STORMWATER ANALYSIS & CALCULATIONS REPORT

for

43 ESTABROOK AVENUE
GRAFTON, MASSACHUSETTS
(PHASE 2 SOLAR DEVELOPMENT)

Prepared for:

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August 1, 2014

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CALCULATION METHODS

- TR 20 SCS Unit Hydrograph Procedure
- Runoff Curve Numbers
- Time of Concentration by TR55 Methodology
- Reach and Pond Rating by the Storage-Indication Method
- Manning Equation

SOURCE OF DATA

- Technical Report No. 20
- Technical Report No. 55
- Technical Paper No. 40
- Field Survey by Meridian Associates, Inc.
- Soil Testing by Alexander F. Parker (MA CSE#1848)
- Soil Borings by Geosyntec Consultants Inc.
- Massachusetts Stormwater Handbook February 2008
- Cornell University Publication No. RR-93-5; September 1993; "Northeast Regional Climate Center Atlas of Precipitation Extremes for the Northeastern United States and Southeastern Canada"

REPORT SUMMARY:

Calculation Objective

The purpose of this drainage analysis is to design a stormwater management system that will not increase peak rates and volumes of stormwater runoff that will flow offsite from pre to post development at the selected design points during the 2, 10, and 100-year design storm events.

The following analysis is separated into existing conditions and proposed conditions for ease of comparison. Drainage maps have been incorporated into this report to depict existing and proposed watershed areas and subcatchments for the site.

This stormwater management hydrological study has been prepared in accordance with the Rules and Regulations Governing the Subdivision of Land: Grafton, Massachusetts (Sections 3.3.3.19 and 4.7.8) and Town of Grafton Stormwater Management By-Law.

Classification of Soils:

The drainage class of the various soil types on the locus property has been categorized by applying the information provided by the soil maps prepared by the United States Department of Agriculture, National Resource Conservation Service (hereon referred to as the USDA NRCS). Based upon the USDA NRCS Soil Maps, two (2) soil groups exist within the subcatchment areas that are used throughout this drainage analysis. The two different soil types are as follows:

- Chatfield-Hollis-Rock Outcrop complex; 3-15% Slopes, Hydrologic Soil Group B.
- Paxton Fine Sandy Loam; 3-8% Slopes, Hydrological Soil Group C.
- Paxton Fine Sandy Loam; 8-15% Slopes, Hydrological Soil Group C.
- Paxton Fine Sandy Loam; 3-8% Slopes, extremely stony, Hydrological Soil Group C.

Chatfield-Hollis-Rock Outcrop complex

This unit consists of well drained to somewhat excessively drained soils on hills and ridges. Seasonal high groundwater is typically found at depths of more than 80" below the existing grade. Parent material is generally friable, moderately-deep coarse-loamy basal till derived from gneiss over. The permeability of this soil is moderate or moderately rapid throughout.

Paxton Fine Sandy Loam

The Paxton series consists of very deep, gently to strongly sloping, and well drained soils. Seasonal high groundwater is typically found at depths of 18-30" below the existing

grade. Parent material is generally friable coarse-loamy eolian deposits over dense coarse-loamy lodgment till derived from schist. The permeability of this soil is moderate in the subsoil and slow or very slow in the substratum.

Selection of Storm Events

The storm event rainfall frequencies have been selected based upon the Massachusetts Stormwater Guidelines requirements. Storm event rainfall data has been compiled from the Cornell University Publication No. RR-93-5 (September 1993) "Northeast Regional Climate Center Atlas of Precipitation Extremes for the Northeastern United States and Southeastern Canada". Rainfall frequency data has been provided as follows:

Frequency (Years)	Rainfall [24 hour event (inches)]*
2	2.86
10	4.31
100	7.79

*Up-to-date rainfall amounts were taken from the "Extreme Precipitation in New York and New England; An Interactive Web Tool for Extreme Precipitation Analysis" website (http://precip.eas.cornell.edu). (See appendix).

Existing Site Overview

The project area is comprised of mostly agricultural land (hay fields) and bordered by wooded land to the north and south. The area included within the drainage analysis currently slopes southerly towards Estabrook Avenue with an average grade of 6-8%. The stormwater runoff patterns established within the pre-development conditions are based on existing topography which indicates that the runoff flows to three design points which are listed below:

- Design Point #1 **(DP1)** is located at the edge of the Bordering Vegetative Wetland to the southwest of the locus area and west of the existing dwelling.

- Design Point #2 **(DP2)** is located at the edge of the Bordering Vegetative Wetland along and on the northern edge of Estabrook Avenue to the south of the locus area.

- Design Point #3 **(DP3)** is located at the edge of the eastern ridgeline where the topography begins to slope steeply towards a Bordering Vegetative Wetland east of the locus area. (The slope will remain unchanged from pre to post conditions).

The existing site has been broken into three (3) subcatchments as depicted on the Pre-Development Drainage Plan. The following summarizes the various hydraulic conditions and areas comprising the pre-hydrologic model:

- **Subcatchment SC1 –** This is denoted as SC1 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of a barn, a cellular tower and associated buildings, a storage trailer, gravel access paths, previously approved gravel access drive, existing meadow (agricultural use), and wooded land. Stormwater runoff generated in this subcatchment flows southwesterly to a Bordering Vegetative Wetland **(DP1)**.

- **Subcatchment SC2 –** This is denoted as SC2 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use), and wooded land. Stormwater runoff generated in this subcatchment flows southerly to the Bordering Vegetative Wetland **(DP2)**.

- **Subcatchment SC3 –** This is denoted as SC3 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use) and wooded land. Stormwater runoff generated in this subcatchment flows easterly to a ridgeline **(DP3)** directing runoff towards a Bordering Vegetative Wetland east of the locus area.

Proposed Site Overview

The proposed project is comprised of the development of a solar electric generating facility, the construction of a gravel access road, detention ponds, riprap level spreaders, inverter/transformer stations, VFI breaker with relay controller, new utility poles and risers, fencing, gates, and associated seeding and stabilization. The existing runoff patterns will be maintained with limited selective grading. The proposed solar facility will be installed using a screw and post system which minimizes impact on the existing topography and reduces the need for excess earthwork.

A drainage system has been designed and incorporated into the existing topography in order to manage stormwater runoff in an appropriate and responsible manner. More specifically, peak rates and volumes of stormwater runoff in the proposed conditions will not result in an increase in the 2, 10, and 100-year storm events at the selected design points.

The proposed site has been broken into subcatchments as depicted on the Post-Development Drainage Plan. The following summarizes the various hydraulic conditions and areas comprising the post-hydrologic model.

- **Subcatchment SC100 –** This is denoted as SC100 on the accompanying Post-Development Drainage Plan. The subcatchment area consists of a barn, existing meadow (agricultural use), gravel access paths, previously approved gravel access drive, and wooded areas along with a portion of the proposed gravel access path and "Solar Farm Seed Mix" grassed areas. Stormwater runoff generated in this

subcatchment will flow overland to a Bordering Vegetative Wetland depicted as Design Point 1 (**DP1**).

- **Subcatchment SC101 –** This is denoted as SC101 on the accompanying Post-Development Drainage Plan. The subcatchment area consists of a cellular tower and associated buildings, existing meadow (agricultural use), gravel access paths, previously approved gravel access drive, and wooded areas along with a proposed detention pond, a portion of the proposed gravel access drive and "Solar Farm Seed Mix" grassed areas. Stormwater runoff generated in this subcatchment will flow overland to proposed detention pond #1 (**P1**).

- **Subcatchment SC200 –** This is denoted as SC200 on the accompanying Post-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use), overgrown brush/scrub vegetation and wooded areas. Stormwater runoff generated in this subcatchment will flow overland to a Bordering Vegetative Wetland depicted as Design Point 2 (**DP2**).

- **Subcatchment SC201 –** This is denoted as SC201 on the accompanying Post-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use), gravel access path, and wooded areas along with a proposed detention pond, a portion of the proposed gravel access path and "Solar Farm Seed Mix" grassed areas. Stormwater runoff generated in this subcatchment will flow overland to proposed detention pond #2A (**P2A**).

- **Subcatchment SC202 –** This is denoted as SC202 on the accompanying Post-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use) and wooded areas along with a proposed detention pond, a portion of the proposed gravel access drive and "Solar Farm Seed Mix" grassed areas. Stormwater runoff generated in this subcatchment will flow overland to proposed detention pond #2B (**P2B**).

- **Subcatchment SC300 –** This is denoted as SC300 on the accompanying Pre-Development Drainage Plan. The subcatchment area consists of existing meadow (agricultural use) and wooded land. Stormwater runoff generated in this subcatchment flows easterly to a ridgeline (**DP3**) directing runoff towards a Bordering Vegetative Wetland east of the locus area.

Stormwater mitigation is not proposed within subcatchment SC300; therefore the offsite drainage area contributing to SC3 and SC300, based on the Town of Grafton GIS, has not been modeled. The contributing area to the north consists entirely of woods.

Proposed Detention Pond #1 (P1) will have a primary 6" ductile iron outlet pipe with a perforated riser pipe discharging runoff to a riprap level spreader. The pond also contains a riprap outlet weir with a riprap level spreader discharge for runoff in larger storms.

Proposed Detention Pond #2A (P2A) will have a primary 12" ductile iron outlet pipe with a perforated riser pipe discharging runoff to a riprap level spreader. The pond also contains a riprap outlet weir with a riprap level spreader discharge for runoff in larger storms.

Proposed Detention Pond #2A (P2A) will have a primary 12" ductile iron outlet pipe with a perforated riser pipe discharging runoff to a riprap level spreader. The pond also contains a riprap outlet weir with a riprap level spreader discharge for runoff in larger storms.

The following Table demonstrates the peak flows and volumes resulting from the stormwater analysis described in this report.

Summary of Flows at Design Point 1

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	6.55	38,418	4.15	34,496
10-Year (4.31 in./hr.)	17.19	90,811	16.85	80,732
100-Year (7.79 in./hr.)	48.60	247,993	45.96	218,641

Summary of Flows at Design Point 2

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	3.52	20,510	2.01	9,164
10-Year (4.31 in./hr.)	9.26	48,482	7.08	30,831
100-Year (7.79 in./hr.)	26.13	132,397	25.93	109,286

Summary of Flows at Design Point 3

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	0.57	2,677	0.41	1,933
10-Year (4.31 in./hr.)	1.52	6,328	1.08	4,568
100-Year (7.79 in./hr.)	4.29	17,282	3.06	12,475

* CFS – Cubic Feet Per Second
* CF – Cubic Feet

Conclusion

The calculations demonstrate that the proposed development will not result in an increase in the peak rate or volume of stormwater runoff for the 2-year, 10-year, or 100-year 24-hour storm events at the three (3) selected design points.

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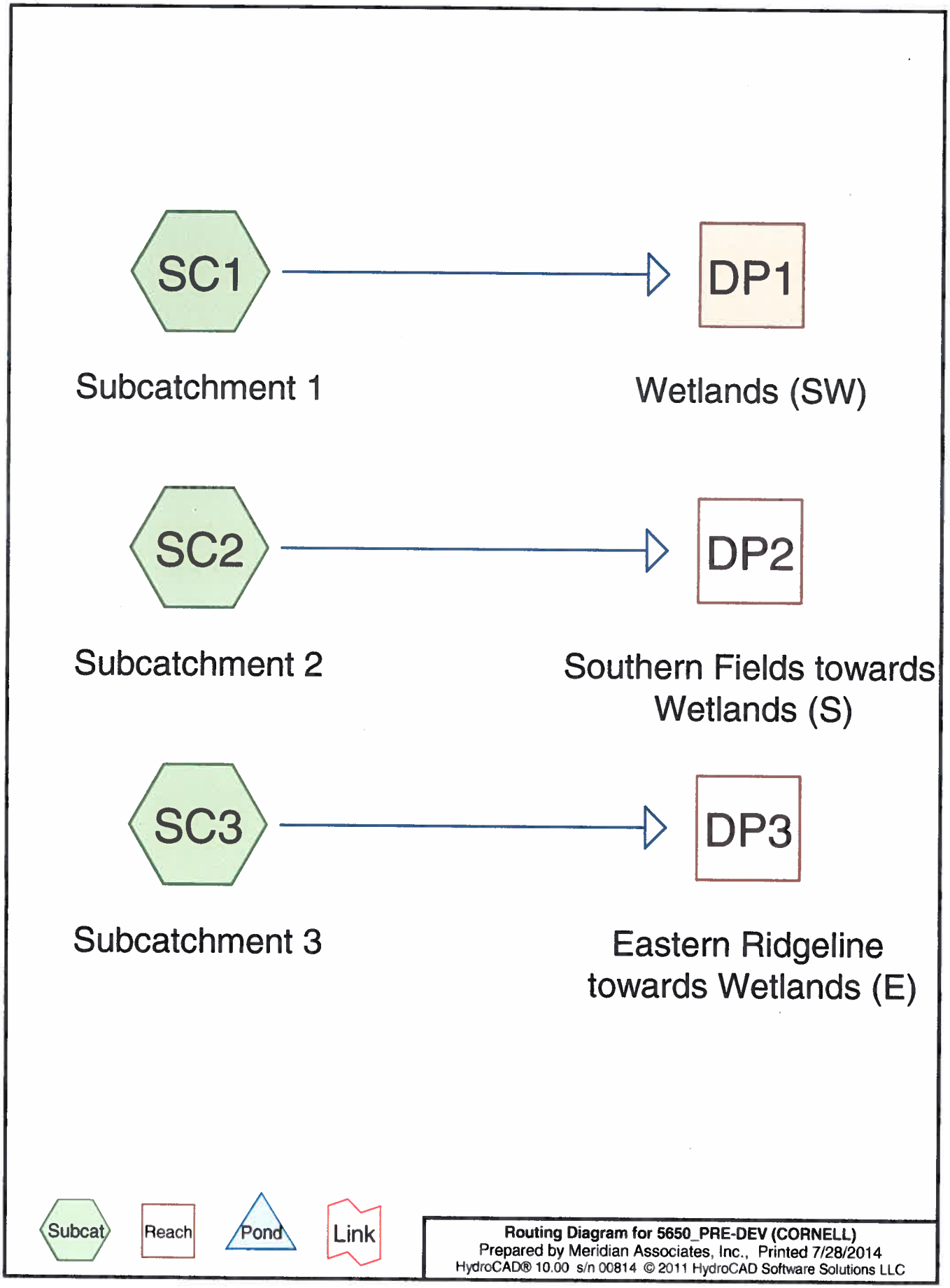
EXISTING CONDITIONS
WATERSHED ROUTING DIAGRAM


SC1
DP1
Subcatchment 1
Wetlands (SW)
SC2
DP2
Subcatchment 2
Southern Fields towards Wetlands (S)
SC3
DP3
Subcatchment 3
Eastern Ridgeline towards Wetlands (E)
Subcat
Reach
Pond
Link
Routing Diagram for 5650_PRE-DEV (CORNELL)
Prepared by Meridian Associates, Inc., Printed 7/28/2014
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EXISTING CONDITIONS
2-YEAR DESIGN

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC1: Subcatchment 1 Runoff Area=676,754 sf 0.40% Impervious Runoff Depth=0.68"
Flow Length=1,330' Tc=25.5 min CN=71 Runoff=6.55 cfs 38,418 cf

Subcatchment SC2: Subcatchment 2 Runoff Area=361,300 sf 0.00% Impervious Runoff Depth=0.68"
Flow Length=1,430' Tc=25.1 min CN=71 Runoff=3.52 cfs 20,510 cf

Subcatchment SC3: Subcatchment 3 Runoff Area=47,160 sf 0.00% Impervious Runoff Depth=0.68"
Flow Length=235' Tc=14.2 min CN=71 Runoff=0.57 cfs 2,677 cf

Reach DP1: Wetlands (SW) Inflow=6.55 cfs 38,418 cf
Outflow=6.55 cfs 38,418 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=3.52 cfs 20,510 cf
Outflow=3.52 cfs 20,510 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=0.57 cfs 2,677 cf
Outflow=0.57 cfs 2,677 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 61,606 cf Average Runoff Depth = 0.68"
99.75% Pervious = 1,082,504 sf 0.25% Impervious = 2,710 sf

Summary for Subcatchment SC1: Subcatchment 1

Runoff = 6.55 cfs @ 12.41 hrs, Volume= 38,418 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
	446,200	71	Meadow, non-grazed, HSG C
	199,850	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
*	9,674	89	Gravel Access, HSG C
*	8,030	89	Previously Approved Gravel Drive, HSG C
*	1,530	85	Gravel Access, HSG B
*	2,710	98	Buildings, HSG C
	676,754	71	Weighted Average
	674,044		99.60% Pervious Area
	2,710		0.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
12.7	1,280	0.0580	1.69		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.5	1,330	Total			

Summary for Subcatchment SC2: Subcatchment 2

Runoff = 3.52 cfs @ 12.41 hrs, Volume= 20,510 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
	297,355	71	Meadow, non-grazed, HSG C
	43,085	70	Woods, Good, HSG C
*	20,860	65	Brush/Scrub Vegetation, Good, HSG C
	361,300	71	Weighted Average
	361,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
11.4	1,200	0.0625	1.75		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.2	180	0.1380	2.60		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.1	1,430	Total			

Summary for Subcatchment SC3: Subcatchment 3

Runoff = 0.57 cfs @ 12.22 hrs, Volume= 2,677 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

Area (sf)	CN	Description
41,837	71	Meadow, non-grazed, HSG C
5,323	70	Woods, Good, HSG C
47,160	71	Weighted Average
47,160		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
1.7	185	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.2	235	Total			

Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 676,754 sf, 0.40% Impervious, Inflow Depth = 0.68" for 2-C event
Inflow = 6.55 cfs @ 12.41 hrs, Volume= 38,418 cf
Outflow = 6.55 cfs @ 12.41 hrs, Volume= 38,418 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 361,300 sf, 0.00% Impervious, Inflow Depth = 0.68" for 2-C event
Inflow = 3.52 cfs @ 12.41 hrs, Volume= 20,510 cf
Outflow = 3.52 cfs @ 12.41 hrs, Volume= 20,510 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	47,160 sf,	0.00% Impervious,	Inflow Depth =	0.68"	for 2-C event
Inflow =	0.57 cfs @	12.22 hrs, Volume=	2,677 cf		
Outflow =	0.57 cfs @	12.22 hrs, Volume=	2,677 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

EXISTING CONDITIONS
10-YEAR DESIGN STORM

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC1: Subcatchment 1 Runoff Area=676,754 sf 0.40% Impervious Runoff Depth=1.61"
Flow Length=1,330' Tc=25.5 min CN=71 Runoff=17.19 cfs 90,811 cf

Subcatchment SC2: Subcatchment 2 Runoff Area=361,300 sf 0.00% Impervious Runoff Depth=1.61"
Flow Length=1,430' Tc=25.1 min CN=71 Runoff=9.26 cfs 48,482 cf

Subcatchment SC3: Subcatchment 3 Runoff Area=47,160 sf 0.00% Impervious Runoff Depth=1.61"
Flow Length=235' Tc=14.2 min CN=71 Runoff=1.52 cfs 6,328 cf

Reach DP1: Wetlands (SW) Inflow=17.19 cfs 90,811 cf
Outflow=17.19 cfs 90,811 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=9.26 cfs 48,482 cf
Outflow=9.26 cfs 48,482 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=1.52 cfs 6,328 cf
Outflow=1.52 cfs 6,328 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 145,621 cf Average Runoff Depth = 1.61"
99.75% Pervious = 1,082,504 sf 0.25% Impervious = 2,710 sf

Summary for Subcatchment SC1: Subcatchment 1

Runoff = 17.19 cfs @ 12.38 hrs, Volume= 90,811 cf, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
	446,200	71	Meadow, non-grazed, HSG C
	199,850	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
*	9,674	89	Gravel Access, HSG C
*	8,030	89	Previously Approved Gravel Drive, HSG C
*	1,530	85	Gravel Access, HSG B
*	2,710	98	Buildings, HSG C
	676,754	71	Weighted Average
	674,044		99.60% Pervious Area
	2,710		0.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
12.7	1,280	0.0580	1.69		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.5	1,330	Total			

Summary for Subcatchment SC2: Subcatchment 2

Runoff = 9.26 cfs @ 12.37 hrs, Volume= 48,482 cf, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
	297,355	71	Meadow, non-grazed, HSG C
	43,085	70	Woods, Good, HSG C
*	20,860	65	Brush/Scrub Vegetation, Good, HSG C
	361,300	71	Weighted Average
	361,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
11.4	1,200	0.0625	1.75		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.2	180	0.1380	2.60		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.1	1,430	Total			

Summary for Subcatchment SC3: Subcatchment 3

Runoff = 1.52 cfs @ 12.21 hrs, Volume= 6,328 cf, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

Area (sf)	CN	Description
41,837	71	Meadow, non-grazed, HSG C
5,323	70	Woods, Good, HSG C
47,160	71	Weighted Average
47,160		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
1.7	185	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.2	235	Total			

Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 676,754 sf, 0.40% Impervious, Inflow Depth = 1.61" for 10-C event
Inflow = 17.19 cfs @ 12.38 hrs, Volume= 90,811 cf
Outflow = 17.19 cfs @ 12.38 hrs, Volume= 90,811 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 361,300 sf, 0.00% Impervious, Inflow Depth = 1.61" for 10-C event
Inflow = 9.26 cfs @ 12.37 hrs, Volume= 48,482 cf
Outflow = 9.26 cfs @ 12.37 hrs, Volume= 48,482 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	47,160 sf,	0.00% Impervious,	Inflow Depth =	1.61"	for 10-C event
Inflow =	1.52 cfs @	12.21 hrs, Volume=	6,328 cf		
Outflow =	1.52 cfs @	12.21 hrs, Volume=	6,328 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

EXISTING CONDITIONS
100-YEAR DESIGN STORM

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC1: Subcatchment 1 Runoff Area=676,754 sf 0.40% Impervious Runoff Depth=4.40"
Flow Length=1,330' Tc=25.5 min CN=71 Runoff=48.60 cfs 247,993 cf

Subcatchment SC2: Subcatchment 2 Runoff Area=361,300 sf 0.00% Impervious Runoff Depth=4.40"
Flow Length=1,430' Tc=25.1 min CN=71 Runoff=26.13 cfs 132,397 cf

Subcatchment SC3: Subcatchment 3 Runoff Area=47,160 sf 0.00% Impervious Runoff Depth=4.40"
Flow Length=235' Tc=14.2 min CN=71 Runoff=4.29 cfs 17,282 cf

Reach DP1: Wetlands (SW) Inflow=48.60 cfs 247,993 cf
Outflow=48.60 cfs 247,993 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=26.13 cfs 132,397 cf
Outflow=26.13 cfs 132,397 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=4.29 cfs 17,282 cf
Outflow=4.29 cfs 17,282 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 397,672 cf Average Runoff Depth = 4.40"
99.75% Pervious = 1,082,504 sf 0.25% Impervious = 2,710 sf

Summary for Subcatchment SC1: Subcatchment 1

Runoff = 48.60 cfs @ 12.36 hrs, Volume= 247,993 cf, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
	446,200	71	Meadow, non-grazed, HSG C
	199,850	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
*	9,674	89	Gravel Access, HSG C
*	8,030	89	Previously Approved Gravel Drive, HSG C
*	1,530	85	Gravel Access, HSG B
*	2,710	98	Buildings, HSG C
	676,754	71	Weighted Average
	674,044		99.60% Pervious Area
	2,710		0.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
12.7	1,280	0.0580	1.69		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.5	1,330	Total			

Summary for Subcatchment SC2: Subcatchment 2

Runoff = 26.13 cfs @ 12.35 hrs, Volume= 132,397 cf, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
	297,355	71	Meadow, non-grazed, HSG C
	43,085	70	Woods, Good, HSG C
*	20,860	65	Brush/Scrub Vegetation, Good, HSG C
	361,300	71	Weighted Average
	361,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
11.4	1,200	0.0625	1.75		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.2	180	0.1380	2.60		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
25.1	1,430	Total			

Summary for Subcatchment SC3: Subcatchment 3

Runoff = 4.29 cfs @ 12.20 hrs, Volume= 17,282 cf, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

Area (sf)	CN	Description
41,837	71	Meadow, non-grazed, HSG C
5,323	70	Woods, Good, HSG C
47,160	71	Weighted Average
47,160		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
1.7	185	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.2	235	Total			

Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 676,754 sf, 0.40% Impervious, Inflow Depth = 4.40" for 100-C event
Inflow = 48.60 cfs @ 12.36 hrs, Volume= 247,993 cf
Outflow = 48.60 cfs @ 12.36 hrs, Volume= 247,993 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 361,300 sf, 0.00% Impervious, Inflow Depth = 4.40" for 100-C event
Inflow = 26.13 cfs @ 12.35 hrs, Volume= 132,397 cf
Outflow = 26.13 cfs @ 12.35 hrs, Volume= 132,397 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

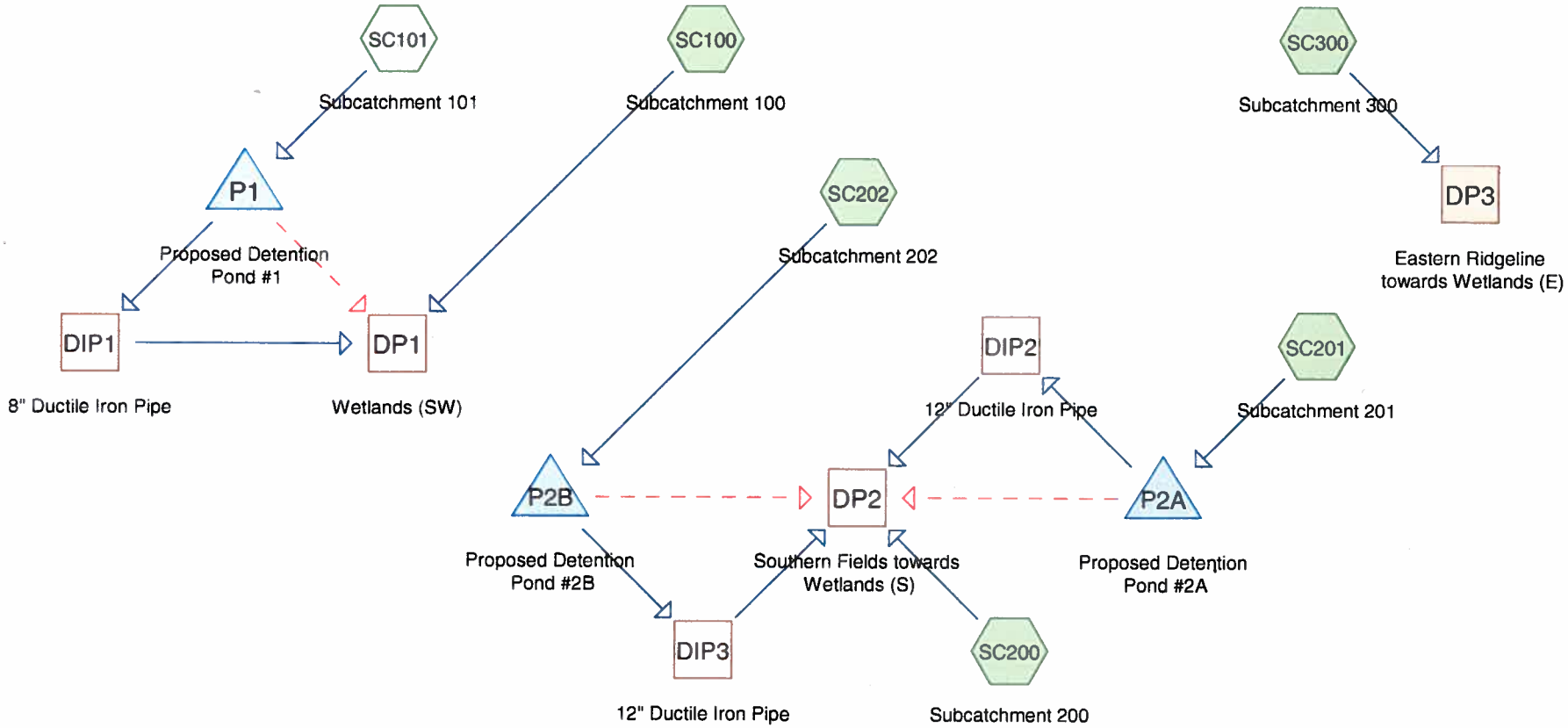
Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	47,160 sf,	0.00% Impervious,	Inflow Depth =	4.40"	for 100-C event
Inflow =	4.29 cfs @	12.20 hrs, Volume=	17,282 cf		
Outflow =	4.29 cfs @	12.20 hrs, Volume=	17,282 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

PROPOSED CONDITIONS
WATERSHED ROUTING DIAGRAM



Routing Diagram for 5650_POST-DEV (CORNELL)
Prepared by Meridian Associates, Inc., Printed 7/28/2014
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PROPOSED CONDITIONS
2-YEAR DESIGN STORM

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC100: Subcatchment 100 Runoff Area=133,362 sf 1.59% Impervious Runoff Depth=0.77"
Flow Length=670' Tc=12.2 min CN=73 Runoff=2.01 cfs 8,586 cf

Subcatchment SC101: Subcatchment 101 Runoff Area=456,407 sf 0.30% Impervious Runoff Depth=0.68"
Flow Length=944' Tc=20.9 min CN=71 Runoff=4.77 cfs 25,909 cf

Subcatchment SC200: Subcatchment 200 Runoff Area=139,369 sf 0.00% Impervious Runoff Depth=0.64"
Flow Length=534' Tc=10.6 min CN=70 Runoff=1.71 cfs 7,409 cf

Subcatchment SC201: Subcatchment 201 Runoff Area=135,460 sf 0.00% Impervious Runoff Depth=0.77"
Flow Length=710' Tc=16.8 min CN=73 Runoff=1.82 cfs 8,721 cf

Subcatchment SC202: Subcatchment 202 Runoff Area=186,572 sf 0.00% Impervious Runoff Depth=0.73"
Flow Length=908' Tc=20.6 min CN=72 Runoff=2.14 cfs 11,289 cf

Subcatchment SC300: Subcatchment 300 Runoff Area=34,044 sf 0.00% Impervious Runoff Depth=0.68"
Flow Length=255' Tc=14.7 min CN=71 Runoff=0.41 cfs 1,933 cf

Reach DIP1: 8" Ductile Iron Pipe Avg. Flow Depth=0.42' Max Vel=7.05 fps Inflow=1.63 cfs 24,575 cf
8.0" Round Pipe n=0.011 L=40.0' S=0.0250 '/' Capacity=2.26 cfs Outflow=1.63 cfs 24,575 cf

Reach DIP2: 12" Ductile Iron Pipe Avg. Flow Depth=0.14' Max Vel=5.19 fps Inflow=0.36 cfs 541 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=0.35 cfs 541 cf

Reach DIP3: 12" Ductile Iron Pipe Avg. Flow Depth=0.20' Max Vel=6.30 fps Inflow=0.68 cfs 1,214 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=0.68 cfs 1,214 cf

Reach DP1: Wetlands (SW) Inflow=4.15 cfs 34,496 cf
Outflow=4.15 cfs 34,496 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=2.01 cfs 9,164 cf
Outflow=2.01 cfs 9,164 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=0.41 cfs 1,933 cf
Outflow=0.41 cfs 1,933 cf

Pond P1: Proposed Detention Pond #1 Peak Elev=486.57' Storage=5,622 cf Inflow=4.77 cfs 25,909 cf
Primary=1.63 cfs 24,575 cf Secondary=1.81 cfs 1,335 cf Outflow=3.44 cfs 25,909 cf

Pond P2A: Proposed Detention Pond #2A Peak Elev=487.26' Storage=542 cf Inflow=1.82 cfs 8,721 cf
Discarded=1.02 cfs 8,180 cf Primary=0.36 cfs 541 cf Secondary=0.00 cfs 0 cf Outflow=1.38 cfs 8,721 cf

Pond P2B: Proposed Detention Pond #2B Peak Elev=487.38' Storage=723 cf Inflow=2.14 cfs 11,289 cf
Discarded=1.02 cfs 10,075 cf Primary=0.68 cfs 1,214 cf Secondary=0.00 cfs 0 cf Outflow=1.70 cfs 11,289 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 63,847 cf Average Runoff Depth = 0.71"
99.68% Pervious = 1,081,704 sf 0.32% Impervious = 3,510 sf

Summary for Subcatchment SC100: Subcatchment 100

Runoff = 2.01 cfs @ 12.19 hrs, Volume= 8,586 cf, Depth= 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
*	1,618	89	Proposed Gravel Drive, HSG C
	94,515	71	Meadow, non-grazed, HSG C
	22,104	70	Woods, Good, HSG C
*	6,519	89	Gravel Access, HSG C
	6,480	89	Previously Approved Gravel Drive, HSG C
*	2,126	98	Buildings, HSG C
	133,362	73	Weighted Average
	131,236		98.41% Pervious Area
	2,126		1.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.0800	0.11		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
4.9	620	0.0900	2.10		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
12.2	670	Total			

Summary for Subcatchment SC101: Subcatchment 101

Runoff = 4.77 cfs @ 12.34 hrs, Volume= 25,909 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
*	800	98	Proposed Concrete Pads, HSG C
*	20,351	89	Proposed Gravel Drive, HSG C
	249,913	71	Meadow, non-grazed, HSG C
	169,973	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
	1,550	89	Previously Approved Gravel Drive, HSG C
*	2,946	89	Gravel Access, HSG C
*	1,530	85	Gravel Access, HSG B
*	584	98	Buildings, HSG C
	456,407	71	Weighted Average
	455,023		99.70% Pervious Area
	1,384		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
2.4	230	0.0500	1.57		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
6.0	664	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.9	944	Total			

Summary for Subcatchment SC200: Subcatchment 200

Runoff = 1.71 cfs @ 12.17 hrs, Volume= 7,409 cf, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
	109,090	71	Meadow, non-grazed, HSG C
	6,006	70	Woods, Good, HSG C
*	24,273	65	Brush/Scrub Vegetation, Good, HSG C
	139,369	70	Weighted Average
	139,369		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	50	0.1000	0.12		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
2.6	356	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.3	128	0.1100	1.66		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
10.6	534	Total			

Summary for Subcatchment SC201: Subcatchment 201

Runoff = 1.82 cfs @ 12.26 hrs, Volume= 8,721 cf, Depth= 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
*	12,931	89	Proposed Gravel Drive, HSG C
	117,740	71	Meadow, non-grazed, HSG C
	4,648	70	Woods, Good, HSG C
*	141	89	Gravel Access, HSG C
	135,460	73	Weighted Average
	135,460		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0300	0.08		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
5.9	660	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
16.8	710	Total			

Summary for Subcatchment SC202: Subcatchment 202

Runoff = 2.14 cfs @ 12.33 hrs, Volume= 11,289 cf, Depth= 0.73"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

	Area (sf)	CN	Description
*	7,024	89	Proposed Gravel Drive, HSG C
	4,395	70	Woods, Good, HSG C
	175,153	71	Meadow, non-grazed, HSG C
	186,572	72	Weighted Average
	186,572		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
8.1	858	0.0640	1.77		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.6	908	Total			

Summary for Subcatchment SC300: Subcatchment 300

Runoff = 0.41 cfs @ 12.24 hrs, Volume= 1,933 cf, Depth= 0.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-C Rainfall=2.86"

Area (sf)	CN	Description
32,784	71	Meadow, non-grazed, HSG C
1,260	70	Woods, Good, HSG C
34,044	71	Weighted Average
34,044		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
1.9	205	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.7	255	Total			

Summary for Reach DIP1: 8" Ductile Iron Pipe

[52] Hint: Inlet/Outlet conditions not evaluated
[88] Warning: Qout>Qin may require Finer Routing>1

Inflow Area = 456,407 sf, 0.30% Impervious, Inflow Depth = 0.65" for 2-C event
Inflow = 1.63 cfs @ 12.62 hrs, Volume= 24,575 cf
Outflow = 1.63 cfs @ 12.65 hrs, Volume= 24,575 cf, Atten= 0%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.05 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.01 fps, Avg. Travel Time= 0.2 min

Peak Storage= 9 cf @ 12.65 hrs
Average Depth at Peak Storage= 0.42'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 2.26 cfs

8.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0250 '/'
Inlet Invert= 483.00', Outlet Invert= 482.00'

Summary for Reach DIP2: 12" Ductile Iron Pipe

[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 135,460 sf, 0.00% Impervious, Inflow Depth = 0.05" for 2-C event
Inflow = 0.36 cfs @ 12.46 hrs, Volume= 541 cf
Outflow = 0.35 cfs @ 12.46 hrs, Volume= 541 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.19 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.12 fps, Avg. Travel Time= 0.6 min

Peak Storage= 3 cf @ 12.46 hrs
Average Depth at Peak Storage= 0.14'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'

Summary for Reach DIP3: 12" Ductile Iron Pipe

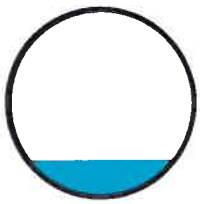
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 186,572 sf, 0.00% Impervious, Inflow Depth = 0.08" for 2-C event
Inflow = 0.68 cfs @ 12.52 hrs, Volume= 1,214 cf
Outflow = 0.68 cfs @ 12.52 hrs, Volume= 1,214 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.30 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.23 fps, Avg. Travel Time= 0.5 min

Peak Storage= 4 cf @ 12.52 hrs
Average Depth at Peak Storage= 0.20'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'



Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 589,769 sf, 0.60% Impervious, Inflow Depth = 0.70" for 2-C event
Inflow = 4.15 cfs @ 12.61 hrs, Volume= 34,496 cf
Outflow = 4.15 cfs @ 12.61 hrs, Volume= 34,496 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 461,401 sf, 0.00% Impervious, Inflow Depth = 0.24" for 2-C event
Inflow = 2.01 cfs @ 12.41 hrs, Volume= 9,164 cf
Outflow = 2.01 cfs @ 12.41 hrs, Volume= 9,164 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 34,044 sf, 0.00% Impervious, Inflow Depth = 0.68" for 2-C event
Inflow = 0.41 cfs @ 12.24 hrs, Volume= 1,933 cf
Outflow = 0.41 cfs @ 12.24 hrs, Volume= 1,933 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Proposed Detention Pond #1

Inflow Area = 456,407 sf, 0.30% Impervious, Inflow Depth = 0.68" for 2-C event
Inflow = 4.77 cfs @ 12.34 hrs, Volume= 25,909 cf
Outflow = 3.44 cfs @ 12.62 hrs, Volume= 25,909 cf, Atten= 28%, Lag= 16.7 min
Primary = 1.63 cfs @ 12.62 hrs, Volume= 24,575 cf
Secondary = 1.81 cfs @ 12.62 hrs, Volume= 1,335 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 486.57' @ 12.62 hrs Surf.Area= 3,837 sf Storage= 5,622 cf

Plug-Flow detention time= 52.5 min calculated for 25,909 cf (100% of inflow)
Center-of-Mass det. time= 51.7 min (946.2 - 894.6)

Volume	Invert	Avail.Storage	Storage Description
#1	484.00'	12,673 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
484.00	818	133.0	0	0	818
486.00	3,081	244.0	3,658	3,658	4,169
488.00	6,105	353.0	9,015	12,673	9,382

Device	Routing	Invert	Outlet Devices
#1	Primary	484.00'	**4.0" Vert. 4" Orifice in Riser** C= 0.600
#2	Primary	485.50'	**6.0" Horiz. 6" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#3	Secondary	486.50'	**40.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=1.63 cfs @ 12.62 hrs HW=486.56' (Free Discharge)
└**1=4" Orifice in Riser** (Orifice Controls 0.65 cfs @ 7.46 fps)
└**2=6" Perforated Riser Pipe** (Orifice Controls 0.98 cfs @ 4.97 fps)

Secondary OutFlow Max=1.65 cfs @ 12.62 hrs HW=486.57' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Weir Controls 1.65 cfs @ 0.64 fps)

Summary for Pond P2A: Proposed Detention Pond #2A

Inflow Area = 135,460 sf, 0.00% Impervious, Inflow Depth = 0.77" for 2-C event
Inflow = 1.82 cfs @ 12.26 hrs, Volume= 8,721 cf
Outflow = 1.38 cfs @ 12.46 hrs, Volume= 8,721 cf, Atten= 25%, Lag= 11.7 min
Discarded = 1.02 cfs @ 12.15 hrs, Volume= 8,180 cf
Primary = 0.36 cfs @ 12.46 hrs, Volume= 541 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 487.26' @ 12.46 hrs Surf.Area= 2,427 sf Storage= 542 cf

Plug-Flow detention time= 2.3 min calculated for 8,715 cf (100% of inflow)
Center-of-Mass det. time= 2.3 min (885.5 - 883.2)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,601 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,780	165.0	0	0	1,780
488.00	4,838	300.0	3,184	3,184	6,781
489.00	7,866	405.0	6,291	9,475	12,682
490.00	10,446	476.0	9,126	18,601	17,679

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=1.02 cfs @ 12.15 hrs HW=487.05' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=0.35 cfs @ 12.46 hrs HW=487.26' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 0.35 cfs @ 1.73 fps)
└**3=12" Perforated Riser Pipe** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=487.00' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond P2B: Proposed Detention Pond #2B

Inflow Area =	186,572 sf,	0.00% Impervious,	Inflow Depth =	0.73"	for 2-C event
Inflow =	2.14 cfs @	12.33 hrs, Volume=	11,289 cf		
Outflow =	1.70 cfs @	12.52 hrs, Volume=	11,289 cf,	Atten= 20%,	Lag= 11.6 min
Discarded =	1.02 cfs @	12.15 hrs, Volume=	10,075 cf		
Primary =	0.68 cfs @	12.52 hrs, Volume=	1,214 cf		
Secondary =	0.00 cfs @	0.00 hrs, Volume=	0 cf		

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 487.38' @ 12.52 hrs Surf.Area= 2,390 sf Storage= 723 cf

Plug-Flow detention time= 2.5 min calculated for 11,281 cf (100% of inflow)
Center-of-Mass det. time= 2.5 min (892.9 - 890.4)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,869 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,413	162.0	0	0	1,413
488.00	4,486	319.0	2,806	2,806	7,427
489.00	8,214	461.0	6,257	9,062	16,250
490.00	11,491	582.0	9,807	18,869	26,306

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=1.02 cfs @ 12.15 hrs HW=487.04' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=0.68 cfs @ 12.52 hrs HW=487.38' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 0.68 cfs @ 2.11 fps)
└**3=12" Perforated Riser Pipe** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=487.00' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

PROPOSED CONDITIONS
10-YEAR DESIGN STORM

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC100: Subcatchment 100 Runoff Area=133,362 sf 1.59% Impervious Runoff Depth=1.75"
Flow Length=670' Tc=12.2 min CN=73 Runoff=4.96 cfs 19,489 cf

Subcatchment SC101: Subcatchment 101 Runoff Area=456,407 sf 0.30% Impervious Runoff Depth=1.61"
Flow Length=944' Tc=20.9 min CN=71 Runoff=12.62 cfs 61,244 cf

Subcatchment SC200: Subcatchment 200 Runoff Area=139,369 sf 0.00% Impervious Runoff Depth=1.54"
Flow Length=534' Tc=10.6 min CN=70 Runoff=4.72 cfs 17,893 cf

Subcatchment SC201: Subcatchment 201 Runoff Area=135,460 sf 0.00% Impervious Runoff Depth=1.75"
Flow Length=710' Tc=16.8 min CN=73 Runoff=4.50 cfs 19,795 cf

Subcatchment SC202: Subcatchment 202 Runoff Area=186,572 sf 0.00% Impervious Runoff Depth=1.68"
Flow Length=908' Tc=20.6 min CN=72 Runoff=5.45 cfs 26,139 cf

Subcatchment SC300: Subcatchment 300 Runoff Area=34,044 sf 0.00% Impervious Runoff Depth=1.61"
Flow Length=255' Tc=14.7 min CN=71 Runoff=1.08 cfs 4,568 cf

Reach DIP1: 8" Ductile Iron Pipe Avg. Flow Depth=0.44' Max Vel=7.12 fps Inflow=1.72 cfs 40,631 cf
8.0" Round Pipe n=0.011 L=40.0' S=0.0250 '/' Capacity=2.26 cfs Outflow=1.72 cfs 40,631 cf

Reach DIP2: 12" Ductile Iron Pipe Avg. Flow Depth=0.32' Max Vel=8.32 fps Inflow=1.79 cfs 4,890 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=1.79 cfs 4,890 cf

Reach DIP3: 12" Ductile Iron Pipe Avg. Flow Depth=0.43' Max Vel=9.70 fps Inflow=3.13 cfs 8,049 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=3.13 cfs 8,049 cf

Reach DP1: Wetlands (SW) Inflow=16.85 cfs 80,732 cf
Outflow=16.85 cfs 80,732 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=7.08 cfs 30,831 cf
Outflow=7.08 cfs 30,831 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=1.08 cfs 4,568 cf
Outflow=1.08 cfs 4,568 cf

Pond P1: Proposed Detention Pond #1 Peak Elev=486.73' Storage=6,246 cf Inflow=12.62 cfs 61,244 cf
Primary=1.72 cfs 40,631 cf Secondary=10.83 cfs 20,613 cf Outflow=12.55 cfs 61,244 cf

Pond P2A: Proposed Detention Pond #2A Peak Elev=487.89' Storage=2,672 cf Inflow=4.50 cfs 19,795 cf
Discarded=1.02 cfs 14,906 cf Primary=1.79 cfs 4,890 cf Secondary=0.00 cfs 0 cf Outflow=2.81 cfs 19,795 cf

Pond P2B: Proposed Detention Pond #2B Peak Elev=488.07' Storage=3,114 cf Inflow=5.45 cfs 26,139 cf
Discarded=1.02 cfs 18,091 cf Primary=3.13 cfs 8,049 cf Secondary=0.00 cfs 0 cf Outflow=4.15 cfs 26,139 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 149,128 cf Average Runoff Depth = 1.65"
99.68% Pervious = 1,081,704 sf 0.32% Impervious = 3,510 sf

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Summary for Subcatchment SC100: Subcatchment 100

Runoff = 4.96 cfs @ 12.18 hrs, Volume= 19,489 cf, Depth= 1.75"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
*	1,618	89	Proposed Gravel Drive, HSG C
	94,515	71	Meadow, non-grazed, HSG C
	22,104	70	Woods, Good, HSG C
*	6,519	89	Gravel Access, HSG C
	6,480	89	Previously Approved Gravel Drive, HSG C
*	2,126	98	Buildings, HSG C
	133,362	73	Weighted Average
	131,236		98.41% Pervious Area
	2,126		1.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.0800	0.11		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
4.9	620	0.0900	2.10		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
12.2	670	Total			

Summary for Subcatchment SC101: Subcatchment 101

Runoff = 12.62 cfs @ 12.31 hrs, Volume= 61,244 cf, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
*	800	98	Proposed Concrete Pads, HSG C
*	20,351	89	Proposed Gravel Drive, HSG C
	249,913	71	Meadow, non-grazed, HSG C
	169,973	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
	1,550	89	Previously Approved Gravel Drive, HSG C
*	2,946	89	Gravel Access, HSG C
*	1,530	85	Gravel Access, HSG B
*	584	98	Buildings, HSG C
	456,407	71	Weighted Average
	455,023		99.70% Pervious Area
	1,384		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
2.4	230	0.0500	1.57		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
6.0	664	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.9	944	Total			

Summary for Subcatchment SC200: Subcatchment 200

Runoff = 4.72 cfs @ 12.16 hrs, Volume= 17,893 cf, Depth= 1.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
	109,090	71	Meadow, non-grazed, HSG C
	6,006	70	Woods, Good, HSG C
*	24,273	65	Brush/Scrub Vegetation, Good, HSG C
	139,369	70	Weighted Average
	139,369		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	50	0.1000	0.12		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
2.6	356	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.3	128	0.1100	1.66		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
10.6	534	Total			

Summary for Subcatchment SC201: Subcatchment 201

Runoff = 4.50 cfs @ 12.24 hrs, Volume= 19,795 cf, Depth= 1.75"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
*	12,931	89	Proposed Gravel Drive, HSG C
	117,740	71	Meadow, non-grazed, HSG C
	4,648	70	Woods, Good, HSG C
*	141	89	Gravel Access, HSG C
	135,460	73	Weighted Average
	135,460		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0300	0.08		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
5.9	660	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
16.8	710	Total			

Summary for Subcatchment SC202: Subcatchment 202

Runoff = 5.45 cfs @ 12.30 hrs, Volume= 26,139 cf, Depth= 1.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

	Area (sf)	CN	Description
*	7,024	89	Proposed Gravel Drive, HSG C
	4,395	70	Woods, Good, HSG C
	175,153	71	Meadow, non-grazed, HSG C
	186,572	72	Weighted Average
	186,572		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
8.1	858	0.0640	1.77		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.6	908	Total			

Summary for Subcatchment SC300: Subcatchment 300

Runoff = 1.08 cfs @ 12.22 hrs, Volume= 4,568 cf, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-C Rainfall=4.31"

Area (sf)	CN	Description
32,784	71	Meadow, non-grazed, HSG C
1,260	70	Woods, Good, HSG C
34,044	71	Weighted Average
34,044		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
1.9	205	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.7	255	Total			

Summary for Reach DIP1: 8" Ductile Iron Pipe

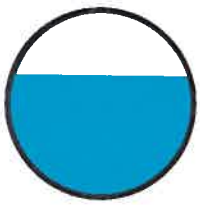
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 456,407 sf, 0.30% Impervious, Inflow Depth = 1.07" for 10-C event
Inflow = 1.72 cfs @ 12.33 hrs, Volume= 40,631 cf
Outflow = 1.72 cfs @ 12.31 hrs, Volume= 40,631 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.12 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.45 fps, Avg. Travel Time= 0.2 min

Peak Storage= 10 cf @ 12.31 hrs
Average Depth at Peak Storage= 0.44'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 2.26 cfs

8.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0250 '/'
Inlet Invert= 483.00', Outlet Invert= 482.00'



Summary for Reach DIP2: 12" Ductile Iron Pipe

[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 135,460 sf, 0.00% Impervious, Inflow Depth = 0.43" for 10-C event
Inflow = 1.79 cfs @ 12.50 hrs, Volume= 4,890 cf
Outflow = 1.79 cfs @ 12.50 hrs, Volume= 4,890 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.32 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.54 fps, Avg. Travel Time= 0.4 min

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Peak Storage= 9 cf @ 12.50 hrs
Average Depth at Peak Storage= 0.32'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'

Summary for Reach DIP3: 12" Ductile Iron Pipe

[52] Hint: Inlet/Outlet conditions not evaluated
[88] Warning: Qout>Qin may require Finer Routing>1

Inflow Area =	186,572 sf,	0.00% Impervious,	Inflow Depth =	0.52"	for 10-C event
Inflow =	3.13 cfs @	12.50 hrs, Volume=	8,049 cf		
Outflow =	3.13 cfs @	12.50 hrs, Volume=	8,049 cf,	Atten= 0%,	Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.70 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.73 fps, Avg. Travel Time= 0.4 min

Peak Storage= 13 cf @ 12.50 hrs
Average Depth at Peak Storage= 0.43'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'

Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	589,769 sf,	0.60% Impervious,	Inflow Depth =	1.64"	for 10-C event
Inflow =	16.85 cfs @	12.27 hrs, Volume=	80,732 cf		
Outflow =	16.85 cfs @	12.27 hrs, Volume=	80,732 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	461,401 sf,	0.00% Impervious,	Inflow Depth =	0.80"	for 10-C event
Inflow =	7.08 cfs @	12.44 hrs, Volume=	30,831 cf		
Outflow =	7.08 cfs @	12.44 hrs, Volume=	30,831 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	34,044 sf,	0.00% Impervious,	Inflow Depth =	1.61"	for 10-C event
Inflow =	1.08 cfs @	12.22 hrs, Volume=	4,568 cf		
Outflow =	1.08 cfs @	12.22 hrs, Volume=	4,568 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Proposed Detention Pond #1

Inflow Area =	456,407 sf,	0.30% Impervious,	Inflow Depth =	1.61"	for 10-C event
Inflow =	12.62 cfs @	12.31 hrs, Volume=	61,244 cf		
Outflow =	12.55 cfs @	12.33 hrs, Volume=	61,244 cf,	Atten= 1%,	Lag= 1.3 min
Primary =	1.72 cfs @	12.33 hrs, Volume=	40,631 cf		
Secondary =	10.83 cfs @	12.33 hrs, Volume=	20,613 cf		

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 486.73' @ 12.33 hrs Surf.Area= 4,062 sf Storage= 6,246 cf

Plug-Flow detention time= 38.5 min calculated for 61,201 cf (100% of inflow)
Center-of-Mass det. time= 38.6 min (905.7 - 867.1)

Volume	Invert	Avail.Storage	Storage Description
#1	484.00'	12,673 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

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Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
484.00	818	133.0	0	0	818
486.00	3,081	244.0	3,658	3,658	4,169
488.00	6,105	353.0	9,015	12,673	9,382

Device	Routing	Invert	Outlet Devices
#1	Primary	484.00'	**4.0" Vert. 4" Orifice in Riser** C= 0.600
#2	Primary	485.50'	**6.0" Horiz. 6" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#3	Secondary	486.50'	**40.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=1.72 cfs @ 12.33 hrs HW=486.73' (Free Discharge)
↑**1=4" Orifice in Riser** (Orifice Controls 0.67 cfs @ 7.70 fps)
└**2=6" Perforated Riser Pipe** (Orifice Controls 1.05 cfs @ 5.33 fps)

Secondary OutFlow Max=10.73 cfs @ 12.33 hrs HW=486.73' (Free Discharge)
↑**3=Broad-Crested Rectangular Weir** (Weir Controls 10.73 cfs @ 1.19 fps)

Summary for Pond P2A: Proposed Detention Pond #2A

Inflow Area =	135,460 sf,	0.00% Impervious,	Inflow Depth = 1.75"	for 10-C event
Inflow =	4.50 cfs @	12.24 hrs, Volume=	19,795 cf	
Outflow =	2.81 cfs @	12.50 hrs, Volume=	19,795 cf,	Atten= 38%, Lag= 15.3 min
Discarded =	1.02 cfs @	11.95 hrs, Volume=	14,906 cf	
Primary =	1.79 cfs @	12.50 hrs, Volume=	4,890 cf	
Secondary =	0.00 cfs @	0.00 hrs, Volume=	0 cf	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 487.89' @ 12.50 hrs Surf.Area= 4,426 sf Storage= 2,672 cf

Plug-Flow detention time= 6.6 min calculated for 19,782 cf (100% of inflow)
Center-of-Mass det. time= 6.6 min (864.3 - 857.7)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,601 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,780	165.0	0	0	1,780
488.00	4,838	300.0	3,184	3,184	6,781
489.00	7,866	405.0	6,291	9,475	12,682
490.00	10,446	476.0	9,126	18,601	17,679

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=1.02 cfs @ 11.95 hrs HW=487.04' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=1.79 cfs @ 12.50 hrs HW=487.89' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 1.51 cfs @ 3.85 fps)
└**3=12" Perforated Riser Pipe** (Weir Controls 0.27 cfs @ 0.98 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=487.00' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond P2B: Proposed Detention Pond #2B

Inflow Area =	186,572 sf,	0.00% Impervious,	Inflow Depth =	1.68"	for 10-C event
Inflow =	5.45 cfs @	12.30 hrs, Volume=	26,139 cf		
Outflow =	4.15 cfs @	12.50 hrs, Volume=	26,139 cf,	Atten= 24%,	Lag= 11.8 min
Discarded =	1.02 cfs @	11.95 hrs, Volume=	18,091 cf		
Primary =	3.13 cfs @	12.50 hrs, Volume=	8,049 cf		
Secondary =	0.00 cfs @	0.00 hrs, Volume=	0 cf		

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 488.07' @ 12.50 hrs Surf.Area= 4,702 sf Storage= 3,114 cf

Plug-Flow detention time= 6.2 min calculated for 26,121 cf (100% of inflow)
Center-of-Mass det. time= 6.2 min (870.2 - 864.0)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,869 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,413	162.0	0	0	1,413
488.00	4,486	319.0	2,806	2,806	7,427
489.00	8,214	461.0	6,257	9,062	16,250
490.00	11,491	582.0	9,807	18,869	26,306

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=1.02 cfs @ 11.95 hrs HW=487.05' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=3.13 cfs @ 12.50 hrs HW=488.07' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 1.71 cfs @ 4.35 fps)
└**3=12" Perforated Riser Pipe** (Weir Controls 1.42 cfs @ 1.69 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=487.00' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

PROPOSED CONDITIONS
100-YEAR DESIGN STORM

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC100: Subcatchment 100 Runoff Area=133,362 sf 1.59% Impervious Runoff Depth=4.62"
Flow Length=670' Tc=12.2 min CN=73 Runoff=13.47 cfs 51,392 cf

Subcatchment SC101: Subcatchment 101 Runoff Area=456,407 sf 0.30% Impervious Runoff Depth=4.40"
Flow Length=944' Tc=20.9 min CN=71 Runoff=35.65 cfs 167,248 cf

Subcatchment SC200: Subcatchment 200 Runoff Area=139,369 sf 0.00% Impervious Runoff Depth=4.28"
Flow Length=534' Tc=10.6 min CN=70 Runoff=13.66 cfs 49,759 cf

Subcatchment SC201: Subcatchment 201 Runoff Area=135,460 sf 0.00% Impervious Runoff Depth=4.62"
Flow Length=710' Tc=16.8 min CN=73 Runoff=12.13 cfs 52,201 cf

Subcatchment SC202: Subcatchment 202 Runoff Area=186,572 sf 0.00% Impervious Runoff Depth=4.51"
Flow Length=908' Tc=20.6 min CN=72 Runoff=15.03 cfs 70,130 cf

Subcatchment SC300: Subcatchment 300 Runoff Area=34,044 sf 0.00% Impervious Runoff Depth=4.40"
Flow Length=255' Tc=14.7 min CN=71 Runoff=3.06 cfs 12,475 cf

Reach DIP1: 8" Ductile Iron Pipe Avg. Flow Depth=0.46' Max Vel=7.22 fps Inflow=1.85 cfs 68,708 cf
8.0" Round Pipe n=0.011 L=40.0' S=0.0250 '/' Capacity=2.26 cfs Outflow=1.85 cfs 68,708 cf

Reach DIP2: 12" Ductile Iron Pipe Avg. Flow Depth=0.65' Max Vel=11.42 fps Inflow=6.18 cfs 22,967 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=6.18 cfs 22,967 cf

Reach DIP3: 12" Ductile Iron Pipe Avg. Flow Depth=0.68' Max Vel=11.55 fps Inflow=6.58 cfs 30,684 cf
12.0" Round Pipe n=0.011 L=40.0' S=0.0375 '/' Capacity=8.15 cfs Outflow=6.58 cfs 30,684 cf

Reach DP1: Wetlands (SW) Inflow=45.96 cfs 218,641 cf
Outflow=45.96 cfs 218,641 cf

Reach DP2: Southern Fields towards Wetlands (S) Inflow=25.93 cfs 109,286 cf
Outflow=25.93 cfs 109,286 cf

Reach DP3: Eastern Ridgeline towards Wetlands (E) Inflow=3.06 cfs 12,475 cf
Outflow=3.06 cfs 12,475 cf

Pond P1: Proposed Detention Pond #1 Peak Elev=486.97' Storage=7,281 cf Inflow=35.65 cfs 167,248 cf
Primary=1.85 cfs 68,708 cf Secondary=33.79 cfs 98,541 cf Outflow=35.64 cfs 167,248 cf

Pond P2A: Proposed Detention Pond #2A Peak Elev=488.82' Storage=8,101 cf Inflow=12.13 cfs 52,201 cf
Discarded=1.02 cfs 28,733 cf Primary=6.18 cfs 22,967 cf Secondary=0.97 cfs 501 cf Outflow=8.18 cfs 52,201 cf

Pond P2B: Proposed Detention Pond #2B Peak Elev=488.97' Storage=8,834 cf Inflow=15.03 cfs 70,130 cf
Discarded=1.02 cfs 34,072 cf Primary=6.58 cfs 30,684 cf Secondary=5.62 cfs 5,375 cf Outflow=13.22 cfs 70,130 cf

Total Runoff Area = 1,085,214 sf Runoff Volume = 403,206 cf Average Runoff Depth = 4.46"
99.68% Pervious = 1,081,704 sf 0.32% Impervious = 3,510 sf

5650_POST-DEV (CORNELL)
Prepared by Meridian Associates, Inc.

Summary for Subcatchment SC100: Subcatchment 100

Runoff = 13.47 cfs @ 12.17 hrs, Volume= 51,392 cf, Depth= 4.62"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
*	1,618	89	Proposed Gravel Drive, HSG C
	94,515	71	Meadow, non-grazed, HSG C
	22,104	70	Woods, Good, HSG C
*	6,519	89	Gravel Access, HSG C
	6,480	89	Previously Approved Gravel Drive, HSG C
*	2,126	98	Buildings, HSG C
	133,362	73	Weighted Average
	131,236		98.41% Pervious Area
	2,126		1.59% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.0800	0.11		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
4.9	620	0.0900	2.10		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
12.2	670	Total			

Summary for Subcatchment SC101: Subcatchment 101

Runoff = 35.65 cfs @ 12.29 hrs, Volume= 167,248 cf, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
*	800	98	Proposed Concrete Pads, HSG C
*	20,351	89	Proposed Gravel Drive, HSG C
	249,913	71	Meadow, non-grazed, HSG C
	169,973	70	Woods, Good, HSG C
	8,760	55	Woods, Good, HSG B
	1,550	89	Previously Approved Gravel Drive, HSG C
*	2,946	89	Gravel Access, HSG C
*	1,530	85	Gravel Access, HSG B
*	584	98	Buildings, HSG C
	456,407	71	Weighted Average
	455,023		99.70% Pervious Area
	1,384		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
2.4	230	0.0500	1.57		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
6.0	664	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.9	944	Total			

Summary for Subcatchment SC200: Subcatchment 200

Runoff = 13.66 cfs @ 12.15 hrs, Volume= 49,759 cf, Depth= 4.28"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
	109,090	71	Meadow, non-grazed, HSG C
	6,006	70	Woods, Good, HSG C
*	24,273	65	Brush/Scrub Vegetation, Good, HSG C
	139,369	70	Weighted Average
	139,369		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	50	0.1000	0.12		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
2.6	356	0.1100	2.32		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
1.3	128	0.1100	1.66		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
10.6	534	Total			

Summary for Subcatchment SC201: Subcatchment 201

Runoff = 12.13 cfs @ 12.23 hrs, Volume= 52,201 cf, Depth= 4.62"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
*	12,931	89	Proposed Gravel Drive, HSG C
	117,740	71	Meadow, non-grazed, HSG C
	4,648	70	Woods, Good, HSG C
*	141	89	Gravel Access, HSG C
	135,460	73	Weighted Average
	135,460		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0300	0.08		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
5.9	660	0.0700	1.85		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
16.8	710	Total			

Summary for Subcatchment SC202: Subcatchment 202

Runoff = 15.03 cfs @ 12.29 hrs, Volume= 70,130 cf, Depth= 4.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

	Area (sf)	CN	Description
*	7,024	89	Proposed Gravel Drive, HSG C
	4,395	70	Woods, Good, HSG C
	175,153	71	Meadow, non-grazed, HSG C
	186,572	72	Weighted Average
	186,572		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
8.1	858	0.0640	1.77		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
20.6	908	Total			

Summary for Subcatchment SC300: Subcatchment 300

Runoff = 3.06 cfs @ 12.21 hrs, Volume= 12,475 cf, Depth= 4.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-C Rainfall=7.79"

Area (sf)	CN	Description
32,784	71	Meadow, non-grazed, HSG C
1,260	70	Woods, Good, HSG C
34,044	71	Weighted Average
34,044		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.8	50	0.0200	0.07		**Sheet Flow, Sheet Flow** Grass: Bermuda n= 0.410 P2= 3.10"
1.9	205	0.0650	1.78		**Shallow Concentrated Flow, Shallow Concentrated Flow** Short Grass Pasture Kv= 7.0 fps
14.7	255	Total			

Summary for Reach DIP1: 8" Ductile Iron Pipe

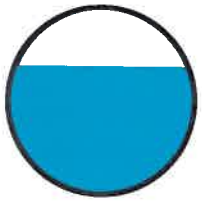
[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 456,407 sf, 0.30% Impervious, Inflow Depth = 1.81" for 100-C event
Inflow = 1.85 cfs @ 12.30 hrs, Volume= 68,708 cf
Outflow = 1.85 cfs @ 12.31 hrs, Volume= 68,708 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 7.22 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.99 fps, Avg. Travel Time= 0.2 min

Peak Storage= 10 cf @ 12.30 hrs
Average Depth at Peak Storage= 0.46'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 2.26 cfs

8.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0250 '/'
Inlet Invert= 483.00', Outlet Invert= 482.00'



Summary for Reach DIP2: 12" Ductile Iron Pipe

[52] Hint: Inlet/Outlet conditions not evaluated

Inflow Area = 135,460 sf, 0.00% Impervious, Inflow Depth = 2.03" for 100-C event
Inflow = 6.18 cfs @ 12.44 hrs, Volume= 22,967 cf
Outflow = 6.18 cfs @ 12.44 hrs, Volume= 22,967 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.42 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.25 fps, Avg. Travel Time= 0.3 min

Peak Storage= 22 cf @ 12.43 hrs
Average Depth at Peak Storage= 0.65'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'

Summary for Reach DIP3: 12" Ductile Iron Pipe

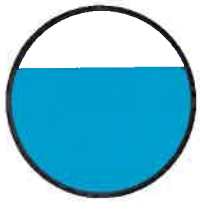
[52] Hint: Inlet/Outlet conditions not evaluated
[88] Warning: Qout>Qin may require Finer Routing>1

Inflow Area =	186,572 sf,	0.00% Impervious,	Inflow Depth =	1.97"	for 100-C event
Inflow =	6.58 cfs @	12.41 hrs, Volume=	30,684 cf		
Outflow =	6.58 cfs @	12.41 hrs, Volume=	30,684 cf,	Atten= 0%,	Lag= 0.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 11.55 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.71 fps, Avg. Travel Time= 0.2 min

Peak Storage= 23 cf @ 12.41 hrs
Average Depth at Peak Storage= 0.68'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.15 cfs

12.0" Round Pipe
n= 0.011 Steel, smooth
Length= 40.0' Slope= 0.0375 '/'
Inlet Invert= 485.50', Outlet Invert= 484.00'



Summary for Reach DP1: Wetlands (SW)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	589,769 sf,	0.60% Impervious,	Inflow Depth =	4.45"	for 100-C event
Inflow =	45.96 cfs @	12.27 hrs, Volume=	218,641 cf		
Outflow =	45.96 cfs @	12.27 hrs, Volume=	218,641 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP2: Southern Fields towards Wetlands (S)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	461,401 sf,	0.00% Impervious,	Inflow Depth =	2.84"	for 100-C event
Inflow =	25.93 cfs @	12.39 hrs, Volume=	109,286 cf		
Outflow =	25.93 cfs @	12.39 hrs, Volume=	109,286 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Reach DP3: Eastern Ridgeline towards Wetlands (E)

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	34,044 sf,	0.00% Impervious,	Inflow Depth =	4.40"	for 100-C event
Inflow =	3.06 cfs @	12.21 hrs, Volume=	12,475 cf		
Outflow =	3.06 cfs @	12.21 hrs, Volume=	12,475 cf,	Atten= 0%,	Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond P1: Proposed Detention Pond #1

Inflow Area =	456,407 sf,	0.30% Impervious,	Inflow Depth =	4.40"	for 100-C event
Inflow =	35.65 cfs @	12.29 hrs, Volume=	167,248 cf		
Outflow =	35.64 cfs @	12.30 hrs, Volume=	167,248 cf,	Atten= 0%,	Lag= 0.7 min
Primary =	1.85 cfs @	12.30 hrs, Volume=	68,708 cf		
Secondary =	33.79 cfs @	12.30 hrs, Volume=	98,541 cf		

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 486.97' @ 12.30 hrs Surf.Area= 4,421 sf Storage= 7,281 cf

Plug-Flow detention time= 22.8 min calculated for 167,132 cf (100% of inflow)
Center-of-Mass det. time= 22.9 min (860.6 - 837.7)

Volume	Invert	Avail.Storage	Storage Description
#1	484.00'	12,673 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
484.00	818	133.0	0	0	818
486.00	3,081	244.0	3,658	3,658	4,169
488.00	6,105	353.0	9,015	12,673	9,382

Device	Routing	Invert	Outlet Devices
#1	Primary	484.00'	**4.0" Vert. 4" Orifice in Riser** C= 0.600
#2	Primary	485.50'	**6.0" Horiz. 6" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#3	Secondary	486.50'	**40.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=1.85 cfs @ 12.30 hrs HW=486.97' (Free Discharge)
└**1=4" Orifice in Riser** (Orifice Controls 0.70 cfs @ 8.06 fps)
└**2=6" Perforated Riser Pipe** (Orifice Controls 1.15 cfs @ 5.84 fps)

Secondary OutFlow Max=33.71 cfs @ 12.30 hrs HW=486.97' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Weir Controls 33.71 cfs @ 1.79 fps)

Summary for Pond P2A: Proposed Detention Pond #2A

Inflow Area = 135,460 sf, 0.00% Impervious, Inflow Depth = 4.62" for 100-C event
Inflow = 12.13 cfs @ 12.23 hrs, Volume= 52,201 cf
Outflow = 8.18 cfs @ 12.44 hrs, Volume= 52,201 cf, Atten= 33%, Lag= 12.5 min
Discarded = 1.02 cfs @ 11.50 hrs, Volume= 28,733 cf
Primary = 6.18 cfs @ 12.44 hrs, Volume= 22,967 cf
Secondary = 0.97 cfs @ 12.44 hrs, Volume= 501 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 488.82' @ 12.44 hrs Surf.Area= 7,261 sf Storage= 8,101 cf

Plug-Flow detention time= 9.5 min calculated for 52,165 cf (100% of inflow)
Center-of-Mass det. time= 9.5 min (839.0 - 829.6)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,601 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,780	165.0	0	0	1,780
488.00	4,838	300.0	3,184	3,184	6,781
489.00	7,866	405.0	6,291	9,475	12,682
490.00	10,446	476.0	9,126	18,601	17,679

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=1.02 cfs @ 11.50 hrs HW=487.03' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=6.18 cfs @ 12.44 hrs HW=488.82' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 2.37 cfs @ 6.03 fps)
└**3=12" Perforated Riser Pipe** (Orifice Controls 3.81 cfs @ 4.85 fps)

Secondary OutFlow Max=0.92 cfs @ 12.44 hrs HW=488.82' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 0.92 cfs @ 0.69 fps)

Summary for Pond P2B: Proposed Detention Pond #2B

Inflow Area =	186,572 sf,	0.00% Impervious,	Inflow Depth =	4.51"	for 100-C event
Inflow =	15.03 cfs @	12.29 hrs, Volume=	70,130 cf		
Outflow =	13.22 cfs @	12.41 hrs, Volume=	70,130 cf,	Atten= 12%,	Lag= 7.3 min
Discarded =	1.02 cfs @	11.30 hrs, Volume=	34,072 cf		
Primary =	6.58 cfs @	12.41 hrs, Volume=	30,684 cf		
Secondary =	5.62 cfs @	12.41 hrs, Volume=	5,375 cf		

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 488.97' @ 12.41 hrs Surf.Area= 8,095 sf Storage= 8,834 cf

Plug-Flow detention time= 8.8 min calculated for 70,082 cf (100% of inflow)
Center-of-Mass det. time= 8.8 min (844.0 - 835.3)

Volume	Invert	Avail.Storage	Storage Description
#1	487.00'	18,869 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
487.00	1,413	162.0	0	0	1,413
488.00	4,486	319.0	2,806	2,806	7,427
489.00	8,214	461.0	6,257	9,062	16,250
490.00	11,491	582.0	9,807	18,869	26,306

Device	Routing	Invert	Outlet Devices
#1	Discarded	487.00'	**1.02 cfs Exfiltration at all elevations**
#2	Primary	487.00'	**6.0" Vert. 6" Orifice in Riser X 2.00** C= 0.600
#3	Primary	487.80'	**12.0" Horiz. 12" Perforated Riser Pipe** C= 0.600 Limited to weir flow at low heads
#4	Secondary	488.75'	**20.0' long x 17.5' breadth Broad-Crested Rectangular Weir**

Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60
Coef. (English)	2.68	2.70	2.70	2.64	2.63	2.64	2.64	2.63

Discarded OutFlow Max=1.02 cfs @ 11.30 hrs HW=487.03' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 1.02 cfs)

Primary OutFlow Max=6.57 cfs @ 12.41 hrs HW=488.97' (Free Discharge)
├**2=6" Orifice in Riser** (Orifice Controls 2.48 cfs @ 6.31 fps)
└**3=12" Perforated Riser Pipe** (Orifice Controls 4.09 cfs @ 5.21 fps)

Secondary OutFlow Max=5.54 cfs @ 12.41 hrs HW=488.97' (Free Discharge)
└**4=Broad-Crested Rectangular Weir** (Weir Controls 5.54 cfs @ 1.26 fps)

APPENDIX

OPERATION & MAINTENANCE PROGRAM

OPERATION AND MAINTENANCE PROGRAM
for
A PROPOSED STORMWATER MANAGEMENT SYSTEM
located at
43 ESTABROOK AVENUE
GRAFTON, MASSACHUSETTS
(PHASE 2 SOLAR DEVELOPMENT)

Applicant:

BlueWave Capital, LLC
75 Arlington Street
Boston, Massachusetts 02116

Prepared by:

Meridian Associates, Inc.
500 Cummings Center, Suite 5950
Beverly, Massachusetts 01915
(978) 299-0447

August 1, 2014

Project Name: Knowlton Farms Solar Development
(Phase 2)
43 Estabrook Avenue
Grafton, Massachusetts 01519

Owner Name: Patricia K. Knowlton
43 Estabrook Avenue
Grafton, Massachusetts 01519

Party Responsible for Maintenance During Construction:
BlueWave Capital, LLC.
John DeVillars
75 Arlington Street
Boston, MA 02116

Party Responsible for Maintenance After Construction:
BlueWave Capital, LLC.
John DeVillars
75 Arlington Street
Boston, MA 02116

Erosion and Sedimentation Control Measures during Construction Activities

Haybales

Staked haybales will be installed upgradient of the resource areas as depicted on the Erosion & Sediment Control Plan. The haybales shall be installed prior to the commencement of any work on-site and in accordance with the design plans. An additional supply of haybales shall be on-site to replace and/or repair any haybales that have been disturbed or are in poor condition. The line of haybales shall be inspected and maintained on a weekly basis and after every major storm event (2-year or greater) during construction. No construction activities are to occur beyond the haybale line at any time. Deposited sediments shall be removed when the volume of the deposition reaches approximately one-half the height of the hay bale.

Stockpiles

All unused debris, soil, and other material shall be stockpiled in locations of relatively flat grades, away from any trees identified to be saved and upgradient of the haybales. Stockpile side slopes shall not be greater than 2:1. All stockpiles shall be surrounded by a row of haybales, and shall be placed outside the 100 foot buffer to any bordering vegetated wetland. Surrounding haybales shall be inspected and maintained on a daily basis.

Surface Stabilization

Once the forested areas have been cleared and grubbed, the entire area will be tilled Following the installation of the array, areas of exposed soils will be seeded with the *Solar Farm Seed Mix* provided by Ersnt Conservation Seeds. This seed mix contains a variety of low-growing, low-maintenance fescues that will stabilize the ground surface.

Construction Tracking Pad

A construction tracking pad shall be installed at the designated entrances/exits to the site, as shown on the Site & Erosion Control plans, to the site to reduce the amount of sediment transported off site. The construction tracking pad shall be inspected weekly.

Removal of Sediment and Erosion Controls

At the completion of construction activities and after receiving approval from the Town of Grafton, all physical sediment and erosion controls shall be removed from the site and Estabrook Avenue per Town of Grafton. The areas where the controls have been removed shall be seeded and stabilized immediately upon removal.

Long-Term Inspection and Maintenance Measures after Construction

Erosion Control

Eroded sediments can adversely affect the performance of the stormwater management system. Eroding or barren areas should be immediately re-vegetated.

Areas immediately Down-Slope of Rip-Rap

The grassed areas immediately at the discharge point and down-slope of the rip rap shall be inspected after major storm events, or at minimum twice per year. These locations will be subject to concentrated flows and therefore may be prone to erosion and the formation of "gulleys" or channels. If any "gulleys" or channels are observed, they should immediately be repaired by installing sod and reseeding with grass. These areas shall be reseeded until a stable groundcover is established.

Detention Ponds

Detention ponds shall be checked bi-annually and after every major storm event for rilling, gullying, erosions and debris removal. Maintenance mowing shall occur as needed.

Debris and Litter Removal

Trash may collect in the BMP's, potentially causing clogging of the facilities. All debris and litter shall be removed when necessary, and after each storm event. Sediment and debris collected from vacuuming and/or sweeping should be disposed of at a permitted waste disposal facility. Avoid disposing of this material on site, where it could be washed into the proposed detention ponds.

Solar Seed Mix Grass Mowing

Grass shall be inspected annually and maintenance mowing shall occur as needed. All lawn mowing to take place will be done with a mulch mower so grass clippings will not be an issue.

Good Housekeeping Practices (in accordance with Standard 10 of the Stormwater Management Handbook to prevent illicit discharges)

Provisions for storing paints, cleaners, automotive waste and other potentially hazardous household waste products inside or under cover

- All materials on site will be stored inside in a neat, orderly, manner in their appropriate containers with the original manufacturer's label.
- Only store enough material necessary. Whenever possible, all of a product shall be used up before disposing of container.
- Manufacturer, local, and State recommendations for proper use and disposal shall be followed.

Vehicle washing controls

- A commercial car wash shall be used when possible. Car washes treat and/or recycle water.
- Cars shall be washed on gravel, grass, or other permeable surfaces to allow filtration to occur.
- Use biodegradable soaps.
- A water hose with a nozzle that automatically turns off when left unattended.

Requirements for routine inspection and maintenance of stormwater BMPs
See Inspection and Maintenance Measures after Construction.

Spill prevention and response plans
Spill Control Practices shall be in conformance with the guidelines set forth in the National Pollutant Discharge Elimination System (NPDES) Stormwater Pollution Prevention Plan (SWPPP)

Provisions for maintenance of lawns, gardens, and other landscaped areas

- Grass shall not be cut shorter than 2 to 3 inches and mulch clipping should be left on lawn as a natural fertilizer.
- Use low volume water approaches such as drip-type or sprinkler systems. Water plants only when needed to enhance root growth and avoid runoff problems.
- The use of mulch shall be utilized where possible. Mulch helps retain water and prevents erosion.

Requirements for storage and use of fertilizers, herbicides and pesticides

- Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizer will be worked into the soil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.
- Do not fertilize before a rainstorm.
- Consider using organic fertilizers. They release nutrients more slowly.
- Pesticides shall be applied on lawns and gardens only when necessary and applied only in the minimum amounts recommended by the manufacturer.

Pet waste management

- Scoop up and seal pet wastes in a plastic bag. Dispose of properly, in the garbage.

Provisions for operation and management of septic systems

Not Applicable

Provisions for solid waste management

- All solid waste shall be disposed of or recycled in accordance with local town regulations.

Snow disposal and plowing plans relative to Resource Area

- Snow shall be plowed and stored on gravel, grass, or other permeable surfaces to allow filtration to occur.
- Once snow melts all sand salt and debris shall be extracted from surface and properly disposed of.
- Snow shall not be disposed of in any resource area or waterbody.
- Avoid disposing snow on top of storm drain catchbasins or stormwater drainage swale.

Winter Road Salt and/or Sand use and storage restrictions

- Salt storage piles should be located outside the 100-year buffer zone and shall be covered at all times.
- The amount of road salt applied should be regulated to prevent over salting of roadways and increasing runoff concentrations. Alternative materials, such as sand or gravel, should be used in especially sensitive areas.

Roadway and Parking Lot sweeping schedule

- Pavement sweeping shall be conducted at a frequency of not less than once per year.
- Removal of any accumulated sand, grit, and debris from driveway after the snow melts shall be completed shortly after snow melts for the season.

Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL

Not Applicable

Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan

To be determined by the owner.

List of Emergency contacts for implementing Long-Term Pollution Prevention Plan

To be determined by the owner.

STORMWATER MANAGEMENT
CONSTRUCTION PHASE

INSPECTION SCHEDULE AND EVALUATION CHECKLIST

PROJECT LOCATION: 43 Estabrook Avenue, Grafton, Massachusetts **WEATHER:** _____

Inspection Date	*Inspector*	*Area Inspected*	*Required Inspection Frequency if BMP*	*Comments*	*Recommendation*	*Follow-up Inspection Required (yes/no)*
		Haybales	*Weekly and After Major Storm Events*			
		Construction Tracking Pad	*Weekly and After Major Storm Events*			

(1) Refer to the Massachusetts Stormwater Handbook, Volume Two: Stormwater Technical Handbook (February 2008) for recommendations regarding frequency for inspection and maintenance of specific BMP's.

(2) Inspections to be conducted by a qualified professional such as an environmental scientist or civil engineer.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended.

Other notes: (Include deviations from: Con. Comm. Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

Stormwater Control Manager: _____

STORMWATER MANAGEMENT
AFTER CONSTRUCTION

INSPECTION SCHEDULE AND EVALUATION CHECKLIST

PROJECT LOCATION: 43 Estabrook Avenue, Grafton Massachusetts **WEATHER:**_____

Inspection Date	*Inspector*	*Area Inspected*	*Required Inspection Frequency if BMP*	*Comments*	*Recommendation*	*Follow-up Inspection Required (yes/no)*
		Detention Pond	*Bi-annually and After Major Storm Event*			
		Areas immediately downslope of Rip-Rap	*Bi-annually and After Major Storm Event*			

(3) Refer to the Massachusetts Stormwater Handbook, Volume Two: Stormwater Technical Handbook (February 2008) for recommendations regarding frequency for inspection and maintenance of specific BMP's.

(4) Inspections to be conducted by a qualified professional such as an environmental scientist or civil engineer.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended.

Other notes: (Include deviations from: Con. Comm. Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

Stormwater Control Manager: _____

STORMWATER MANAGEMENT

STORMWATER MANAGEMENT

for

43 ESTABROOK AVENUE
GRAFTON, MASSACHUSETTS
(PHASE 2 SOLAR DEVELOPMENT)

Prepared for:

BlueWave Capital, LLC
75 Arlington Street
Boston, Massachusetts 02116

Prepared by:

Meridian Associates, Inc.
500 Cummings Center, Suite 5950
Beverly, Massachusetts 01915
(978) 299-0447

August 1, 2014

MERIDIAN ASSOCIATES

Stormwater Management Standards

Project Narrative:

This site is located off of 43 Estabrook Avenue on an undeveloped parcel of land. The area is comprised of gravel access paths, existing meadow (agricultural use) and wooded land with areas of brush/scrub vegetation and existing wetlands. The land currently slopes in three (3) general directions to bordering vegetated wetlands.

The proposed project is comprised of the development of the existing undeveloped agricultural land into a solar energy generating facility. The existing runoff patterns onsite will be maintained with limited selective grading. The proposed solar facility will be installed using a screw and post system providing low impact development on the existing topography of the locus area.

This proposed development will include the construction of a gravel access drive, inverter/transformer stations, VFI breaker with relay controller, new utility poles and risers, fencing, gates, and associated seeding.

The solar energy generating facility has been designed and incorporated into the existing topography in order to manage stormwater runoff in an appropriate and responsible manner.

The following are the DEP Stormwater Standards as outlined in the Wetlands Regulations:

Standard 1: No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

The existing project topography directs the stormwater runoff from the area of the proposed work across the site toward existing bordering vegetated wetlands. There currently is no treatment of stormwater prior to discharge to the wetlands. The proposed conditions will not have a point source discharge and will direct stormwater in the same general patterns as the existing conditions, across proposed "solar farm mix" grassed areas (low-growth, low-maintenance). and through a series of proposed detention ponds prior to discharging through a level spreader toward the existing bordering vegetated wetlands.

Standard 2: Peak Rate Attenuation - Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.

For the purpose of analyzing pre and post development stormwater peak rates of runoff, three (3) design points have been selected based on existing topographic conditions and were used for both the pre and the post calculations. Comparison values for pre and post development stormwater peak rates are given for the design points only.

The storm events that were used to calculate peak runoff rates for pre and post construction conditions are compiled from the Cornell University Publication No. RR-93-5 (September 1993) "Northeast Regional Climate Center Atlas of Precipitation Extremes for the

Northeastern United States and Southeastern Canada". Full detail of peak rate attenuation along with supplemental stormwater calculations utilizing HydroCAD as well as pre and post drainage site plans can be found in appendix of the "Stormwater Analysis & Calculations Report". The details of this report show that the peak rates of runoff for the 2-year, 10-year and 100 year events have been reduced from pre to post conditions.

The hydrologic calculations from HydroCAD has been included in the "Stormwater Analysis & Calculations Report"

Proposed Design Point and Subcatchment Areas

This site currently slopes in three (3) general directions with varying grades. The existing stormwater runoff patterns are based on existing topography which indicates that the runoff flows to three design points:

- Design Point #1 **(DP1)** is located at the edge of the Bordering Vegetative Wetland to the southwest of the locus area and west of the existing dwelling.
- Design Point #2 **(DP2)** is located at the top edge of the Bordering Vegetative Wetland along and on the northern edge of Estabrook Avenue to the south of the locus area.
- Design Point #3 **(DP3)** is located at the edge of the eastern ridgeline where the topography begins to slope steeply towards a Bordering Vegetative Wetland east of the locus area. (The slope will remain unchanged from pre to post conditions).

Summary of Flows at Design Point 1

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	6.55	38,418	5.21	34,480
10-Year (4.31 in./hr.)	17.19	90,811	16.24	80,716
100-Year (7.79 in./hr.)	48.60	247,993	45.81	218,624

Summary of Flows at Design Point 2

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	3.52	20,510	2.01	9,164
10-Year (4.31 in./hr.)	9.26	48,482	7.08	30,831
100-Year (7.79 in./hr.)	26.13	132,397	25.93	109,286

Summary of Flows at Design Point 3

Storm Event	Existing Conditions (Pre) Peak Flow (CFS)	Existing Conditions (Pre) Volume (CF)	Proposed Conditions (Post) Peak Flow (CFS)	Proposed Conditions (Post) Volume (CF)
2-Year (2.86 in./hr.)	0.57	2,677	0.41	1,933
10-Year (4.31 in./hr.)	1.52	6,328	1.08	4,568
100-Year (7.79 in./hr.)	4.29	17,282	3.06	12,475

* CFS – Cubic Feet Per Second
* CF – Cubic Feet

The tables above outline the results of the hydrologic model. As required by Standard #2, the project has adequately attenuated for potential increase in peak stormwater flows.

Standard 3: Recharge - Loss of annual recharge to groundwater shall be eliminated or minimized…at a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This standard is met when the stormwater management system is designed to infiltrate the required recharge volume in accordance with the Mass Stormwater Handbook.

Onsite soil testing was conducted by Alexander F. Parker (Certified Soil Evaluator #1848) on July 14, 2014 in the areas depicted on the attached plan. The testing revealed that ground water ranged from 38" (detention pond #1 area) to an average of 80" throughout the remaining test pits below the existing surface. The NCRS soil map classifies the soil throughout the entire site to be of Hydrological Soil Group C. Soil testing revealed that the parent material consisted of sandy loam (Hydrological Soil Group B). The amount of groundwater recharge that would be required is negligible and the proposed stormwater management system will promote groundwater recharge.

Standard 4: Water Quality – Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). The standard is met with pollution prevention plans, stormwater BMP's sized to capture required water quality volume, and pretreatment measures.

The project proposes a minimal amount of impervious area (800 s.f.) for the concrete equipment pads. Therefore with the stormwater traveling over hundreds of feet of naturally vegetated land cover before and after runoff enters into detention pond #1 all prior to discharging to the existing wetlands will accommodate for any minor TSS needed to be removed. The amount of TSS removal that would be required is negligible and the proposed stormwater management system will promote TSS removal.

Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs) – Source control and pollution prevention shall be implemented in accordance with the Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.

Stormwater Standard 5 is not applicable to this project. The proposed development will not subject the site to higher potential pollutant loads as defined in the Massachusetts Department of Environmental protection Wetlands and Water Quality Regulations.

LUHPPLs are identified in 310 CMR 22.20B(2) and C(2)(a)-(k) and (m) and CMR 22.21(2)(a)(1)-(8) and (b)(1)-(6), areas within a site that are the location of activities that are subject to an individual National Pollutant Discharge Elimination System (NPDES) permit or the NPDES Multi-sector General Permit; auto fueling facilities, exterior fleet storage areas, exterior vehicle service and equipment cleaning areas; marinas and boatyards; parking lots with high-intensity-use; confined disposal facilities and disposal sites.

Standard 6: Critical Areas – Stormwater discharges to critical areas require the use of specific source control and pollution prevention measures and specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas.

Stormwater Standard 6 is not applicable to this project given that proposed stormwater does not discharge near a critical area. Critical areas being Outstanding Resource Waters and Special Resource Waters as designated in 314 CMR 4.0, recharge areas for public water supplies as defined in 310 CMR 22.02, bathing beaches as defined in 105 CMR 445.000, cold-water fisheries and shellfish growing areas as defined in 314 CMR 9.02 and 310 CMR 10.04. The existing wetland is not considered a critical area therefore Standard #6 does not applies to this project.

Standard 7: Redevelopments – A redevelopment project is required to meet Standards 1-6 only to the maximum extent practicable. Remaining standards shall be met as well as the project shall improve the existing conditions.

Stormwater Standard 7 is not applicable to this project. Within the Stormwater Management Handbook (volume 1 chapter 1 page 20), the definition of a redevelopment project includes, "development, rehabilitation, expansion and phased projects on previously developed sites, provided the redevelopment results in no net increase in impervious area".

This project will not result in a reduction of impervious area in the proposed conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan shall be implemented.

An *Operation and Maintenance Program for Proposed Stormwater Management System* is included with this report. The program details the construction period operation and maintenance plan and sequencing for pollution prevention measures and erosion and sedimentation controls. Locations of erosion control measures for the project are depicted on the site plan set accompanying this report.

Standard 9: A long term Operation and Maintenance Plan shall be implemented.

An *Operation and Maintenance Program for a Proposed Stormwater Management System* is included with this report. The long term operation and maintenance section of the program provides details and the schedule for routine and non-routine maintenance tasks to be implemented at the completion of the project.

Standard 10: Prohibition of Illicit Discharges – Illicit discharges to the stormwater management system are prohibited.

Illicit discharges to the stormwater management system are discharges that are not entirely comprised of stormwater. Discharges to the stormwater management system from the following activities or facilities are permissible: Firefighting, water line flushing, landscape irrigation, uncontaminated groundwater, potable water sources, foundation drains, air conditioning condensation, footing drains, individual resident car washing, flows from riparian habitats and wetlands, dechlorinated water from swimming pools, water used for street washing and water used to clean residential buildings without detergents. All other illicit discharges are prohibited.

There are no known illicit discharges anticipated through the completion of this project. During construction and post construction procedures are provided to dissipate the potential for illicit discharges to the drainage system. Post construction preventions of illicit discharges are described in the Operation and Maintenance Program under the Good Housekeeping Practices section of the report.

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CHECKLIST FOR STORMWATER REPORT

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

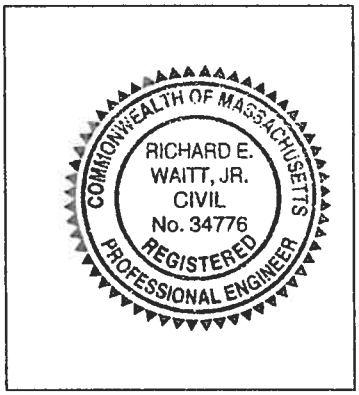
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



Signature and Date 8/1/14

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☐ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Low Impact Design screw & post racking system

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☐ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☐ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☒ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☐ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☐ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☒ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

USDA NATURAL RESOURCE CONSERVATION SERVICE

NATIONAL COOPERATIVE SOIL SURVEY

Hydrologic Soil Group—Worcester County, Massachusetts, Southern Part
(Grafton Phase 2)

Map Scale: 1:5,400 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 1:25,000.

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: http://websoilsurvey.nrcs.usda.gov
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: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 6, Dec 17, 2013

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

Date(s) aerial images were photographed: Mar 30, 2011—May 1, 2011

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Worcester County, Massachusetts, Southern Part (MA615)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
102C	Chatfield-Hollis-Rock outcrop complex, 3 to 15 percent slopes	B	3.1	3.8%
260B	Sudbury fine sandy loam,3 to 8 percent slopes	B	0.1	0.1%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	C	18.8	22.9%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	C	25.7	31.2%
307B	Paxton fine sandy loam, 3 to 8 percent slopes, extremely stony	C	25.0	30.4%
307E	Paxton fine sandy loam, 15 to 35 percent slopes, extremely stony	C	8.1	9.8%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C	1.3	1.6%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	B	0.2	0.2%
Totals for Area of Interest			**82.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

CORNELL UNIVERSITY
PUBLICATION No. RR-93-5
(SEPTEMBER 1993)

CLIMATIC MAPS
PRECIPITATION ACCUMULATIONS

Extreme Precipitation Tables

Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	Massachusetts
Location	43 Estabrook Avenue, Grafton ,Massachusetts
Longitude	71.663 degrees West
Latitude	42.225 degrees North
Elevation	Unknown/Unavailable
Date/Time	Wed, 23 Jul 2014 09:29:11 -0400

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.28	0.43	0.54	0.70	0.88	1.11	**1yr**	0.76	1.07	1.29	1.63	2.08	2.65	2.89	**1yr**	2.35	2.78	3.20	3.89	4.50	**1yr**
2yr	0.35	0.54	0.67	0.88	1.11	1.40	**2yr**	0.96	1.28	1.62	2.04	2.57	3.23	3.50	**2yr**	2.86	3.37	3.87	4.59	5.23	**2yr**
5yr	0.41	0.64	0.80	1.08	1.38	1.76	**5yr**	1.19	1.59	2.04	2.58	3.25	4.08	4.46	**5yr**	3.61	4.29	4.91	5.77	6.47	**5yr**
10yr	0.46	0.73	0.92	1.25	1.63	2.09	**10yr**	1.40	1.88	2.44	3.09	3.89	4.87	5.35	**10yr**	4.31	5.14	5.88	6.87	7.62	**10yr**
25yr	0.55	0.87	1.11	1.53	2.02	2.62	**25yr**	1.75	2.34	3.08	3.91	4.92	6.16	6.81	**25yr**	5.45	6.55	7.47	8.65	9.44	**25yr**
50yr	0.61	0.98	1.26	1.77	2.39	3.14	**50yr**	2.06	2.76	3.69	4.69	5.90	7.36	8.18	**50yr**	6.51	7.87	8.96	10.29	11.12	**50yr**
100yr	0.70	1.14	1.47	2.08	2.83	3.73	**100yr**	2.44	3.25	4.40	5.61	7.06	8.80	9.84	**100yr**	7.79	9.46	10.74	12.26	13.09	**100yr**
200yr	0.80	1.30	1.69	2.42	3.34	4.45	**200yr**	2.89	3.85	5.26	6.72	8.45	10.52	11.83	**200yr**	9.31	11.38	12.89	14.60	15.42	**200yr**
500yr	0.96	1.58	2.06	2.99	4.18	5.60	**500yr**	3.61	4.79	6.65	8.51	10.72	13.34	15.12	**500yr**	11.81	14.54	16.40	18.42	19.15	**500yr**

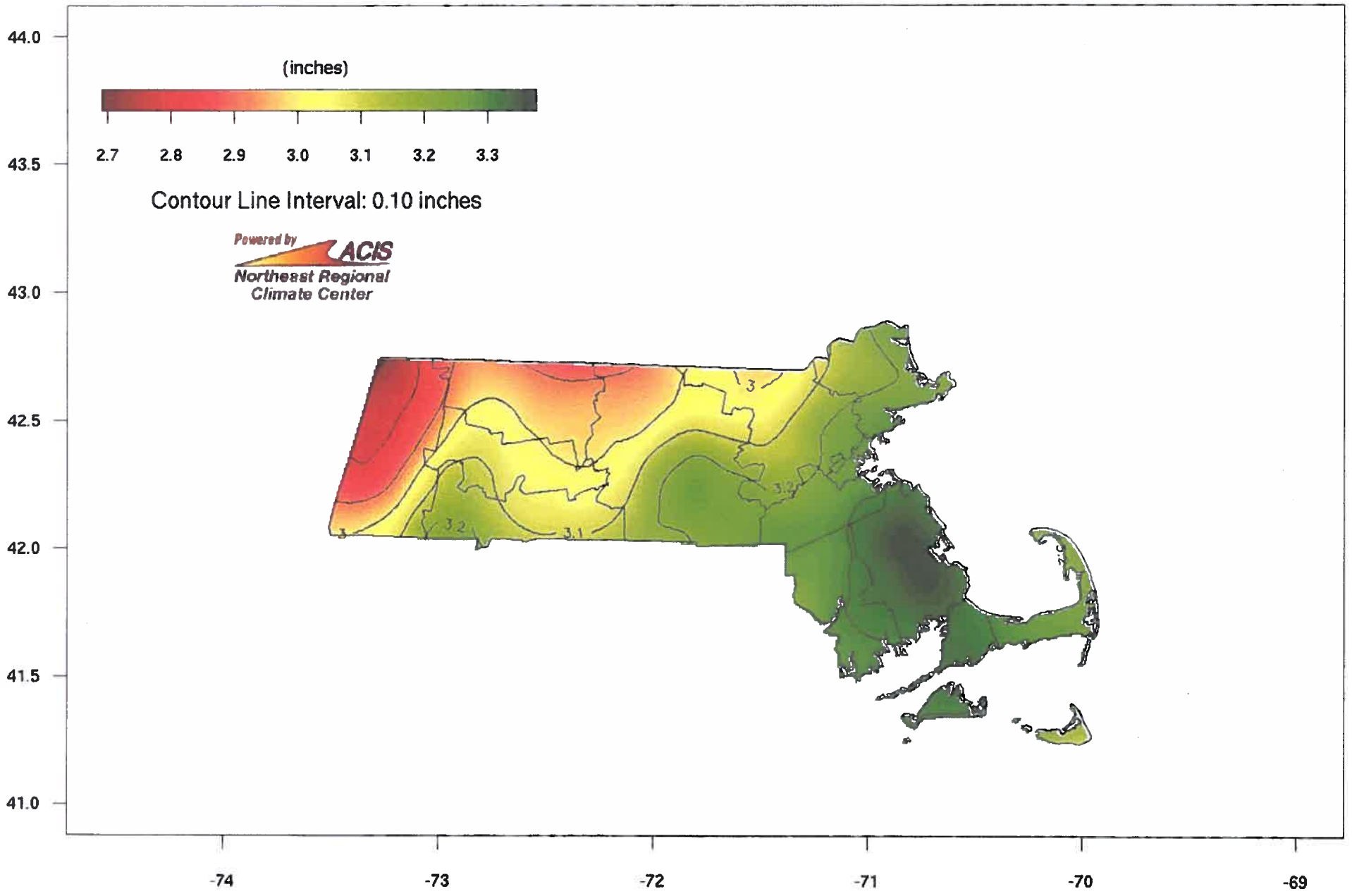
Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.22	0.33	0.41	0.55	0.67	0.95	**1yr**	0.58	0.93	1.09	1.43	1.87	2.42	2.65	**1yr**	2.15	2.54	2.76	3.52	4.17	**1yr**
2yr	0.34	0.53	0.65	0.88	1.08	1.26	**2yr**	0.93	1.24	1.45	1.90	2.43	3.15	3.40	**2yr**	2.79	3.27	3.76	4.45	5.07	**2yr**
5yr	0.38	0.59	0.73	1.00	1.28	1.51	**5yr**	1.10	1.48	1.72	2.24	2.86	3.76	4.13	**5yr**	3.33	3.97	4.56	5.31	6.01	**5yr**
10yr	0.42	0.65	0.81	1.12	1.45	1.72	**10yr**	1.25	1.68	1.94	2.54	3.22	4.31	4.78	**10yr**	3.81	4.60	5.28	6.05	6.82	**10yr**
25yr	0.49	0.74	0.92	1.32	1.73	2.05	**25yr**	1.50	2.00	2.30	3.01	3.79	5.16	5.80	**25yr**	4.56	5.58	6.43	7.16	8.04	**25yr**
50yr	0.54	0.82	1.02	1.47	1.98	2.33	**50yr**	1.71	2.28	2.62	3.42	4.29	5.89	6.74	**50yr**	5.21	6.48	7.48	8.15	9.13	**50yr**
100yr	0.60	0.91	1.14	1.64	2.26	2.65	**100yr**	1.95	2.59	2.98	3.89	4.86	6.75	7.84	**100yr**	5.98	7.54	8.72	9.27	10.37	**100yr**
200yr	0.67	1.00	1.27	1.84	2.57	3.03	**200yr**	2.22	2.97	3.39	4.43	5.51	7.73	9.12	**200yr**	6.84	8.77	10.16	10.54	11.80	**200yr**
500yr	0.77	1.15	1.48	2.14	3.05	3.62	**500yr**	2.63	3.54	4.02	5.28	6.54	9.27	11.18	**500yr**	8.20	10.75	12.48	12.46	14.01	**500yr**

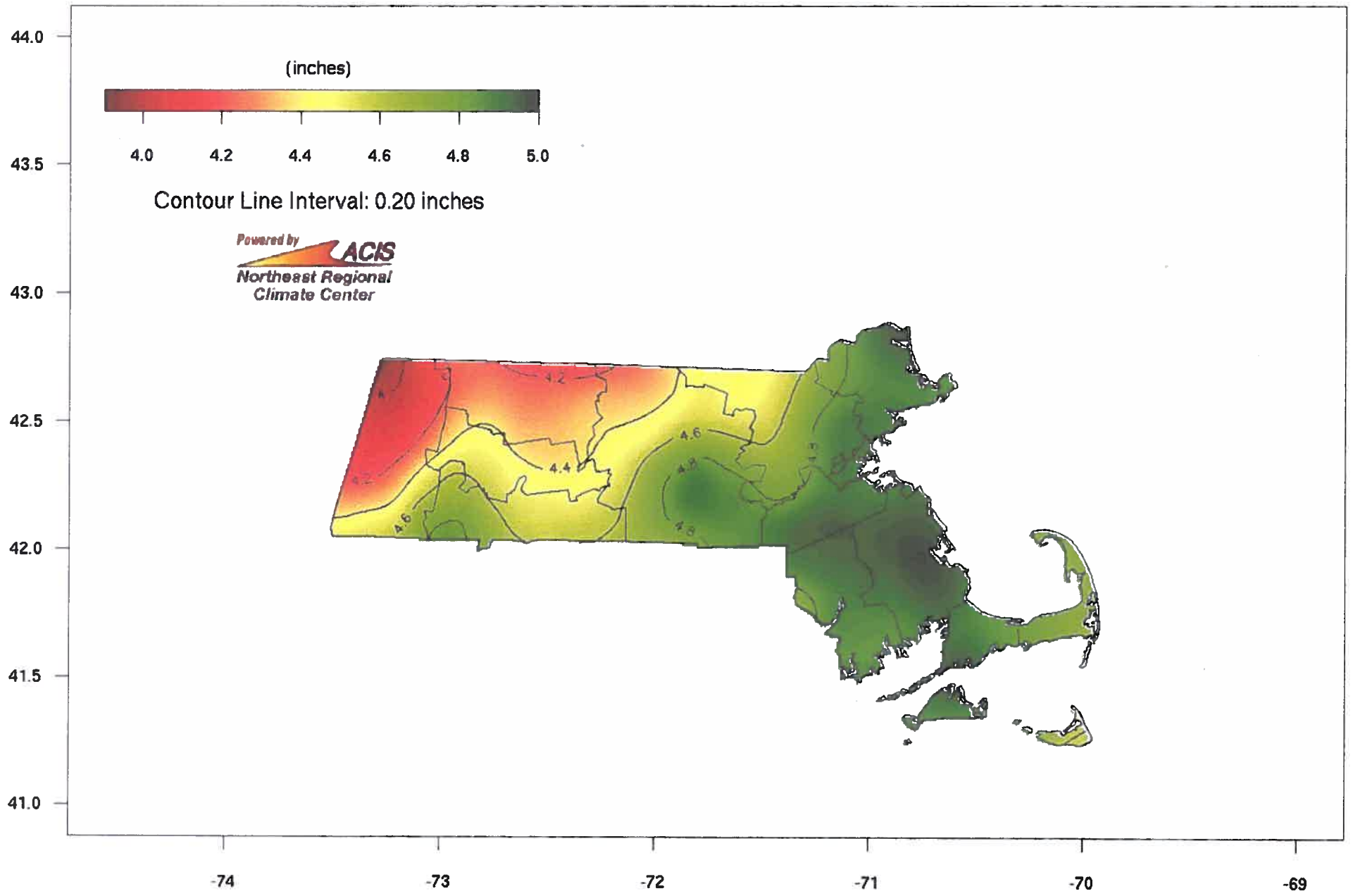
Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.32	0.49	0.59	0.80	0.98	1.19	**1yr**	0.85	1.16	1.37	1.75	2.29	2.93	3.19	**1yr**	2.59	3.07	3.49	4.23	4.82	**1yr**
2yr	0.36	0.56	0.69	0.93	1.15	1.35	**2yr**	0.99	1.32	1.55	2.02	2.58	3.37	3.64	**2yr**	2.98	3.50	4.02	4.78	5.41	**2yr**
5yr	0.44	0.68	0.85	1.17	1.48	1.77	**5yr**	1.28	1.73	2.02	2.59	3.27	4.40	4.81	**5yr**	3.89	4.62	5.28	6.24	6.98	**5yr**
10yr	0.52	0.81	1.00	1.39	1.80	2.16	**10yr**	1.56	2.12	2.48	3.13	3.91	5.40	5.96	**10yr**	4.78	5.73	6.51	7.66	8.48	**10yr**
25yr	0.66	1.00	1.25	1.78	2.34	2.83	**25yr**	2.02	2.77	3.22	4.01	4.96	7.10	7.92	**25yr**	6.28	7.61	8.57	10.07	10.98	**25yr**
50yr	0.78	1.19	1.48	2.12	2.86	3.47	**50yr**	2.47	3.39	3.96	4.84	5.94	8.73	9.80	**50yr**	7.72	9.43	10.55	12.39	13.36	**50yr**
100yr	0.93	1.41	1.76	2.55	3.49	4.26	**100yr**	3.01	4.16	4.85	5.85	7.12	10.73	12.15	**100yr**	9.50	11.69	12.99	15.26	16.26	**100yr**
200yr	1.11	1.67	2.12	3.06	4.27	5.23	**200yr**	3.69	5.12	5.95	7.06	8.52	13.19	15.06	**200yr**	11.67	14.48	15.99	18.80	19.73	**200yr**
500yr	1.41	2.10	2.70	3.93	5.58	6.87	**500yr**	4.82	6.72	7.81	9.07	10.80	17.33	19.98	**500yr**	15.34	19.22	21.03	24.77	25.54	**500yr**

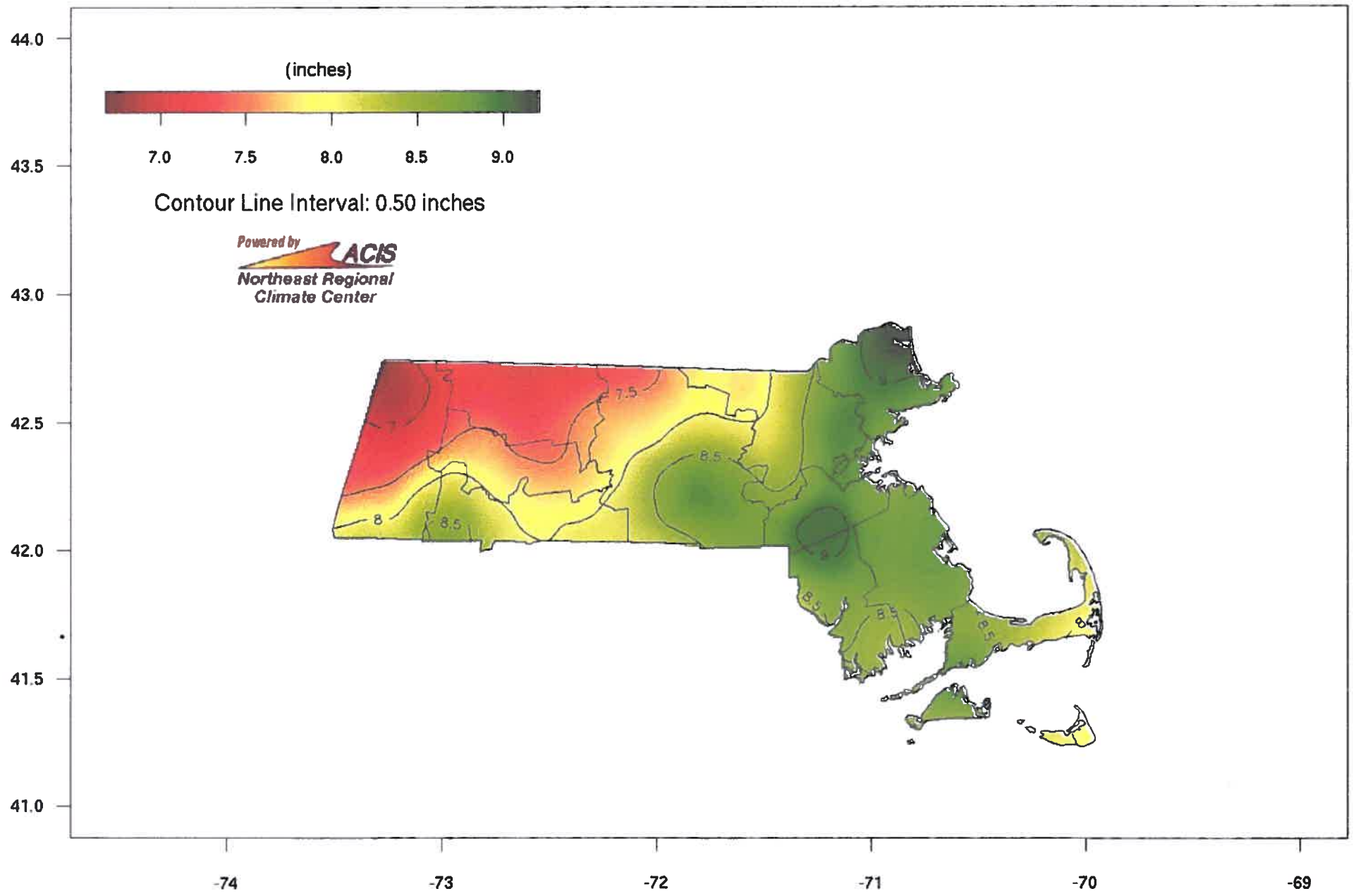
Extreme Precipitation Estimates
24hr 2yr

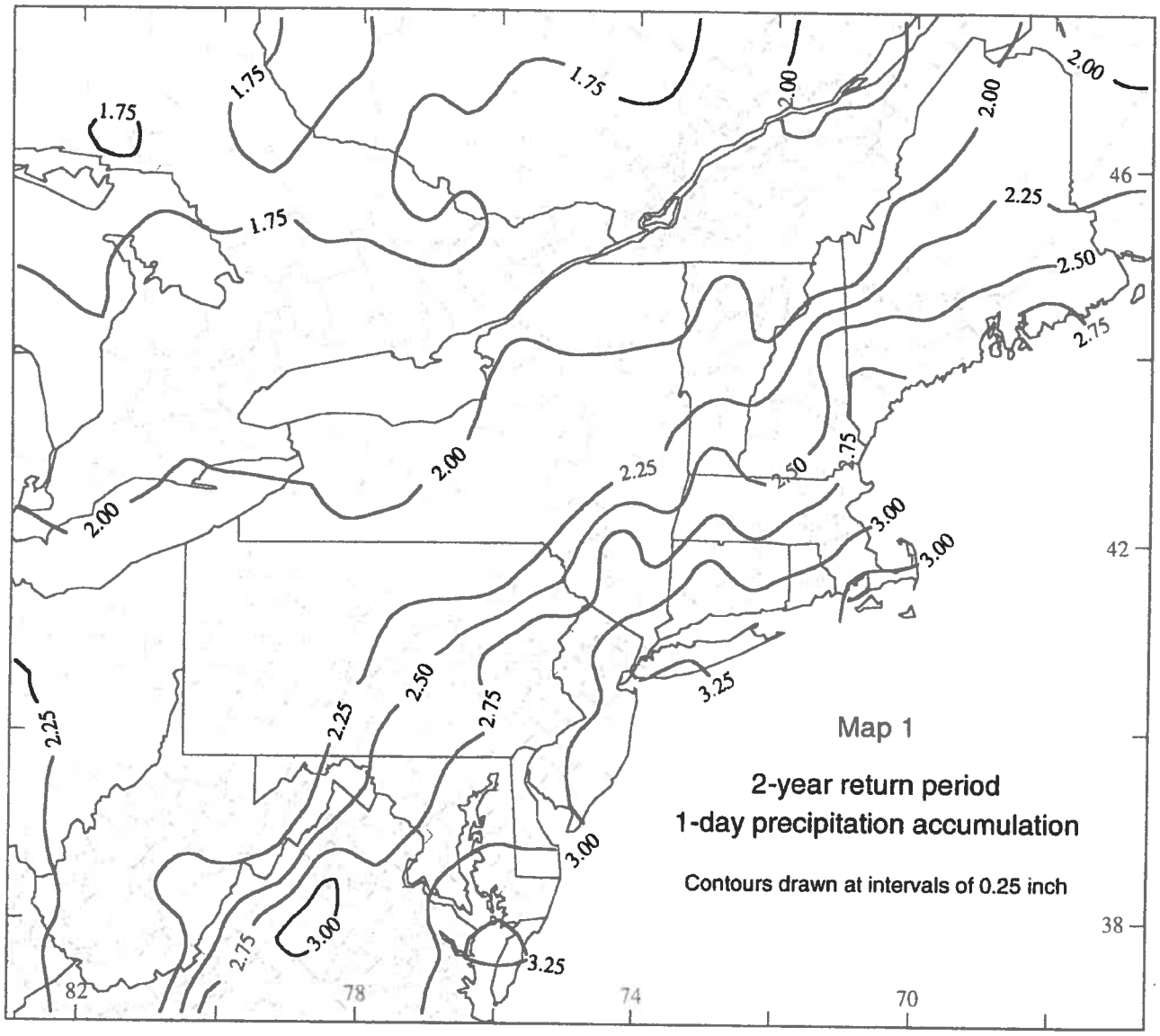


Extreme Precipitation Estimates
24hr 10yr



Extreme Precipitation Estimates
24hr 100yr




1.75
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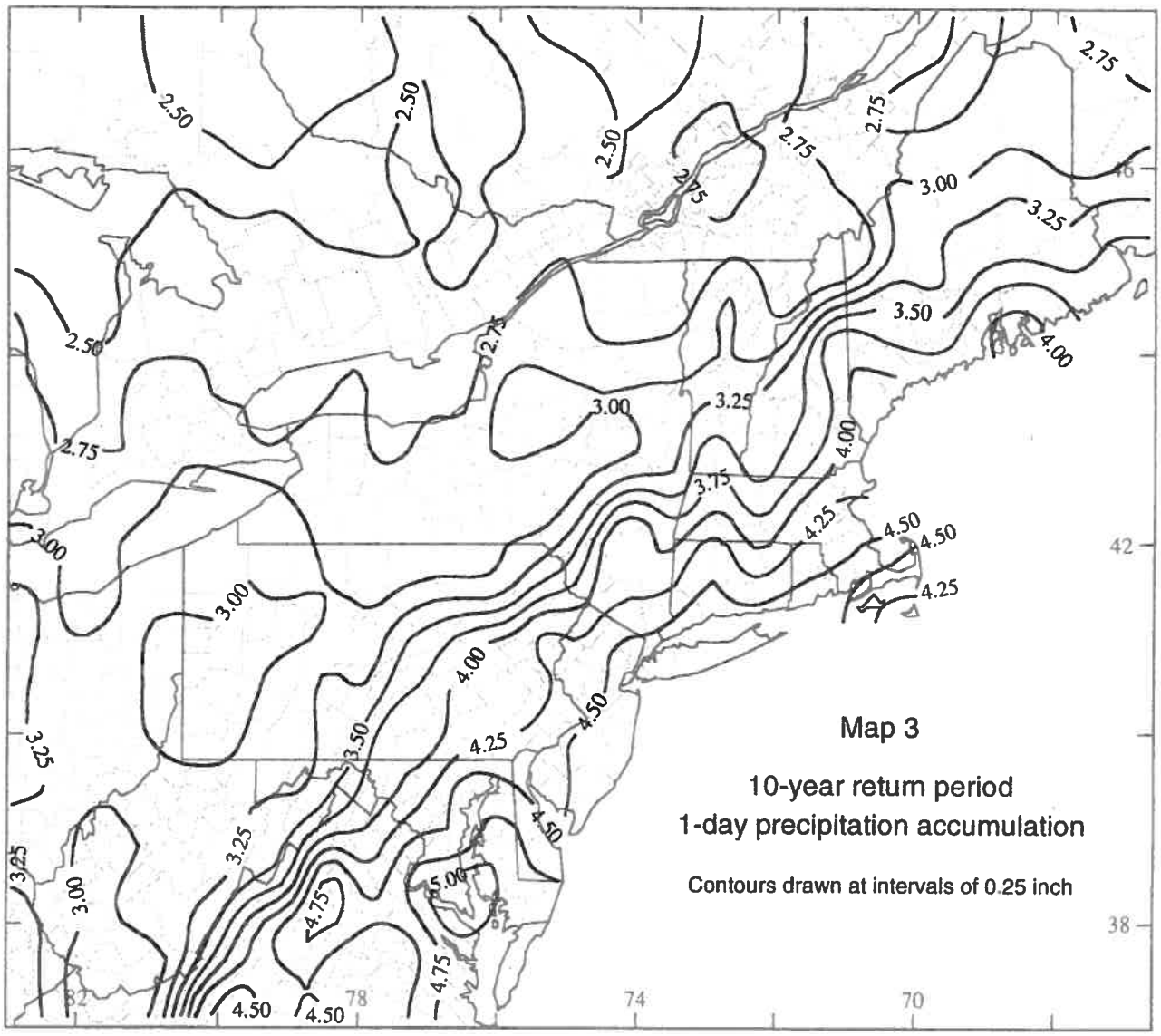
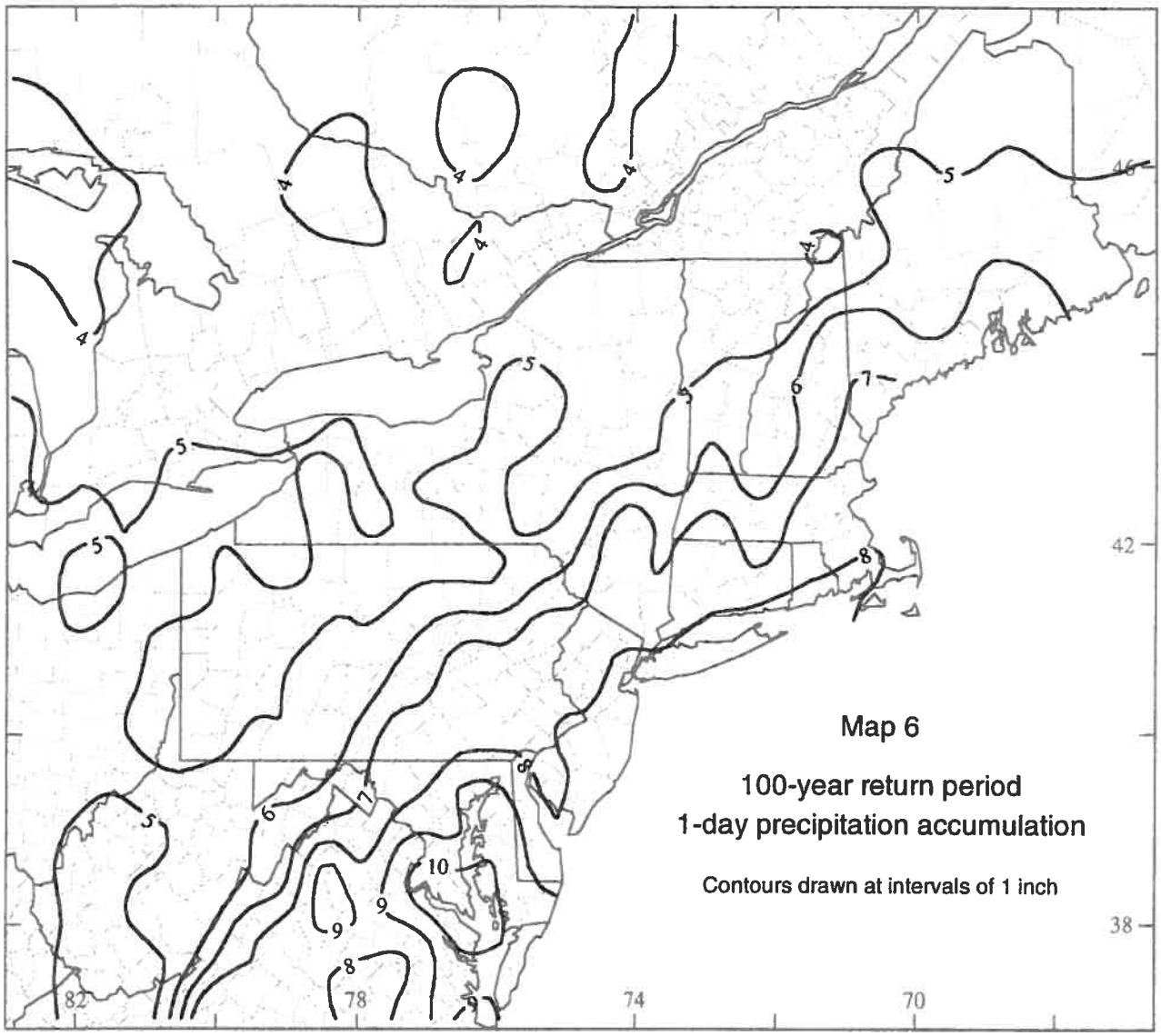
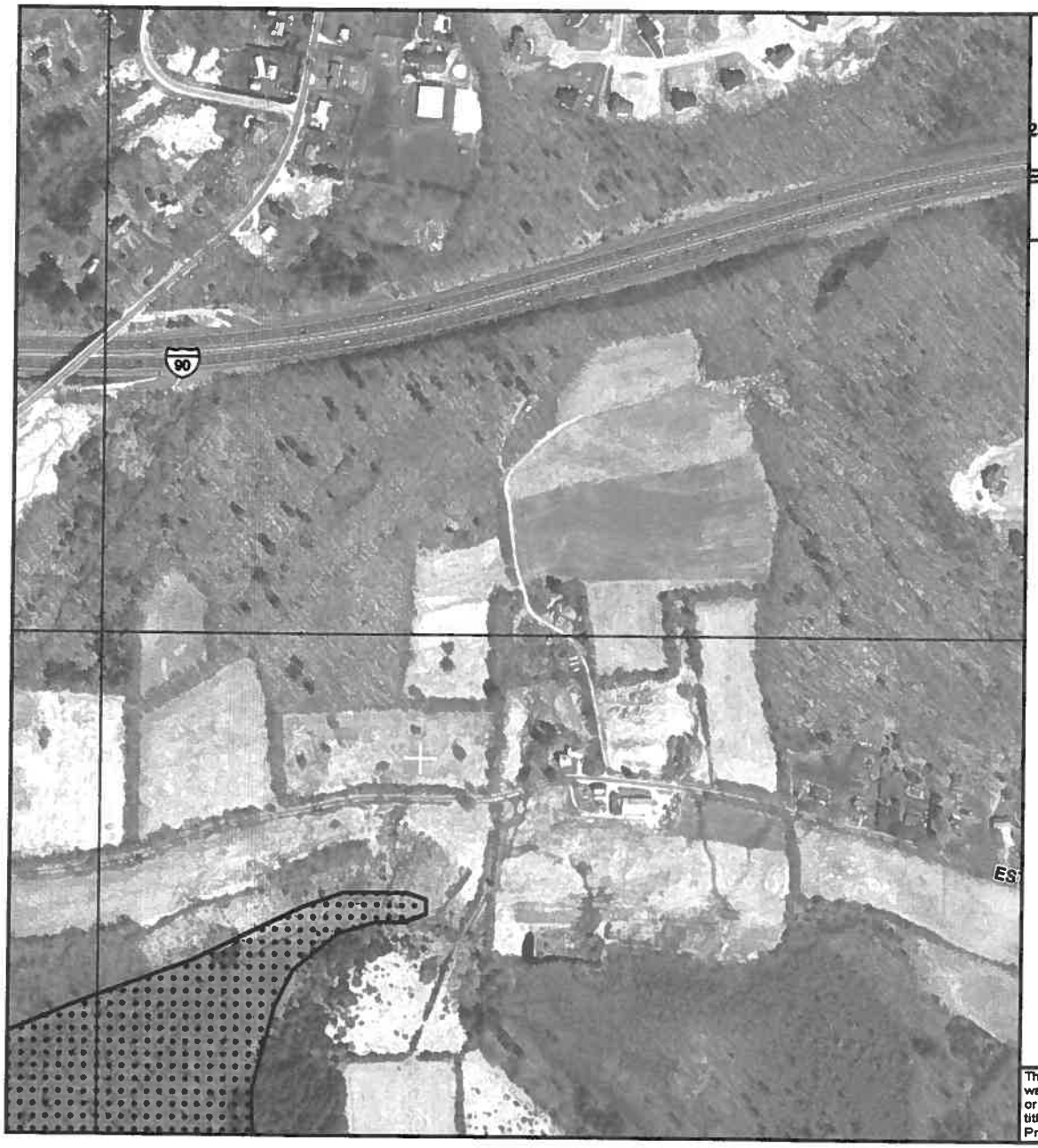
46
42
38
82
78
74
70
Map 1
2-year return period
1-day precipitation accumulation
Contours drawn at intervals of 0.25 inch


Map 3
10-year return period
1-day precipitation accumulation
Contours drawn at intervals of 0.25 inch
42
38
82
78
74
70


Map 6
100-year return period
1-day precipitation accumulation
Contours drawn at intervals of 1 inch
46
42
38
82
78
74
70

FEDERAL EMERGENCY MANAGEMENT AGENCY

FLOOD INSURANCE RATE MAP



MAP SCALE 1" = 500'

250 0 500 1000

FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0831E

FIRM

FLOOD INSURANCE RATE MAP

WORCESTER COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 831 OF 1075

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GRAFTON, TOWN OF	250306	0831	E
WESTBOROUGH, TOWN OF	250344	0831	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

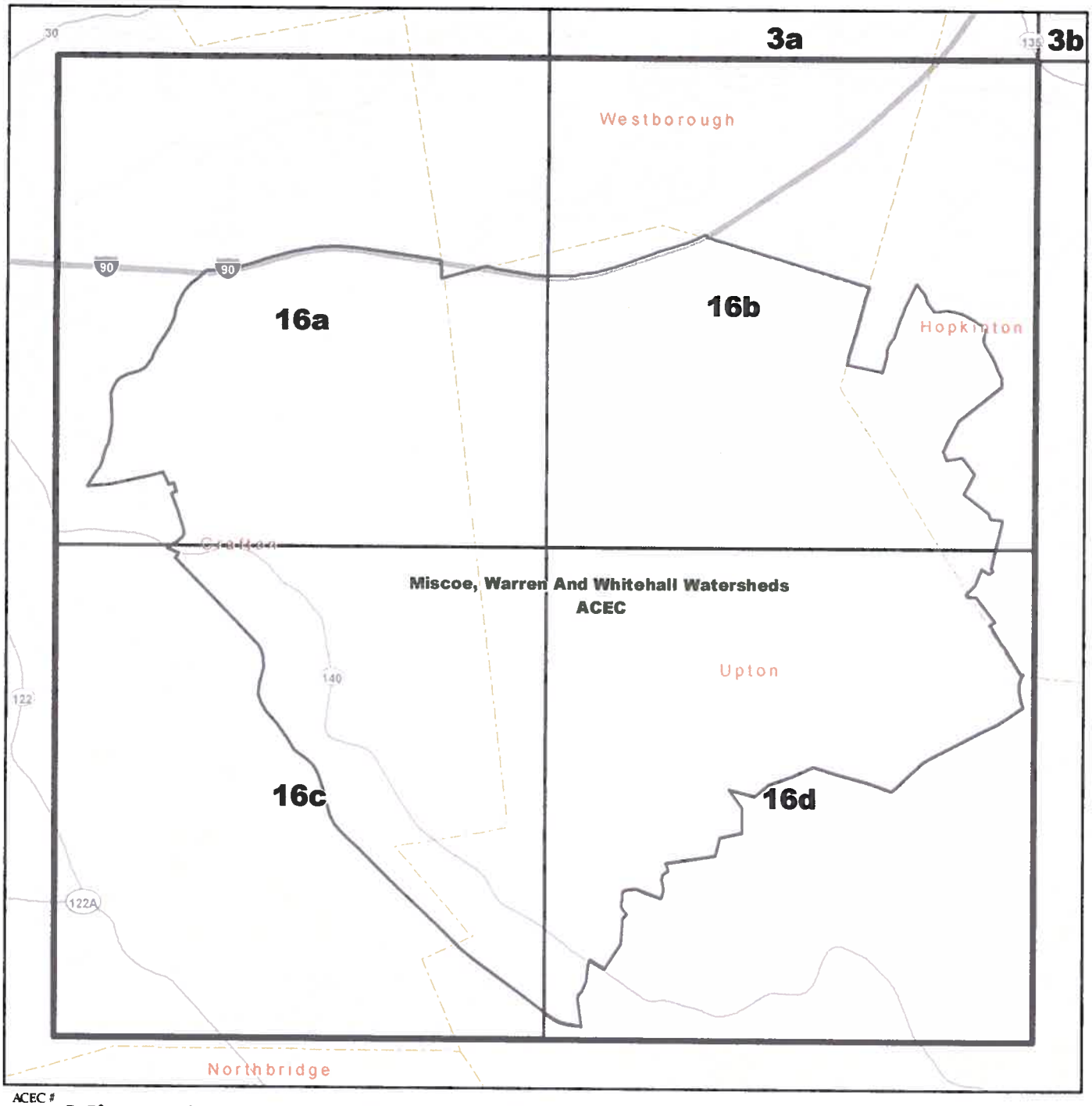
MAP NUMBER
25027C0831E

EFFECTIVE DATE
JULY 4, 2011

Federal Emergency Management Agency

AREAS OF CRITICAL ENVIRONMENTAL CONCERN

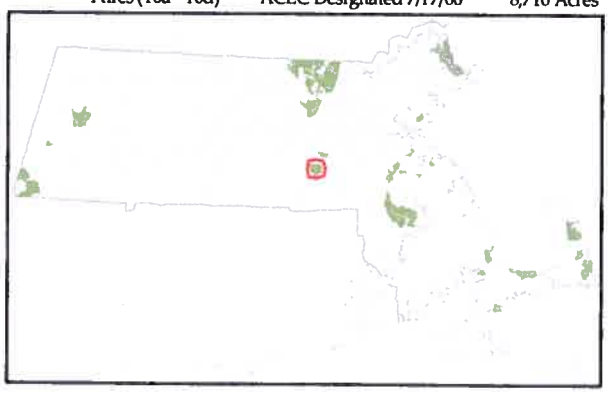
"MISCOE, WARREN, WHITEHALL WATERSHEDS"



ACEC # 16

Miscoe Warren And Whitehall Watersheds ACEC - Index Map

4 tiles (16a - 16d) ACEC Designated 7/17/00 8,710 Acres



Massachusetts Department of Conservation and Recreation

Areas of Critical Environmental Concern (ACEC) Program

This index map shows the locations of the map tiles that are available as individual sections of 1:24,000 USGS maps. The map number is the ACEC number plus a sequential letter, e.g. "21a". Some smaller ACECs may have only one tile. Determine which tiles you want to view, note their map tile numbers, and open them individually from the ACEC website.

For more information:

www.mass.gov/dcr/stewardship/acec

Town Boundary
ACEC Map Tiles
ACECs

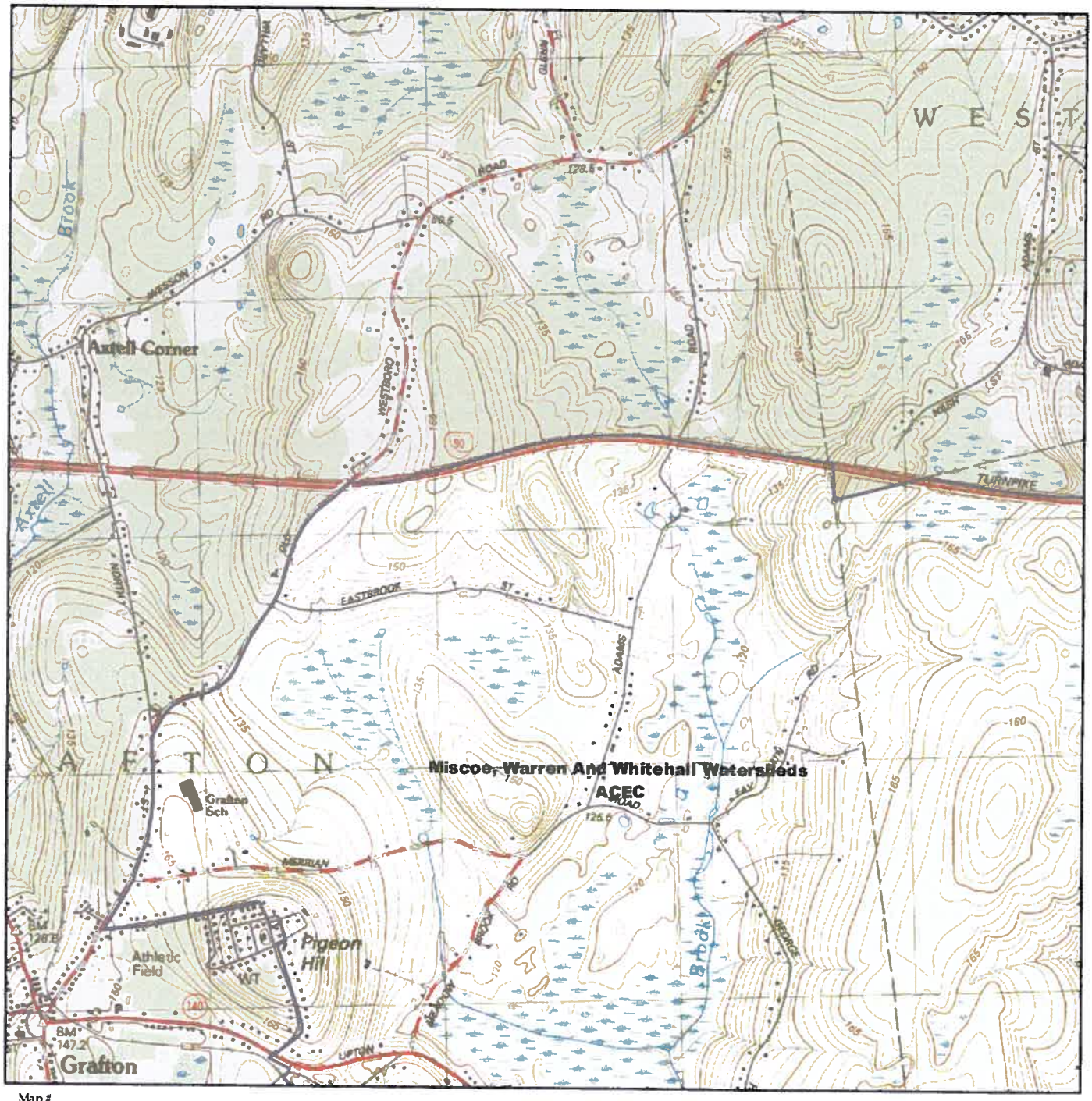
ACEC Boundaries by Type

- Road/Rail based
- River based
- Wetland based
- Floodplain based
- Tide based
- Contour based
- Political boundary
- Property line based
- Other
- Digital update required

dcr Massachusetts

1 inch equals 0.8 miles

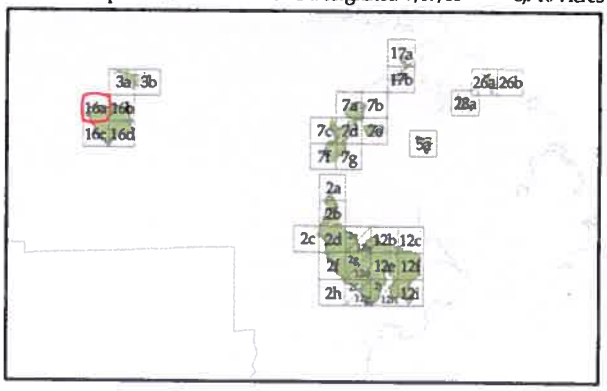
N



Map # **16a**

Miscoe, Warren And Whitehall Watersheds ACEC

Map Tile 1 of 4 ACEC Designated 7/17/00 8,710 Acres



Massachusetts Department of Conservation and Recreation

Areas of Critical Environmental Concern (ACEC) Program

This map is intended to be used with the written boundary description contained in the ACEC designation document. The mapped boundary is not to be used by itself for definitive ACEC boundary delineation or regulatory interpretation. For review of site-specific projects within the ACEC boundary, determinations may need to be made in the field or in consultation with ACEC Program Staff.

For more information:

www.mass.gov/dcr/stewardship/acec

ACEC Boundaries by Type

- Road/Rail based
- River based
- Wetland based
- Floodplain based
- Tide based
- Contour based
- Political boundary
- Property line based
- Other
- Digital update required

Areas not within an ACEC are shaded with a gray mask.

dcr Massachusetts

0.25 miles

N

SOIL SUITABILITY ASSESSMENT FOR ON-SITE STORMWATER DRAINAGE CONTROL

COMMONWEALTH OF MASSACHUSETTS

GRAFTON, MASSACHUSETTS

SOIL SUITABILITY ASSESSMENT FOR ON-SITE STORMWATER DRAINAGE CONTROL

SITE INFORMATION

Monday, July 14th, 2014

Street Address: #43 Estabrook Avenue City/Town: Grafton State: Massachusetts Zip Code: 01519 County: Worcester

Land Use: Prime farmland: hay field Latitude: ~42°13'28.9" N Longitude: ~71°39'49.4"W Elevation: ~450 – 490 feet

PUBLISHED SOIL DATA AND MAP UNIT DESCRIPTION

Physiographic Division: Appalachian Highlands Physio. Province: New England Physio. Section: Seaboard lowland section

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

NRCS/USDA web soil survey: Worcester County, Massachusetts, Southern part. Map Scale: 1:400'

Soil hydric or upland: Upland Average depth to water table: 7" Depth to restrictive feature: 18-30" to densic material

Frequency of flooding: None Frequency of ponding: None Available water capacity: Low (~3.3")

Natural Drainage Class: Well drained Hydrologic Soil Group: C Ksat: Very low to moderately high (0.00 – 0.20 in/hr)

Soil limitations: Compact substratum, low available water capacity, low saturated hydraulic conductivity, deep water table.

WETLAND AREA & USGS WELL MEASUREMENTS

National Wetland Inventory Map: NA Wetlands Conservancy Program: NA Bordering vegetative wetland: >200 feet

Current Water Resource Condition (USGS): Well Site # 422341071464901-MA-WSW 26 West Boylston, MA.

Well completed in Sand and gravel aquifer. N100GLCIAL national aquifer.

Well depth: 16.8 feet Borehole depth: 17.0 feet Land surface altitude: 485.00 feet above NGVD29

Most recent data value: 7.65' on 07/14/14 (depth to water level in feet below land surface). Range: Normal

NATIONAL FLOOD INSURANCE RATE MAP

Above 500 year flood boundary? Yes Within 500 year flood boundary? No Within 100 year flood boundary? No

SURFICIAL GEOLOGY:

Surficial geology map: Qgm: Middle Wisconsin aged, ice-advance ground moraine. Map scale: 1:24,000'

Geologic parent material: Highly compressive subglacial till deposits

Geomorphic landform: Drumlinoid ridge Landform position (2D): Shoulder Landform position (3D): Nose slope

Slope gradient: ~5-16% Down slope shape: Convex Across slope shape: Convex Slope complexity: Simple

Bedrock outcropping in immediate vicinity: None Glacial erratics in immediate vicinity: None

TP14-1 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 0914

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10+ feet Drainage way: 50+ feet Drinking water well: 100+ feet

Wetlands: 200+ feet Open water body: 500+ feet Abutting septic system: 20+ feet

SOIL PROFILE ▶ TP14-1

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 10"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
10 → 23"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
23 → 52"	C_1	Loamy Sand	10YR52 grayish brown	none observed	Structurless, mixed medium to coarse grained mineral content, weakly stratified, poorly graded slumped bedding, dry matrix, low silt content, 40% sub-rounded to sub-angular gravel content, clear smooth boundary.
52 → 111"	C_{2d}	Sandy Loam	2.5Y54 lite olive brown	none observed	Friable, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls), weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix, no bedrock encountered at test pit depth.

Depth to bedrock: > 111" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-1 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: >111" (below land surface)

Type: _____ Abundance: _____ Size: _____ Contrast: _____

Shape: _____ Moisture state: _____ Location: _____

Hardness: _____ Boundary: _____ Concentration color: _____ Reduction color: _____

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ____ inches below grade

Observed water weeping from side of deep hole: ____ inches below grade

Observed depth to redoximorphic features: ____ inches below grade

Groundwater adjustment: ____

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ▶ 8.41 feet

Depth of naturally occurring pervious material in TP14-1 Upper boundary: 10"
Lower boundary: 111"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848* — June 1998

Printed name of evaluator & license number — Date of Soil Evaluator Certification

Unofficial soil testing. — 07/14/14

Town witness — Date of soil testing

TP14-2 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 1005

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10^{+} feet Drainage way: 50^{+} feet Drinking water well: 100^{+} feet

Wetlands: 200^{+} feet Open water body: 500^{+} feet Abutting septic system: 20^{+} feet

SOIL PROFILE ▸ TP14-2

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 11"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
11 → 18"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
18 → 112"	C_d	Sandy Loam	2.5Y54 lite olive brown	@ 72" (c,1,d)	Friable to slightly firm, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls) , weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix, no bedrock encountered at test pit depth..

Depth to bedrock: > 112" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-2 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: 72" (below land surface)

Type: Masses on grain surfaces Abundance: Common Size: Fine Contrast: Distinct

Shape: Irregular/ stringy and spherical Moisture state: Slightly damp Location: C_d matrix

Hardness: Soft Boundary: Diffuse Concentration color: 7.5R 5/8 (dark red) Reduction color: 10Y 7/1 (greenish gray)

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ___ inches below grade

Observed water weeping from side of deep hole: ___ inches below grade

Observed depth to redoximorphic features: 72" inches below grade

Groundwater adjustment: ___

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ▶ 8.41 feet

Depth of naturally occurring pervious material in TP14-2 Upper boundary: 11"
Lower boundary: 112"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848* — June 1998

Printed name of evaluator & license number — Date of Soil Evaluator Certification

Unofficial soil testing. — 07/14/14

Town witness — Date of soil testing

TP14-3 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 1040

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10+ feet Drainage way: 50+ feet Drinking water well: 100+ feet

Wetlands: 200+ feet Open water body: 500+ feet Abutting septic system: 20+ feet

SOIL PROFILE ▶ TP14-3

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 10"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
10 → 17"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
17 → 116"	C_d	Sandy Loam	2.5Y54 lite olive brown	@ 69" (c,1,d)	Friable to slightly firm, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls), weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix, no bedrock encountered at test pit depth..

Depth to bedrock: > 116" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-3 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: 69" (below land surface)

Type: Masses on grain surfaces Abundance: Common Size: Fine Contrast: Distinct

Shape: Irregular/ stringy and spherical Moisture state: Slightly damp Location: C_d matrix

Hardness: Soft Boundary: Diffuse Concentration color: 7.5R 5/8 (dark red) Reduction color: 10Y 7/1 (greenish gray)

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ____ inches below grade

Observed water weeping from side of deep hole: ____ inches below grade

Observed depth to redoximorphic features: 69" inches below grade

Groundwater adjustment: ____

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ▶ 8.83 feet

Depth of naturally occurring pervious material in TP14-3 Upper boundary: 10"
Lower boundary: 116"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848*
Printed name of evaluator & license number

June 1998
Date of Soil Evaluator Certification

Unofficial soil testing.
Town witness

07/14/14
Date of soil testing

TP14-4 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 1120

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10^{+} feet Drainage way: 50^{+} feet Drinking water well: 100^{+} feet

Wetlands: 200^{+} feet Open water body: 500^{+} feet Abutting septic system: 20^{+} feet

SOIL PROFILE ▶ TP14-4

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 09"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
09 → 20"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
20 → 114"	C_d	Sandy Loam	2.5Y54 lite olive brown	@ 72" (c,l,d)	Friable to slightly firm, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls), weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix, no bedrock encountered at test pit depth.

Depth to bedrock: > 114" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-4 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: 72" (below land surface)

Type: Masses on grain surfaces Abundance: Common Size: Fine Contrast: Distinct

Shape: Irregular/ stringy and spherical Moisture state: Slightly damp Location: C_d matrix

Hardness: Soft Boundary: Diffuse Concentration color: 7.5R 5/8 (dark red) Reduction color: 10Y 7/1 (greenish gray)

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ____ inches below grade

Observed water weeping from side of deep hole: ____ inches below grade

Observed depth to redoximorphic features: 72" inches below grade

Groundwater adjustment: ____

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ▶ 8.75 feet

Depth of naturally occurring pervious material in TP14-4 Upper boundary: 09"
Lower boundary: 114"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848* — Printed name of evaluator & license number

June 1998 — Date of Soil Evaluator Certification

Unofficial soil testing. — Town witness

07/14/14 — Date of soil testing

TP14-5 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 1145

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10+ feet Drainage way: 50+ feet Drinking water well: 100+ feet

Wetlands: 200+ feet Open water body: 500+ feet Abutting septic system: 20+ feet

SOIL PROFILE ▶ TP14-5

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 03"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
03 → 08"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
08 → 109"	C_d	Sandy Loam	2.5Y54 lite olive brown	@ 64" (c,2,d)	Friable to slightly firm, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls), weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix. Saprolitic muscovite schist encountered in test pit. Soft to hard rock at various degrees of decomposition. Fe and Mn colors dominate matrix.

Depth to bedrock: > 109" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-5 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: 64" (below land surface)

Type: Masses on grain surfaces Abundance: Common Size: Medium Contrast: Distinct

Shape: Irregular/ stringy and spherical Moisture state: Slightly damp Location: C_d matrix

Hardness: Soft Boundary: Diffuse Concentration color: 7.5R 5/8 (dark red) Reduction color: 10Y 7/1 (greenish gray)

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ___ inches below grade

Observed water weeping from side of deep hole: ___ inches below grade

Observed depth to redoximorphic features: 64" inches below grade

Groundwater adjustment: ___

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ▶ 8.41 feet

Depth of naturally occurring pervious material in TP14-5 Upper boundary: 08"
Lower boundary: 109"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848* — Printed name of evaluator & license number

June 1998 — Date of Soil Evaluator Certification

Unofficial soil testing. — Town witness

07/14/14 — Date of soil testing

TP14-6 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

Date: July 14, 2014

Time: 1230

Weather: partly cloudy, humid, warm, 87°F, calm.

Position on landscape: Side slope of hill Slope aspect: Southerly Vegetation: Meadow & hay grasses

Property line: 10^{+} feet Drainage way: 50^{+} feet Drinking water well: 100^{+} feet

Wetlands: 200^{+} feet Open water body: 500^{+} feet Abutting septic system: 20^{-} feet

SOIL PROFILE ▸ TP14-6

Depth below land surface (inches)	Soil Horizon/ Layer	Soil Texture (USDA/ NRCS)	Soil Color (EarthColors)	Redoxomorphic Features from ESHGWT	Consistence, structure (grade & size), grain size, soil moisture state, roots, clasts, stratification, artifacts, restrictive features, horizon boundary etc.
00 → 09"	A_p	Sandy Loam	10YR22 very dark brown	none observed	Soft to very soft, fine to medium granular structure (moderate grade), fine grained mineral content, dry matrix, many fine grass roots, free of clasts, plowed horizon showing clear smooth boundary.
09 → 18"	B_w	Sandy Loam	2.5YR56 lite olive brown	none observed	Soft to very soft, medium to coarse sub-angular blocky structure (moderate grade), fine to medium grained mineral content, dry matrix, few fine grass roots, free of clasts, diffuse wavy boundary.
18 → 106"	C_d	Sandy Loam	2.5Y54 lite olive brown	@ 38" (m,2,p)	Friable to slightly firm, medium to coarse sub-angular platy structure (strong grade), mixed very fine to fine grained mineral content, slightly damp, tight compact matrix, moderate silt content (smearing of pit walls), weakly stratified, 40% sub-rounded to angular gravel content, 30% sub-rounded to sub-angular cobble content, clasts tightly nested in matrix.

Depth to bedrock: > 106" Hydrologic Soil Group: C Drainage Class: Well drained

Soil map unit: 305B/C – Paxton fine sandy loam (sandy, mixed, mesic, Typic Dystrochrepts), 3-15% slopes.

TP14-6 DEEP OBSERVATION HOLE

#43 Estabrook Avenue, Grafton, Massachusetts

DEPTH TO APPARENT/ PHREATIC GROUNDWATER TABLE: *Not Observed*

Apparent water seeping from pit face:_____ (Below land surface) Depth to stabilized apparent water: _____ (Below land surface)

Soil moisture state: Dry to slightly damp

ESTIMATED SEASONAL HIGH GROUNDWATER TABLE:

Depth of Estimated Seasonal High Groundwater Table: 38" (below land surface)

Type: Masses on grain surfaces Abundance: Many Size: Medium Contrast: Prominent

Shape: Irregular/ stringy and spherical Moisture state: Slightly damp Location: C_d matrix

Hardness: Soft Boundary: Diffuse Concentration color: 7.5R 5/8 (dark red) Reduction color: 10Y 7/1 (greenish gray)

DETERMINATION OF HIGH GROUNDWATER ELEVATION

Observed depth to stabilized phreatic water: ____ inches below grade

Observed water weeping from side of deep hole: ____ inches below grade

Observed depth to redoximorphic features: 38" inches below grade

Groundwater adjustment: ____

DEPTH OF NATURALLY OCCURRING PERVIOUS MATERIAL: ► 8.08 feet

Depth of naturally occurring pervious material in TP14-6 Upper boundary: 09"
Lower boundary: 106"

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.017.

Alexander F. Parker *License #1848*
Printed name of evaluator & license number

June 1998
Date of Soil Evaluator Certification

Unofficial soil testing.
Town witness

07/14/14
Date of soil testing

GEOSYNTEC CONSULTANTS
GEOTECHNICAL INVESTIGATION

Geosyntec consultants

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www.geosyntec.com

Memorandum

Date: 3 July 2014

To: Rick Wait, Jr. and Adam Christie, Meridian Associates

From: Youngmin Cho, Ph.D., Mike Toth, and David J. Bonnett, P.E., Geosyntec Consultants

Subject: Geotechnical Investigation
43 Estabrook Avenue Solar Development Project – Phase 2
Grafton, Massachusetts

This memorandum presents the findings of a limited field investigation conducted for the proposed solar development at 43 Estabrook Avenue in Grafton, Massachusetts (the Site). A summary of site conditions and regional geology along with the results of geotechnical borings performed at the Site on 25 and 26 June 2014 are presented below.

REGIONAL GEOLOGY AND SITE CONDITIONS

Located in Worcester County, Massachusetts, Grafton is situated in the northern portion of the Blackstone River Valley. The terrain consists primarily of drumlins with ridgelines oriented north to south, containing unconsolidated clay, gravel, and/or sand. The majority of soil deposits consist of well graded, poorly sorted materials including boulders and stones deposited by glacial activity. According to Bedrock Geologic Map of the Grafton Quadrangle, Worcester County, Massachusetts, prepared by Walsh, G.J., Aleinikoff, J.N., and Dorias, M.J. of United States Geological Survey (USGS), dated July 2011, the bedrock and rock outcrops in the Grafton area typically consist of deformed Neoproterozoic to early Paleozoic crystalline metamorphic and intrusive igneous rock.

The proposed solar development is located on a parcel of land that includes open fields and wooded areas. Open portions of the land were formerly used for agriculture. The site appears to be free-draining as topography, generally south-facing slope. Rock outcrops are sporadic throughout the parcel.

SUBSURFACE EXPLORATION PROGRAM

Technical Drilling Services of Sterling, Massachusetts, was subcontracted by Geosyntec to advanced ten soil borings, SB-1 through SB-10, to a depth of 18 ft below ground surface (bgs) within the proposed development area. The approximate locations of the soil borings were field-verified and recorded using hand-held GPS survey equipment. Boring locations are presented on the attached Figure 1. The borings were advanced using 4.25-inch inner diameter hollow stem augers to the target depth or until refusal occurred. Continuous standard penetration testing (SPT) and split spoon sampling were performed at each location. Sampling was performed at 2 ft intervals.

SUBSURFACE CONDITIONS

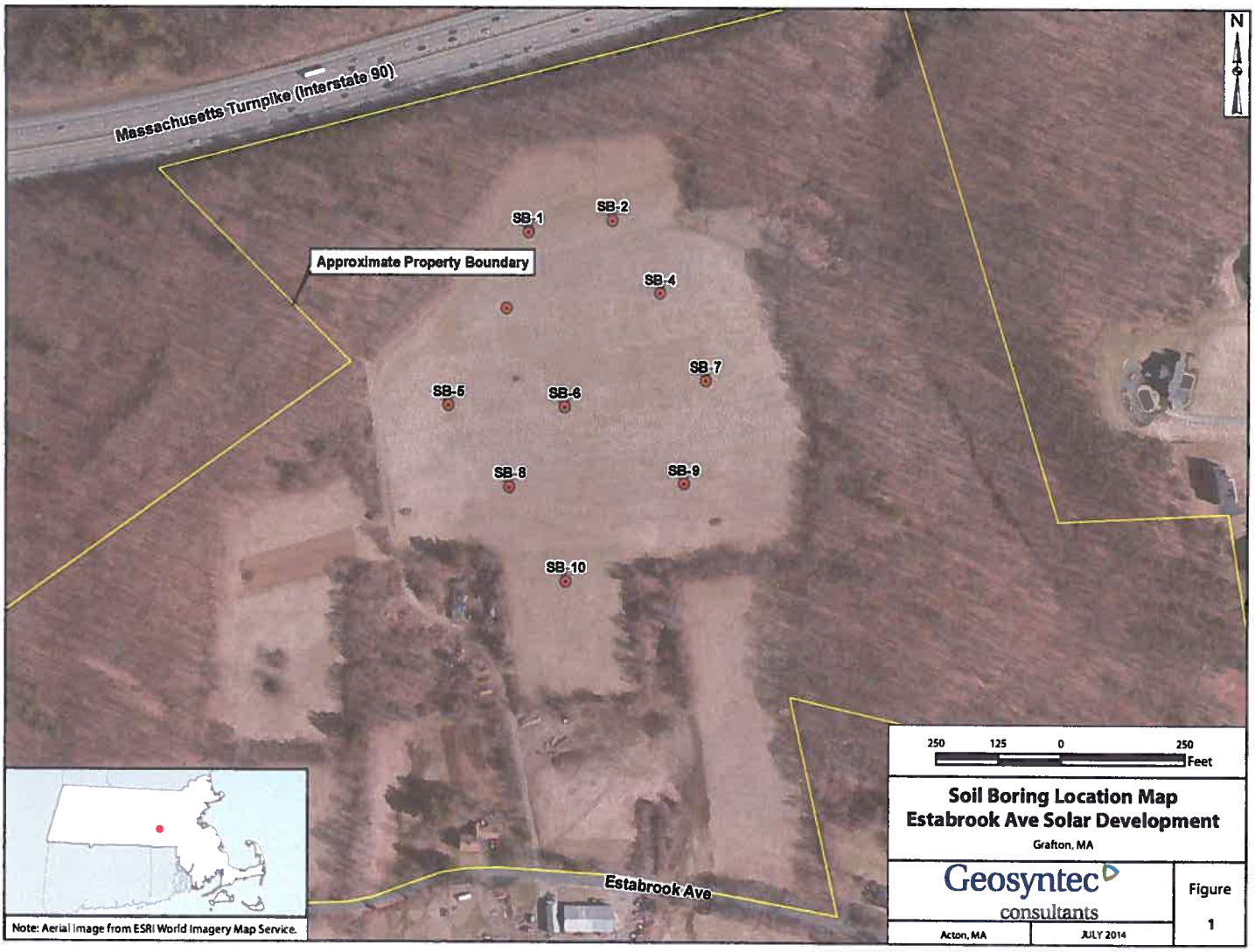
Logs for the ten borings advanced including soil descriptions and blow count records are presented in Attachment A. Soil samples obtained from the borings were generally observed to consist of silty fine sand with trace coarse sand. Boulders were prevalent in the soil strata as boulder fragments were observed generally throughout the entire boring depths. The SPT blow counts (N values) recorded during sampling indicate the soils generally range in density from loose at shallow depths to very dense at larger depths. At SB-2, SB-5, SB-6, SB-7, SB-9, and SB-10, bedrock was encountered at relatively shallow depths, ranging from 4.5 to 17.5 ft bgs, with boulders and rock outcrops observed within the proposed solar development area (Phase 2). Due to the presence of boulders, SPT rods were refused advancement at locations SB-3, SB-6, and SB-8. Soils were mostly dry to moist, and groundwater was observed only at 17 ft bgs at location SB-4.

For reference and comparison to the results of the field investigation, additional soil data provided by the National Resources Conservation Service (NRCS) web soil survey is presented in Attachment B.

Based on the results of this field investigation, the soil encountered during drilling and sampling is suitable for installing a driven type of foundation system (e.g., soil crew or pile) to a depth of 6 ft to 10 ft bgs. It should be noted that bedrock was observed at 4.5 ft bgs in SB-5, which is shallower than other locations. Therefore, any foundation design should account for the shallow bedrock formation.

* * * * *

Attachments: Figure 1
Boring Logs
NRCS Soil Survey



Soil Boring Location Map
Estabrook Ave Solar Development
Grafton, MA

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Acton, MA | JULY 2014

Figure 1

ATTACHMENT A

BORING LOGS

Geosyntec consultants

Borehole No. SB-1

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,634.08 E 611,882.55
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Geologic Samples: Sample Interval (ft)	Geologic Samples: Recovery (in)	Geologic Samples: SPT Blowcount (per 6-inches)	Comments
0			SILTY FINE SAND: light brown to olive gray, dry	SM	0-2	22	3-2-2-3	
			SILTY FINE SAND: light brown to olive gray, dry	SM	2-4	20	32-24-21-16	
5			SILTY FINE SAND: light brown to olive gray, dry	SM	4-6	18	14-14-11-12	
			SILTY FINE SAND: some medium sand and boulder, light brown to olive gray, dry	SM	6-8	16	14-15-14-18	
			FINE SAND: some silt, light gray to light brown, dry	SP	8-10	12	9-19-14-17	
10			FINE SAND: some silt, light gray to light brown, dry	SP	10-12	16	5-18-13-50	
			Borehole Terminated at 12.0 ft					
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

Geosyntec consultants

Borehole No. SB-2

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,658.43 E 612,052.29
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			FINE SAND: boulder, light brown, dry	SP	0-2	5	10-22-32-24	
			SILT: some sand and boulder, light brown, dry	ML	2-4	18	22-29-21-15	
5			SILT: some sand and boulder, light brown, dry	ML	4-6	18	22-25-27-35	
			SAND AND WEATHERED BEDROCK: gray, dry	SPG	6-7	1	100	
			Borehole Terminated at 7.0 ft					Refusal at 7.0 ft
10								
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

Geosyntec consultants

Borehole No. SB-3

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,482.34 E 611,839.26
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILT: some sand, light brown to olive gray, dry	ML	0-2	22	3-2-4-5	
			SILTY FINE SAND AND BOULDER: olive gray to light brown, dry	SM	2-4	14	6-19-24-28	
5			SILTY FINE SAND AND BOULDER: olive gray to light brown, dry	SM	4-6	18	24-20-15-18	
			FINE SAND: boulder, light gray, dry	SP	6-8	12	24-22-18-37	
			FINE SAND AND BOULDER: yellowish orange, dry	SP	8-9	6	11-100	
			Borehole Terminated at 9.0 ft					Refusal at 9.0 ft
10								
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations.

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Borehole No. SB-4

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,511.58 E 612,147.71
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILTY FINE SAND: boulder, light brown, dry	SM	0-2	18	3-10-25-24	
			SILTY FINE SAND: boulder, light brown, dry	SM	2-4	20	27-22-19-18	
5			SAND AND GRAVEL: gray, dry	SM	4-6	4	17-14-16-14	
			SAND: boulder, light gray to light brown, dry	SP	6-8	24	23-17-26-24	
			SILTY FINE SAND: boulder, light brown to light gray, dry	SM	8-10	12	11-10-11-22	
10			SILTY FINE SAND: boulder, light brown, moist	SM	10-12	15	4-5-17-38	
			SILTY FINE SAND: boulder, light brown, moist	SM	12-14	15	25-35-37-33	
15			FINE SAND AND BOULDER: light brown, moist	SP	14-16	12	21-21-29-52	
	▽		FINE SAND AND BOULDER: light brown, Saturated, GT @ 17' bgs	SP	16-18	8	14-29-27-31	
			Borehole Terminated at 18.0 ft					

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)

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Borehole No. SB-5

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,286.91 E 611,722.81
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Geologic Samples: Sample Interval (ft)	Geologic Samples: Recovery (in)	Geologic Samples: SPT Blowcount (per 6-inches)	Comments
0			FINE SAND AND BOULDER: light brown, dry	SP	0-2	12	3-3-6-10	
			FINE SAND AND BOULDER: light brown to light gray, dry	SP	2-4	12	17-19-21-23	
			WEATHERED BEDROCK: whit to light gray, dry		4-4.5	6	58-100	
5			Borehole Terminated at 4.5 ft					Refusal at 4.5 ft
10								
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations.

Geosyntec consultants

Borehole No. SB-6

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Youngmin Cho	**Borehole Coordinates:**	N 2,907,282.94 E 611,957.28
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILT: some fine sand, light brown, dry	ML	0-2	16	3-7-17-18	
			SILT AND BOULDER: some sand, light brown, dry	ML	2-4	4	120	Refusal at 2.5 ft, augered to 4.0 ft bgs.
5			SILT AND BOULDER: some sand, light brown, dry	ML	4-6	14	9-16-17-19	
			SILT: some sand and boulder, light brown, dry	ML	6-8	22	17-9-9-23	
			WEATHERED BEDROCK: some silty fine sand, whit to light gray, dry		8-9.7	18	20-24-120	
10			Borehole Terminated at 9.7 ft					Refusal at 9.7 ft
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

Geosyntec consultants

Borehole No. SB-7

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Mike Toth	**Borehole Coordinates:**	N 2,907,337.03 E 612,240.57
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	25 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILT: light brown, dry	ML	0-2	12	3-4-4-4	
			SILT: some fine sand and boulder, light brown, dry	ML	2-4	18	19-17-25-22	
5			SANDY SILT AND BOULDER: light brown to light gray, dry	ML	4-6	18	17-18-26-46	
			FINE SAND AND WEATHERED BEDROCK: light brown to light gray, dry	SP	6-7	6	54-100	
			Borehole Terminated at 7.0 ft					Refusal at 7.0 ft
10								
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb. 30" drop)
Ground water not encountered during drilling operations.

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Borehole No. SB-8

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Youngmin Cho	**Borehole Coordinates:**	N 2,907,122.80 E 611,846.34
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	26 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILTY FINE SAND: some coarse sand and boulder, light brown, dry	SM	0-2	18	2-3-4-4	
			BOULDER: some fine sand, light gray to light brown, dry		2-4	18	30-35-46-37	
5			BOULDER: some fine sand, light gray to light brown, dry		4-6	12	56-35-36-37	
			SILTY FINE SAND: some coarse sand and boulder, brown, dry	SM	6-8	24	28-16-17-19	
			SILTY FINE SAND AND BOULDER: olive gray to brown, dry	SM	8-8.25	3	120	Refusal at 8.3 ft
			Borehole Terminated at 8.3 ft					
10								
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

Geosyntec consultants

Borehole No. SB-9

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Youngmin Cho	**Borehole Coordinates:**	N 2,907,129.19 E 612,197.44
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	26 June 2014
Borehole Diameter:	8 inches		

Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILTY FINE SAND: trace of coarse sand, yellowish orange, dry	SM	0-2	6	2-3-3-2	
			SILTY FINE SAND: trace of coarse sand, yellowish orange, dry	SM	2-4	18	4-3-4-5	
5			SILTY FINE SAND: boulder and trace of coarse sand, olive gray, dry	SM	4-6	5	5-12-16-25	
			SILTY FINE SAND: some coarse sand and boulder, light gray, dry	SM	6-8	22	25-26-23-27	
			SILTY FINE SAND: some coarse sand and boulder, light gray, dry	SM	8-10	18	7-34-35-22	
10			SILTY FINE SAND: boulder, olive gray, dry	SM	10-12	24	17-12-24-19	
			SILTY FINE SAND: boulder, some coarse sand, yellowish orange, dry	SM	12-14	20	19-19-19-22	
15			SILTY FINE SAND: boulder, some coarse sand, yellowish orange, dry	SM	14-16	18	12-7-19-27	
			SILTY FINE SAND AND WEATHERED BEDROCK: some coarse sand, yellowish orange, dry	SM	16-17.5	16	37-45-120	
			Borehole Terminated at 17.5 ft					Refusal at 17.5 ft

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

Geosyntec consultants

Borehole No. SB-10

Borehole Log

Project No.:	BE0191	**Project Name:**	43 Estabroon Ave.
Client:	Meridian Associates	**Location:**	Grafton, MA
Logged By:	Youngmin Cho	**Borehole Coordinates:**	N 2,906,933.87 E 611,960.37
Reviewed By:	Jon Gillen	**Site Datum:**	NAD 83 Massachusetts Mainland
Drilling Company:	Technical Drilling Services	**Ground Surface Elevation:**	Not Surveyed
Driller:	Brett Baryk	**Top PVC Casing Elevation:**	Not Applicable
Drilling Method:	4.25 Hollow Stem Augers	**Well Material:**	NA
Sampling Method:	2 Split Spoon	**Completion Date:**	26 June 2014
Borehole Diameter:	8 inches		

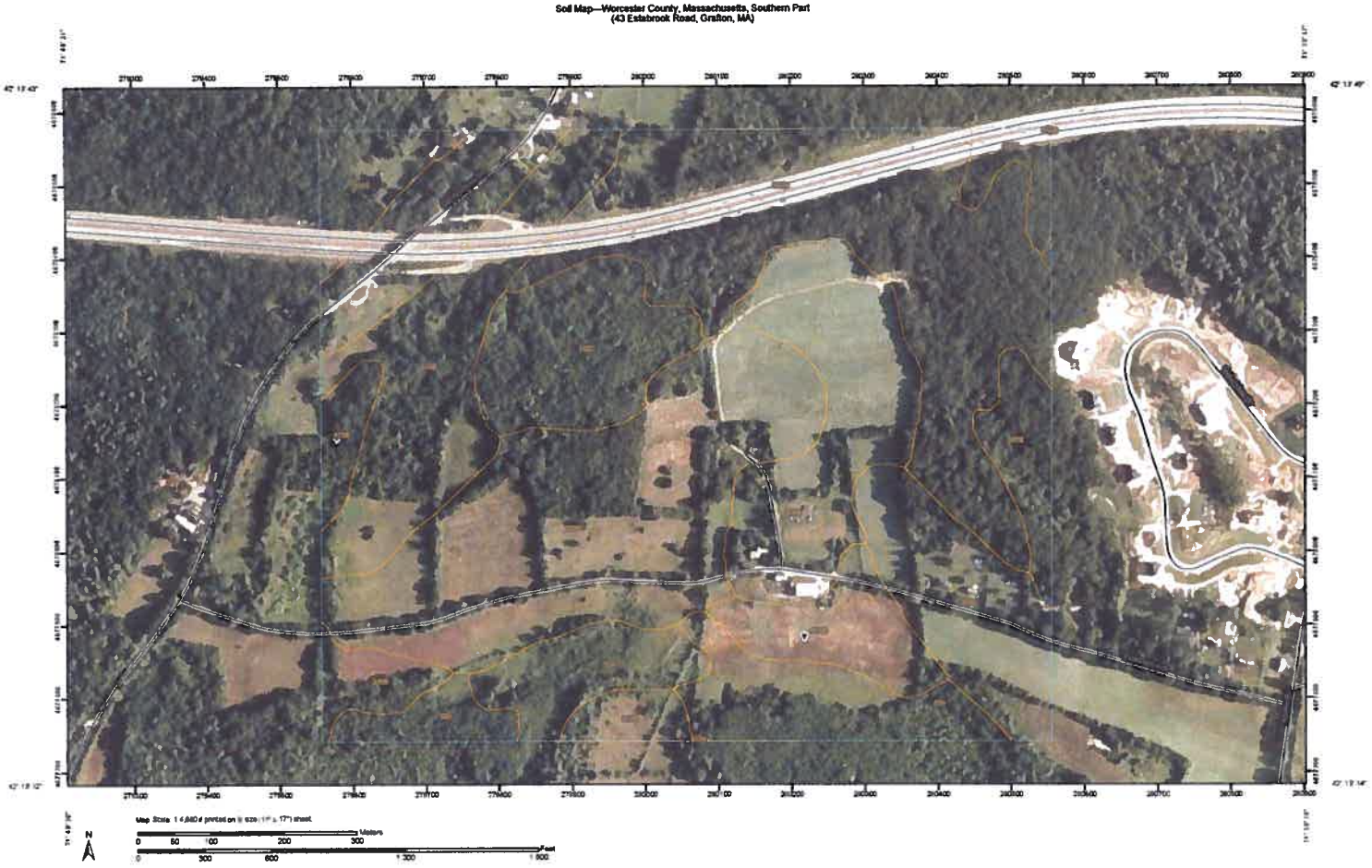
Depth (ft)	Water Level	Stratigraphy	Lithologic Description	Geologic Samples: Unified Soil Classification	Sample Interval (ft)	Recovery (in)	SPT Blowcount (per 6-inches)	Comments
0			SILTY FINE SAND AND BOULDER: brown, dry	SM	0-2	12	5-4-6-20	
			SILTY FINE SAND AND BOULDER: light gray, dry	SM	2-4	21	21-19-16-15	
5			SILTY FINE SAND AND BOULDER: brown to olive gray, dry	SM	4-6	21	15-30-19-20	
			SILTY FINE SAND AND BOULDER: brown to olive gray, dry	SM	6-8	20	31-32-29-30	
			SILTY FINE SAND AND BOULDER: brown to olive gray, dry	SM	8-10	18	10-14-12-6	
10			SILTY FINE SAND AND WEATHERED BEDROCK: brown to olive gray, dry	SM	10-11	6	18-19-25-120	Refusal at 11.0 ft
			Borehole Terminated at 11.0 ft					
15								

Notes: bgs = below ground surface
SPT = Standard Penetration Test (140 lb, 30" drop)
Ground water not encountered during drilling operations

ATTACHMENT B

NRCS SOIL SURVEY

Soil Map—Worcester County, Massachusetts, Southern Part
(43 Estabrook Road, Grafton, MA)



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

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
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:4,680 if printed on B size (11" × 17") sheet.

The soil surveys that comprise your AOI were mapped at 1:25,000.

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 accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 19N NAD83

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

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 5, Jan 30, 2007

Date(s) aerial images were photographed: 8/19/2003

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

Worcester County, Massachusetts, Southern Part (MA615)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
52A	Freetown muck, 0 to 1 percent slopes	13.4	6.5%
73A	Whitman sandy loam, 0 to 3 percent slopes, extremely stony	7.2	3.5%
102C	Chatfield-Hollis-Rock outcrop complex, 3 to 15 percent slopes	22.6	11.0%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	19.2	9.3%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	53.0	25.8%
307B	Paxton fine sandy loam, 3 to 8 percent slopes, extremely stony	41.5	20.2%
307E	Paxton fine sandy loam, 15 to 35 percent slopes, extremely stony	4.9	2.4%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	33.5	16.3%
312B	Woodbridge fine sandy loam, 3 to 8 percent slopes, extremely stony	5.0	2.4%
420B	Canton fine sandy loam, 3 to 8 percent slopes	2.7	1.3%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	2.7	1.3%
Totals for Area of Interest		**205.8**	**100.0%**