FINAL

HYDROGEOLOGIC EVALUATION
ROUTE 6 (EXIT 12) CLOVERLEAF SITE
TOWN OF ORLEANS, MASSACHUSETTS

Prepared for:
Town of Orleans
19 School Road
Orleans, Massachusetts 02653

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October 2017

Project No. 60476644

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1. INTRODUCTION AND BACKGROUND

The Hydrogeologic Evaluation Technical Memorandum documents the approach used to evaluate Route 6 (Exit 12) Cloverleaf (Figure 1) for a groundwater discharge from the proposed Downtown Area wastewater treatment facility (WWTF). This Memorandum includes the following:

- Description of the initial steps taken in the process of evaluating groundwater discharge sites;
- Summary of existing data that is available to help evaluate the Route 6 (Exit 12) Cloverleaf site;
- Summary of field investigations conducted at Route 6 (Exit 12) Cloverleaf site;
- Evaluation of field investigations and other available data;
- Results of groundwater flow modeling and groundwater mounding analysis; and
- Recommended maximum discharge capacity for the Route 6 (Exit 12) Cloverleaf site.

The purpose of this document is to provide a transparent and objective assessment of the Route 6 (Exit 12) Cloverleaf site for the discharge of WWTF effluent. If the Town chooses to use the site for a groundwater discharge, a Hydrogeologic Evaluation will be submitted to the Massachusetts Department of Environmental Protection (MassDEP) as part of the Groundwater Discharge Permit (GWDP) application process.


MID CAPE HIGHWAY
WEST ROAD
OAK RIDGE LANE
RAMP-RT 6 WB TO RT 6A
CRANBERRY HIGHWAY
RAMP-RT 6A TO RT 6 WB
RAMP-RT 6A TO RT 6 EB
6A
Route 6 (Exit 12) Cloverleaf Site
6
FINLAY ROAD
RAMP-RT 6 EB TO RT 6A
MID CAPE HIGHWAY
BAKERS POND ROAD
OPA'S WAY
LONG VIEW DRIVE
FIREMANS KNOLL
G:\Projects\MUNI\60476644\ORL\Maps\GWD_Cloverleaf_Figure1.mxd
FIGURE 1
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
LOCUS MAP
0 150 300
Feet
AECOM

2. PROPOSED COLLECTION, TREATMENT, AND DISCHARGE FACILITIES

2.1. Collection Area and WWTF

MEP estimates that approximately 7,000 kilograms per year (kg/yr) nitrate load of the nitrate load from existing and future septic load will need to be removed from the Town Cove Watershed to meet the nutrient load reduction target for Town Cove. The OWQAP evaluated traditional and non-traditional nutrient reduction technologies for nitrate removal within the watershed. Due to the significant nitrate load removal within the Town Cove Watershed, the OWQAP proposed to manage a significant portion of the nitrate load through the construction of wastewater collection, treatment, and disposal facilities in the Consensus Plan. Flow from the collection area will be primarily residential and commercial. Flows are estimated at 260,000 gallons per day (gpd). The proposed collection area is shown on Figure 2. The method of treatment is also being evaluated although a sequencing batch reactor (SBR) facility is considered likely. The location of potential discharge sites are shown on Figure 3.

2.2. Discharge Sites Considered

Nine potential locations for groundwater discharge of wastewater treatment facility effluent were considered including:

- Overland Way (Parcels 1/1A);
- Route 6 Interchange (Exit 12 Cloverleaf);
- Thayer Property (Orleans Market Place);
- Old Colony Apartments (Old Colony Way);
- Hole in One Restaurant Parking (Cranberry Highway);
- Depot Square (Old Colony Way);
- Orleans Elementary (46 Eldredge Park Way);
- Nauset Regional Middle School (70 Eldredge Park Way); and
- Orleans Firebirds Baseball Field (80 Eldredge Park Way).

2.3. Site Suitability Criteria and Analysis

A Site Selection Matrix was developed for objective evaluation of selected discharge sites. The Matrix includes criteria for Site Suitability, Permitting, Project Evaluation and Other/Overriding Considerations. These criteria address environmental, land use and implementation features of the proposed discharge locations. Permitting criteria assess regulatory requirements and potential conflicts related to the proposed discharge locations. Project evaluation criteria evaluate the benefits gained from a proposed discharge site. The site selection screening was based on data available at the time of the screening process.

AECOM collected site specific information for each, conducted site visits, and evaluated the potential performance effectiveness. A rating system was then developed to quantify how well each site met a specific criterion. The point-based system used is as follows.

A. Project Evaluation

- Watershed total maximum daily load (TMDL) – Discharging to a watershed with a nitrate total maximum daily load may require higher treatment levels at the wastewater treatment facility significantly increasing capitol and O&M costs.
- Conclusion of Previous Studies – The quality and conclusion of previous studies can impact the tasks necessary to perform the required MassDEP Hydrogeologic Evaluation.

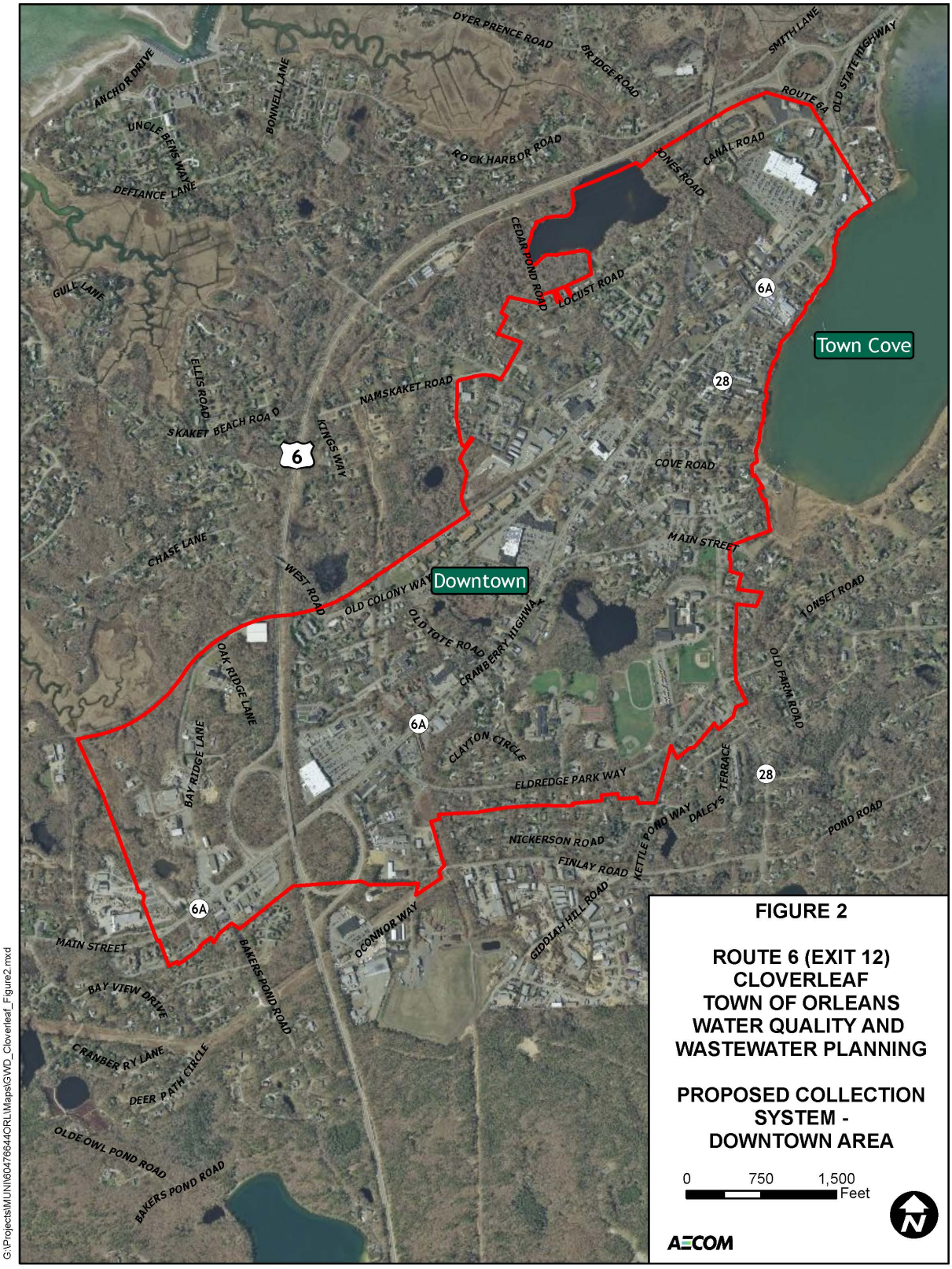
DYER PRENCE ROAD
BRIDGE ROAD
SMITH LANE
OLD STATE HIGHWAY
ROUTE 6A
ANCHOR DRIVE
UNCLE BENS WAY
BONNELL LANE
ROCK HARBOR ROAD
JONES ROAD
CANAL ROAD
DEFIANCE LANE
CEDAR POND ROAD
LOCUST ROAD
GULL LANE
6A
Town Cove
ELLIS ROAD
NAMSKAKET ROAD
28
SKAKET BEACH ROAD
KINGS WAY
6
COVE ROAD
CHASE LANE
MAIN STREET
WEST ROAD
OLD COLONY WAY
Downtown
TONSET ROAD
OLD TOTE ROAD
CRANBERRY HIGHWAY
OAK RIDGE LANE
OLD FARM ROAD
6A
BAY RIDGE LANE
CLAYTON CIRCLE
ELDREDGE PARK WAY
28
DALEY'S TERRACE
KETTLE POND WAY
POND ROAD
NICKERSON ROAD
FINLAY ROAD
6A
MAIN STREET
O'CONNOR WAY
GIDDIAH HILL ROAD
BAKERS POND ROAD
BAY VIEW DRIVE
CRANBERRY LANE
DEER PATH CIRCLE
OLDE OWL POND ROAD
BAKERS POND ROAD
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FIGURE 2
ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND WASTEWATER PLANNING
PROPOSED COLLECTION SYSTEM - DOWNTOWN AREA
0
750
1,500
Feet
N
AECOM

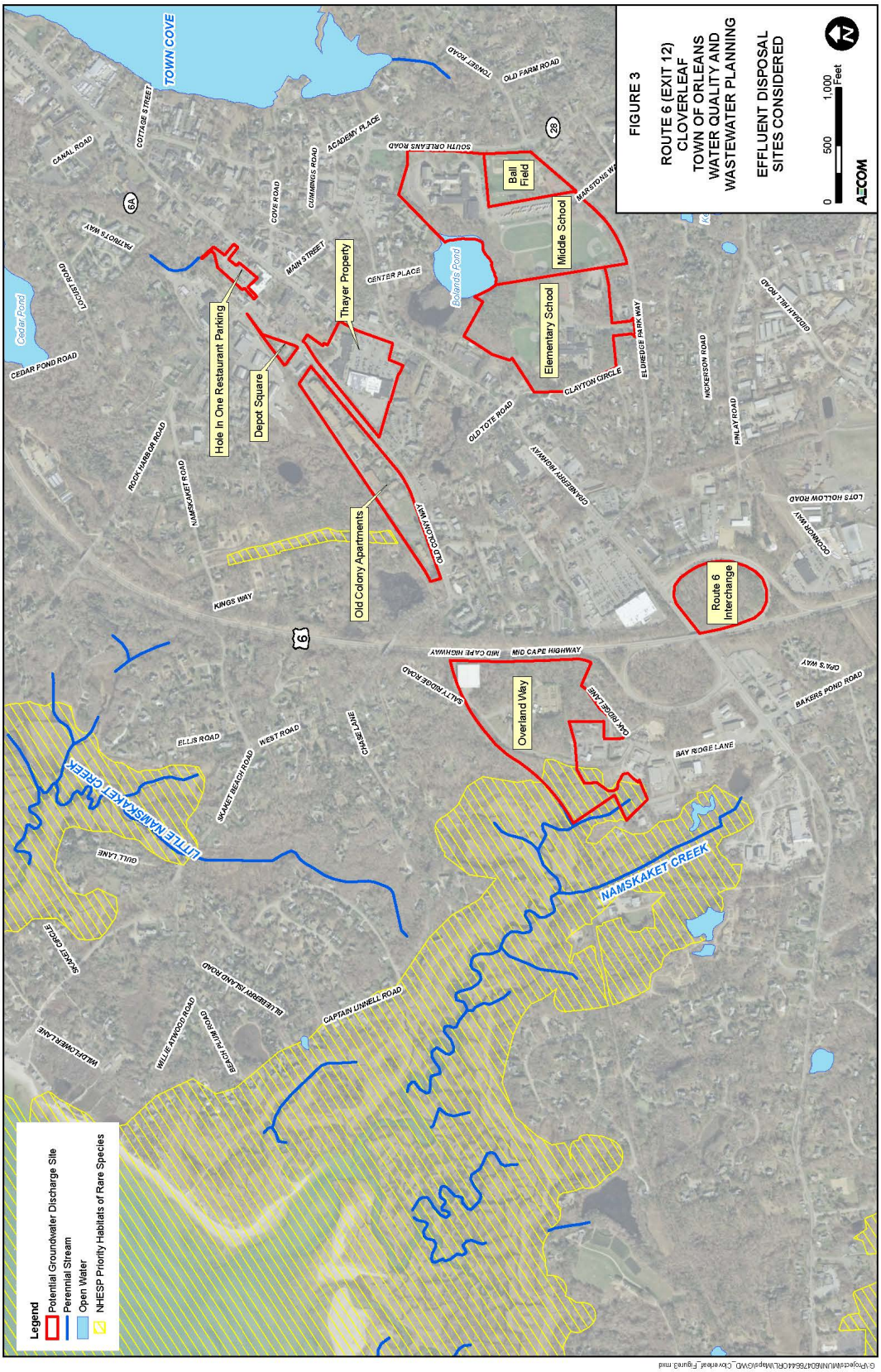
FIGURE 3
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
EFFLUENT DISPOSAL
SITES CONSIDERED
0
500
1,000
Feet
AECOM
TOWN COVE
Cedar Pond
Bolands Pond
Ball Field
Middle School
Elementary School
Thayer Property
Hole In One Restaurant Parking
Depot Square
Old Colony Apartments
Route 6 Interchange
Overland Way
LITTLE NAMSKAKET CREEK
NAMSKAKET CREEK
TOWNER ROAD
OLD FARM ROAD
SOUTH ORLEANS ROAD
ACADEMY PLACE
CANAL ROAD
COTTAGE STREET
MAIN STREET
CENTER PLACE
CEDAR POND ROAD
CLAYTON CIRCLE
OLD TOTE ROAD
KINGS WAY
MID CAPE HIGHWAY
SALTY RIDGE ROAD
BAY RIDGE LANE
BAKERS POND ROAD
ELLIS ROAD
WEST ROAD
SKAKET BEACH ROAD
GULL LANE
CAPTAIN LINNELL ROAD
Legend
Potential Groundwater Discharge Site
Perennial Stream
Open Water
NHESP Priority Habitats of Rare Species

The Site Selection Matrix includes the following criteria that can be understood from currently available information and excluding hydrogeology which will be the subject of the investigations:

B. Site Suitability

- Property Ownership – Town owned, open space, privately owned, developed, undeveloped,
- Distance from wastewater treatment facility – The length of the force main and route it would follow must be installed significantly affecting overall costs.
- Ease of Access/Use of Property – Whether the discharge area is in an open area, under an existing parking lot, or in a developed area can affect the size and cost of the discharge area as well as installation and maintenance costs.
- Site Topography - Significant changes in elevation may affect construction and monitoring.
- Present Use of Site – Developed sites may be difficult to gain an easement agreement or right-of-way for a groundwater discharge.
- Potential Use of Site – Sites that are zoned or slated for future development may be more difficult to get permission to access and can impact the purchase price of parcel or alter the value of Town owned land.
- Depth to Groundwater - Deeper water table increases costs and may affect feasibility.
- Subsurface Soils Profile – Finer, lower transitivity soils (silt and clay) between the ground surface and 20 feet or so below the groundwater table can limit the amount of groundwater that can be discharged as well as the method of discharge (open bed, subsurface, wick, etc.).
- Area Available for Groundwater Discharge – Smaller discharge areas limit the amount of groundwater discharge potentially requiring discharge infrastructure at several locations.
- Downgradient Water Use – Public water supply or potable water supply wells are located nearby or down gradient.

C. Permitting

- Potential for Watershed/Estuary Impacts - Distance from surface water and wetland resource areas/ water use considerations.
- Potential Impacts to an ACEC.
- Presence of Rare and Endangered species.
- Required Effluent Discharge Quality – Site specific and surrounding conditions can impact required wastewater treatment facility discharge quality such as disinfection, nitrate levels, etc.
- Groundwater Discharge Method(s) – Capital and O&M costs for groundwater discharge methods vary. Site conditions can impact what discharge methods can be used.

2.4. Findings and Recommendations

The site suitability evaluation process resulted in the following ranking of sites:

- Overland Way (Sites 1/1A) – 13 Points
- Route 6 Interchange (Exit 12 Cloverleaf) – 8 Points
- Depot Square (Old Colony Way) – 5 Points
- Old Colony Apartments (Old Colony Way) – 5 Points

- Thayer Property (Orleans Market Place) – 1 Point
- Hole in One Restaurant Parking (Cranberry Highway) – 1 Point

2.5. Site Review and Shortlisted Sites

The initial groundwater discharge sites were reviewed by the Selectmen at an open meeting on Wednesday December 14, 2016. Two locations were initially shortlisted for hydrogeologic evaluation; Route 6A (Exit 12) Cloverleaf and the Overland Way.

The Route 6 (Exit 12) Cloverleaf site was considered for two primary reasons. First, the site is located relatively close to the proposed WWTF at Overland Way; second, the site is located outside the Town Cove Watershed allowing for the complete removal of the nitrate load from nitrate impacted watershed. Preliminary model runs of the USGS Monomoy Lens Groundwater Model indicated that most if not all of the discharge up to 150,000 gpd would flow under the Namskaket and Little Namskaket Marshes discharging to Cape Cod Bay, outside of an estuary where the effluent nitrate could be a potential issue. Flows of 150,000 gpd or greater indicated that a small percentage of the discharge could enter the outer reaches of the Namskaket and Little Namskaket Marshes near the mouth of the streams. The focus of this report is the hydrogeologic evaluation that was performed at the Route 6 (Exit 12) Cloverleaf site including the groundwater model results resulting from the calibrated groundwater mode.

The Route 6 (Exit 12) Cloverleaf site is located in west Orleans at the interchange of Route 6 and Route 6A (Figure 4). The parcel is owned by the Commonwealth of Massachusetts, MassDOT. In the fall of 2015, the Town approached MassDOT for permission to access the Cloverleaf site to perform a hydrogeologic investigation. In February 2017 a site access permit was obtained from MassDOT (Appendix A). In March 2017, a hydrogeologic evaluation commenced to evaluate the site for a groundwater discharge.

On December 15, 2016, a proposed scope of work to conduct a Hydrogeologic Site Evaluation was submitted to MassDEP for review and comment. The notification of the proposed scope of work was published in Volume 85, Issue 4 on December 23, 2015 of the Environmental Monitor and was open to public comment. The Proposed Hydrogeologic Site Evaluation was approved by MassDEP on May 16, 2017. Copies of the proposed Hydrogeologic Evaluation scope of work, Environmental Monitor Notification and MassDEP approval letter are provided in Appendix A. The following Technical Memorandum reports on the scope of work, methodology, findings, conclusions, and recommendations of the Route 6 (Exit 12) Cloverleaf Hydrogeologic Evaluation.

2.6. Effluent Disposal – Primary and Reserve Discharge Areas

The potential discharge area at Route 6 (Exit 12) Cloverleaf is shown on Figure 4. The potential discharge area is approximated at 75,000 square feet (sqft) based on site topography. However, there is no agreement with MassDOT on the size or location of the discharge area. These as well as other details will need to be discussed and end eventually agreed to by MassDOT.

At this time the location of the primary and reserve discharge areas within the highlighted area has not been determined. However, it is likely that the primary discharge would take place at the site with the reserve discharge designated for a second site.

Based on the soils investigations performed by AECOM, the primary and potentially reserve discharge facilities will be designed using a percolation rate less than 2 minutes per inch. This percolation rate has been verified by percolation tests conducted on March 1, 2017. At the time of this report, the Town of Orleans is considering wicks for the primary groundwater discharge.

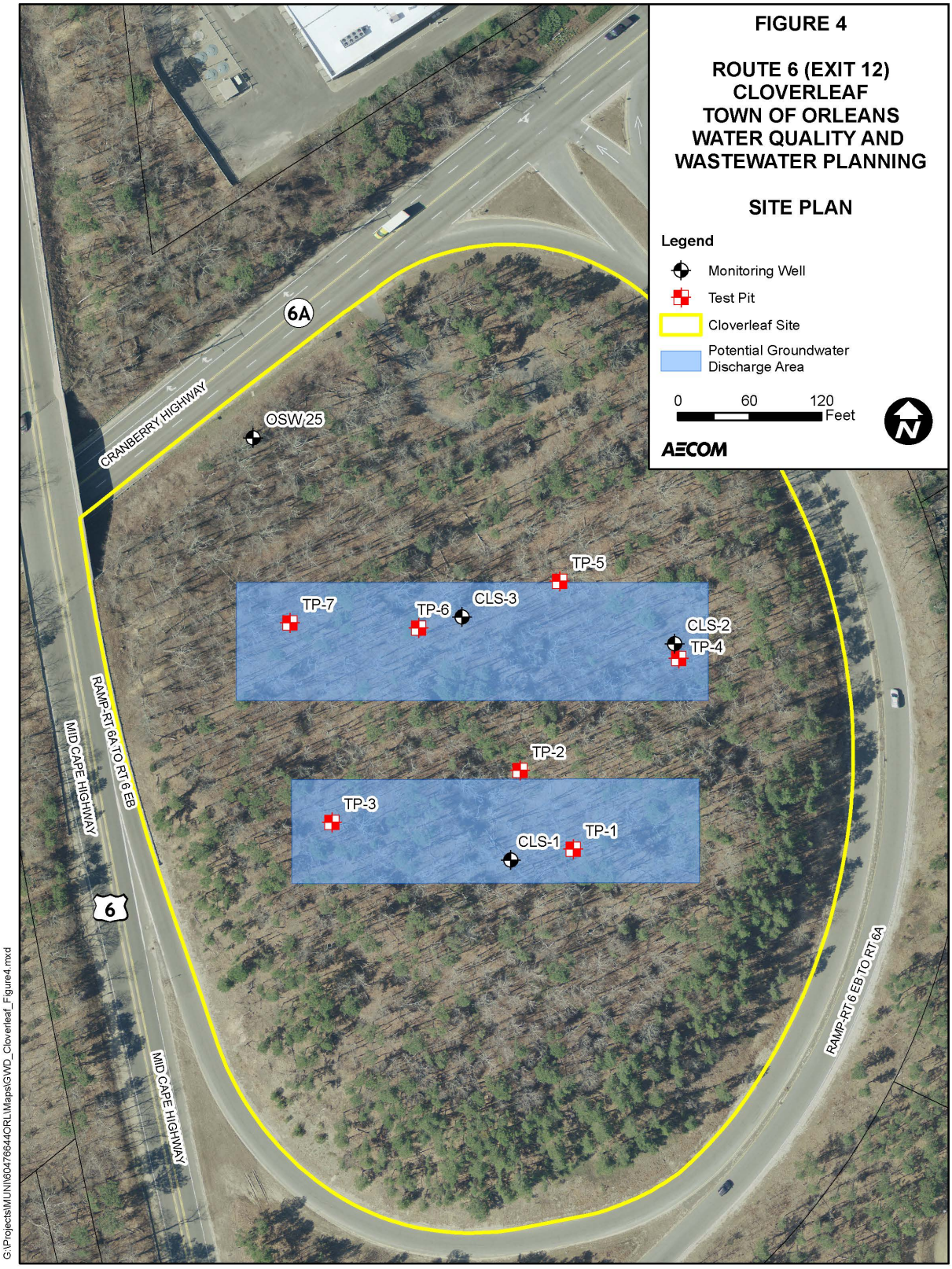
FIGURE 4
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
SITE PLAN
Legend
Monitoring Well
Test Pit
Cloverleaf Site
Potential Groundwater Discharge Area
0
60
120
Feet
AECOM
6A
CRANBERRY HIGHWAY
OSW 25
TP-5
TP-7
TP-6
CLS-3
CLS-2
TP-4
TP-2
TP-3
CLS-1
TP-1
RAMP-RT 6A TO RT 6 EB
MID CAPE HIGHWAY
6
MID CAPE HIGHWAY
RAMP-RT 6 EB TO RT 6A
G:\Projects\MUNI\60476644\ORL\Maps\GWD_Cloverleaf_Figure4.mxd

3. HYDROGEOLOGIC INVESTIGATION

Results of the hydrogeologic investigation are included in the following sections. AECOM's investigations included the excavation of test pits, performing Title 5 percolation tests, the installation of soil borings and monitoring wells, and grain-size analysis of soil samples. The data obtained were used to evaluate subsurface conditions, estimate the groundwater flow direction and calculate aquifer characteristics. Results of the field investigations and data analysis were incorporated into a numerical groundwater flow model to simulate groundwater flow across the site and estimate groundwater mounding under various discharge scenarios. A summary of these investigations follows.

3.1. Previous Subsurface Investigations

Prior to AECOM's hydrogeologic evaluation, no detailed site investigations had been performed at the site.

Regionally, in the early 1990s, the CCC investigated soils, water level and water quality data across the Town of Orleans. The CCC gathered existing soil boring and water level data from numerous previous investigations. The CCC also had numerous additional soil borings and monitoring wells installed to evaluate soil and groundwater elevations across the Town of Orleans. Once collected, data was summarized in a report titled "Orleans Water Table Mapping Project, Orleans Massachusetts", dated May 1995. Soil boring logs, water level and groundwater elevation data, well location maps, geologic cross-sections and groundwater contour maps are included in the report.

The US Geological Survey (USGS) installed a monitoring well (OSW-25) in 1975.

3.2. Test Pit Excavation and Percolation Tests

On March 1, 2017 a total of 7 test pits and 2 percolation test were conducted by AECOM at the potential discharge site (Figure 4). The test pits were performed to evaluate the overall suitability of the subsurface soils for the potential discharge. The test pits were excavated to depths of between 132 and 174 inches (11.0 and 14.5 feet).

Test pits TP-1 through TP-7, were witnessed by MassDEP. All test pits and percolation test were excavated under the direction of a Massachusetts licensed soil evaluator Mr. John Schnaible R.S. of Coastal Engineering Company of Orleans, SE 2166. Mr. Adekunle Teniola of MassDEP SERO was present during the excavations. Copies of the test pit data and Soil Evaluator Forms, including the percolation test results, are contained in Appendix B.

3.3. Soil Boring and Monitoring Well Installation

A total of four soil borings and three monitoring wells were installed by AECOM March 6, 2017 through April 11, 2017. Continuous sampling was conducted from the ground surface to depths of between 60 and 80 feet at locations CLS-1, CLS-2, and CLS-3 (Figure 4). Soil borings to a depth of approximately 60 feet were installed with a Geoprobe 6600 direct push rig, and soil core samples were collected for soil type characterization. Due to the depth to the water table, the direct push rig could not collect soil samples below 60 feet. A CME auger rig was used to collect split spoon sample below 60 feet. At all locations, an attempt to collect continuous soil samples to a minimum of 20 feet below the water table were made.

Monitoring wells were installed at locations CLS-1, CLS-2, and CLS-3. Each monitoring well consisted of ten-foot sections of schedule 40 PVC riser pipe attached to 10-foot sections of 10-slot well screen. An artificial sand pack was installed between the well and the formation from the base of the well to approximately 2 feet above the well screen. The sand pack was then capped by approximately 2 feet of bentonite pellets and allowed to hydrate. Grout was then installed to a depth of 5 to 10 feet below the ground surface.

The monitoring wells were used to determine the water table elevation. All wells were surveyed for location and elevation relative to NAVD 1988. Water table elevations were used to estimate groundwater flow patterns (Section 4.0). Copies of the boring logs with monitoring well details are provided in Appendix C. A summary of the well construction details is provided in Table 1.

3.4. Grain-Size Analysis

Soil samples were collected during the installation of the soil borings. Select samples were submitted to a laboratory for grain size analysis. Copies of the grain-size analysis reports are provided in Appendix D. Results of the soils analysis are discussed in Section 4.2.

Table 1

OBSERVATION WELL CONSTRUCTION AND WATER-LEVEL SUMMARY
ROUTE 6 (EXIT 12) CLOVERLEAF SITE
ORLEANS, MASSACHUSETTS

Observation Well	Diameter (inches)	Borehole Depth	Depth of Screened Interval	Ground Elevation	Northing	Easting	Top of PVC Elevation (ft msl)	Depth to Water Table (4 25 17)	Groundwater Elevation (ft msl)
CLS-1	**2.0**	**98**	**91.5-101.5**	98.5	2747481.708	1064740.808	100.89	86.42	14.47
CLS-2	**2.0**			85.4	2747662.213	1064877.471	87.33	73.11	14.22
CLS-3	**2.0**	**105**	**76-86**	85.8	2747684.466	1064699.986	87.90	73.57	14.33
					Lat Long (NAD 27)				
OSW-22	**2.0**	**52**	**52**	39	41°47'26"	69°58'16"	39.10	34.64	4.46

Notes
All depths in feet below ground level (bgl)
All elevations in feet mean sea level (msl)
ft = feet

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4. HYDROGEOLOGIC CONDITIONS AND DATA ANALYSIS

4.1. Geology, Groundwater Flow and Boundary Conditions

Orleans is underlain by glacially derived sediments deposited 15,000 or so years ago during the waning stages of continental glaciation. The sediments consist of outwash deposited from the melting of the Cape Cod Bay and South Channel Lobes of the glacier (Wordsworth and Wigglesworth, 1934). The Harwich Outwash Plain deposits were derived from the Cape Cod Bay Lobe, while the Nauset Heights and Eastham plain deposits were derived from the South Channel Lobe (Oldale et.al., 1971).

According to Koteff and Cotton (1962) coarse sand and gravel deposits (Harwich Outwash Plain Deposits) are underlain by coarse sands to clayey silts followed by compact basal till directly overlying bedrock. The relatively thin layer of basal till indicates that the soils were deposited as the result of a single glaciation. Previous seismic investigations in the Orleans beach area indicate the bedrock surface at about 400 feet below sea level (Oldale and Tuttle, 1964).

The Route 6 (Exit 12) Cloverleaf parcel is underlain by Harwich Outwash Plan Deposits, as mapped by Oldale et.al (1971). According to Oldale, these deposits consist primarily of medium to very course sand and pebble to cobble gravel. In general, these deposits are fairly well sorted and very permeable. Till and boulders can be found shallow or overlying the deposits. Clayey silt can also be found in the deposits.

Due west and north of the site, lake deposits and lake bottom deposits from the Cape Cod Bay proglacial lake are mapped by Oldale et.al. (1971). the deposits due west of the site are described as being gravely sand, pebble and gravel cobble gravel. Clayey silt and till can also be found. Deposits further to the northwest and north of the outwash deposits are described as being more gravely and clayey silt.

Geologic conditions found at the Route 6 (Exit 12) Cloverleaf site through AECOM's field investigations are consistent with the deposits described above. Test Pit excavations generally revealed fine or fine to medium sands (loamy sand) extending to depths between 11 to 14.5 feet below the ground surface. A course to medium sand was excavated at TP-2.

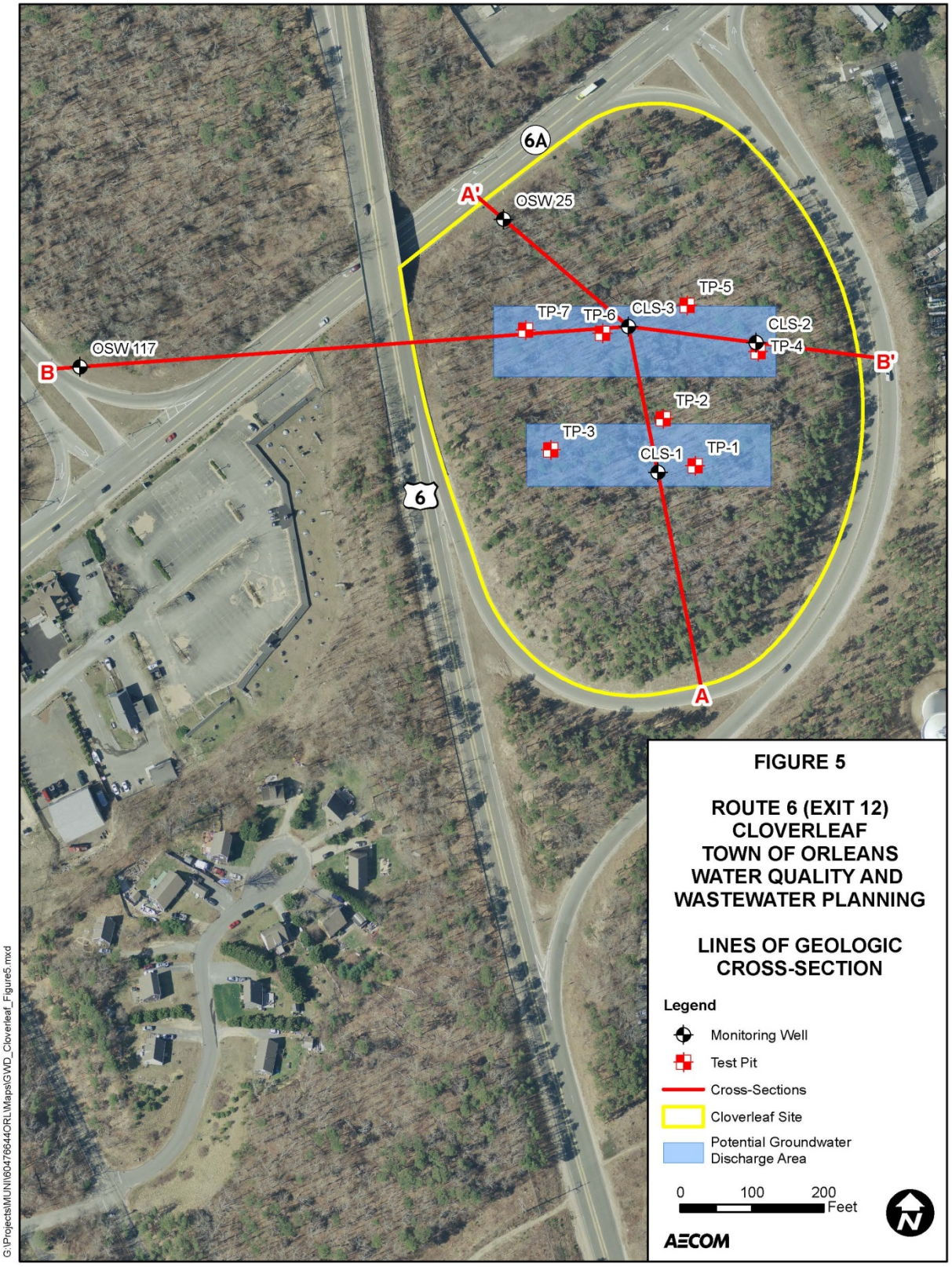
Percolation tests were performed in the medium to fine sands at TP-1 and the fine sands at TP-2. After saturation, the percolation rate at both locations was less than 2 minutes per inch indicating that the underlying shallow sands are suitable for a groundwater discharge system. Copies of the soil evaluator forms are provided in Appendix B. Copies of soil boring logs are in Appendix C.

In general, the soils encountered at CLS-1, CLS-2, and CLS-3 were a tan to light brown fine or fine-to-medium sand with low percentages of silt from a depth of 5 to approximately 60 feet. Within this interval, thin layers of silty sand, silt and silt with varying amounts of clay were encountered. These layers appeared to be discontinuous across the site. If the site were to be developed, additional monitoring wells as well as wicks would be installed at various locations across the site. These fine soil layers should be logged and correlated with other site soil boring logs.

Between 60 and 110 ft, in general the soils became finer and more variable. There were layers of clay, silt mixed sands and silt as well as medium to course sands. Most layers were no more than 2 feet thick. The variations in soil type did not appear to be continuous across the site, but a discontinuous layers of highly variable soils. Overall the conductivity of the lower soils was significantly less than those of the upper soils, but did not appear to be continuous enough prevent a groundwater discharge from infiltrating into the lower soils.

Groundwater was not encountered in any of the test pits, but was measured in the monitoring wells at a depth of approximately 65 to 75 feet below ground surface.

The lines of geologic cross-section are shown on Figure 5. The geologic cross-sections A-A' and B-B' (Figure 6 and Figure 7, respectively) graphically depict geologic conditions locally and regionally. Well logs used to construct the geologic cross- section are in Appendix C.


6A
A'
OSW 25
TP-5
TP-7
TP-6
CLS-3
CLS-2
TP-4
B'
OSW 117
B
TP-2
TP-3
CLS-1
TP-1
6
A
FIGURE 5
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
LINES OF GEOLOGIC
CROSS-SECTION
Legend
Monitoring Well
Test Pit
Cross-Sections
Cloverleaf Site
Potential Groundwater
Discharge Area
0
100
200
Feet
AECOM
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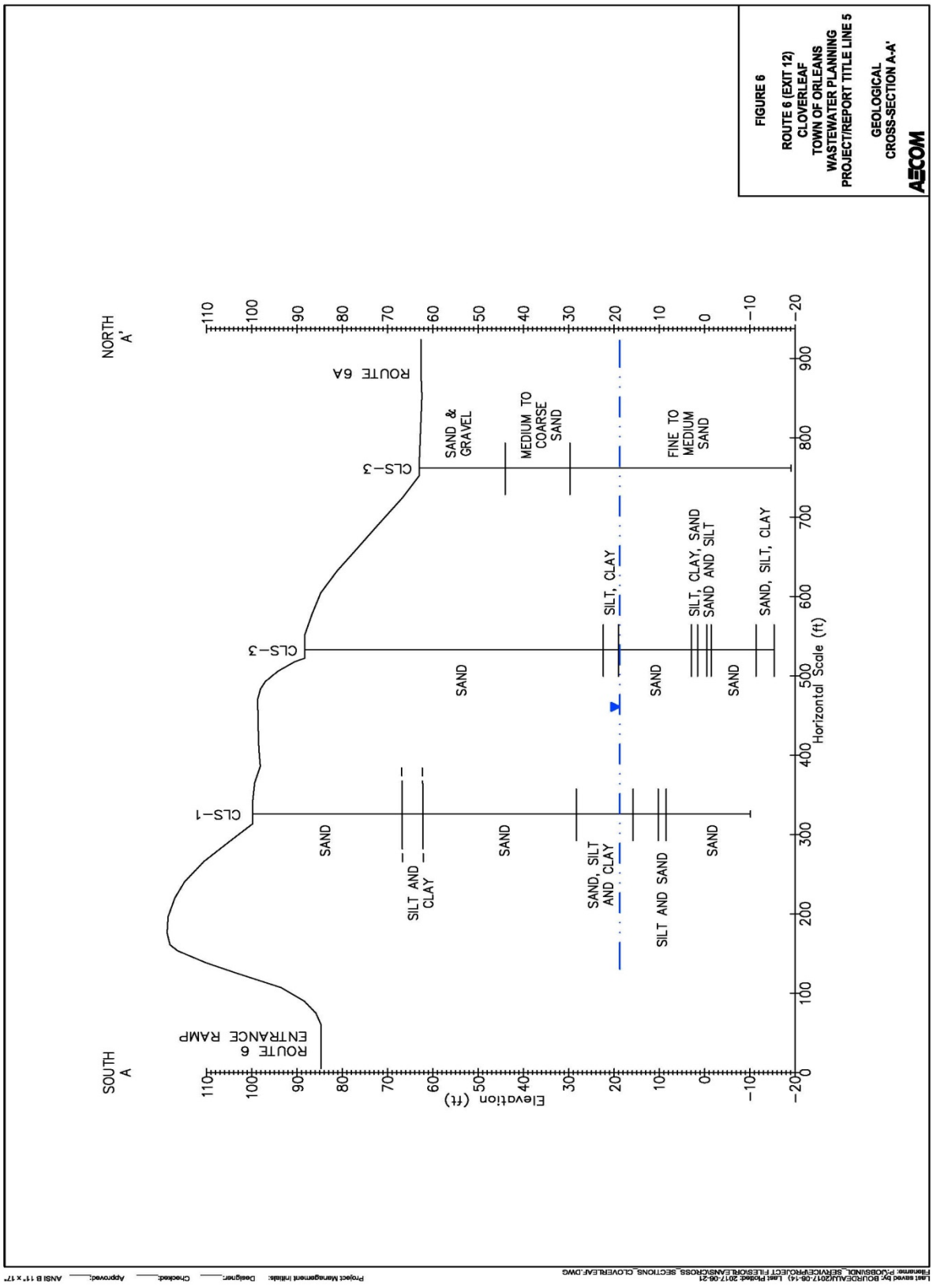
FIGURE 6
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WASTEWATER PLANNING
PROJECT/REPORT TITLE LINE 5
GEOLOGICAL
CROSS-SECTION A-A'
AECOM
NORTH
A'
SOUTH
A
ROUTE 6A
ROUTE 6
ENTRANCE RAMP
CLS-3
CLS-3
CLS-1
SAND & GRAVEL
MEDIUM TO COARSE SAND
FINE TO MEDIUM SAND
SILT, CLAY
SILT, CLAY, SAND
SAND AND SILT
SAND, SILT, CLAY
SAND
SAND
SAND
SAND
SILT AND CLAY
SAND, SILT AND CLAY
SILT AND SAND
Elevation (ft)
Horizontal Scale (ft)
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
0
100
200
300
400
500
600
700
800
900
Project Management Initials:
Designer:
Checked:
Approved:
ANSI B 11" x 17"

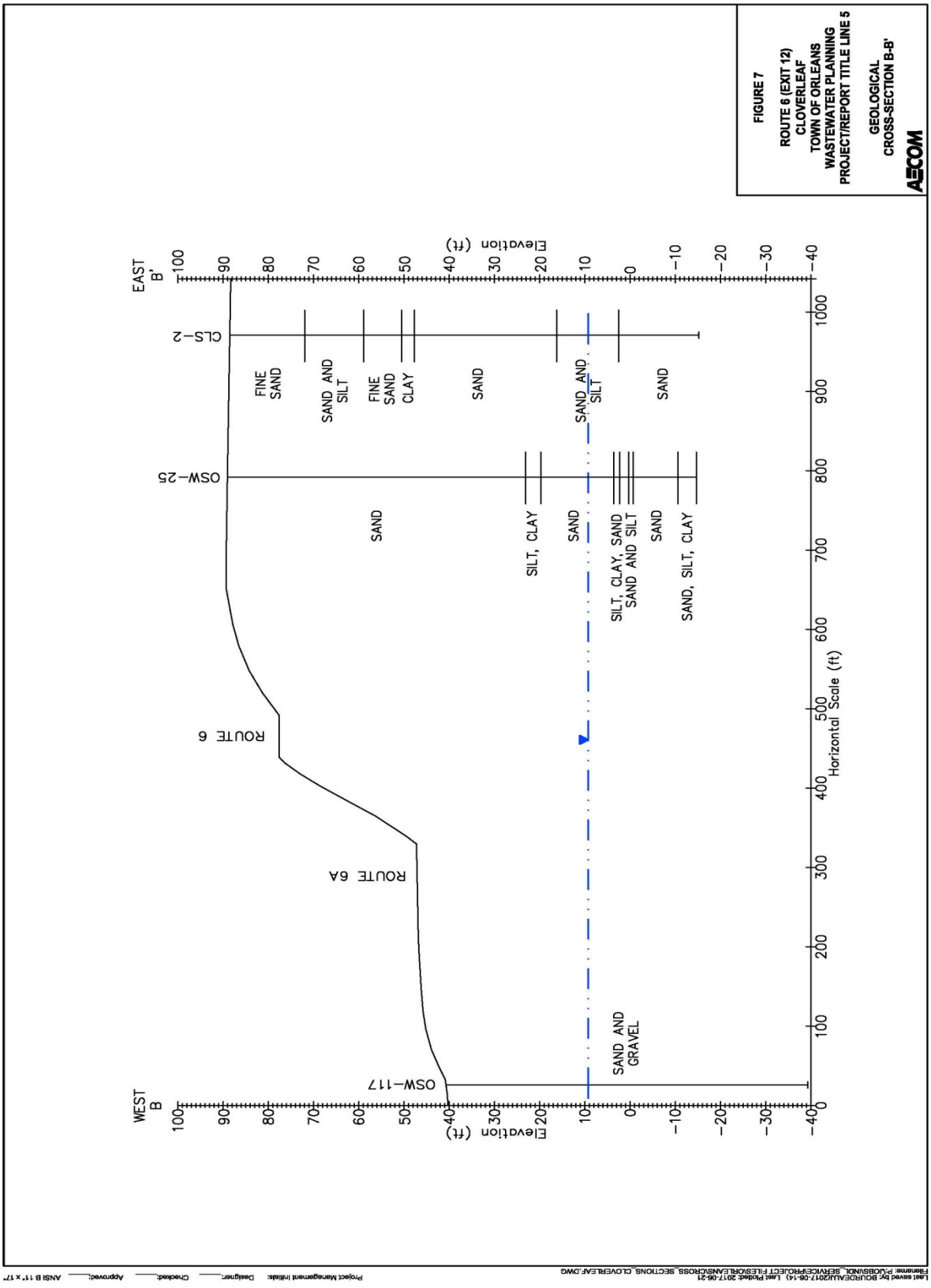
FIGURE 7
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WASTEWATER PLANNING
PROJECT/REPORT TITLE LINE 5
GEOLOGICAL
CROSS-SECTION B-B'
AECOM
EAST
B'
WEST
B
Elevation (ft)
Horizontal Scale (ft)
CLS-2
OSW-25
OSW-117
ROUTE 6
ROUTE 6A
FINE SAND
SAND AND SILT
FINE SAND CLAY
SAND
SAND AND SILT
SAND
SAND
SILT, CLAY
SAND
SILT, CLAY, SAND SAND AND SILT
SAND
SAND, SILT, CLAY
SAND AND GRAVEL

According to USGS and CCC water table maps, groundwater flows north northwesterly across the site toward the Namskaket and Little Namskaket Marshes (USGS, 2005). The drainage divide to Namskaket and Little Namskaket Marshes is located approximately 250 feet west of the discharge.

4.2. Calculated Aquifer Values

Aquifer characteristics were estimated through laboratory grain-size analysis described as follows.

Samples collected from selected soil boring and test pit excavations were submitted to a laboratory for grain-size analysis. In total, 13 soil samples were submitted for grain-size analysis, four samples each from soil borings at CLS-1, CLS-2 and CLS-3.

Hydraulic conductivity (K) and porosity (n) values for each of the 13 samples were estimated using several numerical methods including Kozeny-Carman (Carman, 1937), Shepards (1989), Hazen (1892), and Slitcher (1992).

Average calculated hydraulic conductivity values from the grain-size analysis ranged from 0.05 feet per day (ft/day) for silt to 255 ft/day. For silt to silty sands samples, conductivity values ranged from and 0.05 ft/day to and 7.8 ft/day. For the poorly graded sand with silt to sandy soils underlying the site, conductivity ranged from 10 to 295 ft/day. Including the results of the finer soils, the calculated average for depth ranges of 0 to 60 feet, 60 to 80 feet and 80 to 110 feet was 119, 20, and 31 ft/day, respectively. Averaging the results from all of the samples at all locations, results in a conductivity of approximately 45 ft/day. The calculated hydraulic conductivity values estimated from the grain-size analysis are summarized in Table 2. Laboratory reports for the soils analysis are provided in Appendix D. The hydraulic conductivity approximation reports are provided in Appendix E.

4.3. Groundwater

The study area is located in a watershed that discharges to the Namskaket, Little Namskaket or Cape Cod Bay Watersheds. Locally, groundwater flows northwest. Water levels measured on April 25, 2017, from 3 observation wells were used to estimate the groundwater flow direction across the study area. Each well was surveyed relative to NAVD 1988. Using the survey data, the water levels obtained at each location were converted to elevation in feet msl. A summary of groundwater elevation data is provided in Table 1.

The static groundwater elevations were plotted on a map and approximated contours of the potentiometric surface were drawn. The resulting contours are shown on Figure 8. Contours were inferred between monitoring well locations. Based on the contours, groundwater flow across the site is 0.0016 ft/ft to the north-northeast. The hydraulic gradient was calculated between the 14.25 and 14.50 foot contour at a distance of approximately 160 ft/ft. The groundwater contours are shown on Figure 8.

The historically high groundwater levels were estimated for the site. To evaluate whether the groundwater mound resulting from the discharge would cause the water table to rise to within four feet of the bottom of the discharge beds or ground surface at the site. High groundwater levels were estimated by comparing water levels collected at the Route 6 (Exit 12) Cloverleaf site with water level data at a USGS reference well on the same day. The long-term reference well selected was OSW-22. Reference Well OSW-22 is a USGS well located approximately 8,700 feet west of the Route 6 (Exit 12) Cloverleaf site in Orleans, which has been monitored since 1967, and is screened in a similar formation and hydrogeologic setting as the Route 6 (Exit 12) Cloverleaf Site.

Water Levels were collected at the Route 6 (Exit 12) Cloverleaf site and the reference well site on the same day: April 25, 2017. The observed groundwater level at OSW-22 was the compared to the historic high water level for that site. The high water level on record was 1.80 feet higher than observed on April 25, 2017. Using the method developed by Frimpter, the 1.80 feet difference was added to the Route 6 (Exit 12) Cloverleaf water table elevations measured on the same date, adjusting the Route 6 (Exit 12) Cloverleaf site water table elevations to simulate high water level conditions (Frimpter, 1980).

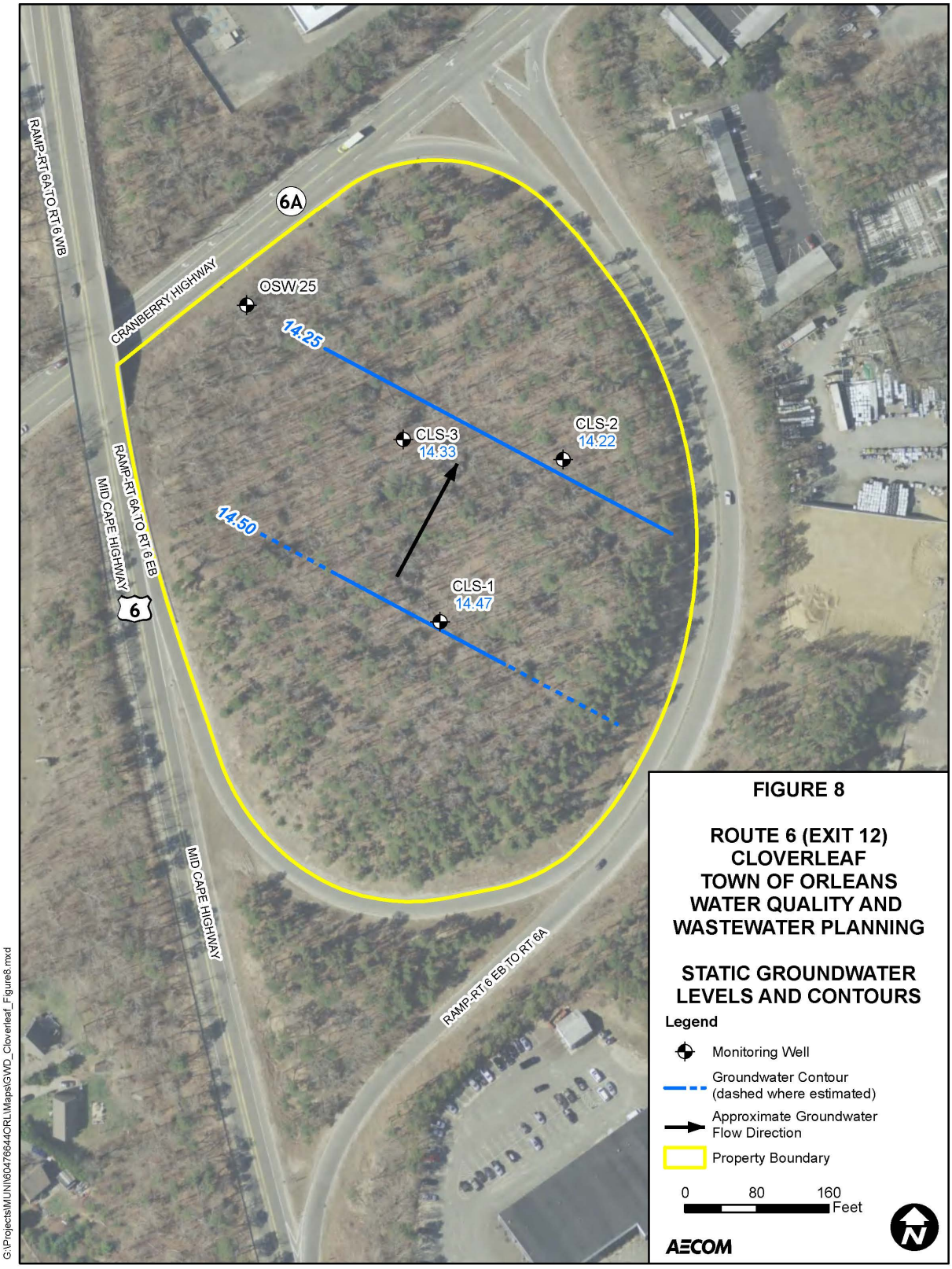
RAMP-RT 6A TO RT 6 WB
6A
CRANBERRY HIGHWAY
OSW 25
14.25
CLS-3
14.33
CLS-2
14.22
RAMP-RT 6A TO RT 6 EB
MID CAPE HIGHWAY
6
14.50
CLS-1
14.47
MID CAPE HIGHWAY
RAMP-RT 6 EB TO RT 6A
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FIGURE 8
ROUTE 6 (EXIT 12)
CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
STATIC GROUNDWATER
LEVELS AND CONTOURS
Legend
Monitoring Well
Groundwater Contour
(dashed where estimated)
Approximate Groundwater
Flow Direction
Property Boundary
0
80
160
Feet
AECOM

Table 2

Summary of Aquifer Charactistics - Grain-size Analysis

Soil sample	Depth (ft)	D10 (mm)	D50 (mm)	D60 (mm)	U(d60/d10)	n (porosity)	Classification	Fines(%)	Kozeny-Carman Ksat (ft/day)	Sheperds Ksat (ft/day)	Hazen Ksat (ft/day)	Slitcher Ksat (ft/day)	Sample Average (FT/day)
TTS-1-TP 10-15	10-15.0	0.0963	0.2044	0.2319	2.41	0.42	Poorly graded SAND with Silt	0.06	45.83	34.00	39.71	14.57	**33.53**
TTS-1 45-46.5	45-46.5	0.0056	0.0823	0.1225	21.7	0.26	Silty SAND	0.47		7.58	0.05	0.01	**2.55**
TTS-2-TP 10-15	10-15.0	0.1632	0.5646	0.7039	4.31	0.37	Poorly graded SAND	0.04	77.44	181.76	92.58		**117.26**
TTS-2 21-21.5	21-21.5	0.0124	0.1754	0.2763	22.32	0.26	Silty SAND	0.33		26.41		0.05	**13.23**
TTS-3 15-16.5	15-16.5	0.0035	0.0168	0.021	5.91	0.34	SILT	0.98		0.55		0.01	**0.28**
TTS-4 15.5-16.5	15.5-16.5	0.0032	0.0798	0.1482	46.95	0.26	Silty SAND	0.49		7.20		0.00	**3.60**

Grain size outside the equation applicability range

Insufficient grain size data

Based on average K value for Silt

4.4. Surface Water

The nearest surface water body is the upper reaches of Namskaket Marsh. At its closest point, Namskaket Marsh is located approximately 1,200 feet due west of the potential discharge area. However, groundwater flow is to the north northwest where the marsh is closer to 1,800 feet from the discharge. The marshes and tidal area of Little Namskaket are located approximately 4,000 feet to the north northwest of the closest area of the discharge (Figure 1).

4.5. Groundwater

The study area is located in a watershed that discharges to the Namskaket, Little Namskaket or Cape Cod Bay Watersheds. Locally, groundwater flows northwest. Water levels measured on April 25, 2017, from 3 observation wells were used to estimate the groundwater flow direction across the study area. Each well was surveyed relative to NAVD 1988. Using the survey data, the water levels obtained at each location were converted to elevation in feet msl. A summary of groundwater elevation data is provided in Table 1.

The static groundwater elevations were plotted on a map and approximated contours of the potentiometric surface were drawn. The resulting contours are shown on Figure 8. Contours were inferred between monitoring well locations. Based on the contours, groundwater flow across the site is 0.0016 ft/ft to the north-northeast. The hydraulic gradient was calculated between the 14.25 and 14.50 foot contour at a distance of approximately 160 ft/ft. The groundwater contours are shown on Figure 8.

The historically high groundwater levels were estimated for the site. To evaluate whether the groundwater mound resulting from the discharge would cause the water table to rise to within four feet of the bottom of the discharge beds or ground surface at the site. High groundwater levels were estimated by comparing water levels collected at the Route 6 (Exit 12) Cloverleaf site with water level data at a USGS reference well on the same day. The long-term reference well selected was OSW-22. Reference Well OSW-22 is a USGS well located approximately 8,700 feet west of the Route 6 (Exit 12) Cloverleaf site in Orleans, which has been monitored since 1967, and is screened in a similar formation and hydrogeologic setting as the Route 6 (Exit 12) Cloverleaf Site.

Water Levels were collected at the Route 6 (Exit 12) Cloverleaf site and the reference well site on the same day: April 25, 2017. The observed groundwater level at OSW-22 was the compared to the historic high water level for that site. The high water level on record was 1.80 feet higher than observed on April 25, 2017. Using the method developed by Frimpter, the 1.80 feet difference was added to the Route 6 (Exit 12) Cloverleaf water table elevations measured on the same date, adjusting the Route 6 (Exit 12) Cloverleaf site water table elevations to simulate high water level conditions (Frimpter, 1980).

4.6. Surface Water

The nearest surface water body is the upper reaches of Namskaket Marsh. At its closest point, Namskaket Marsh is located approximately 1,200 feet due west of the potential discharge area. However, groundwater flow is to the north northwest where the marsh is closer to 1,800 feet from the discharge. The marshes and tidal area of Little Namskaket are located approximately 4,000 feet to the north northwest of the closest area of the discharge (Figure 1).

5. GROUNDWATER MODELING EVALUATION

Groundwater modeling was performed by AECOM as a part of the evaluation of disposal options to provide feedback on potential designs; this feedback can then be used to help make design decisions. Specifically for this project, numerical groundwater flow modeling was used by AECOM to predict changes in groundwater elevations and flow directions based on the volume of discharge.

More specifically, the purpose of the groundwater modeling was to: (a) evaluate the potential impacts of the groundwater discharge on ambient groundwater flow and water levels; (b) evaluate where the effluent originating from the discharge at Route 6 (Exit 12) Cloverleaf site discharges; and (c) estimate the nitrate load discharging to each watershed.

5.1. Modeling Method

A regional three-dimensional groundwater flow model of the Monomoy Lens was developed by the USGS as a tool for understanding the groundwater flow system and water budget (USGS, 2004). This regional groundwater flow model formed the basis of the model modified by AECOM for the purpose of performing groundwater discharge simulations.

MODFLOW was used by AECOM for this analysis (MacDonald and Harbaugh, 1988). The three-dimensional groundwater flow model was coupled with a particle tracking model called MODPATH (Pollack, 2004) in order to illustrate the potential movement of groundwater over time. Both of these models were used on the GMS platform, Version 10.0.

5.2. Conceptual Model of the Aquifer System

A conceptual site model (CSM) of a groundwater flow system is a representation of how an aquifer functions based on available data. Geologic maps and cross-sections, groundwater flow maps, and the generalized water balance (the volume of water entering and leaving the aquifer) are common elements of a conceptual aquifer model. AECOM's understanding of how the Town of Orleans groundwater flow system functions is based on the geological and hydrological data presented in Sections 3.0 and 4.0; additionally the CSM is based on the work done and reported on by the USGS (2004).

The CSM for hydrogeology and groundwater flow in the Monomoy Lens is well documented in the USGS (2004) report. Overall, the CSM documented in the USGS (2004) report is the same as is used for AECOM's modeling effort. However, AECOM's investigation of the Route 6 (Exit 12) Cloverleaf site completed in December 2015-January 2016 was used to verify the USGS's CSM. AECOM's work included new wells and hydraulic testing of the aquifer (to estimate K). These results of the investigation and data analysis are discussed in Sections 3.0 and 4.0 of this document.

In general, the aquifer in the Town of Orleans is a relatively simple water table aquifer composed of relatively homogeneous deposits of sand with trace amounts of gravel and silt. The bottom of the aquifer is assumed to coincide with the bottom of the numerical model, around -350 feet elevation below sea level.

According to the USGS's CSM, water enters the aquifer system primarily in the form of rainfall recharge. Rainfall recharge is expected to be around 29 inches per year except in wetlands, lakes, oceans where it may be low or zero. Groundwater then leaves the aquifer system through surface water features, such as lakes, streams, wetlands, marshes and the ocean.

5.3. Model Design and Updates

The numerical groundwater flow modeling was completed using the USGS numerical groundwater flow model of the Monomoy Lens as a basis. This model is documented in "Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts" (USGS, 2005). Modeling files were received from the USGS and were imported into the GMS 10.0 platform. GMS is a pre- and post-processor for MODFLOW-2000 that facilitates data input, and depiction and interpretation of output.

5.3.1. Model design

The model prepared by the USGS, and modified by AECOM, is structured as follows:

- The USGS model runs as a steady-state model, which incorporates long-term average conditions and does not include shorter-term (i.e., transient) changes in storage;
- The USGS model domain included the entire Monomoy Lens; a map of this domain is included in Appendix 1 (USGS, 2004) Figure 1-1A. The model domain updated by AECOM is bounded primarily by surface water features (streams, marshes, inlets, estuaries, and ocean). The southwestern limit of the model domain was adjusted from the full regional model; a no flow boundary was assigned there to coincide with the groundwater divide;
- The original USGS model and AECOM modified model are both 20 layers. In this area of the Monomoy Lens, the groundwater table is low enough such that many of the upper layers go dry. The first layer that is wet over the entire model domain is layer 8. The bottom updated model domain ranges from approximately -300 to -400 feet elevation below sea level. With the exception of the lowest model layer, the model layers are uniform thickness across the model domain, see Appendix 1 (USGS, 2004) Figure 1-1B;
- The model grid was changed from 400 by 400 foot nodes to 100 by 100 foot nodes across the model domain (Figure 9). Drain nodes and boundary conditions are also shown on Figure 9;
- USGS assigned rainfall recharge using a variable array for the model domain. The rainfall recharge rate ranges (0 to 33.7 in/year, with a model wide average of 22.9 inches per year. Lesser rates or zero rainfall recharge rates were assigned to wetlands, open water, and/or oceans. Figure 10 shows rainfall recharge distribution across the model domain. In the calibration process, AECOM increased the recharge, discussed below in the calibration section.
- USGS simulated surface water features in a variety of ways:
    - Streams, wetlands, marshes, estuaries and other drainages were simulated using the drain (DRN) package;
    - The Atlantic Ocean and Cape Cod Bay were simulated with a general head boundary (GHB);
    - Lakes were simulated with horizontal flow boundaries (HFB) and high hydraulic conductivity; and
    - The original model included using the stream (STR) package for some surface water drainages, but when the model domain was made smaller, those features were excluded. Therefore, the updated model does not use the stream package.
- Hydraulic conductivity values used in the USGS model ranged from 10 ft/day for sandy silts to 300 ft/day for sand and gravel deposits. The distributions of hydraulic conductivity values for layer 8 (the layer representing the water table aquifer) are shown in Figure 11. The hydraulic conductivity values for layers 7 and 8 are identical in the area of the potential discharge. High hydraulic conductivities (50,000 ft/day) were used for lakes. AECOM's recent site investigations completed at the Route 6 (Exit 12) Cloverleaf site indicated that the soils were fine- to coarse-grained sediments, resulting in hydraulic conductivity values ranging from 10 to 295 ft/day for the sandy soils underlying the site. The average conductivity also decreased with depth. These values were consistent with the USGS model for these areas; therefore no changes to horizontal or vertical hydraulic conductivity in the updated AECOM model.

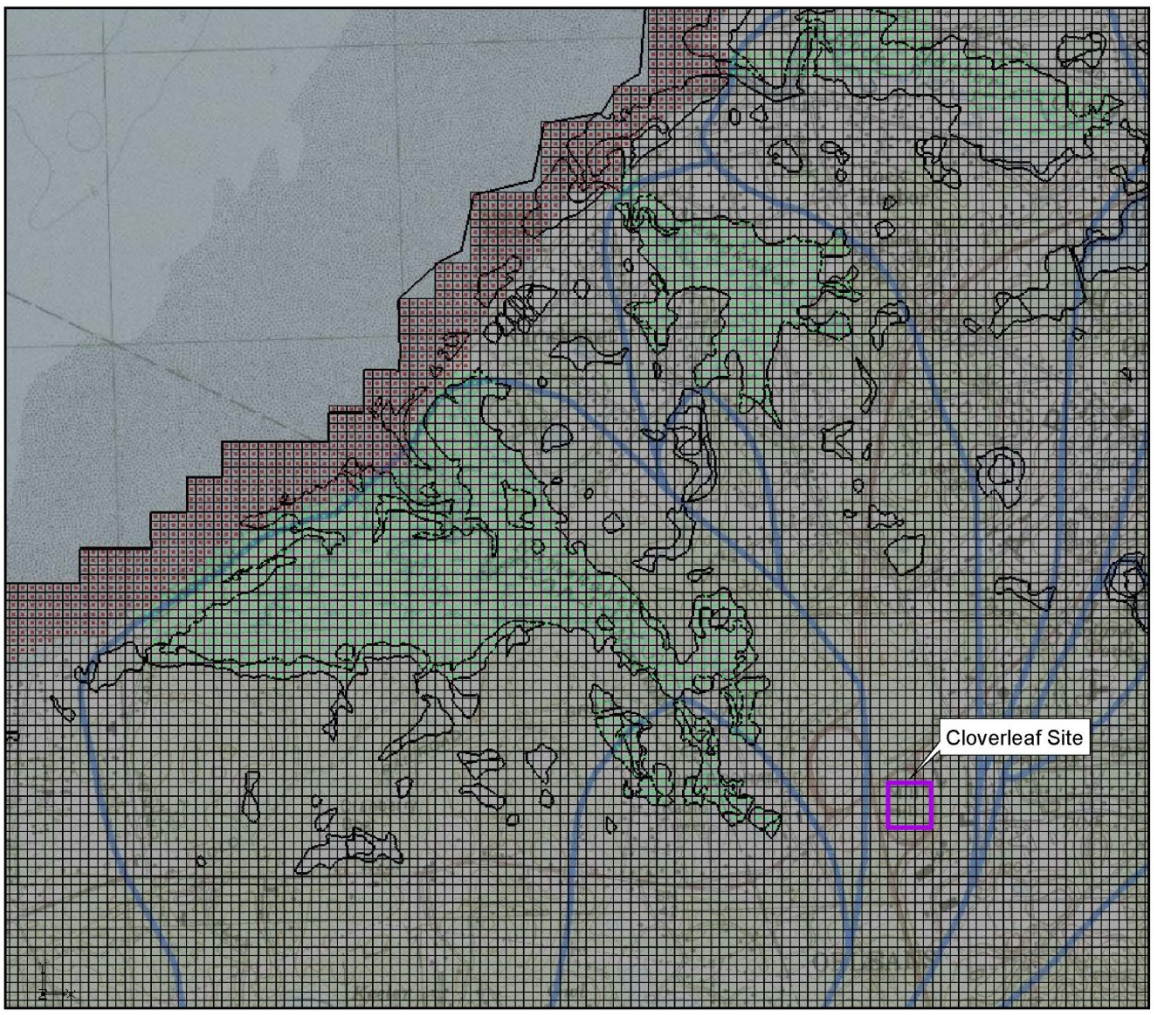

FIGURE 9

**ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING**

MODEL GRID AND LOCATION OF GENERAL HEAD BOUNDARIES AND DRAIN NODES

Legend

- Model Drain Nodes
- Boundary of Model Domain
- General Head Boundary

AECOM

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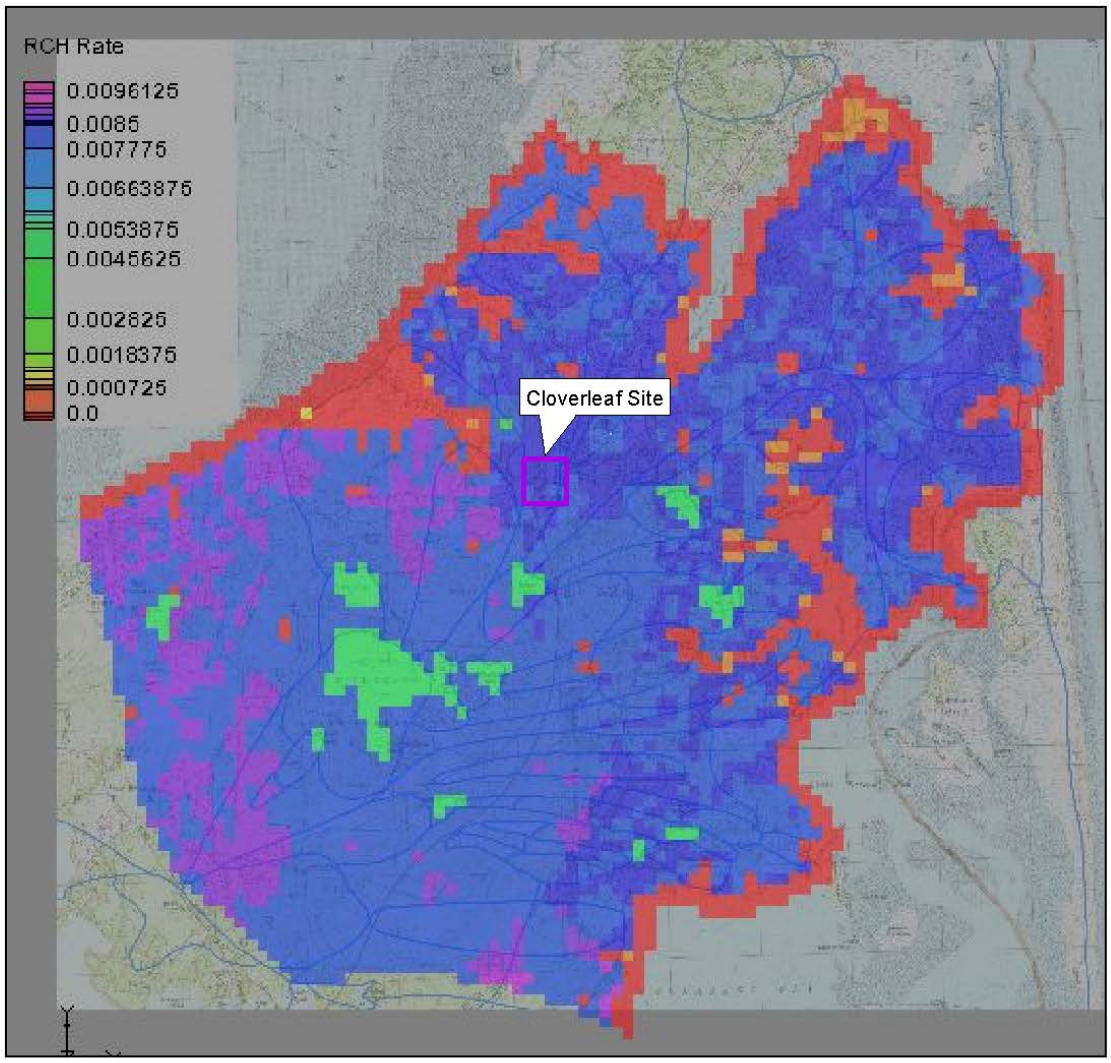

FIGURE 10

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

MODEL RECHARGE DISTRIBUTION

Legend

RCH Rate (in. per yr.)	
0	15.99
2.54	27.24
3.62	29.78
9.9	30.88
	31.61

AECOM

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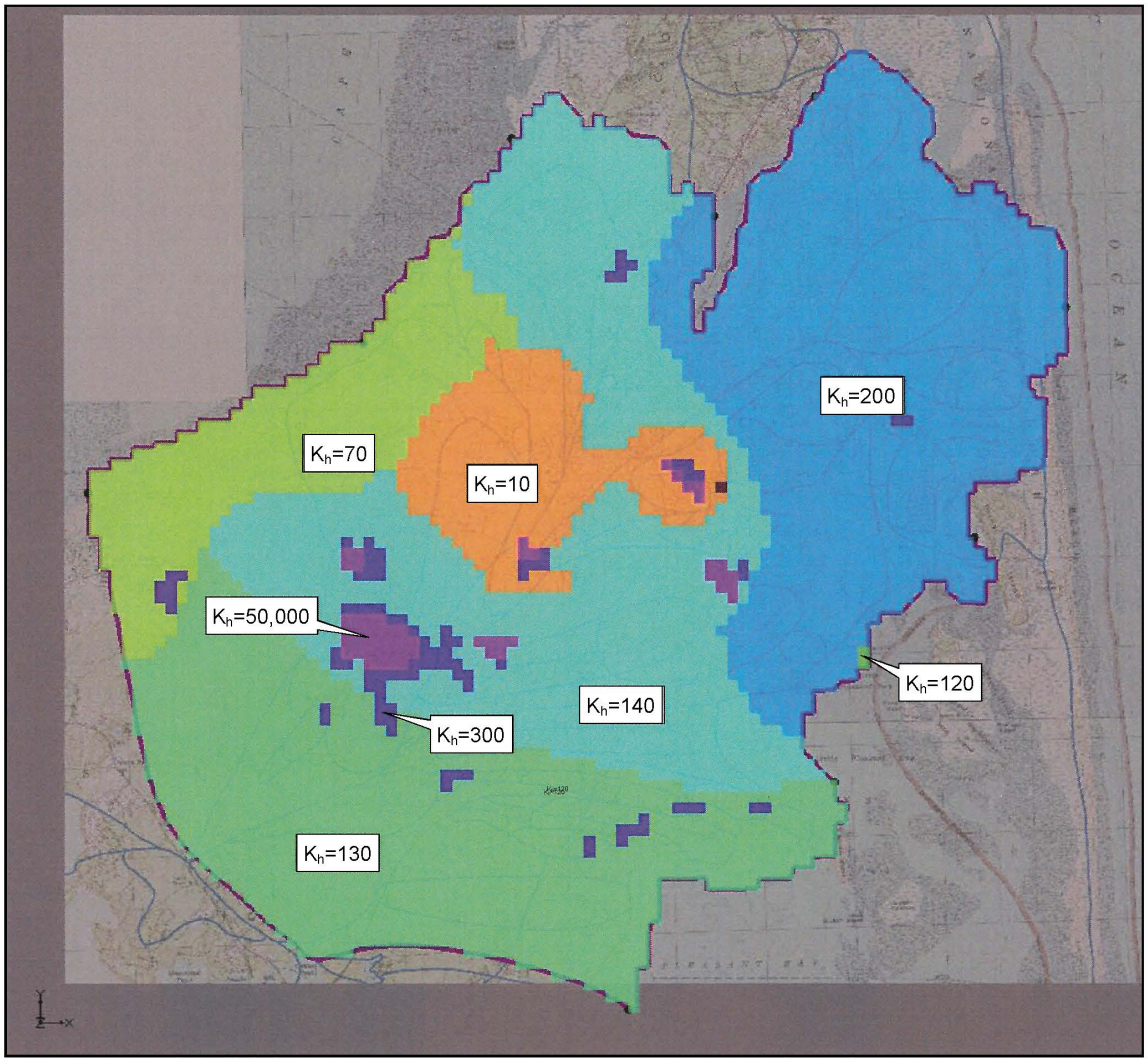

FIGURE 11

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

MODEL HYDRAULIC CONDUCTIVITY VALUES (FT/DAY), K_h, IN MODEL LAYER 8

Legend

Boundary of Model Domain

AECOM

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- The original USGS model included groundwater extraction consistent with water usage using the well (WEL) package. Extraction rates are summarized in Appendix 1 of the USGS (2004) report Table 1-3. AECOM made no changes to the well rates for the updated model domain. However, AECOM used the WEL package to simulate the groundwater discharge at the Route 6 (Exit 12) Cloverleaf site. This is discussed in the Simulations section, below.

5.3.2. AECOM Model Updates

AECOM made a number of changes to the model by to meet model objectives. They are as follows:

- AECOM converted the solver package to the PCG2 package from the LMG package based on a recommendation from the USGS in the model documentation that accompanied the model files ("…due to licensing restrictions, the USGS is no longer able to publicly distribute the Algebraic Multi-Grid (AMG) solver, on which the Link-AMG (LMG) Package relies. There are two possible solutions: (a) use a standard solver publicly available from USGS, such as SIP or PCG2 or (b) obtain the AMG/LMG solver from Fraunhofer-Institute for Algorithms and Scientific Computing (SCAI).");
- AECOM refined the grid around the Route 6 (Exit 12) Cloverleaf site. The USGS model used a grid size of 400 feet by 400 feet over the entire model domain. AECOM adjusted the grid to 100 by 100 feet. This was completed to provide better resolution on the model inputs (i.e., discharge areas) and outputs; and
- In refining the grid, AECOM updated some model features:
    - Drain cell conductances were adjusted to reflect the new dimensions of the grid cells.
    - General head boundary conductances were adjusted to reflect the new dimensions of the grid cells.
    - Horizontal flow barrier segments were added as needed to encompass the ponds/lakes in the model domain.

Figure 9 shows AECOM's updated model grid, general head boundaries and drain nodes. The distribution of recharge is shown in Figure 10. The hydraulic conductivity values used by the USGS and AECOM are shown in Figure 11.

After AECOM made the changes above, the model was verified to be a good representation of the original USGS model in the following ways:

- A comparison of predicted groundwater elevations was made in select cells/areas to demonstrate that AECOM's new version of the model predicted groundwater elevations similar to that predicted by the USGS model. Generally, the differences were less than 0.5 feet and lower in many instances. There are a handful of cells where AECOM model predictions are greater than 1 foot, but these are far from the areas of interest and so should not impact model predictions;
- A comparison of groundwater flow directions as demonstrated with particle tracking. Particles were seeded in select areas to verify that groundwater flow paths and divides are similar as those mapped by the USGS. Generally speaking the AECOM version of the model was the same or similar to the particle tracking under ambient conditions from the USGS version of the model;

- AECOM made a comparison of mass balance generated by the two models. More specifically, recharge, well, general head boundary, drain boundary volumes were compared to verify that the water balances were the same or similar to the USGS model. Table 3 summarizes the comparison. The percent differences on the water budget components are very small; most differences can be attributed, in part, to the regridding and resulting changes to conductances of the drain and general head boundaries; and
- The change in model solver (from LMG to PCG2), which results in a slightly different solution.

In summary, AECOM made a number of changes to the original USGS model domain and structure to better meet the project objectives. Despite the changes, the AECOM model replicated the USGS output adequately; differences can be explained and are not expected to impact model predictions. Overall, AECOM considers this model a good tool to complete a preliminary evaluation of effluent disposal scenarios.

5.4. Model Calibration

USGS calibrated the full Monomoy Lens model and this process is described in Appendix 1 of the USGS report (2004). In accordance with our scope, AECOM verified that the calibration was maintained after the domain and grid were updated as discussed above. In summary:

- Simulated groundwater elevations from the USGS model compared favorably to the simulated groundwater elevations generated in the AECOM model;
- Simulated groundwater flow paths from the USGS model compared favorably to the simulated groundwater flow paths generated in the AECOM model; and
- The water budget of the USGS model (for the area of interest) compared favorably with the water budget for the AECOM model.

Regionally, the updated model was able to reproduce the results from the original USGS model very closely.

On April 25, 2017, groundwater levels were measured at the Route 6 (Exit 12) Cloverleaf monitoring wells (CLS-1 through CLS-3) and numerous other wells in Orleans. An estimate of high groundwater levels at Route 6 (Exit 12) Cloverleaf and across the model domain were made based on the differences observed between high and current groundwater levels at OSW-22. The simulated groundwater levels at the target locations predicted by the model indicating that the USGS calibrated model was simulating groundwater levels below the estimated high water table elevations. Therefore, the model was further calibrated to better simulate the estimated high water table conditions.

Numerous model runs were performed varying several parameters, including rainfall recharge, hydraulic conductivity values, the location of the model drain nodes used to simulate the Namskaket and Little Namskaket Marshes, the drain node elevation, and the drain node conductivity. At the conclusion of the calibration process, the following changes were made:

- Rainfall recharge was increased by 25 percent, from 22.9 inches to 28.6 inches;
- The location of the Namskaket Marsh drain nodes, those within approximately 4,000 feet east of the discharge, were changed to better simulate the geometry of the march boundary;
- The Namskaket Marsh drain node elevations and conductivity values within 4,000 feet of the discharge were made consistent; and
- The elevation of the Namskaket Marsh drain node elevations and conductivity values within 4,000 feet of the discharge were made consistent.

TABLE 3
COMPARISON OF MASS BALANCE
TOWN OF ORLEANS
WATER QUALITY AND WASTEWATER PLANNING

	SUBSET OF REGIONAL[1]	UPDATED MODEL[2]	DIFFERENCE	% DIFFERENCE FROM ORIGINAL
IN (ft^3/day):				
CONSTANT HEAD	0.00	0.00		
WELLS	0.00	0.00		
DRAINS	0.00	0.00		
GENERAL HEAD	0.00	0.00		
RECHARGE	3,899,661.85	3,906,112.50	-6,450.64	-0.17%
STREAM LEAKAGE	0.00	NA		
OUT (ft^3/day):				
CONSTANT HEAD	0.00	0.00		
WELLS	239,703.00	239,703.00	0.00	
DRAINS	2,137,289.64	2,152,853.94	-15,564.31	-0.73%
GENERAL HEAD	1,472,953.97	1,513,555.55	-40,601.58	-2.76%
RECHARGE	0.00	0.00		
STREAM LEAKAGE	0.00	NA		

Notes:
1 - Using Zonebudget, calculated based on approximate same domain as the Updated Model
2 - Using Zonebudget.

At the conclusion of the calibration process, the model was considered a good tool for conducting predictive simulations. The simulated groundwater elevations compared favorably to estimates for high groundwater elevation conditions. The results of the calibrated steady-state model output (water table levels) are shown in Figure 12. In the simulated contours are for Layer 8 of the model. Table 4 summarizes the estimated high water table and model simulated elevations. Table 4 also summarizes the comparison between the calculated high water level conditions and the model simulated groundwater levels

5.5. Predictive Simulations

AECOM's calibrated groundwater flow model was used to simulate eight discharge scenarios to predict groundwater mounding and the flow of groundwater from the discharge sites. The Route 6 (Exit 12) Cloverleaf site is proposed to be the primary discharge area for the groundwater discharge. The entire discharge from the WWTF is proposed to be discharged at this area.

AECOM ran a base case run with zero discharge. The resulting groundwater contours and residuals are shown on Figure 12. The model generated contours represent high water table conditions across the modeled area. The monitoring well locations shown on the figure are locations where water level data was collected on April 25 and high water table conditions were estimated (Section 5.4). The residual are the calculated difference between the model simulated and the estimated high water table condition at each monitoring well location.

Well locations where the model predicted water table elevation is within 0.5 feet of the estimated high water table elevation is indicated by dark green. Lighter green symbols indicate that the simulated water table elevation is between 0.5 and on 1.0 feet of the calculated high water table. Light and dark red symbols represent locations where the residual is between 1.0 and 2.0 feet, and is greater than 2.0 feet, respectively. Monitoring well symbols with a "+" are locations where the model simulated water table elevation is higher than the estimate water table conditions for that site. A negative ("-") indicated that the simulated water table is lower than the estimated high water table elevation.

Also shown on Figure 12 is a graph plotting model simulated and estimated high water table elevations at each monitoring well location. The residual at each location is the distance between the diagonal line and point plotted. The closer the point to the diagonal line, the lower the residual and the closer the model is simulation high water table conditions. As indicated by the scatter plot, the points are fairly evenly distributed above and below the diagonal line and the residuals are also relatively close to the line. Both indicate that the model is reasonable calibrated to the estimated high water table conditions.

Additionally, eight separate discharge simulations (Simulations A through H) were modeled using the calibrated model. Each simulation scenario assumes a different discharge rate (between no discharge and a flow of 500,000 gpd) under the high water-table conditions described above. The simulation results are illustrated in Figure 13 through Figure 20.

- Based on particle tracking travel times, the model predicts that groundwater in the discharge area will reach Cape Cod Bay in approximately 75 years. Simulation A – 25,000 gpd - Figure 13 shows groundwater flow using the particle-tracking module. The discharge points of the groundwater discharge are shown by the particle track endpoints. The simulation indicates that a majority of the groundwater discharge flows northwest discharging into Cape Cod Bay. A small portion of the WWTF discharge may enter Little Namskaket Marsh although a majority of the flow is under Little Namskaket to Cape Cod Bay based on the particle traces. (Figure 13). The baseline groundwater elevation at its highest point under the discharge area is approximately 18.0 feet indicating 0.45 feet of mound.

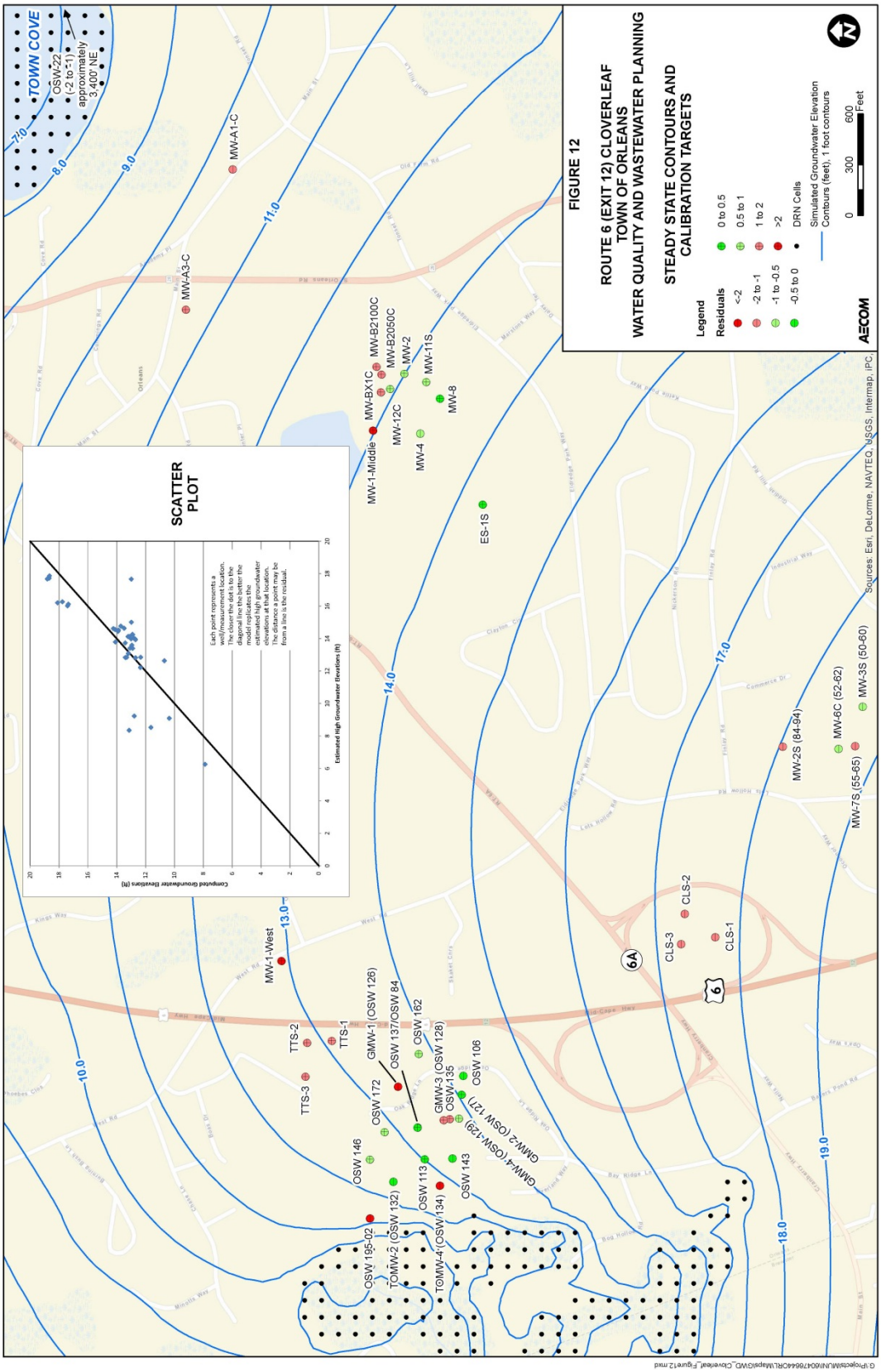
FIGURE 12
ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND WASTEWATER PLANNING
STEADY STATE CONTOURS AND
CALIBRATION TARGETS
Legend
Residuals
<-2
-2 to -1
-1 to -0.5
-0.5 to 0
0 to 0.5
0.5 to 1
1 to 2
>2
DRN Cells
Simulated Groundwater Elevation
Contours (feet), 1 foot contours
0
300
600
Feet
AECOM
SCATTER PLOT
Computed Groundwater Elevations (ft)
Estimated High Groundwater Elevations (ft)
Each point represents a well/measurement location. The closer each is to the diagonal line the better the model replicates the estimated high groundwater elevation at that location. The distance a point may be from a line is the residual.
TOWN COVE
OSW-22
(-2 to -1)
approximately
3,400' NE
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
17.0
18.0
19.0
MW-A1-C
MW-A3-C
MW-1-Middle
MW-BX1C
MW-B2100C
MW-B2050C
MW-2
MW-11S
MW-8
MW-12C
MW-4
ES-1S
MW-1-West
TTS-2
TTS-1
TTS-3
GMW-1 (OSW 126)
OSW 137/OSW 84
OSW 162
GMW-3 (OSW 128)
OSW 135
OSW 106
OSW 172
GMW-4 (OSW 129)
GMW-2 (OSW 127)
OSW 143
OSW 146
OSW 113
OSW 195-02
TOMW-2 (OSW 132)
TOMW-4 (OSW 134)
CLS-3
CLS-2
CLS-1
6A
6
MW-2S (84-94)
MW-6C (52-62)
MW-7S (55-65)
MW-3S (60-60)
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC,
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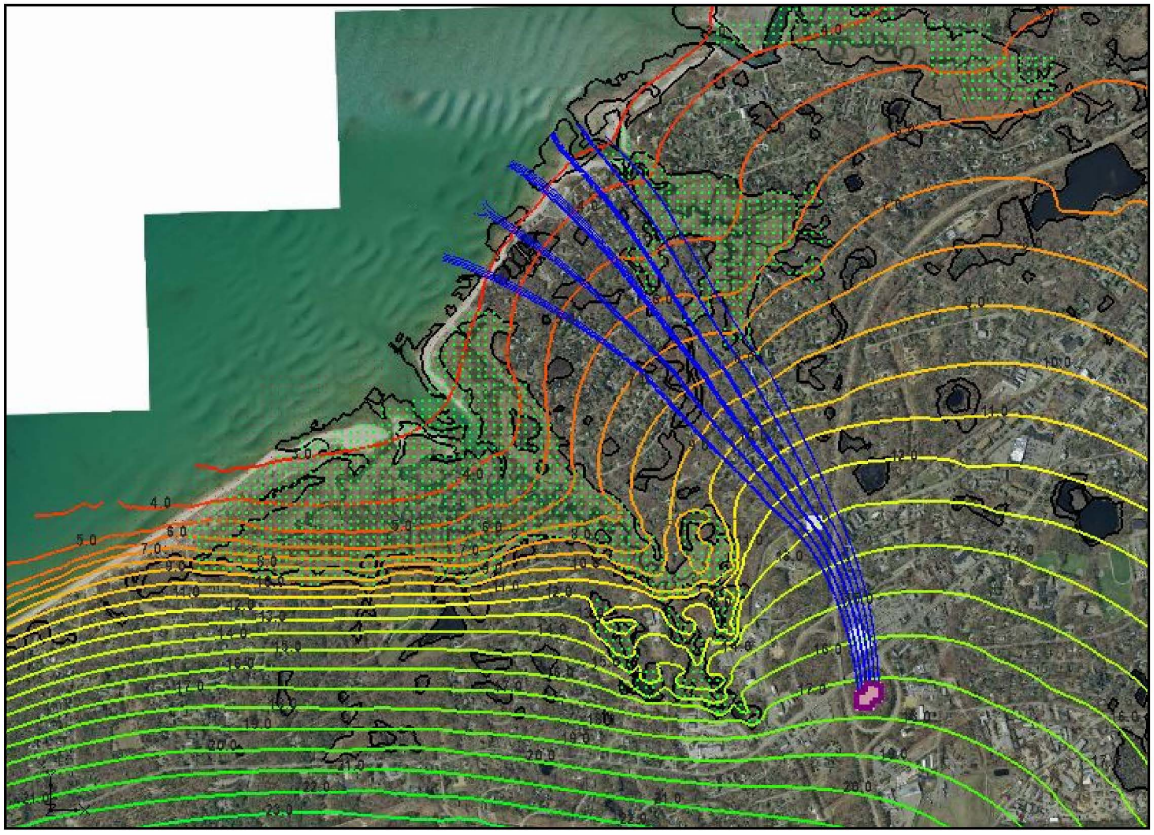
Table 4
Comparison of High Water Table Conditions

Location	Estimated High Groundwater Elevations (feet)	Computed Groundwater Elevations (feet)	Residuals (feet)	Average Residual
MW-2S (84-94)-Shallow	16.21	18.10	-1.89	-0.002
MW-3S (50-60)-Shallow	17.72	18.68	-0.96	
MW-6C (52-62) -Shallow	17.87	18.66	-0.79	
MW-7S (55-65)-Shallow	17.68	18.81	-1.13	
MW-1-Middle-Shallow	15.01	12.99	2.02	
MW-2-Shallow	13.99	12.99	1.00	
MW-4-Shallow	12.84	13.41	-0.57	
MW-8-Shallow	13.74	13.41	0.33	
MW-11S-Shallow	14.13	13.21	0.92	
MW-12C-Shallow	13.6	12.95	0.65	
MW-B2050C-Shallow	14.02	12.81	1.21	
MW-BX1C-Shallow	14.24	12.89	1.35	
MW-B2100C-Shallow	13.98	12.73	1.25	
ES-1S-Shallow	14.62	14.24	0.38	
CLS-1-Shallow	16.27	17.76	-1.49	
CLS-2-Shallow	16.02	17.40	-1.38	
CLS-3-Shallow	16.13	17.34	-1.21	
TTS-1-Shallow	14.14	13.13	1.01	
TTS-2-Shallow	14.26	12.91	1.35	
TTS-3-Shallow	13.94	12.69	1.25	
OSW 137-Shallow	13.08	13.19	-0.11	
OSW 84-	13.41	13.08	0.33	
OSW 135-Shallow	14.64	13.49	1.15	
OSW 146-Shallow	12.85	12.34	0.51	
OSW 143-Shallow	12.85	13.31	-0.46	
OSW 162-Shallow	8.35	13.13	-4.78	
OSW 172-Shallow	13.4	12.89	0.51	
OSW 113-Shallow	12.82	12.70	0.12	
OSW 106-Shallow	13.8	14.09	-0.29	
OSW 195-02-Shallow	8.53	11.63	-3.10	
OSW 132- Shallow	12.22	12.36	-0.14	
OSW 134-Shallow	9.23	12.79	-3.56	
GMW-2 (OSW 127)-Shallow	14.56	14.12	0.44	
GMW-3 (OSW 128)-Shallow	14.77	13.72	1.05	
GMW-4 (OSW 129)-Shallow	14.45	13.91	0.54	
OSW 126-Shallow	14.52	13.88	0.64	
MW-1-West-Shallow	17.67	12.98	4.69	
MW-A1-C-Shallow	9.09	10.35	-1.26	
MW-A3-C-Shallow	12.64	10.70	1.94	
OSW-22-Shallow	6.26	7.88	-1.62	



Groundwater Mounding

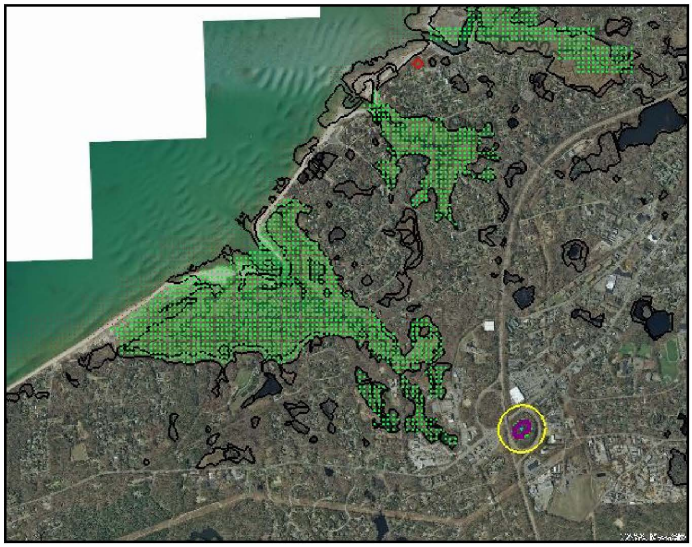


FIGURE 13

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION A - 25,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.1 ft)

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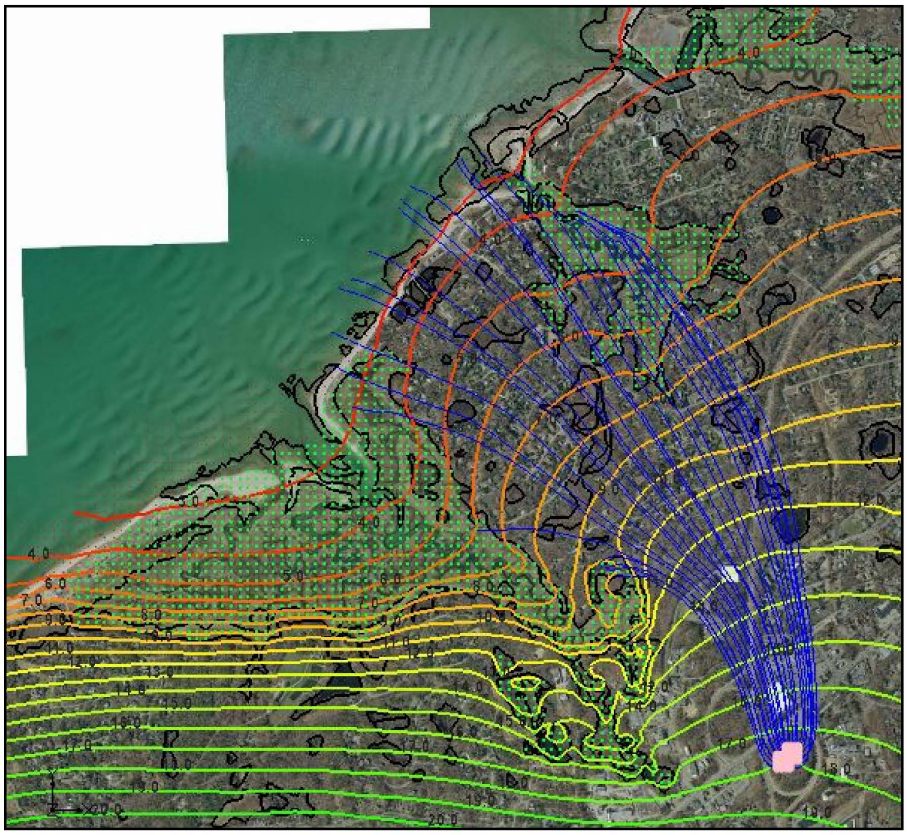

Groundwater Mounding

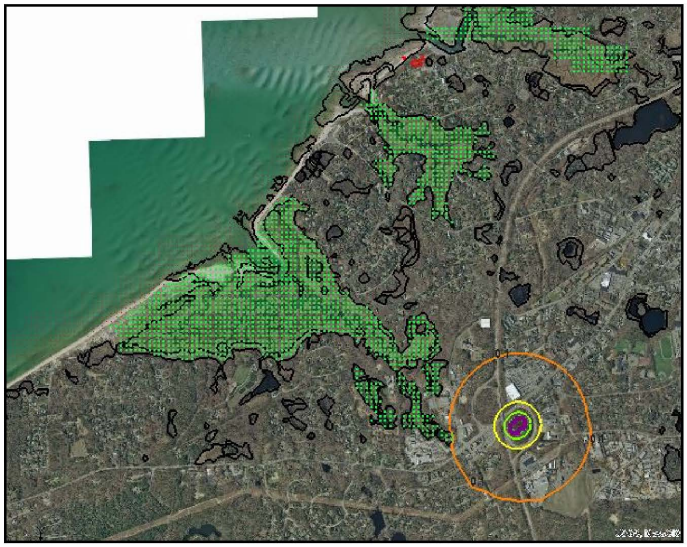

FIGURE 14

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION B - 50,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.1 ft)

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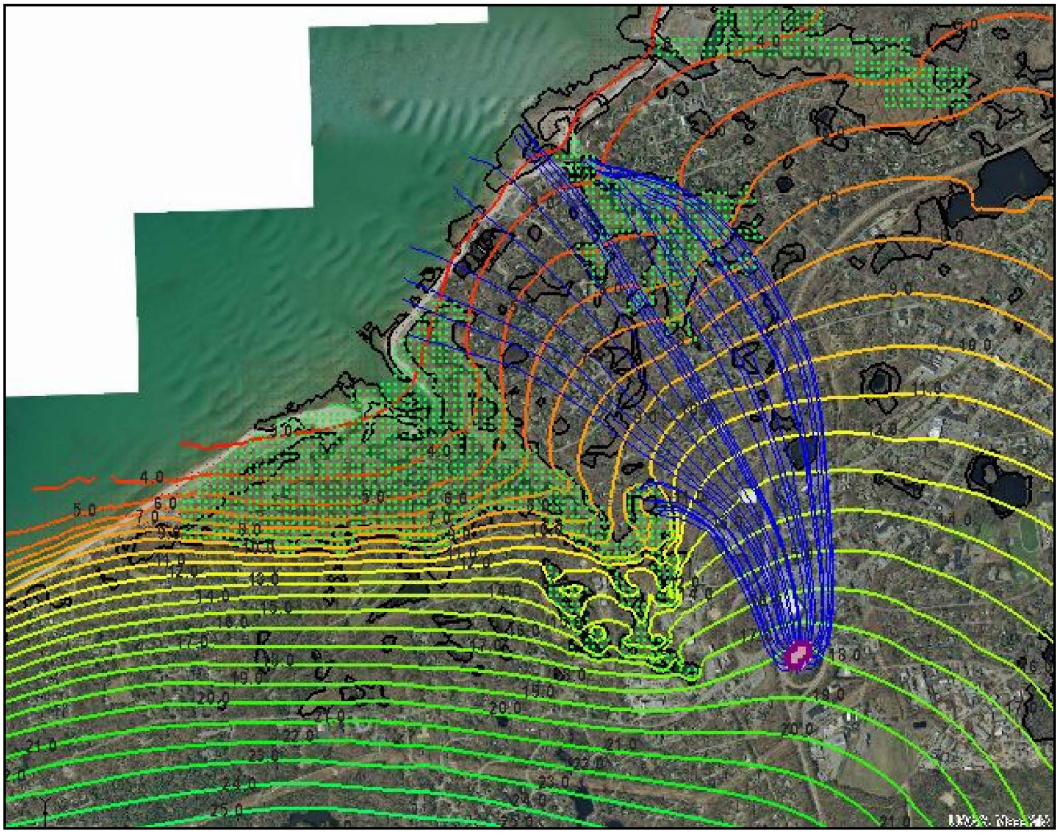

Groundwater Mounding

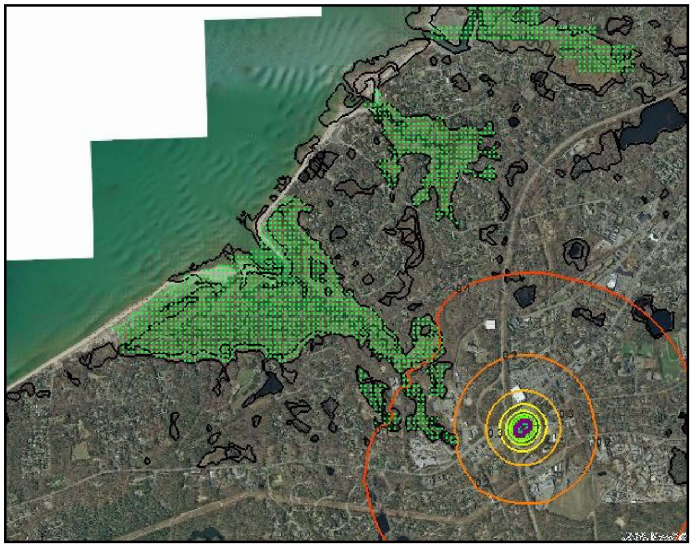

FIGURE 15

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION C - 100,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.1 ft)

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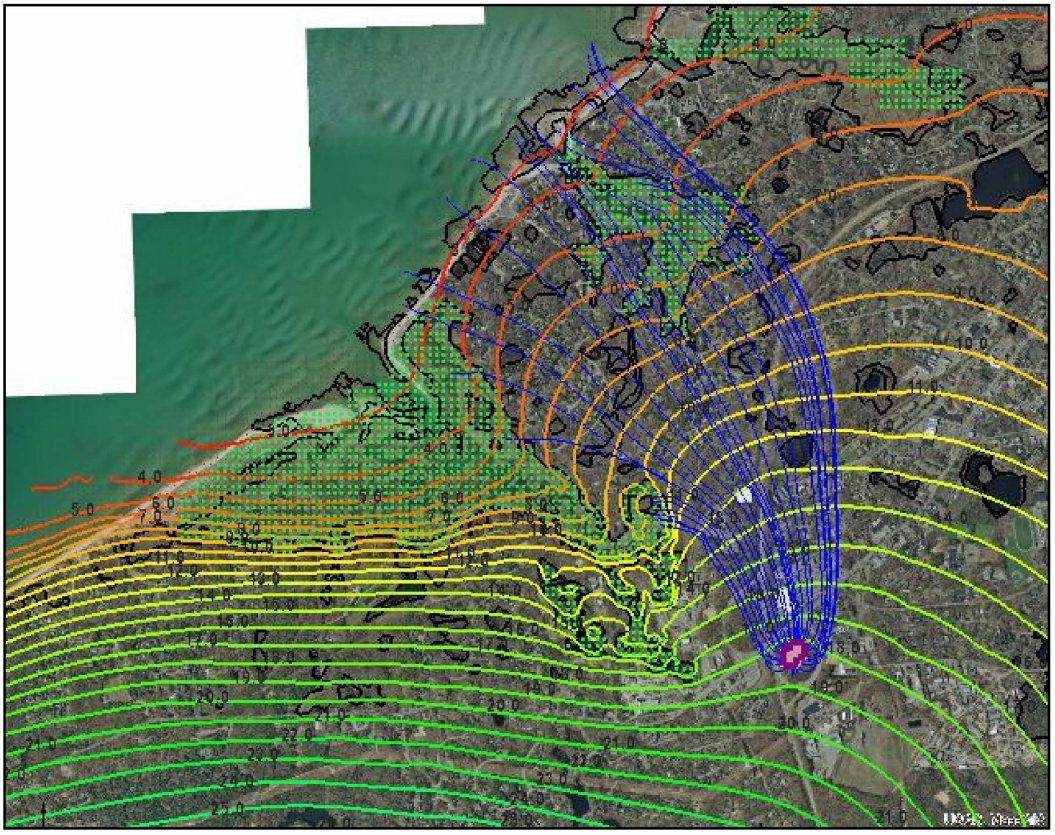

Groundwater Mounding

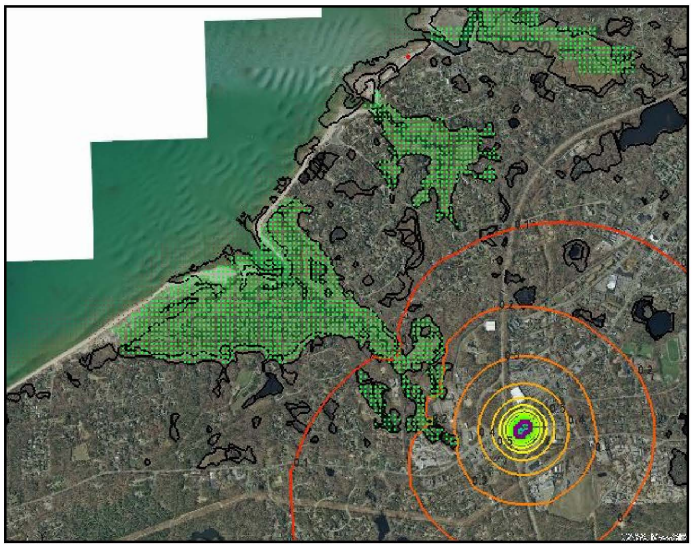

FIGURE 16

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION D - 150,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.1 ft)

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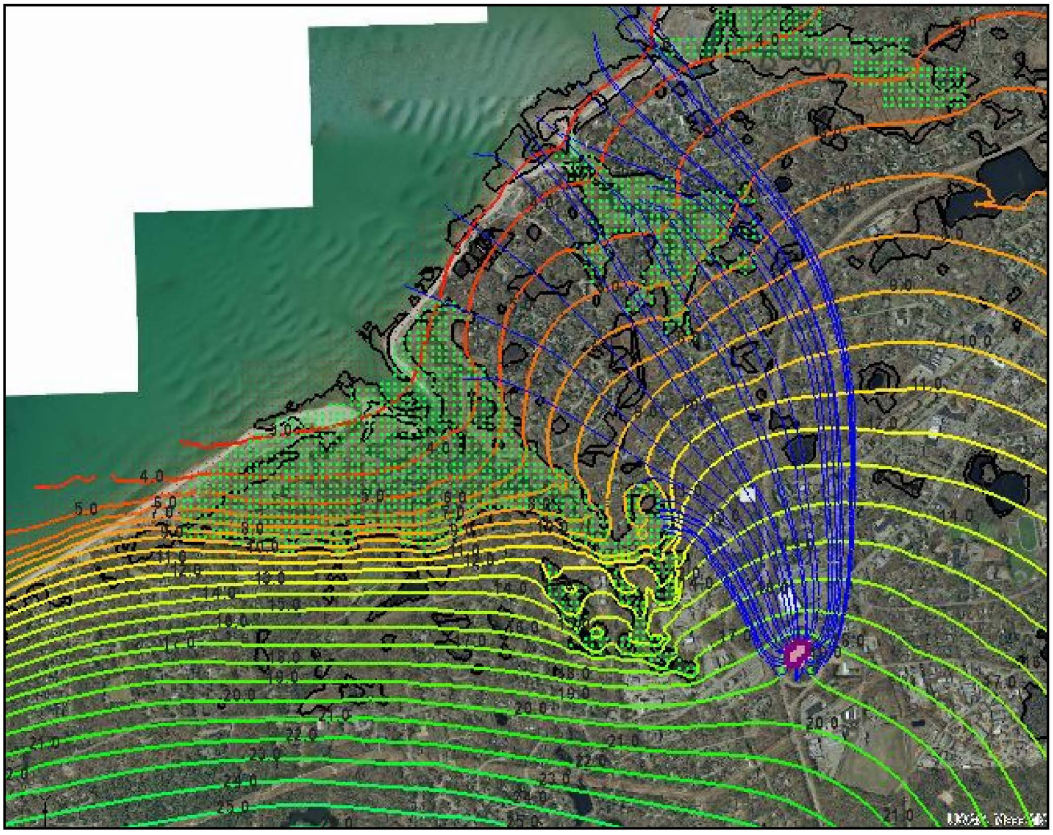

Groundwater Mounding

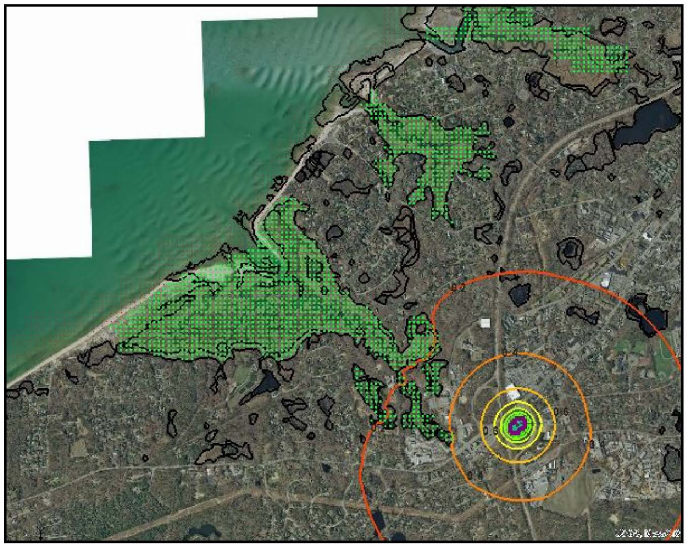

FIGURE 17

**ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING**

SIMULATION E - 200,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.2 ft)

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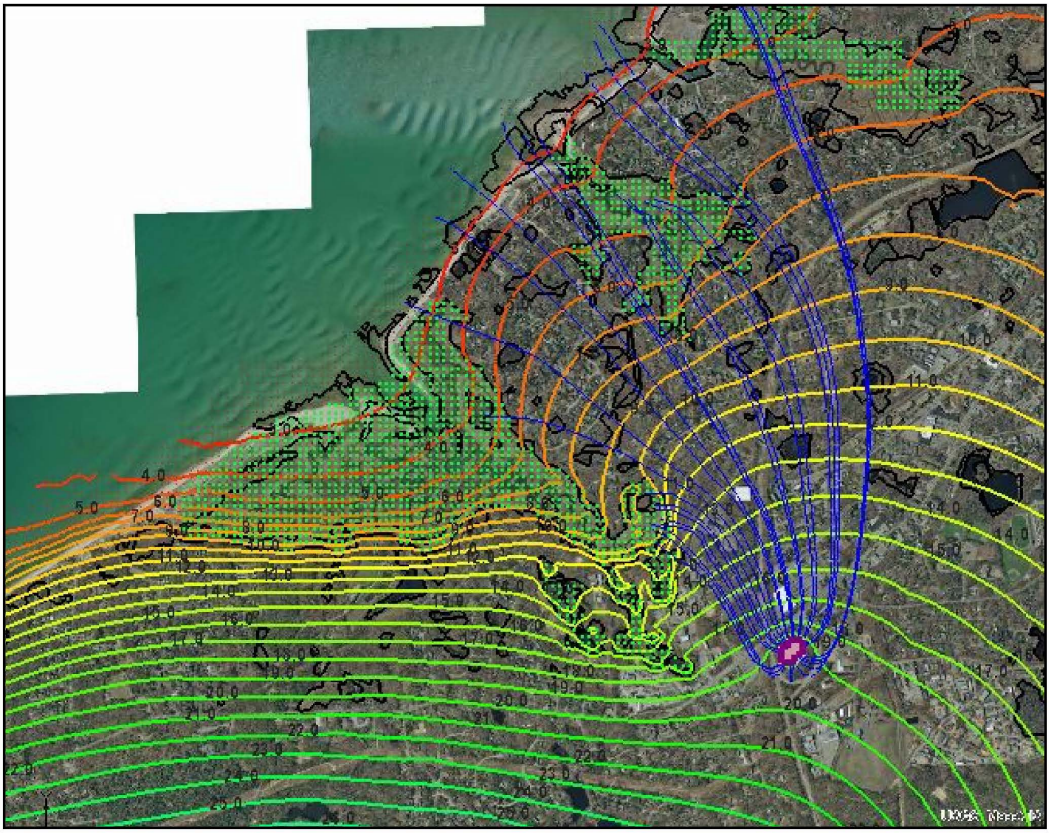

Groundwater Mounding

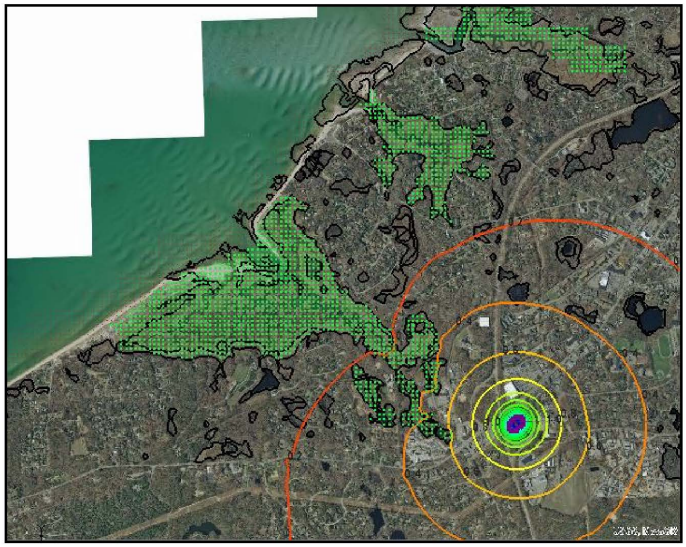

FIGURE 18

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION F - 300,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.2 ft)

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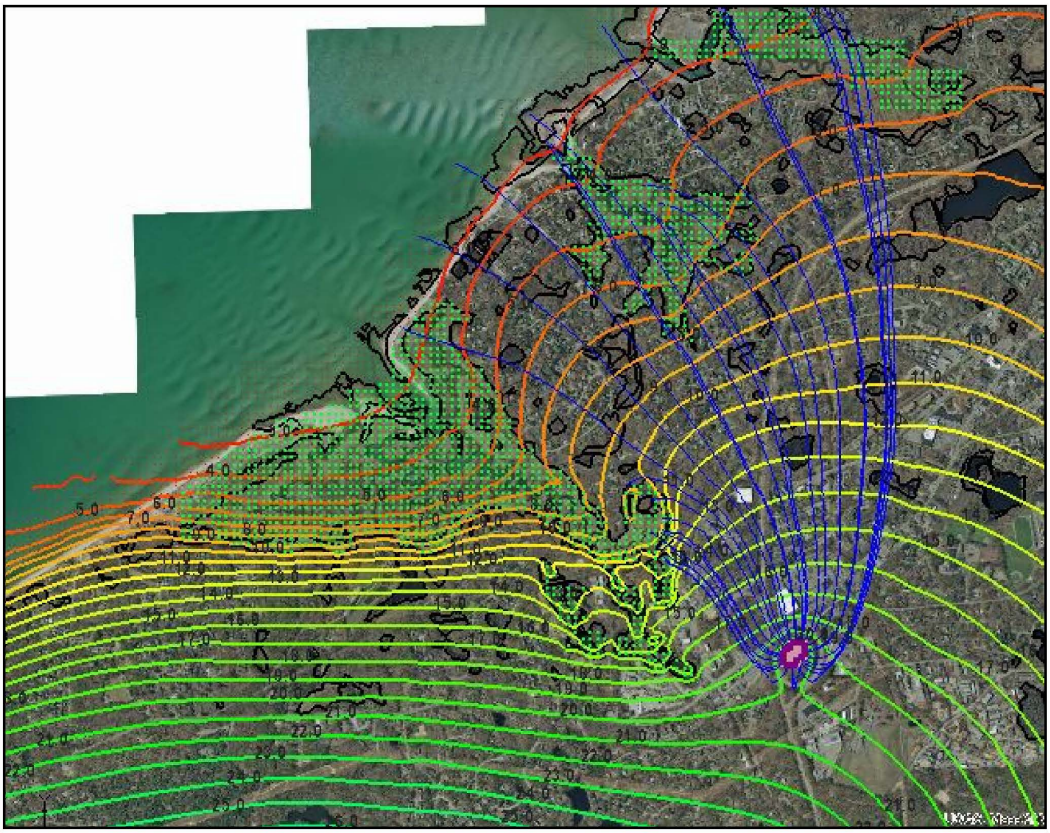

Groundwater Mounding

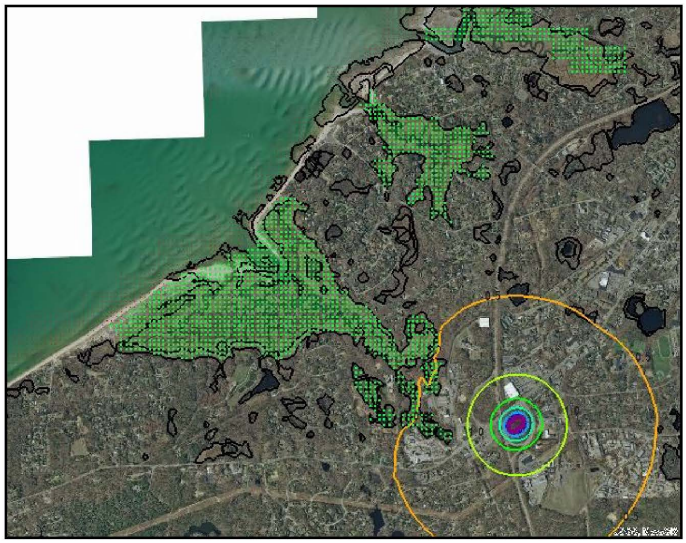

FIGURE 19

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION G - 400,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.5 ft)

AECOM

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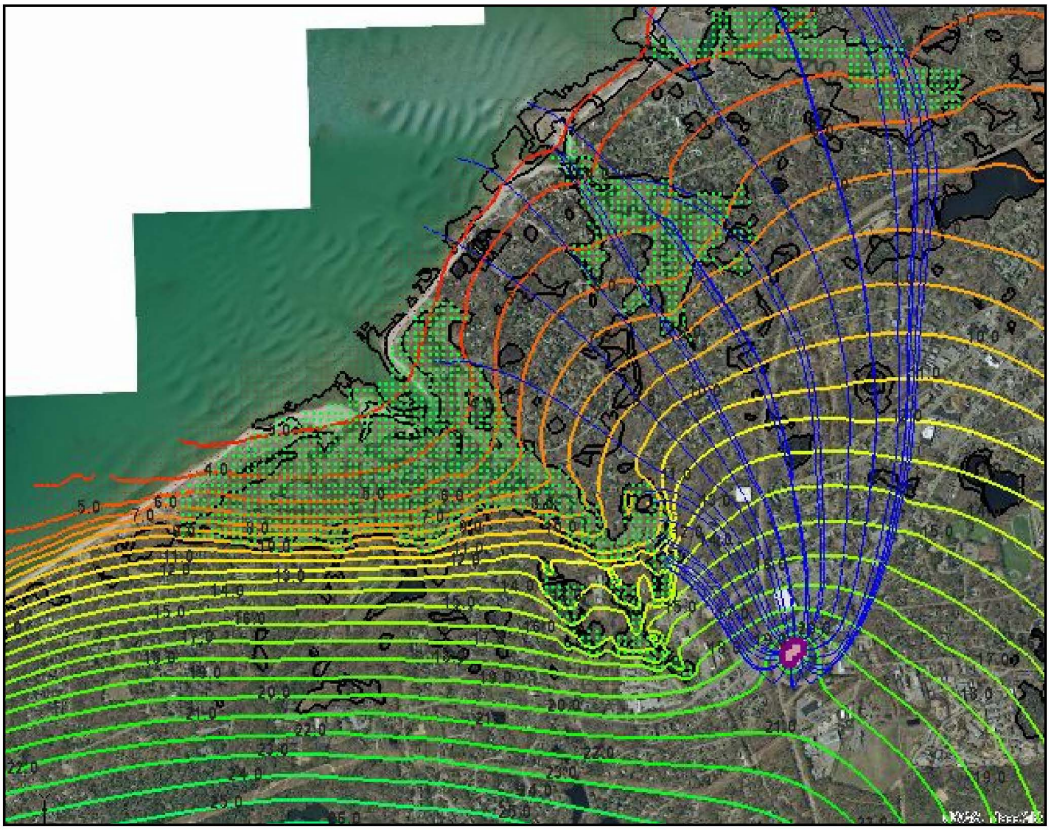

Groundwater Mounding

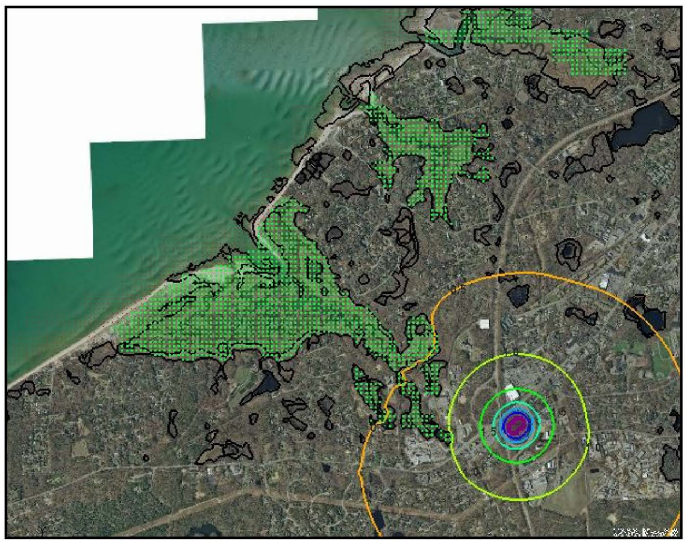

FIGURE 20

ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING

SIMULATION H - 500,000 gpd

Legend

- Groundwater Discharge Area
- Model Drain Nodes
- Simulated Groundwater Discharge Flow Path
- 5.0 Simulated Groundwater Contours (ft)
- Groundwater Mound Contour (contour interval 0.5 ft)

AECOM

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- Simulation B – 50,000 gpd - Figure 14 shows the simulated paths of groundwater flow as determined by the particle-tracking module. At a discharge rate of 50,000 gpd, the model indicates that a majority of the groundwater discharge flows northwest discharging to Cape Cod Bay. As indicated by the particle traces, a small portion of the WWTF discharge enters Namskaket, and Little Namskaket Marshes. Compared to Simulation A, the flow path distribution is slightly wider. The groundwater elevation below the discharge at its highest point is approximately 18.39 feet, indicating 0.89 feet of mound.
- Simulation C – 100,000 gpd - Figure 15 shows the results of Simulation B, treated effluent discharge at a rate of 100,000 gpd. The maximum mound elevation is predicted to be approximately 19.23 feet or 1.73 feet above the ambient groundwater levels. With the ground elevation being at least 70 feet, the top of the mound would be at least 50 feet below ground surface.
- Simulation D – 150,000 gpd - Simulation C (Figure 16) shows the simulated paths of groundwater flow as estimated by the groundwater model. At 150,000 gpd, the model predicts that the groundwater discharge will discharge to Cape Cod Bay, Namskaket Marsh and Little Namskaket Marsh, with most of the flow going to Cape Cod Bay. The groundwater elevation at the top of the mound would be approximately 20 feet, or 2.5 feet of mounding. The estimated high groundwater condition would bring the mound to approximately 50 feet below the ground surface. The overall distribution of applied groundwater spread of the discharge continues to widen when compared to simulation as well as at lower discharge rates (Figure 15).
- Simulation E – 200,000 gpd - Figure 17 also shows the simulated paths of groundwater flow as determined by the particle-tracking module for a discharge rate of 200,000 gpd. As with model Simulation D, the model results indicate that most of the groundwater will discharge to Cape Cod Bay. Some of the discharge reaches Namskaket, Little Namskaket and potentially Rock Harbor. The overall distribution of applied groundwater continues to widen with increasing flows, but the top of the mound continues to remain approximately 50 feet below the ground surface.
- Simulation F – 300,000 gpd - Model Simulation E, simulates a groundwater discharge of 300,000 gpd. Figure 18 shows the model results of Scenario Simulation E. The maximum mound height, directly below the discharge, is predicted to be approximately 4.8 feet above the ambient (no flow) groundwater levels. This is approximately 48 feet below ground surface. MassDEP requires a four-foot separation between the bottom of the infiltration beds and the high water table.
- Simulation G – 400,000 gpd – In this simulation, a groundwater discharge of 400,000 gpd was modeled. Figure 19 shows the model results of Simulation F. Some of the discharge reaches Namskaket, Little Namskaket and Rock Harbor. The maximum mound height, directly below the discharge, is approximately 2.1 feet above the ambient groundwater levels. This is approximately 46 feet below ground surface.
- Simulation H – 500,000 gpd - In this simulation, a groundwater discharge of 500,000 gpd was modeled. The model results for Simulation G are shown on Figure 20. The maximum mound height below the discharge area is approximately 7.4 feet. This is approximately mounded water table elevation is 45 feet below the ground surface, well over the minimum 4-foot separation required by MassDEP.

A higher rate of discharge above 500,000 gpd was not simulated.

5.6. Estimated Nitrate Loading to Surface Water Bodies

MODFLOW was used to simulate groundwater mounding and gradients from the proposed groundwater discharge location (Section 5.5). MODPATH was used to depict groundwater flow paths from the discharge location to demonstrate where groundwater may discharge into surface water bodies (i.e. Namskaket Marsh, Little Namskaket Marsh, Cape Cod Bay). In order to calculate the concentration and mass flux of nitrate (nitrate load) into surface water bodies, AECOM used MT3DMS in conjunction with the MODFLOW groundwater flow field.

MT3DMS is a three-dimensional fate and transport model developed by the US Army Corps of Engineers (Zheng, et al., 1999) that simulates source term characteristics, dispersion, retardation, and degradation in order to predict attenuation of dissolved phase constituents in the groundwater. AECOM completed this modeling using the pre/post-processor GMS 10.2.5 (Aquaveo, 2017).

To estimate the mass loading in the surface water bodies for this project, the following assumptions were made:

- Degradation was not considered a significant attenuation process for the simulations. In other words, nitrate dies not degrade in groundwater, a conservative assumption;
- Longitudinal dispersion was assumed to be 10 ft and transverse and vertical dispersion were assumed to be one-tenth and one-hundredth of the longitudinal dispersion, respectively;
- A discharge concentration of 10 mg/L of nitrate; and
- Travel times from disposal to discharge were estimated using particle tracking. Steady state was not quite achieved in Cape Cod Bay and the deep layers of the model for the Cloverleaf site until approximately 100,000 days (almost 274 years).

The model was run for three discharge simulations, 100,000, 200,000, and 400,000 gpd. The MT3DMS output is an estimated concentration at each model cell. For each surface water body, an array of cells was defined. In general these distributions of concentrations are similar to the particle pathlines shown in Figures 15, 17, and 19.

In order to calculate the nitrate load to each surface water body, the concentrations within the array of cells defined for each water body was multiplied by the groundwater discharging from each model cell with a drain (marsh) or general head (ocean) boundary condition. The fluxes are provided by the cell-by-cell flow file generated in the MODFLOW run.

USGS Monomoy Lens Model, general head boundaries were used to represent Cape Cod Bay. For Cape Cod Bay, the mass flux for all cells representing Cape Cod Bay were summed and converted to kg/year. For Namskaket Marsh, Little Namskaket Marsh, and Rock Harbor, the drain boundary was used to estimate the nitrate load discharged to each. To do so, an additional step was needed to determine which model cells (and fluxes) were assigned to each of these water bodies. Once assigned, the fluxes could be summed over all cells representing each of the three tributaries to Cape Cod Bay. There are drain cells in the model domain that represent other water bodies and are considered “other” in the summary of results discussed below.

In order to calculate the flow to each of the boundaries, we used the USGS calibrated model and “flow budget” tool included in the GMS pre and post processer. This tool reports on the flow in and out of selected cells and boundary conditions. For example, a set of cells were selected to represent Namskaket Marsh and the flow budget tool was used it reported the flow through those drain cells. This was completed separately for the drain cells representing Little Namskaket and Rock Harbor. Flow through the general head boundary cells, representing Cape Cod flow into Cape Cod Bay, was similarly used using the flow budget tool.

Table 5 summarizes the nitrate loading to each of the estuaries after 100,000 days of WWTF loading at flow rate 400,000 gpd. Also summarized in Table 5 is the combined watershed load with the estimated WWTF load. In all watersheds at all three loading rates, the total nitrate load is below the nitrate threshold load for the respective watershed.

Table 5
Estimate of Watershed Load From Route 6 (Exit 12) Cloverleaf Site
Discharge Rate - 400,000 gpd

Estuary	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Estimated WWTF Nitrate Load	Watershed Load with WWTF[3]	Percent of Watershed Load with WWTF
			(kg/yr)		
Namskaket Marsh	3,446	16,750	1,610	5,056	30
Little Namskaket Marsh	2,797	4,650	945	3,742	80
Rock Harbor	ND	ND	43	ND	ND
Cape Cod Bay	ND	ND	2,400	ND	ND

Notes:
[1] Present and Threshold Loads from Draft and Final MEP Reports for Namskaket Marsh, Little Namskaket Marsh, and Rock Harbor. Tri Town WWTF Loads Removed.
[2] Watershed Load = Threshold Load - Present Load
[3] Estimated Watershed Load with WWTF = Present Nitrate Load + Estimated WWTF Load
[4] Threshold Load From Draft MEP Report for Rock Harbor - 1,951 kg/yr (Subject to Change)

gpd = gallons per day
kg/day = kilograms per day
kg/yr = kilograms per year

6. WATER QUALITY

On May 4, 2017, baseline water quality sampling was performed at the Route 6 (Exit 12) Cloverleaf site. Groundwater samples were collected from all three wells installed by AECOM, CLS-1, CLS-2, and CLS-3. The samples were submitted to a Massachusetts certified analytical laboratory for inorganic and organic analyses. In addition, in-situ water quality sampling was performed in the field using an YSI water quality meter.

In general, the water quality results indicate that the groundwater quality results meet Massachusetts's drinking water quality standards. Nitrate and phosphorous levels are relatively low. Chloride levels were also relatively low. Toluene was detected in groundwater from CLS-3 just above the minimum reporting limit. Results of the field and laboratory testing are summarized in Table 6. Copies of the laboratory reports are provided in Appendix F.

TABLE 6
SUMMARY OF LABORATORY WATER-QUALITY RESULTS

Parameter	Units	MRL	Drinking Water Standard[1]	Monitoring Well CLS-1	Monitoring Well CLS-2	Monitoring Well CLS-3
Sample Date:				5/4/17	5/4/17	5/4/17
Field Results:						
pH	S.U.	NA	6.5-8.5[2]	6.83	6.50	6.50
Specific Conductance	μmho/cm	0	NE	97	103	158
Turbidity	NTU	0.25	NE	44.8	355	>1000
Temperature	^{0}C	0.01	NE	12.56	13.58	15.19
ORP	mV	0.1	NE	136.0	156.4	150.0
Dissolved Oxygen	mg/L	2.50	NE	12.65	11.82	5.00
Laboratory Results:						
Sodium	mg/L	2.500	20[3]	12.800	16.600	12.800
Chloride	mg/L	3.0	250[2]	19.5	25.9	20.3
Nitrate-N	mg/L	0.110	10	0.074	<0.03	0.051
Nitrite-N	mg/L	0.010	1	<0.01	<0.11	0.01
Ammonia as N	mg/L	0.10	NE	<0.1	<0.1	<0.1
Total Phosphorus as P	mg/L	0.10	NE	<0.1	<0.1	0.36
Ortho Phosphorus as P	mg/L	0.10	NE	<0.1	<0.1	<0.1
VOCs Toluene	μg/L	1.0	1	ND	1.4	ND

NA = not applicable
ND = not detected
NE = not established
NTU = Nephelometeric turbidity units
μg/L = microgram per liter
S.U. = standard units
VOCs = Volatile Organic Compounds

[1]Mass. Maximum Contaminant Level
[2]Mass. Secondary Maximum Contaminant Level
[3]Mass. DEP Office Research and Standards Goal
mg/L = milligram per liter
μmho/cm = micromho per centimeter
MRL = Minimum Reporting Limit

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7. POTENTIAL IMPACTS

The potential impacts resulting from the proposed groundwater discharge fall into two general categories: 1) potential water quality impacts and 2) potential groundwater mounding impacts. Although the discharge will be treated to high levels, the discharge may contain slightly higher levels of nutrients and other constituents compared to the ambient groundwater. Potential mounding impacts include: one, the discharge of groundwater in areas where groundwater does not presently discharge, and second the rise of groundwater levels under surrounding properties.

As described, groundwater model was used to simulate potential mounding and nutrient loading impacts at several groundwater discharge flow rates between 25,000 and 500,000 gpd. Groundwater mounding results at each of the discharge rates are shown on Figures 13 through 20. Tables summarizing the results of the nitrate loading to estuaries are provided in Appendix G.

When estimating potential groundwater mounding and water quality impacts were modelled, conservative model parameters were used to generate the scenarios. These include:

- The groundwater model simulations used to estimate potential mounding impacts were performed under high water conditions (Section 4.3);
- The groundwater model was used to simulate potential mounding impacts and nutrient loading impacts at several flow rates up to 500,000 gpd. WWTF discharge flows are not expected to exceed 250,000 gpd for the downtown area at buildout. The Meetinghouse Pond sewer area is not expected to exceed a flow of 110,000 gpd and may be discharged at another location. If both sewer areas are treated at the proposed WWTF and discharged at the Cloverleaf Site, the maximum flows at buildout are not expected to exceed 360,000 gpd at Buildout;
- The groundwater model simulations used to estimate potential water quality impacts used an effluent concentration input of 10 mg/L of nitrogen. The expected discharge concentration would likely be less than 5 mg/L, less than half the model input;
- The groundwater model simulations indicate that a majority of the WWTF effluent will flow deep in the aquifer, taking tens of years for the discharge to reach Cape Cod Bay or the Namskaket, Little Namskaket and Rock Harbor estuaries. It is likely that a significant portion of the nitrate load will be removed through natural attenuation due to the significant amount of time the effluent will flow through the deeper, low oxygen aquifer. The nitrate attenuation is not accounted for in the estuaries nitrate load estimation included in this section; and
- USGS soil boring data indicates a significant clay layer in the aquifer in the vicinity of the bike path west of the former Tri Town Septage Treatment Facility (Weiskal, et.al. 2016). There is the possibility that this clay layer extends west and northward under Namskaket Marsh into Cape Cod Bay. If this is the case, the clay layer could reduce groundwater mounding in the Marsh area as well as the amount of nitrate load that may reach the marsh. The clay layer may also extend north and northwestward under portions of Little Namskaket and Rock Harbor Estuaries, again decreasing mounding and nitrate load impacts to theses marsh area. As the extent of the clay layer is presently not known, this clay layer and its potential mitigating impacts were not included in the model design.

The following should also be kept in mind when considering potential groundwater discharge impacts:

- Groundwater model results indicate that it will take 3 to 4 years for the Cloverleaf Site discharge to reach the nearest wetland. It will take between 4 to over 100 years for the discharge to reach of Namskaket, Little Namskaket, Rock Harbor, and Cape Cod Bay Estuaries;
- It will likely take in excess of 10 to 20 years for the town to reach buildout conditions and for WWTF flows to reach the modeled discharge flows; and
- Sea level rise will increase over time, increasing flow in and out of the estuaries and potentially offsetting some of the potential impacts discussed in this section. Sea level rise was not considered in the groundwater modeling simulates.

7.1. Potential Groundwater Mounding Impacts

The primary site of proposed discharge is at Route 6 (Exit 12) Cloverleaf site. Based on AECOM's groundwater model simulations, groundwater mounding would not impact any structures at the Route 6 (Exit 12) Cloverleaf site, or any nearby properties. In general, the average or high water level elevations from groundwater mounding is insignificant compared to the surrounding ground elevations.

The groundwater mounding simulation at a discharge rate of 400,000 gpd indicates that a rise of approximately 0.5 feet may occur at the eastern/southeastern boundary of Namskaket Marsh, as illustrated in Figure 19. Although this groundwater mound prediction is only an estimate, the increase in groundwater elevation in the vicinity of Namskaket Marsh has the potential to alter the hydrology of the marsh sufficiently that a vegetation change may occur. The portion of the Namskaket Marsh that is within the outermost contour of the predicted groundwater mound is an area which includes both a saltmarsh as well as a brackish plant community associated with Hurley's Bog on the south side of the Cape Cod Rail Trail (SMAST, 2016).

Typically, the hydrology driving the presence of hydrophytic plant species is located within the top 12-inches of the soil; therefore, a change in this regime of 6 inches could result in a change to the hydrological conditions experienced by plant species present. Since the discharge would represent an increase in freshwater input to the marsh, it is possible that a shift from salt marsh to freshwater plant species could occur in certain areas of the marsh. These conditions would be particularly favorable to an increase in the extent of *Phragmites*, which already exists in the area (SMAST, 2016). The extent of any vegetation shift is difficult to predict. Therefore, monitoring of the plant species distribution within the eastern/southeastern portion of Namskaket Marsh is recommended just prior to the discharge commencing, in order to document any shifts in plant cover from salt water to freshwater species, including *Phragmites*. Similar to the previous study conducted by SMAST, it is recommended that long-term permanent monitoring plots be established in Namskaket Marsh in the vicinity of the predicted mount in order to annually monitor plant community composition, and thereby document any changes over time. If any changes to the salt marsh community were to occur, such as expansion in *Phragmites* cover, mitigation measures such as restoration or replication of a salt marsh in the vicinity or payment to the Commonwealth's in-lieu fee administered by the Massachusetts Department of Fish and Game should occur.

It should be noted that a recent study conducted by USGS (USGS, 2016) indicated that as a result of sea level rise, groundwater levels on Cape Cod are predicted to rise as high as 2.11 feet, with a more nominal rise of 0.1 foot near inland streams. Given these predictions, it is likely that any effect of the groundwater mounding would be dwarfed by the changes in sea level rise.

It is possible that floodplains at the eastern/southeastern boundary of Namskaket Marsh may be slightly affected as the water table may rise slightly in the low elevation areas around the marshes. Thus, it is possible that the extent of the floodplain may increase slightly as a result of the predicted groundwater mounding. However, any increase would be unlikely to raise the floodplain elevation by a half foot or more which would trigger a modification to the mapped floodplain. In addition, as mentioned above, any increase is likely to be dwarfed by predicted sea level rise.

7.2. Potential Water Quality Impacts

The elimination of the Tri Town Septage Treatment Facility and septic systems will result in long-term improvements in groundwater quality glowing into Namskaket Marsh. No significant short-term impacts on surface water quality are expected. It is likely that improvement in groundwater quality that will eventually lead to better surface water quality to the marsh

The groundwater model estimates that it will take ten or so years after the initiation of the groundwater discharge for the effluent mixed with groundwater to emerge in Cape Cod Bay and Little Namskaket Marsh, and Rock Harbor. When most of the effluent-impacted groundwater eventually emerges, it would likely do so sufficiently offshore or in sufficiently well-mixed areas (i.e. stream channels) that the water quality would not impact Cape Cod Bay or the Namskaket and Little Namskaket Marsh areas. In addition, a relatively small proportion of the effluent (less than one percent) would discharge to Rock Harbor.

Cape Cod Bay has not been evaluated by the Massachusetts Estuaries Project (MEP), but Namskaket and Little Namskaket Marsh and Rock Harbor are all evaluated in MEP reports that identify nitrogen loading thresholds based on hydrodynamic and water quality modelling of these estuarine systems (Howes et. al. 2007a, b and c). The MEP modelling analysis of both the Namskaket and Little Namskaket marsh systems indicates that the marshes are still able to assimilate additional nitrogen without adverse water quality and benthic habitat impacts. The residual nitrogen remaining after treatment at the Route 6 (Exit 12) Cloverleaf site will increase the nitrogen loading to both Namskaket Marsh and Little Namskaket Marsh, but only to approximately 30 percent and 80 percent of their respective MEP nitrogen load target (Table 5).

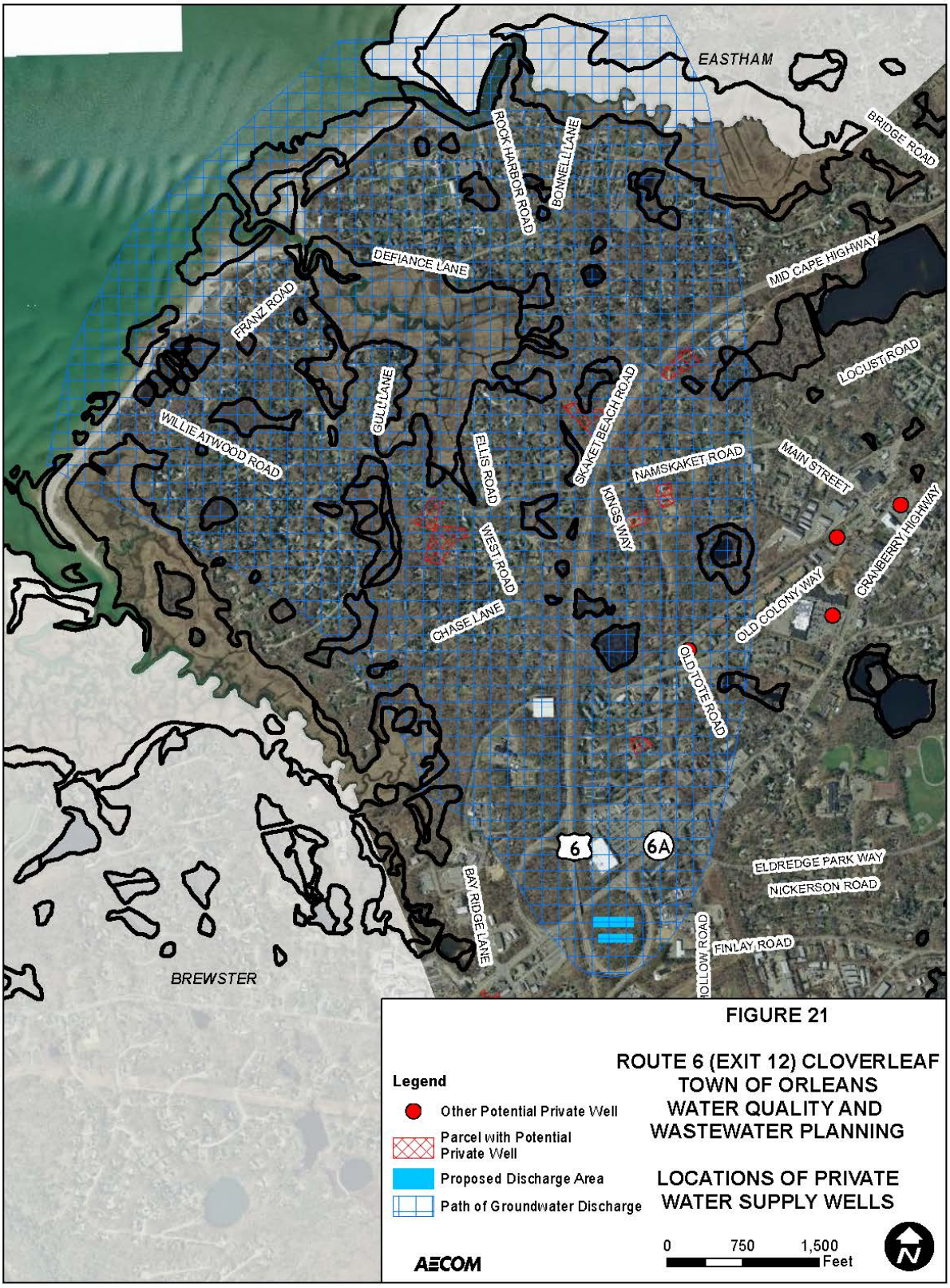
Similarly, the small percentage of effluent expected to discharge to Rock Harbor is predicted to result in a total nitrogen watershed load that is still only three percent of the load target set by the MEP report. Thus, the discharge would still be within the MEP recommended nitrogen loading for all three areas and consequently is not expected to result in an adverse effect on water quality or benthic habitat. Because Cape Cod Bay experiences a tremendous amount of daily flushing, it is not anticipated that the additional nitrogen loading to the Bay would result in adverse water quality or benthic habitat impacts, particularly when coupled with lowered nitrogen loading from the septic systems proposed to be taken offline.

Cape Cod Bay, Little Namskaket Creek (MA 96-26), Namskaket Creek (MA 96-27) and Rock Harbor Creek (MA 96-16) are not identified as impaired for nitrogen in either the MassDEP 2014 303(d) list of impaired waters, nor in the draft 2016 303(d) list of impaired waters. Namskaket Creek, Little Namskaket Creek, and Rock Harbor Creek are all listed as impaired for fecal coliform, and covered under a TMDL for this water quality constituent. The proposed groundwater discharge from the WWTF is expected to be within water quality standards set by the Commonwealth and would therefore comply with TMDL requirements.

There are no known sensitive receptors directly downgradient of the discharge with the exception of potential private water supply wells. According to Town records, several properties are located within the area where the WWTF discharge is predicted to flow (Figure 21). If the wells are for drinking water or irrigation supply, the Town should consider connecting the property to the public water supply as the private well may be located within the influence of the proposed discharge. Address and parcel information for the identified sites are provided in Appendix H.

7.3. Potential Impacts to Coastal Resources

Coastal resources in the area of groundwater mounding and eventual effluent discharge include beaches and associated swimming areas, commercial and recreational shellfishing areas, and marine/estuarine habitat. The groundwater mound and effluent discharge would occur within the Inner Cape Cod Bay Area of Critical Environmental Concern (ACEC), which includes Cape Cod Bay, both Namskaket and Little Namskaket marshes, and Rock Harbor up to the 10-foot ground elevation contour. Because a majority of the WWTF effluent will travel deep beneath these coastal resources and discharge sufficiently offshore or within stream channels where substantial tidal flushing will occur, the potential for nitrate impacts to the marshes is significantly lessened. As discussed in Section 7.2, the discontinued use of the septage treatment facility, the mixing of natural groundwater with the highly treated WWTF effluent, and taking numerous on-site septic systems offline, the water quality to coastal resources is expected to be an overall improvement. Thus the discharge is not expected to adversely affect the ACEC functions.


EASTHAM
BRIDGE ROAD
ROCK HARBOR ROAD
BONNELL LANE
DEFIANCE LANE
MID CAPE HIGHWAY
FRANZ ROAD
LOCUST ROAD
GULL LANE
WILLIE ATWOOD ROAD
ELLIS ROAD
SKAKET BEACH ROAD
NAMSKAKET ROAD
MAIN STREET
KINGS WAY
WEST ROAD
CRANBERRY HIGHWAY
CHASE LANE
OLD COLONY WAY
OLD TOTE ROAD
6
6A
ELDREDGE PARK WAY
NICKERSON ROAD
BAY RIDGE LANE
FINLAY ROAD
HOLLOW ROAD
BREWSTER
G:\Projects\MUNI\60476644\GRL\Maps\GWD_Cloverleaf_Figure21.mxd
FIGURE 21
ROUTE 6 (EXIT 12) CLOVERLEAF
TOWN OF ORLEANS
WATER QUALITY AND
WASTEWATER PLANNING
LOCATIONS OF PRIVATE
WATER SUPPLY WELLS
Legend
Other Potential Private Well
Parcel with Potential Private Well
Proposed Discharge Area
Path of Groundwater Discharge
AECOM
0
750
1,500
Feet
N

7.4. Potential Impacts to Wetlands

As discussed above in Section 7.1, the western extent of the simulated groundwater mound will intercept with the eastern/southeastern boundary of Namskaket Marsh. The mound may result in a shift in plant composition with more freshwater species and fewer salt marsh species, with a potential expansion in extent of *Phragmites* in the short-term. Over a longer time frame these changes may be dwarfed as a result of sea level rise. As described in Section 7.1, monitoring of Namskaket Marsh is recommended to document the long-term plant community stability as well as any potential changes, and if adverse changes are documented, compensatory mitigation can be implemented.

7.5. Potential Impacts to Rare and Endangered Species

According to the MassGIS data layers, Cape Cod Bay, and the area of Namskaket and Little Namskaket Marshes as well as Rock Harbor are mapped as Priority Habitat (Figure 3). The Massachusetts Natural Heritage and Endangered Species Program (NHESP) has not been contacted to determine which species are present in the areas of Cape Cod Bay, Rock Harbor and Namskaket Marsh, and Little Namskaket Marsh where groundwater mounding and eventual effluent discharge may occur. However, as discussed in Section 7.2, no adverse water quality impacts are anticipated to occur to any of these receiving waters. Therefore, water quality is not expected to impact any of the protected species.

As previously discussed (Section 7.1), the proposed discharge would result in a groundwater mound that may intercept the eastern edge of Namskaket Marsh. During consultation with NHESP as part of the preparation and submittal of the 2010 Comprehensive Wastewater Management Plan (CWMP), it was determined that Priority Habitat for four species protected under the Massachusetts Endangered Species Act (MESA) was present at the former Tri-Town Septage Treatment Facility site. The four species identified were: the Eastern Box Turtle (*Terrapene carolina*), the Diamond-backed Terrapin (*Malaclemys terrapin*), Salt Reedgrass (*Spartina cynosuroides)*, and Mitchell's Sedge (*Carex mitchelliana)*. During more recent discussions pertaining to the demolition of the compost shed associated with the former Tri-Town site, MA NHESP indicated that the area west of the site was potential habitat for two state listed plant species. Thus, the estimated mound from a discharge at the Exit 12 Cloverleaf site may extend to areas that include habitat for these and potentially others species.

Additional consultation with NHESP is needed to determine the species potentially present at the discharge site. Mitigation measures could include pre-discharge surveys to document the location of protected plant species and ongoing monitoring to evaluate any impacts on these species. However, monitoring may be necessary to confirm the presence and any impacts on protected species. Salt Reedgrass occurs at the upper fringes of salt marsh, while Mitchell’s sedge occurs in freshwater areas adjacent to salt marsh. These species would be particularly susceptible to changes in salinity and hydrology that may occur as a result of the groundwater mound. Thus, additional consultation with NHESP is necessary to confirm if any mitigation measures would be necessary.

7.6. Summary of Potential Impacts and Discharge Capacity of the Site

As described in this section, the groundwater model was used to simulate potential groundwater mounding and nutrient loading impacts at flow rates between 25,000 and 500,000 gpd. Based on model results, nutrient loading to the Namskaket, Little Namskaket, Rock Harbor, and Cape Cod Bay estuaries would be well within each estuaries capacity to assimilate the additional nitrate load. This is particularly true when considering that the Former Tri Town Facility is no longer contributing nitrate to the Namskaket Marsh and numerous septic systems will be taken offline once the WWTF goes online.

Groundwater mounding could potentially increase in the vicinity of Namskaket Marsh and has the potential to alter the hydrology of the upper reaches of the Namskaket marsh in the vicinity of Hurley's Bog on the south side of the Cape Cod Rail. The portion of the Namskaket Marsh where the highest groundwater mounding is predicted includes both a saltmarsh and brackish plant community associated with Hurley's Bog on the south side of the Cape Cod Rail Trail (SMAST, 2016). Long-term permanent monitoring plots could be established in this area for annually plant community monitoring. If changes are documented over time, mitigation measures would need to be taken. Similar monitoring may be necessary with the areas identified as Priority Habitat or Rare and Endangered Species.

Based on the evaluation of the soils underlying the site, groundwater modeling simulations and results, and evaluation of potential mounding and water quality impacts to sensitive receptors, the Route 6 (Exit 12) Cloverleaf site is suitable for a groundwater discharge rates up to 500,000 gpd.

As required by MassDEP, a conventional reserve discharge area equal to the discharge capacity of the WWTF would need to be identified and approved prior to allowing a discharge at the Route 6 (Exit 12) Cloverleaf site.

8. GROUNDWATER MONITORING PLAN

A groundwater monitoring plan will be implemented to assess both baseline and compliance groundwater quality in the vicinity of the potential primary discharge. The location of the proposed monitoring wells, baseline water quality parameters and compliance water quality parameters are discussed in the following sections.

8.1. Baseline Water Quality

An initial round of water level data and groundwater samples was collected from the proposed monitoring wells in May 2017. A summary of the field and laboratory results is provided in Section 4.0. Prior to discharging effluent, two rounds of groundwater samples will be collected at monitoring well locations CLS-1, CLS-2, and CLS-3 and sent to a laboratory for analysis. Water samples will be analyzed in the field for temperature, pH and specific conductance. Groundwater samples collected from each of the monitoring wells will also be sent to a MassDEP certified laboratory for analysis. At a minimum, laboratory analysis will include nitrate-nitrogen, total nitrogen, total phosphorus, sodium, and volatile organic compounds (VOCs). Groundwater sampling will be conducted in accordance with MassDEP's "Standard References for Monitoring Wells". A round of water levels will also be collected at the time of sampling. The water level data and water quality results will be summarized and submitted to the MassDEP for review.

8.2. Compliance Monitoring

Once the WWTF is operational, groundwater samples will be collected and analyzed to demonstrate that the groundwater quality meets the standards set by MassDEP. Groundwater monitoring will be performed at the three monitoring well locations (CLS-1, CLS-2, and CLS-3) outlined above. The proposed sampling frequency and parameters are as follows:

- Monthly Sampling – Water quality analysis for pH and conductivity will be analyzed on a monthly basis. In addition, a round of water levels will be collected and recorded;
- Quarterly Sampling – In addition to the monthly sampling, total nitrogen, total phosphorus, nitrate-nitrogen, sodium and fecal coliform will be sampled and analyzed quarterly;
- Twice Annual Sampling. In addition to the monthly and quarterly sampling, VOCs will be sampled and analyzed twice annually; and
- Groundwater samples collected during each round will be sent to a MassDEP certified laboratory for analysis. Groundwater sampling will be conducted in accordance with MassDEP's "Standard References for Monitoring Wells". After each round of sampling, the water level data and water quality results will be summarized and submitted to the MassDEP for review.

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Appendix A

Correspondence

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Gang 44

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, Secretary & CEO
Thomas J. Tinlin, Administrator

massDOT
Massachusetts Department of Transportation
Highway Division

Permit #: 5-2017-0056

PERMIT – ORLEANS

Subject to all terms, conditions, and restrictions printed, attached or written below, and on the reverse side hereof, permission is hereby granted to **AECOM**, Mark R. Owen, 9 Jonathan Bourne Drive, Pocasset, MA 02559 to enter upon the State Highway in the Town of **ORLEANS** on Auto Route 6, locally known as Mid-Cape Highway and on Auto Route 6A, locally known as Cranberry Highway, for the purpose of performing three (3) to four (4) soil borings/monitoring wells, six (6) to ten (10) test pits, and groundwater testing and sampling within the State Highway Layout.

This permit is being granted for the installation of three (3) to four (4) soil borings/monitoring wells (SB-1, MW-1, MW-2 and MW-3), six (6) test pits (TP-1, TP-2, TP-3, TP-4, TP-5, TP-6), and performing groundwater testing and sampling for the hydrogeologic evaluation for potential groundwater discharge as part of a preliminary design report for the Orleans Amended Comprehensive Wastewater Management Plan. The hydrogeological evaluation will be performed inside the southeastern cloverleaf ramp of Route 6, Exit 12. The soil borings/monitoring wells will have a 2" diameter and the test pits will be 6' (ft) wide x 12' (ft) long x 16' (ft) deep.

All the work will be performed at the location shown in the attached aerial picture.

Upon completion of the work within the shoulder area, all disturbed areas must be filled and brought up to grade, compacted and loamed and seeded.

The Grantee(s) will be responsible for the work performed under this Permit against cracks, settling or heaves until work is performed on said areas by MassDOT, Highway Division.

The Grantee(s) will be responsible to replace/reset any covers that may be damaged.

WINTERTIME WORK CONDITIONS

Work to be performed between November 15th and April 1st may be allowed WEATHER PERMITTING with prior written approval from the District Highway Director, and must be in conformance with the Massachusetts Highway Department "Standard Specifications for Highways and Bridges" dated 1988, and the "Supplemental Specifications to the Standard Specifications for Highways and Bridges" dated July 1, 2015.

When the air temperature falls below 50° F, extra precautions shall be taken in drying the aggregates, controlling the temperatures of the material and placing and compacting the mixtures.

No bituminous concrete mixture shall be placed unless the breakdown and intermediate rolling can be completed by the time the material has cooled to 170° F, and provided that the density of the completed pavement attains at least 95% of the laboratory compacted density.

"FOLLOWING CONDITIONS APPLY TO PERMITS"

Conditions Relating Particularly to Permits for the Laying of Pipes, Conduits, etc.

After any pipes, conduits, drains or other underground structures are laid, or any excavation is made in the roadway, the trenches or openings shall be properly backfilled with suitable material, the back-filling shall be thoroughly tamped, and the surface of the road over said structures shall be left even with the adjoining ground. If the work is done in cold weather no frozen material shall be used for back-filling.

Wherever the hardened surface of the roadway, gutters, or any part of the surface of the highway is disturbed it shall be replaced in as good condition as before it was disturbed, and if new materials are required they shall correspond with those already in place on the road.

Where service pipes are to cross the highway the connections shall be made without disturbing the hardened surface of the roadway, by driving the pipes under the roadway, or the service pipes shall be carried under and across the road in a larger pipe, unless otherwise ordered by the Director.

The Grantee shall maintain the surface of the roadway over said structures as long as MassDOT may deem necessary, until all signs of the trenches shall have been eliminated.

Conditions Relating Particularly to Permits for the Erection of Poles, Wires, and Overhead Structures, and the Cutting and Trimming of Trees

In the erection of pole lines, unless otherwise herein provided, no trees located within the limits of the State Highway shall be cut or trimmed. No guy wires shall be attached to trees without a special permit from MassDOT, and in no event shall they be so attached as to girdle the trees or in any way interfere with their growth. The wires shall be so protected at all time and places that they shall not interfere with or injure the trees either inside or outside the location of the highway.

Where the cutting or trimming of trees is authorized by this permit, only such cutting and trimming shall be done as may be designated by the Director.

In the construction or reconstruction of pole lines no guy wires shall be erected nearer to the surface of the ground than six feet; provided, however, that the owners of such lines may maintain such guy wires at a lower elevation than six feet from the ground until such time as MassDOT shall notify them to remove said wires or to the elevation first stated.

In order to protect the trees through which any wires may pass, said wires shall be insulated and such other tree guards used as may be directed by the Director.

Where high tension wires are erected under this permit, they shall be so located that, under conditions of maximum severity as regards a coating of ice or snow, there shall be a space of at least eight feet between such high tension wires and other wires.

The Grantee shall, within sixty days from the date of completion of the work, file in the office of MassDOT a plan showing the location of each pole erected in accordance with the permit, said plan to be of such size and in such form as MassDOT may direct.

General and Additional Conditions

Whenever the word "MassDOT" is used herein it shall mean the Massachusetts Department of Transportation of the Commonwealth of Massachusetts.

Whenever the word "Director" is used herein it shall mean the District Highway Director or other authorized representative of MassDOT.

Whenever the word "Grantee" is used herein it shall mean the person or persons, corporation or municipality to whom this permit is granted, or their legal representatives.

During the progress of the work all structures under ground and above ground shall be properly protected from damage or injury; such barriers shall be erected and maintained as may be necessary for the protection of the traveling public; the same shall be properly lighted at night; and the Grantee shall be responsible for the damages to persons or property due to or resulting from any work done under this permit.

Except as herein authorized, no excavation shall be made or obstacle placed within the limits of the State highways in such a manner as to interfere unnecessarily with the travel over said road.

If any grading of sidewalk work done under this permit interferes with the drainage of the State highway in any way, such catch basins and outlets shall be constructed as may be necessary, in the opinion of the Director, to take proper care of such drainage.

Wherever the hardened surface of the roadway is disturbed and the Director may consider it necessary or advisable to do so, said surface will be restored by the employees of MassDOT, at such time as MassDOT may direct, and the expense thereof shall be borne by the Grantee, who shall purchase and deliver on the road the materials necessary for said work if and when directed by the Director. All payments to the supplier and to laborers, inspectors, etc., employed by MassDOT for or on account of the work herein contemplated shall be made by said Grantee forthwith on receipt of written orders, pay rolls, or vouchers approved by MassDOT.

IF THE GRANTEE DOES ANY WORK CONTRARY TO THE ORDERS OF THE DIRECTOR, AND, AFTER DUE NOTICE, FAILS TO CORRECT SUCH WORK OR TO REMOVE STRUCTURES OR MATERIALS ORDERED TO BE REMOVED, OR FAILS TO COMPLETE WITHIN THE SPECIFIED TIME THE WORK AUTHORIZED BY THIS PERMIT, MASSDOT MAY, WITH OR WITHOUT NOTICE, CORRECT OR COMPLETE SUCH WORK IN WHOLE OR IN PART, OR REMOVE SUCH STRUCTURES OR MATERIALS, AND THE GRANTEE SHALL REIMBURSE MASSDOT FOR ANY EXPENSE INCURRED IN CORRECTING AND/OR COMPLETING THE WORK OR REMOVING THE STRUCTURES OR MATERIALS.

ALL OF THE WORK HEREIN CONTEMPLATED SHALL BE DONE UNDER THE SUPERVISION AND TO THE SATISFACTION OF THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION, AND THE ENTIRE EXPENSE THEREOF SHALL BE BORNE BY THE GRANTEE.

On the completion of the work herein contemplated all rubbish and debris shall be removed and the roadway and roadsides shall be left neat and presentable and satisfactory to the Director.

MassDOT hereby reserves the right to order the change of location or the removal of any structure or structures authorized by this permit at any time, said change or removal to be made by and at the expense of the Grantee or its / their successors or assigns.

This permit may be modified or revoked at any time by MassDOT without rendering said MassDOT or the Commonwealth of Massachusetts liable in any way.

The Grantee shall pay the salary, subsistence and travel expenses of any inspector appointed by MassDOT to supervise the work herein contemplated.

All of the above conditions shall be applicable to the work herein authorized, unless the same are inconsistent with the conditions on the face of the permit, in which case the conditions written or printed on the face of the permit shall apply.

The acceptance of this permit or the doing of any work thereunder shall constitute an agreement by the Grantee to comply with all of the conditions and restrictions printed or written herein.

No materials are to be staged within the Right of Way to exceed one day's work limits. Due to possible inclement weather (Snow & Ice) which could occur at any time, you may not exceed placing materials beyond the next day's limit.

Particular care must be taken to prepare the roadway/shoulder areas for public safety at the end of each workday. Excavation activities may be cancelled with the prediction of snow or freezing temperatures.

Steel plates left overnight are not allowed, and if required during the day their use should be very limited.

The Grantee(s) are responsible for assuring that all work associated with this Permit involving pressure washing, pumping, or any other activity causing water to accumulate in the roadway, is closely monitored to avoid icing conditions during the winter season. If necessary, the Grantee(s) will be required to address the issue by spreading salt or other de-icing materials at their expense. If MassDOT is required to respond to an icing condition as a result of the work performed, the Grantee(s) will be billed for all costs incurred by MassDOT, Highway Division to correct this safety issue.

The Grantee(s) will be responsible for the clearing of ice and snow on the State Road(s) where work is performed within the project limits. The roadways shall be reasonably maintained (plowed and chemically treated), to insure safe travel and avoid any conflict with MassDOT Snow and Ice Operations.

PRIOR TO ANY WORK BEING DONE WITHIN THE STATE HIGHWAY LAYOUT, THE GRANTEE MUST CONTACT THE DISTRICT PERMIT ENGINEER AT (508) 884-4306 TO OBTAIN APPROVAL FOR THE PROPOSED WORK SCHEDULE. DURING THE DURATION OF THE PROJECT, THE GRANTEE MUST CONTINUE TO CONTACT THE DISTRICT PERMITS OFFICE, BY THE CLOSE OF BUSINESS ON THURSDAY OF EACH WEEK, TO REQUEST APPROVAL FOR THE FOLLOWING WEEK'S WORK SCHEDULE.

THE GRANTEE(S) MUST ADHERE TO 520 CMR 14.00: EXCAVATION AND TRENCH SAFETY AS PROMULGATED BY THE DEPARTMENT OF PUBLIC SAFETY IN CONJUNCTION WITH THE DIVISION OF OCCUPATIONAL SAFETY PURSUANT TO AUTHORITY GRANTED BY M.G.L. c. 82A § 1. IF NOT ALREADY APPROVED, THE ATTACHED TRENCH PERMIT RIDER MUST BE COMPLETED AND SUBMITTED TO MASSDOT, HIGHWAY DIVISION, BEFORE ANY TRENCH WORK IS PERFORMED UNDER THIS PERMIT.

The Grantee(s) shall be responsible for all litter and debris generated during the proposed work as described herein.

THE BACKFILLING METHOD FOR WORK WITHIN THE HARDENED SURFACE FOR SOIL BORINGS, TEST PITS, OR SMALL TRENCH OPENINGS WILL BE AS FOLLOWS:

Soil borings, test pits or small trench openings (less than 4 feet deep) must be backfilled with Gravel or Dense Graded Crushed Stone properly compacted in accordance with AASHTO Standard Specifications of Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth) (Designation T238-86 Method B - Direct Transmission shall be used to determine in-place density) and Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth) (Designation T239-91). If the depth is larger than 4 feet, then Controlled Density Fill (CDF - M4.08.0, Type 2E Flowable, and Excavatable) should be used. Additionally, the repair must match the existing pavement thickness or a minimum of seven (7) inches of Hot Mix Asphalt consisting of 3" of Hot Mix Asphalt Base Course, 2" of Hot Mix Asphalt Binder Course and 2" of Hot Mix Asphalt Modified Top Course.

The infra-red method must be performed in conjunction with the permanent patch to create a smooth driving surface consistent with the existing roadway. The District Office must be notified two business days prior to starting this work, so that an inspector may be assigned. This mix must be machine laid.

All traffic safety lines if disturbed shall be replaced in kind.

The Grantee(s) shall be responsible for the maintenance and repair of this portion of the roadway and shall perform routine inspections for deficiencies such as settling, heaving, cracks etc. This responsibility shall remain in effect until the resurfacing of this particular portion of highway is performed by MassDOT, Highway Division.

All disturbed areas within the hardened surface of the roadway must be backfilled, compacted and patched with hot mix asphalt/cement concrete as per existing conditions and in accordance with MassDOT, Highway Division, standard specifications. Soil borings in the soft shoulder must be filled and brought up to grade compacted and loamed and seeded.

TIME RESTRICTIONS AND NOTIFICATIONS

DUE TO HEAVY SUMMER TRAFFIC, NO WORK SHALL BE PERFORMED ON THIS PROJECT BETWEEN MEMORIAL DAY WEEKEND AND LABOR DAY WEEKEND WITHOUT PRIOR APPROVAL FROM THE DISTRICT HIGHWAY DIRECTOR.

No work shall be performed in the hardened surface of the roadway between November 15th and April 1st of any year without prior written approval from the District Highway Director.

No pavement shall be laid between November 15th and April 1st of any year without prior written approval from the District Highway Director.

No work shall be performed on this project on Saturdays, Sundays, and Holidays, or on the Friday after a Thursday Holiday. Work is also restricted on the day before and the day after a long Holiday weekend without prior written approval by the District Highway Director.

No equipment, trucks, etc., shall occupy any part of the travelled way except between the hours of 9:00 a.m. and 3:00 p.m., Monday - Friday. In no case will operations exceed the specified hours. This includes the placement of traffic control devices, equipment, or anything that restricts the flow of traffic through the construction zone. Any change in work hours will require prior written approval by the District Highway Director. The 12 minute rule will remain in effect for the duration of the permit.

All other work, off the pavement, on this project is restricted to a normal 8-hour day, Monday - Friday, with the prime Contractor and all subcontractors working on the same shift. Any change in work hours will require prior written approval by the District Highway Director.

GENERAL TRAFFIC MANAGEMENT AND SAFETY REQUIREMENTS

If applicable, any and all variable message boards (VMBs) utilized as part of the approved traffic management plan under this permit must be properly secured with regards to hacking and unauthorized tampering prevention. The Grantee(s) shall adhere to all appropriate security specifications, and take all necessary precautions to mitigate the risk of the boards being hacked. All VMBs shall be stored in a secured area and shall have a lockable, weatherproof enclosure for the operator interface, removable local keyboards which shall be removed whenever possible, and a password protected controller with local administrative passwords changed on a regular basis.

If any portion of the roadway will be blocked with equipment to facilitate the proposed work, the Grantee(s) will be required to adhere to the attached Traffic Management Plan (TMP) or submit a proposed TMP to MassDOT, Highway Division, to be reviewed and approved by the District Traffic Maintenance Engineer prior to working within or impacting the roadway. The plan must include information relating to proper signing, traffic control device placement and police details.

It is imperative to maintain two-way traffic at all times and these operations are managed so that motorists travel "delay" is minimized. At any time during the operation when a traffic delay of over twelve (12) minutes occurs and the situation is worsening, the Resident Engineer, Contractor, or Police Detail will begin to suspend operations. Continuously increasing "delays" of over twelve (12) minutes are not to be permitted.

If traffic must be "stopped", the duration shall not be more than five (5) minutes.

Uniformed State/Local Police Officer(s) and their official vehicle(s) may be necessary to provide protection for those installing and removing all temporary traffic warning signs and devices and to perform all traffic management as required.

The Grantee(s) will monitor the flow of traffic during peak traffic volumes and if necessary, shall suspend all operations. Work will resume at the discretion of the Police detail officer and/or to the satisfaction of the supervising MassDOT, Highway Division, Engineer.

In the event of inclement weather or dense fog, which lessens the visibility of advanced warning signs, vehicles and workers, the Grantee(s) will suspend all operations so as not to interfere with the safety of the motoring public and the operations of work. In the event of snow or icing conditions, all vehicles and equipment must be removed from the roadway and/or shoulder area so as not to interfere with Snow and Ice Operations.

The Grantee(s) shall provide safe and ready means of access and egress to all public and private roads and drives 24 hours per day. Every effort must be made as not to interfere with or inconvenience all abutters throughout the duration of this project.

Signs and traffic control devices are required for advanced notice of the work and within the work area.

The Grantee(s) or Applicant will supply all required signs and traffic warning devices and shall be in accordance with the Massachusetts Manual on Uniform Traffic Control Devices. The number and location of all signs and devices shall be as deemed necessary by the Engineer for the safe and efficient performance of the work and the safety of the travelling public.

All warning devices shall be subject to removal, replacement, and/or repositioning by the applicant as often as deemed necessary by the Engineer.

Cones or non-reflectorized warning devices shall not be left in operating position on the highway when the daytime operations have ceased. If it becomes necessary for MassDOT, Highway Division, to remove the construction warning devices or their appurtenances from the project due to negligence by the applicant, all costs for this work will be charged to the Grantee(s).

All vehicles, except passenger's cars, which are assigned to the permitted project and which operate on the site at speeds of 25 MPH or less, shall have an official SLOW MOVING VEHICLE emblem displayed. All vehicles and equipment on this project must be equipped with back-up alarms.

All personnel who are working on the travelled way or breakdown lanes shall wear approved safety vests and hard hats.

GENERAL CONDITIONS AND APPROVED PROCEDURES

The Grantee(s) must contact the "Dig Safe" Center at 811 to obtain a "Dig Safe" number prior to starting the proposed excavation for the purpose of identifying the location of underground utilities.

IF THE PROPOSED WORK FALLS WITHIN THE AREA OF A SIGNALIZED INTERSECTION, the Grantee(s) must contact the District Traffic Maintenance Engineer at (508) 884-4208 at least two business days prior to the commencement of said work to locate the existing traffic signal conduit/detectors and to coordinate this work so as not to disturb the traffic signals. The Grantee(s) will be responsible to repair/replace all damaged items and will be billed for any cost incurred to restore normal operation to MassDOT, Highway Division, signal equipment to the satisfaction of the Engineer.

Unless otherwise stated, no hardened surface of the State Highway may be disturbed.

When an opening in the roadway is required and permitted herein, the opening must be as small as possible to perform the proposed work.

If the integrity of any existing sidewalks, catch basins, manholes or any other underground structures or equipment is compromised, the Grantee(s) will reconstruct and/or replace all items according to MassDOT, Highway Division, Standards at the cost of the Grantee(s) and to the satisfaction of the Engineer.

The Grantee(s) must not disturb or remove any MassDOT, Highway Division, Bound(s) (MHB) associated with this project. If so disturbed or missing, the bound(s) must be reset/replaced by a Registered Land Surveyor. All procedures and materials must be in compliance with Massachusetts Design and Construction Standards. A copy of the paid bill must be submitted to this office upon completion of said work.

All traffic safety lines if disturbed shall be replaced in kind.

All disturbed areas within the State Highway Layout must be graded, loamed, and seeded to the Engineer's satisfaction.

DRAINAGE AND UTILITY CASTINGS

"The use of risers to adjust drainage and utility structures will not be allowed. All adjustment work done to existing or new drainage structures shall conform to Section 220 of MassDOT, Highway Division, Standard Specifications and according to Plates 201.3.0 and 202.9.0 of MassDOT, Highway Division, Construction Standards."

ENVIRONMENTAL LIABILITY AND COMPLIANCE

The Grantee(s) assumes all risk associated with any environmental condition within the subject property and shall be solely responsible for all costs associated with evaluating, assessing, and remediating, in accordance with all applicable laws, any environmental contamination (1) discovered during Grantee's work or activities under this Permit to the extent such evaluation, assessment or remediation is required for Grantee's work; or (2) resulting from the Grantee's work or activities under this Permit. The Grantee(s) shall notify MassDOT, Highway Division, of any such assessment and remediation activities.

The Grantee(s) is hereby held solely responsible for obtaining and maintaining any and all environmental compliance permits required by local, state, and federal laws and regulations when regular or emergency work is proposed within, or in close proximity to, any wetland area. These environmental compliance requirements include, but are not limited to, a Negative Determination of Applicability or Order of Conditions from the local Conservation Commission, a Water Quality Certificate from the Department of Environmental Protection, and a Programmatic General Permit from the U.S. Army Corps of Engineers. The Grantee(s) shall forward to MassDOT, Highway Division, a copy of each such environmental compliance permit.

CLOSING CONDITIONS

ALL OF SAID WORK SHALL COMPLY WITH THE TERMS AND CONDITIONS HEREIN, AND MUST BE DONE AS DIRECTED BY AND TO THE SATISFACTION OF THE ENGINEER.

All work done under this contract shall be in conformance with the Massachusetts Highway Department "Standard Specifications for Highways and Bridges" dated 1988 and the "Supplemental Specifications to the Standard Specifications for Highways and Bridges" dated July 1, 2015. All construction shall conform to the December 2016 edition of the Massachusetts Department of Transportation, Highway Division "Construction Standard Details (English Edition)"; the latest Manual on Uniform Traffic Control Devices with Massachusetts Amendments; the latest edition to the following: the 1996 Construction and Traffic Standard Details (as related to Traffic Standard details only); the 1990 Standard Drawings for Traffic Signs and Supports; the 1968 Standard Drawings for Traffic Signals and Highway Lighting; the latest edition of American Standard for Nursery Stock; the Plans and these Special Provisions.

The Grantee(s) shall indemnify and save harmless the Commonwealth and MassDOT, Highway Division, against all suits, claims or liability of every name and nature arising at the time out of or in consequence of the acts of the Grantee(s) in the performance of the work covered by this Permit and/or failure to comply with the terms and conditions of this Permit whether by themselves or their employees or subcontractors.

It is noted that the Grantee(s) will be responsible for future corrective actions resulting from defected work under the subject permit. Any damage to roadway and/or shoulder as a result of the permitted work is the Grantee's responsibility and shall be repaired at his/her expense.

THE GRANTEE(S) SHALL CONTACT THE PERMITS SECTION AT (508) 884-4306 WHEN THE WORK REQUIRED UNDER THIS PERMIT HAS BEEN COMPLETED IN ORDER FOR A FINAL INSPECTION TO BE PERFORMED BY MASSDOT, HIGHWAY DIVISION. IF THE COMPLETION OF WORK FORM IS NOT RETURNED, THE LIABILITY ASSUMED UNDER THIS PERMIT WILL CONTINUE.

A COPY OF THIS PERMIT MUST BE ON THE JOB SITE AT ALL TIMES FOR INSPECTION. FAILURE TO HAVE THIS PERMIT AVAILABLE AT THE SITE WILL RESULT IN SUSPENSION OF THE RIGHTS GRANTED BY THE PERMIT.

No work shall be done under this Permit until the Grantee has communicated with and received instructions from MassDOT, Highway Division's District Highway Director at 1000 County Street, Taunton, MA 02780.

The Permit shall be void unless the work herein contemplated shall have been completed before FEBRUARY 22, 2018.

Dated at TAUNTON this 22ND day of FEBRUARY, 2017.

MassDOT-Highway Division,
By

Mary-Joe Perry
District Highway Director

FSJ: fsj bbv
cc: Foreman

massDOT
Massachusetts Department of Transportation
Highway Division

RECEIVED
FEB 14 2017
PERMITS OFFICE

Application for Permit to Access State Highway

This Access Permit Application, including the attached Access Permit Submittal Checklist, must be completed in full by the Applicant. Instructions for this page are located on page 2. Descriptions of the two types of access permits and related categories are located on page 6. MassDOT will make the final determination regarding Access Permit Application type and category.

1. Town/City: Orleans
2. State Highway route number and/or name: Route 6 and 6A
3. Locus/Property Address: Southeast cloverleaf of Interchange 12 between Route 6 and access ramp
4. Description of property and/or facility for which access is sought (attach additional sheets if necessary):
   Inside southeast cloverleaf of Interchange 12. The existing road cut and paved access off of Route 6A will be used to access the site.
5. Description of work to be performed within State Highway Layout (attach additional sheets if necessary):
   Perform a hydrogeologic evaluation including the installation of 3 to 4 soil borings/monitoring wells (2-inch diameter), excavation of 6 to 10 test pits (6 ft wide x 12 feet long x 16 feet deep), and testing and sampling of groundwater from monitoring wells. No work is proposed within 50 feet of the traveled way.
   ☐ **Telecommunications** (wireless or wireline) or **Renewable Energy** (Solar, Wind, etc) – Agreement Process and OREAD* coordination required. (*see pg 2 Instruction)
6. Dig Safe number: 2017 0405682 (See Attached)
7. Applicant Information [1] (See footnote below.)
   Name: AECOM on behalf of the Town of Orleans (Drilling by New England Geotech, Inc.)
   Mailing Address: 9 Jonathan Bourne Drive, Pocasset, MA 02559
   Telephone: 508.833.6964
   Fax: 508.833.6951
   E-Mail: mark.owen@aecom.com
   Signature:
   Print Name: Mark Owen
   Date: 2/6/2017
8. Property Owner
   Name: Commonwealth of Massachusetts
   Mailing address:
   Telephone:
   Fax:
   E-Mail:
   Signature:
   Print Name:
   Date:

Return completed application, including Submittal Checklist, to the District Highway Director for your town/city. Refer to reverse side for appropriate address.

For office use only. Do not write below this line.

1. Application number: 5-2017-0056
2. Date received: FEB 14 2017
3. Fee amount (non-refundable) :
4. Completeness Pre-Review date:
5. MEPA required (yes or no):
   ENF-EOEEA Cert. #
   EIR-EOEEA Cert. #
   Other-EOEEA Cert. #
6. Section 61 Finding date:
7. Mass. Historic Action (yes or no):
8. Plans returned to DHD:
9. Permit Type/Category:
10. Application complete date:
11. Permit written date:
12. Permit issued date: FEB 22 2017
13. Permit denied:
14. Permit Recording date at Registry of Deeds

[1] If an agent is representing an Applicant, the application must include a notarized letter from the Applicant outlining the specified duties and responsibilities of the agent. Where work is proposed on a utility, the utility department must sign the application as the Applicant(s).

Instructions for Completing Application for Permit to Access State Highway

General Instructions

MassDOT's Highway Division is granted authority to issue State Highway Access Permits by M.G.L. Chapter 81, Sec. 21. MassDOT adopted 720 CMR 13.00 under the authority of M.G.L. c. 81, § 21 and M.G.L. c.85 §2. 720 CMR 13.00 supersedes the Standard Operating Procedures for Review of State Highway Access Permits dated November 30, 1971, and board vote of September 17, 1991.

ACCESS is generally defined, but not limited to:
Any physical work performed within the State Highway Layout.

This Application governs issuance of the two types of access permit Applications, Non-Vehicular and Vehicular, which are issued under three categories:

Category I	Minor Vehicle Access Permits
Category II	Major Vehicular Access Permits
Category III	Complex Vehicular Access Permits

Please refer to the **MassDOT Highway Access Permit Submittal Checklist** for details regarding permit types and submittals required.

FEES:
A Check payable to **MassDOT** for the appropriate permit application fee must accompany the permit application. Fees are non-refundable.

Fee schedule for access and Utility Payments:

Residential Access Permits

5 Units or less	$25.00
From 6 to 49 Units	$100.00
Greater than 49 Units	$2000.00

Non-Residential Access Permits

Less than 25,000 square feet	$500.00
From 25,000 to 300,000 square feet	$1000.00
From 300,000 to 750,000 square feet	$2000.00
Greater than 750,000 square feet	$3000.00

Non-Municipal Utility Permits not in conjunction With Access Permits:

Annual blanket utility permit	$500.00
Capital improvements to a utility	$500.00

Specific Instructions (print or type)

Line 1:
List name of municipality in which access is sought.
Line 2:
List name or number of State Highway Route(s) to which access is sought.
Line 3:
List Locus/Property address.
Line 4:
Describe property and/or facility. If access is sought under Category II above, briefly describe facility for which access is sought.

> *Example 1:* Private single family residence at 100 State Road. Approximate size of proposed building 2,500 s.f. Approximate lot size 0.75 acres.
>
> *Example 2:* 500,000 s.f. enclosed shopping mall adjacent to State Route I-290 and Route 20. Approx. lot size 67 acres.

Line 5:
Briefly describe the proposed work to be performed within the State Highway Layout.
*Office of Real Estate and Development (OREAD)

> *Example 1:* Remove 50 feet of existing granite curb on south side of highway in order to construct driveway access and modify the roadway geometry to accommodate left-hand turn.
>
> *Example 2:* Excavate 10 foot x 10 foot section of roadway at Station 100+00 in westbound lane in order to install water service to residence at 100 State Street.

Line 6:
A Dig Safe number must be provided if the work will commence within 30 days of the filing of the permit. **NOTE:** A Dig Safe number must be obtained by calling **1-888-DIG-SAFE** (1-888-344-7233). If construction within the State Highway Layout does not commence within the period allowed by Dig Safe, a new number must be obtained prior to beginning construction. (www.digsafe.com)

Line 7:
Individual or business making application must complete the required information, including application date and signature.

Line 8:
Complete this section only if the individual or business making application is other than the property owner of the land for which the permit applies.

Return completed application, submittal checklist and fee to appropriate District Office listed below. Please contact the Permit Engineer at this address if additional information is required.

District One
270 Main Street
Lenox, MA 01240
Tel. (413) 637-5700
Fax. (413) 637-0309

District Two
811 North King Street
Northampton, MA 01060
Tel. (413) 582-0599
Fax. (413) 582-0596

District Three
403 Belmont Street
Worcester, MA 01604
Tel. (508) 929-3800
Fax. (508) 799-9763

District Four
519 Appleton Street
Arlington, MA 02174
Tel. (781) 641-8300
Fax. (781) 646-5115

District Five
1000 County Street
Taunton, MA 02780
Tel. (508) 824-6633
Fax. (508) 880-6102

District Six
185 Kneeland Street
Boston, MA 02111
Tel. (857) 368-6100
Fax. (857) 368-0106

Highway Division Website:
www.massdot.state.ma.us/highway

massDOT
Massachusetts Department of Transportation
Highway Division

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Access Permit Submittal Checklist

GREY: DOT USE ONLY

This checklist provides the Applicant with a list of required submittals to obtain an Access Permit. However, additional submittals may be required to issue an Access Permit. All Applicants must fill out Part A and one additional part that correlates to the selected application type. To help identify the application type, please see the descriptions on page 6. Check each box that pertains to your application. MassDOT will make the final determination regarding Access Permit Application type and category.

PART A: ALL APPLICANTS MUST FILL OUT

1. APPLICATION TYPE – CHECK ONE

☐ **NON-VEHICULAR:**
- ■ Non-Vehicular – Fill out Part B

☐ **VEHICULAR**
- ☐ Category I – Minor Vehicle Access Permits: Fill out Part C-I
- ☐ Category II – Major Vehicle Access Permits: Fill out Part C-1 and Part C-II
- ☐ Category III – Complex Vehicle Access Permits: Fill out Part C-1 and Part C-III

2. APPLICATION TYPE (Check all applicable boxes)

- ☐ Application Complete
- ☐ Permit corresponds to appropriate MassDOT District
- ☐ Non-refundable check or money order on correct amount payable to: MassDOT
- ☐ Evidence certifying property owner(s) consent
- ☐ Notarized Applicant Letter outlining agent's duties and responsibilities (if applicable)
- ☐ Utility department sign-off as the Applicant(s) (if applicable)

PART B: NON-VEHICULAR PERMITS

☐ **IF NO PHYSICAL MODIFICATION** *to state highway layout – i.e. parade, road race, traffic counts, etc.*

Required submittals:
- ■ Map of route
- ■ Traffic Management Plan (designed in accordance with the Road Flagger & Police Regulations: 701 CMR 7.00)
- ☐ Detour Plan(s) with municipal approval (if applicable)

☐ **IF DRAINAGE:**
- ☐ If requesting connection or discharge to any MassDOT drainage system, contact District Personnel for additional information regarding required submittals.

☐ **IF CONSTRUCTION, RELOCATION OR REPAIR OF UTILITIES:**

Required submittals:
- ☐ **EXISTING PROJECT:** reference(s) to the documents and plans already filed with MassDOT for the affected project
- ☐ **NEW PROJECT/UTILITY WORK:**

Required submittals:
- ☐ Engineered Plan(s) including method of crossing Highway
- ☐ Traffic Management Plan (if applicable)
  (Designed in accordance with the Road Flagger & Police Regulations: 701 CMR 7.00)
- ☐ Detour Plan(s) with municipal approval (if applicable)
- ☐ Tree Cutting or Landscaping Plan (if applicable)
- ☐ Vegetative Plan including plant species and maturity size (if applicable)
- ☐ Blasting Plan (contact District Personnel for additional information)

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PART C-I: VEHICULAR PERMITS

CATEGORY I – Minor Vehicular Access Permits

Required submittals:

- ☐ Engineering Plans
- ☐ ENF - (Environmental Notification Form) Certificate (if applicable)

IF RESIDENTIAL DRIVEWAY:

- ☐ Detailed plan/sketch showing the drive location in relation to the property lines, MassDOT baselines, distance from nearest mile marker, and an easily identifiable fixed object (distance from telephone poles, mail boxes, other drives, etc.).
- ☐ If severe topographic conditions exist, an engineered plan showing the driveway layout, profile and storm water management may be necessary to show that the edge of the proposed drive is protected during and after construction to prevent sediment and debris from entering upon the State Highway Layout (SHLO).

IF COMMERCIAL DRIVEWAY: (where no MEPA review is required)

Required submittals:

- ☐ Two (2) 40 scale plans that include:
  - ☐ A. Route Number, Road Name, Property Address
  - ☐ B. Property Corners and Bounds
  - ☐ C. Lot Line Dimensions, Bearings and Distances
  - ☐ D. State Highway Layout Lines (both sides) and Nearest Massachusetts Highway Bounds (if found).
  - ☐ E. State Highway Baseline and both edges of roadway including any sidewalks and type of edging, if any, and shoulder information (grass, gravel etc.).
  - ☐ F. Any existing drive to be altered or closed shall be indicated. Existing and proposed dimensions should be included for altered drives.
  - ☐ G. Information on all proposed drives including radii, widths, handicap ramps, etc. must be shown.
  - ☐ H. All existing and proposed buildings, utilities, trees, stonewalls, fences etc., should be labeled and shown in their correct location.
  - ☐ I. It is required that all stands, buildings, gasoline pumps and structures of any kind be placed at least 12 feet back from the State Highway Layout Line, since conducting of business within a State Highway Layout is forbidden.
  - ☐ J. Complete detail on drainage; all drives should be constructed on a downgrade from the edge of the highway surface or shoulder to the State Highway Layout Line.
  - ☐ K. Engineered plans will be required to show that storm flows are not directed into the SHLO, using contour lines, where applicant/owner property elevations are raised from the edge of the highway.
  - ☐ L. The plans should identify measures to protect the edge of the proposed drive during and after construction to prevent sediment and debris from entering upon the SHLO.

IF NEW STREET / SUBDIVISION ROAD:

Minor Intersection and Roadway Reconstruction (where no MEPA review is required)

Required submittals:

- ☐ All Commercial Driveway requirements (above) apply in addition to the following: Evidence of acceptance, including its line, grade and proposed drainage, by a local planning board, or other City of Town official with such authority.
- ☐ A street/road profile from its nearest high point and plan of drainage.

Please be advised:

- It will be required that all such future street approaches be constructed on a downgrade, where possible, from the edge of highway surface or shoulder to the State Highway Layout Line.
- Common driveway criteria may apply and must be shown on plans as mentioned above.

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PART C-II: VEHICULAR PERMITS

CATEGORY II – Major Vehicular Access Permits

Required submittals:

- ☐ ☐ Engineering Plans based on the standards in the Manual On Uniform Traffic Control Devices (MUTCD), MassDOT's Project Development & Design Guide or its successor, MassDOT's Standard Specifications for Highway and Bridges, and any current technical policies or engineering directives Issued by MassDOT. All PS&E design submissions must be both in hard copy (one set) and electronic format. Electronic format includes PDF files transmitted to DHD or designee via USB Flash Drive, CD or posted to a FTP site.
- ☐ ☐ In cases where a proposed access is to be shared by multiple development sites, the Applicant(s) will provide evidence of the rights of access between the parties involved prior to the issuance of the Access Permit.
- ☐ ☐ MEPA Certificate
- ☐ ☐ Section 61 Finding

PART C-III: VEHICULAR PERMITS

CATEGORY III – Complex Vehicular Permits

Required submittals:

- ☐ ☐ Engineering Plans based on the standards in the Manual On Uniform Traffic Control Devices (MUTCD), MassDOT's Project Development & Design Guide or its successor, MassDOT's Standard Specifications for Highway and Bridges, and any current technical policies or engineering directives Issued by MassDOT. All PS&E design submissions must be both in hard copy (one set) and electronic format. Electronic format includes PDF files transmitted to DHD or designee via USB Flash Drive, CD or posted to a FTP site.
- ☐ ☐ In cases where a proposed access is to be shared by multiple development sites, the Applicant(s) will provide evidence of the rights of access between the parties involved prior to the issuance of the Access Permit.
- ☐ ☐ MEPA Certificate
- ☐ ☐ Section 61 Finding

Recording of Access Permits

Applicants must record any Vehicular Access Permit and plans or any Non-Vehicular Access Permit and plans involving drainage at the appropriate Registry of Deeds. Any Permit issued by MassDOT that requires recording will not be effective until recorded at the appropriate Registry of Deeds and a notice of recording is submitted to the District Highway Director (DHD). Changes may require the re-recording of permits and related documents. In those cases, permits will not be effective until re-recorded at the Registry of Deeds and a notice of recording is submitted to the DHD.

THERE ARE TWO TYPES OF ACCESS PERMIT APPLICATIONS: VEHICULAR, ISSUED UNDER THREE CATEGORIES & NON-VEHICULAR:

1. VEHICULAR ACCESS PERMITS:

Category I – Minor Vehicular Access Permits:
Access Permits for Projects that require entry to the State Highway Layout (SHLO), require little to no non-signalized modifications, and do not significantly alter the operating characteristics of traffic. These Projects ordinarily do not exceed the Massachusetts Environmental Policy Act (MEPA) transportation thresholds beyond the filing of an Environmental Notification Form (ENF).

Category II - Major Vehicular Access Permits:
Access Permits for Projects that require significant non-signalized modifications that may alter the operating characteristics of traffic at residential or commercial driveway intersecting with the SHLO; that require significant non-signalized modifications that may alter the operating characteristics of traffic at or upon any other intersection or roadway under the jurisdiction of MassDOT; that require the installation of a new traffic signal at a residential or commercial driveway intersecting with the SHLO or at any other intersection or roadway under the jurisdiction of MassDOT; or that require modification of structures, equipment, or hardware at an existing traffic signal at a residential or commercial driveway and its intersection with the SHLO or at any other intersection or roadway under the jurisdiction of MassDOT.

Category III – Complex Vehicular Permits
Access Permits for Complex Projects requiring actions similar to major Projects, but which require a new or altered SHLO; that require significant non-signalized and/or signalized modification within the SHLO over an extended distance or at a number of intersections that significantly alters the operating characteristics of traffic along a corridor; or that require the construction of a new, or modifications to an existing, bridge. These Projects generally require MEPA review and may require Federal review.

2. NON-VEHICULAR ACCESS PERMITS:

Access Permits for Projects that require access to the SHLO that do not involve physical modifications such as a parade or road race; construction, relocation or repair of utilities within the SHLO; tree cutting or landscaping within the SHLO; the use of explosives to remove material from within 250 feet of the SHLO; or connection to or discharge to any MassDOT drainage system (in cases where it can be shown that no practical alternative exists).

CONDITIONS REQUIRING AN ACCESS PERMIT

Vehicular Access Permits are required for:

- New residential or commercial driveways or streets intersecting the SHLO; or,
- Physical modifications to existing residential or commercial driveways or streets at their intersection with the SHLO; or,
- Change in use of an existing residential or commercial driveway onto SHLO that results in a **Substantial Increase in or Impact on Traffic** (as defined below) over the current use; or
- Construction of new or change in use of existing, residential or commercial driveway from properties that abut the SHLO to serve a building or facility, or expansion of a building or facility, that generates a Substantial Increase in or Impact on Traffic.

Substantial Increase in, or Impact on, Traffic as referenced above is defined as:
A Project that meets or exceeds any of the following thresholds:

(i) Generation of 2,000 or more new ADT on roadways providing access to a single location; or,
(ii) Generation of 1,000 or more new ADT on roadways providing access to a single location and construction of 150 or more new parking spaces at a single location; or,
(iii) Construction of 300 or more new parking spaces at a single location; or
(iv) Creation of a change in the type, pattern, or timing of traffic that is determined by MassDOT to generate a significant impact on traffic flow and safety.

Non-vehicular Access Permits are required for:

- Access to the SHLO for Projects that do not involve physical modifications; or
- Connection to or discharge to any MassDOT drainage system (in cases where it can be shown that no practical alternative exists); or
- Construction, relocation or repair of utilities within the SHLO; or
- Tree cutting or landscaping within the SHLO; or
- The use of explosives to remove material from within 250 feet of the SHLO.

In cases where a particular Project or activity may seek both vehicular and non-vehicular access, separate and distinct Permit Applications must be filed.

AECOM
250 Apollo Drive
Chelmsford, MA 01824

978.905.2100 tel
978.905.2101 fax

February 7, 2017

MassDOT, District 5
1000 County St.
Taunton, MA 02780

Reference: **Route 6 Exit 12, Access Permit**
Proposed Hydrogeologic Evaluation
Attachment: Traffic Management and Bat Habitat

Traffic Description

Proposed work at the above referenced location will take place within the southeast cloverleaf of Exit 12 on Route 6 in the Town of Orleans Massachusetts. The site will be accessed from Route 6A through an existing curb cut and paved access road. There will be no work performed within 50 of a traveled way.

As a precaution, New England Geotech, Inc. (NEG) will place a 3' x 3' orange sign approximately 200 feet west of the site access on Route 6A to alert traffic of vehicles entering and exiting. The sign will read "ROAD CONSTRUCTION AHEAD". As necessary, a sufficient number of orange 36' dot cones will be placed around the entrance to allow safe access to the site.

Northern Long-eared Bat Habitat

The hydrogeologic evaluation is proposed within the southeast cloverleaf of Exit 12 of Route 6 in Orleans, MA. The US Fish and Wildlife Service (USFWS) has issued a final rule under the Endangered Species Act section 4(d). In this rule certain protecting regulations may apply in the region of the country within the Northern long-eared bat's (NLEB) range where White Nose Syndrome is a concern. This region encompasses the entire Northeastern US and therefore includes the site. In this area tree clearing is not allowed if it occurs within a 0.25 mile radius of known NLEB hibernacula (at any time of the year), or within a 150-foot radius of a known maternity tree during the pup-rearing season when flightless juvenile bats are being raised (June 1 through July 31).

As of February 6, 2017, the USFWS's most recent mapping of long-eared bat habitat (November 30, 2016), indicates that the proposed work activities are not located with 0.25 miles of a known NLEB hibernacula or within 150 feet from a known NLEB maternity roost tree. Current mapping indicates that the site is approximately 2.9 miles from the closest roost tree located in Eastham, MA. Consultation with the USFWS is therefore not anticipated at this time.

AECOM will notify MassDOT of the need to remove any trees greater than 6inches in diameter. In addition, AECOM will review USFWS mapping within one week of any proposed tree removal.

For reference, we have attached is step-by-step key to procedures that the USFWS has developed for determining whether or not consultation with the USFWS is required for projects.

AECOM

If you have any questions, please contact this office.

Sincerely yours,

AECOM Technical Services, Inc.

Mark R. Owen, CPG
Senior Hydrogeologist

AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559

Direct 508.833.6964
Cell 978.204.0983

mark.owen@aecom.com

U.S. Fish & Wildlife Service

Key to the Northern Long-Eared Bat 4(d) Rule for Non-Federal Activities

A separate key is available for Federal Actions

This key will help you determine if your planned activity may cause prohibited take of northern long-eared bats as defined in the 4(d) rule under the Endangered Species Act and if a permit may be necessary. For more information about the northern long-eared bat and 4(d) rule go to www.fws.gov/midwest/endangered/nleb.

1. Will your activity **purposefully take** (see Definitions below) northern long-eared bats? For example, are you removing bats from a human structure or capturing bats for research?

Yes, my activity includes purposefully taking northern long-eared bats.

- ***Removing bats from human structures is not prohibited***; if you are removing bats from a human structure, you may proceed without a permit and you do not need to contact the U.S. Fish and Wildlife Service.
- ***Research that involves handling bats does require a permit*** after May 4, 2016; if you are conducting research that includes capturing and handling northern long-eared bats, you should contact the U.S. Fish and Wildlife Service to apply for a permit. www.fws.gov/endangered/regions
- ***Other purposeful take*** (see Definitions below) of northern long-eared bats is prohibited.

No, my activity does not include purposefully taking northern long-eared bats.
Continue to #2.

2. Is your activity located **outside the White-nose Syndrome Zone?** For the current White-nose Syndrome Zone map, please see www.fws.gov/midwest/endangered/mammals/nleb/pdf/WNSZone.pdf

Yes, my activity is located outside the white-nose syndrome zone.
Incidental take (see Definitions below) of northern long-eared bats is not prohibited in areas outside the White-nose Syndrome Zone. You may proceed with your activity, you do not need a permit and you do not need to contact the U.S. Fish and Wildlife Service.

No, my activity is located inside the white-nose syndrome zone.
Continue to #3

3. Will your activity take place **within a cave or mine where northern long-eared bats hibernate** (i.e., hibernaculum) **or could it alter the entrance or the environment (physical or other alteration) of** a hibernaculum?

Yes, my activity will take place within a northern long-eared bat hibernaculum or it could alter the entrance or the environment (physical or other alteration) of a hibernaculum.
All take (see Definitions below) of northern long-eared bats within hibernacula is prohibited, including actions that may change the nature of the hibernaculum's environment or entrance to it, even when the bats are not present. If your activity includes work in a hibernaculum or it could alter its entrance or environment, please contact the Service's Ecological Services Field Office located nearest the project area. To find contact information for the Ecological Services Field Offices, please see www.fws.gov/offices.

No, my activity will not take place within a northern long-eared bat hibernaculum or alter its entrance or environment.
Continue to #4

4. Will your action involve **tree removal** (see definition below)?

No, my activity does not include tree removal.
Incidental take (see Definitions below) from activities that do not involve tree removal and do not take place within hibernacula or would not alter the hibernaculum's entrance or environment (see Question #3), are not prohibited, and a permit is not necessary. You may proceed with your activity, you do not need a permit and you do not need to contact the U.S. Fish and Wildlife Service.

Yes - continue to #5

5. Is your activity the **removal of hazardous trees** for protection of human life or property?

Yes, my activity is removing hazardous trees.
Incidental take (see Definitions below) of northern long-eared bats as a result of hazardous tree removal to protect human life or property is not prohibited. You may proceed with your activity, you do not need a permit and you do not need to contact the U.S. Fish and Wildlife Service.

No, my activity is not removing hazardous trees.
Continue to #6

6. Will your tree removal activities include one or both of the following: **1) removing a northern long-eared bat known occupied maternity roost tree or any trees within 150 feet of a known occupied maternity roost tree from June 1 through July 31; or 2) removing any trees within 0.25 miles of a northern long-eared bat hibernaculum at any time of year?**

No
Incidental take (see Definitions below) from tree removal activities is not prohibited unless it results from removing a known occupied maternity roost tree or from tree removal activities within 150 feet of a known occupied maternity roost tree from June 1 through July 31 or results from tree removal activities within 0.25 mile of a hibernaculum at any time. You may proceed with your activity, you do not need a permit and you do not need to contact the U.S. Fish and Wildlife Service.

Yes
Incidental take (see Definitions below) of northern long-eared bats is prohibited if it occurs as a result of removing a known occupied maternity roost tree or removing trees within 150 feet of a known occupied maternity roost tree during the pup season from June 1 through July 31 or as a result of removing trees from within 0.25 mile of a hibernaculum at any time of year. This does not mean that you cannot conduct your activity. Please contact your nearest Ecological Services Field Office and we will work with you to determine if your activity can proceed without harming or killing northern long-eared bats or if you need to apply for a permit. To find contact information for the Ecological Services Field Offices, please see www.fws.gov/offices

How do I know if there is a maternity roost tree or hibernacula on my property or in my project area?
We acknowledge that it can be difficult to determine if a maternity roost tree or a hibernaculum is on your property or in your project area. Location information for both resources is generally kept in state Natural Heritage Inventory databases – the availability of this data varies state-by-state. Many states provide online access to their data, either directly by providing maps or by providing the opportunity to make a data request. In some cases, to protect those resources, access to the information may be limited. Links to state Natural Heritage Inventory databases are available at www.fws.gov/midwest/endangered/mammals/nleb/nhisites.html.

When looking for information on the presence of maternity roost trees or hibernacula within your project area, our expectation is that a project proponent will complete due diligence to determine available data. If information is not available, document your attempt to find the information and move forward with your project.

We do not require private landowners to conduct surveys on their lands. However, surveys can reduce uncertainties and facilitate project planning. Recommended survey methods are available at www.fws.gov/midwest/endangered/mammals/nleb.

Definitions

"Incidental take" is defined by the Endangered Species Act as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." For example, harvesting trees can kill bats that are roosting in the trees, but the purpose of the activity is not to kill bats.

"Known hibernacula" are defined as locations where one or more northern long-eared bats have been detected during hibernation or at the entrance during fall swarming or spring emergence. Given the challenges of surveying for northern long-eared bats in the winter, any hibernacula with northern long-eared bats observed at least once, will continue to be considered "known hibernacula" as long as the hibernacula remains suitable for northern long-eared bat.

"Known occupied maternity roost trees" is defined in the 4(d) rule as trees that have had female northern long-eared bats or juvenile bats tracked to them or the presence of female or juvenile bats is known as a result of other methods. Once documented, northern-long eared bats are known to continue to use the same roosting areas. Therefore, a tree will be considered to be a "known occupied maternity roost" as long as the tree and surrounding habitat remain suitable for northern long-eared bat. The incidental take prohibition for known occupied maternity roosts trees applies only during the during the pup season (June 1 through July 31).

"Purposeful take" is when the reason for the activity or action is to conduct some form of take. For instance, conducting a research project that includes collecting and putting bands on bats is a form of purposeful take. Intentionally killing or harming bats is also purposeful take and is prohibited.

"Take" is defined by the ESA as 'to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any endangered species. Purposeful take is when the reason for the activity or action is to conduct some form of take. For instance, conducting a research project that includes collecting and putting bands on bats is a form of purposeful take.

"Tree removal" is defined in the 4(d) rule as cutting down, harvesting, destroying, trimming, or manipulating in any other way the trees, saplings, snags, or any other form of woody vegetation likely to be used by northern long-eared bats.

Project Manager: Mark Owen
Drill Date:
Project Number: 60476644 10.1.A-Effluent Disposal
Date of Call In: 1/27/2016 good until 2/26/2016

MA, ME, NH, RI, & VT: 1-888-DIG-SAFE / 1-(888) 344-7233 - Vendor #14337
CT: (203) 281-5435/ (800) 922-4455 - Vendor #3805
Upstate NY: (800) 245-2828/ (800) 962-7962
NYC: (800) 272-4480

The information contained in the following two pages is REQUIRED by DIGSAFE and MUST be completed before it will be called in. NO DIGSAFE will be called in unless every item has been completed.

State: MA **Town/City:** Orleans
Site Premarked **Yes** [ ] **No** [ ]
How was it Premarked? White Spray Paint If it was Paint what color?
If it was a stake, was the stake painted and what color (Should be white unless snow on ground).
Was it a flag, what color was the flag (Should be white unless snow on ground)

Street Address: Route 6A interchange, inside Southeast Cloverlea **Business Name:** Mass DOT
(If you have it) **Latitude:** 41.7778 **Longitude:** -70.002
Any other additional information about the site:
This is inside the Southeast Cloverleaf Exit 12 E off of RT 6 going onto RT 6A (Cranberry Highway)
Corner Property? Yes [ ] **No** [ ]
Is site within 500 ft of centerline of road? **Yes** [ ] **No** [ ]
Is site outside 500 ft of centerline of road? If yes how far?
The two cross streets that the site is located between

# of Borings/ monitoring Wells: **Private, Public or Both:** Public
Exactly what Work is being done:
installing wells and Test pit excavations. **Depth:**
Who Work is being Done By and the Town and State they come from: New England Geotech Jamestown RI

Name of Caller: Jodi Hodge Title: Project Admin
OK to Start Date/Time: 02/01/2017 Start Time: 15:30 Dig Safe Number: 20170405682
Renewal Date/Time: Renewed Dig Safe Number:
Utilities Notified:
See Attached

Gas phone # Electric phone #
Site Description exactly as given to Dig Safe:

Water Contacted Yes No Phone #: 508-255-1200 Name of Person: Laura
Sewer Contacted Yes No Phone #: Septic only Name of Person:

Must include a site map with what & where is being done marked on it.

Originals to Project Administrator · 2 Copies one to Project Manager one to field Technician

RECEIVED
FEB 14 2017
PERMITS OFFICE

Request Number: 20170405682 **Date** 01/27/2017 **Time** 15:05

Latitude: 41.7778400 **Longitude:** -70.0021320

State: MASSACHUSETTS **Municipality:** ORLEANS

Address / Intersection: CRANBERRY HWY

Nearest Cross Street 1: US HWY 6 EB **Nearest Cross Street 2:** RAMP

Additional Information: RT 6 EXIT 12 WORKING INSIDE THE SOUTHEAST CLOVERLEAF

SITE MARKED OUT ON ROUTE 6A

Nature Of Work: INSTALLING WELLS AND TEST PITS

Area Of Work: INSIDE THE CLOVERLEAF FROM ROTUE 6 EXIT 12E TO ROUTE 6A

Area Is Premarked: Y **Start Date:** 02/01/2017 **Start Time:** 15:30

Caller: JODI HODGE **Title:** PROJECT ADMIN **Return Call:** B 5PM

Phone#: 978-905-2100 **Fax#:** 978-905-2101 **Alt. Phone#:** 9789052247

Email Address: JODI.HODGE@AECOM.COM

Contractor: AE COM INTERNATIONAL

Address: 250 APOLLO DR **City:** CHELMSFORD **State:** MA **Zip:** 01824

Excavator Doing Work: NEW ENGLAND GEOTECH JAMESTOWN RI

Member Utility List

Code	Abbreviation	Name
CH	NGRDGS	NATIONAL GRID GAS-COLONIAL
CL	NSTREL	NSTAR ELECTRIC-COM
CW	VERIZN	VERIZON
HK	COMCAS	COMCAST - PEMBROKE
ON	ONTARG	ON TARGET LOCATING
RJ	VERIZN	VERIZON

- **There may be non-member utilities in the area that you need to notify.**
- **Electric and other companies may not mark lines they don't own or maintain. You may want to contact them for more information.**
- **The excavator is responsible to maintain markings placed by member utilities...**

DIG SAFE ENCOURAGES A COPY OF THIS ELECTRONIC TICKET ON SITE AT ALL TIMES.

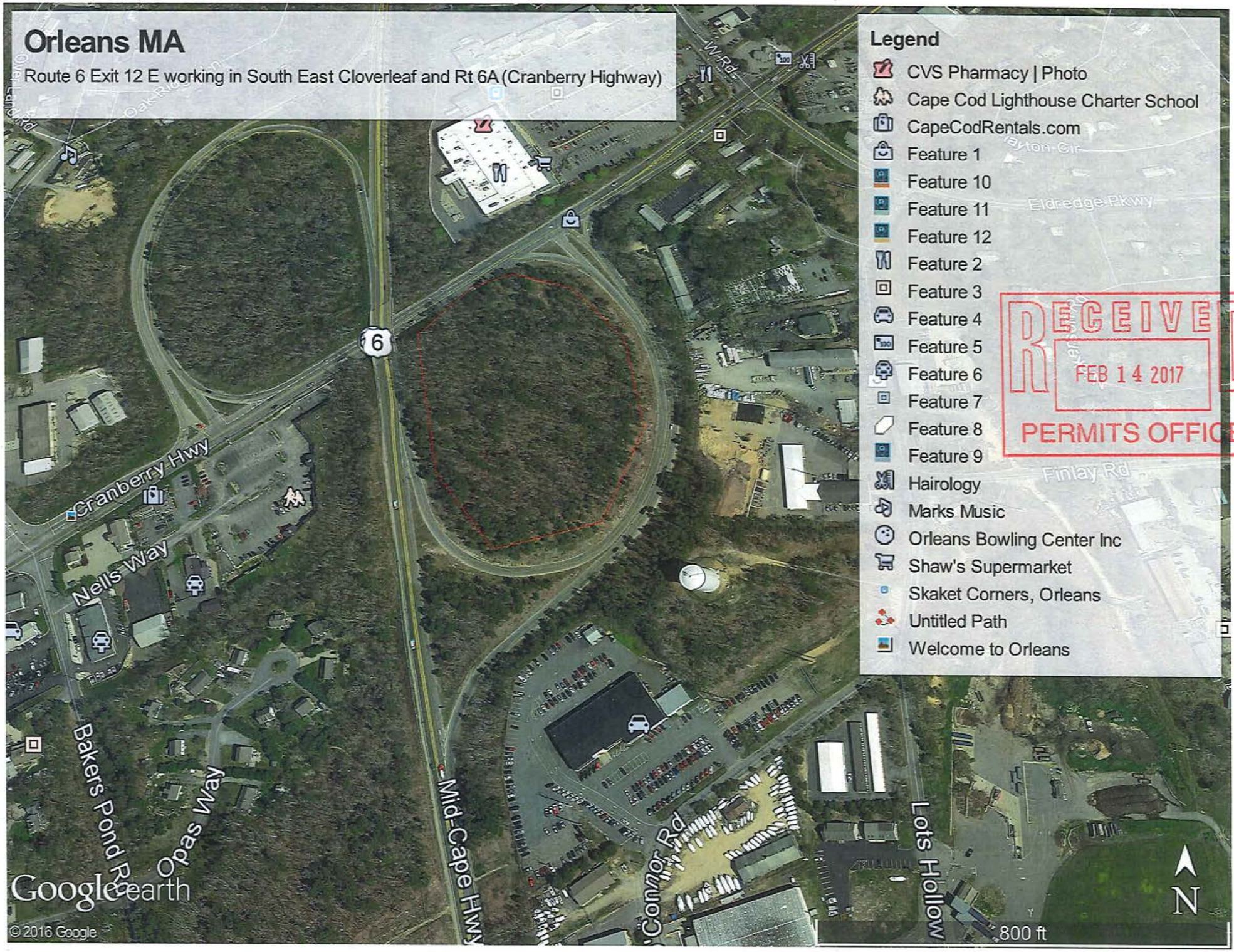
Proposed Test Pit
Proposed Monitoring Well
Proposed Soil Boring
Existing Paved Access

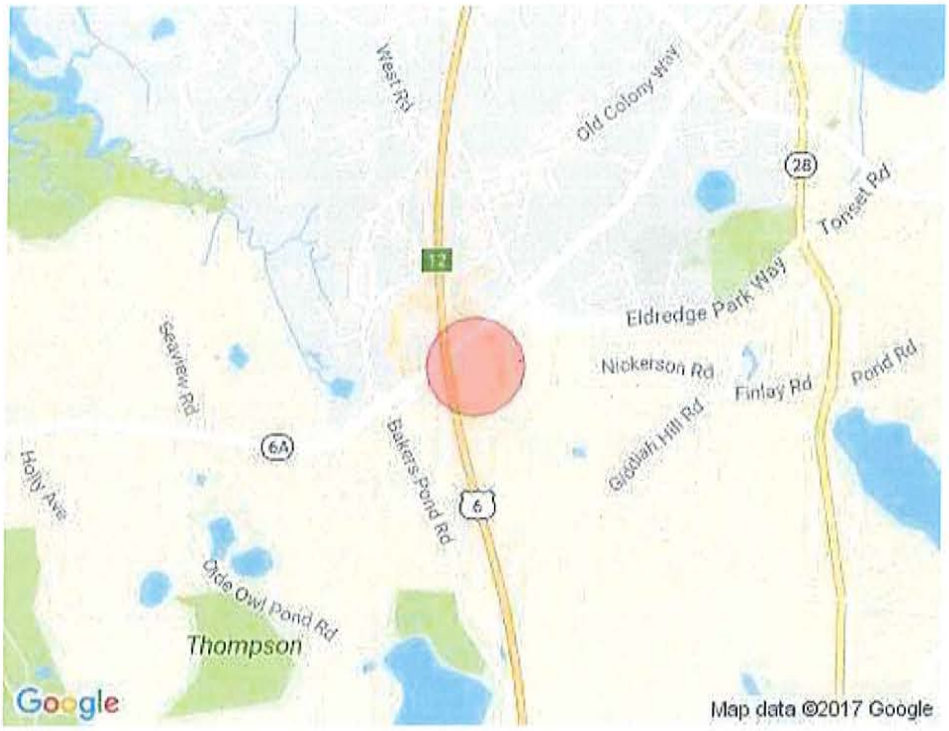
0 40 80 160 Feet

Figure 2
Site Map

Route 6 (Interchange 12) Cloverleaf

AECOM
Built to deliver a better world


Orleans MA
Route 6 Exit 12 E working in South East Cloverleaf and Rt 6A (Cranberry Highway)
Legend
CVS Pharmacy | Photo
Cape Cod Lighthouse Charter School
CapeCodRentals.com
Feature 1
Feature 10
Feature 11
Feature 12
Feature 2
Feature 3
Feature 4
Feature 5
Feature 6
Feature 7
Feature 8
Feature 9
Hairology
Marks Music
Orleans Bowling Center Inc
Shaw's Supermarket
Skaket Corners, Orleans
Untitled Path
Welcome to Orleans
RECEIVED
FEB 14 2017
PERMITS OFFICE
6
Cranberry Hwy
Nells Way
Bakers Pond Rd
Opas Way
Mid-Cape Hwy
O'Connor Rd
Lots Hollow
Finlay Rd
Eldredge Pkwy
W Rd
Oak Ridge Rd
Google earth
© 2016 Google
800 ft
N



Caller/Contractor Details

Caller Name:	JODI HODGE	**Title:**	PROJECT ADMIN
Phone #:	978-905-2100	**Fax #:**	978-905-2101
Alt. Phone #:	9789052247	**Return Call:**	B 5PM
Email Address:	JODI.HODGE@AECOM.COM		
Contractor Name:	AE COM INTERNATIONAL		
Address:	250 APOLLO DR		
City:	CHELMSFORD	**State:**	MA **Zip:** 01824
Contractor Type:	CONTRACTOR		

Location Details

State: MASSACHUSETTS

Municipality: ORLEANS

Latitude: 41.7778400 **Longitude:** -70.0021320

Address / Intersection:

CRANBERRY HWY

Nearest cross street 1: US HWY 6 EB

Nearest cross street 2: RAMP

Additional Information:

RT 6 EXIT 12 WORKING INSIDE THE SOUTHEAST CLOVERLEAF

SITE MARKED OUT ON ROUTE 6A

Nature / Extent of Work Details

Nature of Work: INSTALLING WELLS AND TEST PITS

Area of Work (i.e. st to house, in the st, priv prop):

INSIDE THE CLOVERLEAF FROM ROTUE 6 EXIT 12E TO ROUTE 6A

Area Premarked: YES

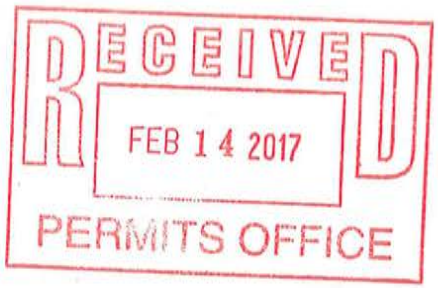
Start Date and Time

Date: 02/01/2017 **Time:** 15:30

Reason: REGULAR

Excavator doing the work:

NEW ENGLAND GEOTECH JAMESTOWN RI



Continue

Appendix B

Test Pit Data and Soil Evaluator Forms

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COASTAL engineering co.

260 Cranberry Highway
Orleans, MA 02653
508.255.6511 P 508.255.6700 F
Orleans | Sandwich | Nantucket
coastalengineeringcompany.com

CEC File No: C18470.00

Date: 03/09/17

COMMONWEALTH OF MASSACHUSETTS
ORLEANS, MASSACHUSETTS

Soil Suitability Assessment for On-site Sewage Disposal

Performed by: *John G. Schnaible, R.S.*
Witnessed by: *Adekunle Teniola, DEP-SERO*

Location Address or Lot #: *Map 40, Map 48* *Exit 12 Cloverleaf Route 6A* *Orleans, MA*	**Owner's Name** *Town of Orleans* *c/o AECOM* *Attn: Thomas Parece* **Address:** *usapimaging@aecom.com* *tom.parece@aecom.com*

New Construction ☒ Repair ☐

Office Review

Published Soil Survey Available: No ☐ Yes ☒
Year Published: *1993* Publication Scale: *1:25000* Soil Map Unit: CoC Carver-Hinesburg
Drainage Class: *Well Drained* Soil Limitations: *Poor Filter*

Surficial Geologic Report Available: No ☐ Yes ☒
Year Published: *1971* Publication Scale: *1:24000*
Geologic Material (Map Unit): *Harwich Outwash Plains*
Landform: *Outwash Plain*

Flood Insurance Rate Map:
Above 500 year flood boundary No ☐ Yes ☒
Within 500 year flood boundary No ☒ Yes ☐
Within 100 year flood boundary No ☒ Yes ☐

Wetland Area:
National Wetland Inventory (map unit) *Upland*
Wetlands Conservancy Program Map (map unit) --

Current Water Resource Conditions (USGS): Month: *February*
Range: Above Normal ☐ Normal ☒ Below Normal ☐
Other References Reviewed: *USGS Quad Maps and Groundwater Maps*

On-site Review

Deep Hole Number: *1* Date: *03/09/17* Time: *9:15* Weather: *Sunny*

Location (identify on site plan) *Middle of Cloverleaf*

Land Use: *Institutional* Slope (%): *8-15* Surface Stones: *No*

Vegetation: *Oak Trees and PineTrees*

Landform: *Outwash Plain*

Position on landscape (sketch on the back): *See Sketch*

Distances from:

Open Water Body *200+* feet
Possible Wet Area *200+* feet
Drinking Water Well *100+* feet
Drainageway *100+* feet
Property Line *100'+* feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0"- 2"	*O*				
2" – 24"	*Fill*				
24" – 30"	*A*	*Loamy Sand*	*10 YR 4/1*		
30" – 60"	*B*	*Loamy Sand*	*10 YR 5/8*		
60" - 150"	*C*	*Sand*	*10 YR 5/6*		*Medium to Fine Sand, Loose*

Parent Material (geologic) *Proglacial Outwash* Depth to Bedrock: *200'+*
Depth to Groundwater: Standing Water in the Hole: *None* Weeping from Pit Face: *None*
Estimated Seasonal High Ground Water: *50'±*

On-site Review

Deep Hole Number: 2 Date: 03/09/17 Time: 9:45 Weather: Sunny

Location (identify on site plan) Middle of Cloverleaf

Land Use: Institutional Slope (%): 8-15 Surface Stones: No

Vegetation: Oak Trees and Pine Trees

Landform: Outwash Plain

Position on landscape (sketch on the back): See Sketch

Distances from:

Open Water Body 200+ feet
Possible Wet Area 200+ feet
Drinking Water Well 100+ feet
Drainageway 100+ feet
Property Line 100'+ feet
Other

DEEP OBSERVATION HOLE LOG					
Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" – 2"	O				
2" – 10"	A	Loamy Sand	10 YR 4/3		
10" – 42"	B	Loamy Sand	10 YR 4/6		
42" - 96"	C1	Sand	10 YR 7/3		Fine sand, Loose
96" – 126"	C2	Loamy Sand	10YR 6/3		Friable
126" – 174"	C3	Sand	10YR 5/1		Fine Sand, Loose

Parent Material (geologic) Proglacial Outwash Depth to Bedrock: 200'+

Depth to Groundwater: Standing Water in the Hole: None Weeping from Pit Face: None

Estimated Seasonal High Ground Water: 50'±

On-site Review

Deep Hole Number: 3 Date: 03/09/17 Time: 10:15 Weather: Sunny

Location (identify on site plan) Middle of Cloverleaf

Land Use: Institutional Slope (%): 8-15 Surface Stones: No

Vegetation: Oak Trees and Pine Trees

Landform: Outwash Plain

Position on landscape (sketch on the back): See Sketch

Distances from:

Open Water Body 200+ feet
Possible Wet Area 200+ feet
Drinking Water Well 100+ feet
Drainageway 100+ feet
Property Line 100+ feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" – 2"	O				
2" – 12"	A	Loamy Sand	10 YR 4/2		
12" – 30"	B	Loamy Sand	10 YR 4/6		
30" – 132"	C	Sand	10 YR 5/6		Coarse to Medium Sand, Loose

Parent Material (geologic) Proglacial Outwash Depth to Bedrock: 200'+
Depth to Groundwater: Standing Water in the Hole: None Weeping from Pit Face: None
Estimated Seasonal High Ground Water: 80'±

On-site Review

Deep Hole Number: *4* Date: *03/09/17* Time: *10:45* Weather: *Sunny*

Location (identify on site plan) *Middle of Cloverleaf*

Land Use: *Institutional* Slope (%): *8-15* Surface Stones: *No*

Vegetation: *Oak Trees and Pine Trees*

Landform: *Outwash Plain*

Position on landscape (sketch on the back): *See Sketch*

Distances from:

Open Water Body *200+* feet
Possible Wet Area *200+* feet
Drinking Water Well *100+* feet
Drainageway *100+* feet
Property Line *100+* feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" – 3"	*O*				
3" – 11"	*A*	*Loamy Sand*	*10 YR 4/2*		
11" – 29"	*E*	*Loamy Sand*	*10 YR 7/2*		
29" – 59"	*B*	*Sand*	*10 YR 5/6*		
59" – 120"	*C1*	*Sand*	*10 YR 6/6*		*Fine Sand*
120" - 144"	*C2*	*Sand*	*10YR 6/3*		*Fine to Medium Sand, Loose*

Parent Material (geologic) *Proglacial Outwash* Depth to Bedrock: *200'+*
Depth to Groundwater: Standing Water in the Hole: *None* Weeping from Pit Face: *None*
Estimated Seasonal High Ground Water: *60'±*

On-site Review

Deep Hole Number: *5* Date: *03/09/17* Time: *11:15* Weather: *Sunny*

Location (identify on site plan) *Middle of Cloverleaf*

Land Use: *Institutional* Slope (%): *8-15* Surface Stones: *No*

Vegetation: *Oak Trees and Pine Trees*

Landform: *Outwash Plain*

Position on landscape (sketch on the back): *See Sketch*

Distances from:

Open Water Body *200+* feet
Possible Wet Area *200+* feet
Drinking Water Well *100+* feet
Drainageway *100+* feet
Property Line *100+* feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" – 2"	*O*				
2" – 12"	*A*	*Loamy Sand*	*10 YR 4/2*		
12" – 42"	*B*	*Loamy Sand*	*10 YR 4/6*		
42" – 60"	*C1*	*Loamy Sand*	*10 YR 5/6*		*Friable*
60" – 144"	*C2*	*Sand*	*10 YR 6/3*		*Fine to Medium sand, Loose*

Parent Material (geologic) *Proglacial Outwash* Depth to Bedrock: *200'+*
Depth to Groundwater: Standing Water in the Hole: *None* Weeping from Pit Face: *None*
Estimated Seasonal High Ground Water: *60'±*

On-site Review

Deep Hole Number: 6 Date: 03/09/17 Time: 11:45 Weather: Sunny

Location (identify on site plan) Middle of Cloverleaf

Land Use: Institutional Slope (%): 8-15 Surface Stones: No

Vegetation: Oak Trees and Pine Trees

Landform: Outwash Plain

Position on landscape (sketch on the back): See Sketch

Distances from:

Open Water Body 200+ feet
Possible Wet Area 200+ feet
Drinking Water Well 100+ feet
Drainageway 100+ feet
Property Line 100+ feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" - 3"	O				
3" – 9"	A	Loamy Sand	10 YR 3/2		
9" – 39"	B	Loamy Sand	10 YR 5/6		
39" – 96"	C1	Loamy Sand	10 YR 6/6		Friable
96" – 156"	C2	Sand	10 YR 7/2		Fine to Medium Sand

Parent Material (geologic) Proglacial Outwash Depth to Bedrock: 200'+
Depth to Groundwater: Standing Water in the Hole: None Weeping from Pit Face: None
Estimated Seasonal High Ground Water: 50'±

On-site Review

Deep Hole Number: 7 Date: 03/09/17 Time: 12:15 Weather: Sunny

Location (identify on site plan) Middle of Cloverleaf

Land Use: Institutional Slope (%): 8 - 15 Surface Stones: No

Vegetation: Oak Trees and Pine Trees

Landform: Outwash Plain

Position on landscape (sketch on the back): See Sketch

Distances from:

Open Water Body 200+ feet
Possible Wet Area 200+ feet
Drinking Water Well 100+ feet
Drainageway 100+ feet
Property Line 100+ feet
Other

DEEP OBSERVATION HOLE LOG

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0" – 3"	O				
3" – 15"	A	Loamy Sand	10YR 3/2		
15" – 36"	B	Loamy Sand	10 YR 5/6		
36" – 144"	C	Sand	10 YR 6/4		Fine to Medium Sand, Loose

Parent Material (geologic) Proglacial Outwash Depth to Bedrock: 200'+
Depth to Groundwater: Standing Water in the Hole: None Weeping from Pit Face: None
Estimated Seasonal High Ground Water: 50±

Location Address or Lot No. *Cloverleaf Exit 12 Route 6A*

COMMONWEALTH OF MASSACHUSETTS
Orleans, Massachusetts

PERCOLATION TEST*		
Date: 03/09/17		Time: 9-noon
Observation Hole #	*1*	*2*
Depth of Perc	*66"*	*78"*
Start Pre-soak	*0:00*	*0:00*
End Pre-soak	*15:00*	*14:00*
Time at 12"	*0:00*	*No water*
Time at 9"	*1:55*	*in hole*
Time at 6"	*3:57*	*after 15*
Time (9" - 6")	*2:02*	*minutes*
Rate Min./Inch	*<2*	*<2*

**** Minimum of 1 percolation test must be performed on both the primary area AND reserve area.***

Site Passed ☒ Site Failed ☐

Performed by: *John G. Schnaible CEC*

Witnessed by: *Adekunle Teniola DEP*

Comments: *The C layer in DOH #1, the C1 and C3 layers in DOH #2, the C layer in DOH #3, the C1 and C2 layers in DOH #4, the C2 layer in DOH #5, C2 layer in DOH #6 and the C layer in DOH #7 are considered suitable for the subsurface disposal of sewage. The Loamy Sands were not qualified.*

COASTAL engineering co.

260 Cranberry Highway
Orleans, MA 02653
508.255.6511 P 508.255.6700 F
Orleans | Sandwich | Nantucket
coastalengineeringcompany.com

Job C18470.00
Sheet No 10 Of 11
Calculated by: JGS Date: 03/09/17
Scale See Attached Plan

SKETCH PLAN SHOWING DEEP OBSERVATION HOLE LOCATIONS:

See Attached Plan

Determination for Seasonal High Water Table

Method Used: N/A

- ☐ Depth observed standing in observation hole _____inches
- ☐ Depth weeping from side of observation hole_____inches
- ☐ Depth to soil mottles _____inches
- ☐ Ground water adjustment_____feet

Index Well Number_____Reading Date_____Index well level_____

Adjustment Factor_____Adjusted ground water level_____

Depth of Naturally Occurring Pervious Material

Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system?

Yes

If not, what is the depth of naturally occurring pervious material?

Certification

I certify that on *April 1995* I have passed the examination approved by the Department of Environmental Protection and that the above analysis was performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017.

Signature_____ SE 2166 Date *03/09/17*

JGS/jgs

F:\SDS\SKPROJ\C18000\C18470\C18470-00_TitleTown-CL\C18470-TT-CL.dwg Apr 20, 2017 - 6:21pm

Point	Northing	Easting	Elevation (Top of Casing)	Elevation (Ground)
MW-CL-1	2747481.708	1064740.808	XX	98.5
MW-CL-2	2747662.213	1064877.471	XX	85.4
MW-CL-3	2747684.466	1064699.986	XX	85.8
DOH-1	2747490.900	1064792.603		97.9
DOH-2	2747556.350	1064748.311		96.0
DOH-3	2747513.005	1064591.337		108.0
DOH-4	2747649.702	1064880.583		85.8
DOH-5	2747713.963	1064781.443		83.7
DOH-6	2747675.103	1064663.776		85.7
DOH-7	2747679.612	1064556.495		82.3
MAG NAIL 1000	2747895.732	1064748.717		76.60

1 inch = 50 ft

50 25 0 50 150

PLAN

ROUTE 6 — EXIT 12
EXIT 7 ON-RAMP

ROUTE 6A

PAVED LOOP

MW-CL-1
MW-CL-2
MW-CL-3
DOH-1
DOH-2
DOH-3
DOH-4
DOH-5
DOH-6
DOH-7
MAG NAIL 1000

BENCH MARK:
TOP OF MAG NAIL
SET IN PAVEMENT
EL=76.60 (NAVD 88)

MASS. COORD. SYSTEM NAD 1983 MAINLAND ZONE

DATUM NOTE:
ELEVATIONS SHOWN HEREON ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 1988)

Coastal Engineering Co., Inc. © 2017

PROJECT NO. C17470.00

SKC-9

1 OF 1 SHEETS

CHECKED BY

DRAWN BY BPM

DATE 4/20/2017

DRAWING FILE C18470-TT-CL.dwg

SCALE AS NOTED

PROJECT
AECOM
EXIT 12 CLOVERLEAF
ORLEANS, MA

SHEET TITLE
WELL PLAN OF LAND SHOWING
MONITOR WELL AND SOIL TEST LOCATIONS

SEAL

NO.	DATE	REVISION	BY

COASTAL engineering co.
280 Canterbury Hwy. Ostwire, MA 02653
508.255.6511 P 508.255.6700 F

Appendix C

Soil Boring Logs

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Project Number: 60476644
Client: Town of Orleans

Site Location: Clover Leaf site
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-1

Boring Number:
Sheet: 1 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME
Inside Diameter: 2"

Well Data

Boring Depth: 98 ft
Screen Depth: 91.5-101.5
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C Hayden, E.Amir, B.Morri
Started: 3/6/2017
Drill Contractor: NE Geotech
Driller: Hayes, T. Desmond
Date Completed: 4/11/2017

Depth	Sample Identification	Rec (ft)	Sorting	Moisture	PID (ppm)	Field Identification	Description	Fill Mat.	Tube	Fill Mat.	Depth
1-5	0 ft to 5 ft					Pre-Cleared to 5 ft	SAND				1-5
6-10	5 ft to 10 ft	2.5 ft		dry		5 to 7.5 ft: Brown-Tan fine sand					6-10
11-15	10 ft to 15 ft	1.5 ft		Dry		10 to 11.5 ft: Brown-Tan fine sand					11-15
16-20	15 ft to 20 ft	5 ft		dry		15 to 16.5 ft: Brown-Tan fine sand 16.5 to 20 ft: Tan fine sand, (Fe-stain @ 12.5-13)					16-20
21-25	20 ft to 25 ft	4.25 ft		dry		20 to 24.25 ft: Tan fine sand,					21-25
26-30	25 ft to 30 ft	3 ft		dry		25 to 27 ft: Tan - Brown fine to medium sand (little coarse sand @26-26.5) 27 to 28 ft: Tan / Brown fine sand					26-30

Project Number: 60476644
Client: Town of Orleans
Site Location: Clover Leaf site, Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-1

Boring Number:
Sheet: 2 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME
Inside Diameter: 2"

Well Data

Boring Depth: 98 ft
Screen Depth: 91.5-101.5
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C.Hayden, E. Amir, B.Mo. Started: 3/6/2017
Drill Contractor: NE Geotech
Driller: Hayes, T. Desmond Date Completed: 4/11/2017

Depth	Sample Identification	Rec (ft)	Sorting	Moisture	PID (ppm)	Field Identification	Description	Fill Mat.	Tube	Fill Mat.	Depth
31	30 ft to 35 ft	3.5 ft		dry		30 to 31.5 ft: Tan / Brown fine sand	SAND				31
32				moist		31.5 to 32.5 ft: Red-orange fine/medium sand					32
33						-31.5-31.7 : Red fine/medium sand					33
34						-31.7-32.5: Orange fine sand (loose) perched water					34
35						32.5 to 33.1 ft: Brown clayey silt, moist and firm -32.5-32.8 : plastic -32.8 - 33.4: non-plastic 33.1 to 33.5 ft: Brown, Red/orange mottled fine sand and silt	SILT				35
36	35 ft to 40 ft	3.3 ft		moist		35 to 36.5 ft: Brown clay, brown fine sand 35.5-35.6	CLAY				36
37						36.5 to 37.5 ft: Brown/grey mottled silt, little fine sand	SILT				37
38											38
39						37.5 to 38.3 ft: Tan fine sand, loose	SAND				39
40											40
41	40 ft to 45 ft	2 ft		moist		43 to 45 ft: Loose tan fine sand, 1" clay layer at 44ft					
42							SAND				
43											
44											
45											
46	45 ft to 50 ft	2 ft		moist		45 to 47 ft: Tan loose fine sand					
47											
48											
49											
50											
51	50 ft to 55 ft	2 ft		moist		50 to 52 ft: Tan Fe-stain - mottled fine sand, loose					
52											
53											
54											
55											
56	55 ft to 60 ft	2 ft		moist		55 to 56 ft: Light brown fine sand, some medium sand, loose	SAND				
57						56 to 57 ft: Tan fine sand, loose					
58											
59											
60											

Project Number: 60476644
Client: Town of Orleans

Site Location: Clover Leaf site
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-1

Boring Number:
Sheet: 3 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME

Project Manager: Mark Owen
Field Tech: C Hayden, E. Amir, B Mc
Date Started: 3/6/2017
Inside Diameter: 2"
Drill Contractor: NE Geotech
Driller: Hayes, T. Desmon
Date Completed: 4/11/2017

Well Data

Boring Depth: 98 ft
Screen Depth: 91.5-101.5
Screen length: 10ft

Depth	Sample Identification	Rec (ft)	Sorting	Moisture	PID (ppm)	Field Identification	Description	Fill Mat.	Tube	Fill Mat.	Depth
	60 ft to 65 ft	2 ft		moist		60 to 62 ft: Tan fine sand dense grey silty fine sand - 60.3-60.6					
	65 ft to 70 ft	2.3 ft		moist		65 to 68 ft: Tan fine sand					
	70 ft to 75 ft	2.3 ft		moist		70 to 73 ft: Tan fine sand End of Boring					
						Start of well install by Desmond Drilling, 2 ft split spoons					
	70 ft to 72 ft	1.6 ft		dry		70 to 71.6 ft: Tan medium sand, clean	Blow count: 4, 7, 11, 15				
	72 ft to 74 ft	1.75 ft		dry		72 to 73.7 ft: Tan fine sand, Fe-staining at 2", 3", 8", 16", trace grey silt 73.7 to 73.75 ft: Grey silt, Fe mottling	Blow count: 6, 11, 13, 15				
	74 ft to 76 ft	1.7 ft		moist		74 to 74.75 ft: Light brown sand, fine silty sand, Fe- mottling 74.75 to 75.1 ft: Grey silt, stiff 75.1 to 75.6 ft: Tan sand, Fe-mottling, trace silt 75.6 to 75.7 ft: Grey silt, stiff	Blow count: 7, 14, 19, 19				
	76 ft to 78 ft	1.6		moist		76 to 76.7 ft: Tan fine sand, clean 76.7 to 77.6 ft: Light brown fine sand, becoming silty fine sand at bottom	Blow count: 8, 12, 17, 23				
	78 ft to 80 ft	1.8		moist		78 to 78.2 ft: Light brown fine sand, clean 78.2 to 78.7 ft: Brown grey mottled silt, stiff 78.7 to 79.3 ft: Brown clayey silt, very stiff, low plasticisty 79.3 to 79.8 ft: Tan fine sand, clean	Blow count: 12, 13, 15, 21				
	80 ft to 82 ft	1.7		moist		80 to 81.4 ft: Light brown sand with Fe-mottling, fine sand, trace silt 81.4 to 81.6 ft: Brown grey mottled silt, stiff 81.6 to 81.7 ft: Light brown medium sand, clean	Blow count: 7, 14, 10, 8				
	82 ft to 84 ft	1.6 ft		moist		82 to 83 ft: Tan fine sand, clean 83 to 83.6 ft: Light brown, silty sand, Fe-staining mottling, stiff	Blow count: 5, 10, 13, 19				
	84 ft to 86 ft	1.7 ft		wet		84 to 85.7 ft: Brown medium sand, little fine sand, trace silt	Blow count: 7, 11, 10, 11				
	86 ft to 88 ft	1.3 ft		wet		86 to 87.3 ft: Brown fine sand, little medium sand, trace silt	Blow count: 5, 6, 10, 11				
	88 ft to 90 ft	1.5 ft		wet		88 to 89 ft: Brown medium sand, some fine sand, trace silt 89 to 89.5 ft: Brown fine sand, trace silt	Blow count: 25				
	90 ft to 92 ft	1.7 ft		wet		90 to 90.25 ft: Brown medium sand, some fine sand 90.25 to 90.3 ft: Brown/grey mottled clayey silt, stiff, low-med plastic 90.3 to 90.6 ft: Brown fine silty sand 90.6 to 91 ft: Brown fine sandy silt 91 to 91.7 ft: Brown fine sand, some med sand, trace silt	Blow count: 25				
	92 ft to 94 ft	1.3 ft		wet		92 to 92.4 ft: Brown fine sand, trace silt 92.4 to 93.3 ft: Brown fine sand, little silt, stiff silt traces	Blow count:50				
	94 ft to 96 ft	2 ft		wet		94 to 95.5 ft: Brown fine sand 95.5 to 96 ft: silt sand layering, grey-brown mottling					
	96 ft to 98 ft	2 ft				96 to 97 ft: fine tan sand, clean 97 to 98 ft: silt layers with some fine sand, grey-brown mottling, clayish					

Project Number: 60476644 Client: Town of Orleans Site Location: Clover Leaf site Orleans, MA	AECOM 250 Apollo Drive Chelmsford, Massachusetts (978) 905-2100	**Boring: CLS-1** Boring Number: Sheet: 3 of 4 Surface Elevation (ft-asl): Equipment: Geoprobe 6620, CME Inside Diameter: 2"
		Well Data Boring Depth: 98 ft Screen Depth: 91.5-101.5 Screen length: 10ft
Project Manager: Mark Owen Drill Contractor: NE Geotech	Field Tech: C.Hayden, E. Amir, B.Mc Driller: Hayes, T. Desmone	Date Started: 3/6/2017 Date Completed: 4/11/2017

Depth	Sample Identification	Rec (ft	Sortin	Moistu	PID (ppm)	Field Identification	Description	Fil Mat.	Tube	Fill Ma	Depth
	98 ft to 100 ft	2 ft		wet		98 to 99 ft: Tan fine silty sand, loose 99 to 100 ft: Tan fine sand with trace silt					
	103 ft to 105	2 ft		wet		103 to 104.5 ft: fine brown sand, trace silts 104.5 to 105 ft: fine brownish tan sand, slightly coarser, clean					
	108 ft to 110 ft	2 ft		wet		108 to 110 ft: Tan-brown fine sand, clean					

Project Number: 60476644 Client: Town of Orleans	AECOM 250 Apollo Drive Chelmsford, Massachusetts (978) 905-2100	**Boring: CLS-2**
Site Location: Overland Way, Tri-Town Orleans, MA	Boring Number: Sheet: 1 of 2 Surface Elevation (ft-asl): Equipment: Geoprobe 6620	**Well Data** Boring Depth: Screen Depth:
Project Manager: Mark Owen Drill Contractor: NE Geotech	Field Tech: C.Hayden Driller: Hayes Date Started: 3/8/2017 Date Completed: 3/8/2017 Inside Diameter: 2"	Screen length:

Depth	Sample Identification	Rec (ft)	Sorting	Moist.	PID (ppm)	Field Identification	Description	Fil Mat.	Tube	Fill Mat.	Depth
1	0 ft to 5 ft	5 ft				Pre-Cleared to 5 ft					1
2											2
3											3
4											4
5											5
6	5 ft to 10 ft	4.4 ft		dry		5 - 7.5 ft: Brown / grey fine sand, little medium sand, trace coarse sands					6
7						7.5 to 8.5 ft: Grey fine sand, trace medium sand					7
8						8.5 to 9.4 ft: Red-brown fine sand					8
9											9
10											10
11	10 ft to 15 ft	4.5 ft		Dry		10 to 14.5 ft: Fine sand - 10-11 : Red brown					11
12						-11-14.45: light brown					12
13						-tree root fibers throughout					13
14											14
15											15
16	15 ft to 20 ft	4.3 ft		dry		15 to 15.8 ft: Light brown fine sand					16
17											17
18						15.8 to 16.6 ft: Light brown fine sand, trace medium sand and gravel					18
19						16.6 to 19.3 ft : Light brown fine/medium sand, mottled from 18.4-19 and color transition to tan at 18.8					19
20											20
21	20 ft to 25 ft	4.3 ft		wet		20 to 20.6 ft: Tan fine sand					21
22						20.6 to 21 ft: Mottled black and brown - red/brown - red - orange silt					22
23						21 to 22.6 ft: Brown silt					23
24						22.6 to 24.3 ft: Brown silty clay with fine sand lenses at 23-23.5, slightly plastic					24
25											25
26	25 ft to 30 ft	3.1 ft		wet		25 to 27.3 ft: Brown clay, slightly plastic					26
27						27.3 to 27.6 ft: Tan fine sand					27
28						27.6 to 27.8 ft: Brown clay, plastic					28
29						27.8 to 28.1 ft: Brown/red silt with little clay varves					29
30											30

Project Number: 60476644
Client: Town of Orleans

Site Location: Overland Way, Tri-Town Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-2

Boring Number:
Sheet: 1 of 2
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620
Inside Diameter: 2"

Well Data

Boring Depth:
Screen Depth:
Screen length:

Project Manager: Mark Owen
Field Tech: C Hayden
Date Started: 3/8/2017
Drill Contractor: NE Geotech
Driller: Hayes
Date Completed: 3/8/2017

Depth	Sample Identification	Rec (ft)	Sorting	Moist	PID (ppm)	Field Identification	Description	Fill Mat	Tube	Fill Mat	Depth
31	30 ft to 35 ft	3 ft		dry		30 to 33ft: Tan brown mottled fine sand					31
32											32
33											33
34											34
35											35
36	35 ft to 40 ft	2.9 ft		wet		35 to 37 ft: Tan red mottled fine sand					36
37						37 to 37.1 ft: clay varve					37
38						37.1 to 37.4 ft: Yellow-tan fine sand					38
39											39
40						37.4 to 37.9 ft: Brown-grey clay, plastic, red-org fine sand pocket at 37.8-37.9					40
41	40 ft to 45 ft	2.7 ft		wet		40 to 40.5 ft: Brown clay, plastic					41
42						40.5 to 41 ft: Iron mottled brown-greey silty clay, plastic					42
43											43
44						41 to 41.9 ft: Tan, fine sand					44
45						41.9 to 42.7 ft: FE-stained mottled brown grey silt clay					45
46											46
47											47
48											48
49											49
50											50
51											51
52											52
53											53
54											54
55											55
56											56
57											57
58											58
59											59
60											60

Project Number: 60476644
Client: Town of Orleans

Site Location: Overland Way, Tri-Town
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-3

Boring Number:
Sheet: 1 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME
Inside Diameter: 2"

Well Data

Boring Depth: 105ft
Screen Depth: 76-86 ft
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C.Hayden
Date Started: 3/8/2017
Drill Contractor: NE Geotech
Driller: Hayes, T.Desmond
Date Completed: 3/31/2017

Depth	Sample Identification	Rec (ft)	Sorting	Moist	PID (ppm)	Field Identification	Description	Fil Mat.	Tube	Fill Ma	Depth
1-5	0 ft to 5 ft	5 ft				Pre-Cleared to 5 ft					1-5
6-10	5 ft to 10 ft	5 ft		dry		5 - 7 ft: Brown/yellow fine sand, trace medium sand and fine gravel 7 to 10 ft: Tan very fine sand (sand and silt at 8.1 - 8.7)					6-10
11-15	10 ft to 15 ft	5 ft		Dry		10 to 14 ft: Tan very fine sand (12.9 - 13.6 very fine sandy silt, clay) slightly plastic, mottled 14 to 15 ft: Mottled tan fine sand					11-15
16-20	15 ft to 20 ft	5 ft		dry		15 to 19 ft: Tan slightly mottled fine sand 19 to 20 ft: Tan fine/medium sand					16-20
21-25	20 ft to 25 ft	5 ft				20 to 25 ft: Tan slightly mottled fine sand					21-25
26-30	25 ft to 30 ft	3.7 ft		wet		25 to 27.2 ft: Tan slightly mottled fine sand 27.2 to 27.7 ft: Brown mottled silty clay (plastic) 27.7 to 28.7 ft: Tan very fine sand					26-30

Project Number: 60476644
Client: Town of Orleans

Site Location: Overland Way, Tri-Town
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-3

Boring Number:
Sheet: 2 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME
Inside Diameter: 2"

Well Data

Boring Depth: 105ft
Screen Depth: 76-86 ft
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C.Hayden
Date Started: 3/8/2017
Drill Contractor: NE Geotech
Driller: Hayes, Desmond
Date Completed: 3/31/2017

Depth	Sample Identification	Rec (ft)	Sorting	Moist	PID (ppm)	Field Identification	Description	Fil Met	Tube	Fill Ma	Depth
31	30 ft to 35 ft	5 ft		wet		30 to 33.2 ft: Tan fine/very fine sand, mottled -30.4 ft: silt varve -32 5 ft: clay varve bordered by iron staining					31
32											32
33											33
34											34
35											35
36	35 ft to 40 ft	3 ft		wet		35 to 38 ft: Tan fine/very fine sand, mottled					36
37											37
38											38
39											39
40											40
41	40 ft to 45 ft	3 7 ft		wet		40 to 43.7 ft: Tan, mottled fine/very fine sand					41
42											42
43											43
44											44
45											45
46	45 ft to 50 ft	3 ft		wet		45 to 48 ft: Tan, mottled fine/very fine sand					46
47											47
48											48
49											49
50											50
51	50 ft to 55 ft	2 6 ft		wet		50 to 52.6 ft: Tan, mottled fine/very fine sand, grey silt layer at 50.5 ft (dry)					51
52											52
53											53
54											54
55											55
56	55 ft to 60 ft	1 5 ft		wet		55 to 56 ft: Tan mottled fine sand 56 to 56.5 ft: Tan mottled fine sand, with brown clay pocket					56
57											57
58											58
59											59
60											60

Project Number: 60476644
Client: Town of Orleans

Site Location: Clover Leaf site
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-3

Boring Number:
Sheet: 3 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CME
Inside Diameter: 2"

Well Data

Boring Depth: 105ft
Screen Depth: 76-86 ft
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C Hayden
Date Started: 3/8/2017
Drill Contractor: NE Geotech/ Des
Driller: Hayes, Desmond
Date Completed: 3/31/2017

Depth	Sample Identification	Rec (ft	Sorting	Moist	PID (ppm)	Field Identification	Description	Filt Mat.	Tube	Fill Mat	Depth
60	60 ft to 65 ft	2 ft		wet		60 to 62 ft: Tan mottled fine sand					
61						pronouced silt varves from 60.-60.5 ft (grey)					
62											
63						------ End of Boring ------					
64											
65						------ Start of well install by Desmond Drilling, 2ft split spoons ------					
66	65 ft to 67 ft	1.7 ft				65 to 66.3 ft: Fe mottled tan fine sand, clay varves at 66-66.2 66.3 to 66.5 ft: Grey, clay plastic 66.5 to 66.7 ft: Fe mottled tan fine sand	Blow count: 7, 10, 9, 9				
67											
68	67 ft to 69 ft	1.7 ft				67 to 68.7 ft: Grey, clay plastic	Blow count: 6, 7, 9, 9				
69											
70	69 ft to 71 ft	1.5 ft		moist wet		69 to 70 ft: Tan - grey fine sand, grey clay lens at 69.3 70 to 70.4 ft: Grey/Red-brown fine sand-silt - clay matrix 70.4 to 70.5 ft: Light brown, Fe-mottled fine sand	Blow count: 5, 8, 8, 10				
71	71 ft to 73 ft	1.6 ft		wet		71 to 71.2 ft: Light brown, Fe-mottled fine sand 71.2 to 71.6 ft: Grey/brown silt, trace fine sand	Blow count: 5, 6, 10, 11				
72				wet wet		71.6 to 71.9 ft: Grey/brown silt, grey clay 71.9 to 72.1 ft: Grey clay, tan/brown fine sand					
73				wet		72.1 to 72.6 ft: Tan/brown fine sand					
74	73 ft to 75 ft	2.0 ft		wet		73 to 75 ft: Brown fine sand, grey silt varve at 74.8	Blow count: 4, 5, 8, 12				
75											
76	75 ft to 77 ft	1.4 ft				75 to 77 ft: Brown fine sand, grey silt varve at 75.7	Blow count: 13				
77											
78	77 ft to 79 ft	1.7 ft				77 to 78.7 ft: Brown fine sand, grey clay varve at 78.1	Blow count: 25				
79	79 ft to 81 ft	1.8 ft				79 to 80.8 ft: Brown fine sand, interm clay pockets from 80-80.3	Blow count: 40				
80											
81	81 ft to 83 ft	0.8 ft				81 to 81.8 ft: Tight brown fine sand, trace medium sand	Blow count: 35				
82											
83	83 ft to 85 ft	1.6 ft				83 to 83.6 ft: Tight brown fine sand, trace medium sand 83.6 to 84.2 ft: Brown fine sand and silt 84.2 to 84.6 ft: Grey tan clayey silt, mottled by fine sand	Blow count: 35				
	85 ft to 87 ft	1.8 ft				85 to 85.4 ft: Brown fine sand little medium sand 85.4 to 86.5 ft: Heavily mottled sandy silt, multiple layers of clay and silt 86.5 to 86.8 ft: Grey silty sand	Blow count: 35				
	87 ft to 89 ft	1.9 ft				87 to 88 ft: Brown fine sand, little silt 88 to 88.9 ft: Brown fine sand, little medium sand	Blow count: 40				
	89 ft to 91 ft	1.2 ft				89 to 90.2 ft: Brown fine sand, little medium sand	Blow count: 45				
	91 ft to 93 ft	1.2 ft				91 to 92.2 ft: Brown fine sand, little medium sand	Blow count: 50				
	93 ft to 95 ft	1.7 ft				93 to 93.8 ft: Brown fine sand, some silt, little medium sand 93.8 to 94.7 ft: Mottled brown/grey fine sand and silt	Blow count: 50				

Project Number: 60476644
Client: Town of Orleans

Site Location: Clover Leaf site
Orleans, MA

AECOM
250 Apollo Drive
Chelmsford, Massachusetts
(978) 905-2100

Boring: CLS-3

Boring Number:
Sheet: 4 of 4
Surface Elevation (ft-asl):
Equipment: Geoprobe 6620, CMEH
Inside Diameter: 2"

Well Data

Boring Depth: 105ft
Screen Depth: 76-86 ft
Screen length: 10ft

Project Manager: Mark Owen
Field Tech: C Hayden
Date Started: 3/8/2017
Drill Contractor: NE Geotech
Driller: Hayes, T. Desmond
Date Completed: 3/31/2017

Depth	Sample Identification	Rec (ft	Sorting	Moisture	PID (ppm)	Field Identification	Description	Fill Mat	Tube	Fill Mat	Depth
95	95 ft to 97 ft	1.0 ft				95 to 96 ft: Brown fine sand, littled medium sand	Blow count: 42				
96											
97	97 ft to 99 ft	1.0 ft				97 to 98 ft: Brown/tan fine sand	Blow count: 40				
98											
99	99 ft to 101 ft	1.6 ft				99 to 100.6 ft: Grey/tan clayey silt	Blow count: 50				
100	101 ft to 103 ft	1.0 ft				101 to 101.5 ft: Brown/tan fine sand, some silt 101.5 to 102 ft: Brown, mottled silt, interlayered by grey clay	Blow count: 42				
101											
102	103 ft to 105 ft	1.7 ft				103 to 103.3 ft: Grey clay transitions to tan iron stained sand 103.3 to 104.1 ft: Brown fine sand, little medium sand 104.1 to 104.5 ft: Grey clay trans to light brown clay silt 104.5 to 104.7 ft: Ttan Fe-stained fine sand, little silt	Blow count: 45				
103											
104											
105											

Project Number: 60476644 Client: Town of Orleans	AECOM 250 Apollo Drive Chelmsford, Massachusetts (978) 905-2100	**Boring: TTS-1**
Site Location: Overland Way, Tri-Town Orleans, MA		Boring Number: Sheet: 1 of 3 Surface Elevation (ft-asl): Equipment: Geoprobe 6620 p Inside Diameter: 2"
Project Manager: Mark Owen Drill Contractor: NE Geotech	Field Tech: C Hayden Driller: Hayes	Started: 3/13/2017 Date Completed: 3/13/2017

Well Data

Boring Depth: 45 ft
Screen Depth: 35 - 45 ft
Screen length: 10 ft

Depth	Sample Identification	Rec (ft)	Sorting	Moisture	PID (ppm)	Field Identification	Description	Fill Mat.	Tube	Fill Mat.	Depth
1-5	0 ft to 5 ft					Pre-Cleared to 5 ft on 03/07/2017 0-8" roots and organic material, 8-60" fine to medium sand with some gravel					1-5
6-10	5 ft to 10 ft	4.5 ft		dry		5 to 9.5 ft: Brown / light brown fine sand					6-10
11-15	10 ft to 15 ft	3.7 ft		Dry		10 to 13.7 ft: Brown to light brown fine sand (12.3-12.7 coarsens to mix with some medium sand)					11-15
16-20	15 ft to 20 ft	3.7 ft		dry		15 to 18.7 ft: Brown / light brown find sand molted throughout					16-20
21-25	20 ft to 25 ft	3.7 ft		dry		20 to 22 ft: Tan / light brown poorly sorted layers of fine sand, medium sand, fine-medium sand, silty sand, and silt 22ft: Rock fragment, Lg gravel 22.1 to 22.8 ft: light brown medium to coarse sand and gravel to fine sand and silt, clay at 22.8 22.8 to 23.7 ft: Tan fine to medium sand					21-25
26-30	25 ft to 30 ft	3.7		dry		25 to 26.1 ft: Tan / orange-tan fine to medium sand - fine sand l 26.1 to 27.6 ft: Brown, tight fine sand, some medium sand, silt "varves" 27.6 to 28.7 ft: Tan fine to medium sand, grey silt / clay varve at 28.2					26-30

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Appendix D

Laboratory Reports - Soils

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CERTIFICATE OF ANALYSIS

Mark Owen
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (60476644 T10.1B)
ESS Laboratory Work Order Number: 1704795

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:03 pm, May 09, 2017

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

Subcontracted Analyses

CTS - Cranston, RI	Grain Size Analysis, Hydrometer Analyses

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

SAMPLE RECEIPT

The following samples were received on April 28, 2017 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1704795-01	CLS-1 70-72	Soil	§
1704795-02	CLS-1 86-88	Soil	§
1704795-03	CLS-1 95.5-96	Soil	§
1704795-04	CLS-1 108-110	Soil	§
1704795-05	CLS-2 21-24	Soil	§
1704795-06	CLS-2 64.66	Soil	§
1704795-07	CLS-2 74-76	Soil	§
1704795-08	CLS-2 80-82	Soil	§
1704795-09	CLS-3 65-69	Soil	§
1704795-10	CLS-3 73-77	Soil	§
1704795-11	CLS-3 87-95	Soil	§
1704795-12	CLS TP-3 15-15	Soil	§
1704795-13	CLS TP-7 10-15	Soil	§
1704795-14	TTS-1-TP 10-15	Soil	§
1704795-15	TTS-1 45-46.5	Soil	§
1704795-16	TTS-2-TP 10-15	Soil	§
1704795-17	TTS-2 21-21.5	Soil	§
1704795-18	TTS-3 15-16.5	Soil	§
1704795-19	TTS-4 15.5-16.5	Soil	§

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

To ensure you are viewing the most current version of the documents below, please clear your internet cookies for www.ESSLaboratory.com. Consult your IT Support personnel for information on how to clear your internet cookies.

Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-1 70-72
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-01
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-1 86-88
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-02
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-1 95.5-96
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-03
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: CLS-1 108-110
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-04
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-2 21-24
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-05
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-2 64.66
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-06
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-2 74-76
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-07
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: CLS-2 80-82
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-08
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-3 65-69
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-09
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-3 73-77
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-10
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-3 87-95
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-11
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS TP-3 15-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-12
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS TP-7 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-13
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-1-TP 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-14
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-1 45-46.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-15
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: TTS-2-TP 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-16
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-2 21-21.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-17
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: TTS-3 15-16.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-18
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: TTS-4 15.5-16.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-19
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Notes and Definitions

Z-08	See Attached
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

LABORATORY TESTING DATA SHEET (1 of 2)

Project Name **Orleans - GWDP** Location Overland Way, MA Reviewed By

Project No. **1704795** Assigned By T. Parece

Project Manager T. Parece Report Date 05.08.17 Date Reviewed *05.08.17*

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests						Corrosivity					Laboratory Log and Soil Description
				Water Content %	LL %	PL %	Gravel %	Sand %	Fines (<#200) %	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Resistivity (Mohms-cm)	GTL Resist	
CLS-1		70-72	17-S-560				0.1	98.0	1.9						Light Brown-White poorly graded sand
CLS-1		86-88	17-S-561				0.0	97.3	2.7						Brown poorly graded sand
CLS-1		95.5-96	17-S-562				0.0	56.4	43.6						Brown silty sand
CLS-1		108-110	17-S-563				0.0	94.3	5.7						Brown poorly graded sand with silt
CLS-2		21-24	17-S-564				0.0	4.4	95.6						Light Brown silt
CLS-2		64-66	17-S-565				0.0	53.0	47.0						Light White-Brown silty sand
CLS-2		74-76	17-S-566				0.0	41.8	58.2						Light Brown sandy silt
CLS-2		80-82	17-S-567				0.0	89.0	11.0						Light Brown poorly graded sand with silt
CLS-3		65-69	17-S-568				0.0	85.6	14.4						Strong Brown silty sand
CLS-3		73-77	17-S-569				0.0	57.3	42.7						Brown silty sand
CLS-3		87-95	17-S-570				0.0	89.6	10.4						Brown poorly graded sand with silt
CLS TP-3		15-15	17-S-571				2.0	96.1	1.9						Red-Brown poorly graded sand

THIELSCH ENGINEERING
195 Frances Avenue
Cranston, RI 02910 401-467-6454

LABORATORY TESTING DATA SHEET (2 of 2)

Project Name **Orleans - GWDP** Location Overland Way, MA Reviewed By

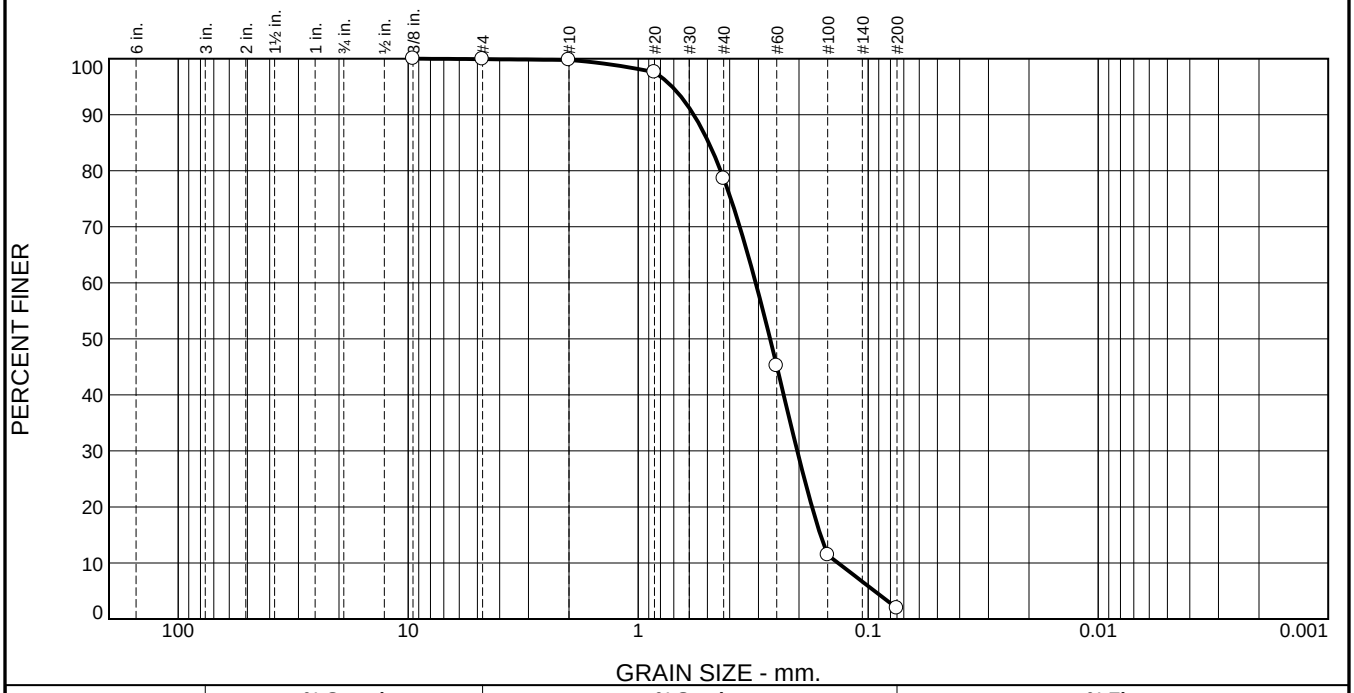
Project No. **1704795** Assigned By T. Parece

Project Manager T. Parece Report Date 05.08.17 Date Reviewed *05.08.17*

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests						Corrosivity					Laboratory Log and Soil Description
				Water Content %	LL %	PL %	Gravel %	Sand %	Fines (<#200) %	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Resistivity (Mohms-cm)	GTL Resist	
CLS-TP-7		10-15	17-S-572				3.3	92.6	4.1						Brown poorly graded sand
TTS-1-TP		10-15	17-S-573				0.1	94.1	5.8						Red-Brown poorly graded sand with silt
TTS-1		45-46.5	17-S-574				0.0	53.0	47.0						Brown silty sand
TTS-2-TP		10-15	17-S-575				14.1	81.8	4.1						Light Brown poorly graded sand
TTS-2		21-21.5	17-S-576				0.0	66.9	33.1						Brown silty sand
TTS-3		15-16.5	17-S-577				0.0	2.5	97.5						Brown silt
TTS-4		15.5-16.5	17-S-578				0.0	51.2	48.8						Brown silty sand

THIELSCH ENGINEERING
195 Frances Avenue
Cranston, RI 02910 401-467-6454

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.1	21.2	76.7	1.9	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.375	100.0		
#4	99.9		
#10	99.8		
#20	97.6		
#40	78.6		
#60	45.2		
#100	11.4		
#200	1.9		

* (no specification provided)

Material Description

Light Brown-White poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.5736 D_{85}= 0.4934 D_{60}= 0.3084
D_{50}= 0.2670 D_{30}= 0.2035 D_{15}= 0.1612
D_{10}= 0.1351 C_u= 2.28 C_c= 0.99

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 70-72' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

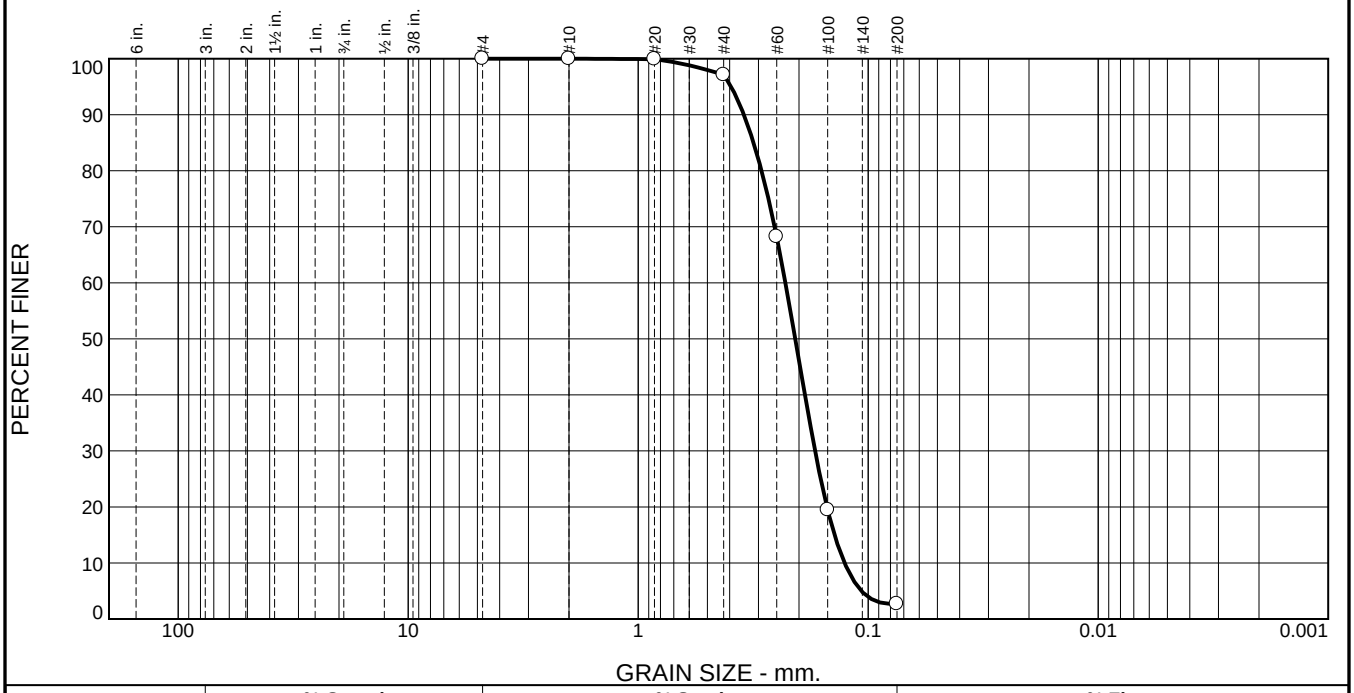
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-560

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.9	94.4	2.7	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.9		
#40	97.1		
#60	68.2		
#100	19.5		
#200	2.7		

* (no specification provided)

Material Description

Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3470 D_{85}= 0.3150 D_{60}= 0.2291
D_{50}= 0.2076 D_{30}= 0.1701 D_{15}= 0.1401
D_{10}= 0.1267 C_u= 1.81 C_c= 1.00

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 86-88' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

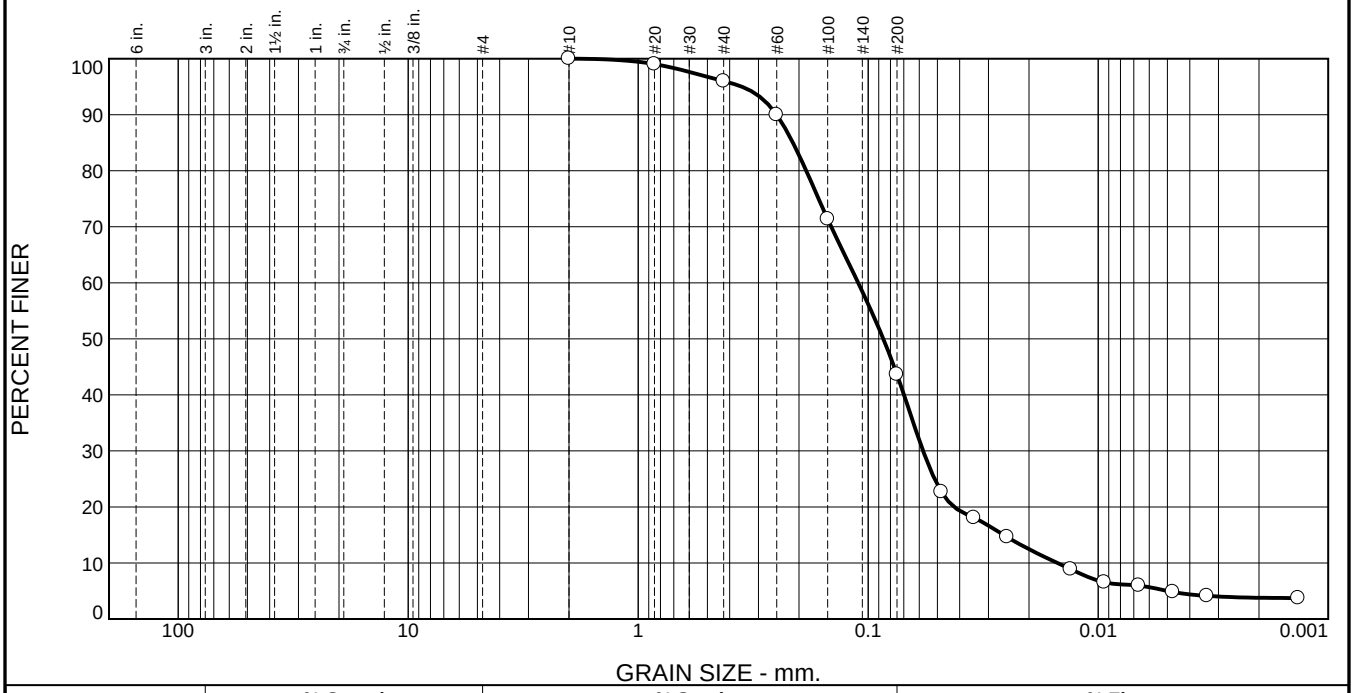
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-561

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	4.0	52.4	39.8	3.8

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.0		
#40	96.0		
#60	90.0		
#100	71.4		
#200	43.6		
0.0481 mm.	22.7		
0.0347 mm.	18.1		
0.0249 mm.	14.6		
0.0132 mm.	8.9		
0.0094 mm.	6.5		
0.0067 mm.	6.0		
0.0047 mm.	4.8		
0.0034 mm.	4.1		
0.0013 mm.	3.7		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.2502 D_{85}= 0.2124 D_{60}= 0.1106
D_{50}= 0.0860 D_{30}= 0.0577 D_{15}= 0.0257
D_{10}= 0.0150 C_u= 7.35 C_c= 2.00

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 95.5-96' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

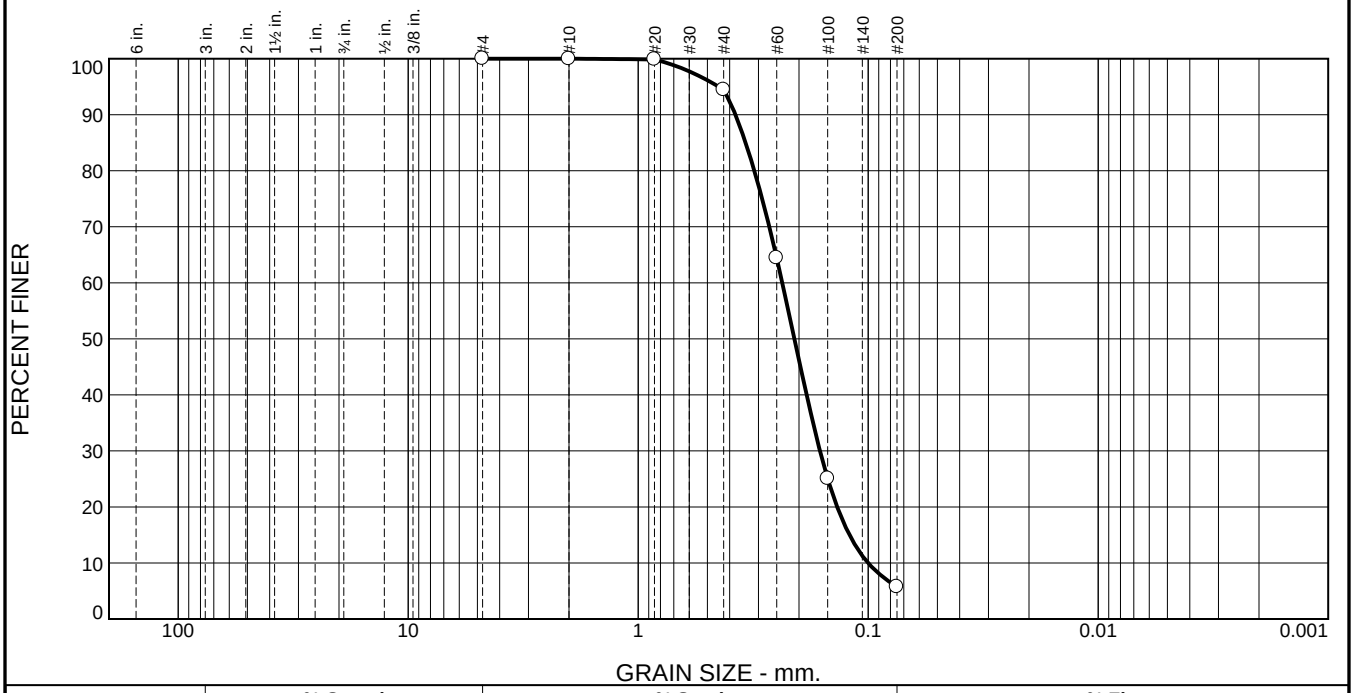
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-562

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	5.5	88.8	5.7	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.9		
#40	94.5		
#60	64.4		
#100	25.0		
#200	5.7		

* (no specification provided)

Material Description

Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3778 D_{85}= 0.3410 D_{60}= 0.2364
D_{50}= 0.2093 D_{30}= 0.1620 D_{15}= 0.1206
D_{10}= 0.1001 C_u= 2.36 C_c= 1.11

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 108-110' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

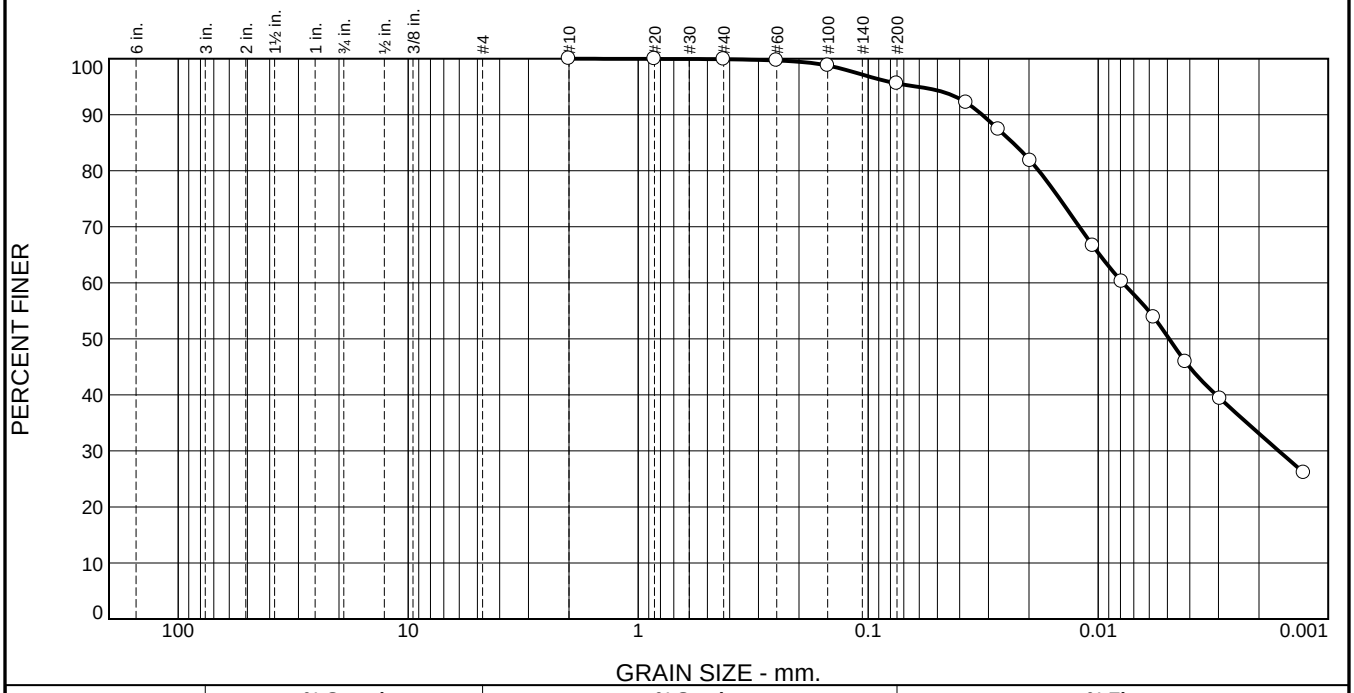
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-563

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	4.3	62.5	33.1

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.7		
#100	98.8		
#200	95.6		
0.0375 mm.	92.2		
0.0272 mm.	87.4		
0.0197 mm.	81.8		
0.0106 mm.	66.6		
0.0079 mm.	60.3		
0.0057 mm.	53.9		
0.0042 mm.	45.9		
0.0030 mm.	39.4		
0.0013 mm.	26.1		

* (no specification provided)

Material Description

Light Brown silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.0320 D_{85}= 0.0235 D_{60}= 0.0078
D_{50}= 0.0049 D_{30}= 0.0016 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 21-24' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

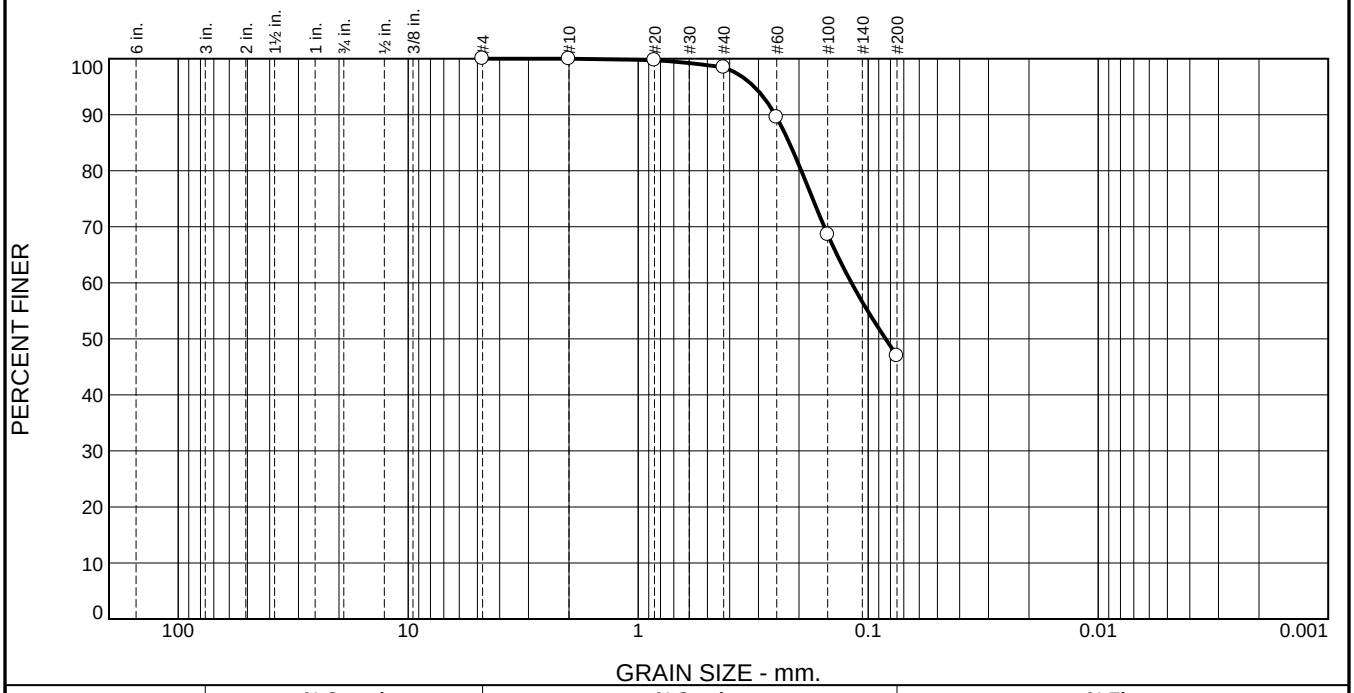
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-564

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.5	51.5	47.0	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.7		
#40	98.5		
#60	89.5		
#100	68.6		
#200	47.0		

* (no specification provided)

Material Description

Light White-Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.2537 D_{85}= 0.2203 D_{60}= 0.1183
D_{50}= 0.0840 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 64-66' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

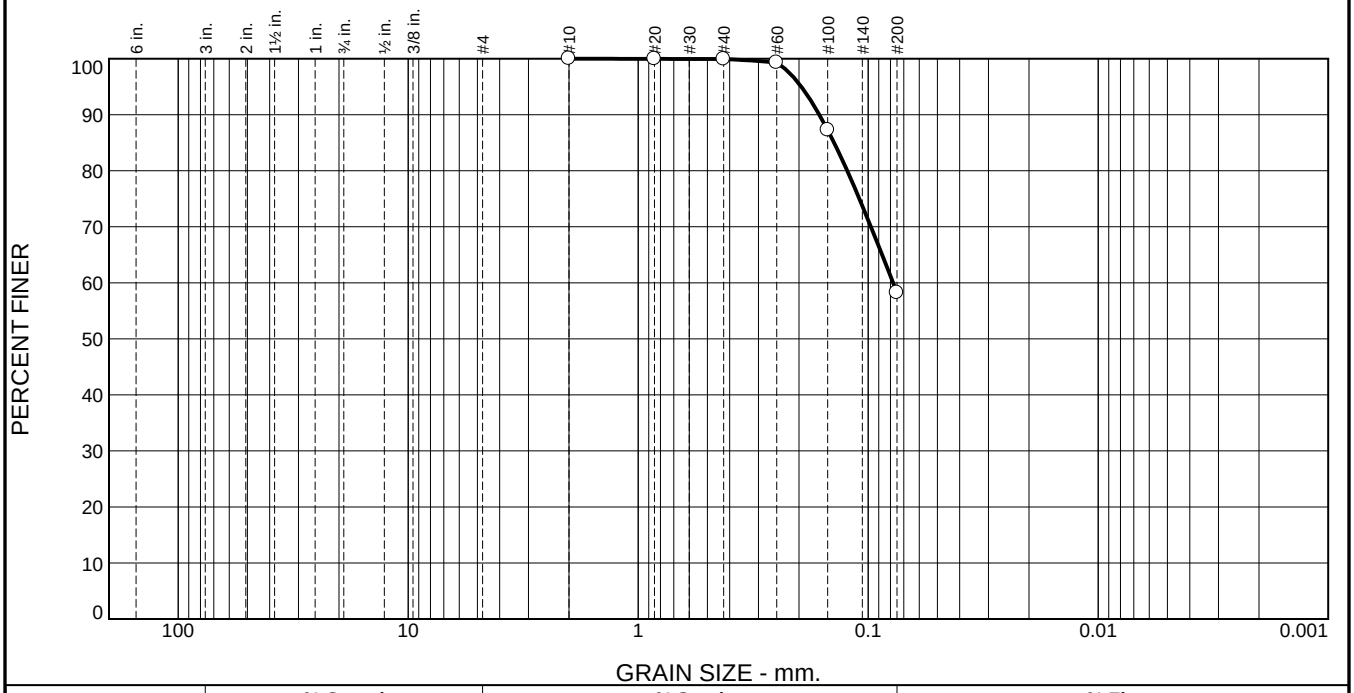
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-565

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	41.7	58.2	

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.3		
#100	87.3		
#200	58.2		

* (no specification provided)

Material Description

Light Brown sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.1630 D_{85}= 0.1407 D_{60}= 0.0779
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 74-76' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

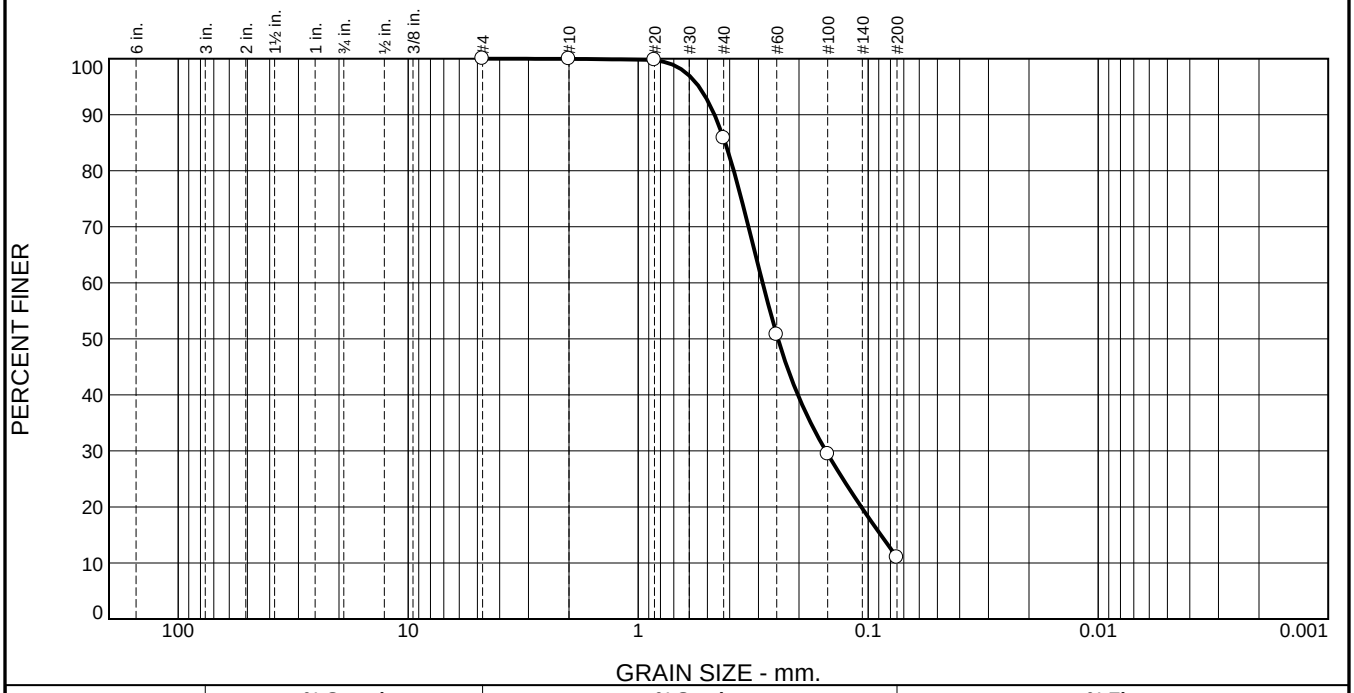
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-566

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	14.2	74.8	11.0	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.8		
#40	85.8		
#60	50.7		
#100	29.5		
#200	11.0		

* (no specification provided)

Material Description

Light Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 0.4656 D_{85}= 0.4184 D_{60}= 0.2878
D_{50}= 0.2469 D_{30}= 0.1527 D_{15}= 0.0881
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 80-82' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

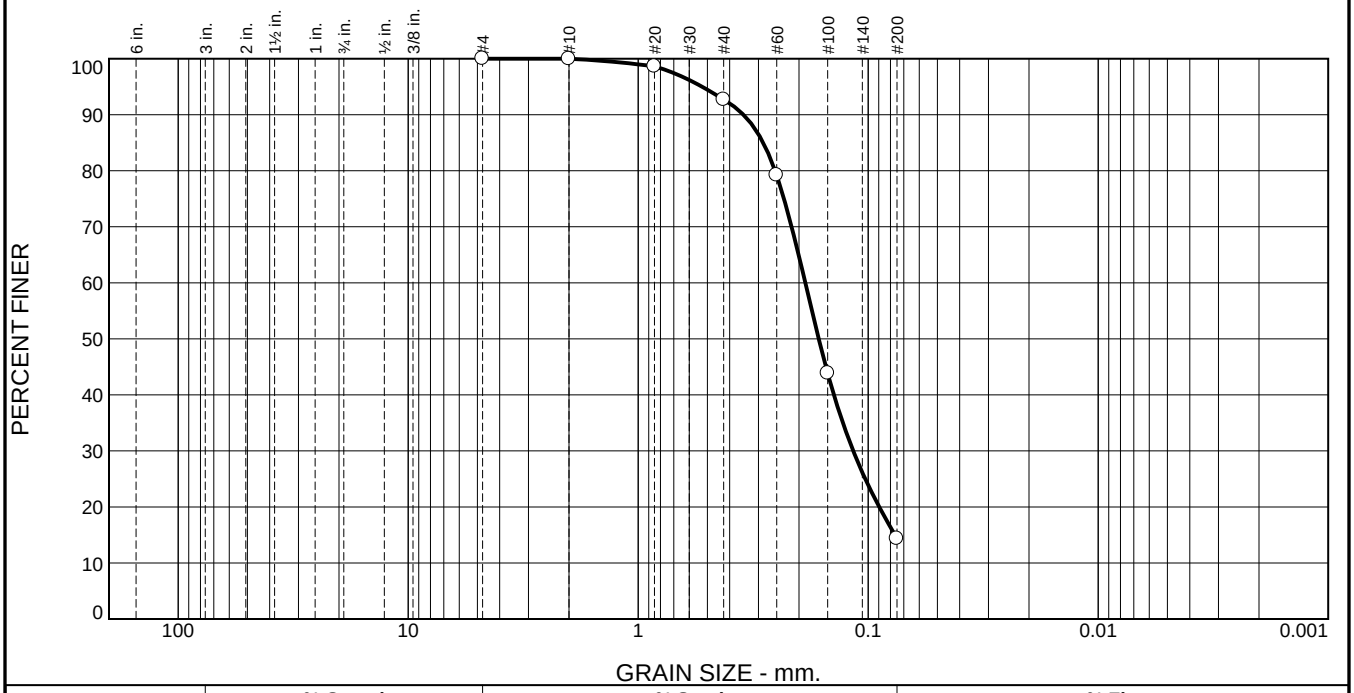
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-567

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	7.3	78.3	14.4	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	98.6		
#40	92.7		
#60	79.2		
#100	43.9		
#200	14.4		

* (no specification provided)

Material Description

Strong Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 0.3484 D_{85}= 0.2860 D_{60}= 0.1876
D_{50}= 0.1640 D_{30}= 0.1162 D_{15}= 0.0766
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 65-69' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

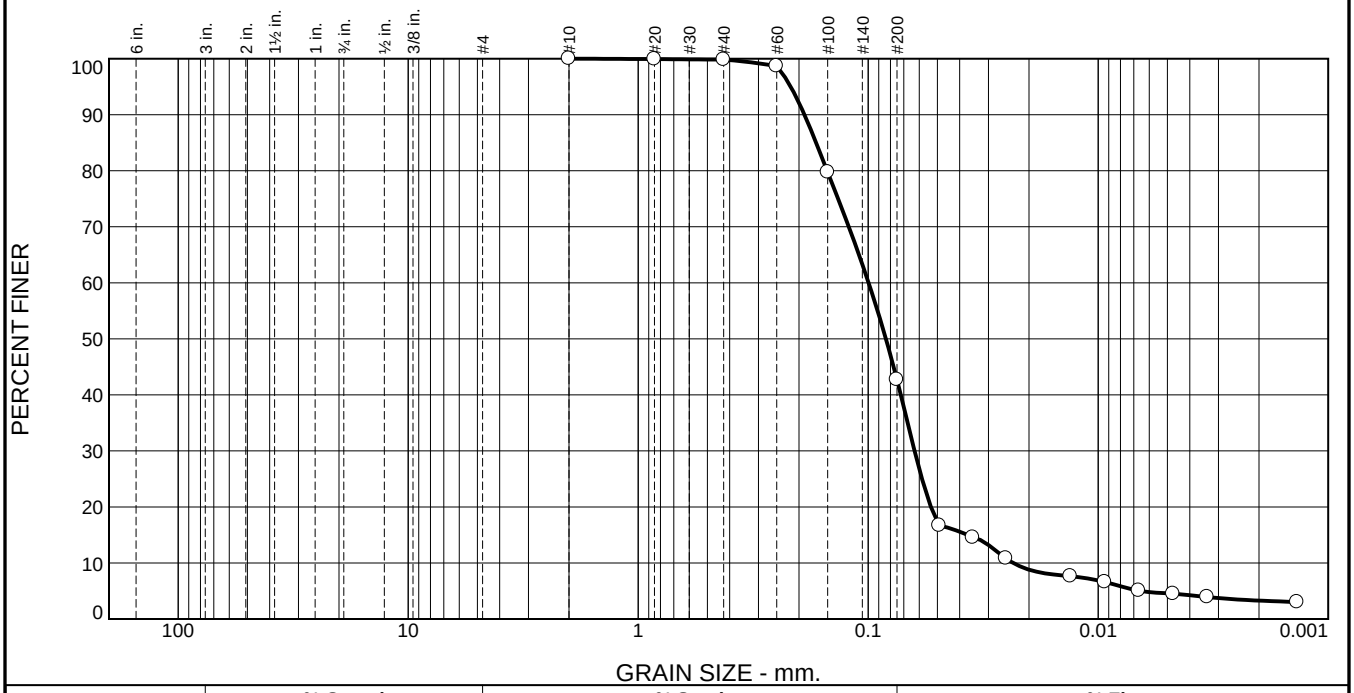
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-568

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	57.1	39.4	3.3

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.9		
#40	99.8		
#60	98.7		
#100	79.7		
#200	42.7		
0.0491 mm.	16.7		
0.0351 mm.	14.6		
0.0252 mm.	10.8		
0.0132 mm.	7.6		
0.0094 mm.	6.6		
0.0067 mm.	5.1		
0.0047 mm.	4.5		
0.0034 mm.	3.9		
0.0014 mm.	3.0		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.1894 D_{85}= 0.1685 D_{60}= 0.0996
D_{50}= 0.0837 D_{30}= 0.0628 D_{15}= 0.0370
D_{10}= 0.0234 C_u= 4.25 C_c= 1.69

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 73-77' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

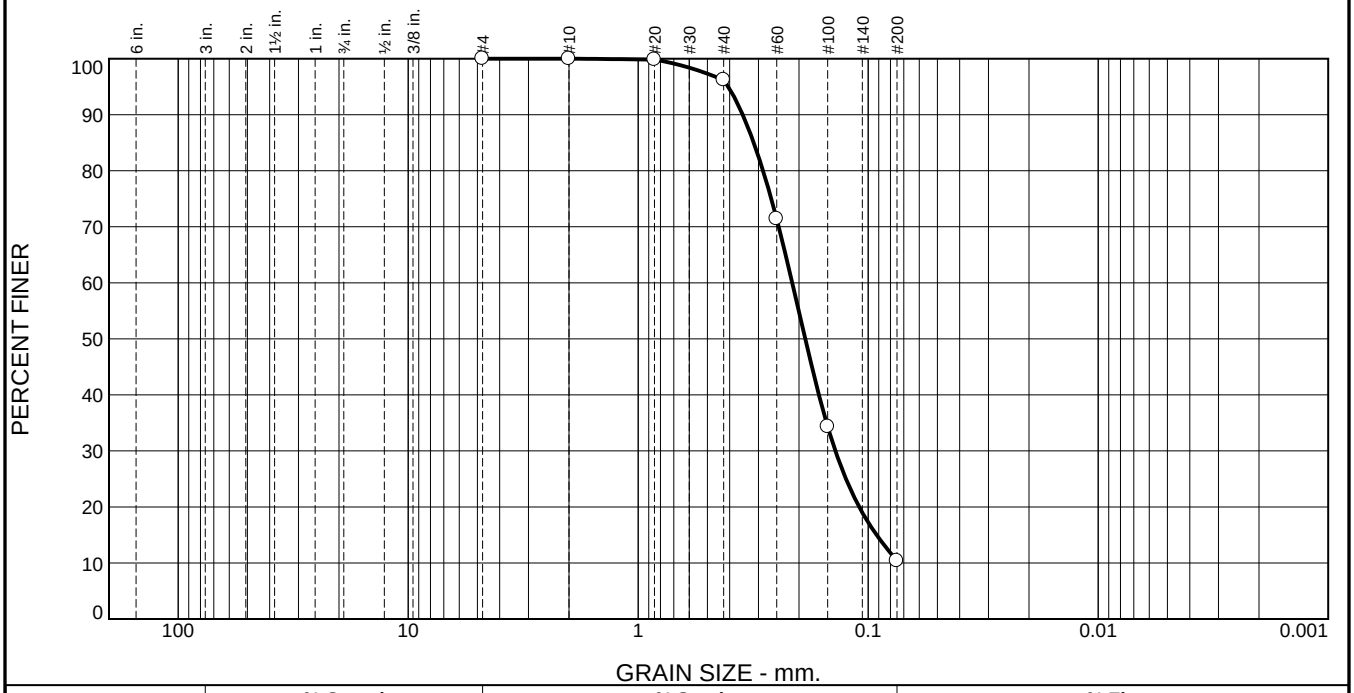
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-569

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.8	85.8	10.4	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.8		
#40	96.2		
#60	71.4		
#100	34.3		
#200	10.4		

* (no specification provided)

Material Description

Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3511 D_{85}= 0.3144 D_{60}= 0.2139
D_{50}= 0.1878 D_{30}= 0.1389 D_{15}= 0.0919
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 87-95' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

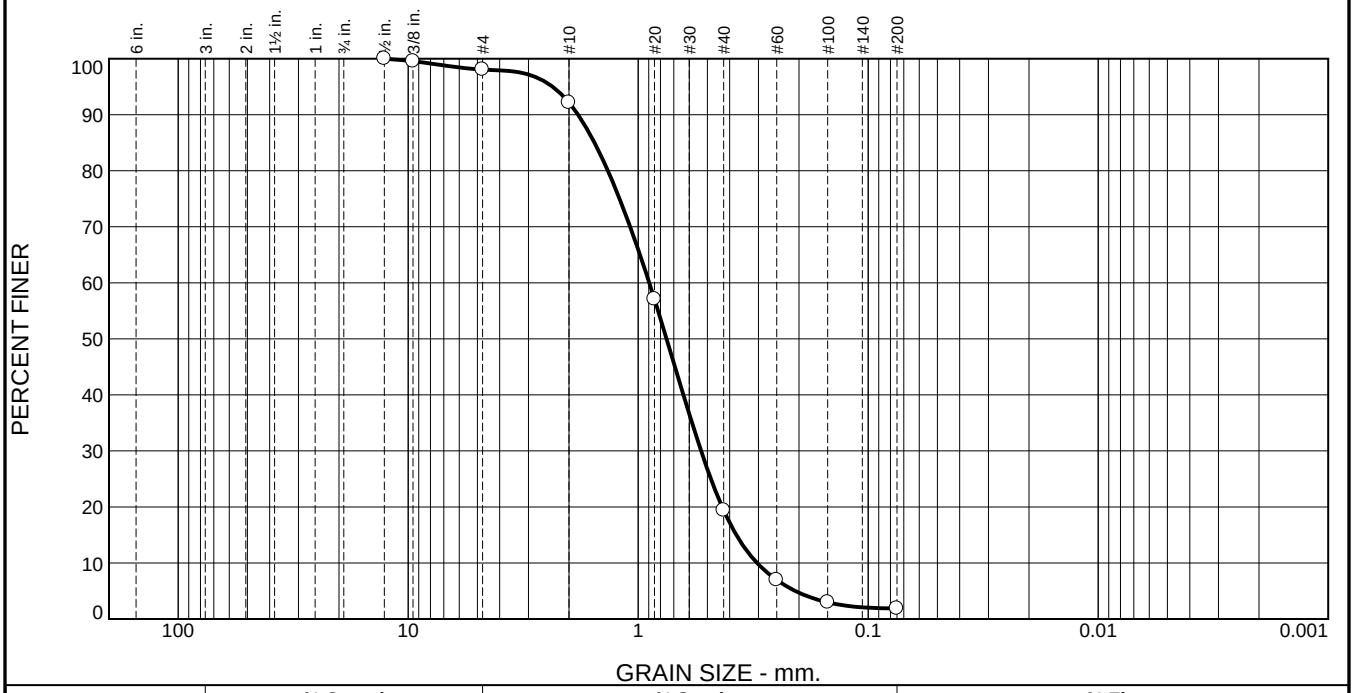
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-570

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	5.8	72.8	17.5	1.9	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.5	100.0		
0.375	99.5		
#4	98.0		
#10	92.2		
#20	57.1		
#40	19.4		
#60	7.0		
#100	3.0		
#200	1.9		

* (no specification provided)

Material Description

Red-Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.8256 D_{85}= 1.5482 D_{60}= 0.8950
D_{50}= 0.7526 D_{30}= 0.5327 D_{15}= 0.3744
D_{10}= 0.3043 C_u= 2.94 C_c= 1.04

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15-15' **Date Sampled:**

Sample Number: CLS-TP-3

Thielsch Engineering Inc.

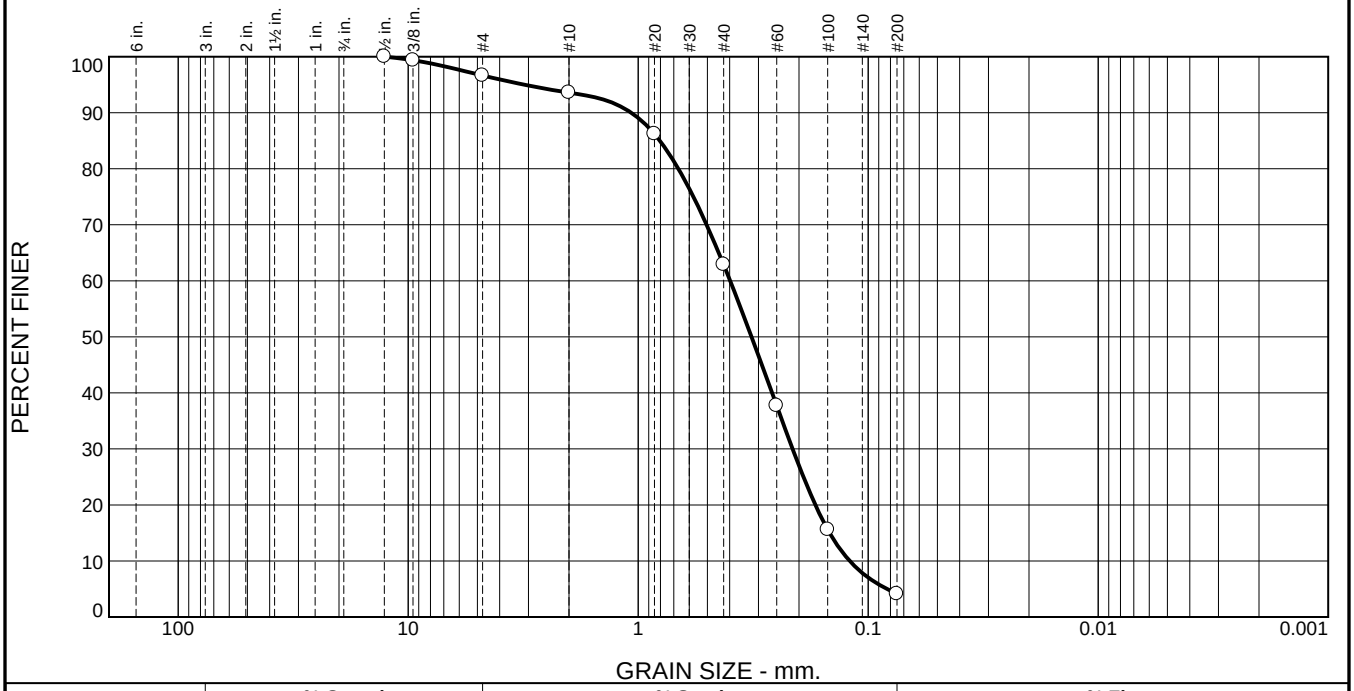
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-571

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.3	3.1	30.7	58.8	4.1	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.5	100.0		
0.375	99.4		
#4	96.7		
#10	93.6		
#20	86.2		
#40	62.9		
#60	37.7		
#100	15.6		
#200	4.1		

* (no specification provided)

Material Description

Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 1.0713 D_{85}= 0.8044 D_{60}= 0.3983
D_{50}= 0.3214 D_{30}= 0.2132 D_{15}= 0.1472
D_{10}= 0.1203 C_u= 3.31 C_c= 0.95

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: CLS-TP-7

Thielsch Engineering Inc.

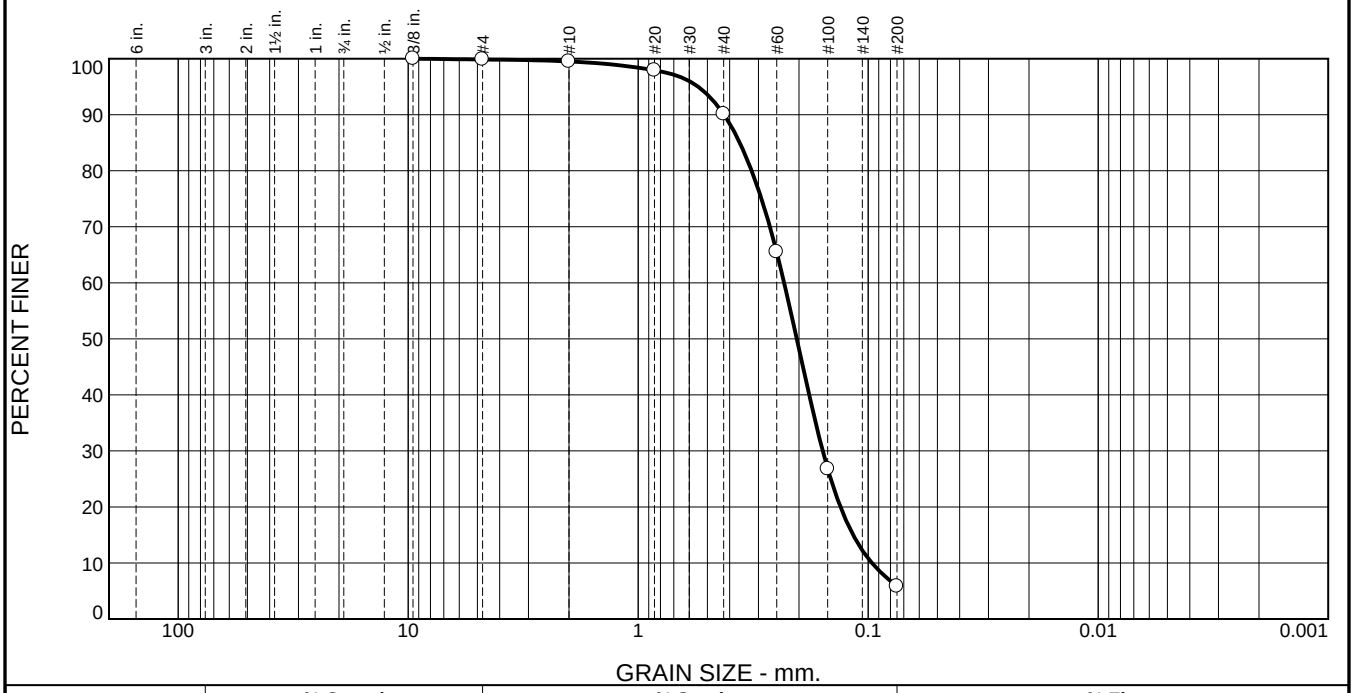
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-572

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.4	9.4	84.3	5.8	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.375	100.0		
#4	99.9		
#10	99.5		
#20	97.9		
#40	90.1		
#60	65.5		
#100	26.8		
#200	5.8		

* (no specification provided)

Material Description

Red-Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.4233 D_{85}= 0.3617 D_{60}= 0.2319
D_{50}= 0.2044 D_{30}= 0.1576 D_{15}= 0.1163
D_{10}= 0.0963 C_u= 2.41 C_c= 1.11

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: TTS-1-TP

Thielsch Engineering Inc.

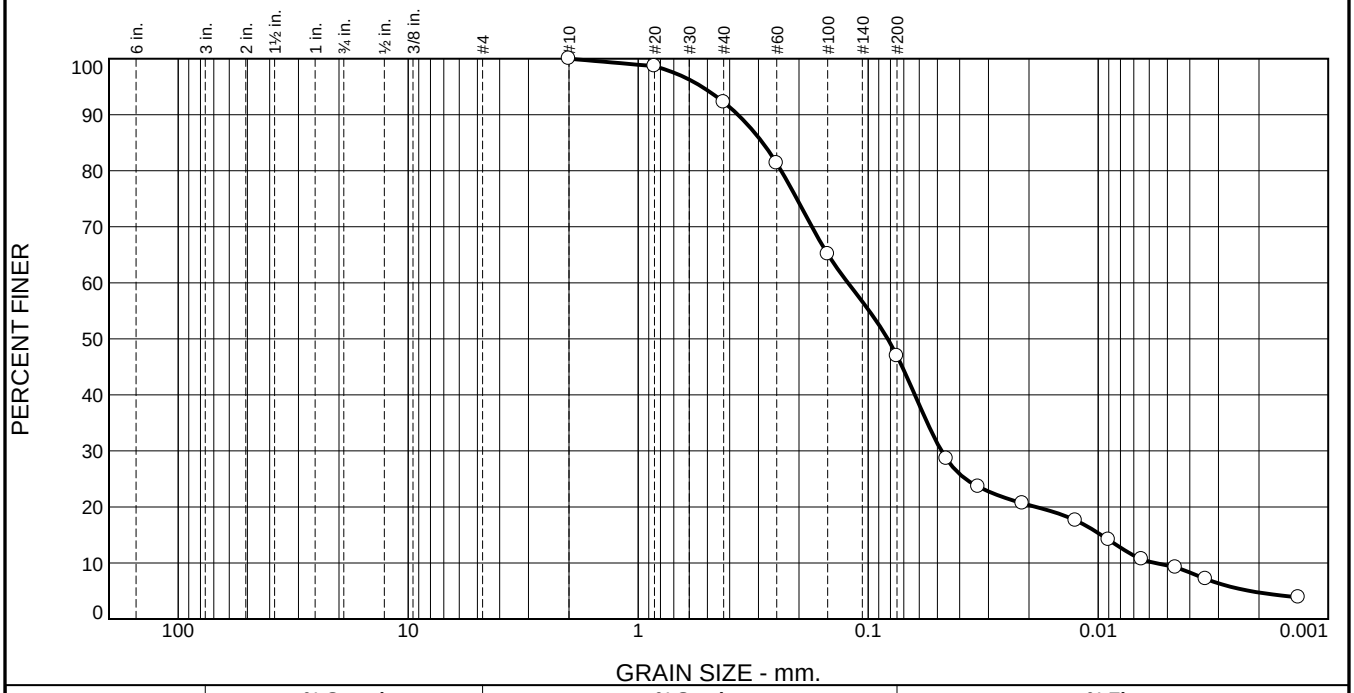
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-573

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	7.8	45.2	42.3	4.7

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	98.7		
#40	92.2		
#60	81.3		
#100	65.1		
#200	47.0		
0.0457 mm.	28.6		
0.0332 mm.	23.6		
0.0214 mm.	20.7		
0.0126 mm.	17.6		
0.0090 mm.	14.2		
0.0065 mm.	10.7		
0.0046 mm.	9.2		
0.0034 mm.	7.2		
0.0013 mm.	3.9		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.3684 D_{85}= 0.2876 D_{60}= 0.1225
D_{50}= 0.0823 D_{30}= 0.0480 D_{15}= 0.0097
D_{10}= 0.0056 C_u= 21.70 C_c= 3.33

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 45.46.5' **Date Sampled:**

Sample Number: TTS-1

Thielsch Engineering Inc.

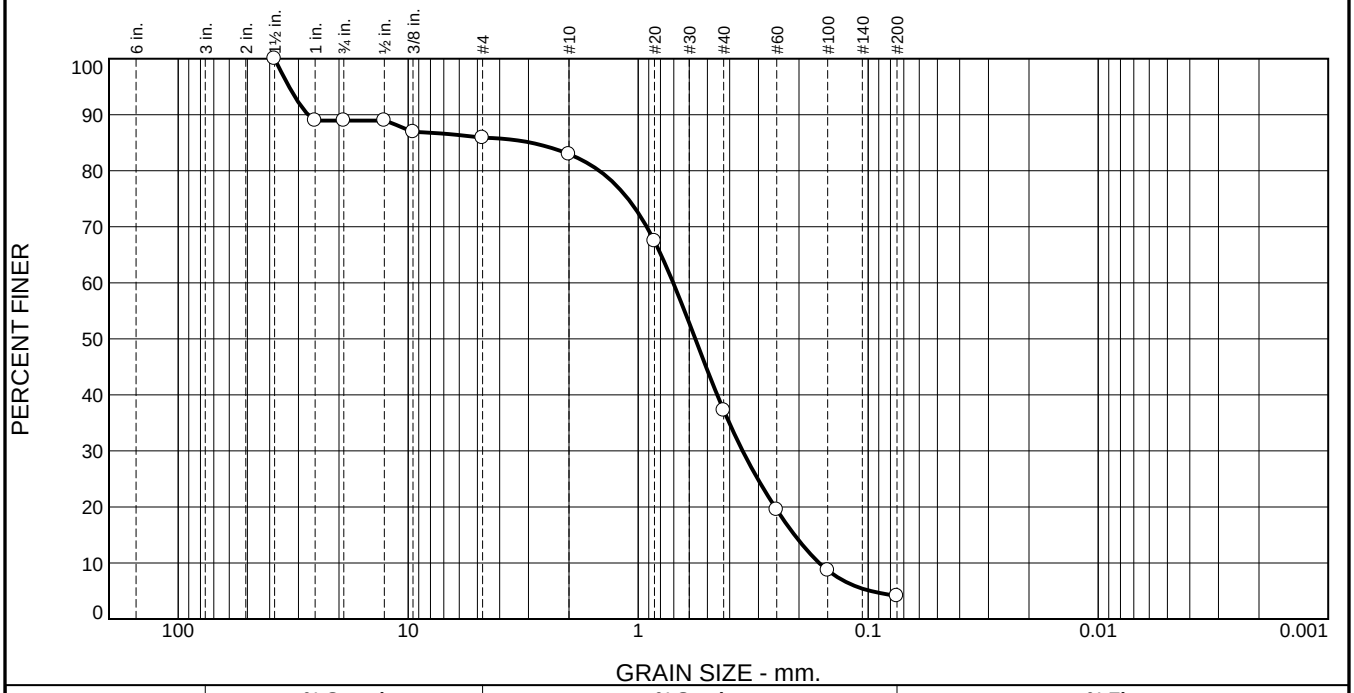
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-574

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	11.0	3.1	2.9	45.7	33.2	4.1	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	89.0		
.75	89.0		
0.5	89.0		
.375	86.9		
#4	85.9		
#10	83.0		
#20	67.5		
#40	37.3		
#60	19.5		
#100	8.7		
#200	4.1		

* (no specification provided)

Material Description

Light Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 27.2477 D_{85}= 2.9193 D_{60}= 0.7039
D_{50}= 0.5646 D_{30}= 0.3514 D_{15}= 0.2091
D_{10}= 0.1632 C_u= 4.31 C_c= 1.07

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: TTS-2-TP

Thielsch Engineering Inc.

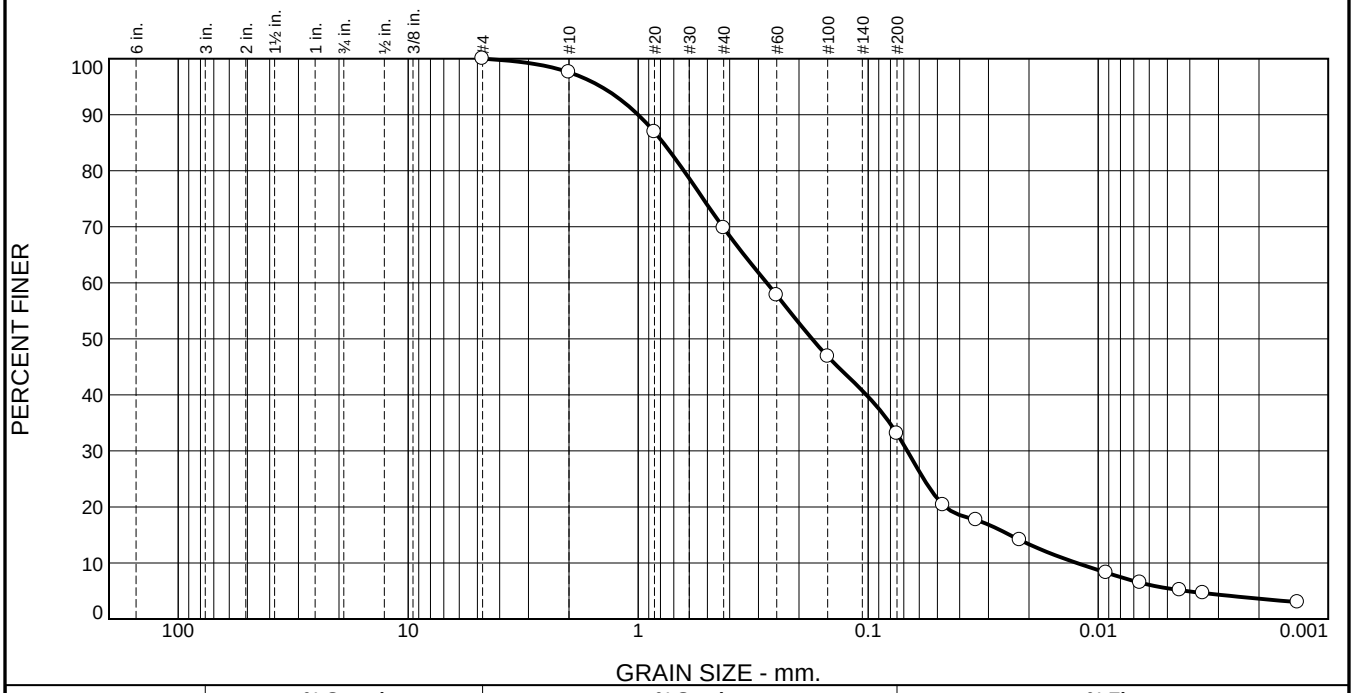
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-575

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	2.4	27.8	36.7	29.5	3.6

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	97.6		
#20	86.9		
#40	69.8		
#60	57.8		
#100	46.9		
#200	33.1		
0.0473 mm.	20.4		
0.0339 mm.	17.7		
0.0219 mm.	14.1		
0.0092 mm.	8.3		
0.0066 mm.	6.5		
0.0044 mm.	5.2		
0.0035 mm.	4.6		
0.0014 mm.	3.0		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 1.0006 D_{85}= 0.7782 D_{60}= 0.2763
D_{50}= 0.1754 D_{30}= 0.0676 D_{15}= 0.0242
D_{10}= 0.0124 C_u= 22.32 C_c= 1.33

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 21-21.5' **Date Sampled:**

Sample Number: TTS-2

Thielsch Engineering Inc.

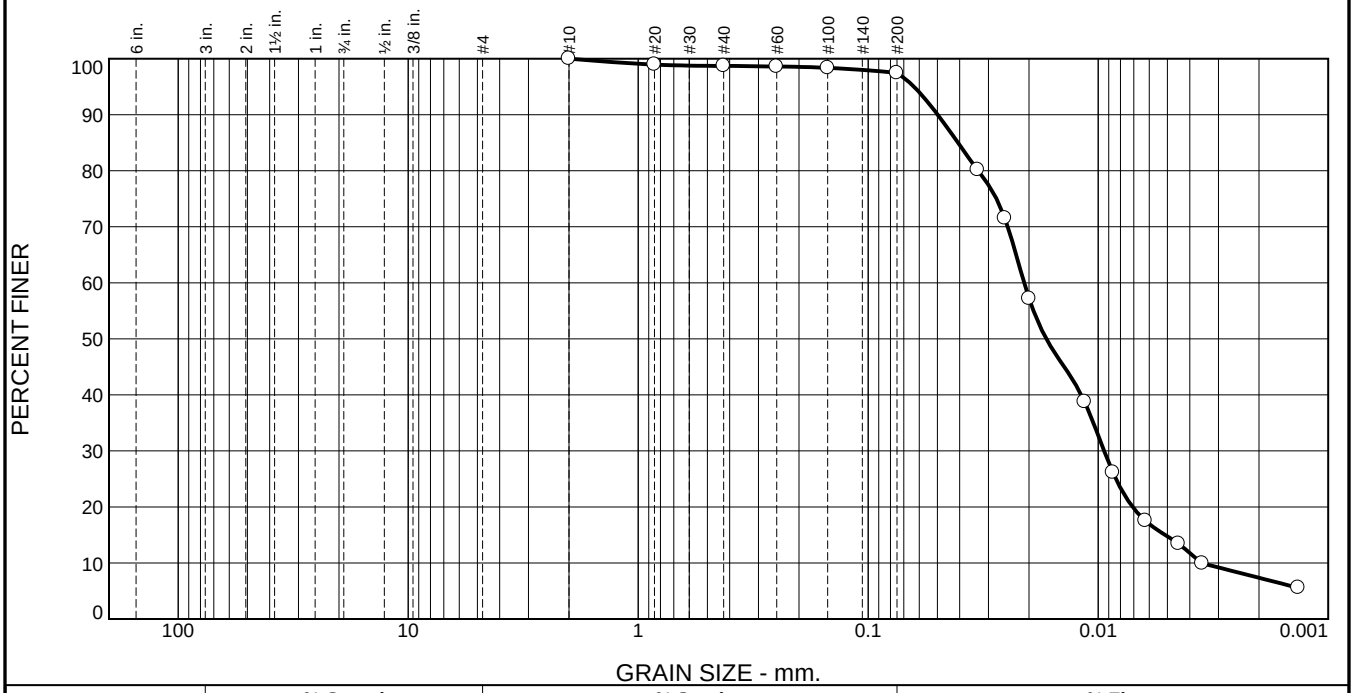
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-576

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.3	1.2	90.1	7.4

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.0		
#40	98.7		
#60	98.6		
#100	98.4		
#200	97.5		
0.0335 mm.	80.2		
0.0255 mm.	71.5		
0.0200 mm.	57.2		
0.0115 mm.	38.8		
0.0086 mm.	26.1		
0.0062 mm.	17.5		
0.0045 mm.	13.4		
0.0035 mm.	9.9		
0.0014 mm.	5.6		

* (no specification provided)

Material Description

Brown silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.0499 D_{85}= 0.0407 D_{60}= 0.0210
D_{50}= 0.0168 D_{30}= 0.0094 D_{15}= 0.0051
D_{10}= 0.0035 C_u= 5.91 C_c= 1.19

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15-16.5' **Date Sampled:**

Sample Number: TTS-3

Thielsch Engineering Inc.

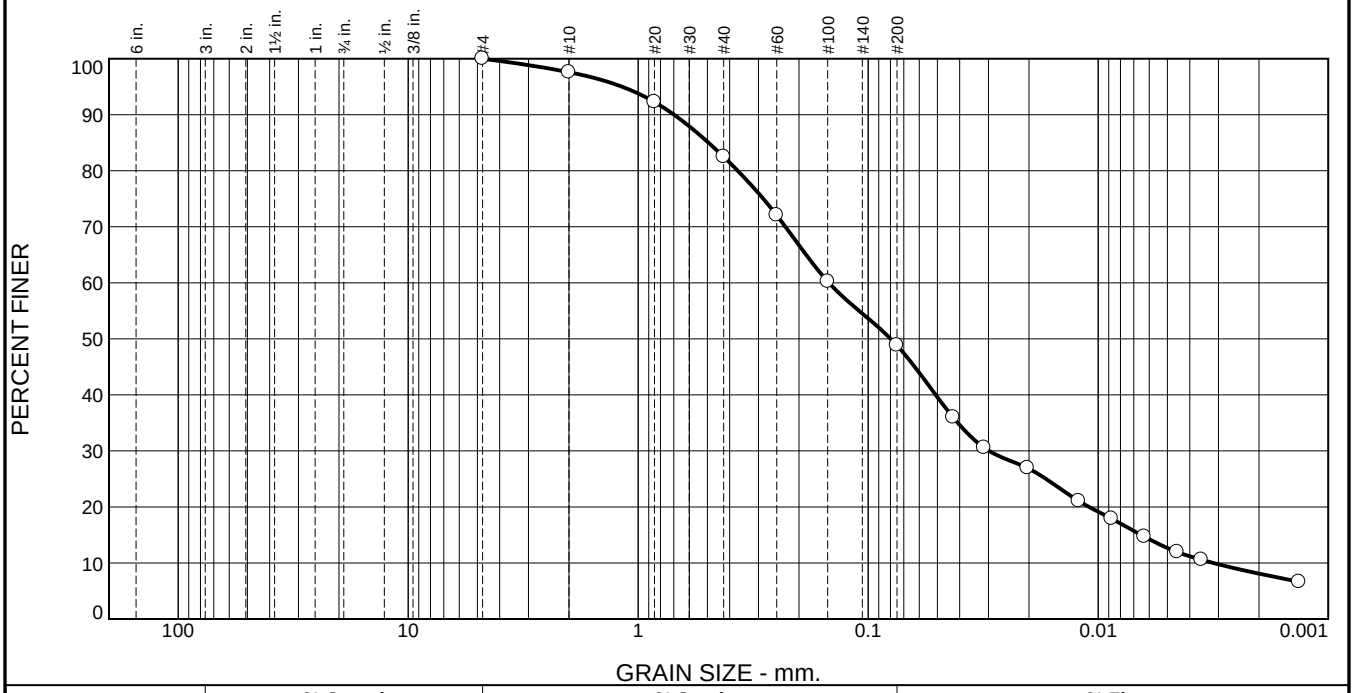
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-577

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	2.4	15.1	33.7	40.7	8.1

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	97.6		
#20	92.3		
#40	82.5		
#60	72.1		
#100	60.2		
#200	48.8		
0.0427 mm.	36.0		
0.0314 mm.	30.6		
0.0203 mm.	27.0		
0.0122 mm.	21.1		
0.0088 mm.	17.9		
0.0063 mm.	14.7		
0.0045 mm.	12.0		
0.0036 mm.	10.6		
0.0013 mm.	6.7		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.6980 D_{85}= 0.4944 D_{60}= 0.1482
D_{50}= 0.0798 D_{30}= 0.0298 D_{15}= 0.0065
D_{10}= 0.0032 C_u= 46.95 C_c= 1.90

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15.5-16.5' **Date Sampled:**

Sample Number: TTS-4

Thielsch Engineering Inc.

Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-578

1704794 4/28/17

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

1704795

Project Name **Orleans - GWDP** Client **Town of Orleans** Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** Site Location **Overland Way** Collected By **Mark Owen**

ESS Project No. _____ Date Assigned _____ Received By _____

Project Manager **T. Parece** Date Received _____ Date Required **Norman**

	Sample Information					Lab No.	Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID		Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
1	CLS - 1	70-72								X												
2	CLS - 1	86-88								X												
3	CLS - 1	95.5-96								X	X											
4	CLS - 1	108-110								X												
5	CLS - 2	21-24								X	X											
6	CLS - 2	64-66								X												
7	CLS - 2	74-76								X	X											
8	CLS - 2	80-82								X												
9	CLS-3	65-69								X												
10	CLS-3	73-77								X	X											
11	CLS-3	87-95								X												
12	CLS TP-3	15-Gst 15	MH							X												
13	CLS-TP-7	10-15	MH							X												

Notes: MH 2 4-28-17 @ 12:55 TCP 4/28/17 12:55 NOICE 22.1

TCP 2 4/28/17 @ 11:20 4/28/17 1659

1704795

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

Project Name **Orleans - GWDP** Client **Town of Orleans** Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** Site Location **Overland Way** Collected By **Mark Owen**

ESS Project No. _____ Date Assigned _____ Received By _____

Project Manager **T. Parece** Date Received _____ Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	#
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
14	TTS - 1	TP	10 - 15							X												
15	TTS - 1		45-46.5							X	X											
16	TTS-2	TP	10 - 15							X												
17	TTS-2		21-21.5							X	X											
18	TTS-3		15-16.5							X	X											
19	TTS-4		15.5-16.5							X	X											

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No 22.1

4/25/17 @ 1420 4/28/17 1659

1704794 4/28/17

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING

401-467-6454

195 Frances Ave., Cranston, RI 02910

1704795

Project Name **Orleans - GWDP** | Client **Town of Orleans** | Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** | Site Location **Overland Way** | Collected By **Mark Owen**

ESS Project No. | Date Assigned | Received By

Project Manager **T. Parece** | Date Received | Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	#
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
1	CLS - 1	70-72								X												
2	CLS - 1	86-88								X												
3	CLS - 1	95.5-96								X	X											
4	CLS - 1	108-110								X												
5	CLS - 2	21-24								X	X											
6	CLS - 2	64-66								X												
7	CLS - 2	74-76								X	X											
8	CLS - 2	80-82								X												
9	CLS-3	65-69								X												
10	CLS-3	73-77								X	X											
11	CLS-3	87-95								X												
12	CLS TP-3	15-~~Oct~~ 15	MA							X												
13	CLS-TP-7	10-15	MA							X												

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No ICE 22.1

4/25/17 @ 1420 4/28/17 1659

1704795

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

Project Name **Orleans - GWDP** | Client **Town of Orleans** | Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** | Site Location **Overland Way** | Collected By **Mark Owen**

ESS Project No. | Date Assigned | Received By

Project Manager **T. Parece** | Date Received | Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	Notes
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
14	TTS - 1	TP	10 - 15							X												
15	TTS - 1		45-46.5							X	X											
16	TTS-2	TP	10 - 15							X												
17	TTS-2		21-21.5							X	X											
18	TTS-3		15-16.5							X	X											
19	TTS-4		15.5-16.5							X	X											

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No 22.1 ICS

4/25/17 @ 1420 4/28/17 1659

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Appendix E

Grain Size Analysis Reports

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Hydraulic Conductivity Approximation
Orleans, MA

Summary of Equations:

Vukovic and Soro n=0.255*(1+0.83^u) U=(d60/d10)

$$n = 0.255\left(1 + 0.83^{U}\right)$$

Sheperds

$$K_{sat} = b * (d_{50})^{c}$$ b and c are read from Sheperds Chart

Hazen Ksat=c(d10)^2; c=1.0 to 1.5; d10 (mm)

$$K = \frac{g}{v} \times 6 \times 10^{-4}\left[1 + 10(n - 0.26)\right] d_{10}^{2}$$

Kozeny-Carman Ksat=g/viscosity*8.3*0.0018[n^3/(1-n)^2]*d10^2

$$K = \frac{g}{v} \times 8.3 \times 10^{-3}\left[\frac{n^{3}}{(1-n)^{2}}\right] d_{10}^{2}$$

Slitcher Ksat=g/viscosity*1*0.01*n^3.287*d10^2

$$K = \frac{g}{v} \times 1 \times 10^{-2}\, n^{3.287}\, d_{10}^{2}$$

g	9.81	m/s^2
viscosity	1.004E-06	m^2/s

Summary of Results

Most widely accepted, fine sand with d10 between 0.1 to 3mm

Wide range of application (see Sheperds Equation chart)

Uniformly graded sand and fine sand with d10 between 0.1 to 3mm, and U<5

Applicable for grain-size between 0.01mm and 5mm

Table 2
Summary of Aquifer Charactistics - Grain-size Analysis

Soil sample	*Depth (ft)*	*D10 (mm)*	*D50 (mm)*	*D60 (mm)*	*U(d60/d10)*	*n (porosity)*	*Classification*	*Fines(%)*	Kozeny-Carman Ksat (ft/day)	Sheperds Ksat (ft/day)	Hazen Ksat (ft/day)	Slitcher Ksat (ft/day)	Sample Average (FT/day)
CLS-1 70-72	70-72	0.1351	0.267	0.3084	2.28	0.42	Poorly graded SAND	0.02	94.10	52.83	79.37	29.59	**63.97**
CLS-1 86-88	86-88	0.1267	0.2076	0.2291	1.81	0.44	Poorly graded SAND	0.03	97.14	34.88	73.88	29.25	**58.79**
CLS-1 95.5-96	95.5-96	0.015	0.086	0.1106	7.35	0.32	Silty SAND	0.44		8.15		0.15	**4.15**
CLS-1 108-110	108-110	0.1001	0.2093	0.2364	2.36	0.42	Poorly graded SAND with Silt	0.06	50.33	35.35	43.16	15.93	**36.19**
CLS-2 21-24	21-24		0.0049	0.0078		0.51	SILT	0.96		0.07			**0.07**
CLS-2 64-66	64-66		0.084	0.1183		0.51	Silty SAND	0.47		7.84			**7.84**
CLS-2 74-76	74-76			0.0779		0.51	Sandy SILT	0.58					**1.79**
CLS-2 80-82	80-82		0.2469	0.2878		0.51	Poorly graded SAND with Silt	0.11		46.43			**46.43**
CLS-3 65-69	65-69		0.164	0.1876		0.51	Silty SAND	0.14		23.64			**23.64**
CLS-3 73-77	73-77	0.0234	0.0837	0.0996	4.25	0.37	Silty SAND	0.43		7.79	1.92	0.58	**3.43**
CLS-3 87-95	87-95		0.1878	0.2139		0.51	Poorly graded SAND with Silt	0.10		29.56	0.00	0.00	**9.85**
CLS TP-3 15-15	15-15	0.3043	0.7526	0.895	2.94	0.40	Poorly graded SAND	0.02	388.48	292.05	372.98	128.71	**295.55**
CLS TP-7 10-15	10-15.0	0.1203	0.3214	0.3983	3.31	0.39	Poorly graded SAND	0.04	54.57	71.74	55.93		**60.75**

Grain size outside the equation applicability range
Insufficient grain size data
Based on average K value for Silt

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Appendix F

Laboratory Reports – Groundwater Quality

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CERTIFICATE OF ANALYSIS

Mark Owen
AECOM Environment - ENSR
9 Jonathon Bourne Dr.
Pocasset, MA 02559

RE: Orleans MA (60476644 T10.1B)
ESS Laboratory Work Order Number: 1704795

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this page, the entire report has been paginated. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

REVIEWED
By ESS Laboratory at 12:03 pm, May 09, 2017

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration is frequently used instead of automated integration because it produces more accurate results.

The test results present in this report are in compliance with TNI and relative state standards, and/or client Quality Assurance Project Plans (QAPP). The laboratory has reviewed the following: Sample Preservations, Hold Times, Initial Calibrations, Continuing Calibrations, Method Blanks, Blank Spikes, Blank Spike Duplicates, Duplicates, Matrix Spikes, Matrix Spike Duplicates, Surrogates and Internal Standards. Any results which were found to be outside of the recommended ranges stated in our SOPs will be noted in the Project Narrative.

Subcontracted Analyses

CTS - Cranston, RI	Grain Size Analysis, Hydrometer Analyses

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

SAMPLE RECEIPT

The following samples were received on April 28, 2017 for the analyses specified on the enclosed Chain of Custody Record.

The samples and analyses listed below were analyzed in accordance with the Guidelines Establishing Test Procedures for the Analysis of Pollutants, 40 CFR Part 136, as amended.

Lab Number	Sample Name	Matrix	Analysis
1704795-01	CLS-1 70-72	Soil	§
1704795-02	CLS-1 86-88	Soil	§
1704795-03	CLS-1 95.5-96	Soil	§
1704795-04	CLS-1 108-110	Soil	§
1704795-05	CLS-2 21-24	Soil	§
1704795-06	CLS-2 64.66	Soil	§
1704795-07	CLS-2 74-76	Soil	§
1704795-08	CLS-2 80-82	Soil	§
1704795-09	CLS-3 65-69	Soil	§
1704795-10	CLS-3 73-77	Soil	§
1704795-11	CLS-3 87-95	Soil	§
1704795-12	CLS TP-3 15-15	Soil	§
1704795-13	CLS TP-7 10-15	Soil	§
1704795-14	TTS-1-TP 10-15	Soil	§
1704795-15	TTS-1 45-46.5	Soil	§
1704795-16	TTS-2-TP 10-15	Soil	§
1704795-17	TTS-2 21-21.5	Soil	§
1704795-18	TTS-3 15-16.5	Soil	§
1704795-19	TTS-4 15.5-16.5	Soil	§

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

DATA USABILITY LINKS

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Definitions of Quality Control Parameters

Semivolatile Organics Internal Standard Information

Semivolatile Organics Surrogate Information

Volatile Organics Internal Standard Information

Volatile Organics Surrogate Information

EPH and VPH Alkane Lists

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

CURRENT SW-846 METHODOLOGY VERSIONS

Analytical Methods

1010A - Flashpoint
6010C - ICP
6020A - ICP MS
7010 - Graphite Furnace
7196A - Hexavalent Chromium
7470A - Aqueous Mercury
7471B - Solid Mercury
8011 - EDB/DBCP/TCP
8015C - GRO/DRO
8081B - Pesticides
8082A - PCB
8100M - TPH
8151A - Herbicides
8260B - VOA
8270D - SVOA
8270D SIM - SVOA Low Level
9014 - Cyanide
9038 - Sulfate
9040C - Aqueous pH
9045D - Solid pH (Corrosivity)
9050A - Specific Conductance
9056A - Anions (IC)
9060A - TOC
9095B - Paint Filter
MADEP 04-1.1 - EPH / VPH

Prep Methods

3005A - Aqueous ICP Digestion
3020A - Aqueous Graphite Furnace / ICP MS Digestion
3050B - Solid ICP / Graphite Furnace / ICP MS Digestion
3060A - Solid Hexavalent Chromium Digestion
3510C - Separatory Funnel Extraction
3520C - Liquid / Liquid Extraction
3540C - Manual Soxhlet Extraction
3541 - Automated Soxhlet Extraction
3546 - Microwave Extraction
3580A - Waste Dilution
5030B - Aqueous Purge and Trap
5030C - Aqueous Purge and Trap
5035 - Solid Purge and Trap

SW846 Reactivity Methods 7.3.3.2 (Reactive Cyanide) and 7.3.4.1 (Reactive Sulfide) have been withdrawn by EPA. These methods are reported per client request and are not NELAP accredited.

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-1 70-72
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-01
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-1 86-88
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-02
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-1 95.5-96
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-03
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: CLS-1 108-110
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-04
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-2 21-24
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-05
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-2 64.66
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-06
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-2 74-76
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-07
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: CLS-2 80-82
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-08
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-3 65-69
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-09
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS-3 73-77
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-10
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: CLS-3 87-95
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-11
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS TP-3 15-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-12
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: CLS TP-7 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-13
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-1-TP 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-14
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-1 45-46.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-15
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Classical Chemistry

Client Sample ID: TTS-2-TP 10-15
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-16
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						

Client Sample ID: TTS-2 21-21.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-17
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: TTS-3 15-16.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-18
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

Client Sample ID: TTS-4 15.5-16.5
Date Sampled: 04/28/17 00:00

ESS Laboratory Sample ID: 1704795-19
Sample Matrix: Soil

All methods used are in accordance with 40 CFR 136.

Analyte	Results	Units	MRL	Method	DF	Analyst	Analyzed
Grain Size	**See Attached**						
Hydrometer	**See Attached**						

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

Notes and Definitions

Z-08	See Attached
ND	Analyte NOT DETECTED at or above the MRL (LOQ), LOD for DoD Reports, MDL for J-Flagged Analytes
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
LOD	Limit of Detection
LOQ	Limit of Quantitation
DL	Detection Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.
NR	No Recovery
[CALC]	Calculated Analyte
SUB	Subcontracted analysis; see attached report
RL	Reporting Limit
EDL	Estimated Detection Limit

CERTIFICATE OF ANALYSIS

Client Name: AECOM Environment - ENSR
Client Project ID: Orleans MA

ESS Laboratory Work Order: 1704795

ESS LABORATORY CERTIFICATIONS AND ACCREDITATIONS

ENVIRONMENTAL

Rhode Island Potable and Non Potable Water: LAI00179
http://www.health.ri.gov/find/labs/analytical/ESS.pdf

Connecticut Potable and Non Potable Water, Solid and Hazardous Waste: PH-0750
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/OutofStateCommercialLaboratories.pdf

Maine Potable and Non Potable Water, and Solid and Hazardous Waste: RI00002
http://www.maine.gov/dhhs/mecdc/environmental-health/dwp/partners/labCert.shtml

Massachusetts Potable and Non Potable Water: M-RI002
http://public.dep.state.ma.us/Labcert/Labcert.aspx

New Hampshire (NELAP accredited) Potable and Non Potable Water, Solid and Hazardous Waste: 2424
http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm

New York (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: 11313
http://www.wadsworth.org/labcert/elap/comm.html

New Jersey (NELAP accredited) Non Potable Water, Solid and Hazardous Waste: RI006
http://datamine2.state.nj.us/DEP_OPRA/OpraMain/pi_main?mode=pi_by_site&sort_order=PI_NAMEA&Select+a+Site:=58715

United States Department of Agriculture Soil Permit: P330-12-00139

Pennsylvania: 68-01752
http://www.dep.pa.gov/Business/OtherPrograms/Labs/Pages/Laboratory-Accreditation-Program.aspx

LABORATORY TESTING DATA SHEET (1 of 2)

Project Name **Orleans - GWDP** Location Overland Way, MA Reviewed By

Project No. **1704795** Assigned By T. Parece

Project Manager T. Parece Report Date 05.08.17 Date Reviewed *05.08.17*

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests						Corrosivity					Laboratory Log and Soil Description
				Water Content %	LL %	PL %	Gravel %	Sand %	Fines (<#200) %	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Resistivity (Mohms-cm)	GTL Resist	
CLS-1		70-72	17-S-560				0.1	98.0	1.9						Light Brown-White poorly graded sand
CLS-1		86-88	17-S-561				0.0	97.3	2.7						Brown poorly graded sand
CLS-1		95.5-96	17-S-562				0.0	56.4	43.6						Brown silty sand
CLS-1		108-110	17-S-563				0.0	94.3	5.7						Brown poorly graded sand with silt
CLS-2		21-24	17-S-564				0.0	4.4	95.6						Light Brown silt
CLS-2		64-66	17-S-565				0.0	53.0	47.0						Light White-Brown silty sand
CLS-2		74-76	17-S-566				0.0	41.8	58.2						Light Brown sandy silt
CLS-2		80-82	17-S-567				0.0	89.0	11.0						Light Brown poorly graded sand with silt
CLS-3		65-69	17-S-568				0.0	85.6	14.4						Strong Brown silty sand
CLS-3		73-77	17-S-569				0.0	57.3	42.7						Brown silty sand
CLS-3		87-95	17-S-570				0.0	89.6	10.4						Brown poorly graded sand with silt
CLS TP-3		15-15	17-S-571				2.0	96.1	1.9						Red-Brown poorly graded sand

THIELSCH ENGINEERING
195 Frances Avenue
Cranston, RI 02910 401-467-6454

LABORATORY TESTING DATA SHEET (2 of 2)

Project Name **Orleans - GWDP** Location Overland Way, MA Reviewed By

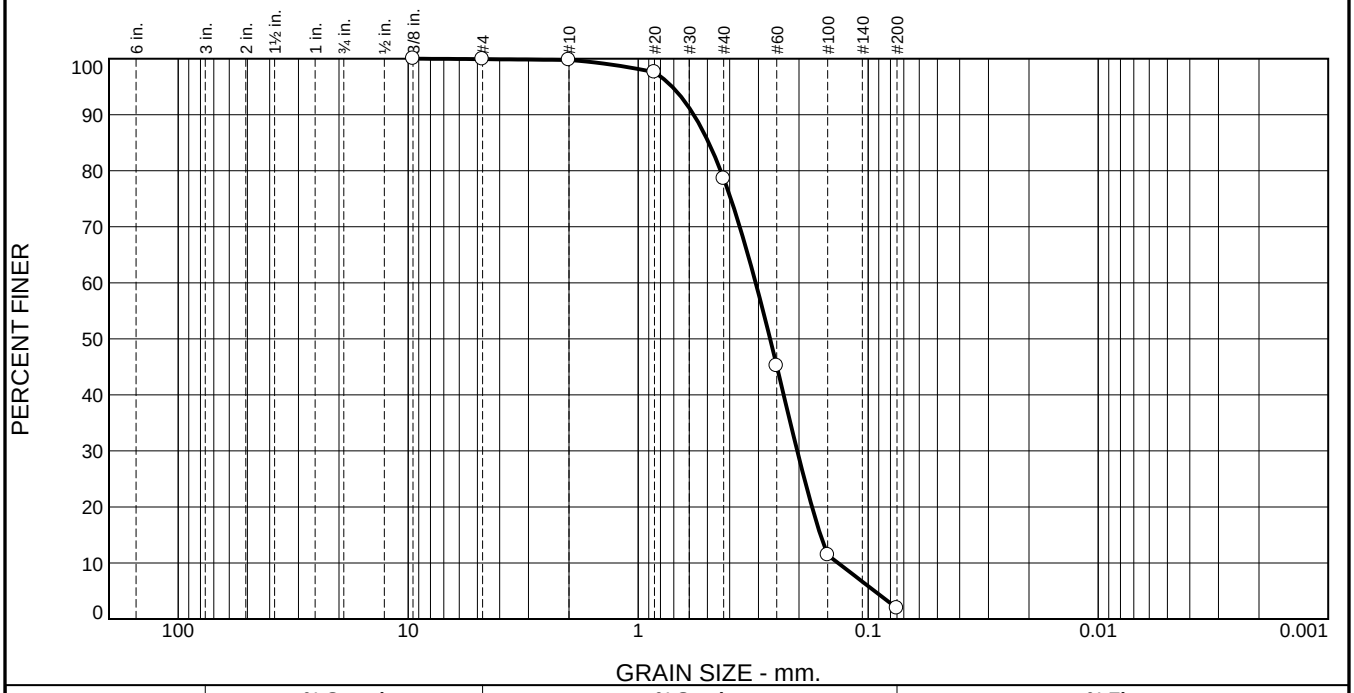
Project No. **1704795** Assigned By T. Parece

Project Manager T. Parece Report Date 05.08.17 Date Reviewed *05.08.17*

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests						Corrosivity					Laboratory Log and Soil Description
				Water Content %	LL %	PL %	Gravel %	Sand %	Fines (<#200) %	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Resistivity (Mohms-cm)	GTL Resist	
CLS-TP-7		10-15	17-S-572				3.3	92.6	4.1						Brown poorly graded sand
TTS-1-TP		10-15	17-S-573				0.1	94.1	5.8						Red-Brown poorly graded sand with silt
TTS-1		45-46.5	17-S-574				0.0	53.0	47.0						Brown silty sand
TTS-2-TP		10-15	17-S-575				14.1	81.8	4.1						Light Brown poorly graded sand
TTS-2		21-21.5	17-S-576				0.0	66.9	33.1						Brown silty sand
TTS-3		15-16.5	17-S-577				0.0	2.5	97.5						Brown silt
TTS-4		15.5-16.5	17-S-578				0.0	51.2	48.8						Brown silty sand

THIELSCH ENGINEERING
195 Frances Avenue
Cranston, RI 02910 401-467-6454

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.1	21.2	76.7	1.9	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.375	100.0		
#4	99.9		
#10	99.8		
#20	97.6		
#40	78.6		
#60	45.2		
#100	11.4		
#200	1.9		

* (no specification provided)

Material Description

Light Brown-White poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.5736 D_{85}= 0.4934 D_{60}= 0.3084
D_{50}= 0.2670 D_{30}= 0.2035 D_{15}= 0.1612
D_{10}= 0.1351 C_u= 2.28 C_c= 0.99

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 70-72' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

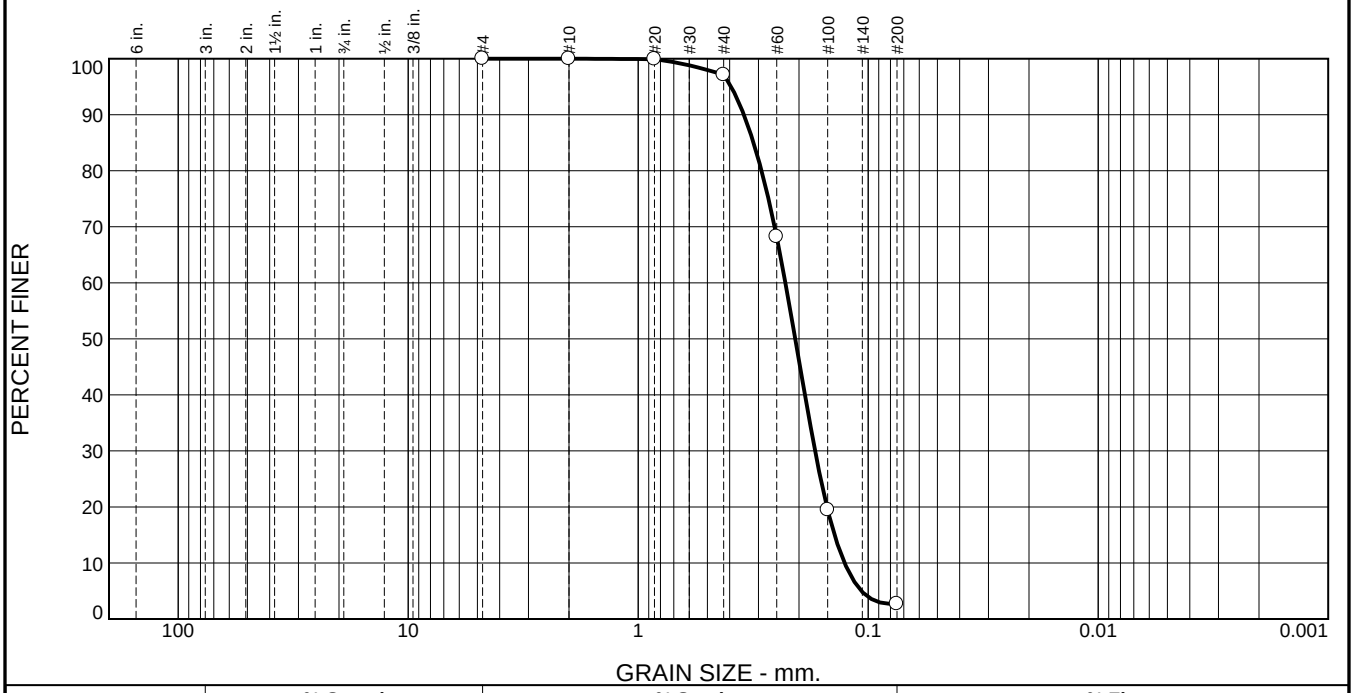
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-560

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.9	94.4	2.7	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.9		
#40	97.1		
#60	68.2		
#100	19.5		
#200	2.7		

* (no specification provided)

Material Description

Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3470 D_{85}= 0.3150 D_{60}= 0.2291
D_{50}= 0.2076 D_{30}= 0.1701 D_{15}= 0.1401
D_{10}= 0.1267 C_u= 1.81 C_c= 1.00

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 86-88' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

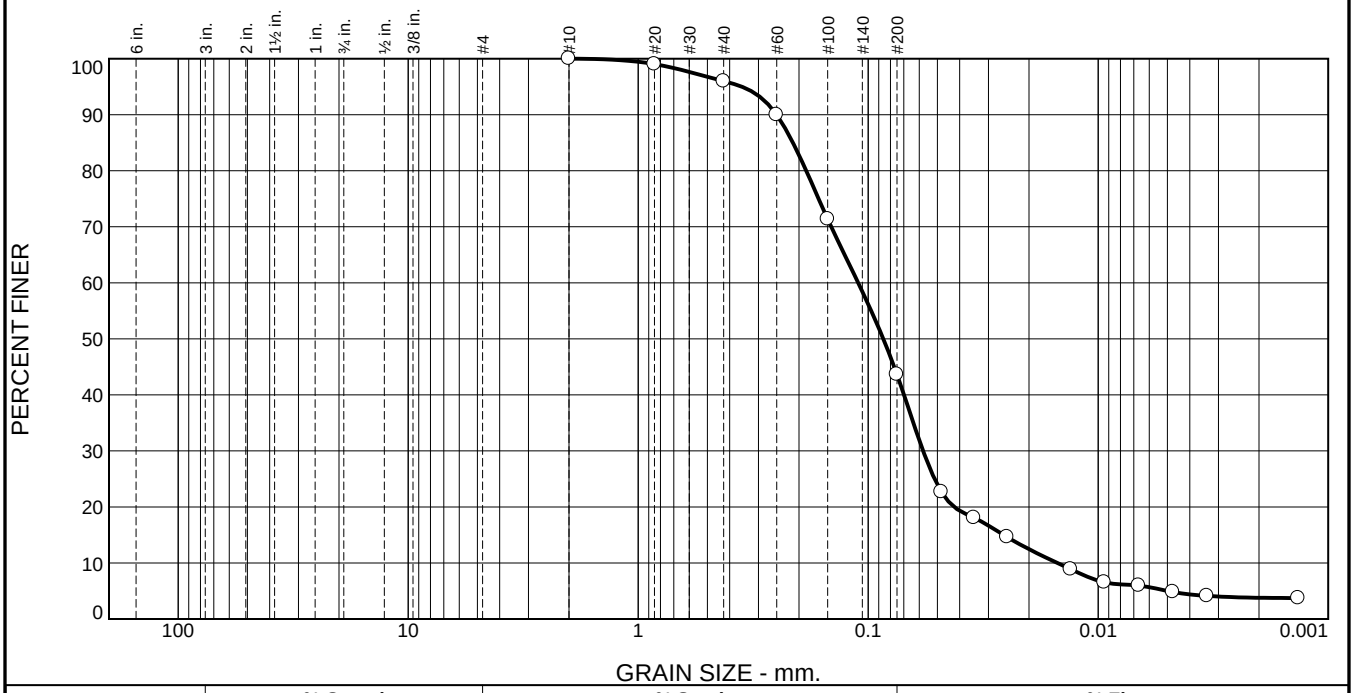
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-561

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	4.0	52.4	39.8	3.8

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.0		
#40	96.0		
#60	90.0		
#100	71.4		
#200	43.6		
0.0481 mm.	22.7		
0.0347 mm.	18.1		
0.0249 mm.	14.6		
0.0132 mm.	8.9		
0.0094 mm.	6.5		
0.0067 mm.	6.0		
0.0047 mm.	4.8		
0.0034 mm.	4.1		
0.0013 mm.	3.7		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.2502 D_{85}= 0.2124 D_{60}= 0.1106
D_{50}= 0.0860 D_{30}= 0.0577 D_{15}= 0.0257
D_{10}= 0.0150 C_u= 7.35 C_c= 2.00

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 95.5-96' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

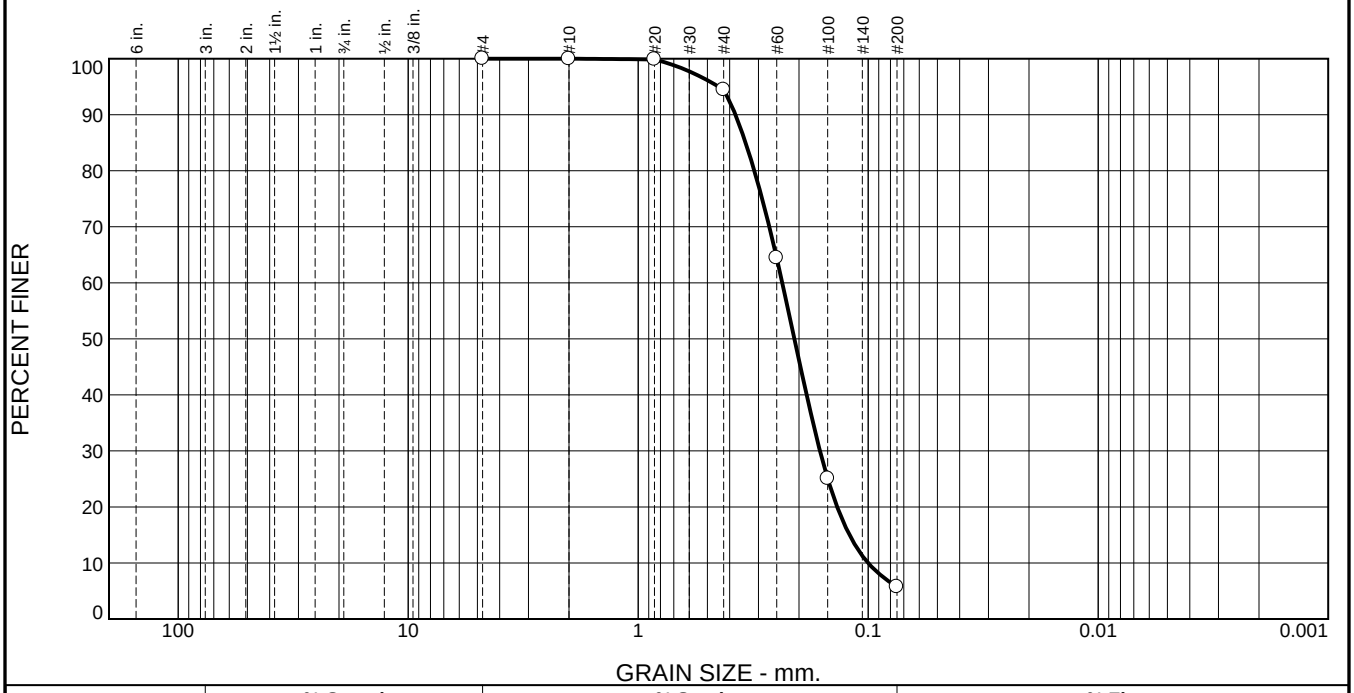
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-562

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	5.5	88.8	5.7	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.9		
#40	94.5		
#60	64.4		
#100	25.0		
#200	5.7		

* (no specification provided)

Material Description

Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3778 D_{85}= 0.3410 D_{60}= 0.2364
D_{50}= 0.2093 D_{30}= 0.1620 D_{15}= 0.1206
D_{10}= 0.1001 C_u= 2.36 C_c= 1.11

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 108-110' **Date Sampled:**

Sample Number: CLS-1

Thielsch Engineering Inc.

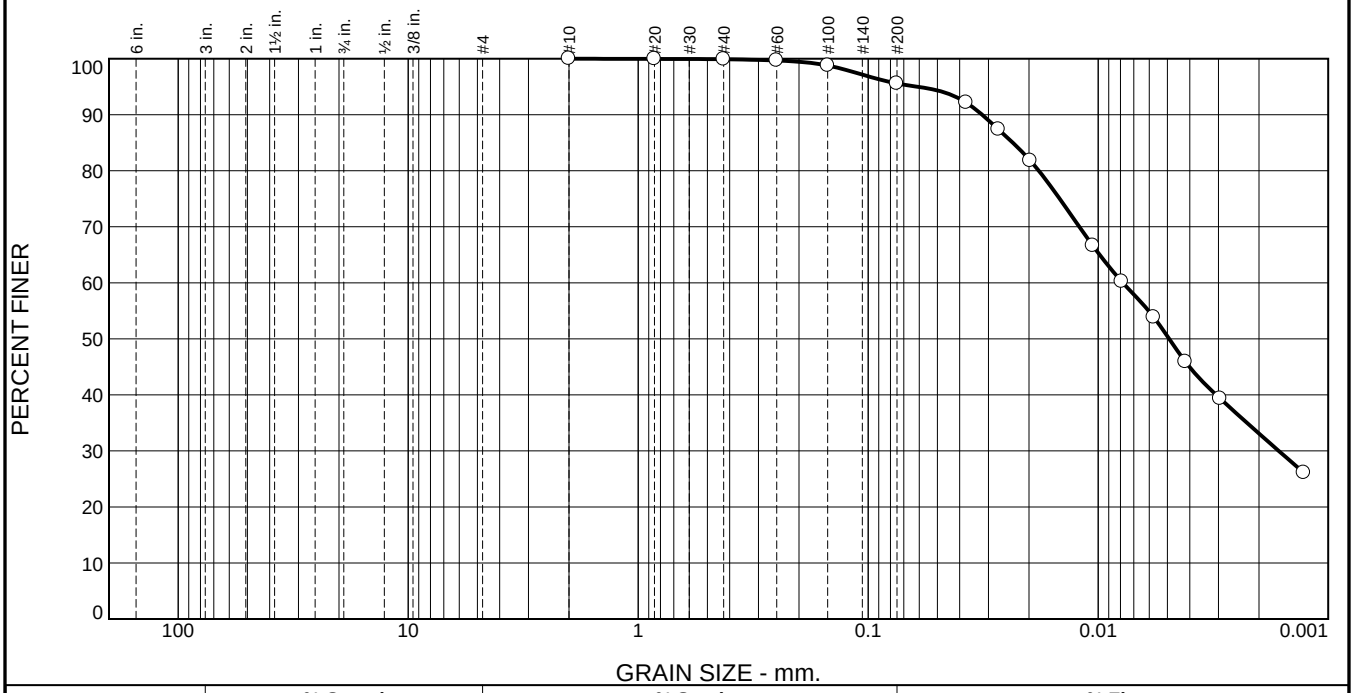
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-563

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	4.3	62.5	33.1

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.7		
#100	98.8		
#200	95.6		
0.0375 mm.	92.2		
0.0272 mm.	87.4		
0.0197 mm.	81.8		
0.0106 mm.	66.6		
0.0079 mm.	60.3		
0.0057 mm.	53.9		
0.0042 mm.	45.9		
0.0030 mm.	39.4		
0.0013 mm.	26.1		

* (no specification provided)

Material Description

Light Brown silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.0320 D_{85}= 0.0235 D_{60}= 0.0078
D_{50}= 0.0049 D_{30}= 0.0016 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 21-24' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

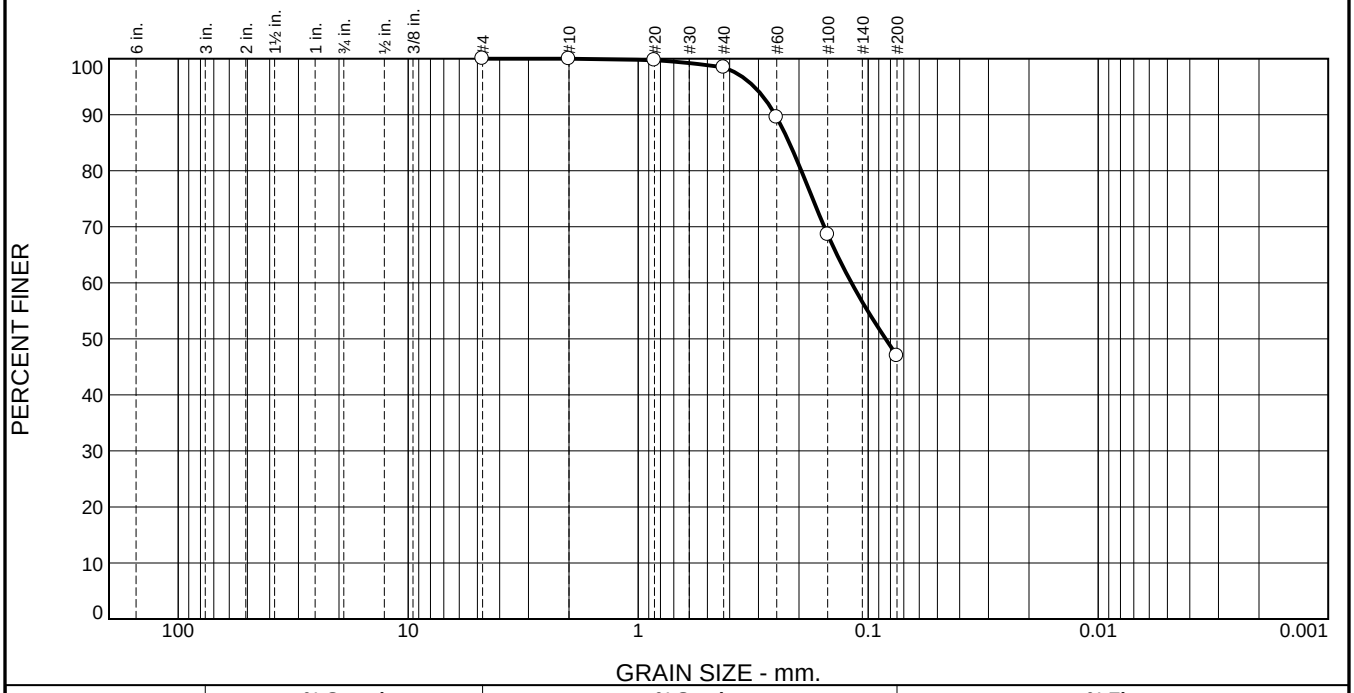
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-564

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.5	51.5	47.0	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.7		
#40	98.5		
#60	89.5		
#100	68.6		
#200	47.0		

* (no specification provided)

Material Description

Light White-Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.2537 D_{85}= 0.2203 D_{60}= 0.1183
D_{50}= 0.0840 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 64-66' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

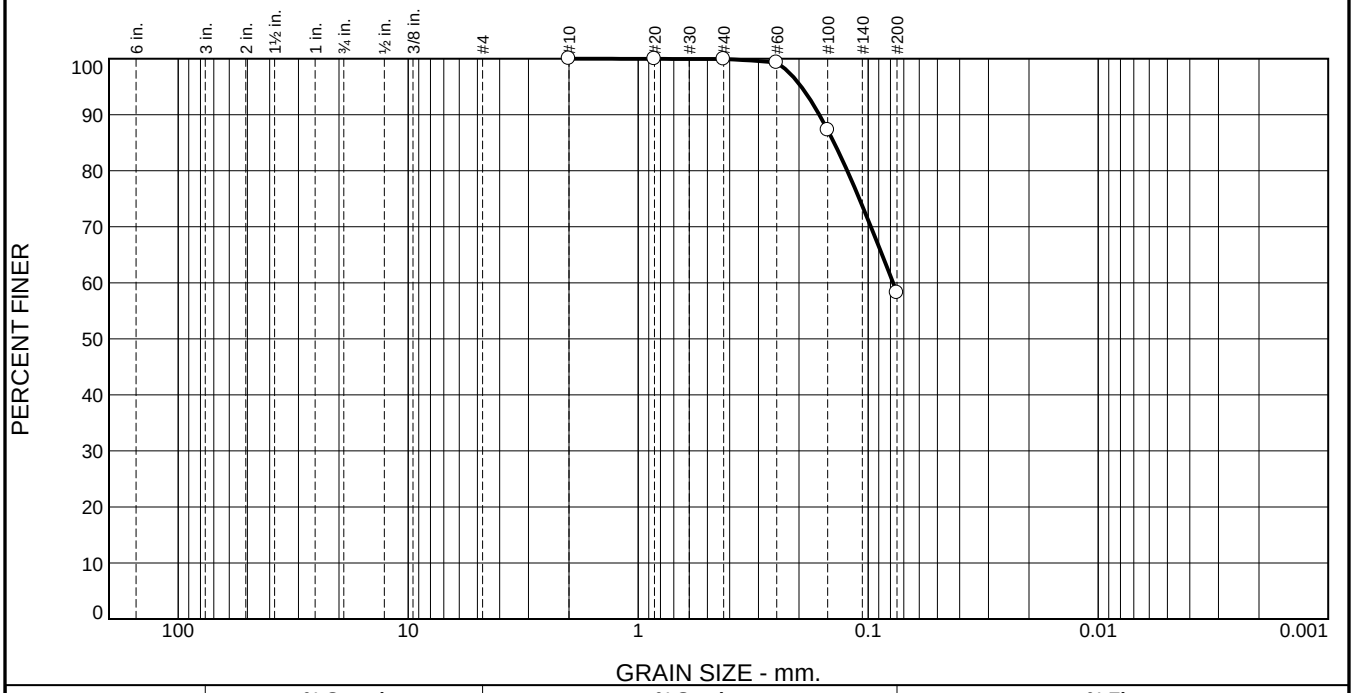
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-565

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	41.7	58.2	

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.3		
#100	87.3		
#200	58.2		

* (no specification provided)

Material Description

Light Brown sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.1630 D_{85}= 0.1407 D_{60}= 0.0779
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 74-76' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

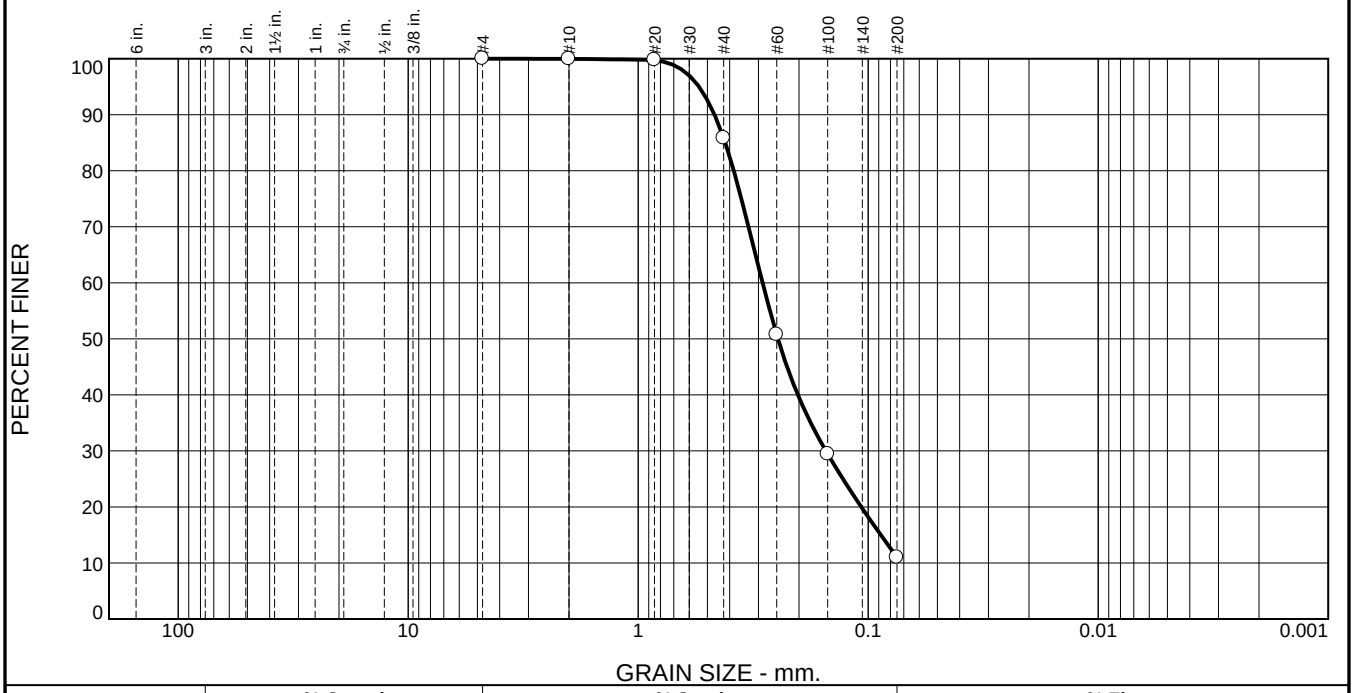
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-566

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	14.2	74.8	11.0	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.8		
#40	85.8		
#60	50.7		
#100	29.5		
#200	11.0		

* (no specification provided)

Material Description

Light Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 0.4656 D_{85}= 0.4184 D_{60}= 0.2878
D_{50}= 0.2469 D_{30}= 0.1527 D_{15}= 0.0881
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 80-82' **Date Sampled:**

Sample Number: CLS-2

Thielsch Engineering Inc.

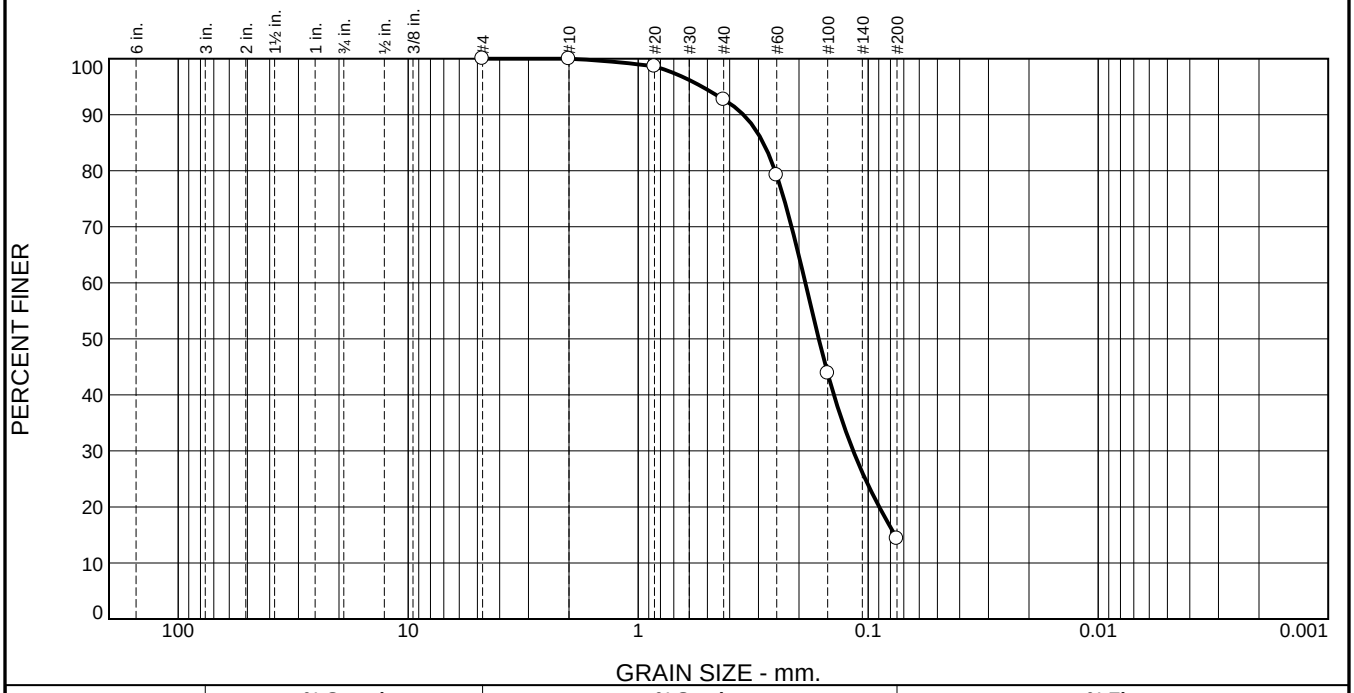
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-567

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	7.3	78.3	14.4	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	98.6		
#40	92.7		
#60	79.2		
#100	43.9		
#200	14.4		

* (no specification provided)

Material Description

Strong Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 0.3484 D_{85}= 0.2860 D_{60}= 0.1876
D_{50}= 0.1640 D_{30}= 0.1162 D_{15}= 0.0766
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 65-69' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

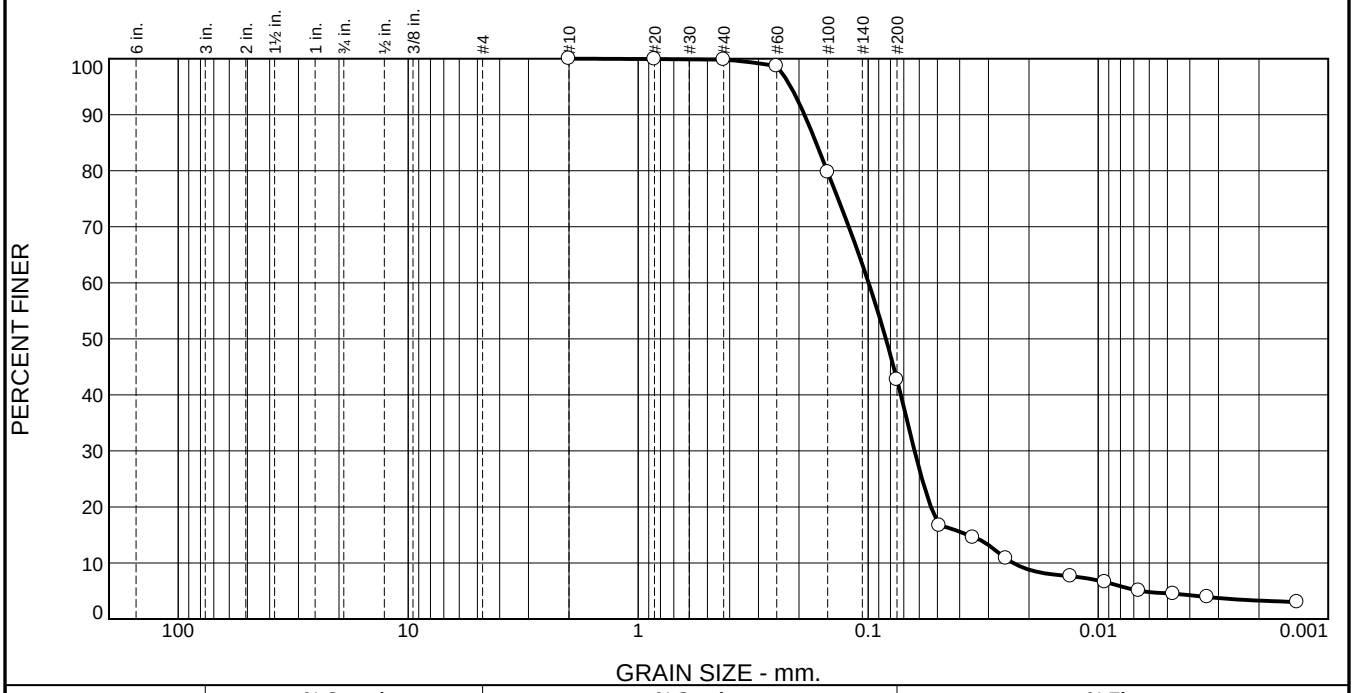
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-568

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	57.1	39.4	3.3

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.9		
#40	99.8		
#60	98.7		
#100	79.7		
#200	42.7		
0.0491 mm.	16.7		
0.0351 mm.	14.6		
0.0252 mm.	10.8		
0.0132 mm.	7.6		
0.0094 mm.	6.6		
0.0067 mm.	5.1		
0.0047 mm.	4.5		
0.0034 mm.	3.9		
0.0014 mm.	3.0		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.1894 D_{85}= 0.1685 D_{60}= 0.0996
D_{50}= 0.0837 D_{30}= 0.0628 D_{15}= 0.0370
D_{10}= 0.0234 C_u= 4.25 C_c= 1.69

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 73-77' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

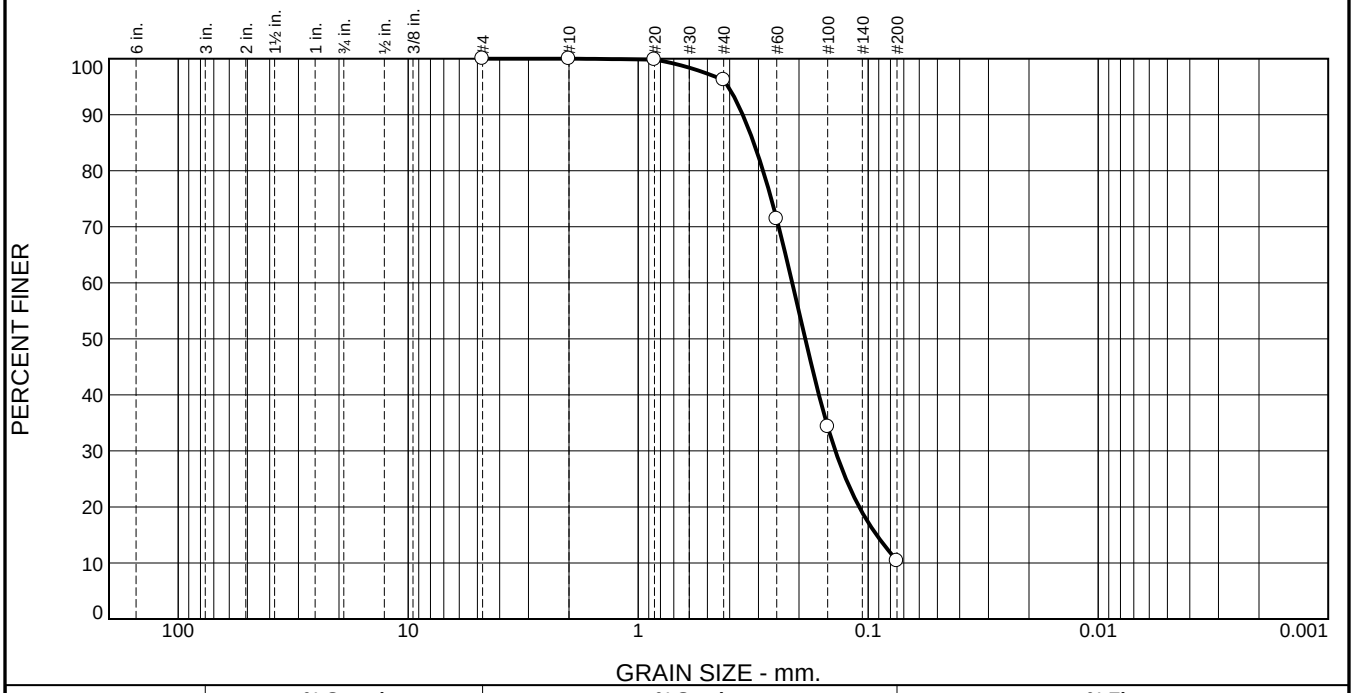
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-569

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.8	85.8	10.4	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.8		
#40	96.2		
#60	71.4		
#100	34.3		
#200	10.4		

* (no specification provided)

Material Description

Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.3511 D_{85}= 0.3144 D_{60}= 0.2139
D_{50}= 0.1878 D_{30}= 0.1389 D_{15}= 0.0919
D_{10}= C_u= C_c=

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 87-95' **Date Sampled:**

Sample Number: CLS-3

Thielsch Engineering Inc.

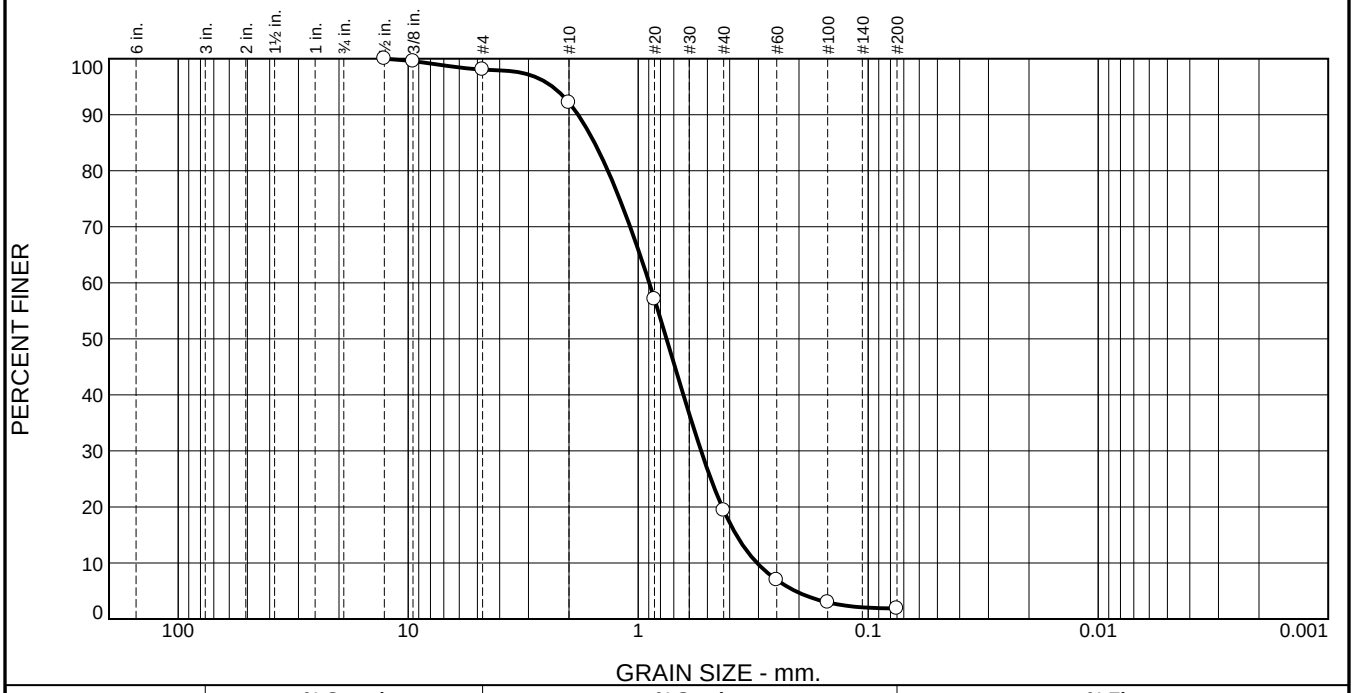
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-570

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.0	5.8	72.8	17.5	1.9	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.5	100.0		
0.375	99.5		
#4	98.0		
#10	92.2		
#20	57.1		
#40	19.4		
#60	7.0		
#100	3.0		
#200	1.9		

* (no specification provided)

Material Description

Red-Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 1.8256 D_{85}= 1.5482 D_{60}= 0.8950
D_{50}= 0.7526 D_{30}= 0.5327 D_{15}= 0.3744
D_{10}= 0.3043 C_u= 2.94 C_c= 1.04

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15-15' **Date Sampled:**

Sample Number: CLS-TP-3

Thielsch Engineering Inc.

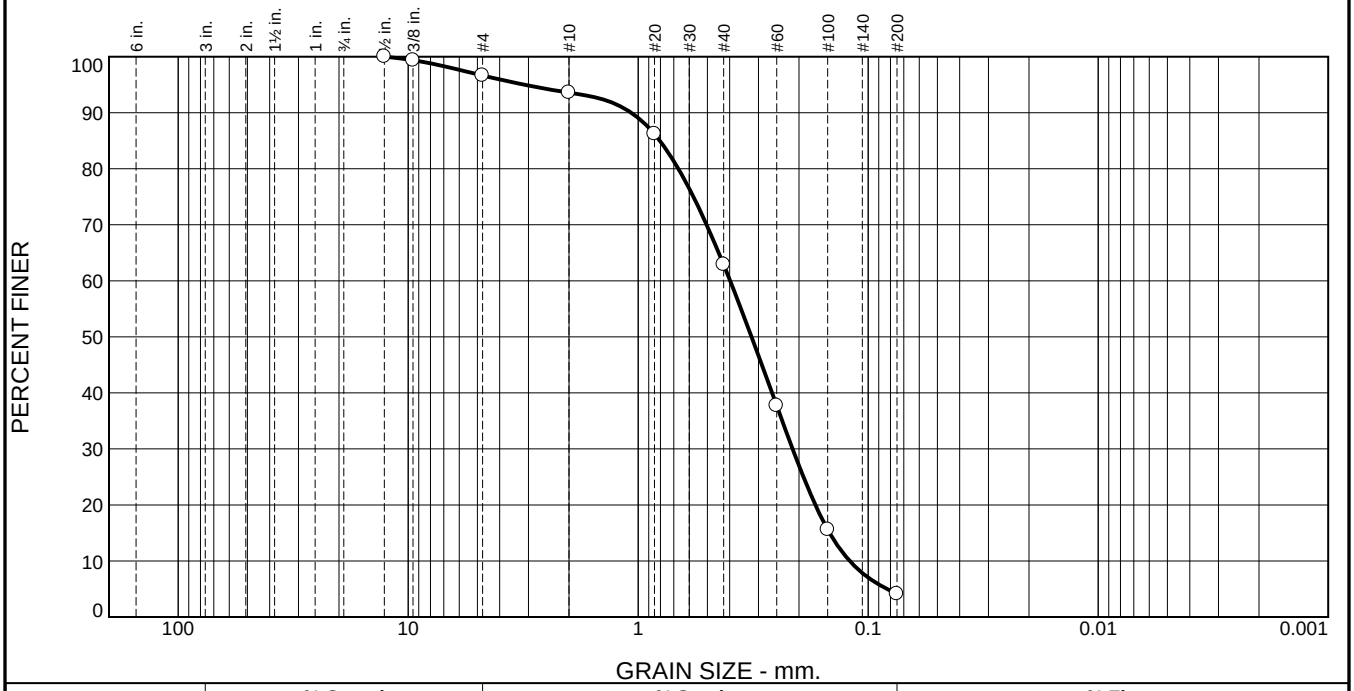
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-571

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.3	3.1	30.7	58.8	4.1	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.5	100.0		
0.375	99.4		
#4	96.7		
#10	93.6		
#20	86.2		
#40	62.9		
#60	37.7		
#100	15.6		
#200	4.1		

* (no specification provided)

Material Description

Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 1.0713 D_{85}= 0.8044 D_{60}= 0.3983
D_{50}= 0.3214 D_{30}= 0.2132 D_{15}= 0.1472
D_{10}= 0.1203 C_u= 3.31 C_c= 0.95

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: CLS-TP-7

Thielsch Engineering Inc.

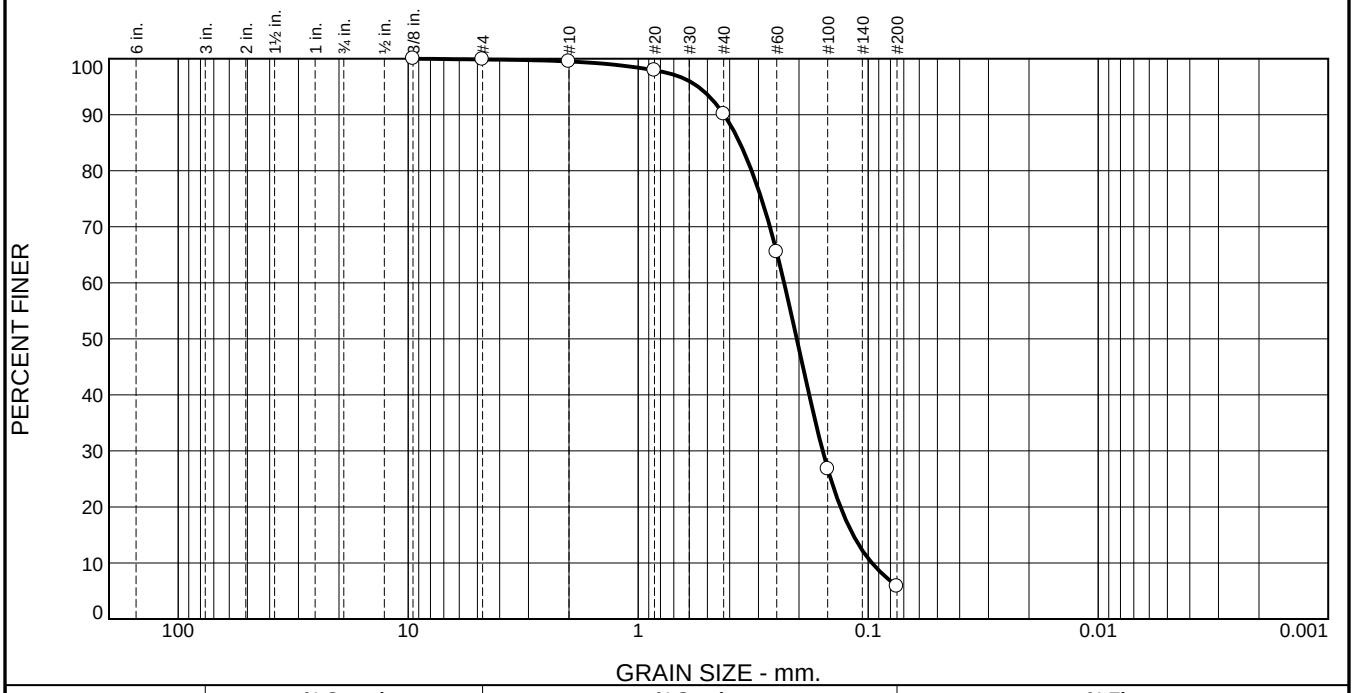
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-572

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.4	9.4	84.3	5.8	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.375	100.0		
#4	99.9		
#10	99.5		
#20	97.9		
#40	90.1		
#60	65.5		
#100	26.8		
#200	5.8		

* (no specification provided)

Material Description

Red-Brown poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP-SM **AASHTO (M 145)=** A-3

Coefficients

D_{90}= 0.4233 D_{85}= 0.3617 D_{60}= 0.2319
D_{50}= 0.2044 D_{30}= 0.1576 D_{15}= 0.1163
D_{10}= 0.0963 C_u= 2.41 C_c= 1.11

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: TTS-1-TP

Thielsch Engineering Inc.

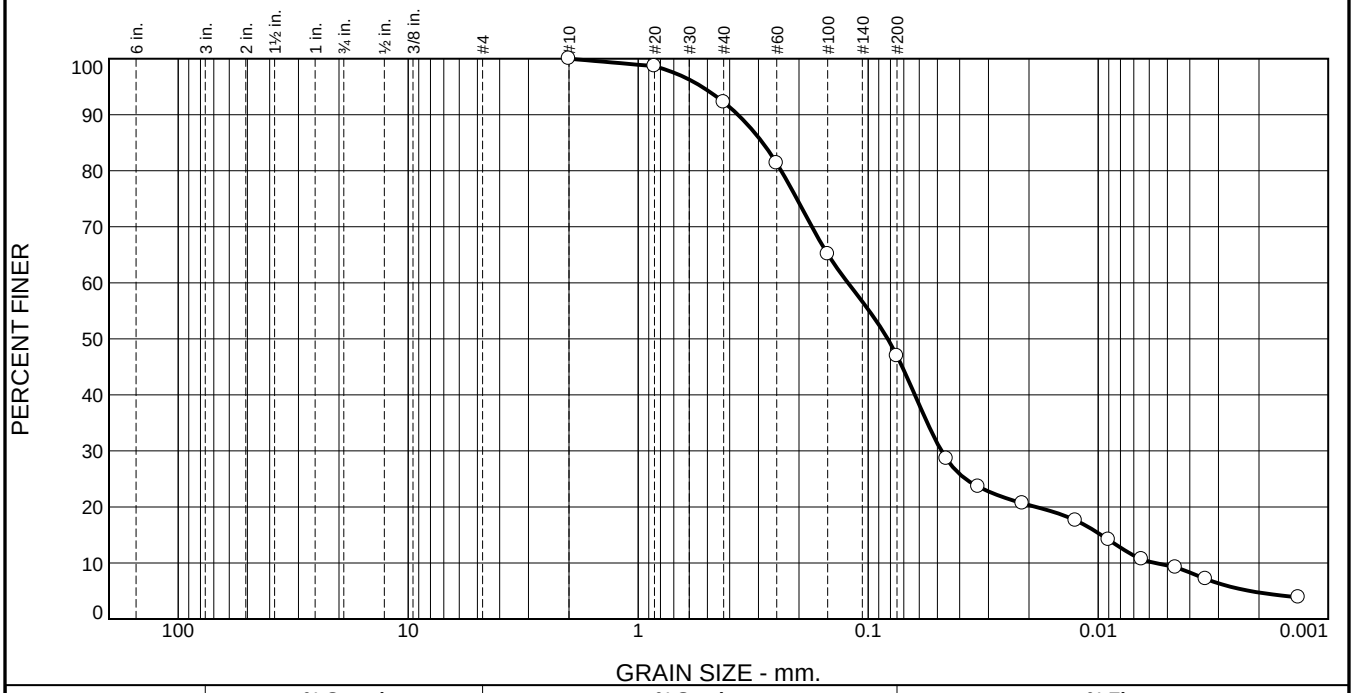
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-573

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	7.8	45.2	42.3	4.7

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	98.7		
#40	92.2		
#60	81.3		
#100	65.1		
#200	47.0		
0.0457 mm.	28.6		
0.0332 mm.	23.6		
0.0214 mm.	20.7		
0.0126 mm.	17.6		
0.0090 mm.	14.2		
0.0065 mm.	10.7		
0.0046 mm.	9.2		
0.0034 mm.	7.2		
0.0013 mm.	3.9		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.3684 D_{85}= 0.2876 D_{60}= 0.1225
D_{50}= 0.0823 D_{30}= 0.0480 D_{15}= 0.0097
D_{10}= 0.0056 C_u= 21.70 C_c= 3.33

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 45.46.5' **Date Sampled:**

Sample Number: TTS-1

Thielsch Engineering Inc.

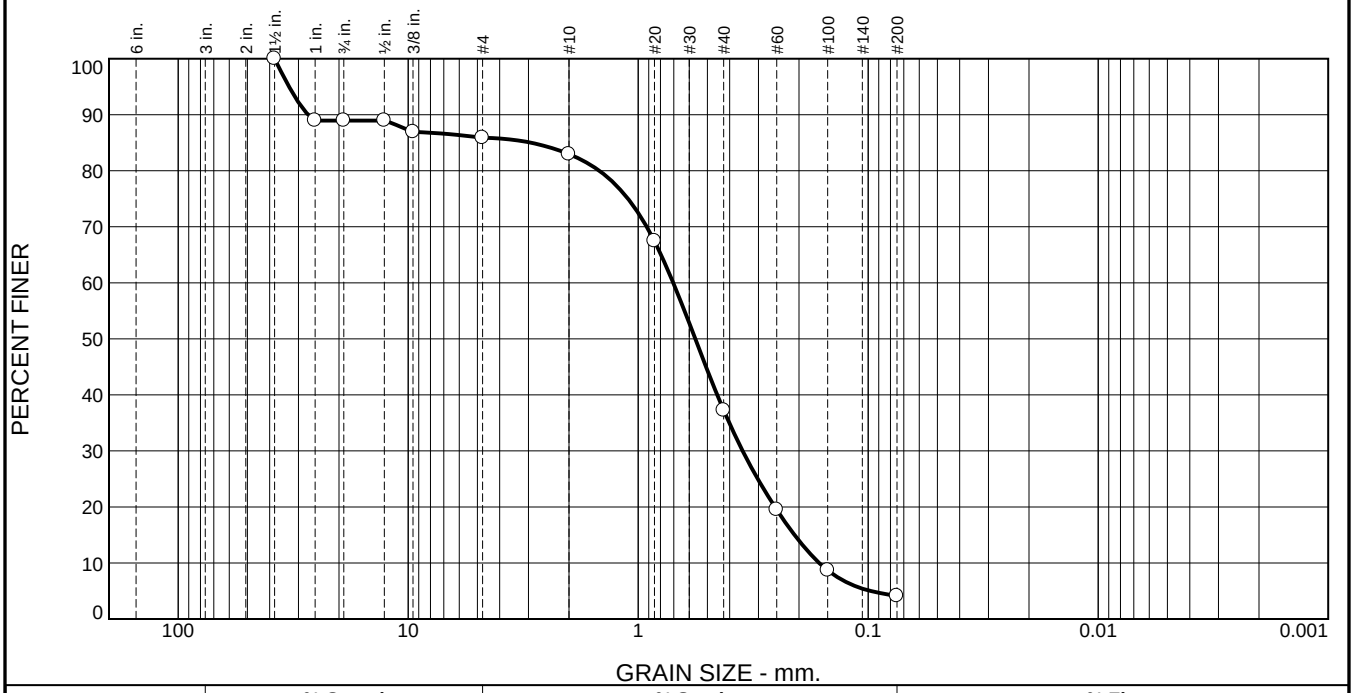
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-574

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	11.0	3.1	2.9	45.7	33.2	4.1	

TEST RESULTS (D6913)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	89.0		
.75	89.0		
0.5	89.0		
.375	86.9		
#4	85.9		
#10	83.0		
#20	67.5		
#40	37.3		
#60	19.5		
#100	8.7		
#200	4.1		

* (no specification provided)

Material Description

Light Brown poorly graded sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SP **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 27.2477 D_{85}= 2.9193 D_{60}= 0.7039
D_{50}= 0.5646 D_{30}= 0.3514 D_{15}= 0.2091
D_{10}= 0.1632 C_u= 4.31 C_c= 1.07

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: JL

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 10-15' **Date Sampled:**

Sample Number: TTS-2-TP

Thielsch Engineering Inc.

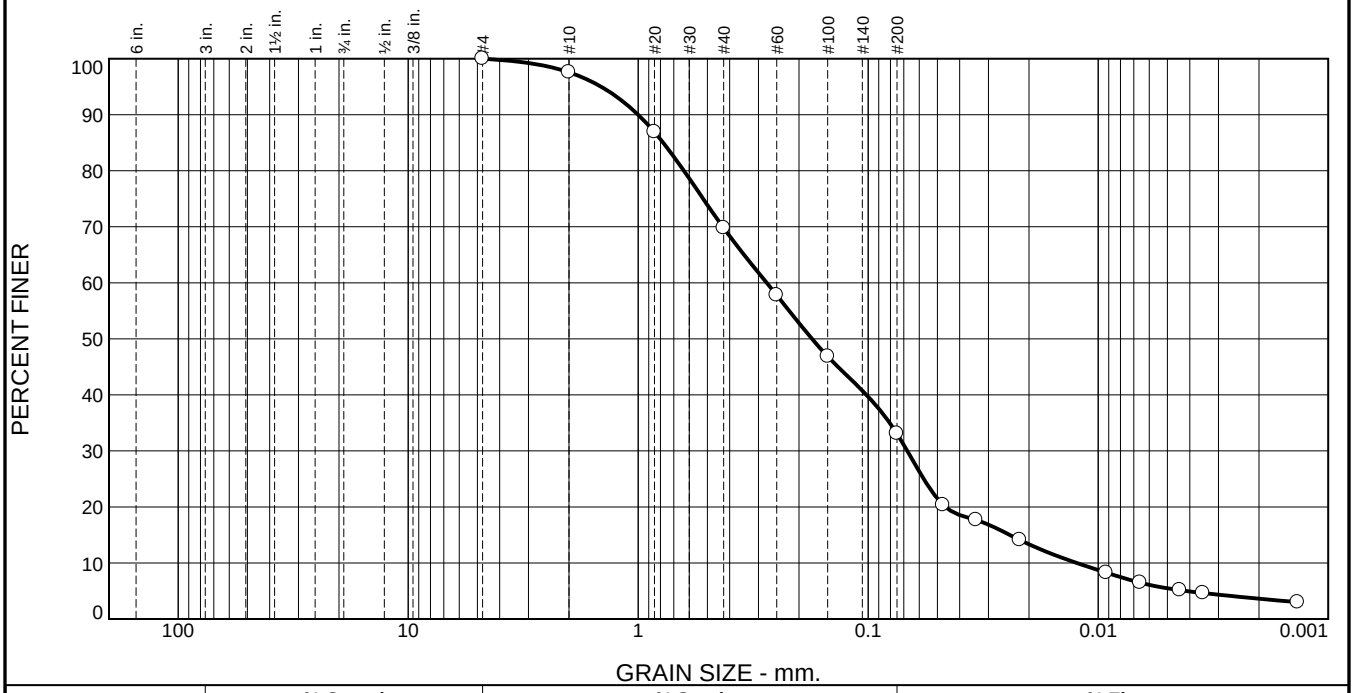
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-575

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	2.4	27.8	36.7	29.5	3.6

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	97.6		
#20	86.9		
#40	69.8		
#60	57.8		
#100	46.9		
#200	33.1		
0.0473 mm.	20.4		
0.0339 mm.	17.7		
0.0219 mm.	14.1		
0.0092 mm.	8.3		
0.0066 mm.	6.5		
0.0044 mm.	5.2		
0.0035 mm.	4.6		
0.0014 mm.	3.0		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 1.0006 D_{85}= 0.7782 D_{60}= 0.2763
D_{50}= 0.1754 D_{30}= 0.0676 D_{15}= 0.0242
D_{10}= 0.0124 C_u= 22.32 C_c= 1.33

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 21-21.5' **Date Sampled:**

Sample Number: TTS-2

Thielsch Engineering Inc.

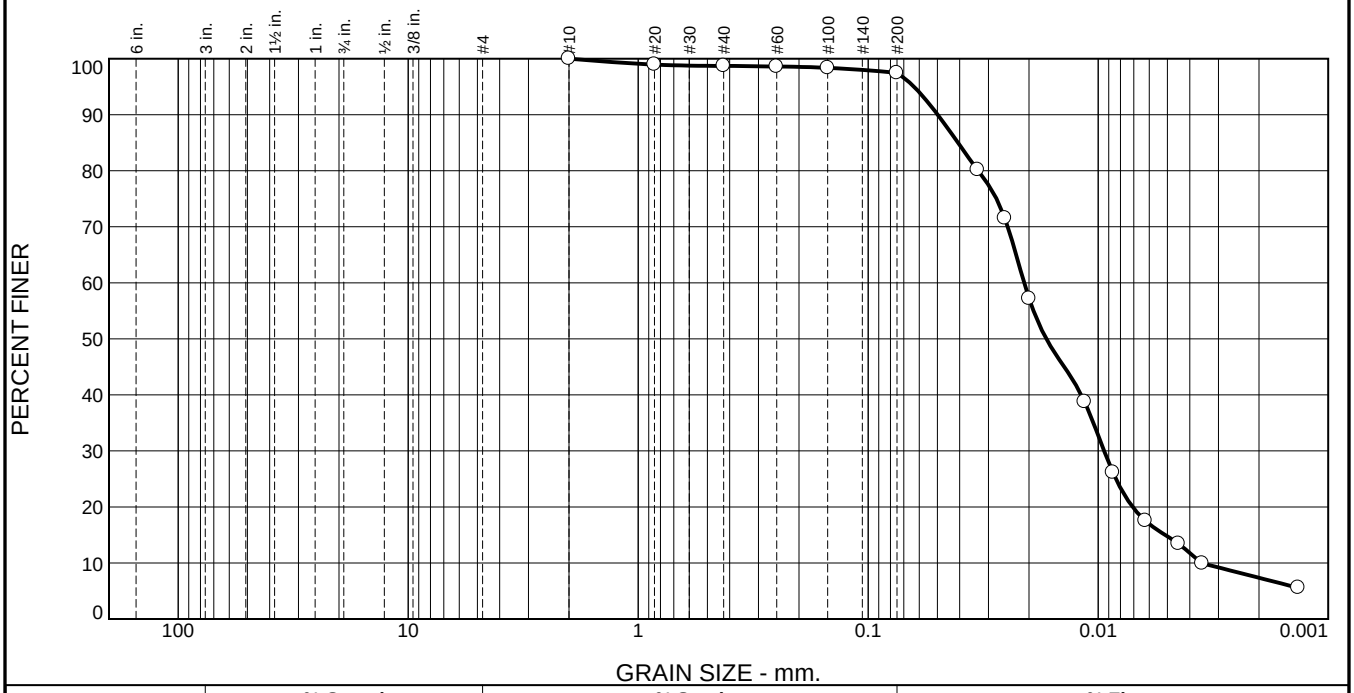
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-576

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.3	1.2	90.1	7.4

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.0		
#40	98.7		
#60	98.6		
#100	98.4		
#200	97.5		
0.0335 mm.	80.2		
0.0255 mm.	71.5		
0.0200 mm.	57.2		
0.0115 mm.	38.8		
0.0086 mm.	26.1		
0.0062 mm.	17.5		
0.0045 mm.	13.4		
0.0035 mm.	9.9		
0.0014 mm.	5.6		

* (no specification provided)

Material Description

Brown silt

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.0499 D_{85}= 0.0407 D_{60}= 0.0210
D_{50}= 0.0168 D_{30}= 0.0094 D_{15}= 0.0051
D_{10}= 0.0035 C_u= 5.91 C_c= 1.19

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15-16.5' **Date Sampled:**

Sample Number: TTS-3

Thielsch Engineering Inc.

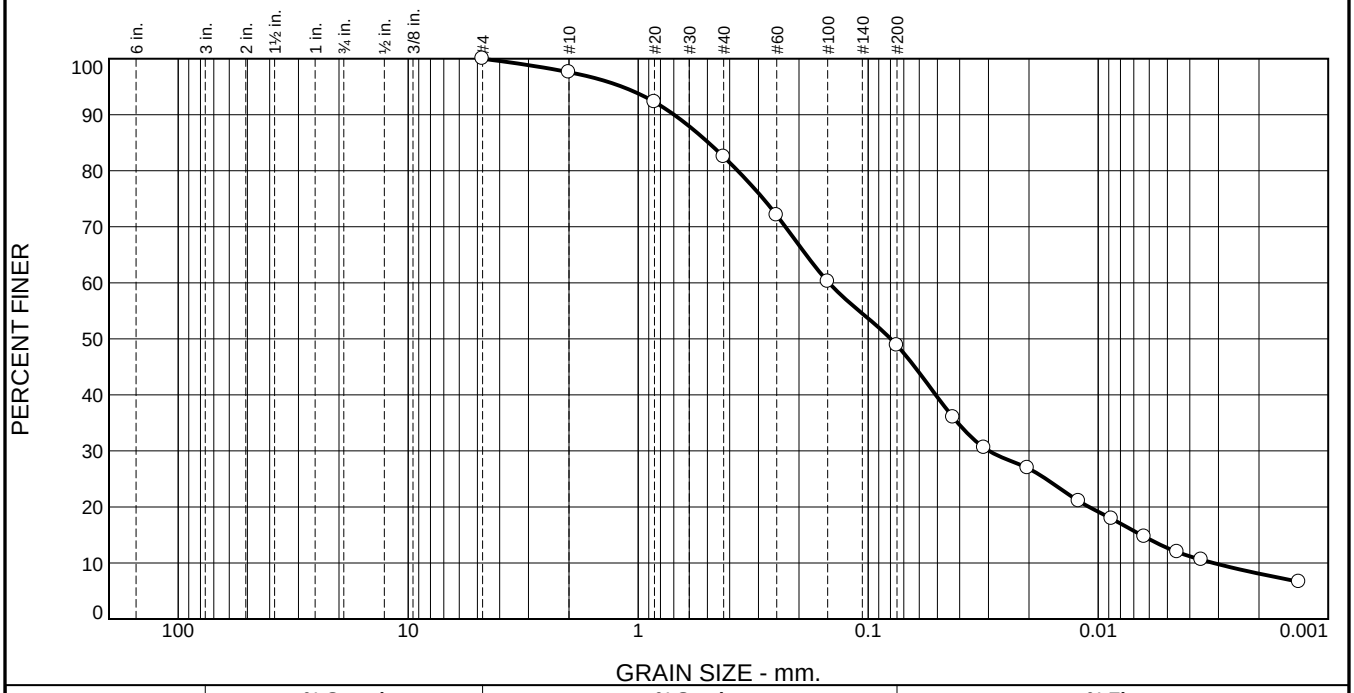
Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-577

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	2.4	15.1	33.7	40.7	8.1

TEST RESULTS (D7928)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	97.6		
#20	92.3		
#40	82.5		
#60	72.1		
#100	60.2		
#200	48.8		
0.0427 mm.	36.0		
0.0314 mm.	30.6		
0.0203 mm.	27.0		
0.0122 mm.	21.1		
0.0088 mm.	17.9		
0.0063 mm.	14.7		
0.0045 mm.	12.0		
0.0036 mm.	10.6		
0.0013 mm.	6.7		

* (no specification provided)

Material Description

Brown silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.6980 D_{85}= 0.4944 D_{60}= 0.1482
D_{50}= 0.0798 D_{30}= 0.0298 D_{15}= 0.0065
D_{10}= 0.0032 C_u= 46.95 C_c= 1.90

Remarks

Date Received: 05.01.17 **Date Tested:** 05.02.17

Tested By: IA

Checked By: Matthew Colman, P.E.

Title: Laboratory Manager

Source of Sample: Composite **Depth:** 15.5-16.5' **Date Sampled:**

Sample Number: TTS-4

Thielsch Engineering Inc.

Cranston, RI

Client: ESS/Town of Orleans

Project: Orleans - GWDP
Overland Way, MA

Project No: 1704795 **Figure** 17-S-578

1704794 4/28/17

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

1704795

Project Name **Orleans - GWDP** Client **Town of Orleans** Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** Site Location **Overland Way** Collected By **Mark Owen**

ESS Project No. _____ Date Assigned _____ Received By _____

Project Manager **T. Parece** Date Received _____ Date Required **Norman**

	Sample Information					Lab No.	Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID		Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
1	CLS - 1	70-72								X												
2	CLS - 1	86-88								X												
3	CLS - 1	95.5-96								X	X											
4	CLS - 1	108-110								X												
5	CLS - 2	21-24								X	X											
6	CLS - 2	64-66								X												
7	CLS - 2	74-76								X	X											
8	CLS - 2	80-82								X												
9	CLS-3	65-69								X												
10	CLS-3	73-77								X	X											
11	CLS-3	87-95								X												
12	CLS TP-3	15-Gst 15	MH							X												
13	CLS-TP-7	10-15	MH							X												

Notes: MH 2 4-28-17 @ 12:55 TCP 4/28/17 12:55 NOICE 22.1

TCP 2 4/28/17 @ 11:20 4/28/17 1659

1704795

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

Project Name **Orleans - GWDP** Client **Town of Orleans** Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** Site Location **Overland Way** Collected By **Mark Owen**

ESS Project No. _____ Date Assigned _____ Received By _____

Project Manager **T. Parece** Date Received _____ Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	#
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
14	TTS - 1	TP	10 - 15							X												
15	TTS - 1		45-46.5							X	X											
16	TTS-2	TP	10 - 15							X												
17	TTS-2		21-21.5							X	X											
18	TTS-3		15-16.5							X	X											
19	TTS-4		15.5-16.5							X	X											

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No 22.1

4/25/17 @ 1420 4/28/17 1659

1704794 4/28/17

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING

401-467-6454

195 Frances Ave., Cranston, RI 02910

1704795

Project Name **Orleans - GWDP** | Client **Town of Orleans** | Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** | Site Location **Overland Way** | Collected By **Mark Owen**

ESS Project No. | Date Assigned | Received By

Project Manager **T. Parece** | Date Received | Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	Notes
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	#
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
1	CLS - 1	70-72								X												
2	CLS - 1	86-88								X												
3	CLS - 1	95.5-96								X	X											
4	CLS - 1	108-110								X												
5	CLS - 2	21-24								X	X											
6	CLS - 2	64-66								X												
7	CLS - 2	74-76								X	X											
8	CLS - 2	80-82								X												
9	CLS-3	65-69								X												
10	CLS-3	73-77								X	X											
11	CLS-3	87-95								X												
12	CLS TP-3	15-~~Oct~~ 15	MA							X												
13	CLS-TP-7	10-15	MA							X												

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No ICE 22.1

4/25/17 @ 1420 4/28/17 1659

1704795

SOILS LABORATORY TESTING ASSIGNMENT SHEET

THIELSCH ENGINEERING 401-467-6454 195 Frances Ave., Cranston, RI 02910

Project Name **Orleans - GWDP** | Client **Town of Orleans** | Assigned By **Mark Owen**

CTS Project No. **60476644.10.1.A** | Site Location **Overland Way** | Collected By **Mark Owen**

ESS Project No. | Date Assigned | Received By

Project Manager **T. Parece** | Date Received | Date Required **Norman**

	Sample Information						Identification Tests							Permeability		Compaction			Strength		Consol.	
	Boring/ Test Pit No.	Sample No.	Depth Ft.	Sample Date	ESS SAMPLE ID	Lab No.	Water Cont. %	LL & PL %	Org. %	Sieve -200 %	Hyd -2μ %	G_s	γ_t pcf	Sand	Clay	Mod.	Std.	CBR	Tor-vane	Type Test $\bar{\sigma}_c$ or σ_c	Cc/ 1+eo	Notes
							D2216	D4318	D2974	D422		D854		D2434	D5084	D1557	D698	D1883		D2166/ D4767/ D2850	D2435	#
14	TTS - 1	TP	10 - 15							X												
15	TTS - 1		45-46.5							X	X											
16	TTS-2	TP	10 - 15							X												
17	TTS-2		21-21.5							X	X											
18	TTS-3		15-16.5							X	X											
19	TTS-4		15.5-16.5							X	X											

Notes: 4-28-17 @ 12:55 4/25/17 12:55 No 22.1 ICS

4/25/17 @ 1420 4/28/17 1659

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Appendix G

Nutrient Loading Results

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Estimate of Watershed Load with WWTF
Town of Orleans
Water Quality and Wastewater Planning

Discharge Rate - 100,000 gpd

Marsh	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]
	(kg/day)					(kg/yr)				
Namskaket Marsk	9.441	45.89	36.449	0.685	35.764	3,446	16,750	13,304	250	13,054
Little Namskaket Marsh	7.663	12.74	5.077	0.904	4.173	2,797	4,650	1,853	330	1,523
Rock Harbor	ND	ND	ND	0.000	ND	ND	ND	ND	0	ND
Cape Cod Bay	ND	ND	ND	2.225	ND	ND	ND	ND	812 1,392	ND

Discharge Rate - 150,000 gpd

Marsh	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]
	(kg/day)					(kg/yr)				
Namskaket Marsk	9.441	45.89	36.449	1.177	35.272	3,446	16,750	13,304	430	12,874
Little Namskaket Marsh	7.663	12.74	5.077	1.299	3.778	2,797	4,650	1,853	474	1,379
Rock Harbor	ND	ND	ND	0.001	ND	ND	ND[4]	ND	0	ND
Cape Cod Bay	ND	ND	ND	3.153	ND	ND	ND	ND	1,151	ND

Discharge Rate - 200,000 gpd

Marsh	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]
	(kg/day)					(kg/yr)				
Namskaket Marsk	9.441	45.89	36.449	1.775	34.674	3,446	16,750	13,304	648	12,656
Little Namskaket Marsh	7.663	12.74	5.077	1.671	3.406	2,797	4,650	1,853	610	1,243
Rock Harbor	ND	ND	ND	0.003	ND	ND	ND	ND	1	ND
Cape Cod Bay	ND	ND	ND	3.997	ND	ND	ND	ND	1,459 2,718	ND

Discharge Rate - 250,000 gpd

Marsh	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]	e	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]
	(kg/day)						(kg/yr)				
Namskaket Marsk	9.441	45.89	36.449	2.374	34.075		3,446	16,750	13,304	866	12,437
Little Namskaket Marsh	7.663	12.74	5.077	2.043	3.034		2,797	4,650	1,853	746	1,107
Rock Harbor	ND	ND	ND	0.004	ND		ND	ND	ND	2	ND
Cape Cod Bay	ND	ND	ND	4.841	ND		ND	ND	ND	1,767	ND

Discharge Rate - 400,000 gpd

Marsh	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]	Present Nitrate Load[1]	Present Nitrate Threshold Load[1]	Watershed Load[2]	Estimated WWTF Nitrate Load	Watershed with WWTF with Load[3]
	(kg/day)					(kg/yr)				
Namskaket Marsk	9.441	45.89	36.449	4.411	32.038	3,446	16,750	13,304	1,610	11,694
Little Namskaket Marsh	7.663	12.74	5.077	2.589	2.488	2,797	4,650	1,853	945	908
Rock Harbor	ND	ND	ND	0.118	ND	ND	ND	ND	43	ND
Cape Cod Bay	ND	ND	ND	6.575	ND	ND	ND	ND	2,400	ND

Notes:

1 Present and Threshold Loads from Draft and Final MEP Reports for Namskaket Marsh, Little Namskaket Marsh, and Rock Harbor. Tritown WWTF Loads Removed.

[2] Watershed Load = Threshold Load - Present Load

[3] Estimated Watershed Load with WWTF = Threshold Load -(Present Load + Estimated WWTF Load)

gpd = gallons per day

kg/day = kilograms per day

kg/yr = kiligrams per year

ND = No Data

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Appendix H

Properties with Potential Private Wells

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Potental Parcels with Private Wells
Route 6 (Exit 12) Cloverleaf Site
Water Quality and Wastewater Planning

	Street Address	MAP	PARCEL	EXTENSION	GIS_
	Parcel With Potential Private Well				
12	BEVAN WY	25	100	2	6328
14	BEVAN WY	25	100	3	6329
11	KINGS WY	25	103	0	1902
40	ROCK HARBOR RD	25	11	0	1242
95	SKAKET BEACH RD	24	2	0	1844
24	WEST RD	40	8	0	2791
99	WEST RD	32	58	0	1971
	Other Potential Private Well				
58	Old Colony Way (Old Colony Place)	Various			

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