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# Stormwater Management Practices, Monitoring, and Maintenance Plan for US Army Garrison at West Point, NY

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April 2023

Environmental Laboratory

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# Abstract

Structural stormwater management practices (SMPs) are designed and installed with the goal of reducing runoff and improving water quality through a variety of built (e.g., underground chamber and filter systems), nature-based and natural features (e.g., rain gardens, swales). In compliance with Section 402 of the US Clean Water Act (CWA), US Army Garrisons at West Point MS4 operators are required to obtain a National Pollutant Discharge Elimination System permit or a New York State Pollutant Discharge Elimination System (SPDES). These permits require development of stormwater management plans to reduce pollutants to meet the appropriate water quality standards. Over 62 structural SMPs have been installed at the US Army Garrison (USAG) to meet permit requirements.

Monitoring and maintenance are essential to maintain and understand the effectiveness of these structures, track their maintenance needs, and improve their function. This document provides guidance for conducting stormwater management practice, inspection, and maintenance at the United States Army Garrison at West Point. The objectives are to inform installation managers on general SMP functions and designs, highlight key maintenance triggers affecting SMP functionality, and provide guidance on when and how to conduct inspections and maintenance actions specific to USAG SMPs and in accordance to NYS DEC.

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# Preface

This study was conducted for the US Military Academy at West Point under MIPR 11640311. The report benefited from peer review comments by Dr. Burton Suedel and Dr. Charles Theiling.

The work was led by the Ecological Resources Branch of the Ecosystem Evaluation and Engineering Division, US Army Engineer Research and Development Center–Environmental Laboratory (ERDC-EL). At the time of publication, Mr. Joseph Minter was chief, EE-E; Mr. Mark Farr was chief, EE; and Dr. Edmond Russo was EL director.

COL Christian Patterson was the commander of ERDC, and Dr. David W. Pittman was the director.

# 1 Introduction

## 1.1 Background

The US Clean Water Act (CWA) National Pollutant Discharge Elimination Systems (NPDES; 33 U.S. Code § 1342) permit program was created in 1972 to address water pollution from point sources under the direction of the US Environmental Protection Agency (USEPA). The success of the NPDES point source pollution program led to stormwater runoff and non-point source pollution becoming the primary contributors of water pollution in the United States (Lee et al. 2006). As urbanization increases, impervious surface areas and pollutants generated by anthropogenic activities increase, stormwater runoff carries more pollutants, and more water is discharged to water bodies inside the urban watersheds. In the urban context, some stormwater pollutants are suspended solids, heavy metals from vehicles and infrastructure (e.g., Cu, Zn, Cd), biodegradable organic matter (e.g., vegetation, fecal matter), nutrients from fertilizers (e.g., nitrogen and phosphorus), organic micropollutants from fuel, tires and asphalt, and plastics and floatables (Barbosa et al. 2012).

The CWA Amendment of 1987 addresses the non-point source pollution and stormwater runoff and set forth a phased approach to regulate municipal separate storm sewer systems (MS4s) through NPDES permits. MS4 permits require control and development of stormwater management plans to reduce pollutants to the maximum extent practical to meet the appropriate water quality standards defined by the permitting authorities (states and USEPA). Phase II small (<100,000 population) MS4 urbanized areas include non-traditional MS4s such as public universities (USEPA 2021).

## 1.2 Stormwater Management Practices (SMPs)

Stormwater management practices (SMPs) refer to a large family of stormwater control measures (e.g., Best Management Practices, Low Impact Development, and Green Infrastructure Practices) as defined by the New York State Department of Environmental Protection. Small MS4s are required to have minimum control measures that can be categorized into nonstructural and structural categories. Nonstructural SMPs include public involvement and education, identifying illicit discharges, trainings,

and policies that prevent stormwater pollution. Structural SMPs (e.g., detention ponds, sand filters, rain gardens) have a physical form and are designed to mitigate impacts of stormwater once generated. These SMPs are implemented in small MS4s with the goal of reducing stormwater runoff quantity and improving water quality to meet federal regulations and state water quality standards (USEPA 2000).

## 1.3 US Army Garrison West Point SMPs

The US Army Garrison (USAG) at West Point is located west of the Hudson River and approximately 50 miles north of New York City. USAG is a small MS4 with a daytime population of approximately 12,700, which includes cadets, active military personnel, civilian, and contract employees. The installations include academic facilities, barracks, shooting ranges, a transportation motor pool, a golf course, and other sports installations, a gas station, an exchange store, commissary, three fire stations (only two with direct impact on SMPs), three wastewater treatment plants, and residential areas.

In compliance with Section 402 of the CWA, USAG MS4 operators are required to obtain a NPDES permit or a New York State Pollutant Discharge Elimination System (SPDES) general permit in accordance with the Environmental Conservation Law, Article 17, Titles 7, 8 and Article 70. To meet permit requirements, there are over 62 structural SMPs installed at USAG, including swales, sand filters, rain gardens, underground filters and chambers, retention ponds, and detention ponds.

## 1.4 Objectives

This report provides guidance for conducting stormwater management practice, inspection, and maintenance at the United States Army Garrison at West Point. The objectives are to inform installation managers on general SMP functions and designs, highlight key maintenance triggers affecting SMP functionality, and provide guidance on when and how to conduct inspections and maintenance actions specific to USAG SMPs and in accordance with NYS DEC.

## 1.5 Purpose and approach

Regular inspection and maintenance activities are required to sustain long term effective performance of structural SMPs. The USAG West Point

SPDES permit No. GP-0-15-003 states that USAG must properly operate and maintain all facilities and systems of treatment and control. The SPDES requires an inventory of post-construction stormwater management practices installed since 10 March 2003 with the SMP procedures for inspection and maintenance per the New York State (NYS) Stormwater Design Manual, the Stormwater Pollution Plan, or other maintenance information. SMP inspection and maintenance schedules should consider the different SMP type's components and functionalities as well as the weather, climate, biological, hydrological, and geological conditions surround the SMPs.

This study addresses the inspection and maintenance of SMPs at the USAG West Point. Researchers conducted two field visits to inspect 62 SMPs at the installation, measure and record important design specifications, and evaluate maintenance needs for each SMP. This manual synthesizes this site-scale information with best available practices from the NYS Stormwater Design Manual (New York State Department of Environmental Conservation 2015), NYS Maintenance Guidance for SMPs (New York State Department of Environmental Conservation 2017), the USAG SPDES permit No. GP-0-15-003, guides from Contech Engineered Solutions®, and multiple stormwater maintenance and design manuals from adjacent states with similar weather to NYS (e.g., Connecticut, Pennsylvania, New Jersey, and Virginia).

# 2 Assessment of SMPs at the US Army Garrison (USAG) West Point

Structural SMPs were inspected, monitored, and evaluated across USAG West Point. This chapter describes the general approach to data collection and common maintenance issues at the installation.

## 2.1 Inspection approach

Stormwater SMPs were identified through a set of iterative procedures in consultation with the installation management team. A prior listing of sites and inspections was used as the initial basis for this analysis and sites were subsequently added through local knowledge of assets, and site-level investigation. This process ultimately identified 62 SMPs at the installation, each of which required detailed inspection and maintenance procedures. This comprehensive listing of SMPs was then inspected relative to historical information, desktop analyses (e.g., aerial photography, Google Earth), and site-scale assessment. Field assessments were conducted over two weeks in the fall of 2021 (Sep 13–117 and Oct 18–22) following standard field safety methods (Appendix A).

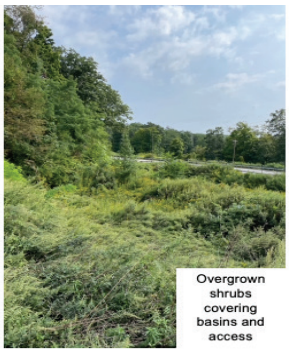
Each SMP was visited at least once and data were recorded in a rapid field assessment sheet. First, data was collected on the SMP location (i.e., GPS coordinates, general location, building numbers, road names), photographed the full SMP, specific components (e.g., outlets, inlets, inspection wells), and visually accessible maintenance issues (e.g., erosion, overgrown vegetation, invasive plants, trash, and debris). Second, basic SMP design characteristic data was collected. This included information on basin size, channel lining, substrate cover, vegetation type, measurements of inlets and outlets, and emergency spillway structures Third, information on SMP condition was collected, which included evidence of erosion, unusual water color and odor, evidence of oil, sediment accumulation, presence of invasive species and animal burrows, and structural damages to grates, pipes, or riser boxes. Fourth, the surrounding areas were visually inspected. These included maintenance access, water drainage areas leading to the SMPs, and surrounding water bodies of concern. We then created a database of findings in Excel and gave each SMP a unique identifier label. This information was condensed into a list of all SMPs and their common maintenance issues (Appendix B). Schematics of all SMPs were also created and have been documented in

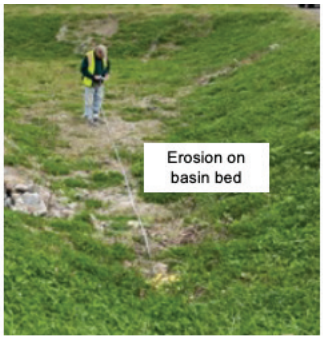
Appendix C. A subset of 15 SMPs were mapped to evaluate for drainage area that discharges into basins using GIS (Appendix D). Dominant plant species were also identified and documented for this subset of SMPs (Appendix D).

## 2.2 Common maintenance issues at USAG West Point

Some common maintenance issues that may cause safety concerns or reduce SMP performance can be visually inspected. General maintenance issues are listed and illustrated in Table 1. Common maintenance issues specific to each SMP at USAG West Point are catalogued in Appendix B. However, proper inspection and maintenance of all SMP components requires a more detailed assessment using the appropriate inspection and maintenance checklists in Chapter 3 for each structural SMP type.

Table 1. Common maintenance issues at USAG West Point.

| | |
|---|---|
| 1. **Clogging** – clogging of inlets and outlets with vegetative litter and rocks is a common issue that may cause serious problems in SMPs (e.g., overflowing, water stagnation, mosquito growth). This may occur more often in residential area SMPs. |   |
| 2. **Trash** – the presence of trash in basins is also conducive to problems in SMP water drainage and damage to inlets and outlets. This may also occur more commonly in residential areas or wherever there is more pedestrian activity. |  |
| 3. **Overgrown vegetation** – overgrown grasses or shrubs may obstruct water flow into an SMP, clog pipes, and affect drainage. It may also limit access around the SMP for inspection and maintenance. This may also create habitat for pests and animals carrying ticks. |   |

| | |
|---|---|
| 4. **Missing or broken grates/drain** – this may cause trash and large debris to get in the underground system, leading to structural damage, clogging, and ponding. Uncovered drains and pipes are also a human and domestic animal safety hazard, especially in residential areas or near sidewalks. |     |
| 5. **Erosion** – high stormwater runoff velocities and volumes may cause erosion to basin slopes, beds, and around inlets and outlets. If left untreated, this may cause structural safety issues. All outfall and bank stability problems should be corrected according to the NY Standards and Specifications for Erosion and Sediment Control (NYS Department of Environmental Conservation 2016). |     |
| 6. **Invasive plant species** – terrestrial and aquatic nonnative plant species outcompete native vegetation, cause diversity loss, habitat loss, affect water and soil quality, and cause changes in topography. If left untreated, they may damage or affect SMP structures and functionality. Common invasive plants in NYS are *Hydrilla, C*ommon reed, Eurasian watermilfoil, and Kudzu (NYS 2022). |   |

# 3 SMP Maintenance Plans

This chapter provides general information on the types of SMPs that are a part of the USAG West Point stormwater management system, the frequency in which inspection and maintenance should be conducted, and checklists for inspection procedures and maintenance actions for each. More information specific to USAG SMPs is available in the Appendices.

## 3.1 Chambers and filters

### 3.1.1 Chamber and filter functionality and components

Chambers and filters are underground stormwater detention systems that temporarily store and filter water to reduce stormwater quantity and improve quality (Figure 1). Underground Contech Engineered Solutions® stormwater management systems work to reduce stormwater runoff quantity and improve water quality by routing surface water through drains, chambers, weirs, inlets and outlets, corrugated pipes, bypass systems, and filters. Drains collect water from impervious surfaces and the chambers and corrugated pipes underground work as detention systems to slow down water and help pollutants settle to the bottom. Weirs inside the chambers use baffle walls to retain fluids and restrict outlet flows. Chambers may also contain StormFilter® cartridges that have filtering media to trap sediment, hydrocarbons, nutrients, metals, and other common pollutants (depending on design specifications). Baffle walls in chambers with filters may also be present in designed underground stormwater management systems to bypass flows when water discharge is too high to remain in chambers.

Figure 1. Example of the US Army Garrison (USAG) West Point chamber and filter underground systems.


### 3.1.2 Frequency of inspection and maintenance

As stated in Contech Engineered Solutions® maintenance guides (Contech Engineered Solutions LLC 2019a, 2019b, 2020, 2022), inspection is required periodically. In general, the company suggests at least one annual inspection and maintenance to be performed during dry weather if required after inspection. For the StormFilter® systems, an inspection should be performed before the winter season and after major storm events to check for potential damages caused by high flows and high sediment accumulation. The average maintenance lifecycle of StormFilter® cartridges is one to five years. If unsure whether filters need replacement, inspection during or after average storms might be needed per checklist and maintenance actions below. Inspection and maintenance should also be more frequent in systems typically more affected by storms or more problematic. Maintenance should also be performed in the event of a known chemical spill in the drainage area surrounding the stormwater system. Furthermore, the USAG SPDES GP-0-15-003 permit states that manhole sumps should be inspected in early Spring and late Fall for sediment and debris accumulation and should be removed if it fills more than 50% of the sump volume. A database of inspection and maintenance records should be ongoing. Table 2 summarizes general inspection and maintenance activity schedules for chambers and filters. Table 3 gives detailed inspection and maintenance actions.

Table 2. Chamber and filter maintenance schedule.

| Inspection Activity | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough chamber and filter inspection | Before Winter and after major storm | Annually* |
| Sediment and debris | Early Spring and late Fall | If sediment or debris fills sump volume >50% |
| Cartridge inspection | During or after average storm | After one to five years of new installation* |
| Chemical spill inspection | Time of spill | When spill occurs |
| Database records | Ongoing | After every inspection and maintenance action |

Table 3. Chamber and filter inspection and maintenance action checklist.

| SMP Component | Inspection Item | Indicator | Verification | Maintenance Action, If Yes |
|---|---|---|---|---|
| 1. Openings | Manhole cover condition | Damaged, cracked or missing | Y / N | Secure area to prevent accidents. Replace cover immediately with Contech Engineering Solutions. |
| | Manhole placement | Manhole not sealed by cover | Y / N | Adjust after inspection making sure manhole is safely sealed. |
| | Storm drain/grate | Obstructed | Y / N | Remove obstruction and dispose properly. |
| | | Damaged, cracked or missing | Y / N | Secure area to prevent accidents. Replace cover immediately with Contech Engineering Solutions. |
| 2. Vault | Vault condition | Accumulated liquid, sediment, or debris | Y / N | Record height of sediment accumulated. Record water level. If sediment on vault floor is > 4" or debris or sediment fill 50% of volume, use shovel or vaccuum truck to remove. |
| | | Presence of trash or vegetative litter | Y / N | Remove and dispose properly. |
| | Bypass condition | Water over internal outlet baffle wall during average rainfall event. | Y / N | Check for clogged inlet, outlet or weir. Check if filters need replacing. |
| | | Presence of trash or vegetative litter | Y / N | Remove and dispose properly. |
| | Corrugated metal pipe | Evidence of salting or de-icing agents | Y / N | Rinse system. |
| | | Presence of trash or vegetative litter | Y / N | Remove and dispose properly. |
| | | Damaged pipe | Y / N | Contact Contech. |

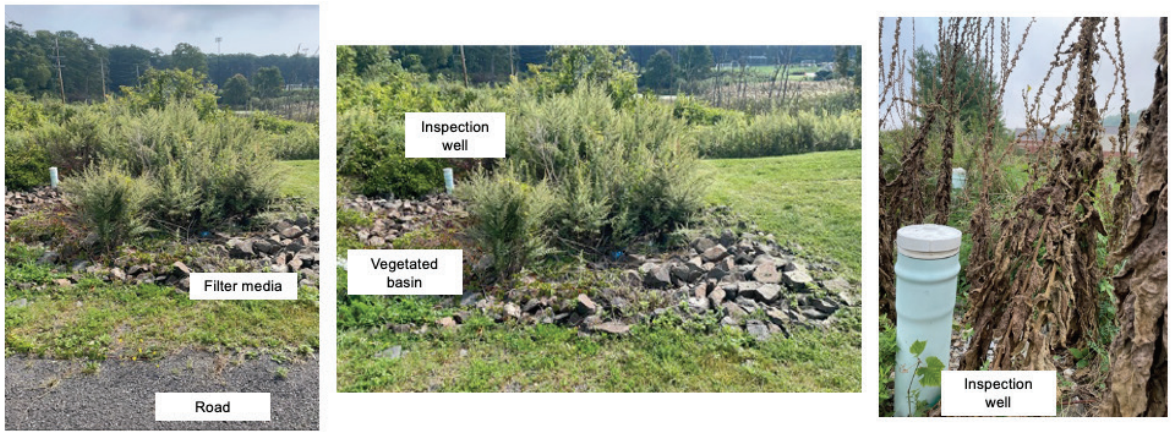
| SMP Component | Inspection Item | Indicator | Verification | Maintenance Action, If Yes |
|---|---|---|---|---|
| 3. Filters | Cartridge condition | Stagnant water >4" above cartridge bottom for > 24 hrs after rain event. | Y / N | Check for clogged inlet, outlet or weir. If problem remains, contact Contech for filter replacement ordering and installation and disposal instructions. |
| | | Sediment accumulated >1/4" on top of cartridge | Y / N | |
| | | Pronounced scum line ≥ 1/4" thick above top cap | Y / N | Contact Contech for filter replacement ordering and installation and disposal instructions. |
| | | Hazardous material release reported | Y / N | |
| 4. Inlet, outlet, or weir | Obstructed inlet, outlet or weir | Accumulated debris, vegetative litter, trash, or sediment | Y / N | Remove and dispose waste causing obstruction properly. Remove sediment. |
| | | Standing water higher than the lowest outlet | Y / N | |
| | Damaged structure | Sign of deterioration, corrosion, bending, or cracking | Y / N | Contact Contech to replace any damaged pipes. |

## 3.2 Sand filters

### 3.2.1 Sand filter functionality and components

Surface sand filters are shallow basins generally small in area and can be vegetated (Figure 2). The primary purpose of sand filters is water quality control within a small drainage area of impervious surface by removal of pollutants such as, bacteria, total suspended solids, and nutrients from runoff through soil percolation. Sand filters may be used in areas adjacent to other SMPs such as wet ponds as pretreatment SMPs (Pennsylvania Department of Environmental Protection 2006). Sand filters are lined with filter media that can be a mixture of sand, gravel, pebbles, cobbles, peat, or granulated activated carbon. Inlets and outlets in sand filters can be present in the form of pipes, direct surface flow (sheet flow) or curb cuts on the side of a road, parking lot, or sidewalk. Some filters can also have an underground component where an underdrain is installed and connected to a series of chambers that work as detention structures to settle pollutants before exiting the SMP (Raspati et al. 2017). In such cases, inspection wells made of PVC pipes may be installed as part of the SMP design to allow for evaluation of the underground conditions.

Figure 2. Example of sand filter components at USAG West Point.




### 3.2.2 Sand filter frequency of inspection and maintenance

Thorough inspection of all sand filter components should be conducted annually and trash and debris inspection should occur at least three times a year to avoid inlet or outlet clogging. Vegetation should be inspected during growing seasons (i.e., Spring to Fall). Mowing, trimming of shrubs, vegetation removal, and plant care should occur whenever vegetation is growing on more than 25% of filter (NYS Department of Environmental Conservation 2015) or when grass height is more than 12 in. (NYS Department of Environmental Conservation 2017). Accumulated sediment removal should occur when sediment is more than 2-in. deep and covers 20% or more of the filter basin. Sediment inspection and maintenance should also be triggered by storm events greater than 1 in. If standing water is present in the basin 48-72 hr after a storm event, further inspection is required to determine the source of clogging and subsequent maintenance (NYS Department of Environmental Conservation 2017). A database of inspection and maintenance records should be ongoing. Table 4 summarizes general inspection and maintenance activity schedules for sand filters. Table 5 is a detailed inspection and maintenance checklist.

Table 4. Sand filter inspection and maintenance schedule.

| Inspection Activity | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough filter inspection | Spring or Fall | Annually |
| Trash and debris inspection | Spring, Summer, and Fall | As needed after inspection |
| Vegetation inspection | Spring, Summer, and Fall | As needed after inspection |
| Sediment inspection | After storm event of >1 inch | As needed after inspection |
| Database records | Ongoing | After every inspection and maintenance action |

### 3.2.3 General sand filter inspection and maintenance

Activities may include but are not limited to:

- Following USAG safety regulations, DPW, and OSHA rules
- Inspecting inlets, outlets, and underdrain
- Assessing SMP components for erosion
- Trash, litter, debris removal, and sediment accumulation removal
- Vegetation maintenance
- Invasive species and pest control
- Keeping a database of inspection and maintenance activities

Table 5. Sand filter inspection and maintenance action checklist.

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 1. Inlets, Outlets | Erosion, rills, gullies | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Extend lining coverage from inlet/outlet slope to bed or surface of SMP. Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Apply seeds, mulch or matting |
| | Obstruction | Standing water, accumulated debris, sediment | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| | Grate | Missing or broken grate | Y / N | Repair or replace grate. |
| | Pipe | Bent, corroded or cracked pipe | Y / N | Repair or replace pipes per original measurement. |
| 2. Observation well | Obstructed well | Accumulated debris, sediment or trash | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| | Well lid | Missing or damaged lid | Y / N | Replace damaged lid. |
| | Well pipe | Bent, corroded or cracked pipe | Y / N | Repair or replace pipes per original measurement. |
| | Erosion around well | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Refill or patch holes with sediment. Reinstall geotextile and riprap. Apply seeds, mulch, or matting. |
| | Damaged or clogged underdrain | Standing water inside observation well 2 days after storm with no obstruction in well or outlet | Y / N | Check if outlet is clogged. If problem remains, clean the observation wells with high water pressure. If problem persists, the underdrain may be damaged and may need repair. |

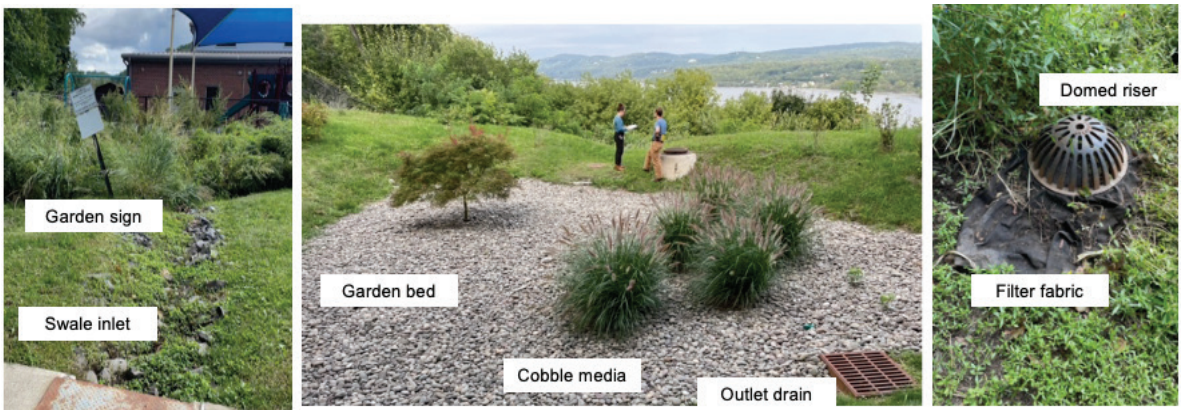
| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 4. Flow path (contributing drainage area) | Flow path entering or leaving SMP | Overgrown vegetation | Y / N | Trim, mow and clear excess vegetation. Dispose properly to avoid re-entry. |
| | | Debris, trash or sediment | Y / N | Remove and dispose properly to avoid re-entry to SMP. |
| 5. Ponding area | Standing water | Stagnant water >48-72 hrs after storm | Y / N | Check underdrain cleanout for clogging by pouring water in it. If water is static in underdrain, it is clogged and needs rinsing. If water leaves through outlet, then clogging is somewhere in the soil layer. Follow instructions in NYSDEC (2017) SMP maintenance guide for soil clogging instructions. |
| | Erosion, bare soil, | Bare soil, loss of vegetation or rip rap, exposed piped | Y / N | Check pipe flow obstructions and remove. Apply erosion control. |
| | Excessive sediment | Sediment > 2'' deep, covering >20% or more of bed | Y / N | Remove sediment and dispose to avoid re-entry. Check source and potential to remove or contain source. |
| | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| 6. Vegetation | Vegetation condition | Vegetation growth over 25% of filter or >12'' high | Y / N | Trim, mow, clear vegetation and dispose properly. |
| | | Grass clippings or vegetative litter | Y / N | Remove vegetative litter and dispose to avoid re-entry to SMP. |
| | Invasive plants | | Y / N | Refer to NYSDEC Nuisance an Invasive Species (2022) for regulation and control. Consult with local Cooperative Extension Office to identify invasive, identify appropriate control technique and properly dispose invasive plants. |
| 7. Surrounding areas | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Animal burrows | Holes in soil or bare patched | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| | Educational signage | Sign not legible, broken or missing parts | Y / N | Add, repair or replace signs. |
| | Maintenance access | Vegetation overgrown | Y / N | Trim, mow, and clear vegetation. Dispose properly. Apply water safe herbicide. |

## 3.3 Rain gardens

### 3.3.1 Rain garden functionality and components

Rain garden SMPs, also called bioretention operations, are categorized as stormwater infiltration practices that use engineered soils and vegetation to capture and treat runoff (Figure 3). Rain gardens capture and temporarily store runoff for water quality treatment in a shallow filter bed composed of sediment and organic matter (e.g., mulch). Filter fabric may be used to prevent fines from entering underlying soil. Filtered runoff may exit the rain garden if it includes an outlet and underdrain system or infiltrate further into the natural soil. A key component of rain gardens is landscaping with native vegetation (tolerant of hydrological variability, salts, and environmental stress) to aid in adsorption of pollutants, water infiltration, and evapotranspiration. Inlets include pipes, drains, curb cuts, sheet overflow, or other SMPs such as swales. Common outlets are domed risers, weirs, pipes, and underdrains (DDOE 2013).

Figure 3. Common rain garden components at USAG, West Point.




### 3.3.2 Rain garden frequency of inspection and maintenance

All rain garden components shall be inspected and maintained as needed annually. Silt and sediment should be removed from the filter bed when its accumulation exceeds two inches and covers 25% or more of surface. If designed with a mulch layer, it must be remulched annually to a total depth of two to three inches. Vegetation should be inspected during the growing seasons and replaced if dead or diseased. Grass height should not be greater than six inches (NYS Department of Environmental Conservation 2015). Invasive plant species should be inspected annually and controlled according to NYIS (NYS 2022). A database of inspection and maintenance records should be ongoing. Table 6 summarizes general

inspection and maintenance activity schedules for rain gardens. Table 7 gives detailed information on inspection and maintenance actions.

Table 6. Rain garden inspection and maintenance schedule.

| Inspection Activity | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough inspection | Spring or Fall | Annually |
| Trash and debris inspection | Spring, Summer, and Fall | At least 3 times a year |
| Vegetation inspection | Spring, Summer, and Fall | As needed after inspection |
| Database records | Ongoing | After every inspection and maintenance action |

Table 7. Rain garden inspection and maintenance action checklist.

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 1. Inlet, outlet | Erosion, rills, gullies | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Extend lining coverage from inlet/outlet slope to bed or surface of SMP. Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Apply seeds, mulching or matting as needed. |
| | Obstruction | Standing water, accumulated debris, sediment, overgrown vegetation | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| | Grate, dome riser | Missing or broken grate | Y / N | Repair or replace grate. |
| | Pipe | Bent, corroded or cracked pipe | Y / N | Repair or replace pipes per original measurement. |
| | Filter fabric | Damaged, torn, clogged with sediment | Y / N | Replace with new permeable fabric. |
| 2. Garden bed | Standing water | Stagnant water >48-72 hrs after storm | Y / N | Clear outlet if clogged. If problem persists, consult with engineer about structural or design problems. |
| | Erosion, bare soil | Bare or loose soil, loss of vegetation or riprap | Y / N | Check pipe clogs or flow obstructions and remove. Apply erosion control measures: Stabilize with lining (geotextile, riprap). Restore and compact soil. Reseed, apply mulch and replant as needed. |
| | Sediment accumulation | Sediment >2'' on bed and covers 25% or more of surface. | Y / N | Remove and dispose properly. Verify source. Note potential areas of improvement. |
| | Trash or debris | | Y / N | Remove trash or debris and dispose properly to avoid re-entry. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 3. Vegetation | Invasive species | Invasive species compose 10% of garden plant community. | Y / N | Refer to NYSDEC Nuisance an Invasive Species (2022) for regulation and control. Consult with local Cooperative Extension Office to identify invasive, identify appropriate control technique and properly dispose invasive plants. |
| | Vegetation condition | Diseased, dying or unhealthy plants. | Y / N | Remove and properly dispose plants. Consult with horticulturist or nursery to replant with appropriate or native plants, identify problem (plague, water quantity, fertilizers) and correct as needed. |
| 4. Flow path (contributing drainage area) | Flow path entering or leaving SMP | Overgrown vegetation | Y / N | Trim, mow and clear excess vegetation. Dispose properly to avoid re-entry. |
| | | Debris, trash or sediment | Y / N | Remove and dispose properly to avoid re-entry to SMP. |
| 5. Surrounding areas | Trash or debris | | Y / N | Remove trash or debris. Dispose properly to avoid re-entry. |
| | Animal burrows | Holes in soil or bare patched | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| | Educational signage | Sign not legible, broken or missing parts | Y / N | Add, repair or replace signs. |
| | Maintenance access | Vegetation overgrown | Y / N | Trim, mow, and clear vegetation. Dispose properly. Apply water safe herbicide. |

### 3.3.3 General inspection and maintenance for rain gardens

- Following USAG safety regulations and OSHA rules
- Inspecting inlets and outlets for clogging or structural damage
- Assessing SMP if standing water present after 72 hr of rain event
- Trash, litter, and debris removal
- Sediment accumulation removal
- Vegetation maintenance
- Invasive species and pest control
- Following landscape maintenance plan
- Keeping a database of inspection and maintenance activities

## 3.4 Swales

### 3.4.1 Swale functionality and components information

Swales are trapezoid or parabolic open channels that are mainly lined with grass or stone with low side and longitudinal channel slopes to avoid erosion (Raspati et al. 2017). Their purpose is to reduce sediment and pollutant transport by lowering runoff velocity and increasing soil infiltration. Inlets can be designed in the form of defined pipes but also in the form of sheet flow to increase time of concentration or a combination of both. Outlets are usually defined pipes leaving the swale. Vegetation and substate mixes of large cobbles and boulders can also be implemented in designs to help increase time of concentration, stabilize soil, and increase soil infiltration. Stony or grass swales are sometimes used as alternatives to concrete drainage systems, roadway median, and curb and gutter systems.

Figure 4. Example of stony and grass swale components at USAG West Point.


### 3.4.2 Swale frequency of inspection and maintenance

Thorough inspection of all swale components should be conducted annually. Inspection should occur in early spring, especially if large amounts of snow fell during the winter. Trash and debris obstruction may be problematic in swales, compromising water inflow and outflow; therefore, inspection and removal should be conducted at least once during the spring, summer, and fall. Vegetation inspection and maintenance should be conducted from Spring to Fall (growing seasons). Invasive plants should be identified and removed. A database of inspection and maintenance records should be ongoing. Table 8 summarizes general

inspection and maintenance activity schedules for swales. Table 9 provides instruction on inspection and maintenance.

Table 8. Swale inspection and maintenance schedule.

| Inspection Activity | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough swale inspection | Early Spring or Fall | Annually |
| Trash and debris inspection | Summer, Fall, and Spring | As needs after inspection |
| Vegetation inspection | Spring, Summer and Fall | As needed after inspection |
| Database records | Ongoing | After every inspection and maintenance action |

Table 9. Swale inspection and maintenance action checklist.

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 1. Inlets, outlets | Erosion, rills, gullies | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Extend lining coverage from inlet/outlet slope to bed or surface of SMP. Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Apply seeds, mulch or matting as needed |
| | Obstruction | Standing water, accumulated debris, sediment, overgrown vegetation | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| | Pipe | Bent, corroded, or cracked pipe | Y / N | Repair or replace pipes per original measurement. |
| 2. Basin bed | Standing water | | Y / N | Clear outlet if clogged. If problem persists, consult with engineer about structural or design problems. |
| | Erosion, bare soil | Bare or loose soil, loss of vegetation or riprap | Y / N | Check pipe clogs or flow obstructions and remove. Apply erosion control measures: Stabilize with lining (geotextile, riprap). Restore and compact soil. Reseed, apply mulch and replant as needed. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| | Sediment accumulation | Accumulated sediment or debris that may cause clogging or flow obstruction | Y / N | Remove and dispose properly. Verify source. Note potential areas of improvement. |
| | Trash or debris | | Y / N | Remove trash or debris and dispose properly to avoid re-entry. |
| | Plant litter | Grass clippings or vegetative litter | Y / N | Remove plant litter and dispose to avoid re-entry to SMP. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| 3. Vegetation | Grass height | Grass growth over 6” | Y / N | Trim, mow, clear vegetation and dispose properly. |
| | Invasive plants | | Y / N | Refer to NYSDEC Nuisance an Invasive Species (2022) for regulation and control. Consult with local Cooperative Extension Office to identify invasive, identify appropriate control technique and properly dispose invasive plants. |
| 4. Basin embankments | Erosion | Loss of vegetation on side slope or bottom of swale, bare soil, channelization, gullies, rills | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| 5. Flow path (contributing drainage area) | Flow path entering or leaving SMP | Overgrown vegetation | Y / N | Trim, mow and clear excess vegetation. Dispose properly to avoid re-entry. |
| | | Debris, trash, or sediment | Y / N | Remove and dispose properly to avoid re-entry to SMP. |
| 6. Surrounding areas | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Animal burrows | Holes in soil or bare patched | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| | Educational signage | Sign not legible, broken, or missing parts | Y / N | Add, repair, or replace signs. |
| | Maintenance access | Vegetation overgrown | Y / N | Trim, mow, and clear vegetation. Dispose properly. Apply water safe herbicide. |

### 3.4.3 General inspection and maintenance

Activities for this may include but are not limited to:

- Following USAG safety regulations, DPW, and OSHA rules
- Inspecting inlets and outlets for clogging
- Assessing SMP components for erosion
- Trash, litter, and debris removal
- Sediment accumulation removal
- Vegetation maintenance
- Invasive species and pest control
- Keeping a database of inspection and maintenance activities

## 3.5 Detention basin

### 3.5.1 Detention basin functionality and components information

Dry detention basins are excavated or impounded (when berm or dam is included in the design) basins that maintain water volume storage (usually 24–72 hr) to control peak water flows and allow solids to settle (Massachusetts Department of Environmental Protection 2004). Detention time can be extended with lengthened flow paths, internal berms, elevated stage outlets, and vegetation. Dry detention basins may also be designed in combination with other SMPs such as swales to help remove other pollutants and slow water velocity going into the basins. Inlets could be considered part of another SMP (e.g., a vegetated swale), surface overflow, drains, and pipes with riprap aprons or other energy dissipators. Outlet structures are typically staged having pipes at different heights in an outlet control structure made of concrete with grated tops or trash racks (Virginia Department of Transportation 2016).

Figure 5. Detention basin components.

### 3.5.2 Detention basin frequency of inspection and maintenance

Thorough inspection of all detention basin components should be conducted annually. Trash and debris inspection and maintenance should occur at least three times a year (e.g., Spring, Summer, and Fall) and after every storm greater than one inch, especially in residential areas where clogging of inlets and outlets is a common problem. This includes inside outlet control structures. Vegetation inspection and identified maintenance needs (e.g., mowing, trimming, removal) should occur during growing seasons (Spring to Fall) to ensure no overgrowth (of invasives and non-invasives) and no obstruction of water paths, inlets, outlets, and proper maintenance access. Invasive species should be inspected and controlled according to New York State Invasive Species (NYS 2022). Sediment should be removed from basins as needed at least every 5 to 25 years (Philadelphia Water Department 2020). Furthermore, the USAG SPDES GP-0-15-003 permit states that catchment basin sumps should be inspected in early Spring and late Fall for sediment and debris accumulation and should be removed if it fills more than 50% of the sump volume. A database of inspection and maintenance records should be ongoing. Table 10 summarizes general inspection and maintenance activity schedules for dry detention basins. Table 11 is a detailed checklist of inspection and maintenance actions.

Table 10. Dry detention basin inspection and maintenance schedule.

| Inspection Activity | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough inspection | Spring or Fall | Annually |
| Trash and debris inspection | Spring, Summer, and Fall<br>Or after every storm >1 inch | At least 3 times a year<br>Or when storm > 1 inch occurs |
| Vegetation inspection | Spring, Summer, and Fall | As needed after inspection |
| Sediment inspection | As needed | At least every 5 to 25 years |
| Sediment and debris (catch basin sumps) | Early Spring and Late Fall | If sediment or debris fill >50% of sump volume |
| Database records | Ongoing | After every inspection and maintenance action |

Table 11. Detention pond inspection and maintenance action checklist.

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 1. Inlets, outlets | Erosion | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Extend lining coverage from inlet/outlet slope to bed or surface of SMP. Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Compact soil around pipe. Apply seeds, mulching or matting as needed. Reenforce with compacted soil or sandbags if undercutting occurs. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Obstruction | Standing water, accumulated debris, sediment, overgrown vegetation | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| 2. Outlet control riser box and spillway | Concrete damaged | Cracks, missing pieces | Y / N | Report damage to MS4 coordinator. Repair if damage possibly interfering with structure's function. Consult with engineer if structural integrity concerns (major spalling >1" and rebars exposed). |
| | Damaged or missing grate | Deteriorated grate, broken or missing pieces | Y / N | Report to MS4 coordinator. Replace or fix. |
| 3. Basin bed | Standing water | Stagnant water present after 72 hours of storm, presence of algae | Y / N | Clear outlet if clogged. If problem persists, consult with engineer about problems with design or structure. |
| | Erosion, bare soil | Bare or loose soil, loss of vegetation or riprap | Y / N | Check pipe clogs or flow obstructions and remove. Apply erosion control measures: Stabilize with lining (geotextile, riprap). Restore and compact soil. Reseed, apply mulch and replant as needed. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Sediment accumulation | Accumulated sediment or debris that may cause clogging or flow obstruction | Y / N | Remove and dispose properly. Verify source. Note potential areas of improvement. |
| | Trash or debris | | Y / N | Remove trash or debris and dispose properly to avoid re-entry. |
| | Plant litter | Grass clippings or vegetative litter | Y / N | Remove plant litter and dispose to avoid re-entry to SMP. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| 3. Vegetation | Grass height | Grass growth over 6” | Y / N | Trim, mow, clear vegetation and dispose properly. |
| | Invasive plants | | Y / N | Refer to NYSDEC Nuisance an Invasive Species (2022) for regulation and control. Consult with local Cooperative Extension Office to identify invasive, identify appropriate control technique and properly dispose invasive plants. |

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 4. Basin embankment | Erosion or bare soil | Loss of vegetation on side slope or toe, bare soil, undercutting | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Seepage, soft spots, sink holes | Water flow out of dam, oversaturated or sunken areas | Y / N | Report to MS4 coordinator immediately. May result in bank failure and safety risk. |
| | Woody vegetation on embankment slopes | Trees, bushes, roots growing on the bank sloped | Y / N | Remove woody vegetation growth on slope or toe. Verify potential root damage to basin. Refill holes. Apply erosion control as needed. |
| 5. Flow path (contributing drainage area) | Flow path entering or leaving SMP | Overgrown vegetation | Y / N | Trim, mow, and clear excess vegetation. Dispose properly to avoid re-entry. |
| | | Debris, trash, or sediment | Y / N | Remove and dispose properly to avoid re-entry to SMP. |
| 6. Surrounding areas | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Animal burrows | Holes in soil or bare patched | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| | Educational signage | Sign not present or legible, broken, or missing parts | Y / N | Add sign if not present. Repair or replace existing signs. |
| | Maintenance access | Vegetation overgrown impeding access to outlets, inlets, emergency spillways and weirs | Y / N | Trim, mow, and clear vegetation prioritizing path to outfalls, inlets, emergency spillway and forebay. Dispose properly. Apply water safe herbicide. |

### 3.5.3 General inspection and maintenance

- Following USAG safety regulations and OSHA rules
- Inspecting inlets and outlets for clogging or structural damage
- Assessing SMP if standing water present after 72 hr of rain event
- Assessing SMP components for erosion (cracking, bulging, and sliding)
- Trash, litter, and debris removal
- Sediment accumulation removal
- Vegetation maintenance
- Invasive species and pest control
- Clearing maintenance access
- Keeping a database of inspection and maintenance activities

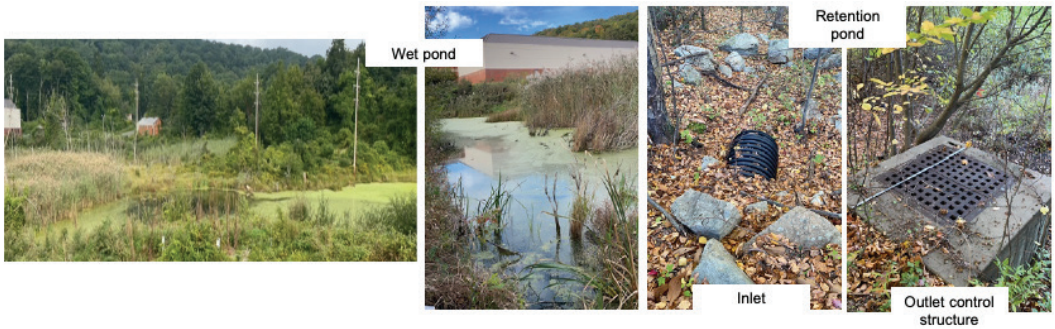
## 3.6 Retention ponds and wet ponds

### 3.6.1 Retention and wet pond functionality and components

Retention ponds and wet ponds are stormwater basins designed to retain water for extended periods of time (more than 72 hr) by having a large contributing watershed with either an impermeable liner or an elevated water table without a liner. Their objective is to reduce stormwater runoff and reduce suspended pollutants by settling them to the bottom of the pond and allowing them to go through processes like sediment adsorption and bacterial and aquatic fungal decomposition. Retention ponds are designed to focus mainly on attenuating peak stormwater runoff, while wet ponds accumulate water over time and hold water for longer periods of time in the basin at a standard level. The outfall structures in retention ponds are designed to be at a level high enough to allow additional storage volume, above the level of a wet pond, that eventually exits the structure when it reaches the outfall height. Wet ponds are typically designed to have longer water residence time.

Some typical components of wet ponds and retention ponds are inlets, forebays to capture sediment load (e.g., earthen berms, concrete weirs, or gabion baskets), a basin, outlets, a drain, maintenance access, and some may have emergency spillways (especially if designed as an online SMP). Other SMPs such as sand filters can be used as upstream pretreatments instead of forebays (NYS Department of Environmental Conservation 2015). Pond designs also include vegetation inside the pool and in the surrounding areas to stabilize pond edges, enhance pollutant uptake, and for general aesthetics (The Connecticut Department of Environmental Protection 2004). Pond buffers are required in NYS and must extend 25 ft from the maximum water surface elevation of the pond (NYS Department of Environmental Conservation 2015).

Figure 6. Wet pond and retention pond components.



### 3.6.2 Wet pond and retention pond frequency of inspection and maintenance

Thorough inspection of all pond components should be conducted annually. Trash and debris inspection and maintenance should occur at least three times a year (e.g., Spring, Summer, and Fall). Mowing of maintenance access leading to forebay, inlet and outlet structures, and the embankment is required annually. Sediment in the forebay and pond needs to be removed every five to six years or whenever 50% of the storage capacity has been lost (NYS Department of Environmental Conservation 2015). Ponds should not be drained during Spring to avoid negative downstream effects caused by acidic and anoxic water. Wet ponds and retention ponds may become breeding habitat for mosquitoes and favorable habitat for invasive aquatic plant species, such as phragmites. Invasive plant species should be inspected annually and controlled according to the NYS invasive species guidance (NYS 2022). A database of inspection and maintenance records should be ongoing. Table 12 summarizes general inspection and maintenance activity schedules for dry detention basins. Table 13 is a detailed checklist of inspection and maintenance actions.

Table 12. General inspection and maintenance activity schedules for dry detention basins.

| Inspection | Time of year | Maintenance Frequency |
|---|---|---|
| Thorough inspection (all structural components) | Spring or Fall | Annually |
| Trash and debris | Spring, Summer, and Fall Or after every storm >1 inch | As needed after inspection Or when storm > 1 inch occurs |
| Vegetation | Spring, Summer, and Fall | As needed after inspection |
| Invasive plant species | Spring, Summer, or Fall | Annual removal |
| Sediment | As needed | Every 5 to 6 yr or when 50% of storage capacity is lost |
| Database records | Ongoing | After every inspection and maintenance action |

Table 13. Retention pond and wet pond inspection and maintenance action checklist.

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 1. Inlets, outlets | Erosion | Bare soil/substrate, exposed geotextile, pipe exposed more than designed | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Extend lining coverage from inlet/outlet slope to bed or surface of SMP. Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Compact soil around pipe. Apply seeds, mulching or matting as needed. Reenforce with compacted soil or sandbags if undercutting occurs. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Obstruction | Accumulated debris, sediment, overgrown vegetation | Y / N | Remove obstruction. Properly dispose waste to avoid re-entry. |
| 2. Outlet control riser box and spillway | Concrete damaged | Cracks, missing pieces | Y / N | Report damage to MS4 coordinator. Repair if damage possibly interfering with structure's function. Consult with engineer if structural integrity concerns (major spalling >1" and rebars exposed). |
| | Damaged or missing grate/ trash rack | Deteriorated grate, broken or missing pieces | Y / N | Report to MS4 coordinator. Replace or fix. |
| 3. Basin | Water level visibly lower than average | | Y / N | If no record of drought, check damages to pond liner. Check damages to pond liner. Verify inflow obstruction or if invasive species are covering > 25% of the pond. Remove inflow obstruction. Check damages to outflow structures. Contact engineer for consultation. |
| | Water color and odor quality | Petroleum odor, oily shee or unnatural odor or color | Y / N | Check for potential contaminant sources like leaks or spills in drainage area, substances poured into storm drains or improper waste management and address the issue. |
| | Visble sediment emerging out of the water | Shallow areas with exposed sediment not part of embankment | Y / N | Check sediment level in pond. Check possible source of excess incoming sediment runoff. If source is identified, apply sediment control measures. Remove and dispose sediment properly. |
| | Trash or debris | Floating or floatable debris | Y / N | Remove trash or debris and dispose properly to avoid re-entry. |
| | Plant litter | Grass clippings or vegetative litter | Y / N | Remove plant litter and dispose to avoid re-entry to SMP. |
| | Presence of animal burrows | Bare patches and/or holes | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| 3. Vegetation | Invasive plants | Less than 25% of pond area is visible, algal growth covering > 20% of surface | Y / N | Refer to NYSDEC Nuisance an Invasive Species (2022) for regulation and control. Consult with local Cooperative Extension Office or qualified pond maintenance company to identify invasive, identify appropriate control technique, identify nutrient source and properly dispose invasive plant. |

| SMP component | Inspection item | Indicator | Verification | Maintenance action, if yes |
|---|---|---|---|---|
| 4. Basin embankment | Erosion or bare soil | Loss of vegetation on side slope or toe, bare soil, undercutting | Y / N | Erosion control: Stabilize with lining (geotextile, riprap). Redirect run-off or dissipate energy. Refill/patch holes or rills with sediment. Report to MS4 coordinator and consult with engineer if signs of moderate to high erosion, undercutting or channelization are present. |
| | Seepage, soft spots, sink holes | Water flow out of dam, oversaturated or sunken areas | Y / N | Report to MS4 coordinator immediately. May result in bank failure and safety risk. |
| | Woody vegetation on embankment | Woody vegetation withing 15 feet of the toe of the embankment | Y / N | Remove woody vegetation growth within 15 ft from toe of the embankment. Verify potential root damage to basin. Refill holes. Apply erosion control as needed. |
| 5. Flow path (contributing drainage area) | Flow path entering or leaving SMP | Overgrown vegetation | Y / N | Trim, mow and clear excess vegetation. Dispose properly to avoid re-entry. |
| | | Debris, trash or sediment | Y / N | Remove and dispose properly to avoid re-entry to SMP. |
| 6. Surrounding areas | Trash or debris | | Y / N | Remove trash or debris. Clear and dispose properly to avoid re-entry. |
| | Animal burrows | Holes in soil or bare patched | Y / N | Contact pest control. Cover or refill burrows and revegetate. |
| | Educational signage | Sign not present or legible, broken or missing parts | Y / N | Add sign if not present. Repair or replace existing signs. |
| | Maintenance access | Vegetation overgrown impeding access to outlets, inlets, emergency spillways and weirs | Y / N | Trim, mow, and clear vegetation prioritizing path to outfalls, inlets, emergency spillway and forebay. Dispose properly. Apply water safe herbicide. |

### 3.6.3 General inspection and maintenance

- Following USAG safety regulations, DPW, and OSHA rules
- Inspecting inlets and outlets for clogging or structural damage
- Assessing SMP components for erosion (cracking, bulging, and sliding)
- Trash, litter, and debris removal
- Sediment accumulation removal
- Vegetation maintenance
- Invasive species and pest control
- Clearing maintenance access
- Keeping a database of inspection and maintenance activities

# 4 Conclusions and Recommendations

This manual provides information on the required and recommended inspection and maintenance actions for stormwater management practices as the US Army Garrisons at West Point, New York. Chapter 2 outlines the general procedures to conduct a large-scale survey of many SMPS, and Chapter 3 provides general recommendations to improve SMP maintenance on a feature-by-feature basis. The manual was developed using information obtained from two site visits (Sept and Oct 2021) to assess 62 current SMPs at the USAG at West Point, following guidelines established in the NYS Stormwater Design Manual (NYS Department of Environmental Conservation 2015), NYS Maintenance Guidance for SMPs (NYS Department of Environmental Conservation 2017), the USAG SPDES permit No. GP-0-15-003, guides from Contech Engineered Solutions®, and guidance from multiple stormwater maintenance and design manuals from adjacent states with similar weather to NYS (e.g., Connecticut, Pennsylvania, New Jersey, and Virginia).

The following are recommended actions to improve SMP functionality at USAG West Point, many of which apply beyond this installation:

- Inspecting more frequently during the 1–5 years following SMP installation to gather information on performance and manage issues before they become larger challenges in subsequent years
- Developing and maintaining a database of newly constructed SMPs to include as-built design specifications, contractor maintenance plans, and recommended maintenance for new features
- Developing and maintaining a database of inspection and maintenance actions performed to track efficacy of management actions
- Creating and keeping an updated contact list of contractors and maintenance companies for maintenance requiring additional consultation and work
- Prohibiting use of heavy machinery on SMPs, especially those with underdrain pipes (e.g., sand filters, rain gardens, retention, and detention ponds)
- Developing a landscaping plan for each feature in consultation with a landscape architect or horticulturist as required by NYS DEC for SMPS ponds and bioretention filtering systems (NYS Department of Environmental Conservation 2015)

- Installing signage indicating maximum depth, warning of possible contamination, and prohibiting swimming, wading, and skating (NYS Department of Environmental Conservation 2015)
- Creating a budget for annual inspection and maintenance of SMPs as well as major repairs such as replacing pipes, containing major erosion, redirecting runoff, replacing filters and pipes, etc. The US Army Corps of Engineers Cost Engineering Center of Expertise (MCX) could potentially provide cost engineering assistance (https://www.nww.usace.army.mil/Missions/Cost-Engineering/)

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# Appendix A: Field Safety Procedures

When performing SMP inspection or maintenance activities, follow safety guidelines and requirements in 29 CFR 1910 OSHA General Industry, AR 385-10 The Army Safety Plan, 27 Nov 2013, DoDI 6055.1 DoD Safety & Occupational Health (SOH) Program, and DPW Safety Program SOP 11-17.

The equipment needed for inspections or maintenance may vary depending on weather conditions, the SMP, and the complexity of the maintenance issue. However, the following is a list of items to consider taking on routine inspection or maintenance tasks.

1. Safety vest
2. Safety boots (steel toed)
3. Sunblock / Bug spray
4. Digital camara or phone to document findings
5. Installation maps and SMP location coordinates
6. Permits to access restricted areas
7. Clipboard, SMP checklists, and pencil
8. Notebook for extra notes
9. Emergency contacts (MS4 Supervisor, military police, emergency room, SMP consultants)
10. Measuring tape and/or stick (to measure pipes or sediment accumulation)

# Appendix B: SMPs at West Point

## B.1 Chambers and Filters at West Point

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | C_Patton_TMP _S_1 | 41.349600, -74.046729 | TMP south Patton Rd closest to drain on road | Chamber in series 1 of 4 | Monitor sediment accumulation |
| 2. | C_Patton_TMP _S_2 | 41.349581, -74.046735 | TMP south Patton Rd | Chamber in series 2 of 4 | Monitor sediment accumulation |
| 3. | C_Patton_TMP _S_3 | 41.349560, -74.046619 | TMP south Patton Rd | Chamber in series 3 of 4 | Monitor sediment accumulation |
| 4. | F_Patton_TMP _S_4 | 41.349510, -74.046639 | TMP south Patton Rd | Filter in series 4 of 4 | Change filter as needed<br>Monitor sediment accumulation |
| 5. | C_Pipeline_ grass_USMAPS _1 | 41.398406, -73.979624 | Cantonment Pipeline Trail USMAPS Prep School | Chamber in series 1 of 3 on grass | Monitor sediment accumulation |
| 6. | C_Pipeline_ grass_USMAPS _2 | 41.398432, -73.979636 | Cantonment Pipeline Trail USMAPS Prep School | Chamber in series 2 of 3 on grass | Monitor sediment accumulation |
| 7. | C_Pipeline_ grass_USMAPS _3 | 41.398470, -73.979643 | Cantonment Pipeline Trail USMAPS Prep School | Chamber in series 3 of 3 in grass | Monitor sediment accumulation |
| 8. | C_Pipeline_ road_USMAPS _1 | 41.398381, -73.980241 | Cantonment Pipeline Trail USMAPS Prep School closest to Reynolds Rd | Chamber in series 1 of 4 on road | Monitor sediment accumulation |
| 9. | C_Pipeline_ road_USMAPS _2 | 41.398369, -73.980168 | Cantonment Pipeline Trail USMAPS Prep School closest to Reynolds Rd | Chamber in series 2 of 4 on road | Monitor sediment accumulation |
| 10. | C_Pipeline_ road_USMAPS _3 | 41.398362, -73.980108 | Cantonment Pipeline Trail USMAPS Prep School closest to Reynolds Rd | Chamber in series 3 of 4 on road | Monitor sediment accumulation |

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 11. | C_Pipeline_ road_USMAPS _4 | 41.398361, -73.980054 | Cantonment Pipeline Trail USMAPS Prep School closest to Reynolds Rd | Chamber in series 4 of 4 on road | Monitor sediment accumulation |
| 12. | C_Cullum_ USAM_1 | 41.391538, -73.954977 | Cantonment Cullum Rd Bld 758 USAM Library closest to Jefferson Pl | Chamber in series 1 of 3 | Monitor sediment accumulation |
| 13. | F_Cullum_ USAM_2 | 41.391556, -73.954915 | Cantonment Cullum Rd Bld 758 USAM Library | Filter in series 2 of 3 | Change filter as needed<br>Monitor sediment accumulation |
| 14. | C_Cullum_ USAM_3 | 41.391592, -73.954934 | Cantonment Cullum Rd Bld 758 USAM Library | Chamber in series 3 of 3 | Monitor sediment accumulation |
| 15. | Cc_S_Davis_1 | 41.389564, -73.957829 | Cantonment South of Davis Barracks Bld 755 | Corrugated chamber in series 1 of 4 | Rusting corrugated pipes<br>Monitor sediment accumulation |
| 16. | Cc_S_Davis_2 | 41.389658, -73.957772 | Cantonment South of Davis Barracks Bld 755 southern-most chamber | Corrugated chamber in series 2 of 4 | Rusting corrugated pipes<br>Monitor sediment accumulation |
| 17. | C_S_Davis_3 | 41.389681, -73.957687 | Cantonment South of Davis Barracks Bld 755 | Chamber and weir in series 3 of 4 | Monitor sediment accumulation |
| 18. | F_S_Davis_4 | 41.389650, -73.957688 | Cantonment South of Davis Barracks Bld 755 | Filter in series 4 of 4 | Change filter as needed<br>Monitor sediment accumulation |
| 19. | Cc_N_Davis_1 | 41.389499, -73.95869 | Cantonment north of Davis Barracks Bld 755 closest to barracks | Corrugated chamber in series 1 of 4 | Rusting corrugated pipes<br>Monitor sediment accumulation |
| 20. | F_N_Davis_2 | 41.39011, -73.95868 | Cantonment north of Davis Barracks Bld 755 | Filter in series 2 of 4 | Change filter as needed |
| 21. | C_N_Davis_3 | 41.39017, -73.95867 | Cantonment north of Davis Barracks Bld 755 | Chamber and weir in series 3 of 4 | Monitor sediment accumulation |

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 22. | C_N_Davis_4 | not found | Cantonment north of Davis Barracks Bld 755 | not found | not found |

C- chamber; Cc- corrugated chamber; F- filter; S- south; N- north; TMP- transportation motor pool; USMAPS- US Military Academy Prep School; Bld- building; Pl- place

## B.2 Sand Filters at West Point

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | Sf_PX_E | 41.3867383, -73.9752556 | Cantonment Commissary Rd Bld 1204 East of PX | SMP system of (3) sand filters (1) retention pond | Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Invasive plants |
| 2. | Sf_PX_ Ordnance_N | 41.3872072, -73.9768552 | Cantonment Ordnance Bld 1204 north of PX | SMP system of (3) sand filters (1) retention pond | Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Invasive plants |
| 3. | Sf_PX_ Ordnance_W | 41.3856813, -73.978848 | Cantonment Ordnance Bld 1245 West of PX | SMP system of (3) sand filters (1) retention pond | Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Invasive plants |

Sf- sand filter; PX- post exchange; E- east; N- north; W- west; Bld- building; Veg- vegetation

## B.3 Rain Gardens at West Point

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | Rg_visitors_ center | 41.3732010, -73.9621691 | Visitor's Center New South Post Rd | Cobble and pebble substrate garden with ~10% veg cover | Some erosion around outlet<br>Blocked inlet/outlet<br>Opportunity for educational sign |
| 2. | Rg_Ordnance | 41.384715, -73.978544 | Cantonment Ordnance Rd | Garden seems to have been paved over | Not functional anymore |
| 3. | Rg_Buckner_ Loop_CDC_1 | 41.40152, -73.96919 | Cantonment Buckner Loop Lee area East | SMP system of (1) small grass swale and (1) rain garden | Trash and debris vegetation litter<br>Overgrown veg<br>Replacing filter fabric around outlet<br>Education sign needs replacing<br>Watch erosion |

| | | | | | |
|---|---|---|---|---|---|
| 4. | Rg_Buckner_ Loop_CDC_2 | 41.40133, -73.96982 | Cantonment Buckner Loop Lee area West | (1) rain garden | Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Education sign needs replacing |

Rg- rain garden; CDC- child development center; Rd- road; Veg- vegetation

## B.4 Swales at West Point

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | Sw_Stony _Fire_Station _S | 41.38380, -73.97837 | Cantonment Ordnance Rd Fire station south | Swale 1 of 2 Stone and grass bottom southernmost closer to Stony Lonesome Rd | Overgrown veg<br>Blocked outlet/inlet<br>Vegetation litter |
| 2. | Sw_Ordnance _Fire_Station _N | 41.384126, -73.978766 | Cantonment Stony Lone-some Rd Fire station north | Swale 2 of 2 Stone and grass bottom northernmost closer to Ordnance Rd | Overgrown veg<br>Blocked outlet/inlet<br>Vegetation litter<br>Erosion near inlet |
| 3. | Sw_USMAPS | 41.396785, -73.976679 | Cantonment Pipeline Trail USMAPS Prep School | SMP system of (1) swale and (1) detention pond with grass and stone bottom | Overgrown veg<br>Blocked outlet/inlet |
| 4. | Sw_Golf_Bld_ 1222 | 41.3832752, -73.9903030 | Golf Course Maintenance Bld 1222 | SMP system of (1) swale and (1) retention pond with grass and stone bottom | Overgrown veg<br>Blocked outlet/inlet<br>Vegetation litter |
| 5. | Sw_Golf_Bld_ 1225 | 41.383938, -73.990933 | Groves Golf Center Bld 1225 | (1) stony swale | Erosion on banks<br>Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Blocked outlet/inlet |
| 6. | Sw_W_ Continental_ OldRes | 41.9823603, -73.9747651 | Cantonment W. Continental Rd | (1) vegetated swale | Overgrown veg<br>Blocked outlet/inlet<br>Trash and debris<br>Vegetation litter<br>Erosion on banks<br>Erosion around inlet |
| 7. | Sw_Buckner_ CDC | 41.40162, -73.96911 | Cantonment Buckner Loop Lee area | SMP system of (1) small grass swale and (1) rain garden | Monitor erosion<br>Monitor overgrown grass |

| | | | | | |
|---|---|---|---|---|---|
| 8. | Sw_Radiere_ W_Continen-tal_Wyllys_Old Res | 41.38077, -73.97413 | Cantonment Radiere Loop Wyllys Rd Old residential area | SMP system of (1) pond with (1) stony swale system with a weir at the pond inlet and energy dissipators grass, cobble, and small boulder bottom | Monitor for erosion Monitor for trash |
| 9. | Sw_ Constitution | 41.4025271, -73.9517997 | Constitution Island | SMP system of (1) Pond w/ (1) swale | |

Sw- swale; N- north; S-south; W- west; CDC- Child Development Center; USMAPS- US Military Academy Prep School; Bld- building; Rd- road; Veg- vegetation

## B.5 Retention Ponds at West Point

| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | RP_TMP_S_1 | 41.350183, -74.046524 | TMP south | Pond 1 of 2 higher elevation grass bottom | Overgrown veg Invasive plants Clogged inlets/outlets Blocked maintenance access |
| 2. | RP_TMP_S_2 | 41.349919, -74.046486 | TMP south | Pond 2 of 2 lower elevation grass bottom | Overgrown veg Invasive plants Clogged inlets/outlets Blocked maintenance access |
| 3. | RP_TMP_N_1 | 41.3552168, -74.0425242 | TMP north | Pond 1 of 2 higher elevation grass bottom | Overgrown veg Invasive plants Clogged inlets/outlets Blocked maintenance access |
| 4. | RP_TMP_N_2 | 41.355161, -74.042297 | TMP north | Pond 2 of 2 lower elevation grass bottom | Overgrown veg Invasive plants Clogged inlets/outlets Blocked maintenance access |
| 5. | RP_PX_E_ | 41.3867383, -73.9752556 | Cantonment East of PX Commissary Rd | SMP system of (3) sand filters (1) retention pond | Trash and debris Overgrown veg Invasive plants Clogged inlets/outlets Blocked maintenance access |
| 6. | RP_Stony_ CDC_S | 41.3846379, -73.9730287 | Cantonment Stony Lonesome Rd and Patrick Rd | Fenced pond w/ underdrain cobble bottom | Animal burrows Overgrown veg Invasive plants Clogged inlets/outlets Monitor erosion |

| | | | | | |
|---|---|---|---|---|---|
| 7. | RP_Stony_Fire _Station | 41.3841235, -73.9788524 | Cantonment Stony Lonesome Rd and Ordnance Rd | Pond w/ (2) swale system sediment bottom | Mosquitoes Vegetation litter<br>Trash<br>Overgrown veg Invasive plants<br>Monitor sediment accumulation |
| 8. | RP_Golf_ Bld1222 | 41.3832752, -73.9903030 | Cantonment Golf Course Maintenance Bld 1222 | Pond w/ (1) swale system cobble and boulder bottom | Vegetation litter<br>Trash<br>Overgrown veg<br>Clogged inlets/outlets |
| 9. | RP_Radiere_ OldRes_NW | 41.3818426, -73.9755483 | Cantonment Radiere Loop and W. Continental Rd Old residential area north-west | (1) Pond grass and cobble bottom | Trash<br>Vegetation litter<br>Clogged inlets/outlets<br>Monitor erosion |
| 10. | RP_Foley_ Bld717 | 41.3846673, -73.9649401 | Cantonment Foley Athletic Bld 717 Howze Pl | (1) Pond w/ trees on banks grass bottom | Vegetation litter<br>Trash<br>Replace mulch<br>Watch damage from trees or bank erosion |
| 11. | RP_Gettys Range_Bld 1303 | 41.3750157, -74.0127716 | Gettysburg Ranges Bld 1303 RR27 | (1) Pond w/ grass bottom weir on box riser | Erosion in box riser<br>Weeds in box riser<br>Vegetation litter |
| 12. | RP_Morgan Farm | 41.3547867, -73.9826350 | Morgan Farm Rd and RR7 | (1) Pond w/ grass bottom | Erosion on bank |
| 13. | RP_ Constitution | 41.4025271, -73.9517997 | Constitution Island | SMP system of (1) Pond w/ (1) swale | |

RP- retention pond; PX- post exchange; S- south; N- north; E- east; NW- northwest; TMP- transportation motor pool; Bld- building; Pl- place; Veg- vegetation

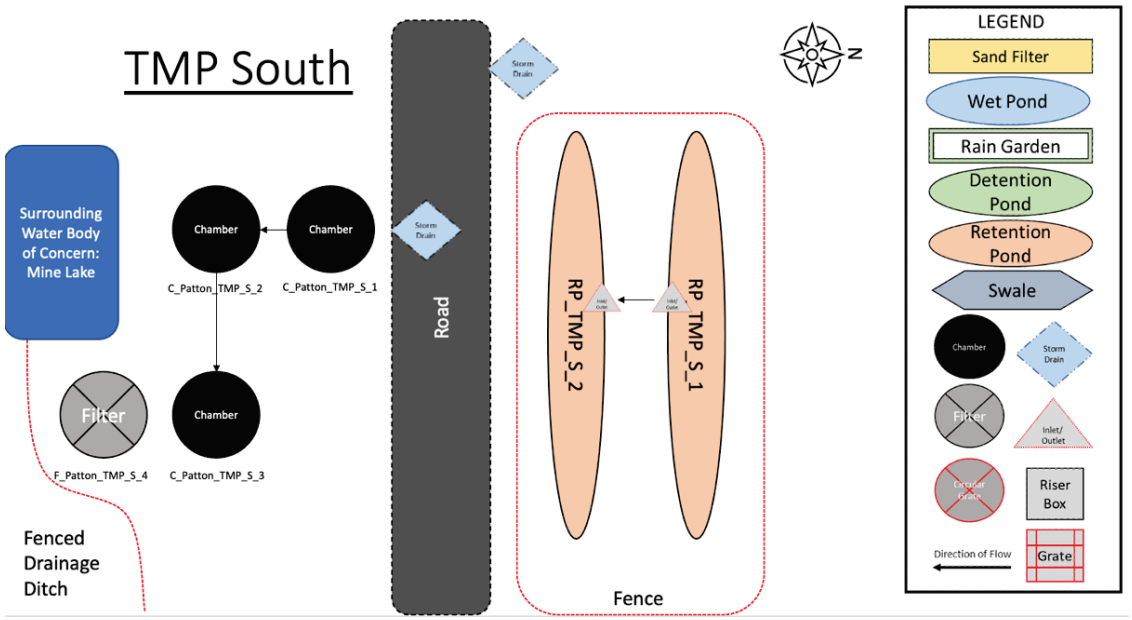
## B.6 Detention Ponds at West Point

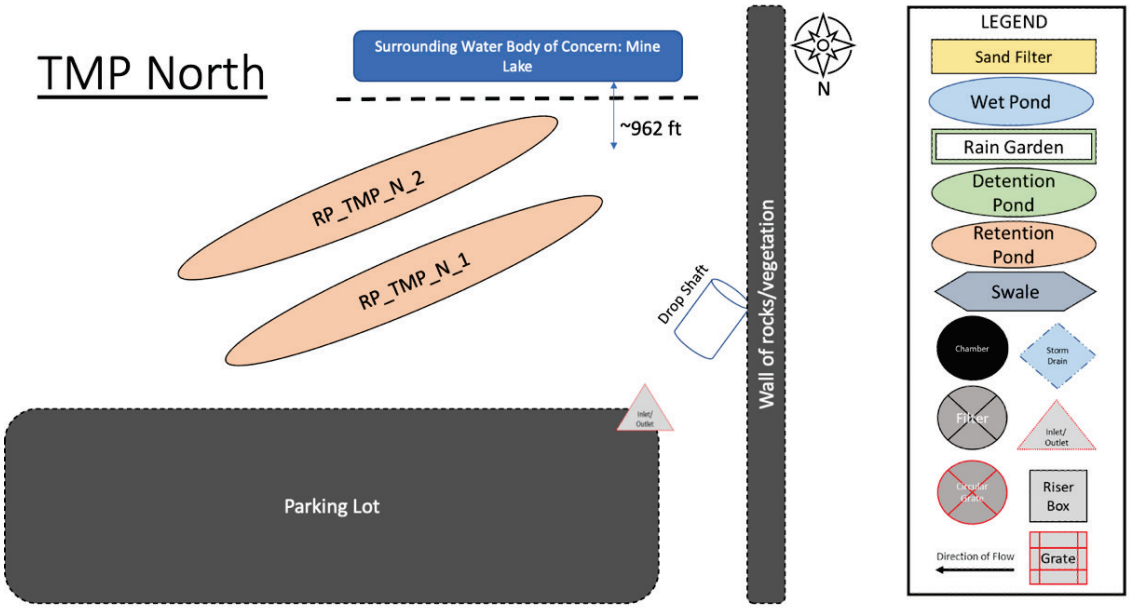
| | Unique ID | Geolocator | Area | SMP description | Common maintenance issues |
|---|---|---|---|---|---|
| 1. | DP_Paterson_ OldRes_1 | 41.382697, -73.974889 | Cantonment Paterson Loop and W. Continental Rd Old residential area | Pond 1 of 2 higher elevation grass bottom | Trash and debris<br>Vegetation litter<br>Clogged inlets/outlets<br>Monitor erosion |
| 2. | DP_Paterson_ _OldRes_2 | 41.382836, -73.974456 | Cantonment Paterson Loop and W. Continental Rd Old residential | Pond 2 of 2 lower elevation grass bottom | Trash and debris<br>Vegetation litter<br>Clogged inlets/outlets<br>Monitor erosion |
| 3. | DP_USMAPS | 41.397022, -73.97451 | Cantonment Pipeline Trail Bld 950 USMAPS Prep School | Pond with (1) swale system with grass and small boulder bottom | Trash and debris<br>Vegetation litter<br>Clogged inlets/outlets<br>Monitor erosion |

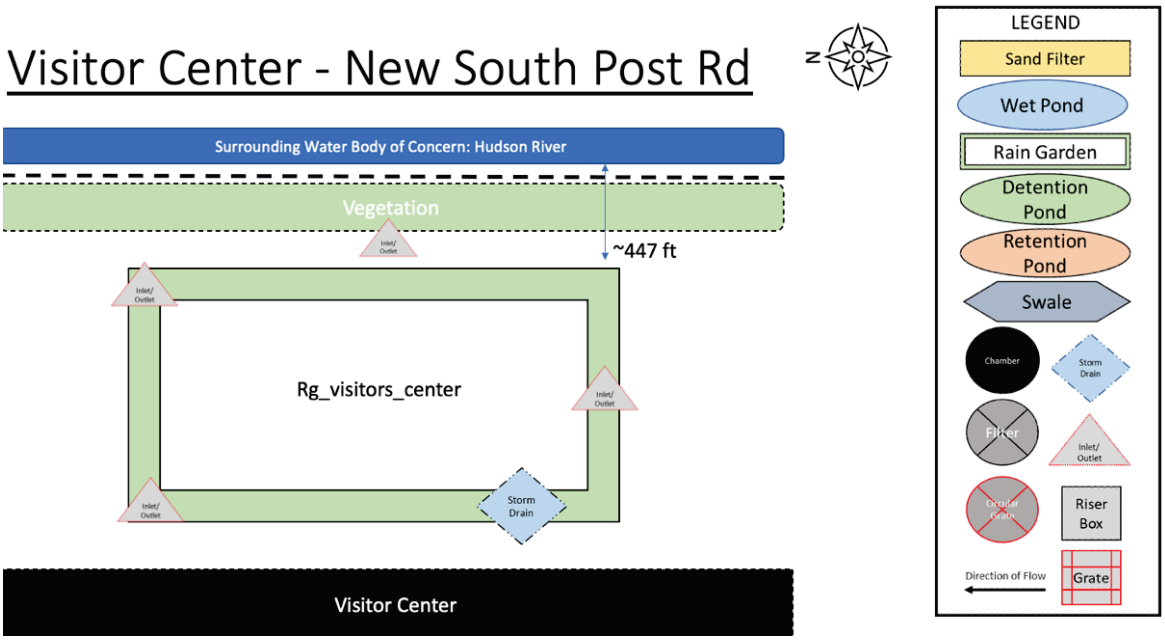
| | | | | | |
|---|---|---|---|---|---|
| 4. | DP_Radiere_ OldRes_NE | 41.381816, -73.973893 | Cantonment Radiere Loop Old residential area northeast | (1) Pond grass and cobble bottom | Trash and debris<br>Clogged inlets/outlets<br>Vegetation litter |
| 5. | DP_Radiere_ W.Cont_OldRes | 41.38091, -73.97382 | Cantonment W. Continental and Wyllys Rd Old residential area | SMP system of (1) pond with (1) stony swale system with a weir at the pond inlet and energy dissipators grass, cobble and small boulder bottom | Overgrown woody vegetation<br>Trash and debris<br>Maintenance access blocked<br>Outlet riser blocked |
| 6. | DP_Heath_ OldRes_SE | 41.380061, -73.975291 | Cantonment Heath Loop Old residential area south-east | (1) Pond with grass and shrubs bottom | Trash and debris<br>Vegetation litter<br>Overgrown veg<br>Clogged inlets/outlet and riser<br>Erosion around inlet<br>Erosion on banks<br>Maintenance access blocked<br>Missing grate on outlet |
| 7. | DP_Heath_ OldRes_NW | 41.381089, -73.977434 | Cantonment Heath Loop Old residential area north-west | (1) Pond with grass bottom | Missing grate on outlet |
| 8. | DP_Heath_ OldRes_W | 41.380311, -73.977841 | Cantonment Heath Loop Old residential area west | (1) Pond grass bottom with cobble for erosion control | Erosion around outlet<br>Clogged inlets/outlets |
| 9. | DP_Heath_ OldRes_S | 41.3798187, -3.9759181 | Cantonment Heath Loop Old residential area south | (1) Pond grass bottom with cobble | Trash and debris<br>Outlet blocked<br>Erosion on banks |
| 10. | DP_Radiere_ OldRes_SE | 41.3809857, -73.9739527 | Cantonment Radiere Loop Old residential area south-east | (1) Pond triangle- shaped grass bottom with cobble for erosion control | Monitor erosion<br>Monitor trash |
| 11. | DP_Stony_ CDC_S | 41.3846379, -73.9730287 | Cantonment Stony Lonesome Rd and Patrick Rd | Fenced pond w/ underdrain cobble bottom | Animal burrows<br>Overgrown veg<br>Invasive plants<br>Clogged inlets/outlets<br>Monitor erosion |

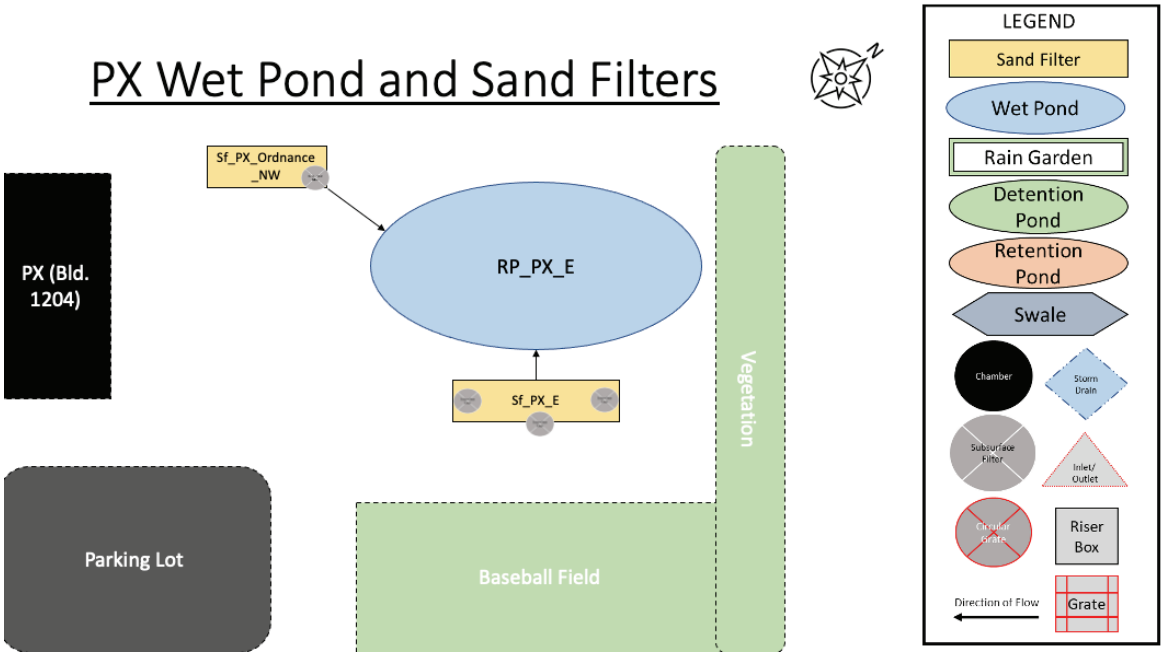
DP- detention pond; OldRes- old residential area; S- south; N- north; E- east; W- west; NW- northwest; TMP- transportation motor pool; USMAPS- US Military Academy Prep School; Bld- building; Pl- place; Veg- vegetation

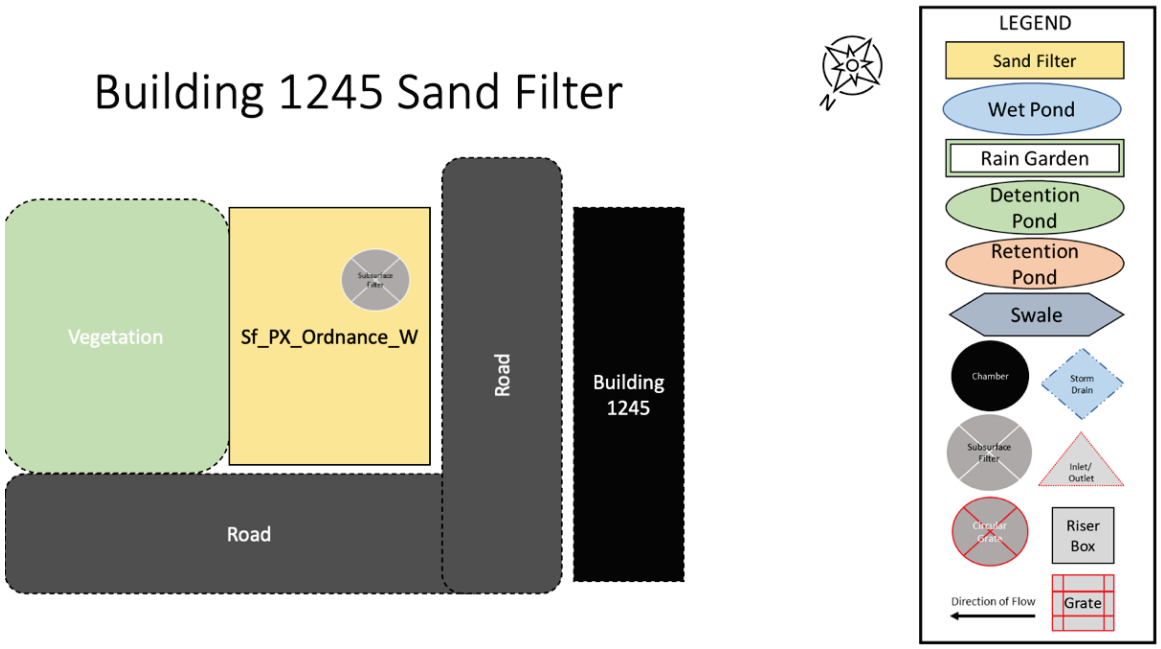
# Appendix C: Schematics for SMPS at West Point

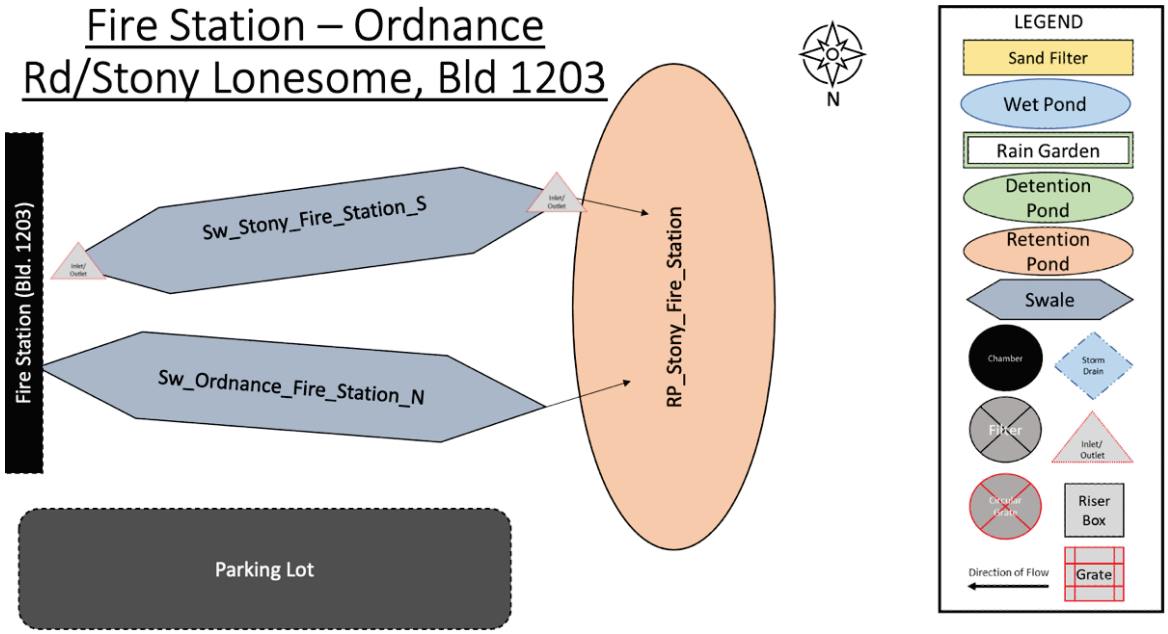


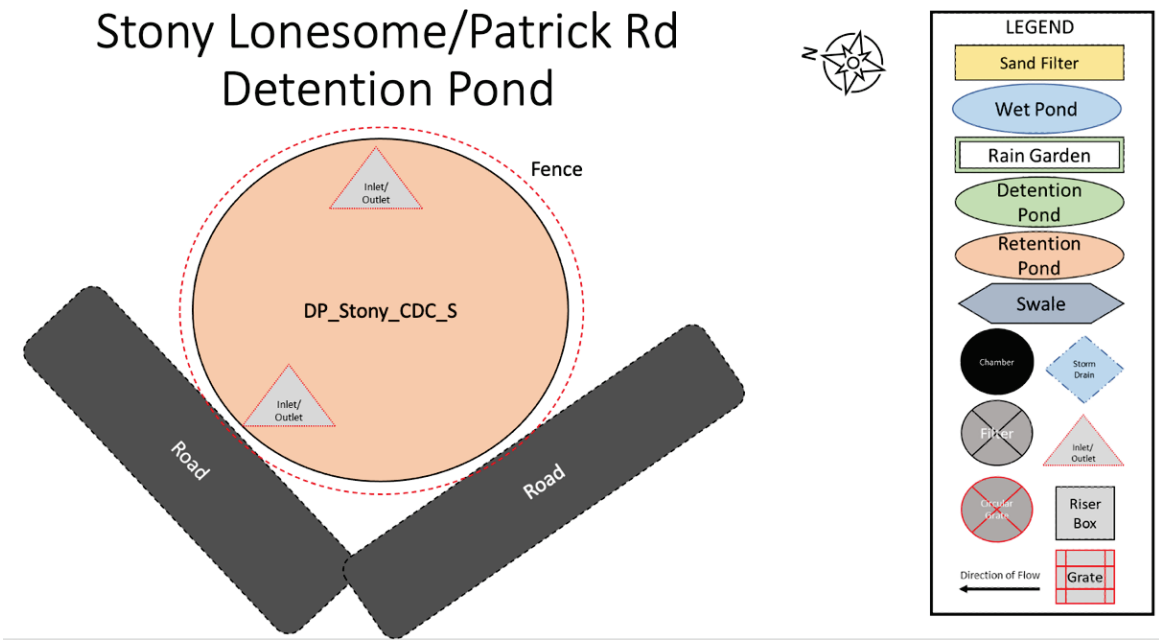



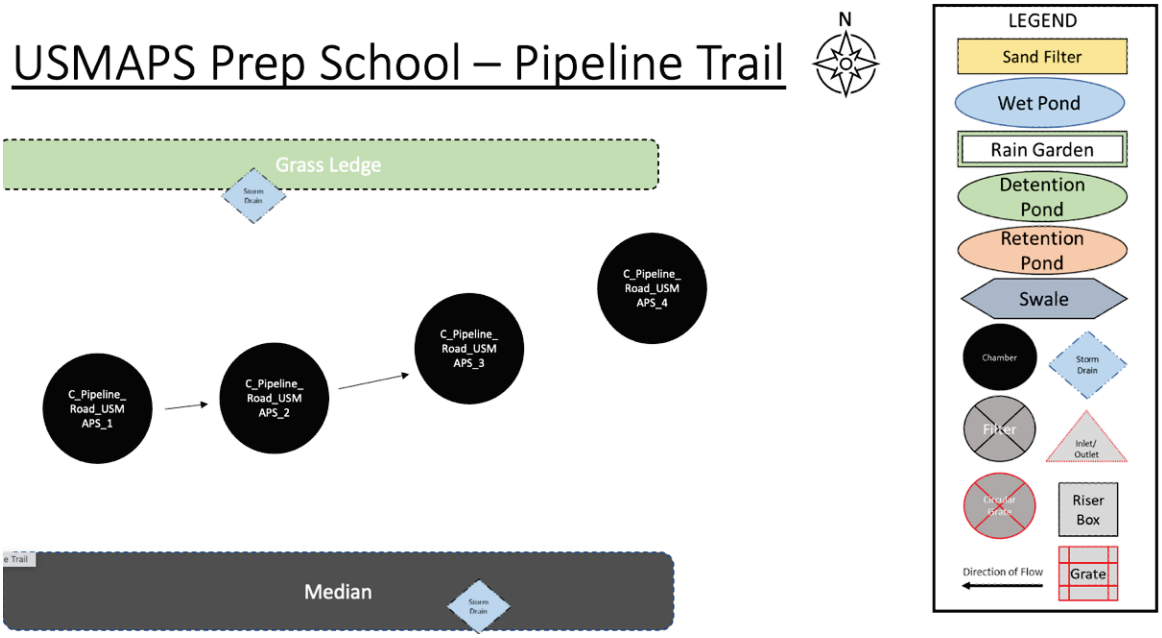

Visitor Center - New South Post Rd
N
Surrounding Water Body of Concern: Hudson River
Vegetation
~447 ft
Inlet/ Outlet
Rg_visitors_center
Storm Drain
Visitor Center
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

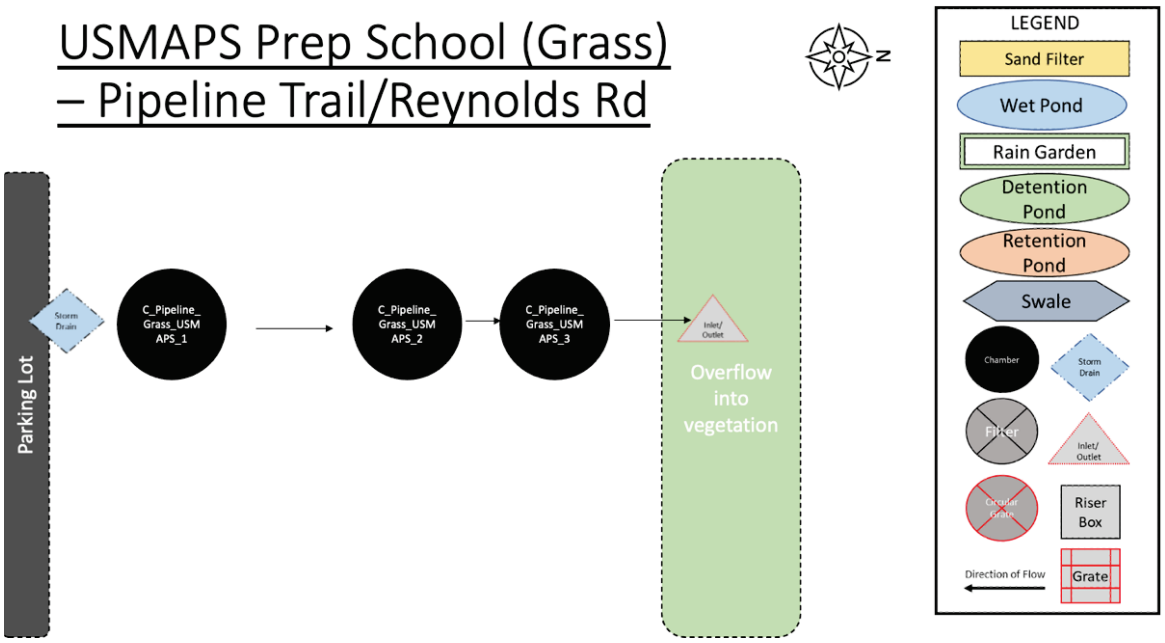

PX Wet Pond and Sand Filters
N
Sf_PX_Ordnance _NW
RP_PX_E
Sf_PX_E
PX (Bld. 1204)
Vegetation
Parking Lot
Baseball Field
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Subsurface Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

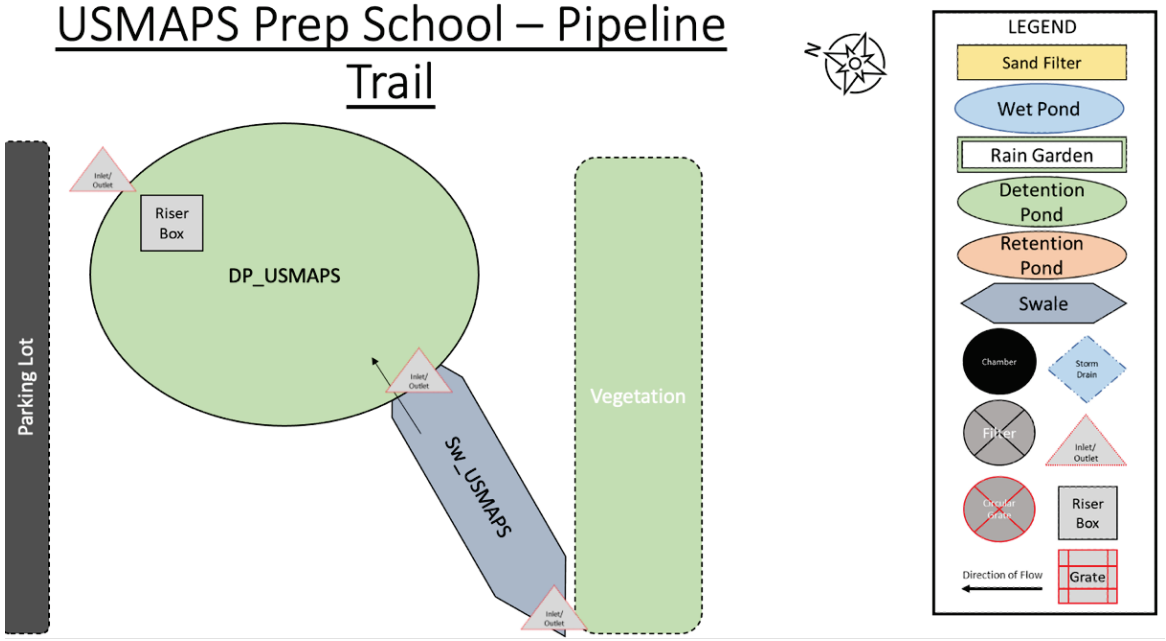

Building 1245 Sand Filter
Vegetation
Sf_PX_Ordnance_W
Road
Road
Building 1245
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Subsurface Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

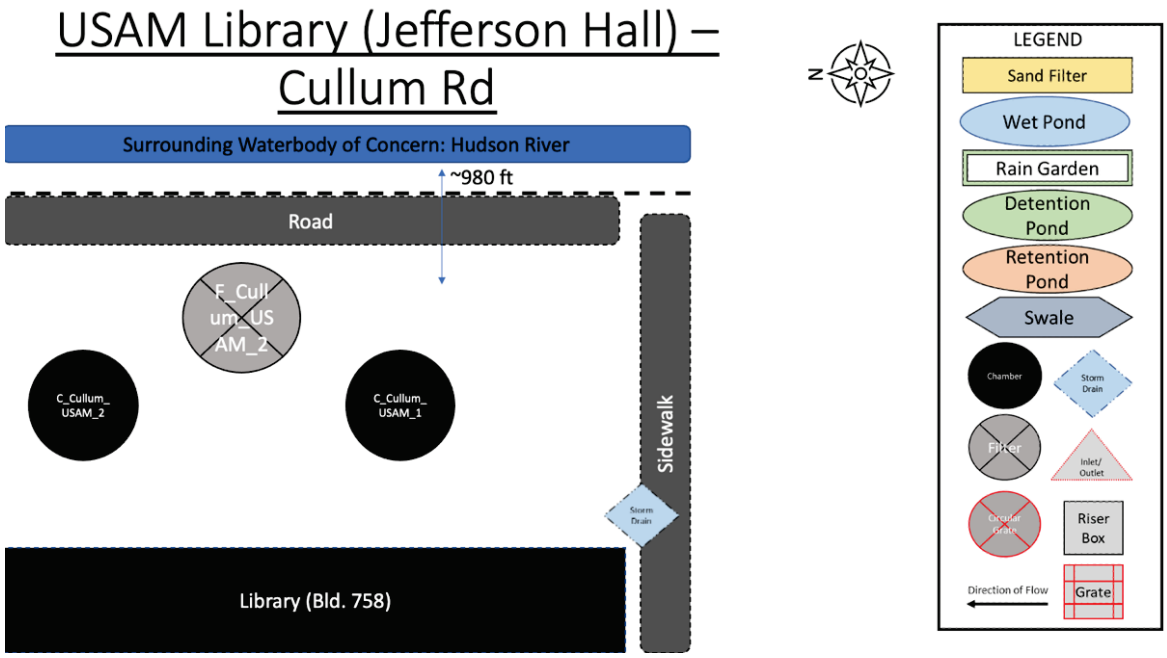

Fire Station – Ordnance Rd/Stony Lonesome, Bld 1203
N
Fire Station (Bld. 1203)
Sw_Stony_Fire_Station_S
Sw_Ordnance_Fire_Station_N
RP_Stony_Fire_Station
Parking Lot
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

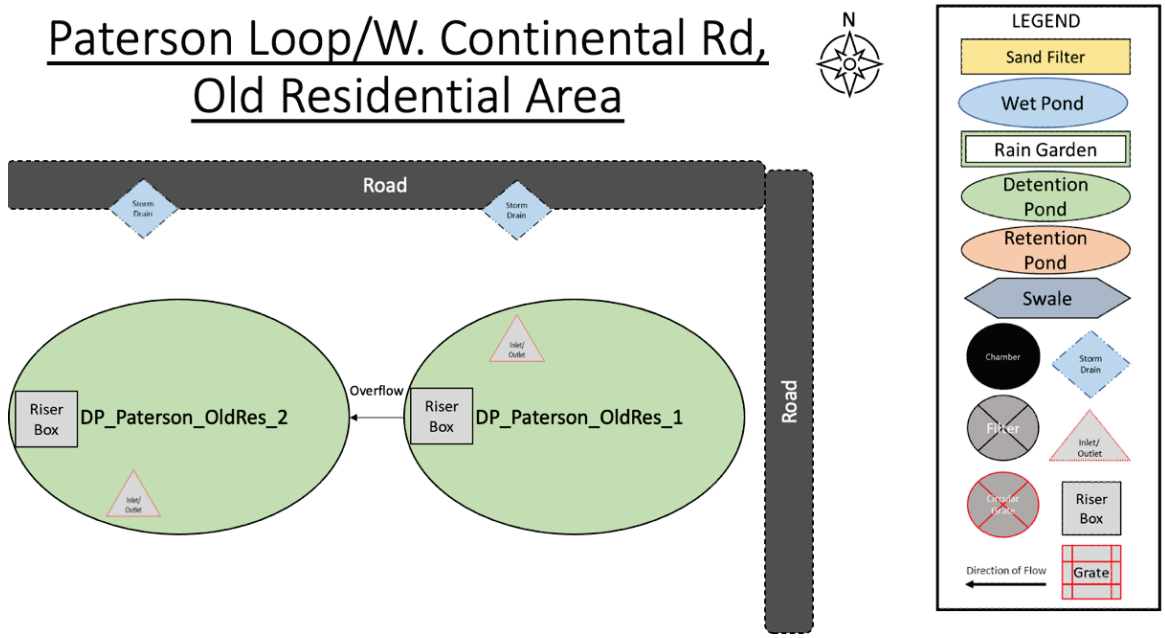

Stony Lonesome/Patrick Rd
Detention Pond
Fence
Inlet/
Outlet
DP_Stony_CDC_S
Inlet/
Outlet
Road
Road
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention
Pond
Retention
Pond
Swale
Chamber
Storm
Drain
Filter
Inlet/
Outlet
Riser
Box
Direction of Flow
Grate

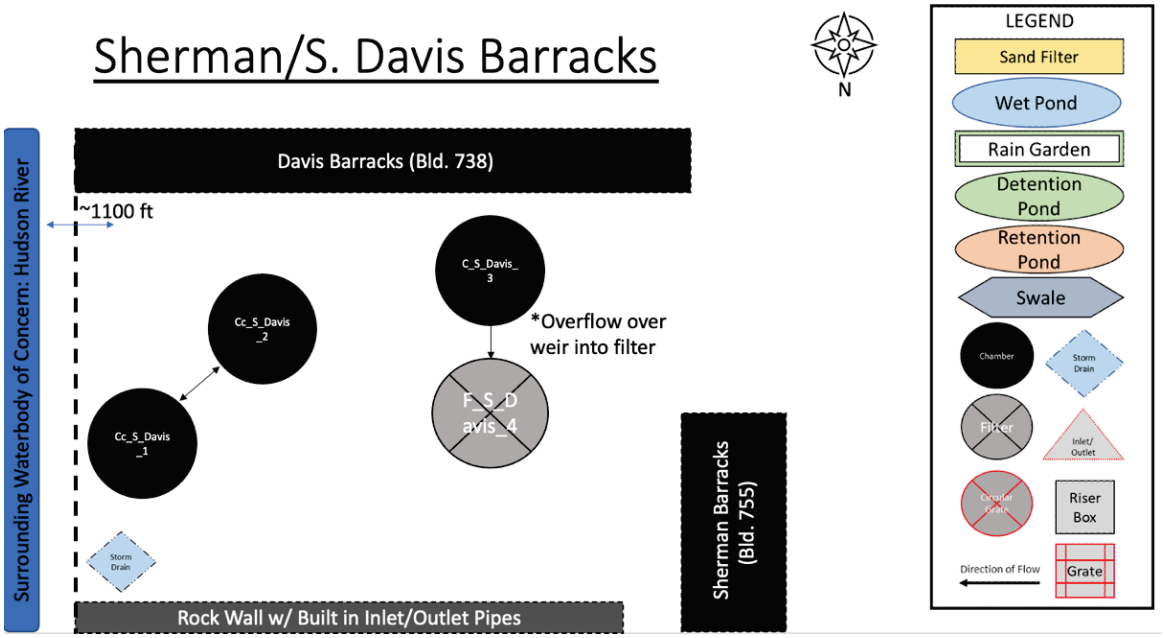

USMAPS Prep School – Pipeline Trail
N
Grass Ledge
Storm
Drain
C_Pipeline_
Road_USM
APS_4
C_Pipeline_
Road_USM
APS_3
C_Pipeline_
Road_USM
APS_2
C_Pipeline_
Road_USM
APS_1
Median
Storm
Drain
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention
Pond
Retention
Pond
Swale
Chamber
Storm
Drain
Filter
Inlet/
Outlet
Riser
Box
Direction of Flow
Grate

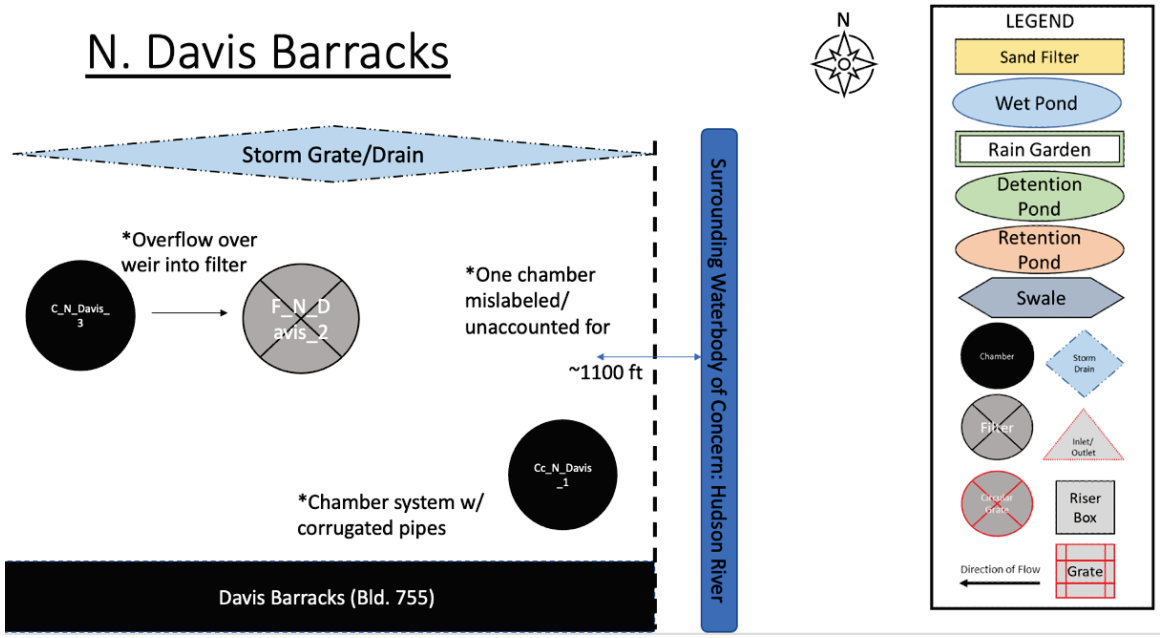

USMAPS Prep School (Grass) – Pipeline Trail/Reynolds Rd
N
Parking Lot
Storm Drain
C_Pipeline_ Grass_USM APS_1
C_Pipeline_ Grass_USM APS_2
C_Pipeline_ Grass_USM APS_3
Inlet/ Outlet
Overflow into vegetation
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow

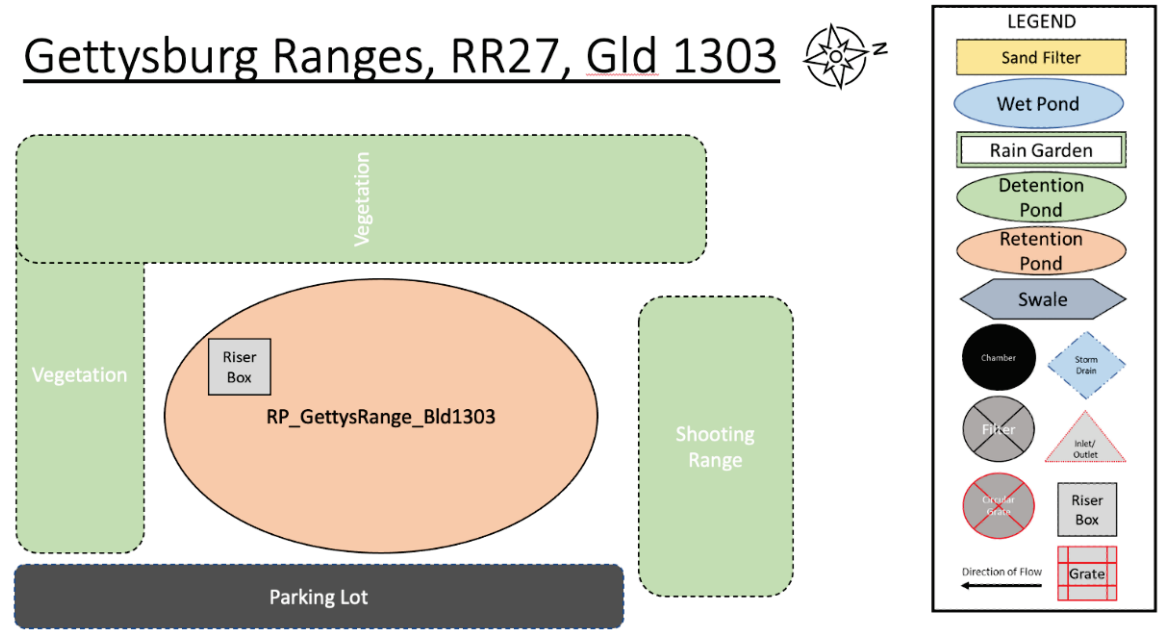

USMAPS Prep School – Pipeline Trail
N
Parking Lot
Inlet/ Outlet
Riser Box
DP_USMAPS
SW_USMAPS
Vegetation
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow

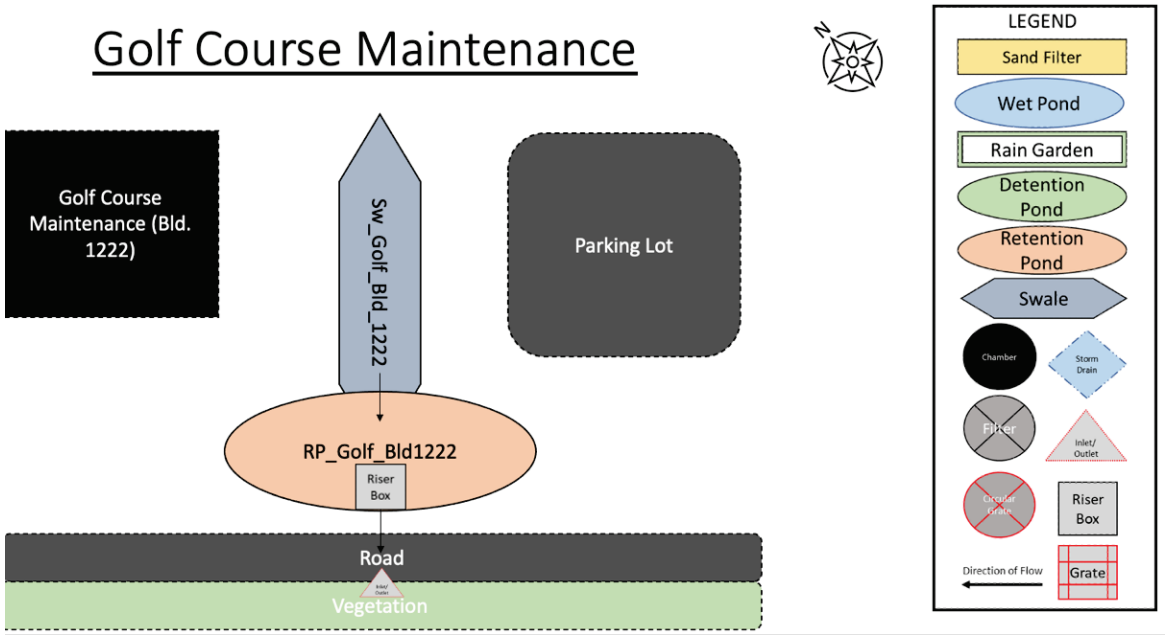

USAM Library (Jefferson Hall) – Cullum Rd
Surrounding Waterbody of Concern: Hudson River
~980 ft
Road
F_Cullum_USAM_2
C_Cullum_USAM_2
C_Cullum_USAM_1
Sidewalk
Storm Drain
Library (Bld. 758)
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

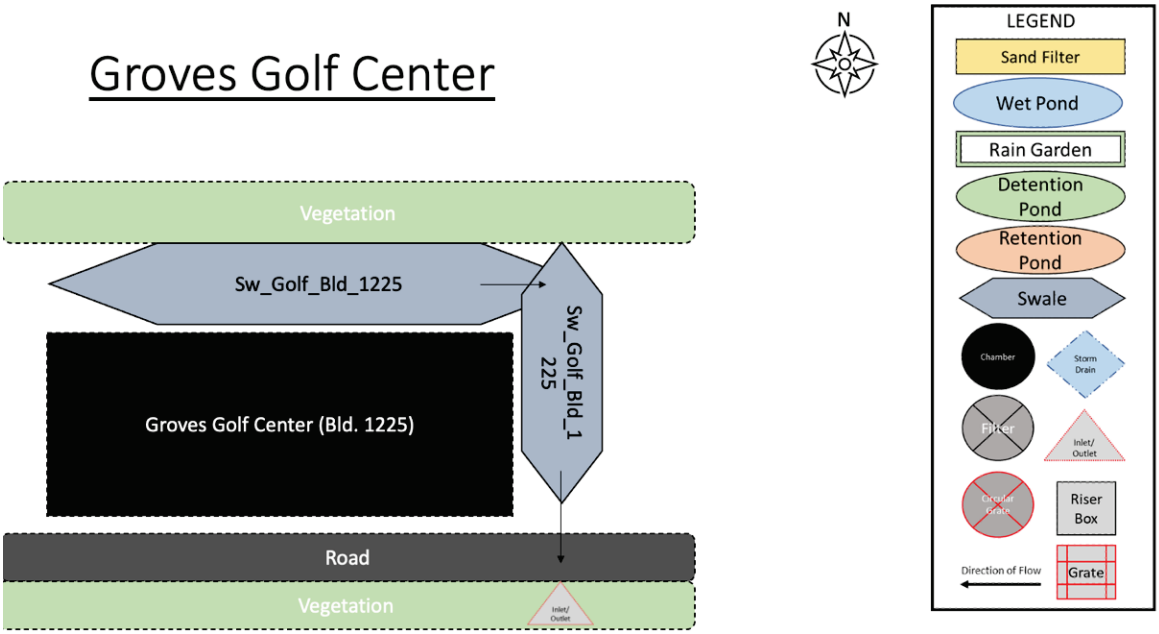

Paterson Loop/W. Continental Rd, Old Residential Area
Road
Storm Drain
Storm Drain
Riser Box
DP_Paterson_OldRes_2
Inlet/ Outlet
Overflow
Riser Box
DP_Paterson_OldRes_1
Inlet/ Outlet
Road
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

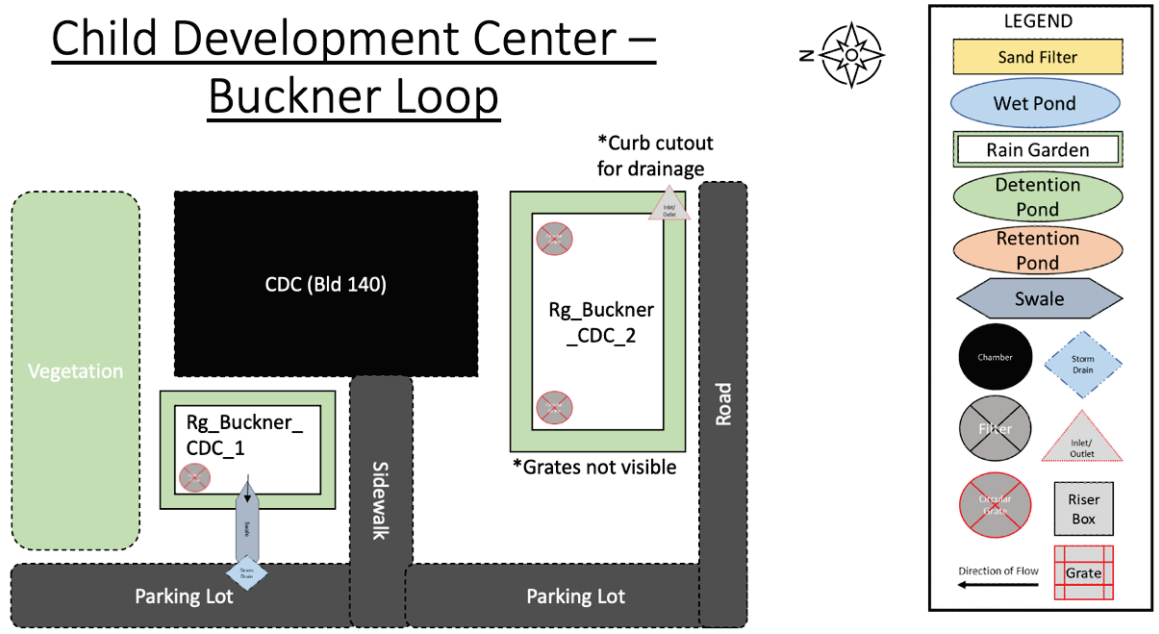

Sherman/S. Davis Barracks
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow
Davis Barracks (Bld. 738)
~1100 ft
Surrounding Waterbody of Concern: Hudson River
C_S_Davis_3
Cc_S_Davis_2
Cc_S_Davis_1
F_S_Davis_4
*Overflow over weir into filter
Sherman Barracks (Bld. 755)
Rock Wall w/ Built in Inlet/Outlet Pipes


N. Davis Barracks
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow
Storm Grate/Drain
*Overflow over weir into filter
C_N_Davis_3
F_N_Davis_2
*One chamber mislabeled/ unaccounted for
~1100 ft
Surrounding Waterbody of Concern: Hudson River
Cc_N_Davis_1
*Chamber system w/ corrugated pipes
Davis Barracks (Bld. 755)

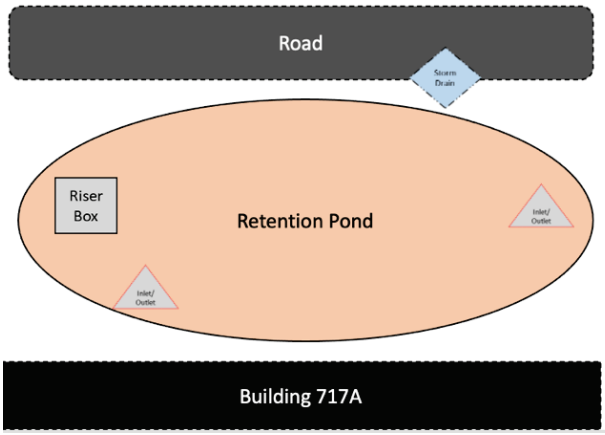

Gettysburg Ranges, RR27, Gld 1303
Vegetation
Vegetation
Riser Box
RP_GettysRange_Bld1303
Shooting Range
Parking Lot
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

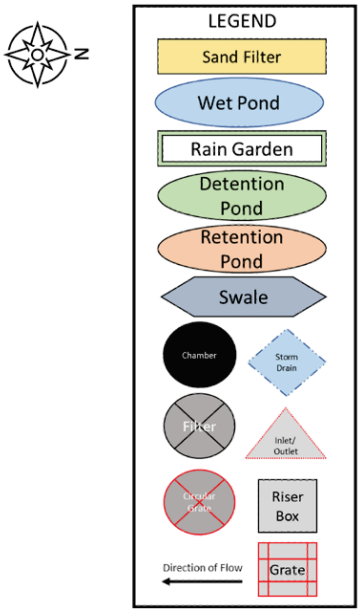

Golf Course Maintenance
Golf Course Maintenance (Bld. 1222)
Sw_Golf_Bld_1222
Parking Lot
RP_Golf_Bld1222
Riser Box
Road
Vegetation
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate


Groves Golf Center
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate
Vegetation
Sw_Golf_Bld_1225
Sw_Golf_Bld_1 225
Groves Golf Center (Bld. 1225)
Road
Vegetation

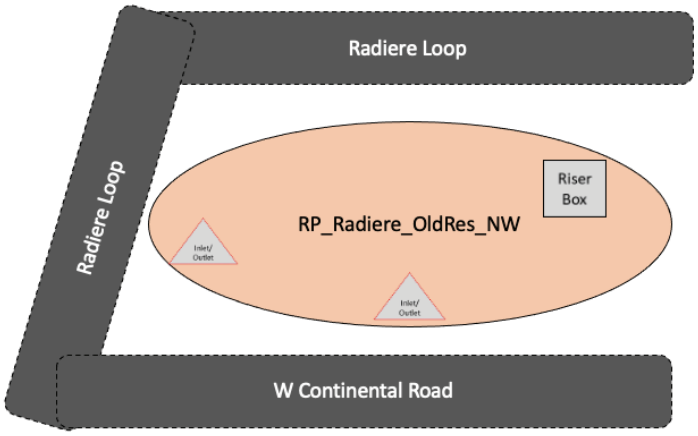

Child Development Center – Buckner Loop
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate
*Curb cutout for drainage
Vegetation
CDC (Bld 140)
Rg_Buckner _CDC_2
Rg_Buckner_ CDC_1
*Grates not visible
Sidewalk
Road
Parking Lot
Parking Lot

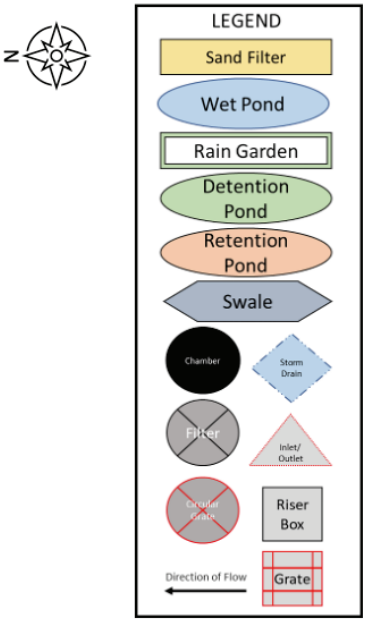
## Foley Athletic

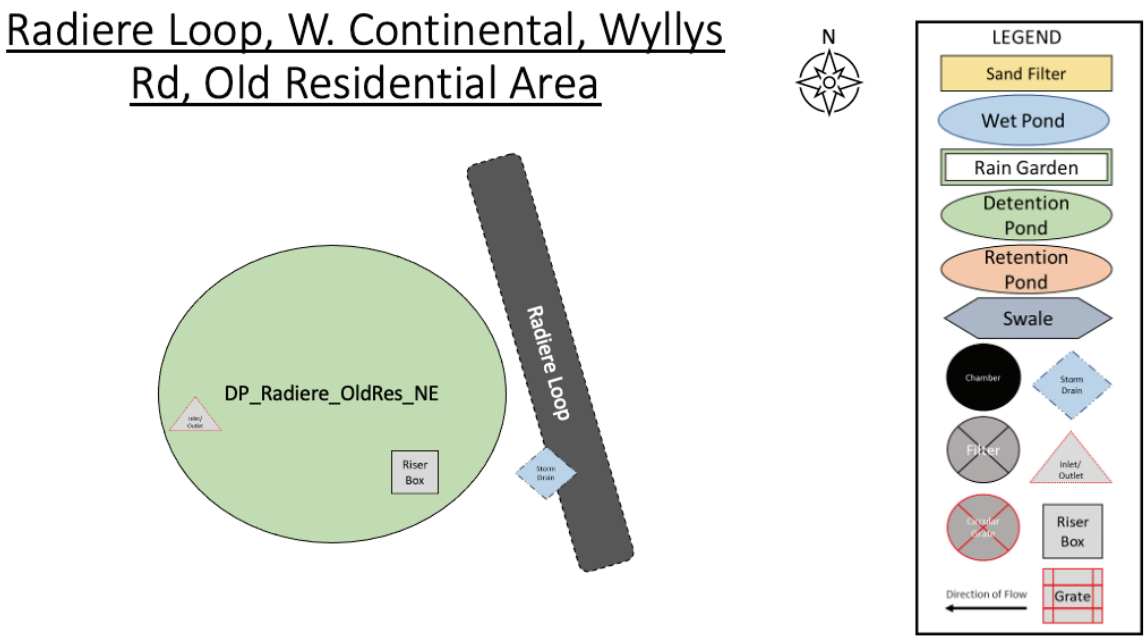


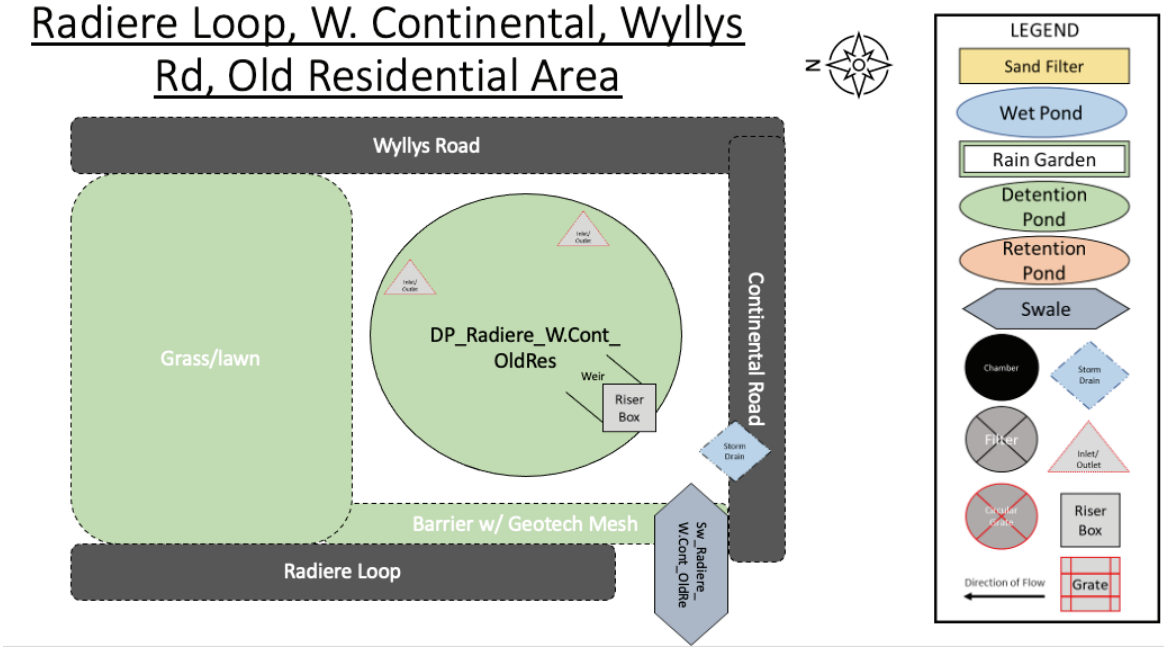



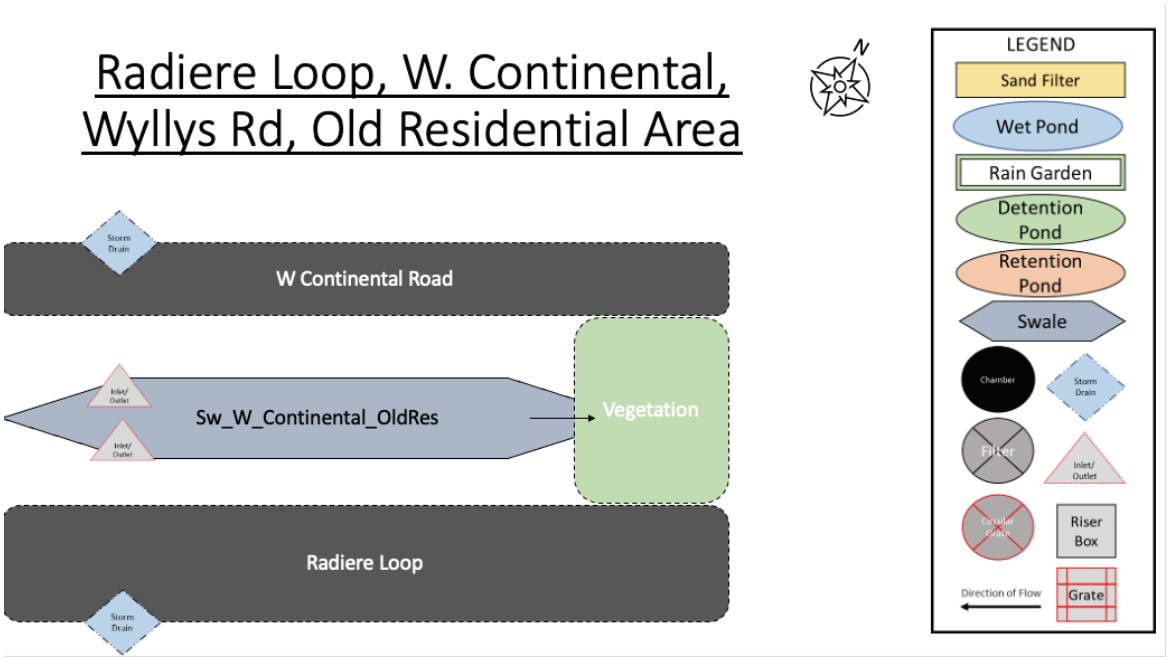

## Radiere Loop/W. Continental Rd, Old Residential Area

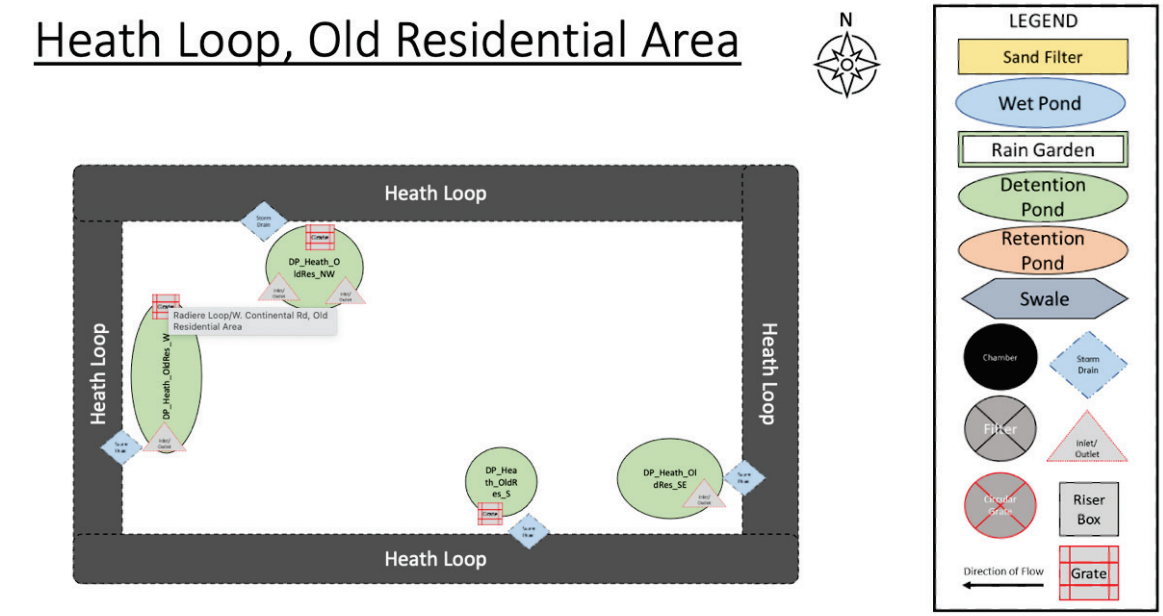


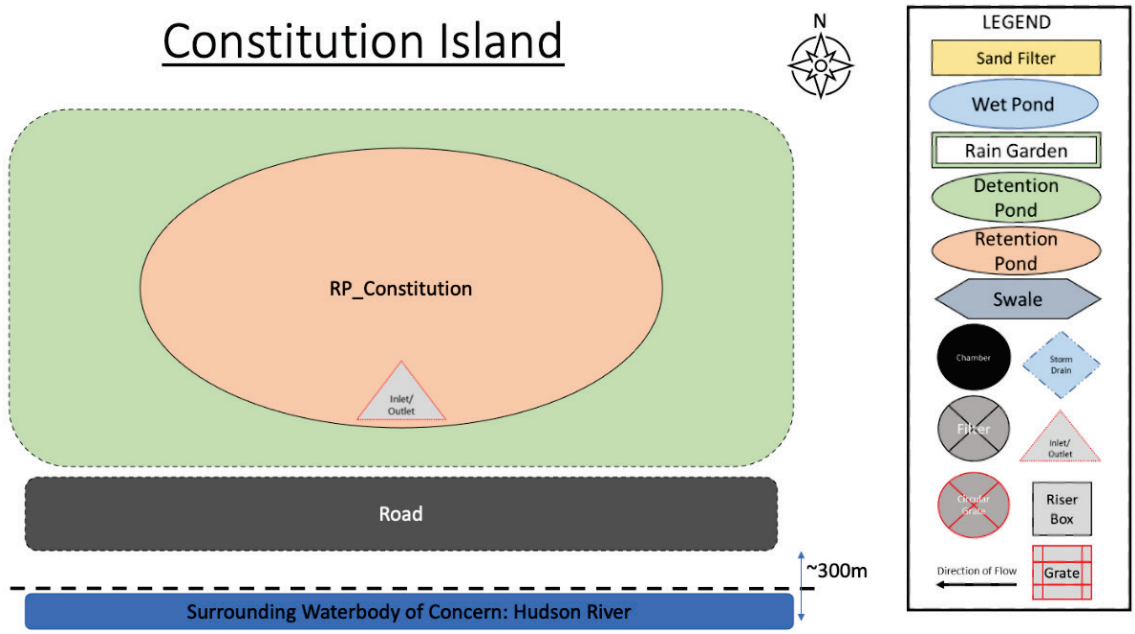



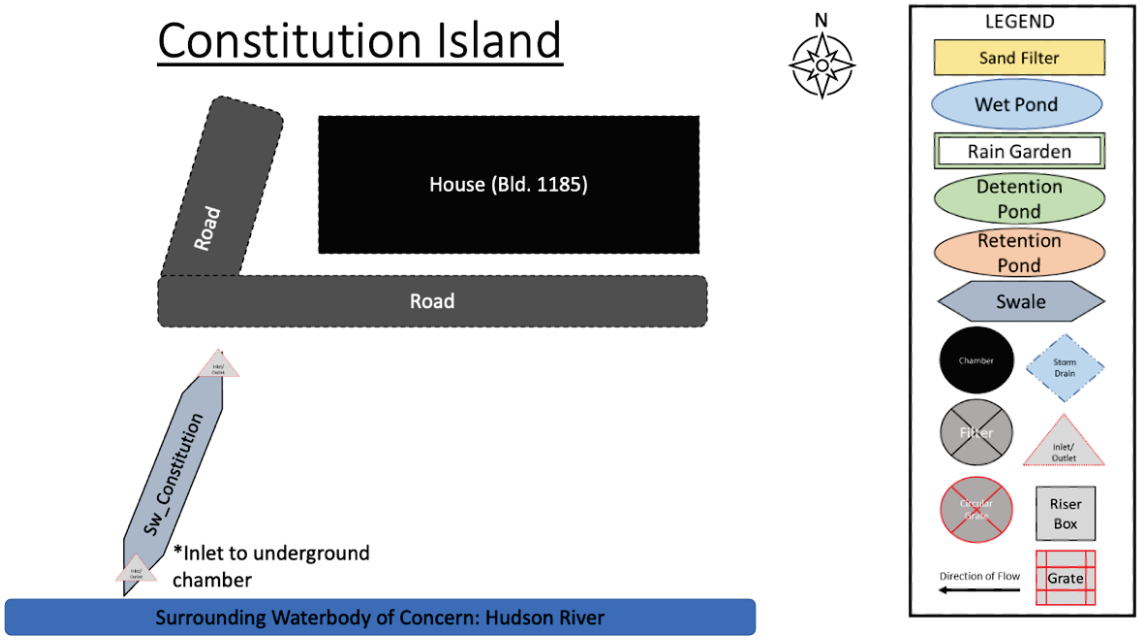

Radiere Loop, W. Continental, Wyllys Rd, Old Residential Area
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow
DP_Radiere_OldRes_NE
Riser Box
Radiere Loop

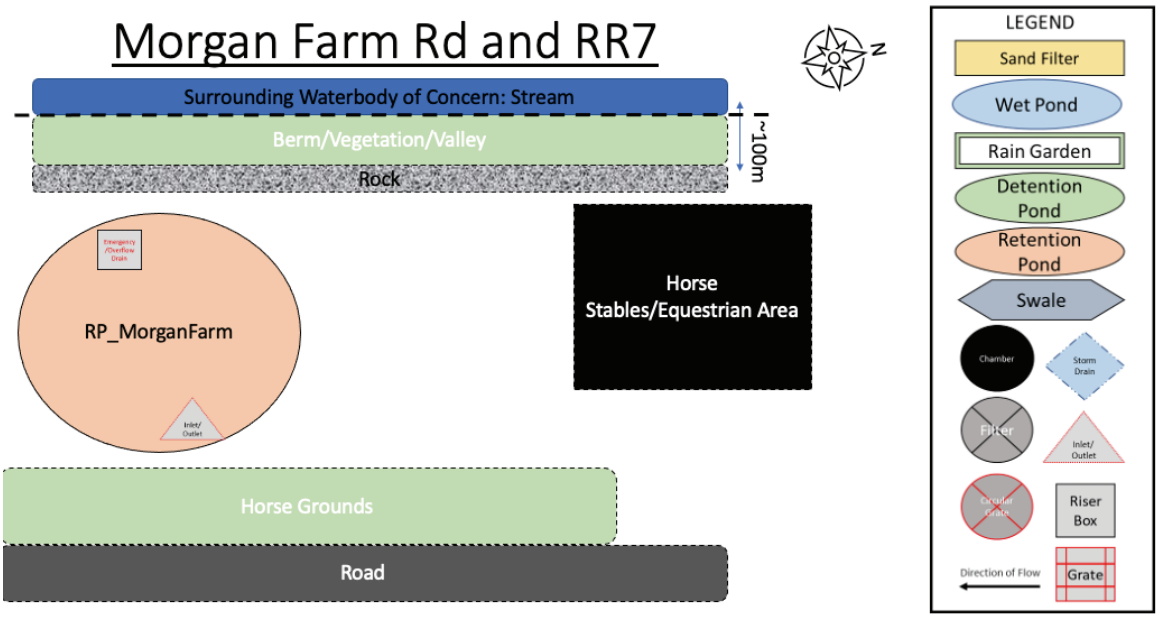

Radiere Loop, W. Continental, Wyllys Rd, Old Residential Area
N
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Grate
Direction of Flow
Wyllys Road
Grass/lawn
DP_Radiere_W.Cont_ OldRes
Weir
Riser Box
Continental Road
Barrier w/ Geotech Mesh
Radiere Loop
Sw_Radiere_ W.Cont_OldRe


Radiere Loop, W. Continental, Wyllys Rd, Old Residential Area
N
W Continental Road
Storm Drain
Inlet/ Outlet
Sw_W_Continental_OldRes
Vegetation
Radiere Loop
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Filter
Riser Box
Direction of Flow
Grate


Heath Loop, Old Residential Area
N
Heath Loop
Heath Loop
Heath Loop
DP_Heath_OldRes_NW
DP_Heath_OldRes_W
Radiere Loop/W. Continental Rd, Old Residential Area
DP_Heath_OldRes_S
DP_Heath_OldRes_SE
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate


Constitution Island
N
RP_Constitution
Inlet/ Outlet
Road
~300m
Surrounding Waterbody of Concern: Hudson River
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate


Constitution Island
N
Road
House (Bld. 1185)
Road
Sw_Constitution
*Inlet to underground chamber
Surrounding Waterbody of Concern: Hudson River
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate


Morgan Farm Rd and RR7
N
Surrounding Waterbody of Concern: Stream
Berm/Vegetation/Valley
Rock
~100m
RP_MorganFarm
Horse
Stables/Equestrian Area
Horse Grounds
Road
LEGEND
Sand Filter
Wet Pond
Rain Garden
Detention Pond
Retention Pond
Swale
Chamber
Storm Drain
Filter
Inlet/ Outlet
Riser Box
Direction of Flow
Grate

# Appendix D: Watershed, Botanical, and Sediment Technical Study US Army Garrisons, West Point, New York


## Watershed, Botanical, and Sediment Technical Study US Army Garrisons, West Point, New York

By
Bruce A. Pruitt, PhD
Certified Professional Hydrologist and Senior Wetland Scientist

The following supplementary report represents the technical study conducted by Dr. Bruce Pruitt at the U.S. Army Military Academy at West Point New York (hereinafter referred to as, "technical study"). This technical study was submitted, at the request of Ms. Darixa Hernandez-Abrams, as an appendix to supplement the "Stormwater Management Practices Monitoring and Maintenance Plan at US Army Garrison at West Point" (Darixa Hernandez-Abrams et al. May 2022). Dr. Pruitt was tasked with assessing the functionality of several storm water basins on the installation in regards to capacity, botany (routine dominance) and sediment characterization. This technical study does not include management recommendations which are contained in the main body of the Monitoring and Maintenance Plan.

This supplementary report included (surface assessments):

1. Mapping the sediment basins bottom and berm using Geographic Position System (GPS).
2. Mapping drainage features which discharged to the basin.
3. Mapping three sand filters.

Remote assessments included:

1. Mapping and estimating the area of the sediment basins using Geographic Information System (GIS).
2. Mapping and estimating the area of the drainage basin that discharges into the sediment basins using GIS.
3. Collection and identification of selected dominant plant species at the laboratory.

Dr. Pruitt was requested to assess 15 basins as described below.

**Fire Station.** Located between Ordinance and Stony Lonesome Roads, the fire station retention pond (ID: RP_Stony_Fire_Station) is down-gradient on a 20-to-30-degree slope near the footslope from the fire station structure and training facility (Figures D-1 and D-2). Two swales (IDs: Sw_Stony_Fire_Station_S and Sw_Ordnance_Fire_Station_N), north & south swales, discharge to the retention pond. Both swales have been stabilized with rip-rap (small boulder size). The drop outlet structure was square with drainage ports on the side and an emergency spillway on the top cover with a steel grating (hereafter referred to as, "typical"). The north drainage swale exhibited excessive herbaceous vegetation growth and should be maintained frequently. The south drainage swale is grassed and maintained by routine mowing. The drainage area is approximately 145.7 acres (Table D-2). The retention pond was elliptical to rectangular shaped with an estimated berm height of 8.8 feet and capacity of 0.89 acre-feet (Table D-1). The basin floor was approximately 90% covered with endemic botanical species. Fourteen species were identified on the basin floor, berm and drainage swales. *Rosa multiflora* was the only introduced species observed and was located on the berm. Typical of cattails, *Typha angustifolia*, observed on the basin floor, has the potential of spreading rapidly and should be controlled. Sediment retention in this basin varied in depth across the basin floor but was approximately 3 to 4 inches deep. The surface horizon was a silt clay loam, matrix color 10YR 4/1, medium subangular blocky structure, and friable. The subhorizon was a fine sandy clay loam with small gravel (2 to 4 mm particle size class), firm angular blocky structure, firm consistency, and many redoximorphic features, mottle color 7.5YR 4/8.

It appears the fire station and training facility were constructed between December 1998 and April 2004. The surface and subsurface horizons

represent a history of sediment deposition over time. As evidenced by the structure, consistency and presence of prominent redox features, the subhorizon horizon was deposited several years ago possibly during and immediately following construction activities. The surface horizon represents more contemporary deposition but is considered insignificant.

**USMAPS (US Military Academy Prep School).** The USMAPS detention basin is located next to the academy at Pipeline Trail off Reynolds Road. It is down a very steep embankment of 45 to 50 degrees near the footslope landscape position (Figure D-3). The drainage area is approximately 47.4 acres (Table D-2). A 24-inch black corrugated plastic pipe discharges from near the top of the embankment near the road. Surface water flows down the steep rip-rapped swale to the basin that turns slightly to the left. The detention pond is lollipop shaped with an estimated berm height of 8 feet and capacity of 0.57 acre-feet (Table D-1). Dominant plant species in the basin include: *Typha angustifolia* (at the base of the rip-rap), *Ambrosia* spp., *Aster* spp. and various grasses and forbs. However, the basin and surrounding drainage in the vicinity is maintained by mowing with the exception of a wet area at the foot of the drainage swale as evidenced by the dense cattail growth. Some recent deposition (1 to 2 in.) and standing water (1 in. inundation) were observed at the foot of the drainage swale (Table D-1). The deposition was a silt clay loam with many small gravel (2-8 mm), weak subangular blocky structure, friable, and 10YR 3/2 color. Consequently, the small area of contemporary sediment deposition is considered an artificial wetland. The outlet structure was typical.

**Morgan Farm.** The West Point FMWR Morgan Farm Riding Stables and Kennel retention pond (ID: RP_Morgan Farm) is located adjacent to the outdoor and indoor equestrian arenas on Morgan Farm Road off Morgan Road (Figures D-5 and D-6). The drainage area is approximately 16.1 acres (Table D-2). The triangle-shaped basin is perhaps the most recently built retention pond that was characterized at West Point during this study. The basin is approximately 0.46 acre-feet with 5.7-ft berms. Surface water from parking lots and roof tops enters the basin predominantly from the north end and flows down a rip-rap ditch (small boulder size). In addition, there is a pipe that drains the outside arena that discharges to the basin on the east side slope. Coarse sand and gravel deposition was observed down-gradient of the pipe. The outdoor arenas have been graded with no vegetation, thus is flat with slopes less than one percent. The predominant

sediment deposition in the retention pond was silt clay loam that varied from 1 to 2 inches deep within the basin. Its consistency was friable with a color of 10YR 4/1. Grasses and forbs dominate the basin which is maintained by mowing. The typical, outlet structure was built into the west berm and had been retrofitted with an automated pump system.

**Stony Child Development Center (CDC).** The CDC detention pond (DP_Stony_CDC_S) is located down-gradient of the CDC. The surrounding drainage basin area is approximately 10.6 acres (Figure D-7 and Table D-2). The basin is nearly circular shaped (Figures D-7 and D-8). The basin is fenced but has no berm. However, the sides of the basin are steep (~ 45 degrees), and the basin floor is over six feet below the surrounding ground elevation. The inlet is a 24-in. thick-walled PVC pipe (possibly schedule 80) within a concrete wing-wall structure. Immediately below the inlet is a subsurface sand filter. The outlet is a 12-in. PVC pipe within a concrete wall. The basin floor is covered with cobble size gravel. No significant embeddedness of fine material between the cobble was observed. The sides of the basin were dominated with *Verbascum thapsus*, *Ambrosia, Ludwigia, Solidago canadensis*, and various grasses and forbs.

**Stony Residential Area.** The Stony Lonesome Residential Area is considered build-out, even though some construction was observed. Two basins, the northeast basin (upper, higher elevation; ID: DP_Paterson_OldRes_1) and the southwest basin (lower elevation; (ID: DP_Paterson_OldRes_2), are in surface water flow alignment and cumulatively provide approximately 3.9 acre-ft capacity (Table D-2). These two basins are located between Paterson Loop and W. Continental Road. The basin floors are approximately 11.7 ft (on average) below the upper side slope elevation. The corner slopes of the upper basin were stabilized with rip-rap (small boulder size). Two 18-in. black corrugated pipes were noted in the basin that were partially collapsed and 75 percent blocked with sediment and debris. Surface water from the upper basin discharges through a typical drop outlet structure to the lower basin. The two basins are separated by a berm that is approximately 5.4 ft above the floor of the southwest basin. Consequently, it is possible surface water could flow from the northeast basin over the intermediate berm into the southwest basin without leaving the uppermost side slopes. However, during the survey, there was no evidence of surface water flow over the intermediate berm which would be highly unlikely. The basins are maintained with grasses on the floor and side slopes. Common planted,

landscape trees on the upper side slopes include white pine, sycamore, river birch and Douglas fir.

**Heath Loop Southeast, West and North.** The southeast (ID: DP_Heath_OldRes_SE ), west (ID: DP_Heath_OldRes_W), and north (ID: DP_Heath_OldRes_N ), detention basins located in the Heath subdivision are treated together here (Figures D-10, 11, and 12). The subdivision is built out, consequently, very little sediment is discharging to the basins. A small low-level outlet grate approximately twelve inches in diameter is located at the lower end of each of the Heath basins. Evidently, flow that accumulates in the basins flows under Heath Loop and is conveyed down-gradient on the opposite side of the road. The integrity of the outflow grate in the northwest and southeast basins have been compromised and need to be replaced. The estimated basin sizes are 0.33, 0.43 and 0.17 acre-ft, respectively (Table D-2). Excessive vegetation, dominated by *Ambrosia, Aster*, and various grasses and forbs, was observed in the southeast basin. However, the west and northwest basins were planted with grasses and forbs and maintained by mowing.

**Constitution Island Wetland.** Constitution Island is located on the Hudson River across from the Military Academy near the village of Cold Spring. Currently, the basin is located up-gradient of a paved access road that runs from east to west (Figure D-13). The basin is considered a natural, permanent wetland area for the following reasons:

- It is visible on 2006 aerial photography prior to the construction of the paved access road which now impounds the wetland.
- It is dominated by obligate hydrophytes and associated wetland-dependent herptiles.
- The predominant water source (headwater slope wetland) is groundwater seepage through granite outcrops as evidenced by ferric hydroxide and organic sheen seepage.

Between 2009 and 2011, the access road was paved and impounded the wetland area. A 12-inch black, corrugated plastic pipe was installed under the road. The pipe extends approximated 200 feet underground to an open swale (ID: Sw_Constitution) where surface water is daylighted to the Hudson River. There is an access (manhole) installed with a grate adjacent to the outbuilding at approximately 130 ft from the road. As evidenced by

the fine sediment deposition inside the pipe at the point of daylighting, flow has occurred in the pipe (chord = 8 in., M = 3/8 in.).

The wetland is approximately 0.31 acre-ft. The entire watershed is approximately 11.2 acres which includes the entire drainage to the Hudson River confluence (Table D-2). Hydric soils were observed in the wetland. The soils were 1 to 3 in. deep and characterized as a silt clay loam, angular to subangular blocky, firm, and color 10YR 4/1. The diversity of hydrophytes in the wetland exceeded all the other basins surveyed during this technical study (Table D-1). Even though the botanical survey was not comprehensive, ten plant species were observed not including plants outside of the permanently inundated area. Because of the uniqueness of this wetland area and the direct connection to the Hudson River, this area should be preserved. Introduced (invasive) species should be mechanically removed (e.g., *Ailanthus altissima*).

**Sand Filters.** The three sand filters, north (ID: Sf_PX_Ordnance_N), west (ID: Sf_PX_Ordnance_W), and east PX (ID: Sf_PX_E) are treated together here. The north and west sand filters are located on Ordinance Road beyond the fire station (Figures D-14 and 15). The east PX sand filter is located on the backslope of the permanent wetland near the baseball diamond to the northeast of the PX parking lot. The north, west and east PX sand filters are 0.01, 0.04, and 0.5 acres in size, respectively. Silt, coarse sand and gravel were observed on Ordinance Road up-gradient of the north and west sand filters. All three filters are characterized with excessive vegetation including *Ambrosia, Aster*, and various grasses and forbs. Excessive annual vegetation can clog sand filters during the remineralization process.

**West Point Transportation Motor Pool, South, and North Retention Ponds.** Located off of SR293 at 1946 Furance Road, the West Point Transportation Motor Pool has two detention ponds, north and south. Due to inaccessibility, the two basins were not mapped using GPS. However, both basins exhibited excessive, annual vegetation growth with annual growth along the berms including introduced species (e.g., *Ailanthus altissima*).

**Post Exchange (PX) Basin.** The PX is located off Stony Lonesome Road and backs up to Ordnance Road. The retention pond (ID: RP_PX_E), which is permanently flooded, is located on the east side of the

PX and to the northwest of the PX parking lot and baseball diamond. The outlet to the basin is located on the west end near the entrance to the PX. The basin is elliptical shaped and lies within a depression with side slopes 30 to 45 degrees and an elevation change of 10 to 12 ft along the south side slope. Due to inaccessibility during the study, the basin was not mapped by GPS. The basin is 1.07 acres (GIS derived), and the watershed size is 23.0 acres (Figure D-17). There is a sand filter (see east PX sand filter above) located on the southeast slope near the parking lot. Ten species of emergent and floating vegetation was observed. A hedge of planted red tips (*Fraser photinia*) and white pine (*Pinus strobus*) were observed on the edge of the parking lot. Two dense stands of the invasive, common reed (*Phragmites australis*) make up about 20 percent coverage of the basin.

**Invasive Species.** Three invasive species were observed across the basins including: *Rosa multiflora* (fire station basin), *Ailanthus altissima* (Constitution Island and TMP South), and *Phragmites australis* (PX basin). Other invasive species are likely. Even though cattail (*Typha* spp.) are endemic to the area, they can spread rapidly especially if a source of phosphorus is available in the water column or soil. An aggressive program to control invasive species should be established. Pruitt et al. 2022 identified several introduced species to the Piedmont physiography including New York (Table D-3). In addition, two web sites on the subject can be searched:

https://www.invasivespeciesinfo.gov/

## Reference

Pruitt, B. A., R. D. Rheinhardt, and C. V. Noble. 2022 (in final *beta* testing). Operational Draft Report. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont Region of the United States.

Figure D-1. Fire Station Retention Pond at Ordinance Road, US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS generated (*bottom*).

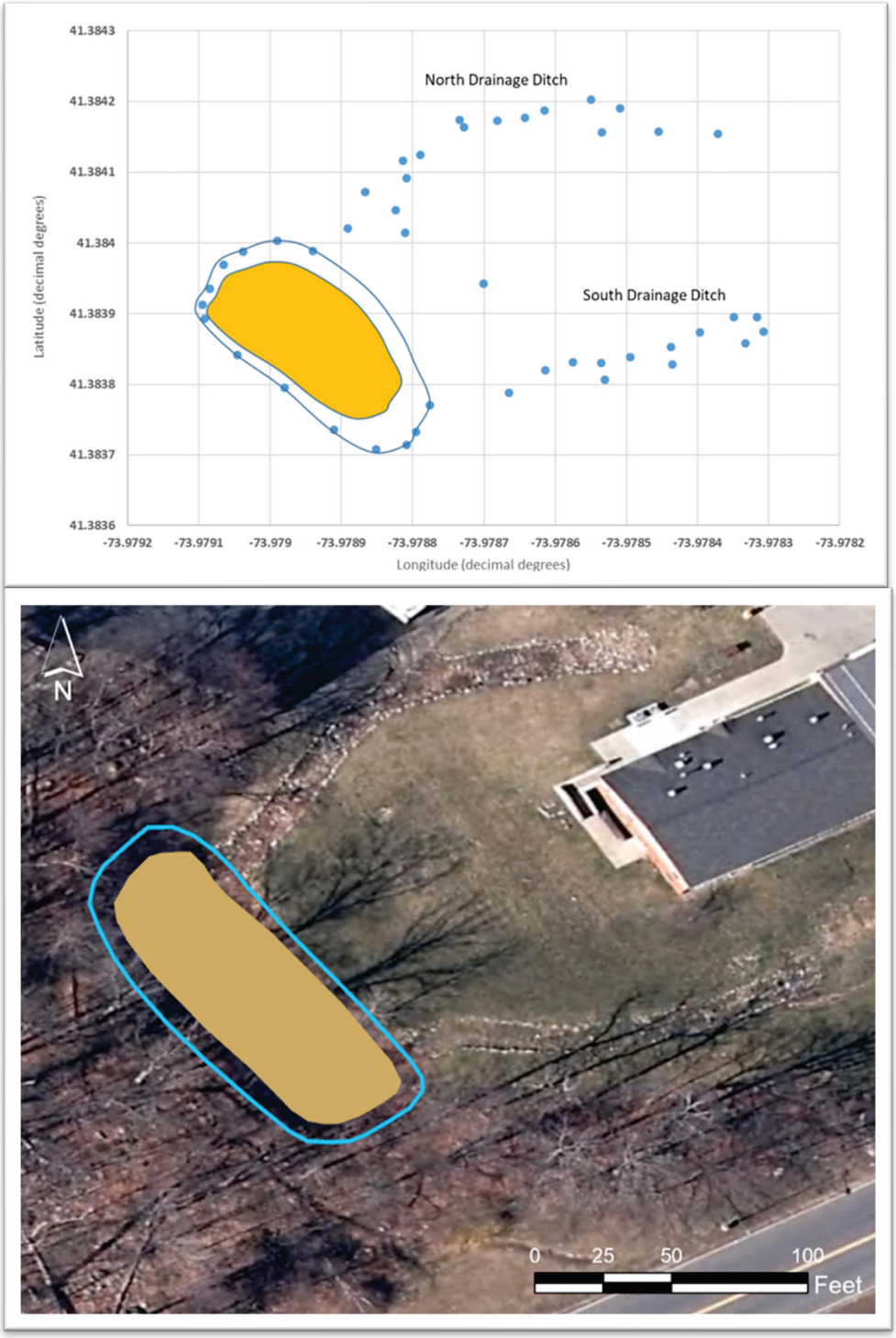


Figure D-2. Fire Station Retention Pond and watershed at Ordinance Road, US Military Academy, West Point, NY. GIS area (*top*), topographic (*bottom*). Green rectangle represents retention pond.

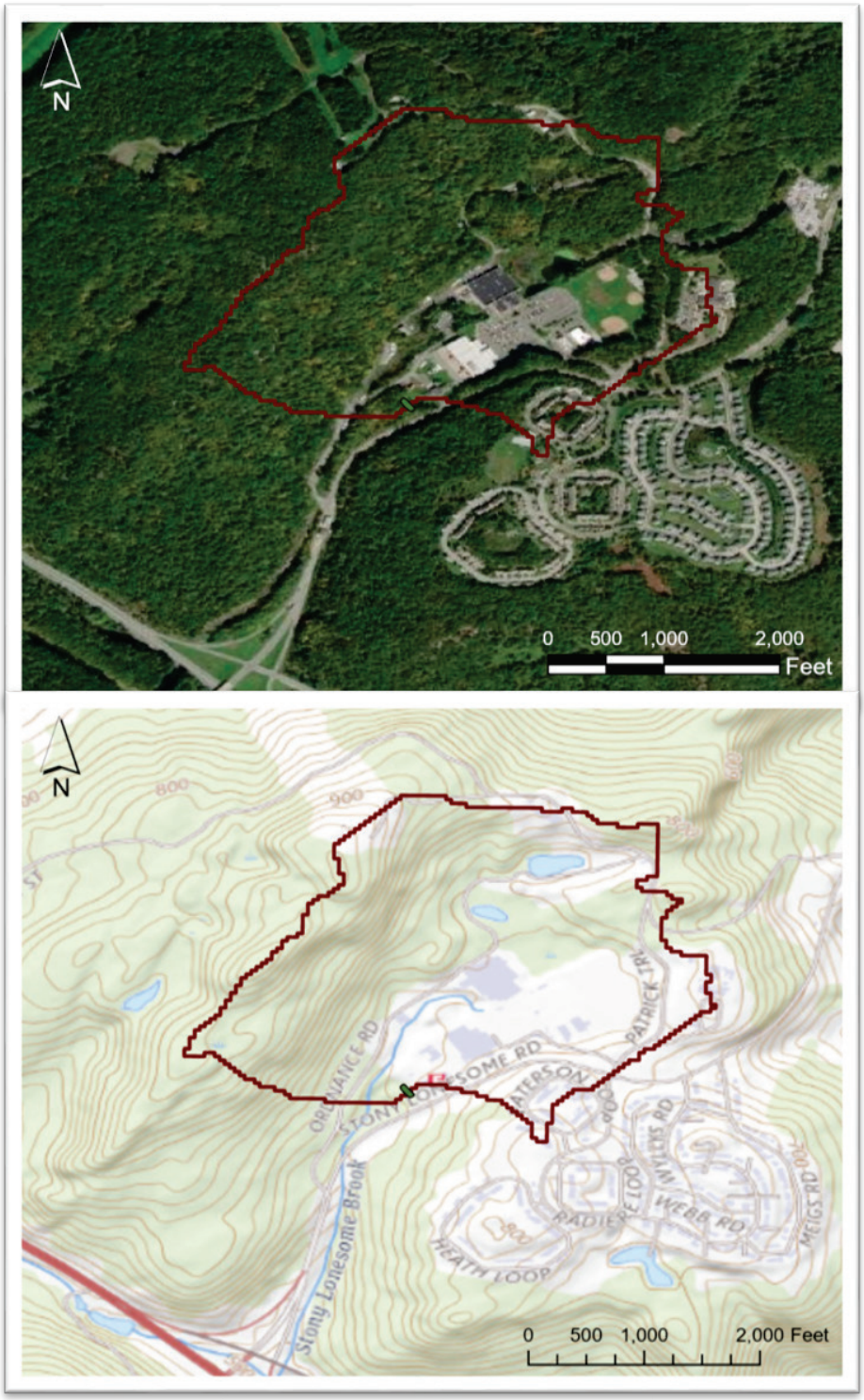


Figure D-3. USMAPS Detention Pond at Pipeline Trail off Reynolds Rd., US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS-generated drainage area (*bottom*). Blue polygon on far right represents detention pond.

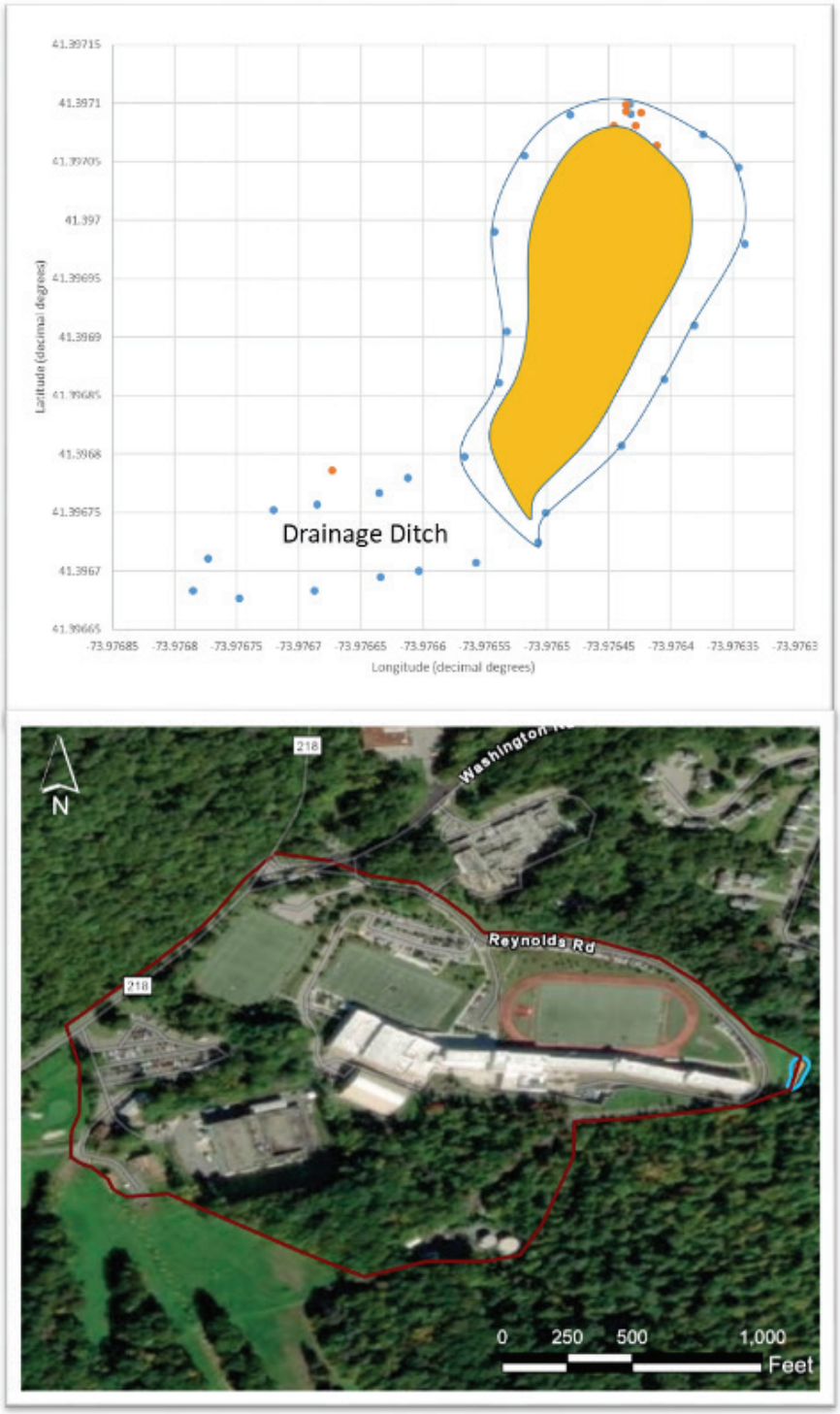


Figure D-4. USMAPS Detention Pond at Pipeline Trail off Reynolds Rd., US Military Academy, West Point, NY. GPS surface assessment. Note erosional ditch does not discharge to detention pond.

Figure D-5. West Point FMWR Morgan Farm Riding Stables and Kennel, US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS-generated drainage basin (*bottom*). Note retention point depicted as yellow polygon.

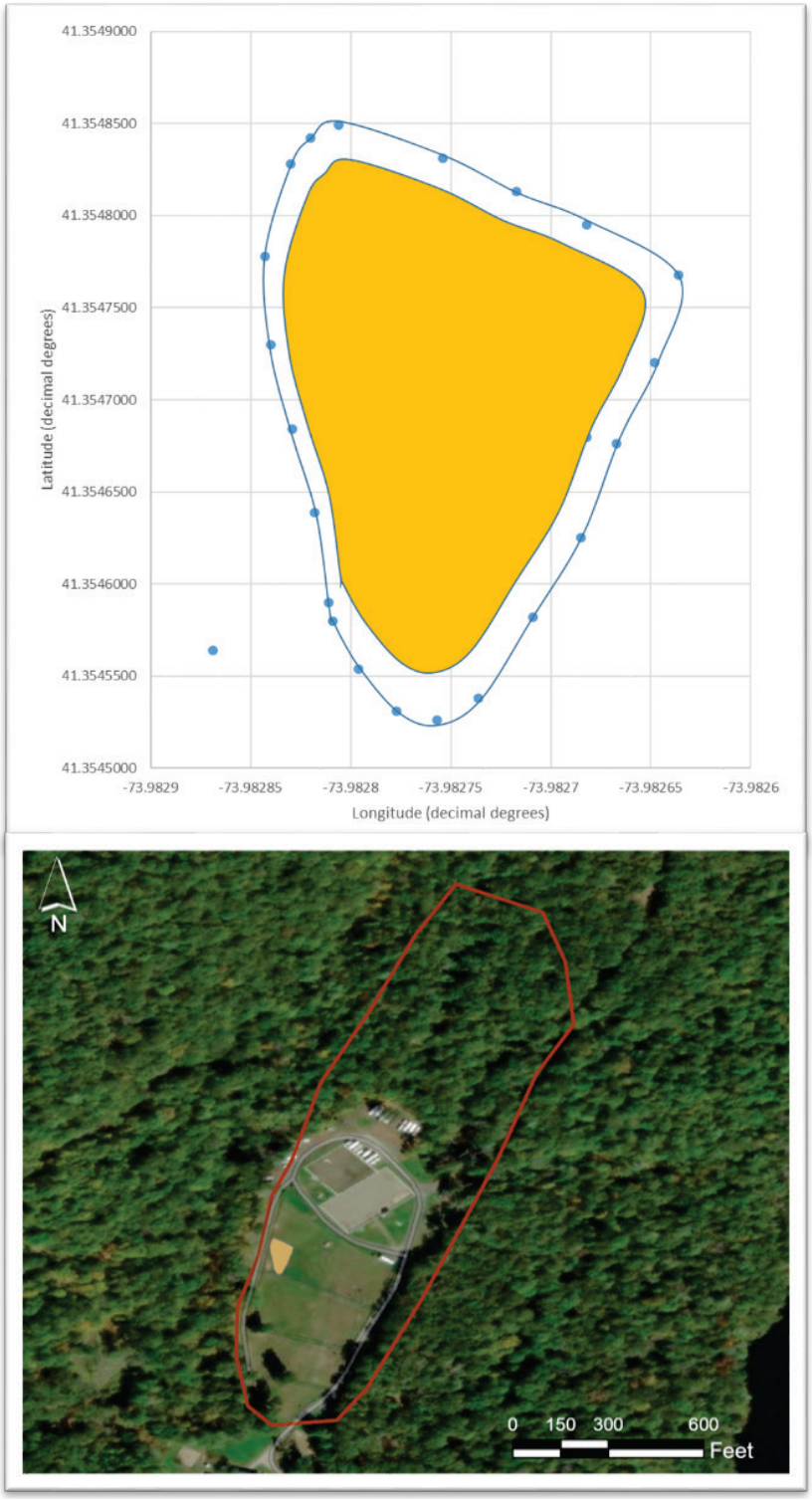


Figure D-6. Retention pond at West Point FMWR Morgan Farm Riding Stables and Kennel, US Military Academy, West Point, NY. Retention pond location and shape approximate due to recent GIS imagery not available.

Figure D-7. Detention pond at Child Development Center at Patrick Trail and Stony Lonesome Rd., US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note detention pond depicted by blue and yellow polygon.

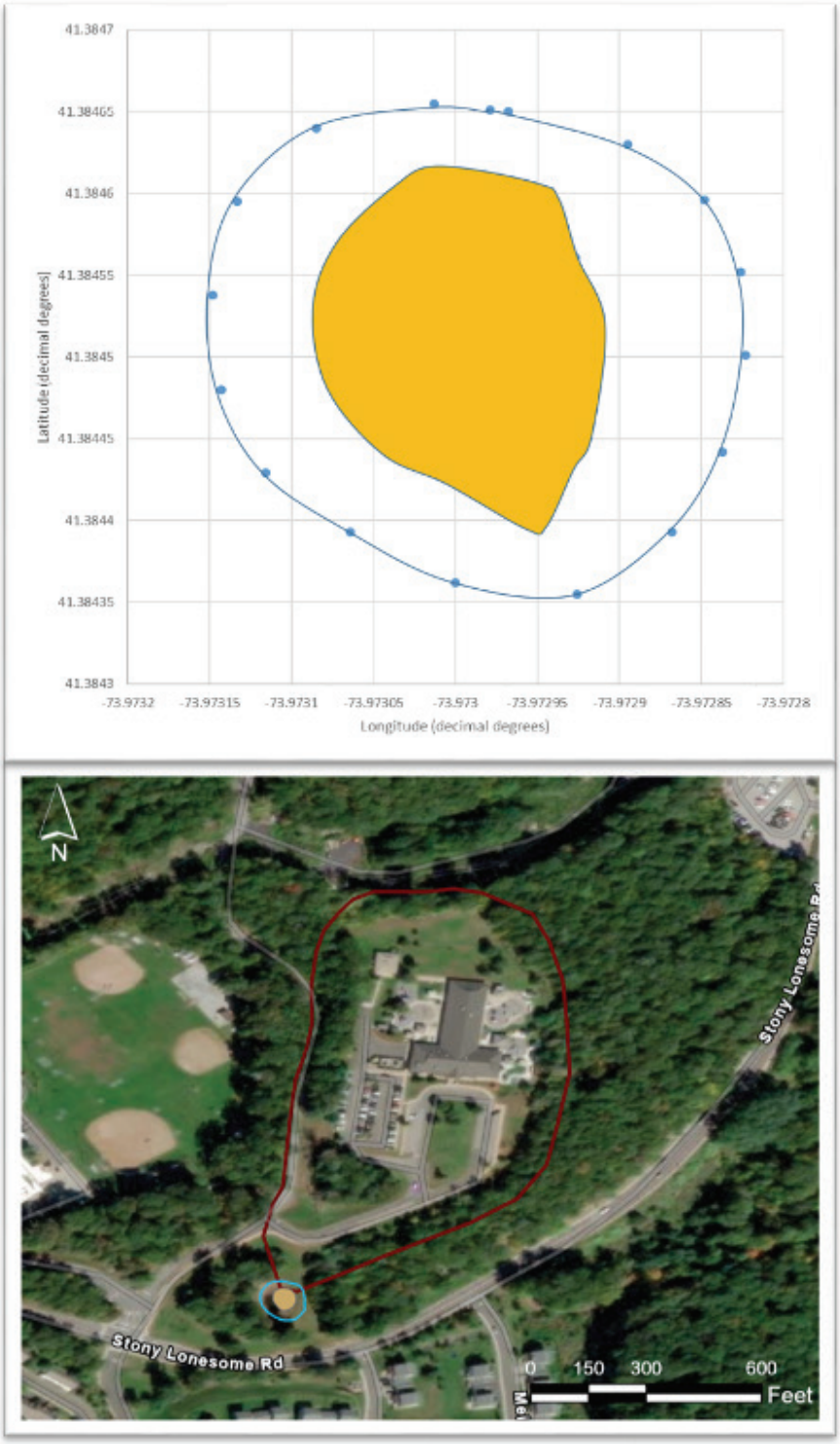


Figure D-8. Detention pond (zoomed in) at Child Development Center at Patrick Trail and Stony Lonesome Rd., US Army Garrisons, West Point, NY.

Figure D-9. Detention pond at Stony Lonesome residential area at W. Continental Rd. and Stony Lonesome Rd., US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note detention pond depicted by blue and yellow polygon.

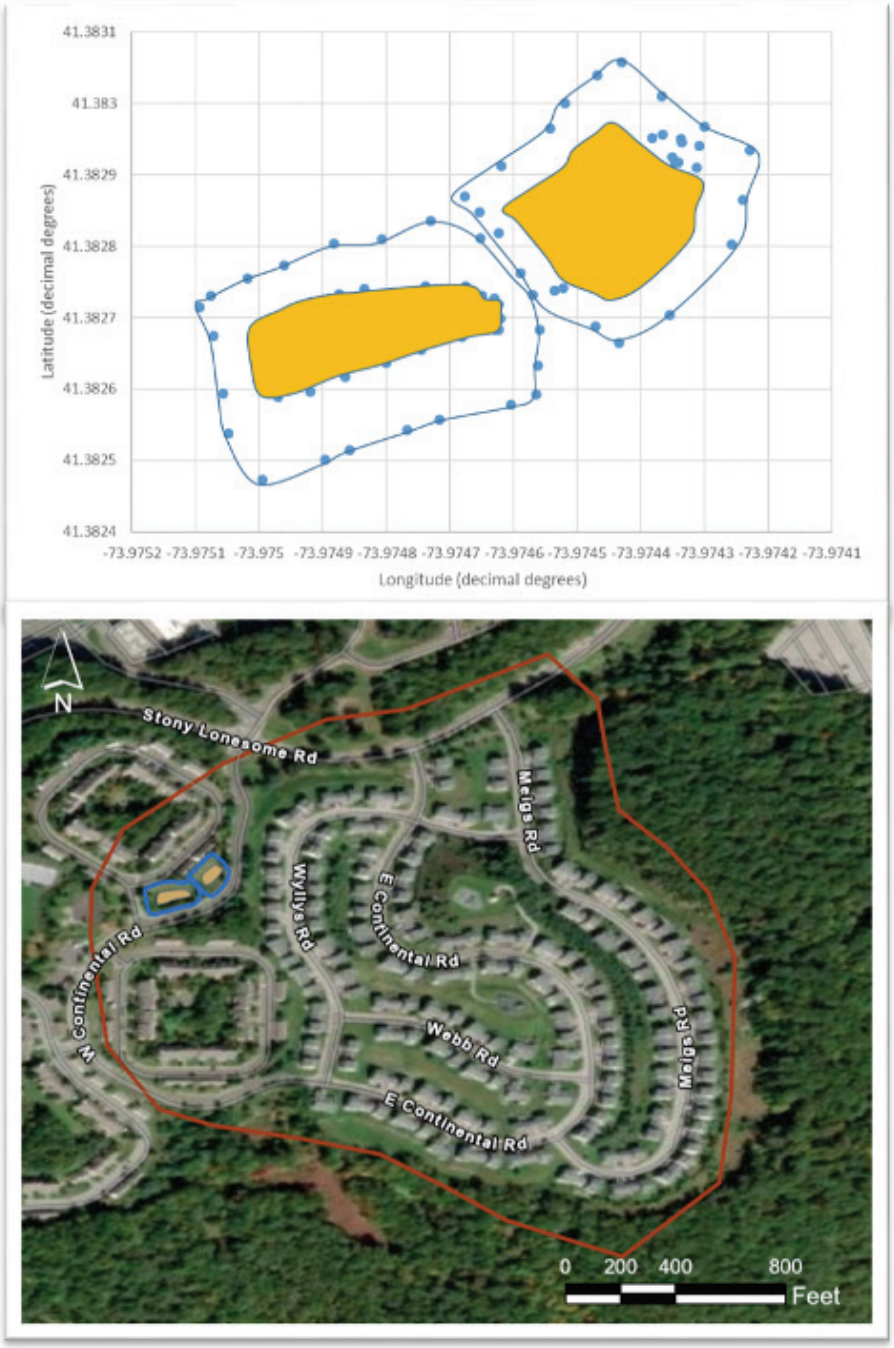


Figure D-10. Southeast detention pond at Heath Loop residential area on Heath Loop Rd. off W. Continental Rd., US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note detention pond depicted by blue and yellow polygon.

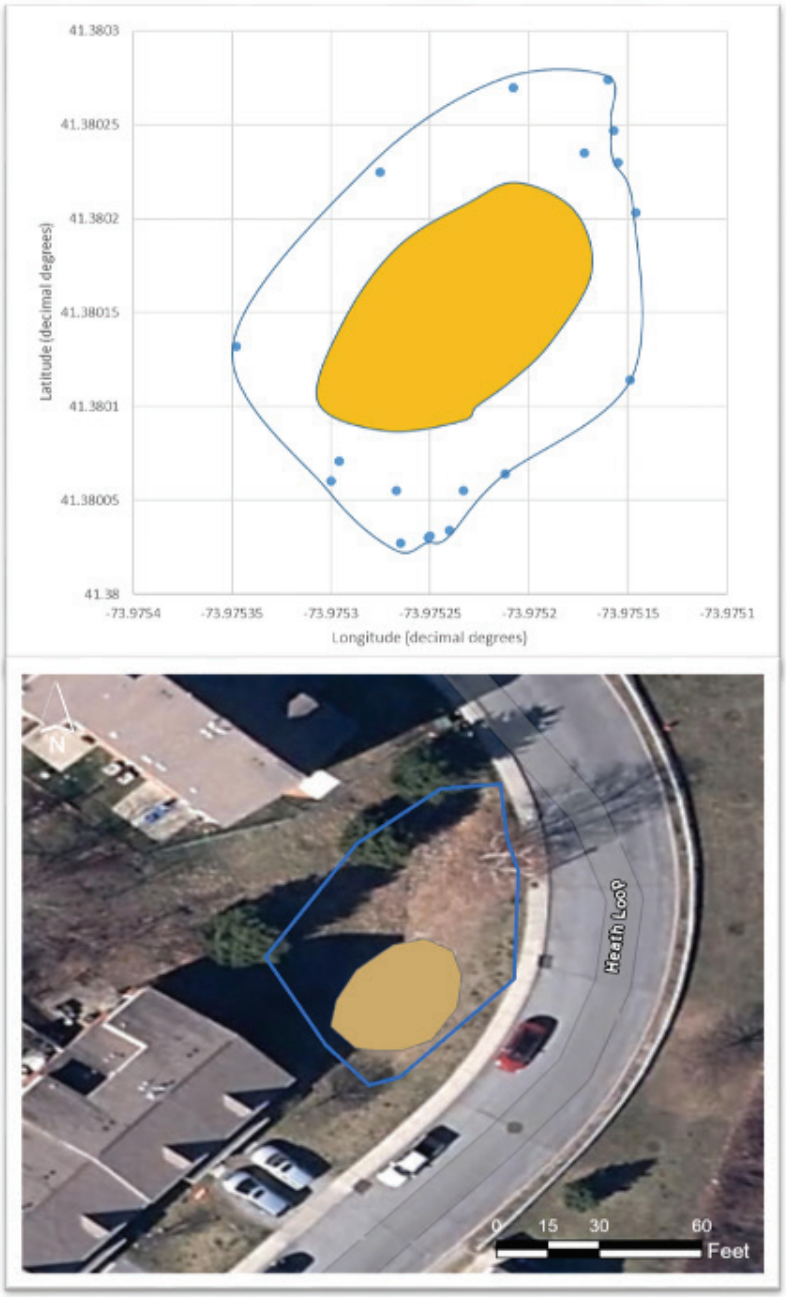


Figure D-11. West detention pond at Heath Loop residential area on Heath Loop Rd. off W. Continental Rd., US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note detention pond depicted by blue and yellow polygon.

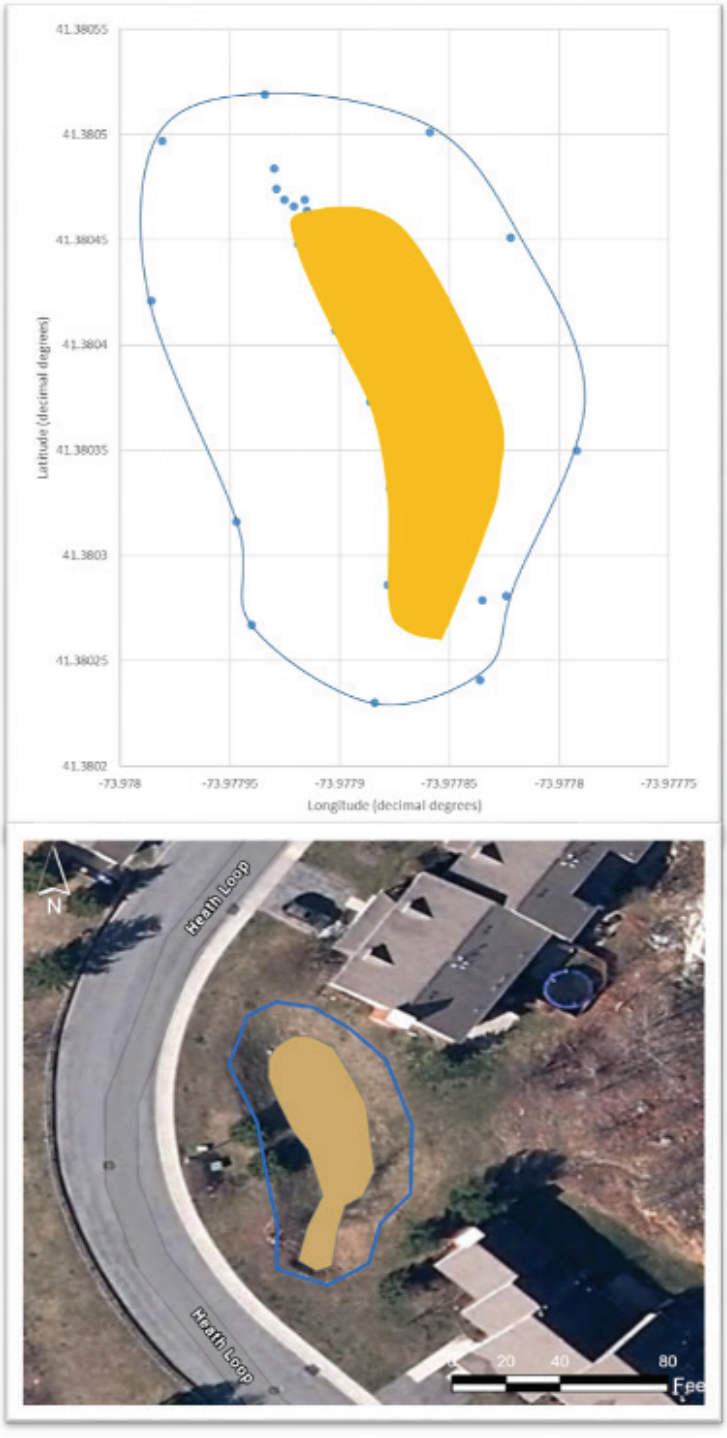


Figure D-12. Northwest detention pond at Heath Loop residential area on Heath Loop Rd. off W. Continental Rd., US Army Garrisons, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note detention pond depicted by blue and yellow polygon.

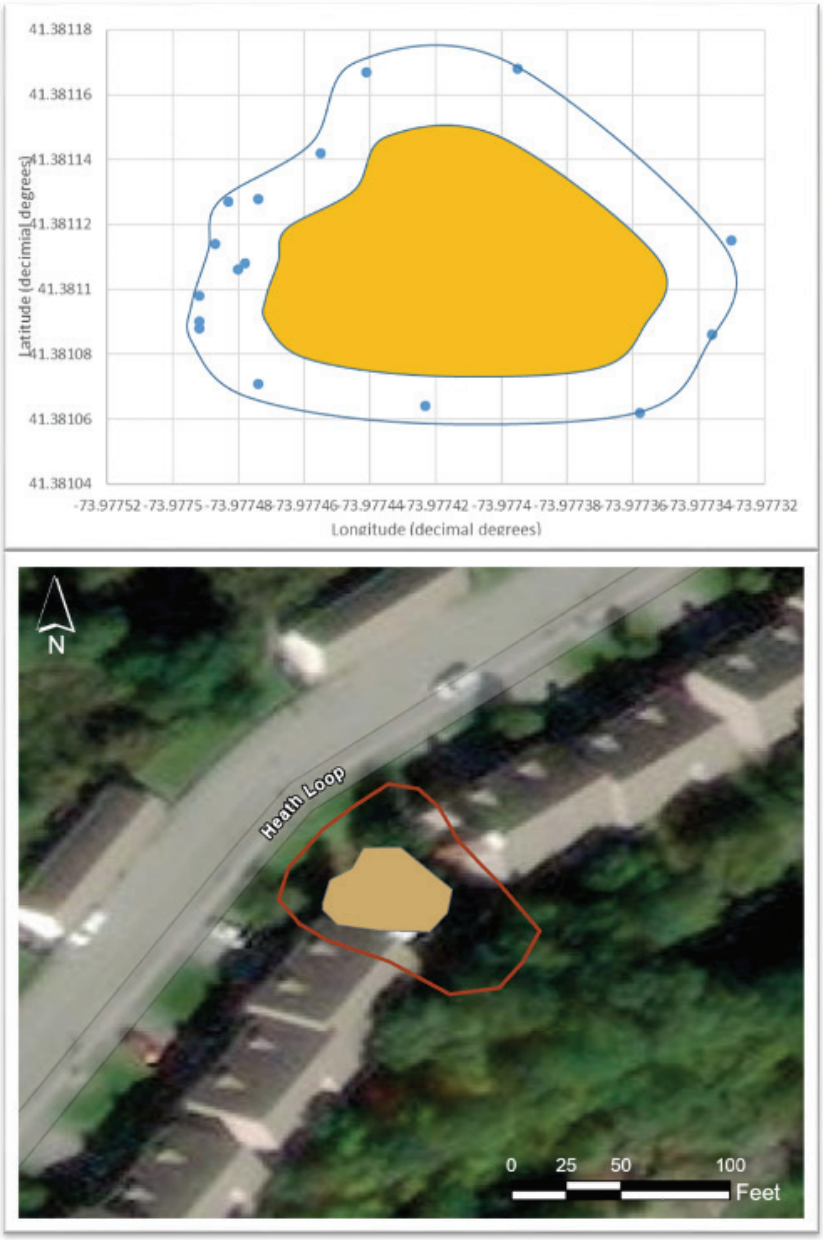


Figure D-13. Impounded wetland area on Constitution Island near Cold Spring, US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS assessment (*bottom*). Note wetland and immediate catchment area depicted by yellow and blue polygons, respectively.

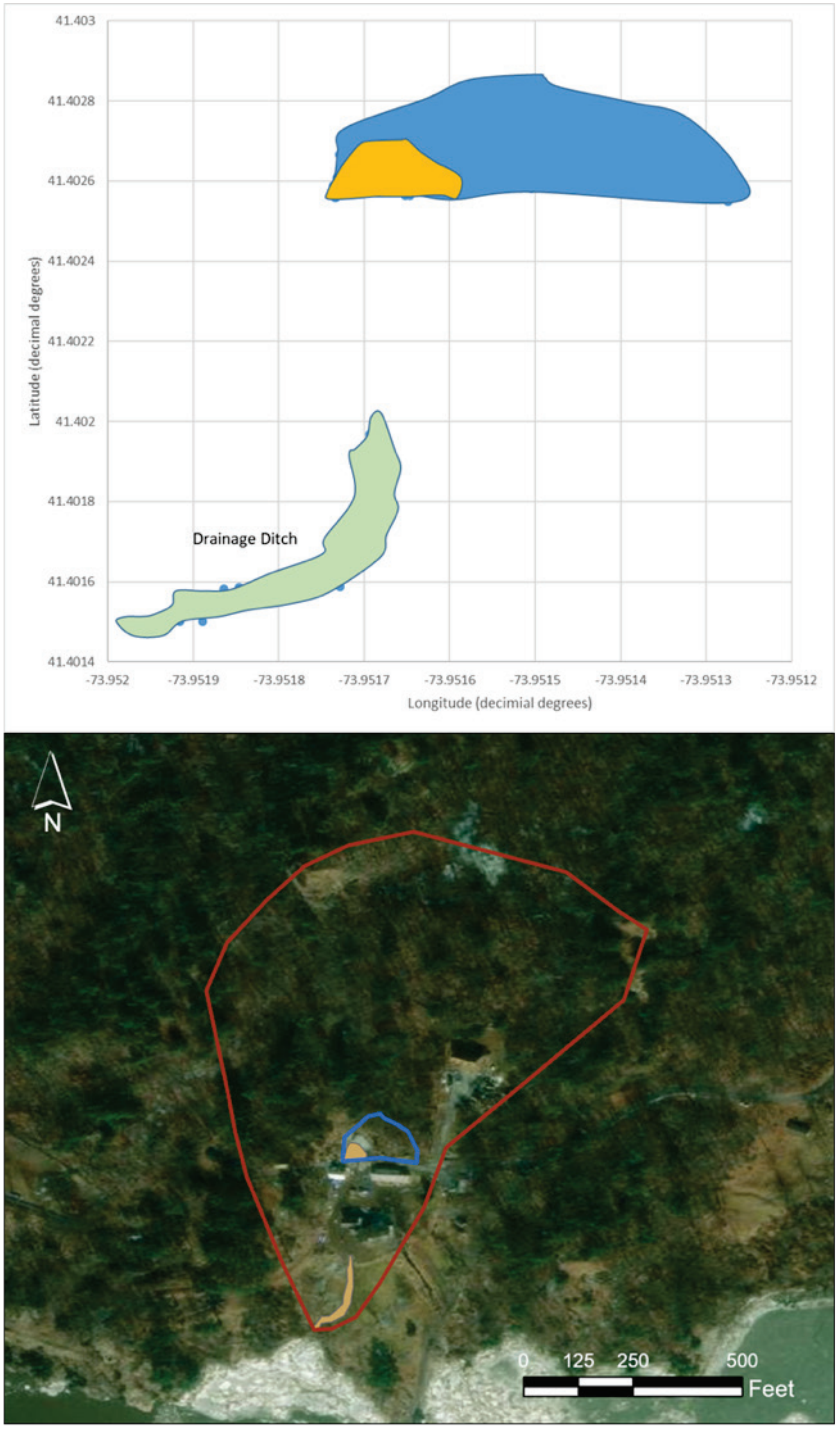


Figure D-14. West sand filter at Ordinance Road near fire station, US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS generated (*bottom*).

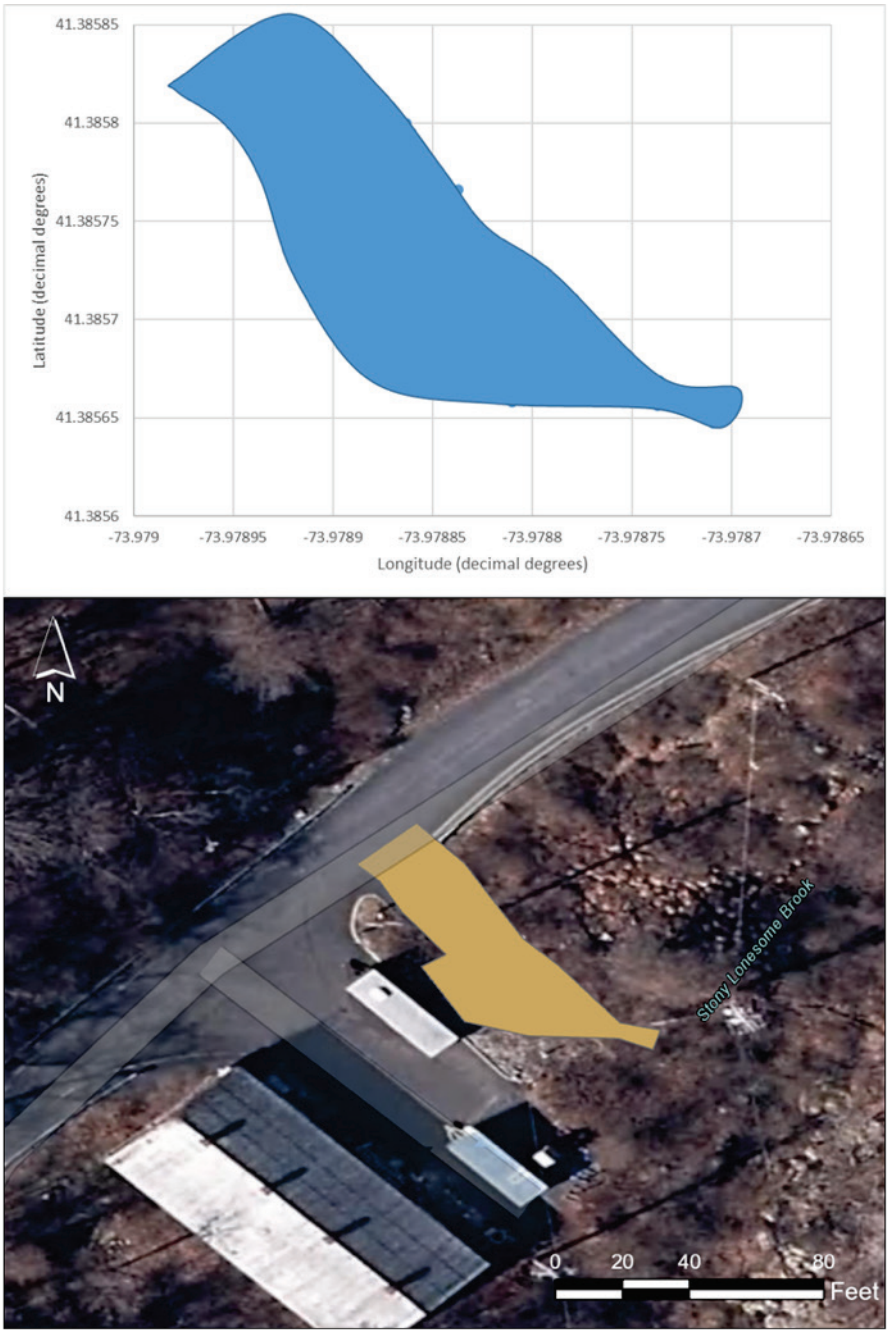


Figure D-15. Northeast sand filter at Ordinance Road near fire station, US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS generated (*bottom*).

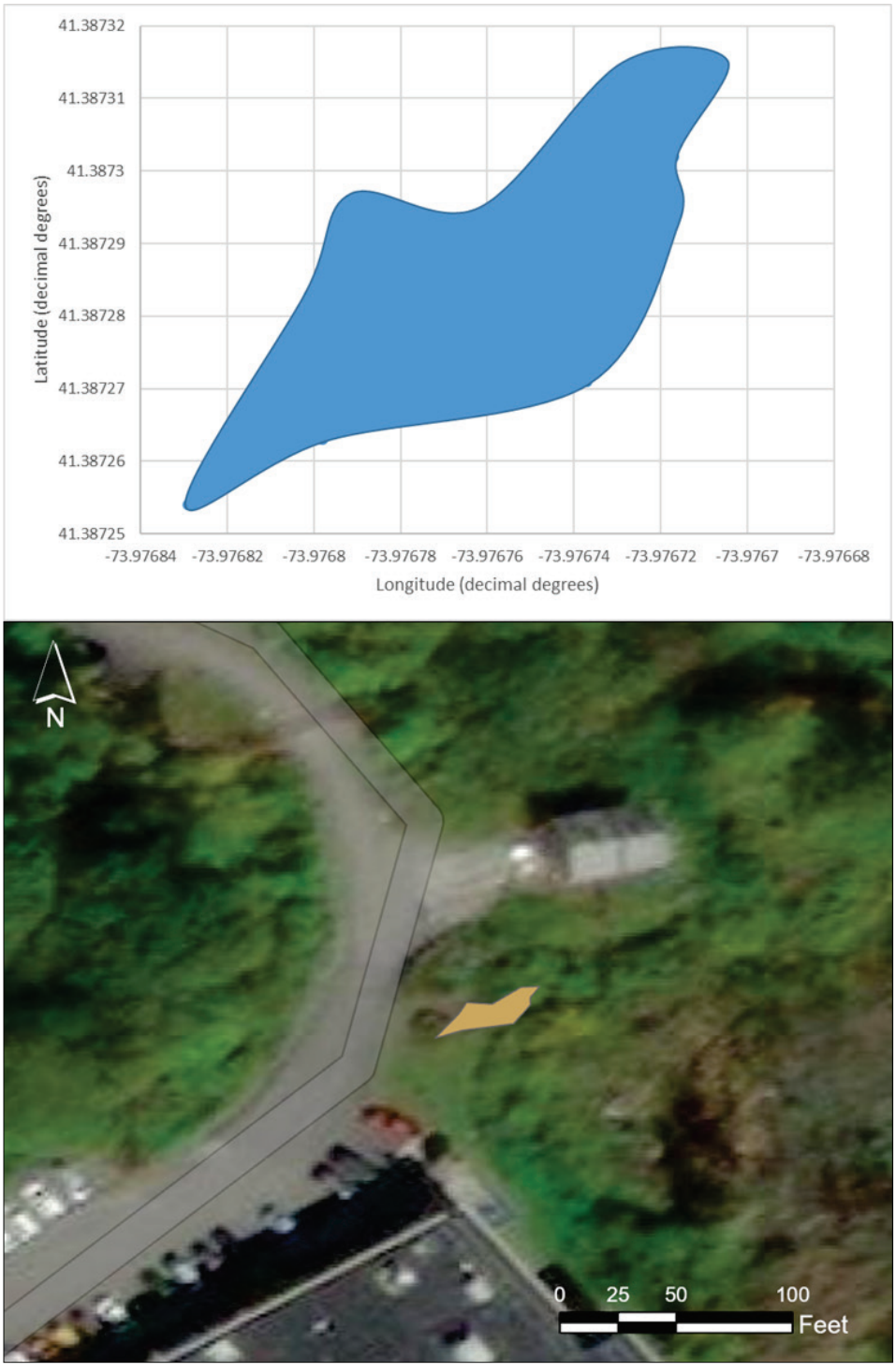


Figure D-16. East exchange sand filter near main exchange off Stony Lonesome Rd., US Military Academy, West Point, NY. GPS surface assessment (*top*), GIS generated (*bottom*).

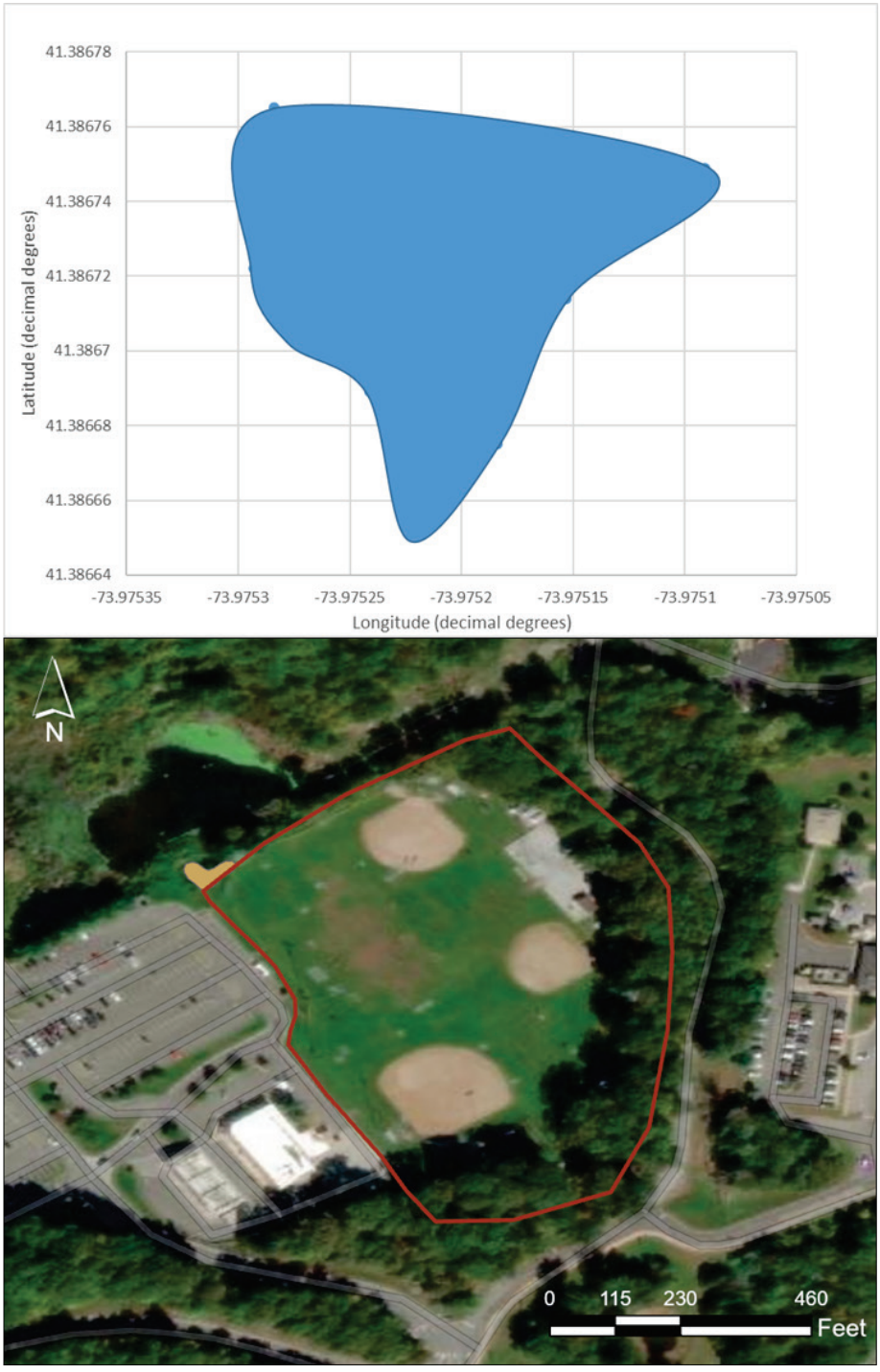


Figure D-17. Post Exchange retention pond off Stony Lonesome Rd., US Military Academy, West Point, NY. GIS surface assessment (*top*), GIS watershed (*bottom*).

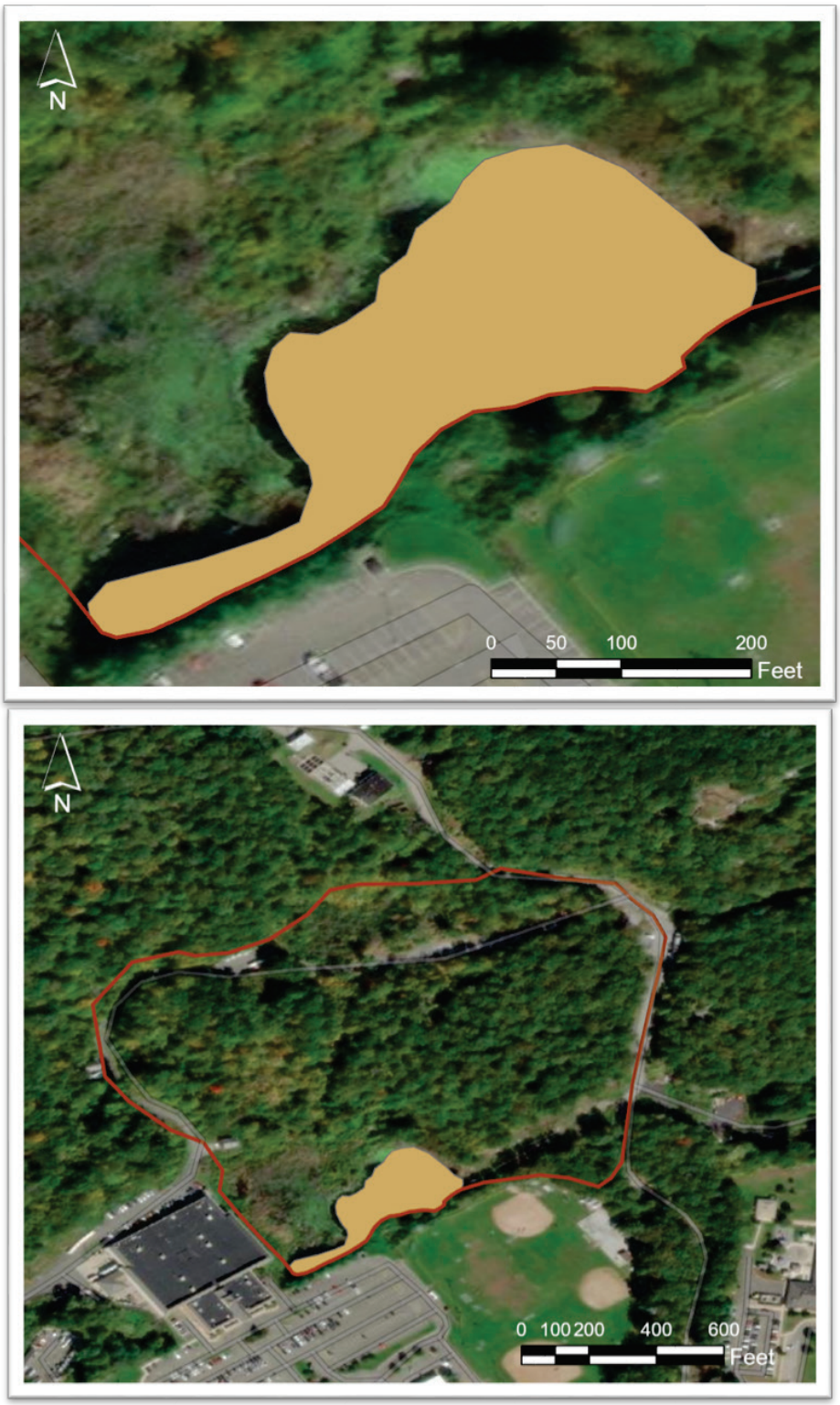


Table D-1. Retention and detention pond characterization, US Army Garrisons, West Point, New York.

| | Landscape | Vegetaton | | | Slope | Texture (Horizon) | | Structure | | Depth (in) | | Consist. | Sediment Color | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Position | Trees | Scrub-Shrub | Herbs/Vines | % | Surface | Sub | Surface | Sub | Surface | Sub | | Matrix | Mottles |
| Fire Station | Footslope | *Carpinus caroliniana* | *Ilex decidua* | *Hydrangea petiolaris* | | | | | | | | | | |
| | | *Platanus occidentalis* | *Rosa multiflora* | *Scripus cyperinus* | | | | | | | | | | |
| | | *Liriodendron tulipifera* | | *Onoclea sensibilis* | 20 to 30 | SiCL | Fine SCL | SAB | AB | 0-1 | 1-3 | Fr | 10YR 4/1 | 7.5YR 4/8 |
| | | *Salix nigra* | | *Woodwardia virginica* | | | | | | | | | | |
| | | *Populus deltoides* | | *Typha angustifolia* | | | | | | | | | | |
| | | | | *Ambrosia spp.* | | | | | | | | | | |
| | | | | *Aster spp.* | | | | | | | | | | |
| Cadet School | Footslope | Basin maintained | none | *Typha angustifolia* | | | | | | | | | | |
| | | | | *Ambrosia spp.* | | SiCL | | | | | | | | |
| | | | | *Aster spp.* | 45 to 50 | w/small | none | SAB | | 0-2 | | Fr | 10YR 3/2 | |
| | | | | Grasses and forbs | | Gravel | | | | | | | | |
| Morgan Farm | Toeslope | Basin maintained, grades from coarse SCL to gravel at pipe | none | Grasses and forbes | <1 | SiCL | none | | | 0-2 | | Fr | 10YR 4/1 | |
| Child Development Center | Backslope | none | none | *Verbascum thapsus* | 1-5 | Cobble bottom | | | | | | | | |
| | | | | *Ambrosia spp.* | | | | | | | | | | |
| | | | | *Ludwigia spp.* | | | | | | | | | | |
| | | | | *Solidago canadensis* | | | | | | | | | | |
| | | | | Grasses and forbs | | | | | | | | | | |
| Stony | Lower Backslope | *Betula nigra* | | Grasses and forbs | 1-5 | | | | | | | | | |
| | | *Platanus occidentalis* | | | | | | | | | | | | |
| | | *Pseudotsuga menziesii* | none | | | | | | | | | | | |
| | | *Pinus strobus* | | | | | | | | | | | | |
| Heath Loop Southeast | Backslope | *Planted Alpine Trees* | | *Ambrosia spp.* | | SiCL | | SAB | AB | 0-2 | | Fr | 10YR 4/1 | |
| | | | none | *Aster spp.* | | | | | | | | | | |
| | | | | Grasses and forbs | | | | | | | | | | |
| Heath Loop West | Backslope | Basin maintained | | Grasses and forbs | | SiCL | | SAB | AB | 0-2 | | Fr | 10YR 3/2 | |
| | | | none | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Heath Loop Northwest | Backslope | Basin maintained | | Grasses and forbs | | SiCL | | SAB | AB | 0-2 | | Fr | 10YR 3/2 | |
| | | | none | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Constitution Island Wetland | | *Ailanthus altissima* | | *Ambrosia spp.* | | SiCL | Fine SCL | SAB | AB | 0-1 | 1-3 | Fr | 10YR 4/1 | |
| | | Catchment with: | | *Aster spp.* | | | | | | | | | | |
| | | mixed pine/oaks | | Panicum spp. | | | | | | | | | | |
| | | | | *Typha angustifolia* | | | | | | | | | | |
| | Backslope | | none | *Typha latifolia* | | | | | | | | | | |
| | | | | *Polygonum hydropiperoides* | | | | | | | | | | |
| | | | | *Ludwigia repens* | | | | | | | | | | |
| | | | | *Juncus effusus* | | | | | | | | | | |
| | | | | *Eleocharis palustris* | | | | | | | | | | |
| | | | | *Solidago canadensis* | | | | | | | | | | |
| Northeast Sand Filter | | | | *Ambrosia spp.* | | Cobble and small boulders (rip-rap) | | | | | | | | |
| | Toeslope | none | none | *Aster spp.* | | Coarse sand and gravel on road edge | | | | | | | | |
| | | | | Grasses and forbes | | | | | | | | | | |
| West Sand Filter | | | | *Ambrosia spp.* | | Silt on road edge (washing into sand trap) | | | | | | | | |
| | Toeslope | none | none | *Aster spp.* | | | | | | | | | | |
| | | | | Grasses and forbs | | | | | | | | | | |
| PX East Sand Filter | | | | *Ambrosia spp.* | | Cobble and small boulders (rip-rap) | | | | | | | | |
| | Backslope | none | none | *Aster spp.* | | Baseball diamond and parking lot upslope | | | | | | | | |
| | | | | Grasses and vines | | | | | | | | | | |
| TMP - South | | *Ailanthus altissima* | *Rhus copallinum* | *Ambrosia spp.* | | Excessive vegetation | | | | | | | | |
| | Toeslope | | | *Aster spp.* | | Inaccessible, not GPS mapped | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | *Solidago canadensis* | | | | | | | | | | |
| TMP - North | | | *Rhus copallinum* | *Ambrosia spp.* | | Excessive vegetation | | | | | | | | |
| | Backslope | | | *Aster spp.* | | Inaccessible, not GPS mapped | | | | | | | | |
| | | | | *Solidago canadensis* | | | | | | | | | | |
| Post Exchange | | *Pinus strobus* | *Ilex decidua* | *Ambrosia spp.* | | 18 to 20 feet downslope to water edge | | | | | | | | |
| | | Many dead snags | *Fraser photinia* | *Aster spp.* | | | | | | | | | | |
| | | Tree stumps | | *Solidago canadensis* | | Duck boxes | | | | | | | | |
| | Toeslope | | | *Phytolacca decandra* | | | | | | | | | | |
| | | | | *Typha latifolia* | | | | | | | | | | |
| | | | | *Phragmites australis* | | | | | | | | | | |
| | | | | *Lemna minor* | | | | | | | | | | |
| | | | | *Rubus idaeus* | | | | | | | | | | |
| | | | | *Vitis rotundifolia* | | | | | | | | | | |
| | | | | *Ludwigia spp.* | | | | | | | | | | |

Table D-2. Basin size, US Army Garrisons, West Point, New York.

| | Basin Volume | | Watershed | | | |
|---|---|---|---|---|---|---|
| | (cuft) | (A-F) | Size (sqft) | Size (acres) | Yield (cuft) | Yield (A-F) |
| Fire Station | 38704 | 0.89 | 6344956 | 145.7 | 1855900 | 42.61 |
| Cadet School | 24779 | 0.57 | 2062746 | 47.4 | 603353 | 13.85 |
| Morgan Farm | 19920 | 0.46 | 703252 | 16.1 | 205701 | 4.72 |
| CDC | 37342 | 0.86 | 462086 | 10.6 | 135160 | 3.10 |
| Stony | 169752 | 3.90 | 2617049 | 60.1 | 765487 | 17.57 |
| Heath Loop SE | 14536 | 0.33 | 3178 | 0.07 | 929.5 | 0.021 |
| Heath Loop West | 18576 | 0.43 | 3593 | 0.08 | 1051 | 0.034 |
| Heath Loop NW | 7614 | 0.17 | 5082 | 0.12 | 1487 | 0.034 |
| Constitution Island | 13412 | 0.31 | 487941 | 11.2 | 142723 | 3.28 |
| West Sand Filter | 1558 | | 1558 | 0.04 | | |
| East Sand Filter | 289 | | 289 | 0.01 | | |
| PX Sand Filter | 1990 | | 1990 | 0.05 | | |
| Post Exchange* | 46476.1 | sqft | 1001944 | 23.0 | | |
| *Post Exchange Basin area in square feet. | | | | | | |

Table D-3. The most common non-native invasive plant species inhabiting Piedmont physiography. From Pruitt et al. 2022 (in final review).

| Species[1] | Southern Piedmont | Northern Piedmont | Common name | Form |
|---|---|---|---|---|
| Ajuga repens | ✓ | | Blue bugle | Herb |
| Euonymus fortunei | ✓ | | Spindle vine | Vine |
| Polygonum convolvulus | ✓ | | Wild buckwheat | Herb |
| Poncirus trifoliata | ✓ | | Hardy orange | Shrub |
| Elaeagnus angustifolia | ✓ | ✓ | Russian olive | Shrub |
| Ligustrum sinense | ✓ | ✓ | Chinese Privet | Shrub |
| Lonicera japonica | ✓ | ✓ | Japanese honeysuckle | Vine/Herb |
| Lonicera morrowii | ✓ | ✓ | Bush honeysuckle | Shrub |
| Rosa multiflora | ✓ | ✓ | Multiflora rose | Shrub |
| Microstegium vimineum | ✓ | ✓ | Nepalese browntop | Herb |
| Ambrosia artemisiifolia | | ✓ | Common ragweed | Herb |
| Berberis thunbergii | | ✓ | Japanese barberry | Shrub |
| Celastrus orbiculatus | | ✓ | Oriental bittersweet | Vine |

[1] All species can occur in Southeastern U.S.

# Definitions

Apron – installed surface (e.g., concrete or riprap) surrounding outlets that prevents erosion or scouring around the outlets and reduces flow velocity to prevent erosion in the basin.

Bypass – structure that allows high flows to be redirected when flows are greater than the maximum flows the structure was designed to treat.

Catch basin – a drain installed in a low area designed to collect water from the surface and transport it to a drainage system undergrounds. It may be considered an outlet in SMPs.

Geotextile fabric – permeable fabric made of polypropylene or polyester that is installed for filtering, soil reinforcement, or erosion protection.

Inlet – SMP component that allows water to enter from the drainage area into the SMP through pipes, curb cuts, channels, ditches, grates, or direct flow over land surface.

Observation well – structure in sand filters that allows for subsurface inspection.

Outlet – SMP component that allows water to exit the SMP and enter the stormwater system, soil, a waterbody, or another SMP through pipes, channels, weirs, emergency spillways, or underdrain pipes.

Outlet baffle wall – a wall near the outlet of a SMP that slows water inflow and promotes sediment settling.

Outlet control riser box – SMP component, typically made of concrete, that regulates the rate of discharge from the SMP and reduces downstream erosion potential. Some may be designed as multi-stage risers that have orifices, smaller than the outlet pipe (3 inches in diameter or smaller), placed at different elevations. Riser boxes may also have weirs integrated in their design.

Outlet control riser pipes – a vertical pipe with a dome-shaped grate that connects surface flow from SMP to an underground outlet.

Riprap – stone layer that protects soil from erosion caused by water runoff.

Sheet flow – water flowing in a thin layer over the ground surface.

Stormwater Management Practice (SMP) – structural (e.g., landscape feature, channel, basin) and non-structural (e.g., policy, regulation, outreach) features used to prevent, detain, infiltrate or control stormwater runoff quality, rate, or quantity.

Toe – the bottom or base of a slope or embankment where the mass of the slope meets a flatter surface.

Underdrain – a perforated underground pipe that slows runoff and directs water to a chamber or other underground SMP

Undercutting – removal of material from the lower portion of an embankment, causing the upper portion to overhang with a higher risk of failing.

Weir – barriers designed to control release of stormwater from SMPs; typically designed with rectangular, trapezoidal, or V-notch shapes, and located within SMPs (e.g., check dams, spillways) or inside outlet control structures. Weirs also help sediment settle on the bottom of a structure, allowing water to overflow the weir with reduced amounts of sediment.

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**14. ABSTRACT**

Structural stormwater management practices (SMPs) are designed and installed with the goal of reducing runoff and improving water quality through a variety of built (e.g., underground chamber and filter systems), nature-based and natural features (e.g., rain gardens, swales). In compliance with Section 402 of the CWA, US Army Garrisons at West Point MS4 operators are required to obtain a National Pollutant Discharge Elimination System permit or a New York State Pollutant Discharge Elimination System (SPDES). These permits require development of stormwater management plans to reduce pollutants to meet the appropriate water quality standards. Over 62 structural SMPs have been installed at USAG to meet permit requirements.

Monitoring and maintenance are essential to maintain and understand the effectiveness of these structures, track their maintenance needs, and improve their function. This document provides guidance for conducting stormwater management practice, inspection, and maintenance at the United States Army Garrison at West Point. The objectives are to inform installation managers on general SMP functions and designs, highlight key maintenance triggers affecting SMP functionality, and provide guidance on when and how to conduct inspections and maintenance actions specific to USAG SMPs and in accordance with NYS DEC.

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