DEPARTMENT OF **ENERGY & ENVIRONMENT**

# Fort Stevens Recreation Center

**Design Report, August 2021**
DPR II – Design and Build 4 LID Sites
Contract Number CW712222

*Prepared by* **Natural Resources Design**
Christopher Sonne, P.E., SITES AP
Barbara Neal, ISA #4283B, RCA#428
Lauren Wheeler, LEED AP, SITES AP
Sylvan Kaufman, PhD

## TABLE OF CONTENTS


| Section | Page |
|---|---|
| **1. Executive Summary** | **3** |
| **2. Project Overview** | **3** |
| **3. Existing Site Conditions** | **5** |
| 3.1 Topographic Survey | 5 |
| 3.2 Site Utilities | 5 |
| 3.3 Soil & Vegetation Conditions | 6 |
| **4. Existing Stormwater Management** | **13** |
| 4.1 Stormwater Runoff Pollutant Loads | 14 |
| 4.2 Stormwater Management Improvements | 15 |
| 4.3 Vegetation Management Opportunities | 16 |
| **5. Conclusions** | **18** |
| **6. BMP Scorecard** | **19** |

**Appendices:**

Appendix A: Survey

Appendix B: Geotechnical Report

Appendix C: Compost Specifications

## 1. EXECUTIVE SUMMARY

Fort Stevens Recreation Center **Design Report (DOEE DPR II – Design and Build 4 LID Sites)** identifies existing site conditions that have influenced the selected Best Management Practice (BMP) designs. Soils along the northern area of the site were found to be suitable for infiltration based BMPs, with very good infiltration capacities identified in the area by the horseshoe pits.

Extensive bank erosion at the upper end of the site appears to be largely due to several existing design and maintenance issues causing stormwater to bypass the storm drainage system and run down the steep banks below the tennis courts. Erosion is also found along the steps leading down to the soccer field and along the turf slope leading down to the soccer field. This condition is exasperated by the shady conditions and steep grades under the mature oak trees in this area. Corrective actions to improve drainage area capture and reduce the likelihood of overflows are described in this report.

There is an extensive stormwater drainage system at the site, including a functioning sand filter that manages most of the Community Center runoff. This system is conveniently piped along the area of the soccer field where a portion of the flow can be diverted and treated in a bioretention basin (BMP-1).

There is a paved DDOT alleyway running along the northern boundary of the site that captures and concentrates stormwater runoff on the surface of the asphalt. The majority of this flow can be captured and treated in a bioretention basin (BMP-2).

Overall, multiple opportunities for stormwater management and site improvements were found for this project. During design development, the potential impact upon the many mature trees on the site was considered.

## 2. PROJECT OVERVIEW

This site is part of a DC Department of Energy & Environment (DOEE) funded stormwater management & nutrient reduction project that includes four park sites within the District of Columbia.

The Fort Stevens Recreation Center is located at 1327 Van Buren St NW where Van Buren Street is to its south, 13$^{th}$ Street to its east, Luzon Avenue to its west and an unnamed public alley on its northern boundary (Figure 1). Located in a residential neighborhood of single-family homes and apartment buildings, Fort Stevens Park consists of approximately eight acres and includes tennis and basketball courts, a playground and splash park, community center, community garden, soccer field, horseshoe pits, and woodland.


*Figure 1: Project Site as provided in DPRII RFP*

General objectives for this project are to design and construct stormwater improvements to reduce stormwater nutrients and volumes from the impervious areas of this site and to protect trees and soils from erosion.

The original objectives identified for this site included:

1) Retrofitting the site with an underground cistern which will capture the stormwater coming from most of the upstream impervious surfaces (e.g. tennis courts, basketball courts, playground, sidewalks, community garden, community center, etc) and reuse it for the irrigation of the soccer field; and

2) Vegetative stabilization of eroding soils and tree protection on the hillsides immediately adjacent to the playing courts and above the soccer field.

The purpose of this **Design Report** is to describe existing site information that impacted stormwater design approaches and scope for this property. Based upon this site data, various stormwater management (SWM) opportunities, limitations and maintenance considerations are presented. This report includes work described within the project proposal and contract as well as other opportunities that became apparent during the site evaluation process.

## 3. EXISTING SITE CONDITIONS

The site information included within this assessment is compiled from several sources of information, including:

- Topographic site survey (Appendix A)
- Geotechnical Evaluation (Appendix B)
- GIS data
- Site visits and observations
- Record Drawings

In areas where discrepancies are identified, field data is given preference over general site data or historical documents, with the nature and significance of the discrepancies noted.

### 3.1 Topographic Survey

A topographic field survey and partial Subsurface Utility Engineering (SUE) evaluation of the site was prepared by Draper Aden Associates, Manassas, Virginia. A copy of this survey is included as Appendix – A. As shown in this survey, the site elevations drop significantly (over vertical 42 feet) from east to west, with recreational areas constructed on a series of three flat areas separated by steep slopes. The area of the park to the north, which is dominated by woodlands, has a consistent slope from east to west and starts to flatten out roughly where it aligns with the soccer field.

### 3.2 Site Utilities

The various utilities serving this site are indicated on the site survey and described below. These have been installed at various stages of the site development over many years. As a result, a variety of materials and installation approaches may be encountered. The following utilities are present at the site:

<u>Natural Gas</u>:

The Community Center building is served with gas from Van Buren Street NW. This service line is located under the paved parking area at the entrance to the building.

<u>Electric</u>:

Electric service to the site originates at a power pole along Van Buren Street NW, then runs in buried conduit under the paved parking area at the entrance to the Community Center. Buried electric wiring is distributed throughout the site to supply lighting (including a large lighting panel on the east side of the basketball court enclosure) and the pumps for the spray park.

Water:

Water service piping to the Community Center is located under the paved parking area at the entrance to the building. Water is also piped to supply the spray park adjacent to the playground.

Stormwater:

Stormwater inlets are located in the southwest corners of the tennis court area, basketball courts, playground/spray park and Community Center areas. These are older square brick structures in varying conditions.

The combined site stormwater flow is piped down the slope to another structure at the soccer field level, which also receives flow from a series of three newer storm inlets located along the edge of the field. There is an existing sand filter in place behind the Community Center building to provide some stormwater treatment. This discharges to the stormwater system described above.

The entire combined stormwater flow from the site is conveyed across the soccer field to a 16+ foot deep square brick stormwater structure located in the southwest corner of the soccer field and ultimately discharges to the public storm sewer system at Luzon Avenue NW. *Note that this final stormwater structure appears to be in poor condition and may warrant replacement in the near future.*

Sanitary Sewer:

The sanitary sewer service from the Community Center and spray park drain is located under the paved parking area adjacent to the building and discharges to a manhole in Van Buren Street NW.

### 3.3 Soil & Vegetation Conditions

Soil Mapping:

Based upon the USDA Websoil Survey (included as part of the geotechnical evaluation report), soils across the site consist of various loams. There are no significant restrictive layers (groundwater, bedrock, dense clays) noted, and soils are generally well drained.

Geotechnical Evaluation:

A field evaluation of existing soil conditions at several locations was performed by Natural Resources Design on July 10, 2019 (revised January 4, 2021). This is included as Appendix – B.

Soil borings were performed at three locations: the edge of the soccer field (BMP location); the Triangle Turf Plaza area near the intersection of Van Buren Street NW and Luzon Avenue NW; and the turf area north of the soccer field, near the existing horseshoe pits.

Well consolidated fill material was noted at the Triangle Turf Plaza. No infiltration testing was performed here due to the unpredictable nature of fill soils. Any infiltration-based stormwater features in this fill soil would require underdrain piping systems.

Soils at the horseshoe pit area (boring B-1) indicated excellent infiltration potential, and a test was performed in this area at boring B-2, as noted below. Soils testing at the corner of the soccer field area (borings B-3 & B-4) indicated limited infiltration is available. An underdrain will be required in this area, but addition of a sump will allow for Enhanced Design function.

Infiltration Testing – A soil infiltration test was performed at borings B-2 & B-4 in conformance with Appendix "P" of the DOEE Stormwater Management requirements. These tests indicated infiltration rates of 0.65 inches/hr (B-2) and 0.16 inches per hour (B-4).Soil Erosion:

Several areas of critical erosion were identified at the project site, as follows:

1) Tennis court corner

The majority of this erosion appears to be due to large volumes of runoff from the tennis courts overflowing the adjacent curbing and scouring the soils on the steep slopes below (Figure 1). During the field inspection, we noted that the drain inlet for the tennis courts has been fitted with a mesh screen which is clogged and causing these overflow conditions (Figure 2).

*Figure 1 - Erosion below southeast corner of the tennis court area located along Van Buren Street.*

*Figure 2 - Plugged inlet at* southeast *corner of tennis court area*

2) Tennis court steps

Additional erosion resulting from tennis court runoff occurs as stormwater flows over the shallow curbing at the northwest end of the courts and down the steps to the fenced tennis court area (Figures 3 and 4). A protective soil matting has been installed on the slopes around the existing oak trees, but it is not clear if this is providing the required degree of soil and tree protection.

*Figure 3 - Erosion below tennis courts*

*Figure 4 - Eroded bank below the sidewalk that abuts the tennis courts (with soil protection matting)*

3) Basketball Court

Eroded soil washes down the slopes and onto the sidewalk and upper entrance to the basketball courts. (Figure 5).

*Figure 5 - Erosion above basketball court area*

4) Soccer Field Steps

During heavy rain events, it appears concentrated stormwater from the area around the Community Center bypasses the existing storm swale and runs down the steep slope to the soccer fields. This has caused significant erosion adjacent to the existing concrete steps (Figure 6).

*Figure 5 - Erosion seen on the right of the upper portion on the steps.*

<u>Existing Vegetation</u>:

The existing vegetation on site (Figure 6) can be divided in two areas. The "developed" area which dominates the site and is located on the southern portion of the park. This area largely consists of very mature trees located on the steep slopes between the tennis courts and playground, and between the Community Center and the soccer field. It also includes a row of trees along Luzon Avenue and mature trees that surround a seating area that abut the Triangle Turf Plaza. There are limited foundation plantings around the recreation center building, a community garden and shrubs on the north side of the Community Center, and some shrubs and perennials in a bioretention cell located at the corner of the splash park.

The “wooded area” consists of a remnant woodland is located at the northern side of the park. It is a combination of mature trees and understory plants with a heavy infestation of invasive plants. Though it should be noted that the management of the vegetation of this area is not within the project scope.

The predominate groundcover plant on the site is turf. Between the tennis courts and 14th Street is a turf strip in good to fair condition. The turf located underneath the shade trees between the tennis courts and playground and by the recreation center and soccer field, is in poor condition due to the shade cast by the mature oaks. The Triangle Turf Plaza is in good condition and the turf located in the tree lawns along the streets is in good to fair condition.


*Figure 6 – Existing Vegetation*

## 4. EXISTING STORMWATER MANAGEMENT

Surface Cover:

Due to the extent of impervious area at this site (2.1 acres, or approximately 26% of the entire site), a significant amount of stormwater runoff is generated. This runoff is directed to a series of inlets and stormwater pipes as described above.

Drainage Patterns:

The majority of surface drainages flow in a southwesterly direction across the site. There is a portion of the site to the north of the large impervious areas that flow through the remnant woodland, discharging to the turf area at the north west corner of the site (near the horseshoe pits). There is also a small asphalt public alleyway along the northern boundary that conveys runoff in the center of the road (reversed crown) and discharges into Luzon Avenue NW.

### 4.1 Stormwater Runoff Pollutant Loads

Based upon estimated nutrient loadings for Phosphorous (P) and Nitrogen (N) from impervious areas of 2.0 lb/ac/yr and 15.4 lb/ac/yr, respectively, the theoretical stormwater nutrient load from this site is 4.2 lb/yr (P) and 32.3 lb/yr (N). Assuming typical reductions for phosphorous and nitrogen of 60% and 40%, the existing sand filter removes 0.54 lb/yr (P) and 2.65 lb/yr (N), resulting in estimated nutrient discharges of 3.66 lb/yr of phosphorous and 29.65 lb/yr of nitrogen.

<u>Stormwater Quality Features</u>:

- There is a small bioretention basin located at the corner of the playground, adjacent to the spray park feature. This basin was installed as part of a retrofit in 2015 and utilizes an existing stormwater inlet as the overflow/control structure. Based upon site observations, this basin has a continuous water flow through it due to overspray and runoff water from the spray park (which is supposed to drain to the sanitary sewer). Water from the basin does not pond to the design depth due to undermining and leakage through the brick storm basin walls. Improvements were made to this feature (by others) in 2020, and this feature is no longer considered for improvements under this contract.
- Sand filter behind community center: A large stormwater sand filter was installed behind the Community Center in 1999 as part of a building renovation. This treatment unit appears to capture the drainage from the building, as well as from some adjacent surface drains. The design drainage area is 18,820 sf impervious and 5,645 sf turf. An inspection of this filter was performed by DOEE and NRD on July 10, 2019. Based upon this inspection, the unit is generally in good condition and appears to be functioning as intended but is due for routine maintenance. Site conditions indicate some of the design drainage area around the building actually bypasses the drain inlets (and thus the sand filter).
- The sand filter discharges to an old brick drainage structure at the corner of the paved area behind the building. This drainage structure also receives the stormwater from the tennis courts, basketball courts and playground/spray park.

### 4.2 Stormwater Management Improvements

Several potential BMPs have been proposed at this site, as described below. In addition, various site improvements are recommended to address site deficiencies. These opportunities are discussed below.

<u>Proposed Best Management Practices:</u>

Stormwater Harvesting and Reuse – This BMP would involve capturing and storing stormwater runoff from the site for reuse as irrigation water at the soccer field. It would include a pretreatment system, underground storage tanks, a post-capture treatment system, pumps, control system and irrigation system. ***Based upon the limitations and operational costs for this system to comply with Health Department requirements, stormwater harvesting and reuse has been eliminated from consideration.***

Bioretention Area 1 – A bioretention basin is proposed at the corner of the soccer field, near Van Buren St. NW. This basin will manage a significant portion of the stormwater from the existing piped stormwater system. A diversion manhole will be installed on the existing 15" dia. storm pipe to direct the design storm to this facility. Larger storms will flow over a weir within the manhole and flow to the existing piped stormwater system. An underdrain and overflow structure will be required for this facility.

Bioretention Area 2 – A bioretention basin is proposed at the horseshoe pit area and used to treat the runoff from the adjacent paved alleyway. Stormwater will be captured from the alleyway by a trench drain and conveyed to the basin. When the basin is at full ponding depth, excess stormwater will overflow a surface weir and flow overland toward the intersection of Luzon and the alley. This basin will NOT have an underdrain system, due to the soil infiltration capacity.

Development of a large bioretention basin within the triangular open area adjacent to the fenced field was considered and developed as a conceptual design. However, the costs to develop this alternative exceeded the available project funds.

Site Improvements:

Tennis courts (northern end) – As shown on Figure 2, a significant portion of the existing tennis court area does not flow to the existing drain structure, resulting in erosion of the hillside below. Curbing modifications will be utilized to address this issue.

Tennis courts (southern end) – The existing drainage structure has been fitted with a mesh grate cover to prevent tennis balls from entering. This mesh cover plugs and causes the system to overflow. This mesh will be removed and the basin will be fenced out of the tennis court play area. Reducing the overflow conditions will lessen downstream soil erosion.

### 4.3 Vegetation Management Opportunities

Soccer Field Hillside Turf:

The area on the hillside that abuts the soccer field is a challenge to manage. The shade from the mature trees provides welcome respite for families watching the games and leads to thin stands of turf and turf weeds that are prone to erosion and wear. You can see areas where the soil has washed away, leaving subsoil that is even more difficult to establish turfgrass on.

The area under the mature trees should be mulched with a 2-3" layer of wood chip mulch for a distance of at least 6-10' from the base of the tree to protect the structural roots surfaces from wear and tear. Care should be taken to not pile up mulch on the tree trunk. Weeds should not be a big problem, as the soil is relatively compacted and the area shady, so weed pressure will not be great. (Note that elimination of the concentrated flows from upstream impervious areas will greatly reduce the erosion pressure on this area.)

There are a few ways to manage the hillside, each with its pros and cons.

1. **Aggressive seeding program**: the site managers could take steps to establish a healthy turfgrass stand in the early fall. This would involve a light scarification of the area (taking care not to damage any large tree roots—best to stay at least 6' from the base of all trees) followed by a 2" layer of compost (see compost specifications). The hillside would then be seeded with a shade tolerant grass seed, and a layer of straw placed on top. The area would have to be cordoned off until the turf is well established, probably the entire fall season, and irrigated to ensure proper germination and establishment. The area close to the

trees could be maintained by mulching with a 2-3" layer of wood mulch. The area would have to be top-dressed with shade tolerant seed each fall to keep up a good turf coverage.

2. **Compost logs**: In the steepest areas, consider installing compost logs to help retain soil and limit erosion. The logs could be installed and staked down, and compost/soil brought in to lessen the slope. The area could be planted with low-growing, shade tolerant shrubs, which would further help stabilize the slope. The issue with this method is that children and shrubs do not "play well" with each other, and shrubs often get stepped on and jumped over. The shrub areas would have to be cordoned off for a few years until a full stand is established and thus less attractive to children's play.
3. **Boulder Seating Walls**: Large, square seating sized rocks could be installed at or near the base of the hillside that would serve both as a seating space and a small retaining wall to ease the slope of the hillside. The area behind the seating wall could then be either planted or seeded (or a combination of the two).

<u>Tennis Courts/Playground Slopes Turf:</u>

The space between the playground and the tennis courts has two distinct landscape areas—the slope between the playground and the concrete walkway, and the slope from the walkway up to the tennis courts. Both areas require specific management to maximize turf establishment and proper mature tree management.

The area between the playground and walkway has a line of mature deciduous trees and the turf is thin, but in most areas the turf is acceptably established. The challenges for this area are shade, compacted soil and sloped topography. NRD recommends that this area be top-dressed with a compost layer of 1.5-2 inches of compost (see compost specifications) and seeded in the early fall with a shade tolerant turfgrass. In the bare patches, the area should be lightly tilled to a depth of 3", compost applied, and then seeded. Areas adjacent to the walkway and sidewalk should be cordoned off until the new turfgrass has become established.

The trees along this walkway should be mulched with a natural hardwood bark mulch to a depth of 2-3", taking care to avoid piling mulch up over the large roots and the base of the trees. The mulch should extend out approximately 4' from the base of the trees—the goal being to avoid having the tree hit by mowing or line trimming equipment. These mulched areas should be relatively weed free as the trees cast so much shade that weed seed germination should be minimal.

The area from the walkway and the tennis courts is also shady and steep, but it has the added challenge of erosion from the water moving off the tennis courts, down the slope and onto the concrete walk. This area has very poor turf, and practically no topsoil left.

NRD recommends curbing and drain improvements (as previously described) to eliminate this overflow. The existing bare areas will be stabilized with compost and seeding.

After final grading, the area can be seeded and covered with straw to enhance germination and establishment. Shade tolerant turfgrass seed should be selected. Contact the local Cooperative Extension or the University of Maryland to learn the most up-to-date fine fescue varieties that could be used in the area. The area should be cordoned off until the turfgrass is established.

Both areas should be re-seeded each fall to rejuvenate the turfgrass stand. Bare spots should be re-seeded and a 1" layer of compost applied.

The turf management plan outlined for the soccer fields is also applicable to the area between the playground and the tennis courts.

## 5. CONCLUSIONS

The Fort Stevens Recreation Center site has several excellent opportunities to improve stormwater management conditions and address existing erosion control problems throughout the site.

Selected alternatives for this site include:

- Curbing and drain improvements at the existing tennis courts and below the recreation center building to direct stormwater into the existing piped infrastructure.
- Stabilizing bare, steep banks with a seeded compost layer.
- Construction of a large bioretention basin to treat a significant portion of the runoff from the site impervious areas (BMP-1).
- Construction of a small bioretention basin to treat the runoff that currently flow down the existing alleyway along the northern border of the site, and onto Luzon Ave NW (BMP-2).

## 6. BMP SCORECARD

# *BMP Scorecard*

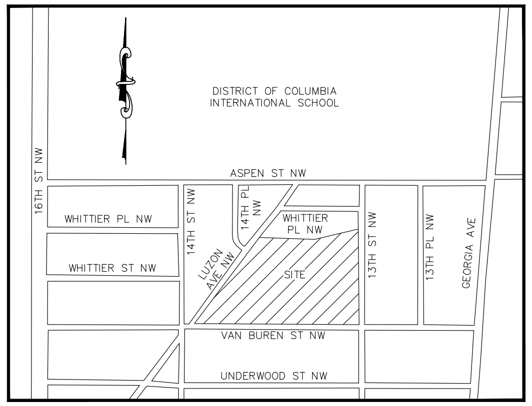
## Fort Stevens Community Center

| BMP Description | CDA (sf) | | | | | SWRv | Volume | Inches Runoff Captured | Pollutant Removal Rates | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Natural | Impervious | Turf | BMP | Total | Required (cf) | Provided (cf) | per Imperv Acre | P | N | TSS |
| CDA 1A (North Tennis Courts) | 0 | 8,410 | 2,430 | 0 | 10,840 | | | | | | |
| CDA 1B (South Tennis Courts) | 0 | 20,880 | 7,110 | 0 | 27,990 | | | | | | |
| CDA 1C (Basketball Courts) | 0 | 11,230 | 5,360 | 0 | 16,590 | | | | | | |
| CDA 1D (Playground) | 0 | 11,730 | 8,680 | 0 | 20,410 | | | | | | |
| CDA 1E (Community Center) | 0 | 18,530 | 3,445 | 0 | 21,975 | | | | | | |
| *BMP-1 Bioretention Basin* | 0 | 68,690 | 27,811 | 1,714 | 98,215 | 7,392 | 4,560 | 0.5 | 53% | 45% | 57% |
| *BMP-2 Bioretention Basin* | 55,716 | 5,200 | 19,096 | 530 | 80,542 | 1,024 | 1,231 | 19.6 | 79% | 68% | 85% |

*CDA 1A through 1E all flow to BMP-1. Flow is restricted by an 8" pipe to the basin, with excess flows diverted to the existing stormwater pipe infrastructure.*

## **Appendix A: Survey**

(See insert on following page)




VICINITY MAP
Scale: 1"=200'

## NOTES:

1.) Source of Meridian: NAD83 based upon: GPS Observations on 6/13/2019.
2.) Vertical datum: NAVD88 based upon: GPS Observations on 6/13/2019.
3.) This survey was prepared without the benefit of a title commitment or title report and all easements and encumbrances that might be disclosed in a title search may not be shown.
4.) Utilities shown are based upon:
____SUE Quality Level D, ASCE 38–02 – compiled records only
____SUE Quality Level C, ASCE 38–02 – visible evidence in conjunction with compiled records.
__X_SUE Quality Level B, ASCE 38–02 – field designation of underground utilities performed by DAA and visible evidence in conjunction with compiled records.
____SUE Quality Level A, ASCE 38–02 – test pits at locations shown hereon performed by (DAA; Other) in conjunction with field designation of underground utilities performed by (DAA; Miss Utility, Ticket # ________ ; Other), visible evidence and compiled records.
____No SUE was performed or requested for this survey. Utilities shown hereon are based on field observation only.
5.) This topographic survey was completed under the direct and responsible charge of John E. Krobath from an actual Ground survey made under my supervision; that the imagery and/or original data was obtained on 7/16/2019; and that this plat and/or map meets minimum accuracy standards unless otherwise noted.
6.) Contour interval: 1'.
7.) This survey was prepared for Natural Resources Design. Draper Aden Associates assumes no liability for reuse or modification of this document.
8.) Property lines are not shown
9.) Draper Aden Associates provides benchmarks for the construction of the improvements shown on these plans. All other existing elevations are for reference to existing conditions only. Do not use spot elevations, finish floor elevations, elevations on manholes, elevations on survey nails, survey hubs, control points (horizontal points provided) or any other points for construction other than the provided benchmarks. Failure to utilize and verify the provided benchmarks could result in damages and additional cost that are the contractor's responsibility.
10.) The property shown hereon is located in Flood Zone X based on a scaled location on FIRM panels #110001006C and #1100010010C effective date September 27, 2010. This flood determination is not a recommendation by Draper Aden Associates to not purchase or purchase Flood Insurance Coverage and does not imply that the referenced property will or will not be free from flood damage.

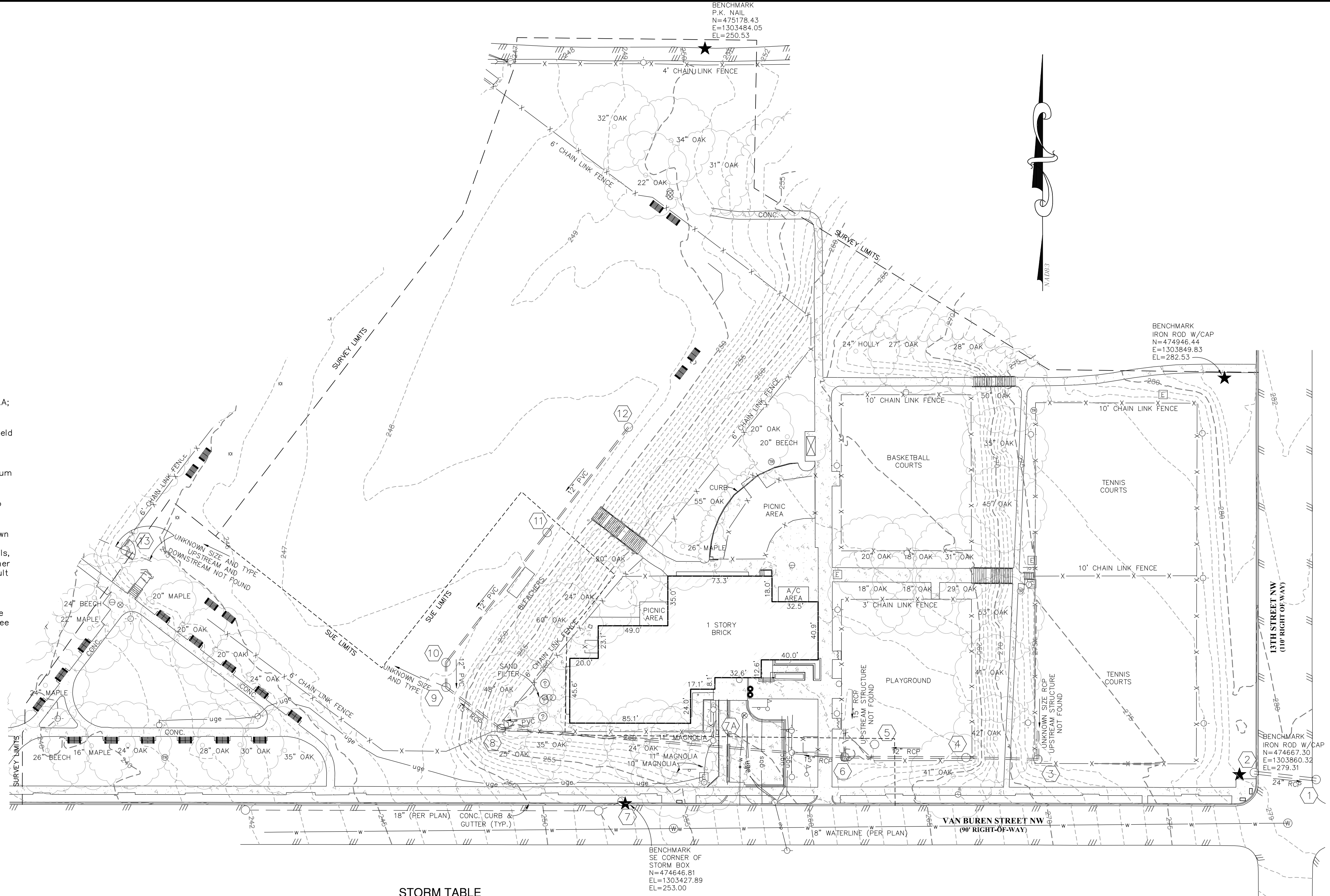
## DRAPER ADEN ASSOCIATES REVIEW

THESE PLANS HAVE BEEN SUBJECTED TO TECHNICAL AND QUALITY REVIEWS BY:

| NAME | | SIGNATURE | DATE |
|---|---|---|---|
| ANTONIO COBIN | SURVEY PARTY CHIEF | Antonio L. Cobin | 7/18/2019 |
| JOHN L. ROBERTSON P.E. | SUBSURFACE UTILITY ENGINEER | | |
| CHAD MARSHALL | PROJECT SURVEYOR | Chad Marshall | 7/18/2019 |
| L.W. KNIGHTING | QUALITY REVIEWER | L.W. Knighting | 7/18/2019 |

## LEGEND

- Property Line
- Contour
- Gas Line
- Overhead Power
- Sanitary Sewer and Manhole
- Storm Line and Manhole
- Storm Line and Inlet
- Underground Cable TV
- Underground Electric
- Underground Telephone
- Underground Fiber Optic
- Unknown Utility
- Waterline
- Asphalt
- Building
- Fence (as noted)
- Stream
- Treeline
- Guy Wire
- Rod Found
- Monument Found
- Telephone Pedestal
- Telephone Manhole
- Telephone Box
- Fire Hydrant
- Water Valve
- Water Meter
- Well
- Benchmark
- Bollard
- Sign (1–post)
- Sign (2–post)
- +1561.3 Spot Elevation
- Deciduous Tree
- Evergreen Tree
- Shrub
- Concrete
- Bench
- Bike Rack
- Electric Box
- Guy Pole
- Electric Marker
- Electrical Manhole
- Utility Pole
- Electric Transformer
- Ground Light
- Light Pole
- Fiber Optic Pedestal
- Fiber Optic Handhole
- Gas Vent
- Gas Valve
- Gas Meter
- Sewer Clean Out
- Wood Post
- Metal Post
- Gravel
- Picnic Table
- Trash Can




## STORM TABLE

1 CURB INLET
TOP=280.11
24" INV. IN=273.86 (NW)

2 CURB INLET
TOP=279.45
24" INV. OUT=274.40 (SE)

3 MANHOLE
TOP=274.26
INV. IN=264.86 (N)
INV. OUT=264.76 (W)

4 MANHOLE
TOP=262.15
INV. IN=258.15 (E)
12" INV. OUT=257.85 (W)

5 DRAIN GRATE
TOP=261.35
CANT ACCESS INVERTS

6 MANHOLE
TOP=261.33
INV. IN=256.28 (N)
12" INV. IN=256.24 (E)
15" INV. OUT=256.03 (SW)

7 CURB INLET
TOP=252.98
COULD NOT ACCESS

7A GRATE
TOP=259.39
BOTTOM=256.29

8 MANHOLE
TOP=260.71
12" INV. IN=250.71 (NE)
15" INV. IN=252.21 (NE)
15" INV. OUT=248.06 (NW)

9 MANHOLE
TOP=247.62
12" INV. IN=242.12 (N)
15" INV. IN=242.32 (SE)
INV. OUT=241.82 (NW)

10 GRATE
TOP=246.38
12" INV. IN=242.78 (S)
12" INV. OUT=242.78 (NE)

11 GRATE
TOP=246.83
12" INV. IN=243.28 (NE)
12" INV. OUT=243.18 (SW)

12 GRATE
TOP=247.35
12" INV. OUT=244.90 (SW)

13 GRATE
TOP=248.64
INV. IN=244.94 (NW)
INV. OUT=236.99 (SW)

1 inch = 40 ft.

DISTRICT OF COLUMBIA
JOHN E. KROBATH
No. LS900362
LICENSED LAND SURVEYOR
7/19/2019

Draper Aden Associates
Engineering • Surveying • Environmental Services
7639 Coppermine Drive
Manassas, VA 20109
703-479-7505
www.daa.com
• Richmond, VA
• Blacksburg, VA
• Charlottesville, VA

# TOPOGRAPHIC SURVEY
# FORT STEVENS PARK
WASHINGTON, D.C.

REVISIONS

DESIGNED BY:
DRAWN BY: CAM
CHECKED BY: LWK
SCALE: 1"=40'
DATE: 7/16/2019
PROJECT NUMBER: 19100112-010506

SHEET 1 OF 1

## Appendix B: Geotechnical Report

(See insert on following page)

# Report of
# Subsurface Exploration, Soil Testing, and Geotechnical Engineering Evaluation

## Fort Stevens Recreation Center

*1327 Van Buren St NW*
*Washington DC*

Natural Resources Design
an ecologically focused design firm
Washington DC

DISTRICT OF COLUMBIA
CHRISTOPHER E. SONNE
PE906009
CIVIL
PROFESSIONAL ENGINEER

*Prepared by:*

**Natural Resources Design, LLC**

1009 Shepherd St. NE
Washington, DC 20017
202.489.6214

July 19, 2019

*Revised 1/8/2021*

## TABLE OF CONTENTS

**SECTION** | **PAGE**

## Contents


1.0 INTRODUCTION .......... 1
  1.1 Project Information .......... 1
  1.2 Scope of Services .......... 1
2.0 SUBSURFACE EXPLORATION PROCEDURES .......... 2
3.0 SITE AND SUBSURFACE CONDITIONS .......... 3
  3.1 Site Description .......... 3
  3.2 Regional Geology .......... 3
4.0 SOILS INFILTRATION .......... 4
  4.1 Methodology .......... 4
  4.2 Field Infiltration Testing .......... 5
5.0 RECOMMENDATIONS .......... 6
6.0 LIMITATIONS .......... 6

# APPENDICES

## APPENDIX A

Site Vicinity Map (Drawing No. 1)

## APPENDIX B

Boring Location Plan (Drawing No. 2)

Boring Logs

## APPENDIX C

Websoil Survey

## APPENDIX D

Infiltration Testing Calculations

# 1.0 INTRODUCTION

## 1.1 Project Information

This site is part of a DC Department of Energy & Environment (DOEE) funded stormwater management & nutrient reduction project that includes four park sites within the District of Columbia. The Fort Stevens Recreation Center consists of approximately five acres and includes tennis and basketball courts, a playground and splash park, community center, community garden and a soccer field. Project objectives are to design and construct stormwater improvements to reduce stormwater nutrients and volumes from the impervious areas of this site. The purpose of this geotechnical evaluation is to provide site soils information for use as part of the Best Management Practice (BMP) stormwater design process.

## 1.2 Scope of Services

The purposes of our involvement on this project were as follows: 1) provide general descriptions of the subsurface soil conditions encountered at the boring location, 2) identify subsurface water levels (if any), and 3) provide geotechnical parameters and recommendations for stormwater infiltration and general construction. To accomplish the above objectives, we undertook the following scope of services:

1) Visited the site to observe existing surface conditions and features;
2) Coordinated with Miss Utility services for utility clearance;
3) Reviewed readily available geologic and subsurface information relative to the project site;
4) Executed a geotechnical subsurface exploration program consisting of six (6) hand-augered borings drilled to the depths indicated in the Boring Logs shown in Appendix B.
5) Performed two (2) field infiltration tests in general accordance with Appendix P of the DC Stormwater Management Handbook to

determine approximate rates of infiltration;

6) Performed field testing on recovered soil samples to ascertain characteristic soil properties;

7) Prepared this written report summarizing our geotechnical engineering work on the project, providing descriptions of the subsurface conditions encountered, and discussing geotechnical related aspects of the proposed construction.

Our geotechnical scope of services did not include foundation or pavement design or recommendations, a survey of boring locations and elevations, quantity estimates, preparation of plans or specifications, or the identification and evaluation of wetland and/or other environmental aspects of the project site.

## 2.0 SUBSURFACE EXPLORATION PROCEDURES

Our geotechnical subsurface exploration program consisted of six (6) test borings designated B-1 through B-6 at the approximate locations shown on the attached Boring Location Plan (Drawing No. 2, Appendix B). In consideration of the methods used in their determination, the boring locations shown on the attached Boring Location Plan should be considered approximate.

Soil borings B-1 & B-2 were performed on January 7, 2021 in the location of BMP-2. Borings B-3 & B-4 were performed on November 19, 2020 at the location of BMP-1.The test borings were performed using a hand auger with a 3-1/4” diameter chuck.

**Boring B-1**, located in the northwest corner of the site (near the horseshoe pits), was advanced to a 100 inches below existing grade. No indications of seasonally high groundwater were observed.

**Boring B-2**, located adjacent to B-1, was advanced to a depth of 76 inches for an infiltration test. Test results are noted in Section 4 of this report.

**Boring B-3**, located in the southeast corner of the soccer field, was advanced to a depth of 83 inches below existing grade. No indications of seasonally high groundwater were observed.

**Boring B-4**, located adjacent to B-3, was advanced to a depth of 59 inches for an infiltration test. Test results are noted in Section 4 of this report.

Upon completion of the field testing, all boreholes were backfilled.

Representative soil samples were visually classified on the basis of texture and plasticity in general accordance with the Unified Soil Classification System (USCS) (ASTM D2487) and/or the Visual-Manual Procedure (ASTM D 2488). The group symbol for each soil type, based on the USCS, is indicated in the parentheses following the soil description on the boring logs. The engineer grouped the various soil types into zones noted on the boring log. The stratification lines designating the interfaces between earth materials on the boring log are approximate; in situ, the transitions may be gradual. Copies of our boring logs (soil profiles) and classification procedures are provided in Appendix B.

# 3.0 SITE AND SUBSURFACE CONDITIONS

## 3.1 Site Description

The tested site areas evaluated all consisted of managed turf areas with minimal (less the 2%) slopes, located along the western side of the site. This is the low end of the site, with the impervious development areas upgradient.

## 3.2 Regional Geology

Based upon the USGS soils mapping for the project site, the underlying site soils at the proposed BMP locations are *Chillum-Urban land complex* – a mixture of silty and gravelly loams with moderately high to high Ksat values (0.20 – 1.98 inches/hour). Hydrologic Soil Group C.

The Websoil Survey report for the entire site is attached as Appendix C.

### 3.2.1 General

The subsurface conditions discussed in the following paragraphs and those shown on the attached boring logs represent an estimate of the subsurface conditions based on interpretation of the boring data using normally accepted geotechnical engineering judgments. Transitions between different soil strata are usually less distinct than those shown on the boring logs. Sometimes the relatively small sample obtained in the field is insufficient to definitely describe the origin of the subsurface material. In these cases, we qualify our origin descriptions with "possible" before the word describing the material's origin (i.e. possible fill, possible residuum, etc.). Although individual test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. Data from the specific test borings are shown on the attached boring logs in Appendix B.

### 3.2.2 Fill/Possible Fill Soils

Fill/Possible Fill may be any material that has been transported and deposited by man. No apparent fill soils were identified in the borings performed on this site.

# 4.0 SOILS INFILTRATION

## 4.1 Methodology

Infiltration testing was performed at both boring locations in accordance with the requirement of Appendix P – Geotechnical Information Requirements for Underground BMPs, Section P.4.

Infiltration testing equipment consisted of a constant head permeameter. Test holes were prepared by hand augering an 8.3 cm diameter bore hole to depths of 76” (B-2) and 59” (B-4).

Infiltration testing was performed until a constant rate of water drop in the device was achieved. Field saturated hydraulic conductivity (Kfs) rates were calculated using the appropriate soil texture chart (“*Most structured soils from clays through loams; Also includes unstructured medium and fine sands”*).

Hydraulic conductivity rates are converted to percolation time using an appropriate conversion factor, as shown in Appendix D.

## 4.2 Field Infiltration Testing

The results of the infiltration field test are included in the table below.

| **Test Location** | **Depth (feet)** | **Field Hydraulic Conductivity** | **Average Rate of Infiltration** |
|---|---|---|---|
| B-2 | 6.33 | 0.65 | inches/hr |
| B-4 | 4.92 | 0.19 | Inches/hr |

## 5.0 RECOMMENDATIONS

The results of our infiltration tests are indicative of general soils' characteristics on this site encountered during our subsurface exploration. The high infiltration rate calculated for the test location at boring B-2 is typical for the sandy soils encountered. Based upon the observed site conditions, it is noted that any subsurface infiltration features utilized on this project do ***not*** need to incorporate an underdrain.
The infiltration rate measured at boring location B-4 allows for incorporation of a sump below the underdrain to provided an Enhanced Bioretention design.

## 6.0 LIMITATIONS

This report has been prepared in accordance with generally accepted engineering practices. No other warranty, express or implied, is made. Our findings and considerations are based on site observations. The findings and considerations do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to re-evaluate our recommendations based upon on-site observations of the conditions.

Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should evaluate earthwork and any pavement construction to verify that the conditions anticipated in design actually exist. Otherwise, we assume no responsibility for construction compliance with the design concepts, specifications, or recommendations.

# APPENDIX A

## *FIGURE 1 – VICINITY MAP*

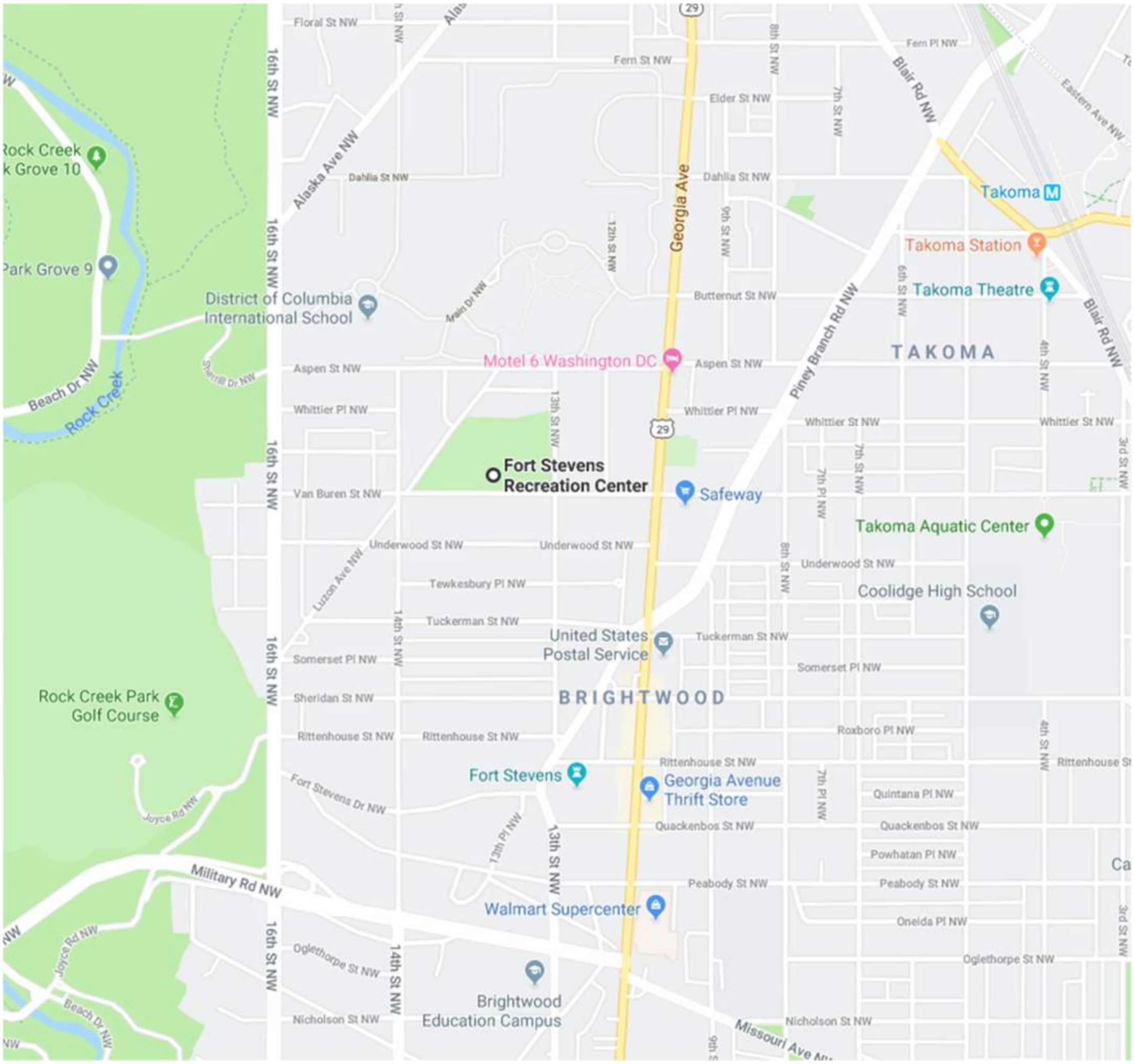



*Figure 1 - Vicinity Map* ***2019©Google***

# APPENDIX B

## *SOILS BORING INFORMATION*

| Project: Fort Stevens | Project Number: 193003 | Client: NRD | Date: 1/7/2021 |
|---|---|---|---|
| Address, City, State: 1327 Van Buren St NW, Washington DC | | Elevation: | Total Depth of Boring: 100" |
| Logged By: C. Sonne, D. Wyatt | | Bit Type: Hand Auger | Diameter: 3.25" |
| Boring No. B-1 | | Groundwater Depth: None Encountered | ***Horseshoe Pit Area (BMP-2)*** |

| Depth (feet) | Sample Type | Sample Number | Graphic Log | DESCRIPTION |
|---|---|---|---|---|
| 0.17 | | | | Topsoil |
| | | | | Sandy loam |
| | | 1 | | |
| | | 2 | | |
| 2.6 | | | | |
| | | | | Sandy clay loam with gravel |
| | | 3 | | |
| 5 | | | | |
| 6 | | | | Coarse Sand |
| | | | | Sandy clay loam with gravel |
| 8 | | | | Boring Terminated (100") |
| 10 | | | | |

Natural Resources Design, LLC

Boring Log: Sheet 1 of 1

▼ StablIized Ground water

▽ Groundwater At time of Drilling

| Project: Fort Stevens | Project Number: 193003 | Client: NRD | Date: 1/7/2021 |
|---|---|---|---|
| Address, City, State: 1327 Van Buren St NW, Washington DC | | Elevation: | Total Depth of Boring: 76" |
| Logged By: C. Sonne, D. Wyatt | | Bit Type: Hand Auger | Diameter: 3.25" |
| Boring No. B-2 | | Groundwater Depth: None Encountered | ***Infiltration Test Area (BMP-2)*** |

| Depth (feet) | Sample Type | Sample Number | Graphic Log | **DESCRIPTION** |
|---|---|---|---|---|
| 0.17 | | | | Topsoil |
| | | | | Sandy loam |
| 2.6 | | | | |
| | | | | Sandy clay loam with gravel |
| 5 | | | | |
| | | | | Coarse sand |
| | | | | Boring Terminated (76") |
| | | | | Infiltration test performed at 76" depth |
| 8 | | | | |
| 10 | | | | |

Natural Resources Design, LLC

Boring Log: Sheet 1 of 1

☒ Bulk/ Bag Sample

▼ StablIized Ground water

▽ Groundwater At time of Drilling

| Project: Fort Stevens | Project Number: 193003 | Client: NRD | Date: 11/19/2020 |
|---|---|---|---|
| Address, City, State: 1327 Van Buren St NW, Washington DC | | Elevation: | Total Depth of Boring: 83" |
| Logged By: C. Sonne | | Bit Type: Hand Auger | Diameter: 3.25" |
| Boring No. B-3 | | Groundwater Depth: None Encountered | ***BMP-1 Area*** |

| Depth (feet) | Sample Type | Sample Number | Graphic Log | **DESCRIPTION** |
|---|---|---|---|---|
| 0.5 | | | | Topsoil |
| | | | | Sandy Loam |
| 2.0 | | | | |
| 3.3 | | | | Sandy Clay Loam |
| 4.2 | | | | 2" Organic Layer |
| 5 | | | | |
| 6.9 | | | | Boring terminated (83") |
| 8 | | | | |
| 10 | | | | |

Natural Resources Design, LLC

Boring Log: Sheet 1 of 1

☒ Bulk/ Bag Sample

Stabllized Ground water

Groundwater At time of Drilling

| Project: Fort Stevens | Project Number: 193003 | Client: NRD | Date: 11/19/2020 |
|---|---|---|---|
| Address, City, State: 1327 Van Buren St NW, Washington DC | | Elevation: | Total Depth of Boring: 59" |
| Logged By: C. Sonne | | Bit Type: Hand Auger | Diameter: 3.25" |
| Boring No. B-4 | | Groundwater Depth: None Encountered | ***BMP-1 Area*** |

| Depth (feet) | Sample Type | Sample Number | Graphic Log | **DESCRIPTION** |
|---|---|---|---|---|
| 0.5 | | | | Topsoil |
| | | | | Sandy Loam |
| 2.0 | | | | |
| 3.3 | | | | |
| | | | | Sandy Clay Loam |
| 4.2 | | | | 3" Layer Organic Layer |
| 4.9 | | | | Boring terminated (59") |
| 8 | | | | |
| 10 | | | | |

Natural Resources Design, LLC

Boring Log: Sheet 1 of 1

Bulk/ Bag Sample

Stabllized Ground water

Groundwater At time of Drilling

# APPENDIX C

## *WEBSOIL SURVEY REPORT*

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

# Custom Soil Resource Report for

# District of Columbia

## Fort Stevens


March 1, 2019

# Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

# Contents

**Preface**.......... 2
**How Soil Surveys Are Made**.......... 5
**Soil Map**.......... 8
Soil Map.......... 9
Legend.......... 10
Map Unit Legend.......... 11
Map Unit Descriptions.......... 11
District of Columbia.......... 13
CcB—Chillum silt loam, 0 to 8 percent slopes.......... 13
CdC—Chillum-Urban land complex, 8 to 15 percent slopes.......... 13
MbC—Manor loam, 8 to 15 percent slopes.......... 15
MdB—Manor-Urban land complex, 0 to 8 percent slopes.......... 16
U9—Udorthents, loamy, smoothed.......... 18
UsC—Urban land-Manor complex, 8 to 15 percent slopes.......... 18
**References**.......... 21

# How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

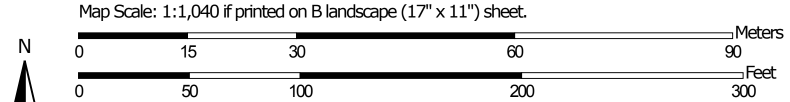
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map


Map Scale: 1:1,040 if printed on B landscape (17" x 11") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

## MAP LEGEND

**Area of Interest (AOI)**

Area of Interest (AOI)

**Soils**

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

**Special Point Features**

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

**Water Features**

Streams and Canals

**Transportation**

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

**Background**

Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: District of Columbia
Survey Area Data: Version 12, Sep 10, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Map Unit Legend

| Map Unit Symbol | Map Unit Name | Acres in AOI | Percent of AOI |
|---|---|---|---|
| CcB | Chillum silt loam, 0 to 8 percent slopes | 0.6 | 5.1% |
| CdC | Chillum-Urban land complex, 8 to 15 percent slopes | 1.3 | 12.4% |
| MbC | Manor loam, 8 to 15 percent slopes | 0.9 | 8.8% |
| MdB | Manor-Urban land complex, 0 to 8 percent slopes | 0.8 | 7.1% |
| U9 | Udorthents, loamy, smoothed | 7.0 | 65.3% |
| UsC | Urban land-Manor complex, 8 to 15 percent slopes | 0.1 | 1.3% |
| **Totals for Area of Interest** | | **10.7** | **100.0%** |

# Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

# District of Columbia

## CcB—Chillum silt loam, 0 to 8 percent slopes

**Map Unit Setting**

*National map unit symbol:* 49sm
*Elevation:* 20 to 370 feet
*Mean annual precipitation:* 30 to 46 inches
*Mean annual air temperature:* 46 to 59 degrees F
*Frost-free period:* 160 to 220 days
*Farmland classification:* All areas are prime farmland

**Map Unit Composition**

*Chillum and similar soils:* 100 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Chillum**

**Typical profile**

*A - 0 to 2 inches:* silt loam
*E - 2 to 9 inches:* gravelly loam
*Bt1 - 9 to 12 inches:* gravelly loam
*Bt2 - 12 to 24 inches:* clay loam
*2BC - 24 to 34 inches:* loamy sand
*3C - 34 to 72 inches:* gravelly silty clay loam

**Properties and qualities**

*Slope:* 0 to 8 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.20 to 1.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 6.1 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 2e
*Hydrologic Soil Group:* C
*Hydric soil rating:* No

## CdC—Chillum-Urban land complex, 8 to 15 percent slopes

**Map Unit Setting**

*National map unit symbol:* 49sr
*Elevation:* 20 to 370 feet
*Mean annual precipitation:* 30 to 55 inches
*Mean annual air temperature:* 45 to 61 degrees F
*Frost-free period:* 160 to 250 days

*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Chillum and similar soils:* 40 percent
*Urban land:* 40 percent
*Minor components:* 20 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Chillum**

**Typical profile**

*A - 0 to 2 inches:* silt loam
*E - 2 to 9 inches:* gravelly loam
*Bt1 - 9 to 12 inches:* gravelly loam
*Bt2 - 12 to 24 inches:* clay loam
*2BC - 24 to 34 inches:* loamy sand
*3C - 34 to 72 inches:* gravelly silty clay loam

**Properties and qualities**

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.20 to 1.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 6.1 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 3e
*Hydrologic Soil Group:* C
*Hydric soil rating:* No

**Description of Urban Land**

**Properties and qualities**

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* 10 inches to
*Runoff class:* Very high

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8s
*Hydric soil rating:* No

**Minor Components**

**Bourne**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Croom**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Sassafras**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Unnamed soils**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

## MbC—Manor loam, 8 to 15 percent slopes

### Map Unit Setting

*National map unit symbol:* 2tkpw
*Elevation:* 50 to 1,080 feet
*Mean annual precipitation:* 35 to 50 inches
*Mean annual air temperature:* 48 to 57 degrees F
*Frost-free period:* 150 to 220 days
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Manor and similar soils:* 85 percent
*Minor components:* 15 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Manor

**Setting**

*Landform:* Hills
*Landform position (two-dimensional):* Summit, shoulder, backslope
*Landform position (three-dimensional):* Side slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Residuum weathered from mica schist

**Typical profile**

*A1 - 0 to 2 inches:* loam
*A2 - 2 to 6 inches:* sandy loam
*Bw1 - 6 to 13 inches:* fine sandy loam
*Bw2 - 13 to 22 inches:* fine sandy loam
*C1 - 22 to 30 inches:* fine sandy loam
*C2 - 30 to 44 inches:* channery coarse sand
*C3 - 44 to 53 inches:* loamy sand
*C4 - 53 to 83 inches:* channery loamy sand
*Cr - 83 to 108 inches:* bedrock
*R - 108 to 138 inches:* bedrock

**Properties and qualities**

*Slope:* 8 to 15 percent
*Percent of area covered with surface fragments:* 0.0 percent

*Depth to restrictive feature:* 59 to 100 inches to paralithic bedrock; 100 to 128 inches to lithic bedrock
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low (0.01 to 0.07 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 8.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 3e
*Hydrologic Soil Group:* B
*Hydric soil rating:* No

### Minor Components

#### Blocktown

*Percent of map unit:* 5 percent
*Landform:* Hillslopes
*Landform position (two-dimensional):* Backslope, shoulder
*Landform position (three-dimensional):* Side slope, interfluve, nose slope
*Down-slope shape:* Convex, linear
*Across-slope shape:* Convex, linear
*Hydric soil rating:* No

#### Glenville

*Percent of map unit:* 5 percent
*Landform:* Swales, drainageways
*Landform position (two-dimensional):* Footslope, toeslope
*Landform position (three-dimensional):* Base slope, head slope
*Down-slope shape:* Concave
*Across-slope shape:* Linear
*Hydric soil rating:* No

#### Mt. airy

*Percent of map unit:* 5 percent
*Landform:* Hillslopes
*Landform position (two-dimensional):* Summit, shoulder
*Landform position (three-dimensional):* Nose slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Hydric soil rating:* No

## MdB—Manor-Urban land complex, 0 to 8 percent slopes

### Map Unit Setting

*National map unit symbol:* 49vc
*Elevation:* 250 to 5,000 feet
*Mean annual precipitation:* 35 to 70 inches

*Mean annual air temperature:* 45 to 61 degrees F
*Frost-free period:* 90 to 235 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Manor and similar soils:* 40 percent
*Urban land:* 40 percent
*Minor components:* 20 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Manor**

**Typical profile**

*A1, A2 - 0 to 6 inches:* loam
*Bw1, Bw2 - 6 to 22 inches:* sandy loam
*C1,C2,C3,C4 - 22 to 72 inches:* channery sandy loam

**Properties and qualities**

*Slope:* 0 to 8 percent
*Depth to restrictive feature:* More than 80 inches
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 1.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 8.8 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 2e
*Hydrologic Soil Group:* B
*Hydric soil rating:* No

**Description of Urban Land**

**Properties and qualities**

*Slope:* 0 to 8 percent
*Depth to restrictive feature:* 10 inches to
*Runoff class:* Very high

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8s
*Hydric soil rating:* No

**Minor Components**

**Glenelg**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Ashe**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Brandywine**

*Percent of map unit:* 5 percent

*Hydric soil rating:* No

**Unnamed soils**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

## U9—Udorthents, loamy, smoothed

### Map Unit Setting

*National map unit symbol:* 49wn
*Mean annual precipitation:* 38 to 44 inches
*Mean annual air temperature:* 48 to 57 degrees F
*Frost-free period:* 150 to 220 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Udorthents and similar soils:* 100 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Udorthents

**Typical profile**

*AC - 0 to 2 inches:* loam
*C - 2 to 72 inches:* gravelly loam

**Properties and qualities**

*Slope:* 0 to 3 percent
*Depth to restrictive feature:* 10 inches to
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately low to very high (0.01 to 19.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Very low (about 1.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8s
*Hydrologic Soil Group:* C
*Hydric soil rating:* No

## UsC—Urban land-Manor complex, 8 to 15 percent slopes

### Map Unit Setting

*National map unit symbol:* 49x3

*Elevation:* 30 to 5,000 feet
*Mean annual precipitation:* 35 to 70 inches
*Mean annual air temperature:* 45 to 61 degrees F
*Frost-free period:* 90 to 250 days
*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Urban land:* 70 percent
*Manor and similar soils:* 5 percent
*Minor components:* 25 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

**Description of Urban Land**

**Properties and qualities**

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* 10 inches to
*Runoff class:* Very high

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 8s
*Hydric soil rating:* No

**Description of Manor**

**Setting**

*Landform:* Ridges, hillslopes
*Landform position (two-dimensional):* Backslope, summit
*Landform position (three-dimensional):* Interfluve, nose slope, side slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Loamy residuum weathered from phyllite and schist

**Typical profile**

*Ap - 0 to 6 inches:* loam
*Bw - 6 to 22 inches:* sandy loam
*C - 22 to 80 inches:* channery loamy sand

**Properties and qualities**

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* 72 to 118 inches to lithic bedrock
*Natural drainage class:* Well drained
*Runoff class:* Medium
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.57 to 1.98 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 8.8 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 3e
*Hydrologic Soil Group:* B
*Hydric soil rating:* No

**Minor Components**

**Glenelg**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Ashe**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Sassafras**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Brandywine**

*Percent of map unit:* 5 percent
*Hydric soil rating:* No

**Joppa**

*Percent of map unit:* 3 percent
*Hydric soil rating:* No

**Unnamed soils**

*Percent of map unit:* 2 percent
*Hydric soil rating:* No

# References


American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

# APPENDIX D

## *INFILTRATION TESTING CALCULATIONS*

**Project:** Fort Stevens – Boring B-2 (BMP-2)

**Performed By:** C. Sonne, D. Wyatt **Date:** 1/7/2021
**Weather Conditions:** Clear, low-40's
**Rainfall in Past 48 Hr.?** 0 in.

| Time | Duration (min) | Elevation (cm) | Elev. Change (cm) | Rate of Drop (cm/min) |
|---|---|---|---|---|
| 9:22 am | | 54.2 | | |
| | 7 | | 1.7 | 0.24 |
| 9:29 | | 55.9 | | |
| | 5 | | 1.1 | 0.22 |
| 9:34 | | 57.0 | | |
| | 5 | | 2.0 | 0.40 |
| 9:41 | | 59.0 | | |
| | 5 | | 2.0 | 0.40 |
| 9:46 | | 61.0 | | |
| | 5 | | 2.0 | 0.40 |
| 9:51 | | 63.0 | | |
| | 5 | | 2.0 | 0.40 |
| 9:56 | | 65.0 | | |
| | 5 | | 2.0 | 0.40 |
| 10:01 | | 67.0 | | |
| | 5 | | 1.5 | 0.30 |
| 10:06 | | 68.5 | | |
| | 5 | | 2.1 | 0.42 |
| 10:11 | | 70.6 | | |
| | | | | |
| | | | **STABILIZED AVG:** | **0.39 cm/min** |

***STABILIZED RATE: 0.39 cm/min***

## *Infiltration Testing Results*

## *Solution for Glover Equation of Ksat*

$K_{sat}$=Q[$\sinh^{-1}$(H/r) – ($r^2$/$H^2$ +1)$^{0.5}$ + r/H]/(2∏$H^2$)

Q = Rate of water infiltration (ml/min) = 31.50 ml/min
H = Static water head (cm) = 15 cm
r = Radius of bore hole = 4.15 cm

Step 1: $K_{sat}$=Q[$\sinh^{-1}$(15/4.15) – ($4.15^2$/$15^2$ +1)$^{0.5}$ + 4.15/15]/(2∏$15^2$)

Step 2: $K_{sat}$=Q[$\sinh^{-1}$(3.6145) – (17.2225/225 +1)$^{0.5}$ + 0.2767]/1413.72

Step3: $K_{sat}$=31.50[1.9968 – 1.0375 + 0.2767]/1413.72

Step 4: $K_{sat}$=31.50[1.236]/1413.72

Step 5: $K_{sat}$= 0.028 cm/min = 0.651 inches/hr

***$K_{sat}$ = 0.65 in/hr***

**Project:** Fort Stevens – Boring B-4 (BMP-1)

**Performed By:** C. Sonne **Date:** 11/19/2020

**Weather Conditions:** Partly cloudy, Mid 40's

**Rainfall in Past 48 Hr.?** 0 in.

| Time | Duration (min) | Elevation (cm) | Elev. Change (cm) | Rate of Drop (cm/min) |
|---|---|---|---|---|
| 11:40 am | | 58.5 | | |
| | 17 | | 5.1 | 0.3 |
| 11:57 am | | 63.6 | | |
| | 5 | | 1.2 | 0.24 |
| 12:06 pm | | 64.8 | | |
| | 5 | | 0.5 | 0.1 |
| 12:11 pm | | 65.3 | | |
| | 5 | | 0.5 | 0.1 |
| 12:16 pm | | 65.8 | | |
| | 5 | | 0.4 | 0.08 |
| 12:21 pm | | 66.4 | | |
| | 5 | | 0.4 | 0.08 |
| 12:26 pm | | 66.8 | | |
| | 5 | | 0.8 | 0.16 |
| 12:31 pm | | 67.6 | | |
| | 5 | | 0.2 | 0.04 |
| 12:36 pm | | 67.8 | | |
| | 5 | | 0.6 | 0.12 |
| 12:41 pm | | 68.4 | | |
| | 5 | | 0.4 | 0.08 |
| 12:46 pm | | 68.8 | | |
| | 5 | | 0.5 | 0.1 |
| 12:51 pm | | 69.3 | | |
| | 5 | | 0.5 | 0.1 |
| 12:56 pm | | 69.8 | | |
| | 5 | | 0.4 | 0.08 |
| 1:01 pm | | 70.2 | | |
| | | | | |
| | | | ***STABILIZED AVG:*** | ***0.095*** |
| | | | | |

***STABILIZED RATE: 0.095 cm/min***

## *Infiltration Testing Results*

## *Solution for Glover Equation of Ksat*

$K_{sat}$=Q[sinh$^{-1}$(H/r) – ($r^2/H^2$ +1)$^{0.5}$ + r/H]/(2∏$H^2$)

Q = Rate of water infiltration (ml/min) = 7.68 ml/min
H = Static water head (cm) = 15 cm
r = Radius of bore hole = 4.15 cm

Step 1: $K_{sat}$=Q[sinh$^{-1}$(15/4.15) – ($4.15^2/15^2$ +1)$^{0.5}$ + 4.15/15]/(2∏$15^2$)

Step 2: $K_{sat}$=Q[sinh$^{-1}$(3.6145) – (17.2225/225 +1)$^{0.5}$ + 0.2767]/1413.72

Step3: $K_{sat}$=7.68[1.9968 – 1.0375 + 0.2767]/1413.72

Step 4: $K_{sat}$=7.68[1.236]/1413.72

Step 5: $K_{sat}$= 0.0067 cm/min = 0.159 inches/hr

***$K_{sat}$ = 0.16 in/hr***

## Appendix C: Compost Specifications

All compost used on the site should have the Seal of Testing Assurance from the US Composting Council. This will ensure that the compost is mature, beneficial for plants, and with acceptable levels of salts. The compost should come from a source that regularly tests its compost for adherence to the standards as outlined by the US Composting Council—at least annually, and even better, twice a year.

The pH of the compost should be between 6.2 and 7.5. Compost outside this pH range should not be used.