DEPARTMENT OF ENERGY & ENVIRONMENT

Natural Resources Design

an ecologically focused design firm

Washington DC

DEPARTMENT OF **ENERGY & ENVIRONMENT**

Douglass Community Center

Project Area Assessment Report, July 2019

DPR II – Design and Build 4 LID Sites

Contract Number CW712222

Prepared By

Natural Resources Design, Inc

Christopher Sonne, P.E., SITES AP

Barbara Neal, ISA #4283B, RCA#428

Lauren Wheeler, LEED AP, SITES AP

Sylvan Kaufman, PhD

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Douglass Community Center **Current Project Area Assessment Report (DOEE DPR II – Design and Build 4 LID Sites)** identifies existing site conditions that could influence the selected Best Management Practice (BMP) designs. There are several factors noted that could have a significant impact upon the original designs anticipated for this location.

During the Kick-Off meeting site visit, DPR informed DOEE and NRD that the proposed stormwater improvements should be shifted away from the central area of the site (where the Community Center and pool are located), due to plans for a major redevelopment of the site. As a result, attention was shifted to the western side of the site, which is currently expected to remain basically unchanged during the upcoming construction.

Recommended improvements include the redesign and reconstruction of the existing bioretention basin by the basketball court. Replacing the existing concrete swale with a grass swale to divert runoff from the basketball court into this new bioretention basin located where the previous bioretention basin would provide a significant benefit.

An evaluation of the potential benefits of subsoiling at the baseball field indicated both surface and subsoils are severely compacted across the entire field. As a result, the longterm stormwater benefits of subsoiling/decompaction for this area are unclear. Further evaluation is recommended.

As part of this assessment, several maintenance issues were noted with the existing stormwater piping system, resulting in ponding on the site near the baseball field and overflow of concentrated runoff to the public alleyway adjacent to the site.

Overall, there appear to be cost-effective stormwater improvement opportunities available that should not create a conflict with upcoming DPR redesigns for the primary areas of the site.

The benefits achieved by decompacting/subsoiling the baseball field will be difficult to enumerate, due to the heavily compacted subsoils. Further consideration of this alternative is recommended.

2. PROJECT OVERVIEW

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

The Douglass Community Center is located in the Anacostia River watershed at 1922 Frederick Douglass Ct. SE and is bounded by Suitland Parkway to the north (Figures 1 & 2). It is located at a residential neighborhood of single-family homes and apartment buildings. The site consists of over five acres and includes basketball courts, a playground, swimming pool, community center, community garden, and baseball field. The site is surrounded by a dense wooded area to the north and west.

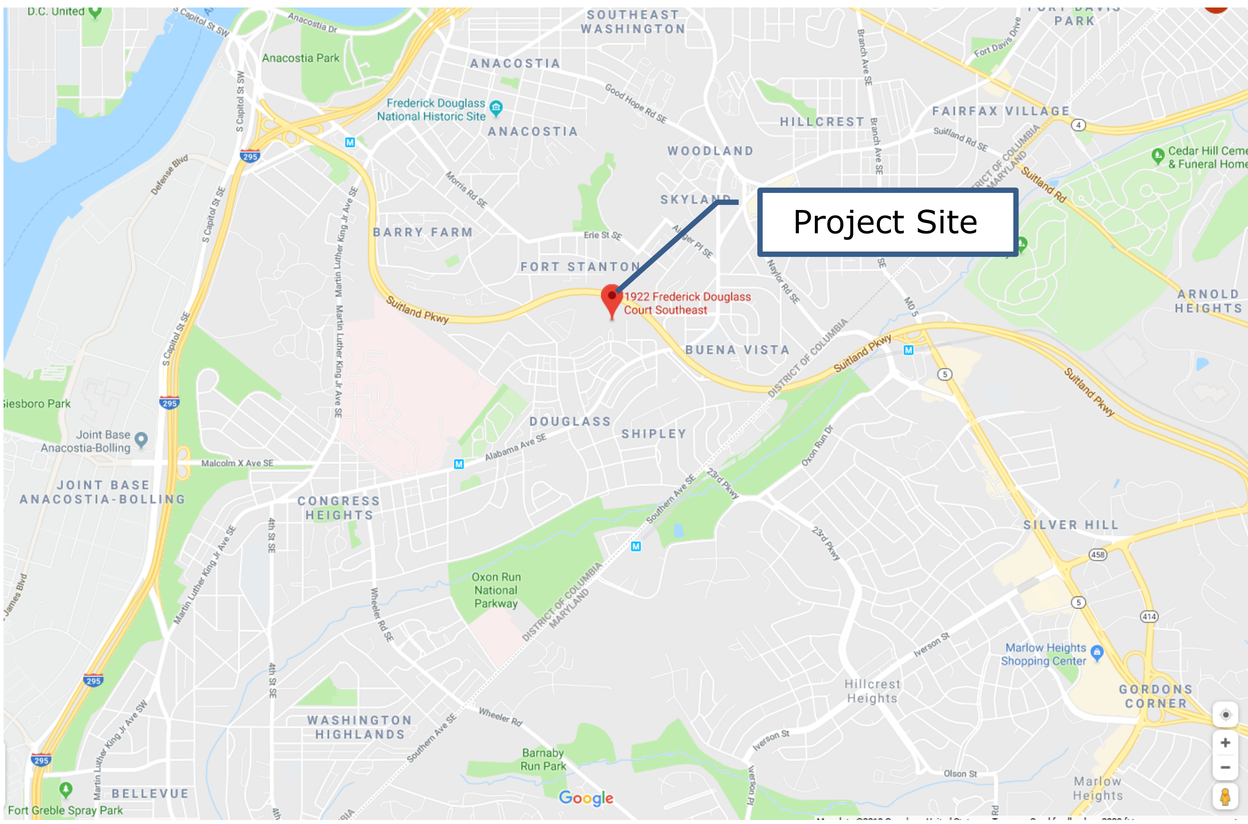


Figure 1: Vicinity Map *© Google 2019*

Figure 2: 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 Department of Parks and Recreation (DPR) has determined that this site will receive a major renovation within the next few years. As a result, the specific objectives identified in the RFP for this site have changed to shift potential site improvements away from the anticipated renovation area.

The purpose of this **Current Project Area Assessment Detailed Report** is to compile existing site information that may impact 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 assessment 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 Topographical Survey

A topographical field survey of the anticipated BMP area was prepared by Sustainable Land Surveys, LLC of Washington, DC. A copy of this survey is included as Appendix A. Topography of the site is fairly flat (2% slopes or less) across most of the site, with a 33% sloping bank from southwest side of the site down to a public alleyway. As shown in this survey, there is an extensive network of surface drains around the baseball field and surrounding turf areas. This system drains to a drop inlet (Inlet 21) located in the southwest corner of the property.

3.2 Site Utilities

Existing site utilities within the survey area include the stormwater infrastructure, as noted above, and ancillary water and underground electric lines serving water fountains and site lighting. Note that not all these lines have been located on the plan. A private SUE contractor will be engaged to mark existing utilities in the proposed project area following the 30% design, as needed.

Stormwater:

There is an existing bioretention basin located to the west of the basketball courts. This basin is poorly maintained and is currently filled with invasive plants (Photo 1).

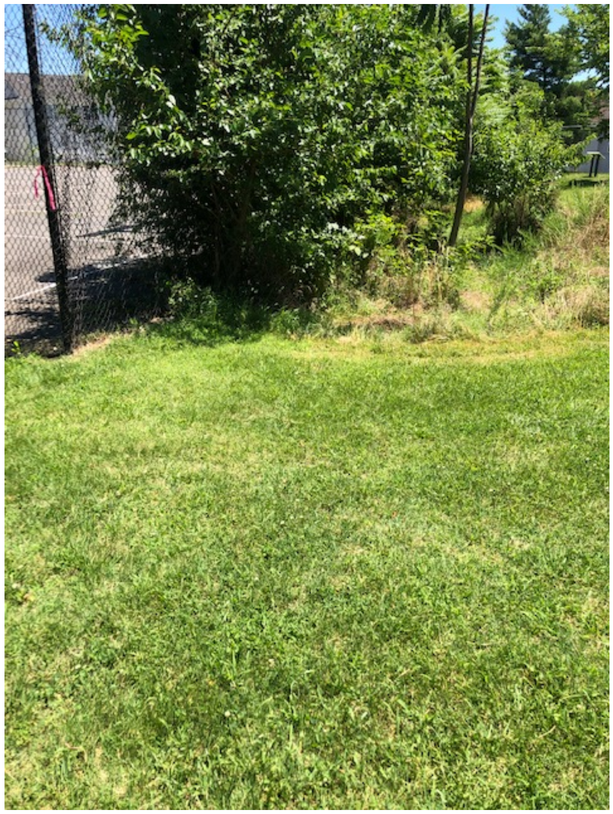


Photo 1 - Existing Bioretention Basin

Design plans for this facility do not appear to be available. There are no indications of any inlet, outlet or underdrain piping within this basin, which appears to be intended to capture sheet flow runoff from the adjacent paved basketball courts. The survey data indicates that most of the basketball court area actually drains to the existing concrete lined ditch which runs south of the basin. There was no indication of any standing water in this basin during a heavy storm event.

Field observations indicate maintenance issues within the existing stormwater system. One of the inlets adjacent to the baseball field (Inlet 20 on the survey) shows evidence of regular ponding around the inlet, indicating it does not drain properly. This was confirmed by a site visit (by the surveyor) during a storm event (Photo 2). In addition, Inlet 21 is apparently not draining properly, resulting in an overflow of stormwater down the adjacent bank and into the public alleyway (Photo 3).

Photo 2- Ponding at Inlet 20

Photo 3- Overflow from Inlet 21

3.3 Soil & Vegetation Conditions

Soil Mapping:

Based upon the USDA Websoil Survey (Appendix B), soils across the site consist of gravelly sandy clay 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 within the existing bioretention basin and across the baseball field was performed by Natural Resources Design on July 18, 2019. This report is included as Appendix B.

A soil boring and infiltration test was performed within the bioretention basin. This evaluation indicated the basin construction consists of approximately 22 inches of bioretention mix over a 12 inch deep gravel drainage layer. There is a layer of nonwoven geotechnical fabric separating these layers. Based on the survey, the ponding depth within this basin is approximately 12 inches.

An evaluation of the degree of compaction across the baseball field area was performed in consideration of possible subsoiling/decompaction methods in this area. This evaluation concluded that subsoil compaction conditions across the field were very high, and that decompacting surface soils will provide little benefit or runoff reduction.

Infiltration Testing:

A soil infiltration test was performed in the subsoils beneath the bioretention base, in conformance with Appendix "O" of the DOEE Stormwater Management requirements. This test was performed with a fixed-head permeameter at a depth of 50". The measured infiltration rate at this site was very good (6.7 inches per hour), indicating excellent potential for retrofitting an infiltration-based stormwater BMP at this location.

Soil Erosion:

Areas of soil erosion and deposition were evident around the baseball infield area. This does not appear to be due to high stormwater surface flows, but to the very fine silty soils used to construct the infield area.

Existing Vegetation:

Vegetation at this site consists primarily of managed turf in good condition. As previously noted, invasive plants have overtaken the existing bioretention basin. There is also invasive plant pressure along the woodland perimeter of the managed turf area, with one section of the asphalt trail around the property being blocked by invasive plant growth.

4. EXISTING STORMWATER MANAGEMENT

Due to the future major renovations planned for this site, this assessment is only considering stormwater management for the western side of the project site, including the basketball courts and baseball field. DPR has indicated that these areas are currently expected to remain as they are following the renovations.

Surface Cover: The asphalt basketball courts and concrete drainage ditch provide 14,600 sf of impervious cover. The asphalt walking trail and baseball team areas provide an additional 2,250 sf of impervious cover (within the survey area). The remainder of the western end of this site consists of managed turf.

Photo 4- Existing Concrete Ditch

Drainage Patterns:

The majority of the baseball field/turf area drainages flow in a southwesterly direction across the site. This flow is intercepted by a series of stormwater drop inlets and piped off the site as previously discussed. Drainage from the basketball courts is primarily intercepted by an existing concrete lined ditch (Photo 4), which conveys it as channel flow to the top of the bank above Inlet 21. There is a large earthen channel on the grass bank below the bioretention pond area. It is not clear if this channel receives runoff from the concrete ditch during large storm events or if it is a legacy from previous stormwater management at the site.

5. STORMWATER MANAGEMENT OPPORTUNITIES

As previously discussed, possible stormwater management approaches for this site have been limited to those areas that are unlikely to be impacted by the upcoming facility retrofit and reconstruction. The opportunities identified include:

Bioretention Basin Retrofit – The existing bioretention basin would be replaced with a new basin in the same general location. The existing concrete ditch will be replaced with a grass swale and modified to direct the 1.2 inch design storm into the new basin. A bypass design may be considered to direct larger storms to the piped drainage infrastructure.

Baseball Field Subsoiling – Subsoiling/de-compacting of the existing outfield area may be considered to reduce the runoff from this large area of managed turf. Based upon the geotechnical evaluation, the long-term benefit of this practice is not fully established.

Stormwater Quality Volumes:

Based upon the site survey and proposed site improvements, NRD has delineated the anticipated drainage areas to the proposed bioretention basin retrofit area to calculate the required Stormwater Retention Volume (SWRv). Following the 30% submittal, NRD will conduct a detailed hydrologic analysis to determine the adequate sizing of this BMP and associated flow control structures.

The required SWRv for the proposed BMPs were calculated in accordance with the DOEE Stormwater Management Guidebook (July 2013). Based upon the project location, this proposed retrofit project uses a 1.2-inch design storm for calculating the SWRv, using Equation 2.1 from the guidebook. Table 1 below shows the drainage area characteristics and SWRv.

		Contributing Drainage Area (CDA)					Stormwater Retention Volume
		Paved	Compacted	Natural	Total	P	(SWRv)
CDA	Description	sf	sf	Sf	Sf	in	Cf
1	Existing Bioretention Basin Retrofit	13,650	2,500	0	16,150	1.2	1,291

Table 1: SWRv Calculations

6. CONCLUSIONS

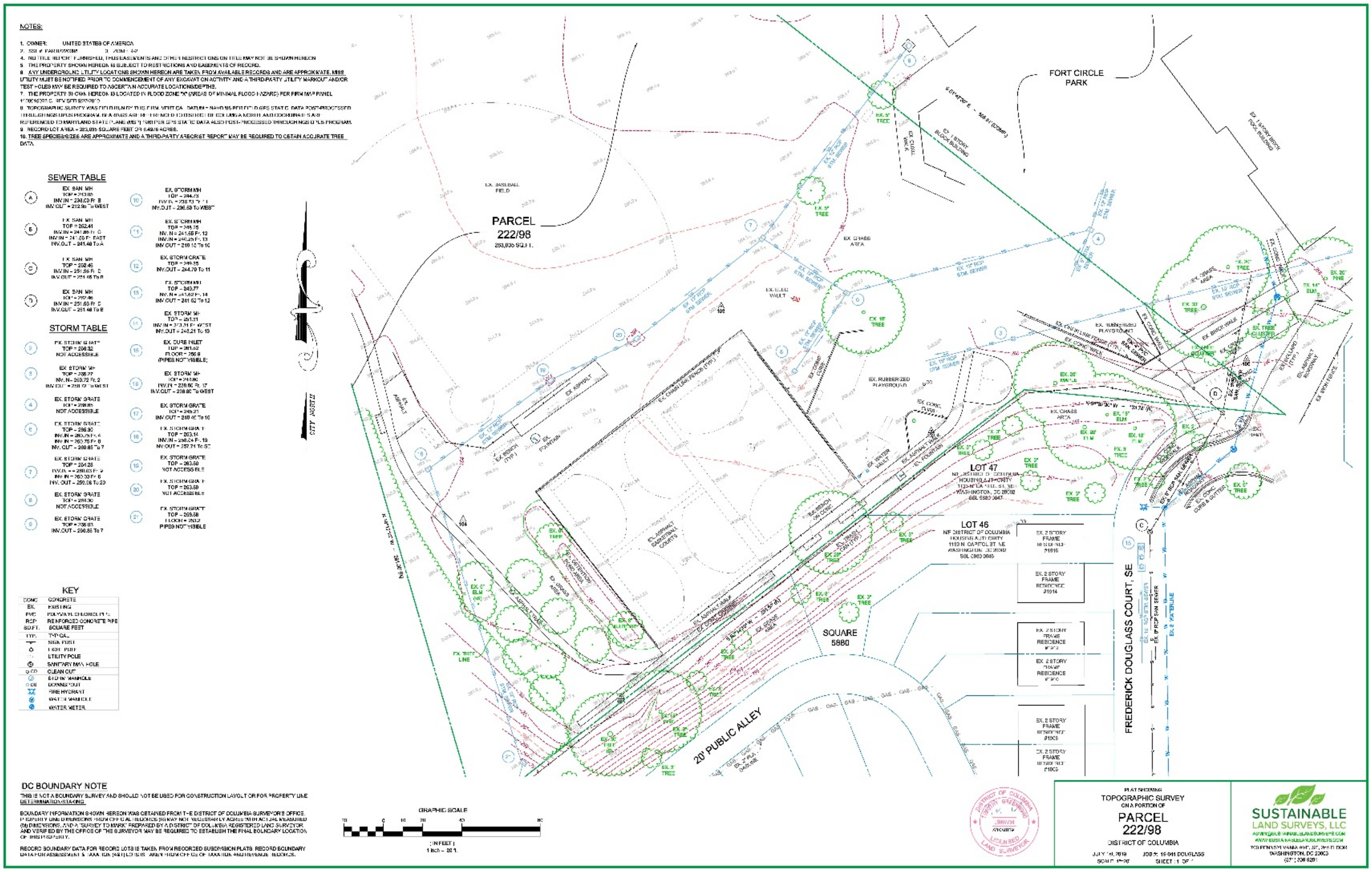
Development of suitable BMPs at the Douglass Center site will be impacted by the proposed site redevelopment, which limits proposed improvements to the western end of the site.

Redesign and reconstruction of the existing bioretention basin adjacent to the basketball courts, in conjunction with replacing the existing concrete swale with a grass swale and inlet control structure, will provide substantial stormwater benefit and improve site aesthetics in this area.

The benefits achieved by decompacting/subsoiling the baseball field will be difficult to enumerate, due to the heavily compacted subsoils. Further consideration of this alternative is recommended.

7. APPENDICES

Appendix A : Survey



Appendix B: Geotechnical Report

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

Douglass Community Center
1922 Frederick Douglass Ct. SE
Washington DC

Natural Resources Design
an ecologically focused design firm
Washington DC

Prepared by:

Natural Resources Design, LLC

1009 Shepherd St. NE

Washington, DC 20017

202.489.6214

July 19, 2019

1. 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 Douglass Community Center consists of basketball courts, a playground, swimming pool, community center, community garden, and baseball 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 andfeatures;
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 one (1) hand-augered boring drilled to the depth indicated in the Boring Log shown in Appendix B;
5. Performed one (1) field infiltration test in general accordancewith Appendix O 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. SUBSURFACE EXPLORATION PROCEDURES

Our geotechnical subsurface exploration program consisted of one (1) test boring designated B-1, as well as a surface compaction evaluation at the existing baseball field area.

The exploration was performed on July 18, 2019 at the approximate location shown on the attached Boring Location Plan (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. The test boring was performed using a hand auger with a 3-1/4" diameter chuck and a vacuum auger with a 6" chuck.

Boring B-1, located in the approximate center of an existing bioretention basin adjacent to the basketball courts, was advanced through the existing bioretention media, geotextile fabric, drainage gravel and subsoil. Boring was terminated at a depth of 50 inches below the surface elevation.

Upon completion of the field testing, the borehole was 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 log (soil profile) is provided in Appendix B.

3.. SITE AND SUBSURFACE CONDITIONS

3.1 Site Description

The area of soils evaluation consisted of a small bioretention basin situated adjacent to a paved basketball court. This basin is overgrown with invasive plants, has no apparent drainage or underdrainage piping, and does not show signs of any significant ponding or runoff capture.

The adjacent baseball field includes an infield area consisting of bare soil. This soil is a fine silty micaceous material. The field has three existing surface drains adjacent to it, one of which shows signs of frequent backup and ponding. Turf in the field appears to be generally in good condition.

3.2 Regional Geology

Based upon the USGS soils mapping for the project site, the underlying site soil in the areas of exploration is as follows:

Croom-Urban land complex – This soil complex consists of 40% urban soils, 40% Croom and similar soils, and 20% minor component soils. The Croom soil series consists of well drained gravelly sandy clay loams with moderately high Ksat values (0.20 – 0.57 inches/hour). Hydrologic Soil Group C

The Websoil Survey report for the project area is attached as Appendix C.

3.3 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 AppendixB.

Fill/Possible Fill Soils

Fill/Possible Fill may be any material that has been transported and deposited by man. The subsoils under the bioretention basin were not identified as fill material.

Infiltration testing was performed in accordance with the requirement of Appendix O – Geotechnical Information Requirements for Underground BMPs, Section O.3.

Infiltration testing equipment consisted of a constant head permeameter.
A test hole was prepared by hand augering an 8.3 cm diameter bore hole to a depth of 50".

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.

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-1	4.16	6.6	inches/hr

8. SUBSOILING EVALUATION

5.1 Methodology

Part of the project scope at this site is the evaluation of soil subsoiling/decompaction to improve the stormwater function (reduce runoff) of the existing baseball outfield area (turf). The approach taken to evaluate the potential benefits of subsoiling at this site was as follows:

Soil moisture levels during testing were good, and the existing turf was well established and healthy.

The soils across the field were mapped out on a 20-foot grid to evaluate the consistence of compaction across the field. Compaction of the upper 4" to 6" layer of soil was compared to soils in the lower 6" to 18". This comparison was made to determine if decompaction of the surface soils is likely to allow surface waters to penetrate into a less compacted subsoil. The results of this evaluation, which involved a total of 139 test points, were as follows:

- Surface Compaction between 200 psi and 300 psi: 19%
- Subsurface Compaction between 200 psi and 300 psi: 1%
- Surface Compaction above 400 psi (no penetration): 9%

The remainder of the tests results indicated compaction values between 300 and 400 psi (highly compacted).

9. RECOMMENDATIONS

Based upon the high infiltration rates in the bioretention basin subsoils, this area is well suited for location of an infiltration-based BMP without requiring installation of an underdrain system. In order to ensure proper function, the existing system should be excavated and reconstructed to current standards.

Subsoiling/decompaction of the baseball field area may provide some benefits and stormwater reductions, but the extent of these improvements is difficult to determine due to the highly compacted subsurface conditions. There do not appear to be compacted surface conditions that are acting as a restrictive soil layer.

10. 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 theboring 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

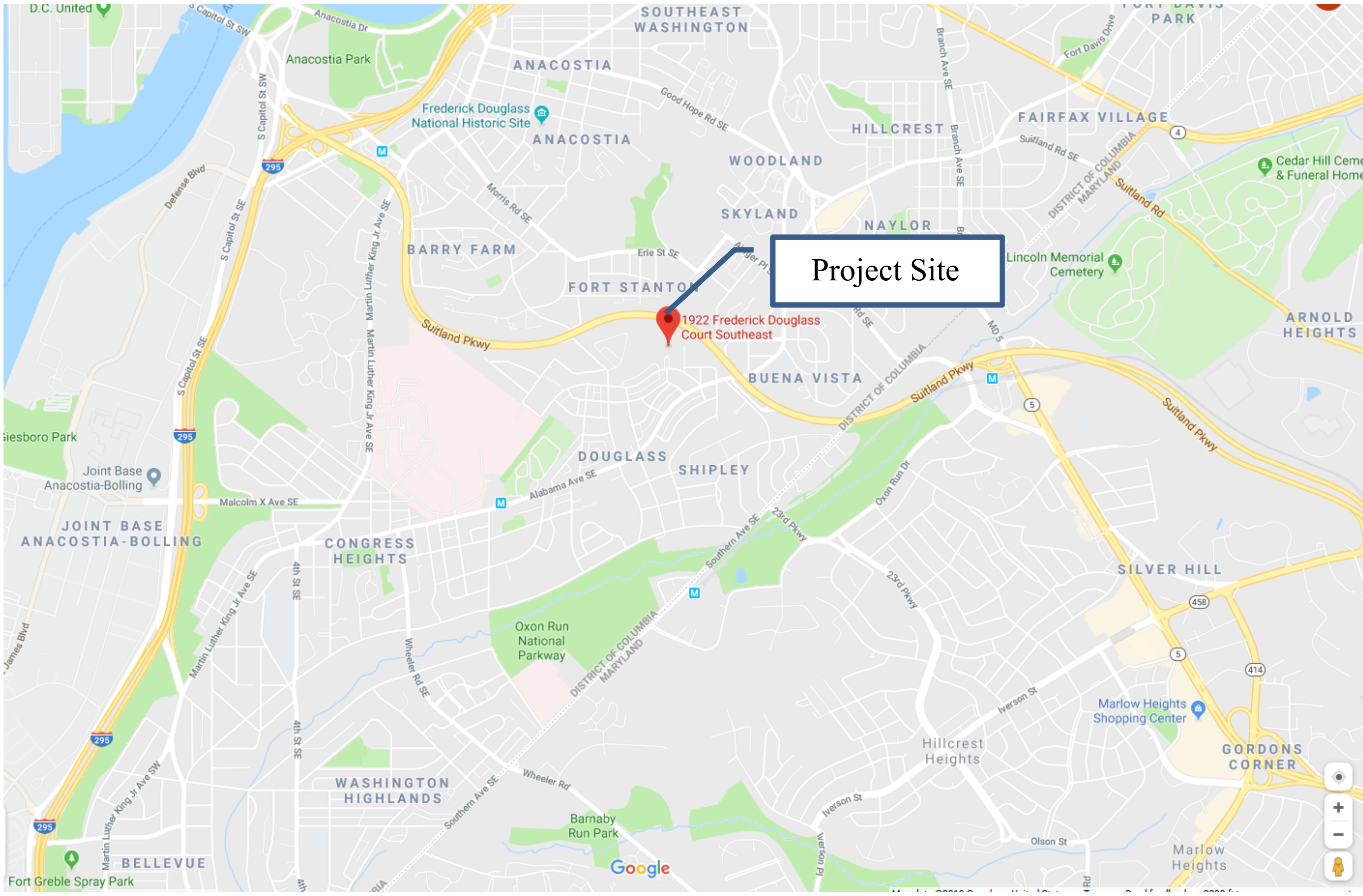


Figure 1 - Vicinity Map *2019©Google*

APPENDIX B

SOILS BORING INFORMATION

Figure 2 – Soil Boring Location

Project:	Project Number:	Client:	Date:
Douglass Comm.	193003	NRD	7/18/2019
Address, City, State: 1327 Van Buren St NW, Washington DC		Elevation:	Total Depth of Boring: 50"
Logged By: C. Sonne		Bit Type: Hand Auger	Diameter: 3.25"
Boring No. B-1		Groundwater Depth: None Encountered	***Existing Bio Basin***

Depth (feet)	Sample Type	Sample Number	Graphic Log	DESCRIPTION
				Bioretention mix (sand with organics)
	☒	1		
				Geotextile layer at 22 inches
1.8				Gravel drainage layer
				Sandy clay loam with gravel
	☒	2		
4.2				Boring Terminated (50")
5				
8				
10				

Natural Resources Design, LLC

Boring Log: Sheet 1 of 1

☒ Bulk/ Bag Sample

▼ Stablized Ground water

▽ Groundwater At time of Drilling

APPENDIX C
WEBSOIL SURVEY REPORT/INFILTRATION TESTING CALCULATIONS

Project: Douglass – Boring B-1

Performed By: C. Sonne **Date:** 7/18/2019
Weather Conditions: Partly cloudy, 95 degrees
Rainfall in Past 48 Hr.? 0.1 in.

Time	Duration (min)	Elevation (cm)	Elev. Change (cm)	Rate of Drop (cm/min)
4:20 pm		68.7		
	5		1.5	0.30
4:25		70.2		
	5		1.6	0.32
4:30		71.8		
	5		1.6	0.32
4:35		73.4		
	5		1.6	0.32
4:40		75.0		
	5		1.4	0.28
4:45		76.4		
	10		2.7	0.27
4:55		79.1		
	5		1.5	0.30
5:00		80.6		
	5		1.4	0.28
5:05		82.0		
	5		1.5	0.30
5:10		83.5		

STABILIZED RATE: 0.28 cm/min

Natural Resources Design
an ecologically focused design firm
Washington DC

CONSTANT HEAD WELL PERMEAMETER
SINGLE PONDED HEIGHT METHOD

Most structured soils from clays through loams; Also includes unstructured medium and fine sands. The first choice for most soils.

d-well hole diameter (cm) H	8.3	a* - sat/unsatflow ratio (cm-1)	0.12
- height of water in well (cm)	15.0	C - shape factor	1.36

R(cm/min)	Kfs (m/sec)
0.01	**5.3E-08**
0.02	**1.1E-07**
0.03	**1.6E-07**
0.04	**2.1E-07**
0.05	**2.7E-07**
0.06	**3.2E-07**
0.07	**3.7E-07**
0.08	**4.3E-07**
0.09	**4.8E-07**
0.10	**5.3E-07**
0.15	**8.0E-07**
0.20	**1.1E-06**
0.25	**1.3E-06**
0.28	1.5E-06
0.30	**1.6E-06**
0.35	**1.9E-06**
0.40	**2.1E-06**
0.45	**2.4E-06**
0.50	**2.7E-06**
0.55	**2.9E-06**
0.60	**3.2E-06**
0.65	**3.5E-06**
0.70	**3.7E-06**
0.75	**4.0E-06**
0.80	**4.3E-06**
0.85	**4.5E-06**
0.90	**4.8E-06**
0.95	**5.1E-06**
1.0	**5.3E-06**
1.1	**5.9E-06**
1.2	**6.4E-06**
1.3	**6.9E-06**
1.4	**7.5E-06**
1.5	**8.0E-06**
1.6	**8.5E-06**
1.7	**9.0E-06**
1.8	**9.6E-06**
1.9	**1.0E-05**
2.0	1.1E-05
2.1	**1.1E-05**
2.2	**1.2E-05**
2.3	**1.2E-05**
2.4	**1.3E-05**
2.5	**1.3E-05**
2.6	**1.4E-05**

R(cm/min)	Kfs (m/sec)
2.7	1.4E-05
2.8	1.5E-05
2.9	1.5E-05
3.0	1.6E-05
3.1	1.6E-05
3.2	1.7E-05
3.3	1.8E-05
3.4	1.8E-05
3.5	1.9E-05
3.6	1.9E-05
3.7	2.0E-05
3.8	2.0E-05
3.9	2.1E-05
4.0	2.1E-05
4.1	2.2E-05
4.2	2.2E-05
4.3	2.3E-05
4.4	2.3E-05
4.5	2.4E-05
4.6	2.4E-05
4.7	2.5E-05
4.8	2.6E-05
4.9	2.6E-05
5.0	2.7E-05
5.5	2.9E-05
6.0	3.2E-05
6.5	3.5E-05
7.0	3.7E-05
7.5	4.0E-05
8.0	4.3E-05
8.5	4.5E-05
9.0	4.8E-05
9.5	5.1E-05
10.0	5.3E-05
11.0	5.9E-05
12.0	6.4E-05
13.0	6.9E-05
14.0	7.5E-05
15.0	8.0E-05
16.0	8.5E-05
17.0	9.0E-05
18.0	9.6E-05
19.0	1.0E-04
20.0	1.1E-04

R(cm/min)	Kfs (m/sec)
21.0	1.1E-04
22.0	1.2E-04
23.0	1.2E-04
24.0	1.3E-04
25.0	1.3E-04
26.0	1.4E-04
27.0	1.4E-04
28.0	1.5E-04
29.0	1.5E-04
30.0	1.6E-04
31.0	1.6E-04
32.0	1.7E-04
33.0	1.8E-04
34.0	1.8E-04
35.0	1.9E-04
36.0	1.9E-04
37.0	2.0E-04
38.0	2.0E-04
39.0	2.1E-04
40.0	2.1E-04
41.0	2.2E-04
42.0	2.2E-04
43.0	2.3E-04
44.0	2.3E-04
45.0	2.4E-04
46.0	2.4E-04
47.0	2.5E-04
48.0	2.6E-04
49.0	2.6E-04
50.0	2.7E-04
52.0	2.SE-04
54.0	2.9E-04
56.0	3.0E-04
58.0	3.1E-04
60.0	3.2E-04
62.0	3.3E-04
64.0	3.4E-04
66.0	3.5E-04
68.0	3.6E-04
70.0	3.7E-04
72.0	3.8E-04
74.0	3.9E-04
76.0	4.0E-04
78.0	4.2E-04

R - quasi steady-state rate of fall

Kfs - field saturated hydraulic conductivity

Perc Time (PT) = Kfs/m; m=conversion factor, based upon soil type (2.28E-07 for this soil type)
PT = 1.5E-06 / 2.28E-07; ***PT = 6.6 inches / hour measured***

United States Department of Agriculture

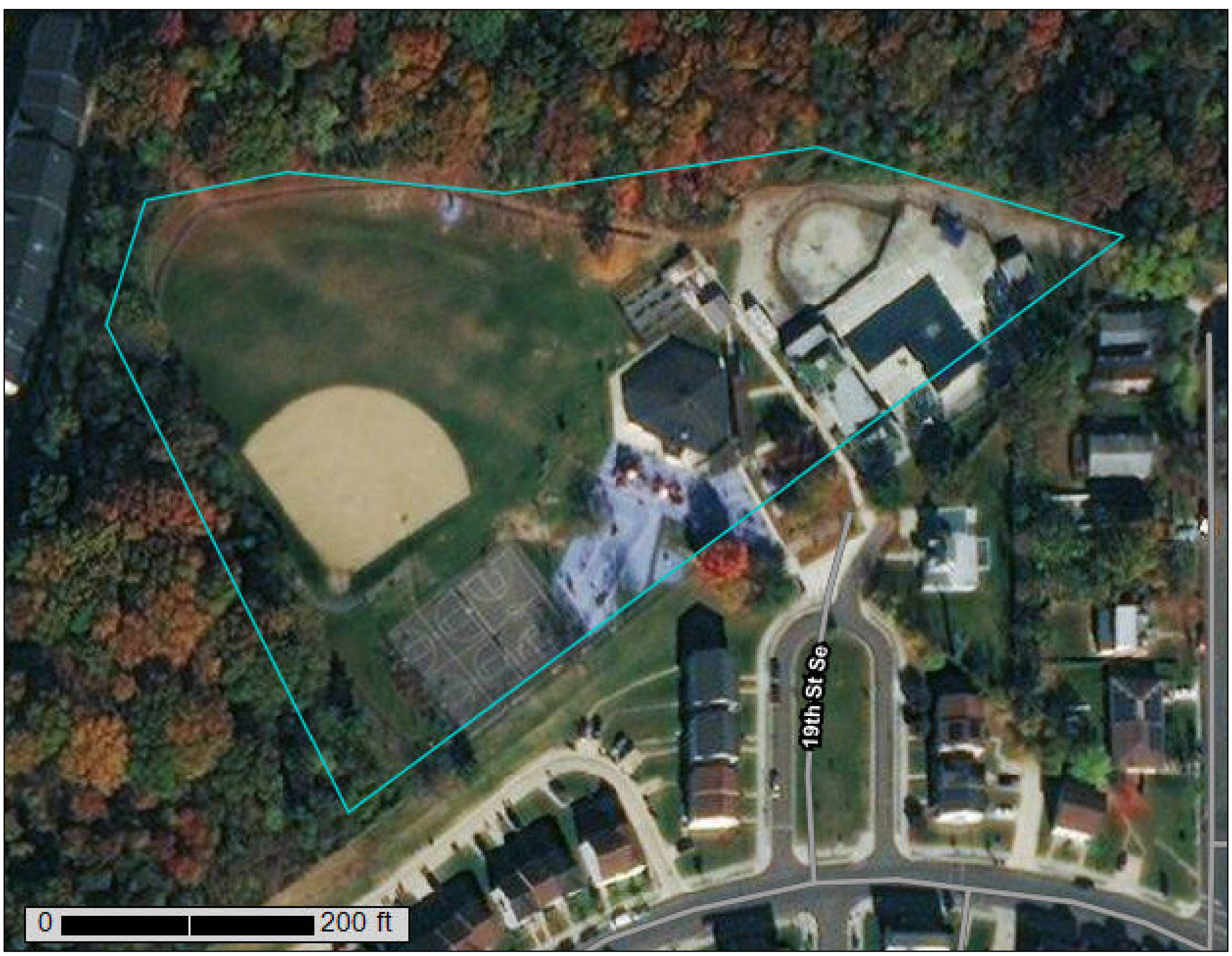
NRCS

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



May 31, 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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require 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

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.

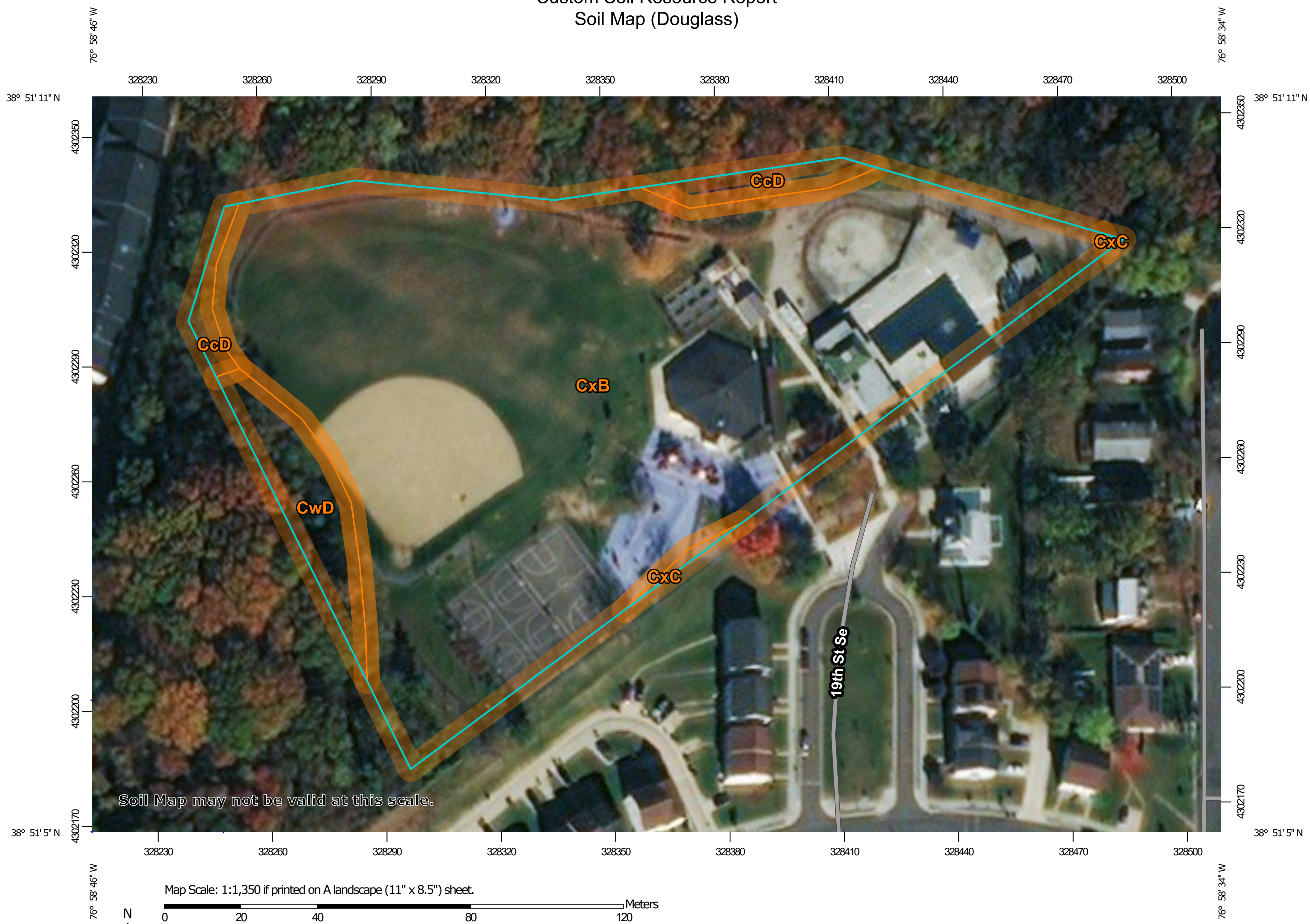
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree 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.

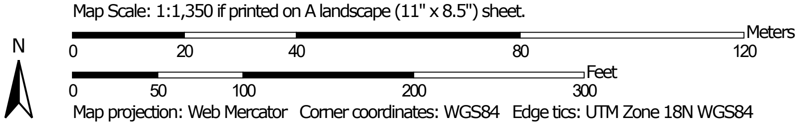
Soil Map

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.

Custom Soil Resource Report
Soil Map (Douglass)



Map Scale: 1:1,350 if printed on A landscape (11" x 8.5") 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 (Douglass)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CcD	Chillum silt loam, 15 to 40 percent slopes	0.1	2.8%
CwD	Croom very gravelly sandy loam, 15 to 40 percent slopes	0.3	5.0%
CxB	Croom-Urban land complex, 0 to 8 percent slopes	4.7	91.9%
CxC	Croom-Urban land complex, 8 to 15 percent slopes	0.0	0.3%
Totals for Area of Interest		**5.1**	**100.0%**

Map Unit Descriptions (Douglass)

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

CcD—Chillum silt loam, 15 to 40 percent slopes

Map Unit Setting

National map unit symbol: 49sp
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: Not 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: 15 to 40 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): 6e
Hydrologic Soil Group: C
Hydric soil rating: No

CwD—Croom very gravelly sandy loam, 15 to 40 percent slopes

Map Unit Setting

National map unit symbol: 49t4
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: Not prime farmland

Map Unit Composition

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

Description of Croom

Typical profile

Ap1 - 0 to 1 inches: very gravelly sandy loam
Ap2 - 1 to 9 inches: loam
Bt1 - 9 to 13 inches: very gravelly clay loam
Bt2 - 13 to 30 inches: extremely gravelly sandy clay loam
Bt3 - 30 to 54 inches: extremely gravelly sandy clay loam
BCt - 54 to 66 inches: extremely gravelly sandy clay loam
BC - 66 to 80 inches: extremely gravelly coarse sandy loam

Properties and qualities

Slope: 15 to 40 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 (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Hydric soil rating: No

CxB—Croom-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 49t5
Elevation: 20 to 650 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

Croom 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 Croom

Typical profile

Ap1 - 0 to 1 inches: very gravelly sandy loam
Ap2 - 1 to 9 inches: loam
Bt1 - 9 to 13 inches: very gravelly clay loam
Bt2 - 13 to 30 inches: extremely gravelly sandy clay loam
Bt3 - 30 to 54 inches: extremely gravelly sandy clay loam
BCt - 54 to 66 inches: extremely gravelly sandy clay loam
BC - 66 to 80 inches: extremely gravelly coarse 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 (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
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

Chillum

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

Beltsville

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

CxC—Croom-Urban land complex, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 49t6
Elevation: 20 to 600 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 64 degrees F
Frost-free period: 160 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Croom 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 Croom

Typical profile

Ap1 - 0 to 1 inches: very gravelly sandy loam
Ap2 - 1 to 9 inches: loam
Bt1 - 9 to 13 inches: very gravelly clay loam
Bt2 - 13 to 30 inches: extremely gravelly sandy clay loam
Bt3 - 30 to 54 inches: extremely gravelly sandy clay loam
BCt - 54 to 66 inches: extremely gravelly sandy clay loam
BC - 66 to 80 inches: extremely gravelly coarse sandy 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 (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 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

Unnamed soils

Percent of map unit: 10 percent
Hydric soil rating: No

Sassafras

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

Chillum

Percent of map unit: 5 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