water quantity. Property ownership for location D is a potential limitation; however, it is located in zoning area RP-5 which specifically states that one of the suggested uses is for open space and stormwater management.

BMPs at locations E and H have limitations in that only three (3) of the four (4) drainage areas could be directed to this location due to the ground elevations and slopes. Also, the site has multiple potential environmental constraints. Additionally, both BMP locations are currently owned by private entities. The BMPs recommended for this location are infiltration BMPs and/or bioretention basins.

Based on discussions with the Township, there are four (4) potential obstacles to the implementation of any regional BMPs at the present time. The first involves the acquisition of required land for a regional BMP and potential conflicts between the goals of the regional stormwater management plan and the land use rights of private property owners. The Township of West Windsor will need to make policy decisions on redevelopment such as negotiating agreements with private property holders or condemnation of private property, and cooperative agreements with NJ Transit for their properties. Having already indicated the location of the conceptual regional BMPs in the "West Windsor Redevelopment Area Regional Stormwater Management Analysis and Build-out Report" will help the Township identify which private properties might be affected and allow it to begin taking early steps to address such conflicts.

The second relates to the cost of implementing the regional stormwater management plan and the funding sources to do so in order that the cost burden does not fall solely on the taxpayers. Since, by ordinance, the individual owners within the study area are responsible to comply with the Township's stormwater management requirements when constructing a major development, the Township may seek to obtain funds from such property owners to construct a regional BMP in lieu of individual ones on each owner's development site. For example, both Somerset County and Princeton Township have previously collected an amount equal to the construction cost of a required onsite BMP from a site developer and used those funds to help pay for a regional BMP that served the proposed development. Such funds are deposited in an account dedicated to regional stormwater management in the watershed or subwatershed in which the contributing development was located. The account is subject to accounting and auditing requirements to insure that contributions are used as intended.

The third obstacle to regional stormwater management implementation is the issue of sequencing. As described above, regional stormwater management contributions have been sought and obtained in the past from site developers in lieu of construction required onsite BMPs. However, such contributions can only be accepted if one of the two following conditions can be met:

- The regional stormwater authority (i.e., the Township) in control of the account has already constructed the regional BMP that will serve the proposed development site or is prepared to undertake such construction in coordination with the proposed development's own construction; or

- The stormwater impacts of the proposed development on their own are not significant and will only gain significance when combined with the impacts of future developments. In this case, construction of the regional BMP can be postponed until such time as the cumulative effects of such development reaches such levels that warrant management actions.

It should also be noted that, if one of the above conditions cannot be met, it may be possible to reach an agreement with an early site developer to have that developer construct the regional BMP as part of the proposed site development. The developer would then be reimbursed from in-lieu contributions or fees collected by the Township from subsequent developments in the area served by the regional BMP.

The final obstacle to regional stormwater management implementation involves two types of potential regulatory conflicts between the Township and NJDEP. The first potential conflict is between the Township's desire to pursue regional stormwater management in the redevelopment area, and its obligations to address the stormwater impacts of land development as part of its Tier A Municipal General Stormwater Permit issued by the NJDEP. The Township's Municipal General Permit requires it to develop stormwater quality, stormwater quality and groundwater recharge requirements for major developments and insure that such requirements are met. Therefore, the Township needs to determine whether delaying construction of a regional BMP after its approval of a major development and/or accepting a contribution to a regional stormwater account in lieu of onsite stormwater BMPs is acceptable under the conditions of its Municipal General Stormwater Permit.

The second potential regulatory conflict could arise if a proposed development in the regional stormwater plan area requires both Township and NJDEP stormwater approval. In such cases, it is necessary to inform the NJDEP of the Township's regional stormwater goals, plans, intentions, and abilities so that review of the proposed development can be conducted by the NJDEP with similar goals and requirements in mind. As such, it is recommended that the Township request a meeting with the NJDEP to review the West Windsor Redevelopment Area Regional Stormwater Management Analysis and Build-out Report to discuss such potential conflicts and coordination of review goals. In doing so, it is important to note that developing a coordinated regional approach with the NJDEP may be simpler to achieve if the regional approach initially addresses only the stormwater quantity and/or groundwater recharge requirements of the Township's General Permit from the NJDEP and the NJDEP's own Stormwater Management Rules (NJAC 7:8) rather than include the federally-mandated stormwater quality requirements as well.

Because of this broader requirement on the federal level to address water quality, it is recommended that each project within the redevelopment provide for individual on-site measures to satisfy the stormwater quality requirements of that specific project. This is a simpler, more measureable goal than attempting to address water quality requirements on a regional level.

If the focus of the project shifts to include the control of some of the more frequent roadway flooding experienced in the area, then additional investigation would be needed. Of particular interest is the existing storm sewer network on the established roadways within the study area. Depending upon the elevations of the existing storm sewer networks, modifications to potential BMP locations as outlined in this report may be necessary.

To progress the implementation of any regional stormwater management BMPs within the study area, it will be necessary to conduct onsite soils investigations. The onsite soils investigations will allow for actual measurements of infiltration rates onsite, validate the seasonal high water table elevations to inform design. For the purposes of this report, no infiltration was assumed when establishing BMP depths at the various locations. In addition, it will be necessary to verify potential utility conflicts at the various BMP sites. Final engineering design would then need to be undertaken and permitting would need to be completed prior to construction of any regional BMP.