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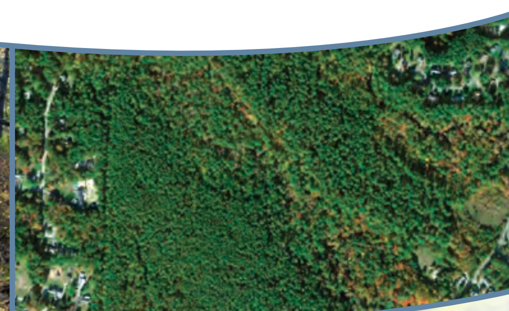
# Hydrogeologic and Hydrologic Study, Proposed Fearing Hill Solar Facility

Wareham, Massachusetts

May 2022



*Prepared for:*
**Town of Wareham**

*Prepared by:*
**Horsley Witten Group, Inc.**

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# 1) INTRODUCTION

This report summarizes the hydrogeologic and hydrologic study conducted by the Horsley Witten Group, Inc. (HW) regarding the proposed solar facility on Fearing Hill in Wareham, Massachusetts (the Site). The primary objective of the study is to assess the potential for the project to create negative impacts to surrounding abutters related to increased groundwater elevations and/or overland stormwater runoff. The solar facility is proposed by Wareham MA 3, LLC (the Applicant), with preliminary design materials submitted by the Applicant's engineer, Atlantic Design Engineers, Inc. (Atlantic). The work conducted in support of the study includes a review of existing information, collection of new field data, and modeling of the groundwater and stormwater changes anticipated to occur from the proposed project.

The proposed solar facility on the Site consists of:

- Conversion of a total of 26.8 acres of the Site from mature forest to solar panels with meadow under, between, and around the panels.
- Approximately 7,333 solar panels, covering approximately 20 acres, with an additional approximately 6.5 acres of clearing around the Site perimeter. Panels to be arranged in rows with a spacing of ten feet between rows.
- Panels to generally cover the southeast and northwest facing slopes of Fearing Hill with access provided from Fearing Hill Road to the south.
- Two electrical transformers and other electrical infrastructure for metering and connection to the grid.
- Stormwater management at the Site provided primarily by two detention basins with overflow to adjacent wetland areas. Two small infiltration trenches are also proposed for water quality treatment of runoff form two small areas of impervious cover.

The nearest neighbors to the Site are two residential homes immediately adjacent to the southern boundary of the Site. Another seven residential properties are located approximately 50 feet away across Fearing Hill Road, and another seven are located on Helen Street 70 to 100 feet from the Site. Between the Site and the homes on Helen Street is the right-of-way of the abandoned Fairhaven Branch Railroad which has been identified by the Town of Wareham as a potential bike route connecting the proposed Marion bikeway to the Cape Cod Canal bike path. Figure 1 is a Site locus depicting key Site features including the proposed development footprint and stormwater detention basins, nearest neighbors, the western drainage ditch between the Site and its nearest western neighbors, and the wetlands to the northwest of the Site.

Homes near the Site are served by individual septic systems for wastewater. Potential hydrologic impacts to these homes include increased stormwater runoff generated from the Site with resulting inundation concerns. Based on field observations of the water table and experience with the regional hydrogeology, HW understands that the area surrounding the Site experiences high groundwater levels. Another key concern investigated in this report is the potential for the proposed development to create negative impacts related to high groundwater.

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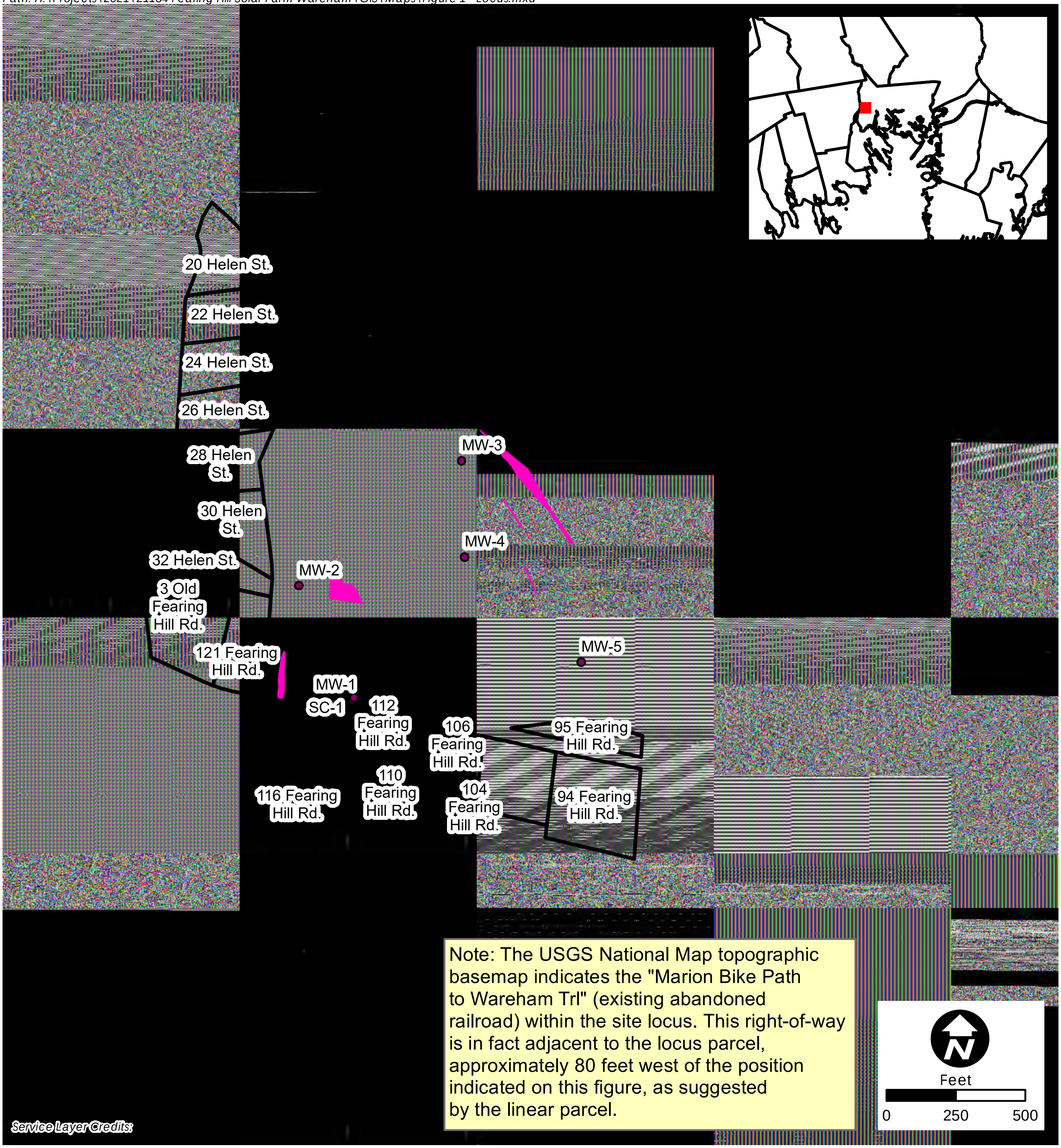
*Path: H:\Projects\2021\21134 Fearing Hill Solar Farm Wareham\GIS\Maps\Figure 1 - Locus.mxd*




Date: 5/17/2022
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

*This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.*

- Monitoring Wells
- Neighboring Parcels of Interest
- Detention Basins (approximate)
- Clearing Extent (approximate)
- Site Locus Parcel
- Wareham Tax Parcels

Figure 1
Locus

Any potential increase in water table elevation (mounding) could impact the performance of nearby septic systems and their compliance with Massachusetts Title 5 regulations. As such, the focus of this study is on potential hydrogeologic and hydrologic concerns for these nearest neighbors.

HW understands that town water is available along Fearing Hill Road, but some residents may still be served by private wells for drinking water. Water quality impacts to private drinking wells is not considered a significant potential concern because the proposed land use and land cover changes are not likely to alter groundwater quality significantly, and not sufficiently to create regulatory concerns. The only potential private drinking water well quality concern would occur if stormwater runoff increased sufficiently to inundate a private well head and allow for "short-circuiting" of surface water down the outside of the well casing. The likelihood of this potential water quality concern is assessed indirectly through the assessment of potential changes in stormwater runoff.

Please note that this is not a formal regulatory review of the proposed project. We have not attempted to assess compliance with local or state regulations. This study focused on the assessment of potential groundwater and stormwater runoff changes anticipated to occur resulting from the proposed project, and any associated impacts to existing neighbors and infrastructure.

## 2) EXISTING INFORMATION REVIEW

The following documents and plans were provided by the Applicant and reviewed by HW:

- Site Plan Application, Fearing Hill Road Solar Project, 91 & 101 Fearing Hill Road, Wareham, MA, prepared by Atlantic Design Engineers, Inc., dated May 17, 2021 (127 pages).
- Stormwater Report, Fearing Hill Road Solar Project, 91 & 101 Fearing Hill Road, Wareham, MA, prepared by Atlantic Design Engineers, Inc., dated May 17, 2021 (90 pages).
- HydroCAD model "3055.01- FEARING HILL RD – PRE," prepared by Atlantic Design Engineers, Inc., received February 17, 2022.
- HydroCAD model "3055.01- FEARING HILL RD – POST," prepared by Atlantic Design Engineers, Inc., received February 17, 2022.
- Site Development Plans, Fearing Hill Road Solar Project, 91 & 101 Fearing Hill Road, Wareham, MA, prepared by Atlantic Design Engineers, Inc., dated May 17, 2021, which includes:
    - Cover Sheet 1
    - Overall Existing Conditions Plan 2
    - Overall Site Development Plan 3
    - Site Development Plan 4
    - Site Development Plan 5
    - Site Development Plan 6
    - Detail Plan 7

HW also reviewed the following supplemental documents:

- "Freshwater Wetland Program and Stormwater Construction Permitting Ground-Mounted Solar Array Guidance," Rhode Island Department of Environmental Management (RIDEM), dated June 2021
- "Hydrogeology and simulation of groundwater flow in the Plymouth-Carver-Kingston-Duxbury aquifer system, southeastern Massachusetts: U.S. Geological Survey Scientific Investigations Report 2009–5063," Masterson, J.P., Carlson, C.S., and Walter, D.A., 2009
- "Hydrologic Response of Solar Farms," Cook, L.M., and McCuen, R.H., Journal of Hydrologic Engineering, 18(5): 536-541, 2009
- "Surficial Materials Map of the Snipatuit Pond Quadrangle, Massachusetts", quadrangle 154 in "Stone, J.R., Stone, B.D., DiGiacomo-Cohen, M.L., and Mabee, S.B., comps., Surficial materials of Massachusetts – A 1:24,000-scale geologic map database: U.S. Geological Survey Scientific Investigations Map 3402" Stone, B.D., DiGiacomo-Cohen, M.L., and Kincare, K.A., 2018
- "Wareham, Massachusetts Bike Path Feasibility Study," Weston and Sampson, August 18, 2010.
- "Wetlands Program Policy 17-1: Photovoltaic System Solar Array Review," Massachusetts Department of Environmental Protection (MADEP), effective September 23, 2017
- Schueler, T, 1987. "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs." Metropolitan Washington Council of Governments. Washington DC. 275 pp.

Following review of the existing information and consultation with Atlantic, HW designed a field program to provide the necessary on-Site subsurface information to inform the hydrogeologic study.

## 3) SITE FIELD WORK PROGRAM

Field work was primarily conducted by Atlantic and its subcontractors, with frequent Site observations made by HW. The completed field work includes:

- Completion of eight test pits;
- Performance of three percolation tests;
- Drilling of six monitoring wells;
- Survey of monitoring well locations and elevations; and
- Collection of water level data manually and using automated water level data loggers.

Maps detailing the locations of the test pits, percolation tests, and monitoring wells are attached in Appendix A, along with the pertinent Title 5 Forms, well boring logs, and well completion reports.

Following completion of the test pits and monitoring wells, HW collected three rounds of water level measurements from the monitoring wells to date, installed data loggers in three of the monitoring wells, and produced water table maps (Figures 3 and 4) for the Site for two different dates using survey information provided by Atlantic. HW is currently conducting preliminary analyses to model groundwater flow at the site, understand runoff effects under existing and proposed conditions, and anticipate groundwater mounding beneath the proposed stormwater management facilities.

## 3.1 Test Pits and Percolation Tests

Test pits (TPs) were dug by Zenith Consulting Engineers, LLC. (ZCE) with HW personnel observing. The first test pit was dug on December 8th, 2021, but due to access limitations, the other test pits and percolation tests were delayed until paths were cleared a few weeks later. The remaining test pits were completed January 5th and 6th, 2022. Please see Attachment A for locations of the TPs and percolation tests, and Attachment B for the TP soil logs and results of the percolation tests.

The following summarizes observed test pit conditions:

- TP-1 is the southernmost test pit at the proposed Fearing Hill Solar Facility Site and is located on the bottom of the southwestern slope of Fearing Hill. It was excavated to a depth of 114 inches (9.50 feet). The topsoil extended to seven inches below grade, followed by primarily Loamy Sand. Estimated depth to seasonal high groundwater (ESHGW) was indicated by soil mottling at 26 inches below ground surface. Groundwater was observed weeping at 58 inches below ground surface. A percolation test conducted in TP1 yielded a percolation rate of 13 minutes per inch.
- TP-2 is the westernmost test pit and is located approximately 400 feet northwest of TP-1 near the bottom of the southwestern downslope of Fearing Hill. It was excavated to a depth of 96 inches (eight feet). The topsoil extended down to 12 inches below grade, followed primarily by Sandy Loam. ESHGW was indicated by soil mottling at 20 inches below ground surface, which was also the depth where the Sandy Loam transitioned to medium sand. The soil texture changed from medium sand to medium to coarse sand and gravel at a depth of 58 inches. Groundwater was observed weeping at 44 inches below ground surface, and standing water was encountered at a depth of 68 inches. A percolation test at TP-2 yielded a percolation rate of less than two minutes per inch.
- TP-3 is located roughly 150 feet northeast of TP-2, directly upgradient towards the crest on the southwest slope of Fearing Hill. It was excavated to a depth of 100 inches (8.33 feet). Topsoil extended to six inches below ground surface, followed by Loamy Sand between 6-18 inches below grade, medium sand between 18-56 inches, and Loamy sand from 56 inches to the bottom. ESHGW was indicated by mottling at 20 inches below grade, and groundwater was observed weeping at 52 inches below grade. No standing water was present.

- TP-4 is located approximately 300 feet northeast of TP-3, at the top of Fearing Hill. It was dug to a depth of 96 inches (eight feet). Topsoil was present to eight inches below ground surface, before transitioning to Sandy Loam. ESHGW was indicated by mottling at 42 inches below grade. No weeping or standing groundwater were observed.
- TP-5 is located about 200 feet northeast of TP-4, on the northeastern downslope of Fearing Hill. It was excavated to a depth of 92 inches (7.66 feet), with topsoil extending to eight inches in depth. Sandy Loam subsoil was encountered between eight inches in depth to the bottom of the pit. ESHGW was indicated by mottling at 28 inches below grade. No weeping or standing groundwater were observed at the time of excavation. The soils at TP-5 were deemed too compact to perform a percolation test.
- TP-6 was located about 200 feet northwest of TP-5, and almost 250 feet due north from TP-4, on the northeastern downslope of Fearing Hill. Topsoil extended to a depth of eight inches, followed by Sandy Loam subsoil down to the excavated depth of 118 inches (9.8 feet). ESHGW was indicated by soil mottling at 38 inches below grade. No weeping or standing groundwater was observed.
- TP-7 is the southeasternmost test pit at the site, located roughly 500 feet east of TP-1. Topsoil extended to a depth of eight inches, followed by Sandy Loam subsoil down to the excavated depth of 96 inches (eight feet). ESHGW was indicated by soil mottling at 26 inches below grade. No weeping or standing groundwater was observed.
- TP-8 is located about 200 feet southeast of TP-5, and about 300 feet due east of TP-4, on the northeastern slope of Fearing Hill. Topsoil extended to a depth of eight inches, followed by Sandy Loam subsoil down to the excavated depth of 110 inches (9.16 feet). ESHGW was indicated by soil mottling at a depth of 36 inches. No weeping or standing groundwater was observed.

### 3.2 Monitoring Well Installation

Monitoring well (MW) installations were overseen by Atlantic with observation by HW personnel. The boreholes were drilled by Northern Drill Service between January 10th and January 13th, 2022, using drive and wash methodology with two-foot-long split spoon samples collected at every 5-foot depth interval below the advancement of drilling in order to characterize the subsurface materials encountered. The location of each monitoring well is shown in Attachment C. Drill rig access to the forested site was difficult. To minimize the amount of tree-clearing disturbance monitoring wells were located along the Site perimeter and at or near the network of existing cart paths in the Site interior. Due to tree blowdowns during storm events in the fall of 2021, significant clearing of downed trees was required to obtain access, even along the existing cart paths. Despite access limitations, monitoring wells were able to be placed in suitable locations to identify groundwater variations across the site.

Except for MW-1, all monitoring wells were completed with ten feet of slotted PVC screen spanning from approximately two feet above the water table to eight feet below the water table. Well screens were backfilled with bagged medium to coarse sand to ensure good communication between the well and the surrounding formation. At the MW-1 location, adjacent shallow and deep monitoring wells were installed to observe the presence of any potential vertical gradients. The shallow well has two feet of screen at and immediately below the water table while the deep well has ten feet of screen with the bottom immediately above bedrock. Monitoring wells were completed with bagged sand to two feet above the screen, followed by two feet of bentonite chips, then sand to just below ground surface (BGS), concrete at the ground surface, PVC casing above the ground surface by approximately two to three feet, and a steel protective casing with a locking cap. Well Completion Reports are included as Attachment D. HW boring logs for the wells are in Attachment E with more detailed soil descriptions than shown on the Driller's logs. Well locations are indicated in Figure 1 above.

The following summarizes the observed MW installations:

- MW-1 was drilled and completed on January 10$^{th}$, 2022. Due to access constraints, MW-1 was drilled approximately 120 feet east of the original intended location. It is the southernmost monitoring well and is closest to Fearing Hill Road. When MW-1 was being drilled at its new location, a boulder halted drilling operations approximately 13 feet BGS. MW-1 was then re-drilled several feet adjacent to the first borehole. The final MW-1 borehole was drilled to a refusal depth of 36 feet. Bedrock was encountered at 34 feet. Groundwater was encountered approximately three feet BGS. Subsurface materials were observed to become somewhat coarser with depth.

  A monitoring well was constructed in this boring with the bottom ten feet of the hole above bedrock screened with slotted PVC. A second adjacent monitoring well with two feet of slotted PVC screen was placed at the water table from three to five feet BGS. The shallow well is depicted on Attachment C as MW SC-1. Going forward, HW will be referring to these two wells as MW-1S and MW-1D, indicating shallow and deep well screens. The adjacent wells, screened at different depths, will help to identify the potential presence of any vertical groundwater gradients.

- MW-2 was completed on January 11$^{th}$, 2022. It is located about 450 feet northwest of MW-1 and is the westernmost monitoring well at the site. Bedrock was encountered at 31 feet BGS, with refusal at 34 feet. Groundwater was encountered approximately 3.5 feet BGS. The subsurface materials encountered were primarily medium to coarse Sand with minimal gradation with depth.

- MW-3 was completed on January 12$^{th}$, 2022 and is the northernmost monitoring well at the Fearing Hill site. Groundwater was encountered at approximately ten feet BGS, and bedrock was encountered at 33 feet BGS. The subsurface materials encountered were primarily fine to medium Sand with some fining with depth.

- MW-4 was drilled on January 13$^{th}$, 2022, near the crest of Fearing Hill. It is approximately 350 feet to the south of MW-3. Groundwater was encountered at approximately 13.5 feet BGS, and bedrock at 16.5 feet BGS. The subsurface materials encountered were primarily fine to medium Sand with some fining with depth.

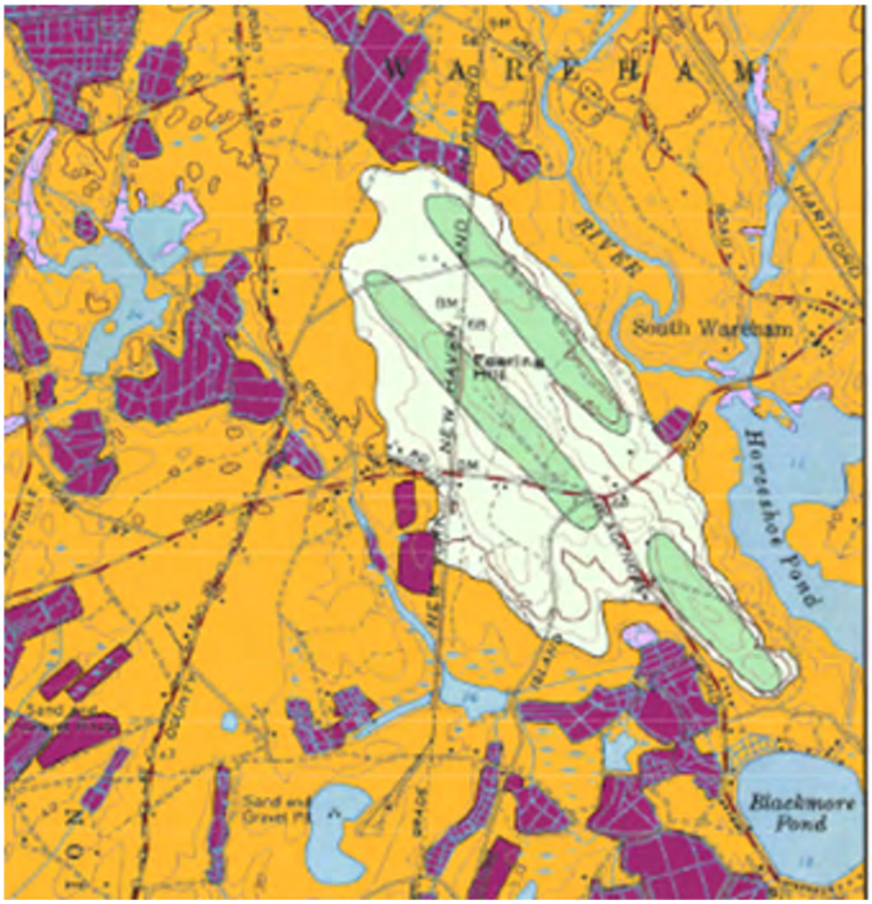
- MW-5 was also completed on January 13th, 2022, about 560 feet to the southeast of MW-4. The subsurface materials encountered were primarily fine to medium Sand with minimal coarsening with depth. Groundwater was encountered at approximately seven feet BGS during drilling, and bedrock was encountered at 19 feet BGS. Note that the groundwater level observation during drilling appears to have been artificially influenced by the drilling process as the well was observed to be dry at subsequent water level measurement rounds on January 26th and February 9th, 2022, despite the well being screened as deep as possible, immediately above bedrock.

The subsurface drilling program revealed geologic materials generally, though not fully, consistent with U.S. Geological Survey (USGS) surficial geologic mapping of the area. Figure 2 shows the USGS surficial geologic mapping for the Site as shown on the Snipatuit Pond Quadrangle Map. The darker green color covering the crest of Fearing Hill is defined by USGS as Thick Till and described as a non-sorted, non-stratified matrix of sand, some silt, and little clay containing some cobbles and boulders that becomes very compact at depth. This unit is mostly associated with drumlin landforms where till thickness commonly exceeds 100 feet. While the subsurface materials encountered at Fearing Hill are compact, as described by the USGS for Thick Till drumlin landforms, and the northwest to southeast orientation of Fearing Hill matches that of other drumlins in the nearby area and broader region of eastern Massachusetts, the depths to bedrock observed at Fearing Hill (as shallow as 16.5 feet at MW-4 at the crest of the hill) are far less than the 100-foot or greater thicknesses described for this drumlin-type unit by USGS. In addition, the subsurface materials encountered at Fearing Hill are in general somewhat coarser grained than the USGS description for Thick Till associated with drumlins.

The lighter colored green comprising the lower elevations of the Site and immediate surrounding area are defined by USGS as Thin Till and described as a non-sorted, non-stratified matrix of sand, some silt, and little clay containing some cobbles and boulders that is loose to moderately compact, and where till thickness is generally less than ten to 15 feet. In some regard, the USGS description for Thin Till is a better match for observed subsurface conditions onsite than is Thick Till. On the other hand, the northwest to southeast orientation of Fearing Hill is consistent with drumlin orientation. Whether the Fearing Hill site is Thin Till as opposed to a Thick Till drumlin landform is not significant for the overall hydrogeologic assessment purposes of this project. Subsurface materials encountered onsite have generally low permeability and high runoff characteristics, regardless of the mapped landform type.

Other geologic materials mapped by USGS for the Site area and shown on Figure 2 are coarse-grained glacial outwash deposits in orange and cranberry bogs in purple.

**Figure 2: USGS surficial geologic mapping of Site area**




## 3.3 Survey

Atlantic surveyed the wells at the Site initially on January 25th, 2022, and then later for better accuracy on February 15th, 2022.The spatial data are in reference to the North American Datum of 1983 (NAD 83) feet, and the elevation data are in reference to the North American Vertical Datum of 1988 (NAVD 88) feet. Survey and other relevant monitoring well data are displayed below in Table 1.

**Table 1: Elevation and location data for Fearing Hill monitoring wells**

| Monitoring Well | Northing (ft) | Easting (ft) | Ground Elevation (ft) | Total Well Depth (ft) | Top of PVC Elevation (ft) |
|---|---|---|---|---|---|
| **MW-1D** | 2741042 | 856272.4 | 62.26 | 36.74 | 65.13 |
| **MW-1S (SC-1)** | 2741050 | 856276.4 | 61.89 | 6.72 | 64.55 |
| **MW-2** | 2741452 | 856079.4 | 64.55 | 14.90 | 67.44 |
| **MW-3** | 2741903 | 856664.6 | 80.90 | 19.90 | 83.44 |
| **MW-4** | 2741556 | 856675.9 | 89.92 | 18.32 | 92.27 |
| **MW-5** | 2741177 | 857095.0 | 83.24 | 19.58 | 85.99 |

## 3.4 Water Table Measurements

Depth-to-water (DTW) and total-well-depth (TWD) measurements were taken by HW as drilling was completed on January 12th and13th, and then three times after on January 26th, February 9th, and April 18th, 2022. Measurements were taken in feet from the top of the PVC casing using a Heron Dipper-T water-level meter. Using the top of PVC monitoring well elevations surveyed by Atlantic, the depth-to-water measurements were then converted to water table elevation data and are listed below in Tables 2-5.

Water table conditions at the Site changed between the three visits. On January 26th, there was little to no snow on the ground, and according to a local weather station approximately half a mile from the Site (West Wareham Weather Underground station ID KMAWESTW35), the last significant precipitation event occurred 11 days prior on January 17th with 0.42 inches of rain. A total of 2.29 inches of precipitation occurred between the January 26th and February 9th Site visits (West Wareham, Weather Underground). At the time of the February 9th Site visit there was a noticeable amount of snow and standing water at the lower elevations at the site. These wetter conditions are reflected in the water level data as water elevations rose between 0.69 and 1.93 feet in the various monitoring wells between January 26th to February 9th, 2022. As expected, there was a greater increase in water table elevation on the sides of the hill, and a lesser increase at the top, as groundwater flowed downhill away from the topographic high. MW-5 remained dry during both Site visits.

Other than the overall wetter conditions observed at the February 9th Site visit relative to the January 26th visit, both water table maps show a consistent pattern of groundwater flow radiating outward from the top of Fearing Hill towards the perimeter of the hill to the west, southwest, south, southeast, and east. No data are available to assess groundwater flow to the north.

In between the February 9th and April 18th Site visits a total of 10.23 inches of precipitation occurred (West Wareham, Weather Underground) and the trees had not yet leafed out. Water levels at that time would, therefore, be anticipated to be at or near the seasonal high for any given year. Examination of the data in Tables 4 and 5 shows that Site water levels at the April 18th measurement round were in fact at or near their monitoring period high for Wells MW-3 and MW-4, located along the ridge of the hill. However, water levels at the lower elevation wells, MW-1 cluster and MW-2, were slightly lower than were observed on February 9th. MW-5 remained dry on April 18th.

Water level data from the shallow and deep well cluster at location MW-1 revealed a moderate to strong downward gradient (0.32, 0.41, 0.24, and 0.11 feet, respectively for January 12th, January 26th, February 9th, and April 18th) over the various measurement rounds. This downward gradient is indicative of prevailing groundwater recharge conditions with groundward traveling downward at the Site before moving laterally away from the hill.

**Table 2: Monitoring well data: January 12th and January 13th, 2022**

| Well | Date | Depth to Water (ft) | Water Table Elevation (ft) |
|---|---|---|---|
| **MW-1D** | 1/12/22 | 5.43 | 59.7 |
| **MW-1S** | 1/12/22 | 3.53 | 61.02 |
| **MW-2** | 1/12/22 | 5.92 | 61.52 |
| **MW-3** | 1/12/22 | 12.46 | 70.98 |
| **MW-4** | 1/13/22 | 15.42 | 76.85 |
| **MW-5** | Did not measure. Well not yet completed | N/A | N/A |

**Table 3: Monitoring well data: January 26th, 2022**

| Well | Depth to Water (ft) | Water Elevation (ft) |
|---|---|---|
| **MW-1D** | 5.84 | 59.29 |
| **MW-1S** | 3.85 | 60.70 |
| **MW-2** | 6.39 | 61.05 |
| **MW-3** | 12.65 | 70.79 |
| **MW-4** | 16.11 | 76.16 |
| **MW-5** | Dry | <66.41 |

**Table 4: Monitoring well data: February 9th, 2022**

| Well | Depth to Water (ft) | Water Elevation (ft) |
|---|---|---|
| **MW-1D** | 3.91 | 61.22 |
| **MW-1S** | 2.09 | 62.46 |
| **MW-2** | 4.54 | 62.90 |
| **MW-3** | 11.13 | 72.31 |
| **MW-4** | 15.42 | 76.85 |
| **MW-5** | Dry | <66.41 |

**Table 5: Monitoring well data: April 18th, 2022**

| Well | Depth to Water (ft) | Water Elevation (ft) |
|---|---|---|
| **MW-1D** | 3.94 | 61.19 |
| **MW-1S** | 2.25 | 62.3 |
| **MW-2** | 5.07 | 62.37 |
| **MW-3** | 8.88 | 74.56 |
| **MW-4** | 10.69 | 81.58 |
| **MW-5** | Dry | <66.41 |

### 3.5 Water Table Mapping

HW made two water table elevation maps using the data from the January 26th and February 9th Site visits (Figures 3 and 4). Initial water level measurements from January 12th and 13th, 2022 were not used because the MW-5 well was not yet complete at those times and because measurements taken immediately after drilling are frequently inaccurate due to the artificial influences of the drilling process. Water table mapping was completed prior to the April 18th monitoring round and the data from that round, although higher overall than prior rounds, would not have created appreciably different mapping of flow directions than already completed. Water table mapping from the MW-1 location used data from the MW-1S shallow well to use consistent data from only wells screened at the water table.

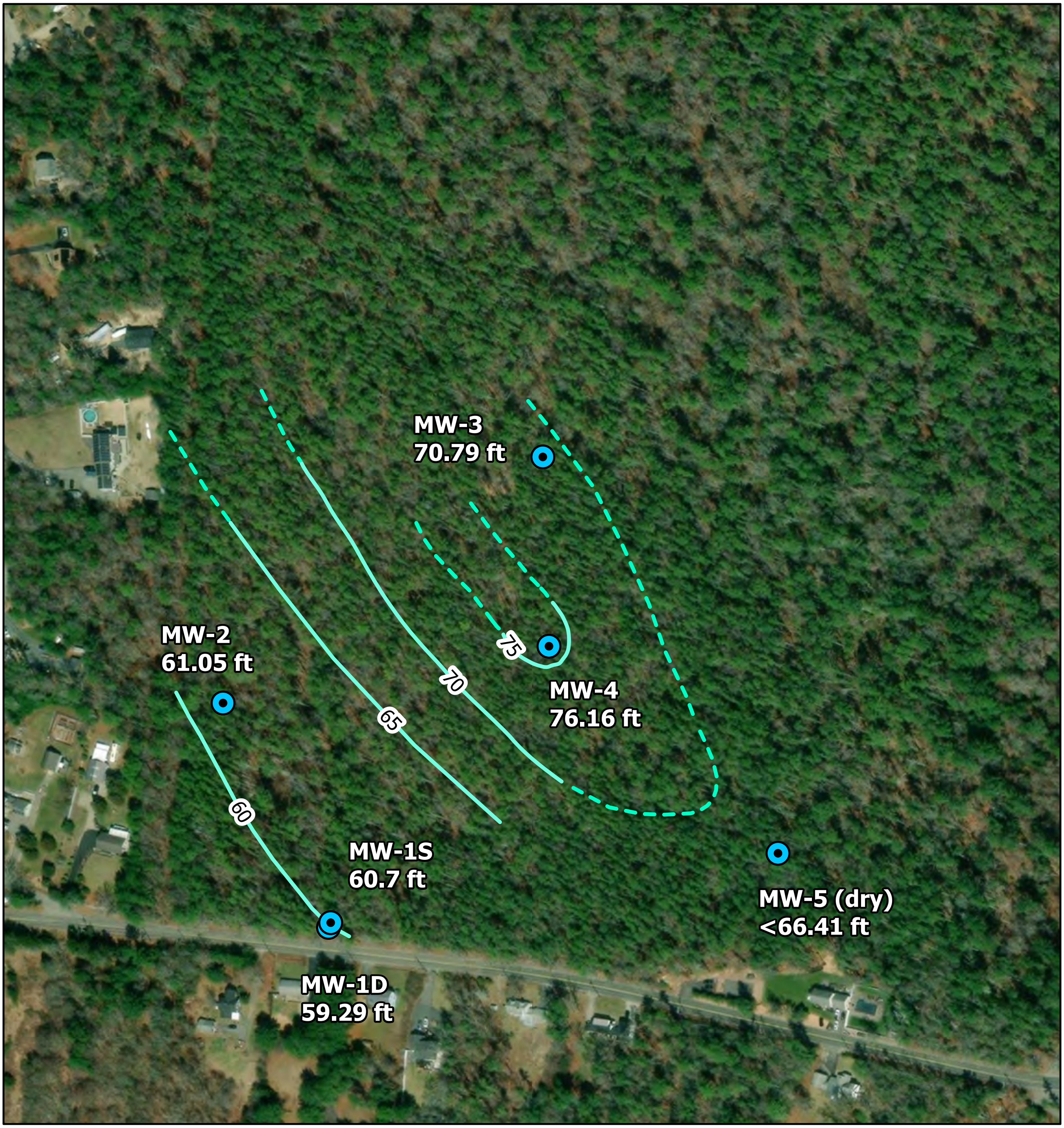
### 3.6 Comparison to USGS Index Well Data

To better place the Site water levels observed during the relatively brief project monitoring period (January 12th to April 18th, 2022) in better historical context, data from nearby USGS index wells was downloaded for comparison. USGS maintains a relatively small subset of index wells equipped with continuous water level loggers from which real time data are available on the internet. The closest of these real time index wells is in Lakeville (MA-LKW 14R), approximately 11 miles northwest from the Site, and data from that well are plotted on Figure 5 along with the continuous water level data collected from the Site monitoring wells for consistency. The USGS Lakeville well is in more permeable sand and gravel deposits than are the Site wells on Fearing Hill, which are in till. Its data record therefore provides a useful analog for what typical water level fluctuations might be expected in a more permeable sand and gravel aquifer under similar climatic influences as experienced at the Site.

USGS also maintains a larger group of index wells from which manual water level measurements are collected monthly. The closest of these index wells to the Site is MA-WFW 51, located approximately two miles to the southeast in the downtown area of Wareham. While close to the Site, this index well is in more permeable sand and gravel deposits than the till deposits at the Site and is also significantly closer to the ocean (where water table fluctuations are typically less than at inland locations). The closest index well to the Site located in till is MA-MTW 82, located approximately 15 miles to the northwest in Middleboro. Available water level data from these two USGS index wells for the Site monitoring period are listed in Table 6, below.

**Table 6: USGS index wells manual data: December 2021 - April 2022**

| Date | Wareham MA-WFW 51 Water Elevation (NAVD88 ft) | Middleboro MA-MTW 82 Water Elevation (NAVD88 ft) |
|---|---|---|
| **12/15/2021** | 11.23 | 34.55 |
| **1/26/2022** | 11.14 | 35.13 |
| **2/22/2022** | | 39.83 |
| **2/23/2022** | 12.41 | |
| **3/28/2022** | | 38.72 |
| **3/29/2022** | 12.57 | |

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**Legend**

- Fearing Hill Monitoring Wells
- Water Table Contours (5 Foot Intervals)
- Interpolated Contours

Datums:

Vertical: NAVD 88
Horizontal: NAD 83

N

0 125 250 500 Feet

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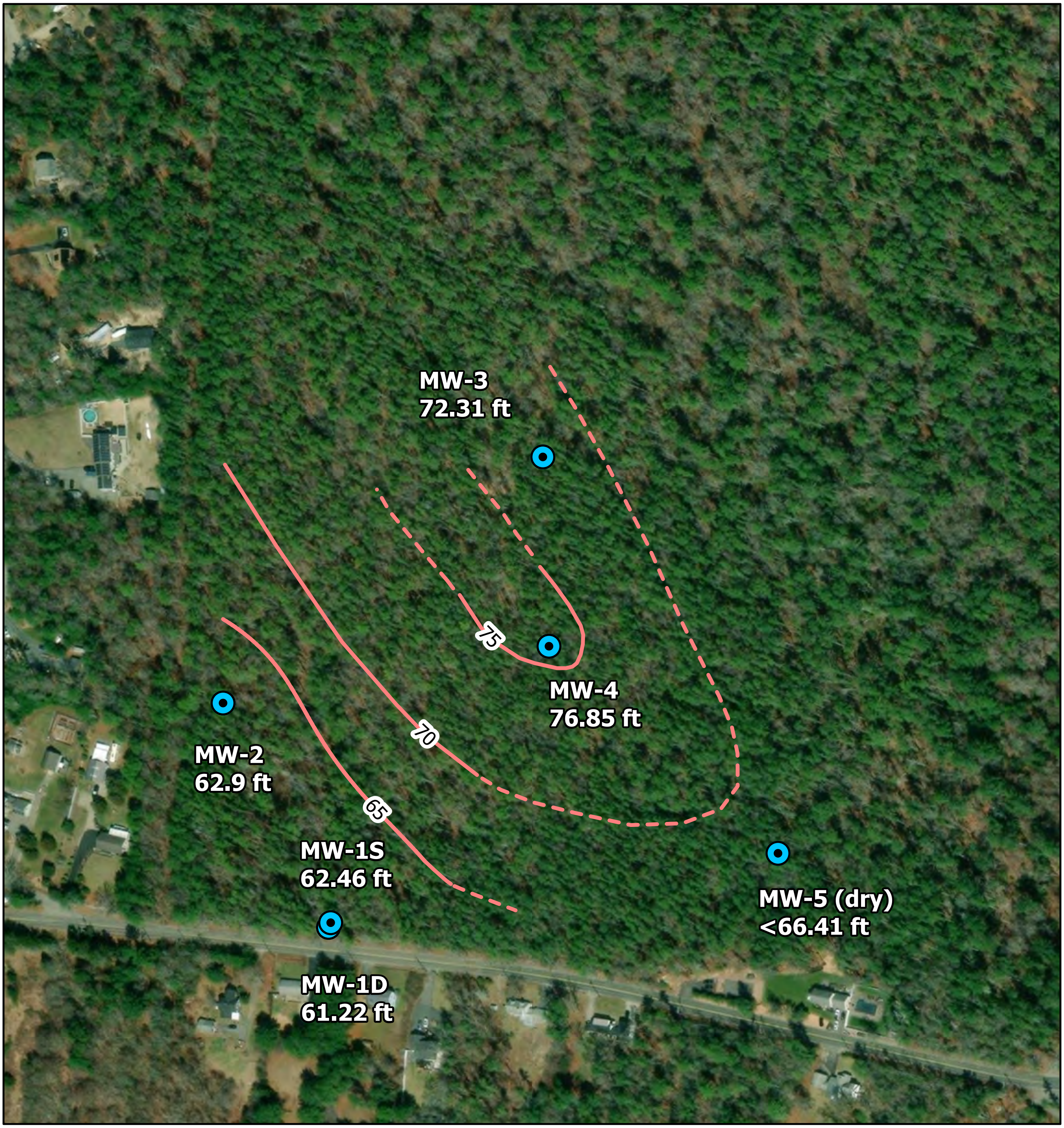
Fearing Hill Water Table Contours
January 26th, 2022

Date: 3/24/2022

Figure 3

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**Legend**

- Fearing Hill Monitoring Wells
- Water Table Contours (5 Foot Intervals)
- Interpolated Contours

Datums:

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Fearing Hill Water Table Contours
February 9th, 2022

Date: 3/24/2022

Figure 4

Visual observation of the Middleboro index well's entire period of record from 1965 to present indicates minimum, maximum, and mean water level elevations of approximately 26.4, 42.5, and 34.0 feet, respectively. Visual observation of the Wareham index well's entire period of record from 1960 to present indicates minimum, maximum, and mean water level elevations of approximately 7.4, 15.6, and 11.0 feet, respectively. Therefore, based on the long-term data from these two index wells, the prevailing hydrologic conditions observed at the Site during the Site monitoring period were generally slightly wetter than the anticipated long-term average conditions, though not appreciably so. Data from the beginning of the Site monitoring period in January 2022 were likely the closest to long-term average conditions.

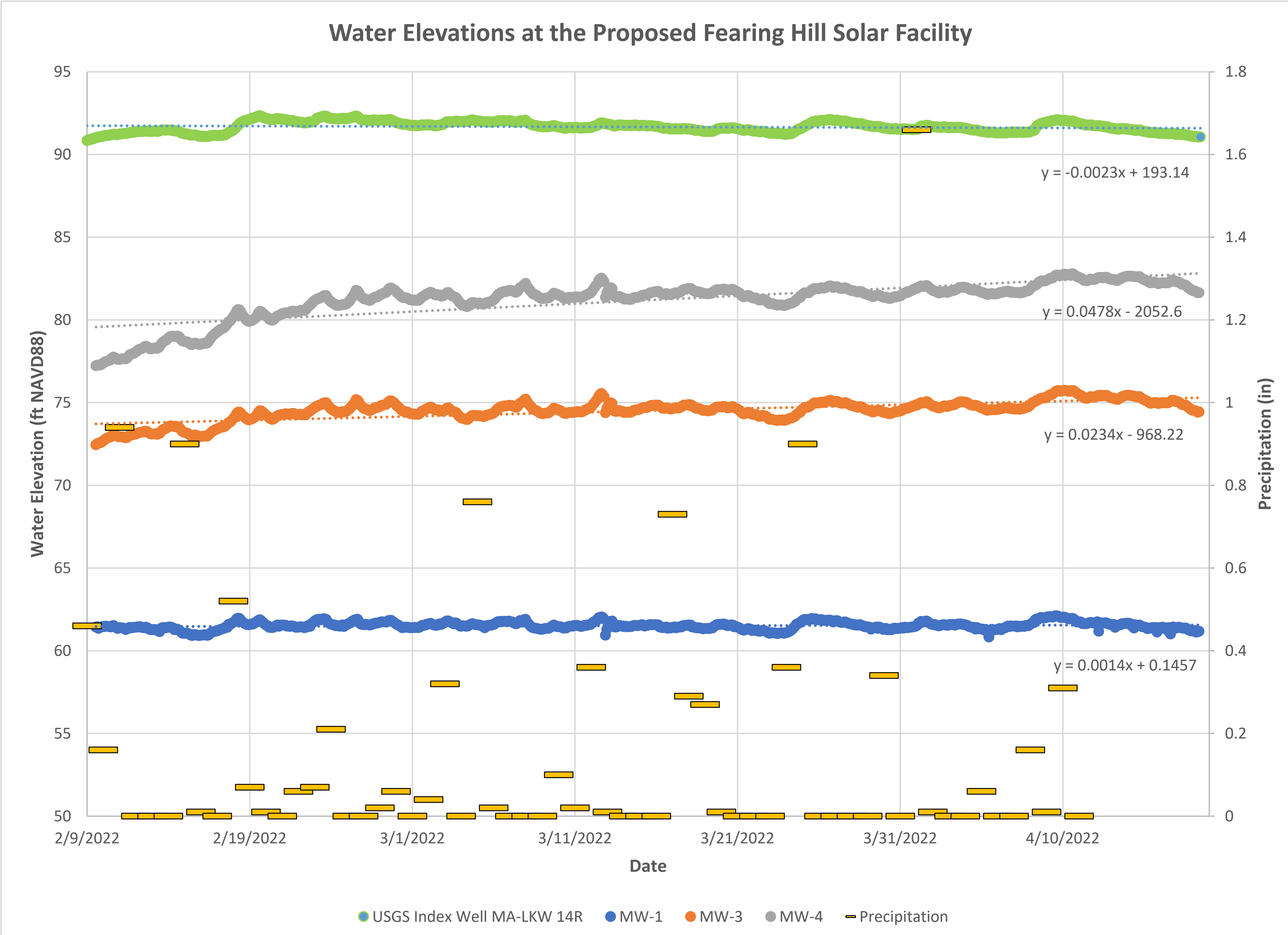
### 3.7 Water Level Logger Data

On February 9th, 2022, Van Essen Diver brand automated water level loggers were placed in wells MW-1, MW-3, and MW-4 to continuously monitor water levels for an extended duration. A separate logger to record barometric pressure was placed on site. The loggers were programmed to take readings every two hours starting at 1100 hours on February 9th. The loggers were removed and data downloaded on April 18, 2022, for a total monitoring period of approximately two and a half months. Figure 5 shows the continuous record of water levels from Site monitoring wells MW-1, MW-3, and MW-4, as well as from USGS Index well MA-LKW 14R in Lakeville, from February 9th to April 18th, 2022. Daily precipitation data from Weather Underground Station ID KMAWESTW35 is also shown on Figure 5.

As can be seen on Figure 5, water levels at Site well MW-1, located at the southwest base of the hill in relatively more permeable materials, exhibits similar water level fluctuations to those observed at the Lakeville index well. Site wells MW-3 and MW-4, located higher on the hill in denser till deposits, exhibit both higher overall water table elevations and a greater range of fluctuations. The greater range and higher frequency of water level fluctuations observed in Site monitoring wells MW-3 and MW-4 are typical of wells located in denser materials with a relatively shallow depth to bedrock. The responses of MW-3 and MW-4 to precipitation events are also greater than for the index well or MW-1 at the base of Fearing Hill. Table 7 lists the minimum, maximum, range, mean, and median water elevations for each of the monitoring wells shown on Figure 5.

**Table 7: Monitoring well water elevation statistics**

| Well | Minimum Water Elevation (ft) | Maximum Water Elevation (ft) | Water Elevation Range (ft) | Mean Water Elevation (ft) | Median Water Elevation (ft) |
|---|---|---|---|---|---|
| **MW-1D** | 60.82 | 62.11 | 1.29 | 61.51 | 61.50 |
| **MW-3** | 72.45 | 75.74 | 3.29 | 74.51 | 74.61 |
| **MW-4** | 77.22 | 82.78 | 5.56 | 81.19 | 81.54 |
| **USGS MA-LKW 14R** | 61.72 | 62.57 | 0.85 | 62.12 | 62.11 |




H:\Projects\2021\21134 Fearing Hill Solar Farm Wareham\Field Data\Logger Data\Compensated\Compiled_Data.xlsx

Figure 5

## 4) STORMWATER RUNOFF ASSESSMENT

Following current standard practices, stormwater runoff from the Site was assessed by Atlantic using HydroCAD modeling software. The purpose of the HydroCAD evaluation is to compare existing to proposed stormwater runoff conditions relative to the ten Massachusetts Stormwater Management Standards (MSWMS). The ten MSWMSs (paraphrased) are:

1. No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.
2. Post-development peak discharge rates may not exceed pre-development peak discharge rates.
3. The annual recharge from the post-development Site shall approximate the annual recharge from pre-development conditions based on soil type.
4. Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).
5. For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.
6. Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook.
7. A redevelopment project is required to meet the following Stormwater Management Standards 2, 3, 4, 5, and 6 only to the maximum extent practicable.
8. A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.
9. A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.
10. All illicit discharges to the stormwater management system are prohibited.

This project has minimal proposed impervious area; therefore, the standards of highest concern are Standard 1 (for erosion control) and Standard 2 (peak discharge and flooding management).

HW modified the Atlantic HydroCAD model based upon our professional judgement and assessment of Site conditions based on the field data collection tasks conducted previously, and then used the modified HydroCAD model to independently assess potential stormwater runoff concerns.

## 4.1 Models prepared by Atlantic Design Engineers

Atlantic prepared a pre- and post-development HydroCAD model for the proposed solar development. The pre-development model consists of two drainage areas and the associated two study points to the east and west of Fearing Hill. Drainage Area 1S is 18.6 acres of woods on the northeast side of Fearing Hill and drains to Study Point 1, the wetland to the northeast of the hill. Drainage Area 2S is 17.6 acres on the southwest side of Fearing Hill and drains to Study Point 2. Less than 1% of Drainage Area 2S is grass and the rest is woods. Appendix B contains the relevant drainage area maps.

The post-development model splits each existing drainage area into two sub-catchments: 1Sa (routed to Detention Pond 1) and 1S; 2Sa (routed to Detention Pond 2) and 2S. The detention ponds were designed to attenuate peak flows from the 2-, 10- and 100-year storms. Total runoff volume as calculated by Atlantic is increased under proposed conditions by 9-20% for both study points for all storms.

## 4.2 Recommended Changes to Modeled Precipitation Values

Atlantic's modeled storm depths use values from the Hydrology Handbook for Conservation Commissioners, published in 2002. HW recommends using the NOAA+ rainfall values to model storm events (NOAA Atlas 14 90% Upper Confidence value multiplied by 0.9). These values are more accurate because of their basis on more current rainfall data and, based on pending draft updates to the Massachusetts Stormwater Handbook, will soon be the required rainfall amounts. Therefore, HW believes it is best practice to use these NOAA+ rainfall values. NOAA+ rainfall values are listed below in Table 8.

**Table 8: Precipitation values for design and hydrologic/hydraulic analysis**

| Storm Frequency (24-hour – Type III Storm) | Precipitation Value (inches) (Hydrology Handbook) | Precipitation Value (inches) (NOAA+) |
|---|---|---|
| **2-year** | 3.40 | 3.68 |
| **10-Year** | 4.70 | 5.44 |
| **25-Year** | N/A | 6.71 |
| **100-Year** | 7.00 | 8.78 |

When the NOAA+ rainfall values are used in Atlantic's original models, the detention basins adequately attenuate the peak flows, but the total runoff volume for post versus pre-development is increased slightly for each storm. See Table 9 below.

**Table 9: pre-and post-development flows with NOAA+ rainfall in Atlantic models**

| DP1 | East Wetland | | | | | |
|---|---|---|---|---|---|---|
| Event | *Pre-development* | | *Post-development* | | Change | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 17.31 | 1.800 | 16.24 | 2.100 | -6% | 17% |
| 10-yr | 37.91 | 3.800 | 35.81 | 4.200 | -6% | 11% |
| 25-yr | 54.25 | 5.400 | 49.88 | 5.900 | -8% | 9% |
| 100-yr | 82.15 | 8.200 | 73.46 | 8.700 | -11% | 6% |

| DP2 | West Wetland | | | | | |
|---|---|---|---|---|---|---|
| Event | *Pre-development* | | *Post-development* | | Change | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 9.66 | 1.200 | 9.33 | 1.400 | -3% | 17% |
| 10-yr | 26.06 | 2.800 | 25.93 | 3.200 | 0% | 14% |
| 25-yr | 39.82 | 4.100 | 38.81 | 4.600 | -3% | 12% |
| 100-yr | 64.20 | 6.500 | 60.94 | 7.100 | -5% | 9% |

| *ALL* | *ALL COMBINED* | | | | | |
|---|---|---|---|---|---|---|
| Event | *Pre-development* | | *Post-development* | | Change | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 26.97 | 3.000 | 25.57 | 3.500 | -5% | 17% |
| 10-yr | 63.97 | 6.600 | 61.74 | 7.400 | -3% | 12% |
| 25-yr | 94.07 | 9.500 | 88.69 | 10.500 | -6% | 11% |
| 100-yr | 146.35 | 14.700 | 134.40 | 15.800 | -8% | 7% |

### 4.3 Recommended Changes to Pre-Development Model

In addition to the use of more updated precipitation values, we also recommend that the Time of Concentration factor and roughness coefficient selected for use in the Atlantic pre-development HydroCAD model be modified to more conservative values. In our opinion, the current Atlantic model overestimates the runoff that the Site currently generates based on the use of those less conservative input factors. HW modified the Atlantic pre-development model and created a new pre-development model that makes the following assumptions:

1. No change to Atlantic drainage areas or curve numbers.
2. Change Time of Concentration for both drainage areas: Sheet flow surface was described as “light underbrush” with a Manning’s roughness coefficient of 0.4. Based on

field observations, HW believes a description of "dense underbrush" is a more accurate description, which would result in a Manning's roughness coefficient of 0.8.

3. Time of Concentration for DA 2S: Shallow concentrated flow path appeared too short, so HW increased the flow length from 500 ft to 800 ft.

When HW's pre-development model is compared to Atlantic's pre-development model, total runoff volumes stay the same, but the peak flows are reduced by approximately 20% for all storms at both study points (see Table 10 below). Therefore, the HW model is a more conservative model from which the post-development models will be compared.

**Table 10: Pre-development Flows for Atlantic Model and HW Model**

| **DP1** | **East Wetland** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (Atlantic)*** | | ***Pre-development (HW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 17.31 | 1.80 | 14.02 | 1.800 | -19% | 0% |
| 10-yr | 37.91 | 3.80 | 30.64 | 3.800 | -19% | 0% |
| 25-yr | 54.25 | 5.40 | 43.84 | 5.400 | -19% | 0% |
| 100-yr | 82.15 | 8.20 | 66.37 | 8.200 | -19% | 0% |

| **DP2** | **West Wetland** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (Atlantic)*** | | ***Pre-development (HW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 9.66 | 1.20 | 7.82 | 1.200 | -19% | 0% |
| 10-yr | 26.06 | 2.80 | 20.76 | 2.800 | -20% | 0% |
| 25-yr | 39.82 | 4.10 | 31.67 | 4.100 | -20% | 0% |
| 100-yr | 64.20 | 6.50 | 51.03 | 6.500 | -21% | 0% |

| ***ALL*** | ***ALL COMBINED*** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (Atlantic)*** | | ***Pre-development (HW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 26.97 | 3.000 | 21.84 | 3.000 | -19% | 0% |
| 10-yr | 63.97 | 6.600 | 51.40 | 6.600 | -20% | 0% |
| 25-yr | 94.07 | 9.500 | 75.51 | 9.500 | -20% | 0% |
| 100-yr | 146.35 | 14.700 | 117.40 | 14.700 | -20% | 0% |

## 4.4 Recommended Changes to Post-Development Stormwater Model

In addition to the use of more updated precipitation values, we also recommend that the Curve Number selected for use in the Atlantic post-development HydroCAD model be modified to a more conservative value. In our opinion the Atlantic post-development model underestimates the runoff that the Site will generate once the panels have been installed because of the Curve Numbers selected for land cover. HW modified the Atlantic post-development model and created a new post-development model that makes the following assumptions:

1. No change to drainage area size or type of cover.
2. No change to Time of Concentration for any drainage area.
3. No change to Curve Number for wooded areas.
4. Change Curve Number for grass areas: The grass areas were classified as “good” condition. Based on recent Rhode Island Department of Environmental Management (RIDEM) guidance for solar facilities (see below), the grass will be “fair” condition. Curve numbers were therefore increased to reflect this condition.

RIDEM has recently published guidance for the design and permitting of ground-mounted solar arrays (RIDEM, 2021). While this project does not fall under RIDEM jurisdiction, this document provides current best practices for ground-mounted solar arrays in the region. The RIDEM guidance states that “In order for modeled ground cover to be considered in “good” hydrologic condition, at least 6” of loam cover must be provided.” Based on field observations and a review of the plans, HW was unable to confirm that 6” of topsoil would be provided throughout the site. In addition, as currently proposed, the panels vary between 12-14 feet in width with ten feet of spacing between the rows. RIDEM guidance recommends a minimum spacing between rows of panels equal to the width of the panels to provide sufficient light for the groundcover. Therefore, HW believes the grass will be in “fair” condition as the project is currently proposed.

When compared to HW’s edited pre-development model, the HW post-development model, created based on the above-listed assumptions, results in up to a 56% increase in peak flow and a 50% increase in total runoff volume exiting the Site under proposed versus existing conditions (Table 11). Therefore, the stormwater basins are undersized to manage the modeled increase in runoff as currently designed.

**Table 11: Pre- and post-development flows for HW Models**

| **DP1** | **East Wetland** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (HW)*** | | ***Post-development (SW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 14.02 | 1.800 | 20.89 | 2.600 | 49% | 44% |
| 10-yr | 30.64 | 3.800 | 41.04 | 4.800 | 34% | 26% |
| 25-yr | 43.84 | 5.400 | 55.36 | 6.600 | 26% | 22% |
| 100-yr | 66.37 | 8.200 | 79.20 | 9.500 | 19% | 16% |

| **DP2** | **West Wetland** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (HW)*** | | ***Post-development (SW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 7.82 | 1.200 | 12.21 | 1.800 | 56% | 50% |
| 10-yr | 20.76 | 2.800 | 30.10 | 3.600 | 45% | 29% |
| 25-yr | 31.67 | 4.100 | 43.24 | 5.100 | 37% | 24% |
| 100-yr | 51.03 | 6.500 | 65.83 | 7.700 | 29% | 18% |

| ***ALL*** | ***ALL COMBINED*** | | | | | |
|---|---|---|---|---|---|---|
| Event | ***Pre-development (HW)*** | | ***Post-development (SW)*** | | **Change** | |
| | Flow, *cfs* | Volume, *a-f* | Flow, *cfs* | Volume, *a-f* | Flow | Volume |
| 2-yr | 21.84 | 3.000 | 33.10 | 4.400 | 52% | 47% |
| 10-yr | 51.40 | 6.600 | 71.14 | 8.400 | 38% | 27% |
| 25-yr | 75.51 | 9.500 | 98.60 | 11.700 | 31% | 23% |
| 100-yr | 117.40 | 14.700 | 145.03 | 17.200 | 24% | 17% |

# 5) GROUNDWATER MOUNDING ASSESSMENT

The proposed Site alterations will convert mature forest landcover to meadow (both under and around solar panels). This land cover change will change the Site's water balance by reducing the amount of transpiration (how trees and other vegetation move water from the root zone up through the canopy to the atmosphere). A reduction in transpiration will result in increases of the runoff and/ or groundwater recharge. Due to the relatively low permeability soils and moderate slopes that characterize the Site, the dominant change in water budget that would result from the proposed land cover change will likely be to generate more stormwater runoff than currently occurs under existing conditions. The Applicant has proposed two, large detention basins, one on either side of the hill (Figure 1), to slow and manage runoff in a means intended to prevent peak runoff exiting the Site from exceeding that which occurs under existing conditions. As discussed above in the Stormwater Runoff section, each basin has outfall pipes of different sizes and at varying elevations to gradually release water from the detention basins during and following rain events. Proposed Detention Basin 1 on the northeastern slope of the hill eventually discharges to a large wetland complex hydraulically connected to the Weweantic River (Figure 1). Any excess runoff volume to this wetland that occurs because of the proposed project is anticipated to be accommodated by the wetland/ Weweantic River without significant observable impacts.

Proposed Detention Basin 2 on the southwestern slope of the hill is proposed to discharge to a former railroad line running north to south along the western Site boundary. This railroad line is shown on the current USGS topographic map as the “Marion Bike Path to Wareham” (Figure 1); however, this bike path has not yet been developed and the area remains as an abandoned railroad grade. The railroad grade has drainage ditches on either side of it. The railroad grade and associated ditches slopes generally north to south towards Fearing Hill Road.

According to water system upgrade plans for Fearing Hill Road (SEA, Inc., 2007), there is a 12-inch diameter culvert with an invert elevation of 56.28 feet that can convey water from the railroad grade/ drainage ditches south across Fearing Hill Road. The SEA plans only show one culvert while there are two drainage ditches, one on either side of the railroad grade. It is uncertain if there are actually two culverts or only one crossing Fearing Hill Road. On April 29, 2022, HW staff observed standing water in the ditches upstream of the culverts approximately one-foot deep. The culvert(s) was/were not visible above this water line; however, movement of water in the drainage ditches downstream of Fearing Hill Road suggest some hydraulic connection exists. The ability of this culvert, or culverts, to convey water south across Fearing Hill Road and away from the Site is an important consideration since the drainage ditch along the railroad grade will receive all overflow water from Detention Basin 2 as currently proposed. To our knowledge, the Fearing Hill culvert, or culverts, have not yet been assessed by the Applicant to understand their hydraulic conveyance capacity.

The nearest neighbors to the Site are also located immediately adjacent to this railroad grade/ ditches. Due to the limited storage capacity of the ditches, the limited conveyance capacity of the culvert or culverts from the ditches crossing Fearing Hill Road, and the proximity of neighbors to the railroad grade/ ditches, any excess runoff volume to this railroad grade/ ditches that occurs because of the proposed project is a more significant concern than is runoff conveyed to the northeastern wetland.

There also two smaller infiltration trenches proposed downstream from Site impermeable areas for compliance with water quality treatment standards. Because those two infiltration trenches are small and located upgradient from the larger detention basins, they are ignored for the purposes of this groundwater mounding assessment. All runoff generated upgradient from each detention basin is assumed to reach that basin.

The detention basins are not designed for infiltration and the Applicant has taken no credit for infiltration from them. However, the basins have not been specifically designed to be impermeable and, therefore, some infiltration will likely occur beneath them. For the purposes of this groundwater mounding analysis, infiltration is assumed to occur beneath the detention basins to provide a conservative assessment of potential groundwater impacts. This conservative assumption of infiltration is essentially the opposite of the conservative assumption of no infiltration described above for the purposes of assessing stormwater runoff impacts.

Potential hydrogeologic impacts from groundwater mounding, if any, are likely to occur because of long-term average (referred to as steady state conditions) changes in groundwater elevation and from short-term (on the order of several days), storm-specific groundwater elevation changes. The steady state and storm event specific groundwater elevation changes were assessed using two different methods:

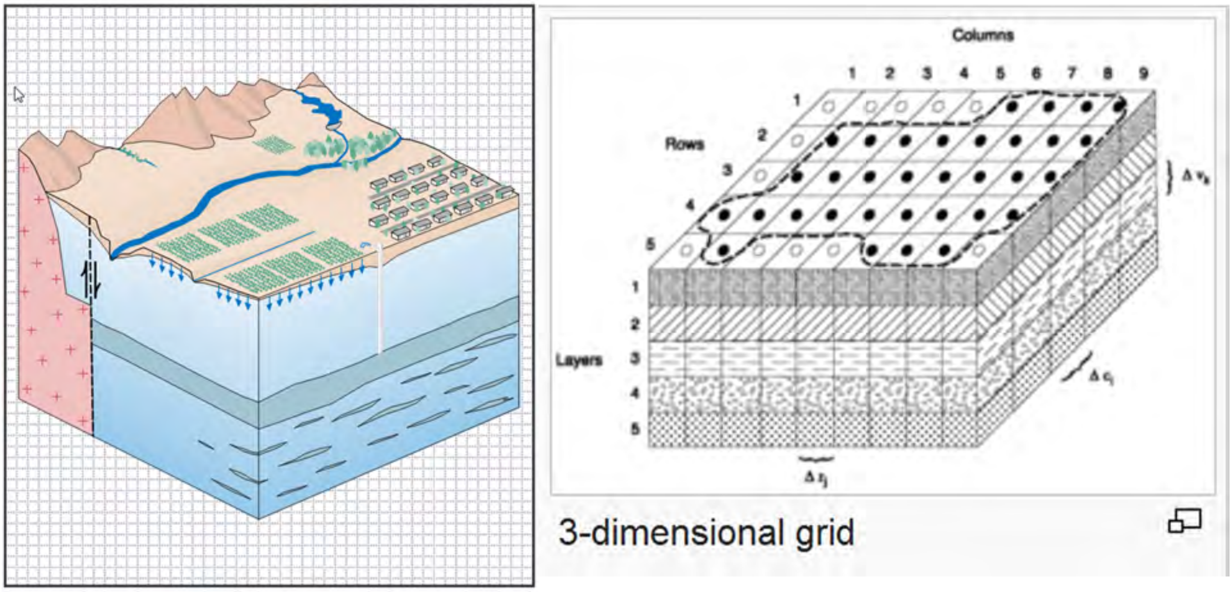
1. MODFLOW numerical groundwater modeling for steady state groundwater assessment; and
2. Hantush Equation Analytical Evaluation for storm event specific assessments.

The Hantush method for estimating the rise (mounding) of groundwater beneath infiltration areas is a relatively simplistic, spreadsheet-based, analytical approach. The MODFLOW model is a robust and highly detailed evaluation using a numerical groundwater model specifically constructed for this Site. Together the two methods provide a means to better evaluate the entirety of potential groundwater changes at the Site.

## 5.1 MODFLOW Modeling Method - Steady State Groundwater Mounding Assessment

Potential steady state groundwater mounding impacts from the proposed project were evaluated by creating a numerical groundwater model using the USGS MODFLOW modeling code (McDonald and Harbaugh, 1988). A numerical MODFLOW model is a detailed, three-dimensional simulation of the hydrogeologic properties of a region (including bedrock elevation, hydraulic conductivity, and recharge, among others) throughout the three-dimensional space. Aquifer properties are defined for each “cell” within the three-dimensional grid and the program solves the differential equations describing groundwater flow between each cell and all its neighbors in an iterative fashion in order to simulate the groundwater elevation for each cell and the resulting overall groundwater flow field of how water moves from one cell to others.

**Figure 6: Example MODFLOW Model Grid (USGS SIR 2004-5269, 2005)**




The model can be calibrated to observed exiting conditions and then be modified to simulate water level results for proposed conditions. In this way, MODFLOW numerical groundwater modeling is a highly useful tool for estimating the groundwater elevation and flow conditions at different locations under varying scenarios of Site alteration. Numerical groundwater modeling is a much more thorough and detailed undertaking than is the analytical spreadsheet-based approach using the Hantush methodology that we utilized for the storm event mounding assessment.

### 5.1.1 MODFLOW Existing Conditions Groundwater Model Creation

The USGS built a regional groundwater MODFLOW model for the entirety of the Plymouth - Carver Aquifer (PCA) in 2009. The Fearing Hill project Site sits on the extreme southwestern boundary of the USGS model and, as such, the USGS model cannot be used directly to evaluate the proposed project at the Site. However, information from the USGS model was used to inform the site-specific model created by HW for this project that centers the Site within the model domain. The locus of the HW groundwater model is shown in Figure 7. The model is bounded to the north and east by the Weweantic River and to the south by a network of bogs and unnamed streams connecting them. These surface water features, modeled as streams, serve as “boundary conditions” for the groundwater system between them and define the elevation of the water table at the edges of the model. The model does not conduct calculations beyond these boundary surface water features.

The model is divided into 20 flat vertical layers to accurately simulate the three-dimensional variability of hydraulic properties and the three-dimensional nature of groundwater movement. The bottom of the model is defined by competent, impermeable bedrock. No model calculations are conducted beneath this bottom. Bedrock elevations within the Site locus were determined based on monitoring well drilling observations. Bedrock elevations outside of the Site locus were extrapolated based on these observations, as well as an understanding of the geological processes which shaped Fearing Hill and the surrounding area. Immediately above the model bottom of competent bedrock, the first active model layer represents a thin layer of weathered bedrock with limited capacity to transmit water. All overlying layers represent the varying glacial sediments (e.g., till and outwash) that comprise the Site and the surrounding area. The following two key aquifer properties are the primary inputs to inform the model:

- Hydraulic conductivity: Hydraulic conductivity (or "K") is a factor that defines the ability of the aquifer materials to transmit water. It is generally associated with permeability but is presented in units of velocity (e.g., feet per day), even though it technically does not define the groundwater velocity of any given location. Higher values of K indicate higher capacity to transmit water. K was estimated in a spatially variable manner within the model based on information from the USGS 2009 PCA regional groundwater model, observed soil conditions from Site monitoring wells, professional judgment of typical hydraulic properties for similar materials, and calibration of the resultant model by comparing the model's simulated water table to observed Site water table elevations. In other words, the spatially variable model K values were varied within reasonable bounds until a good match to Site-observed groundwater conditions was achieved. Table 12 below lists the range of K values used by model zone. In general, K values are lowest at the crest and northeast slope of Fearing Hill, and higher to the southwest. For comparison, the USGS PCA model depicts K values of less than ten feet per day for the glacial till sediments of Fearing Hill with significantly higher K values of between 100-150 feet per day for medium to coarse sand deposits in the region located further away from Fearing Hill.

**Table 12: K values for HW Fearing Hill MODFLOW Model**

| Conductivity (ft/day) | Description and location |
|---|---|
| **1** | Weathered bedrock. Lowest active model layer |
| **4** | Glacial Till; Northeast side of Fearing Hill |
| **7** | Glacial Till; periphery of Fearing Hill |
| **8.5** | Glacial Till; Southwestern slope of Fearing Hill |

- Recharge: Recharge (R) is the amount of precipitation that infiltrates through the subsurface to reach the underlying aquifer. It is the total amount of long-term average precipitation, minus the portion that runs off during storm events, and minus the amount either directly evaporated or captured in the root zone by plants and trees to be transpired. Like K, R is spatially variable and depends on factors such as soil permeability, slope, ground cover, and precipitation. R is applied only to the topmost active layer in the model. In the USGS 2009 PCA aquifer model, recharge rates in the vicinity of Fearing Hill range from eight to 27 inches/year. The lowest rates are associated with cranberry bogs and wetlands where higher amounts of evapotranspiration occur. As with K, higher values of R are associated with coarse sand and gravel materials, and for flat or low-lying locations. Compact and finer grained deposits such as glacial till typically have lower R values. Based on the mapped and observed prevalence of glacial till at Fearing Hill, and the moderate slopes, we used a typical R value for till of ten feet per day in the existing conditions HW model (USGS OFR 91-481, 1991). This R value was applied equally over the topmost active layer of the model.

The HW groundwater model is a steady state model, meaning that it simulates long-term average conditions. It is not intended to simulate responses to individual storm events or other short term, transient phenomena. As such, other aquifer properties, such as storage, are not called on upon by the model for its steady state simulations.

K and R values in the HW model were varied within reasonable bounds during a calibration process where we sought to have the model-predicted water table elevations at Site monitoring wells best match those observed in the field. As discussed above in the Comparison to USGS Index Wells section of this report, the January 26th, 2022 monitoring well data from the Site were the most representative of long-term average hydrologic conditions experienced during the project monitoring period and, therefore, those values were used for the calibration process of the existing conditions model. Table 13 lists the calibration residuals for each Site monitoring well. Residuals are the negative or positive difference between the model-simulated water table elevation at each well and the January 26th observed value. The residuals are quite low indicating a good match of modeled to observed values and providing confidence that the model can accurately simulate both existing and proposed conditions.

**Table 13: MODFLOW Model calibration report**

| Well | Observed water table elevation January 26, 2022 (ft NAVD88) | Calculated water table elevation (ft NAVD88) | Residual (ft) |
|---|---|---|---|
| **MW-1** | 56.80 | 56.32 | 0.48 |
| **MW-2** | 58.63 | 58.57 | 0.06 |
| **MW-3** | 68.44 | 68.34 | 0.10 |
| **MW-4** | 74.50 | 74.75 | -0.25 |

Note: Water was not present in MW-5 during the January 26th gaging round so this well was not included in calibration.

### 5.1.2 Existing Conditions Model Results

Figure 8 includes the model-simulated water table contours for the Site area. Groundwater flows from the north to the southwest and east/southeast towards the surface water model boundary features, with the top of Fearing Hill acting as a groundwater divide between water heading southwest and east/southeast. Model simulated water table contours are in good agreement with field measured water table contours (Figures 3 and 4).

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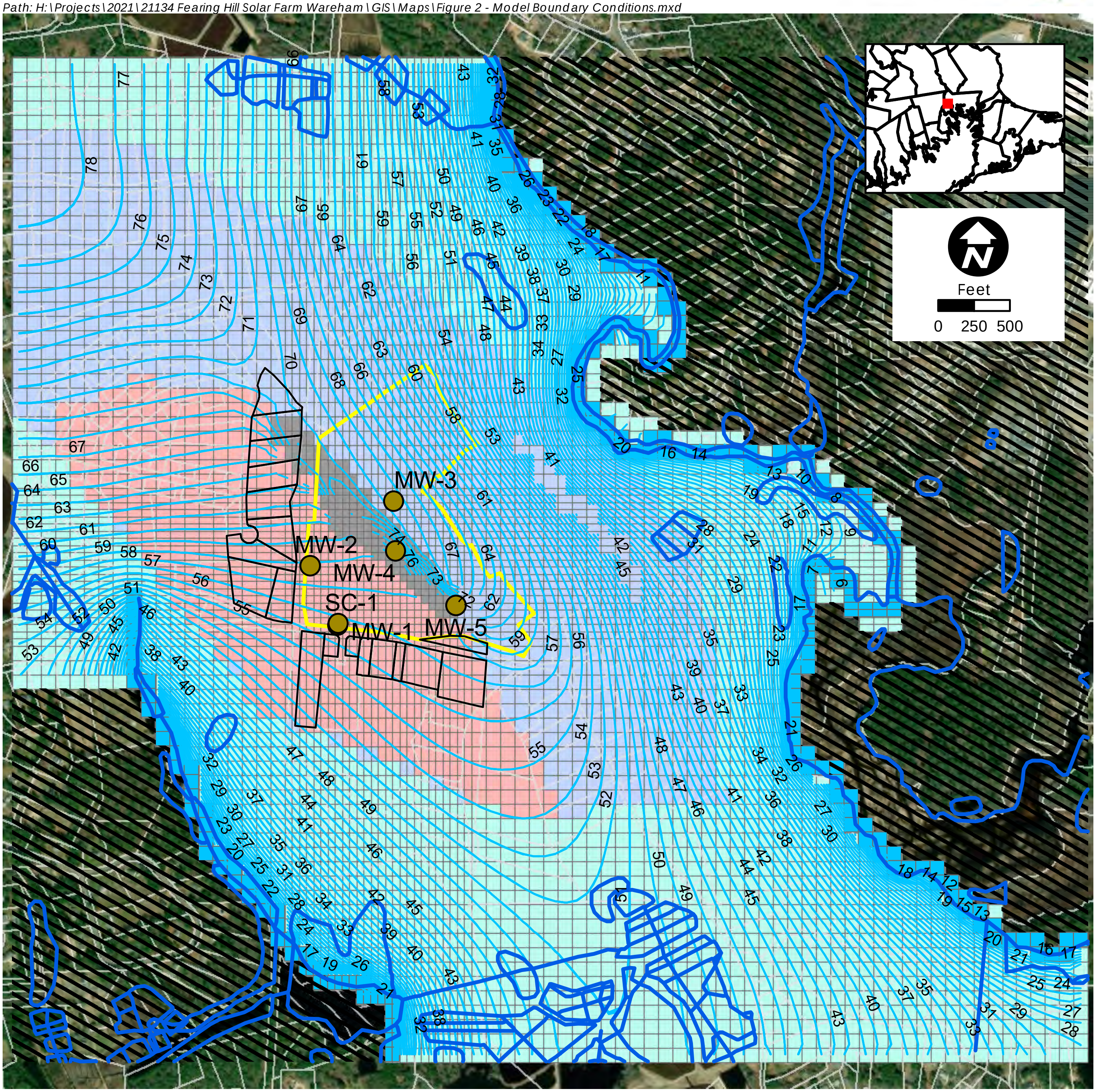
Path: H:\Projects\2021\21134 Fearing Hill Solar Farm Wareham\GIS\Maps\Figure 2 - Model Boundary Conditions.mxd




Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset,

Date: 5/17/2022
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

*This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.*

- Site Locus
- Wareham Tax Parcels
- Neighboring Parcels of Interest
- Monitoring Wells
- Model Baseline Water Table Contours
- Boundary Condition: No Flow
- Boundary Condition: Stream
- Surface Hydrography
- Model Grid

**Property: Hydraulic Conductivity**

- 1 ft/day
- 4 ft/day
- 7 ft/day
- 8.5 ft/day

Hydraulic conductivity values for model Layer 6

Figure **7**
Existing Conditions and Key Model Parameters

### 5.1.3 Proposed Conditions MODFLOW Model

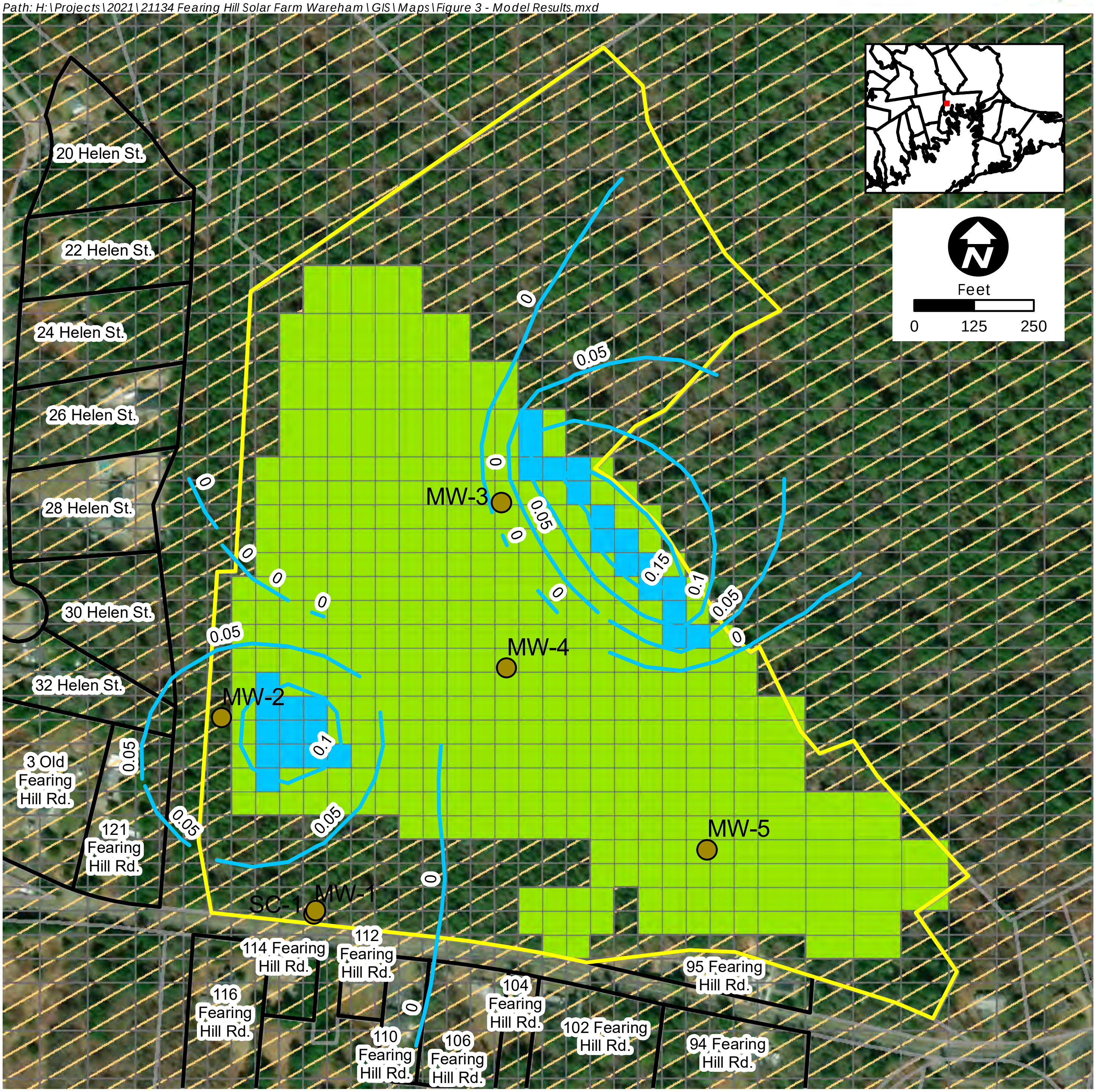
The calibrated existing conditions groundwater model was modified to simulate proposed Site conditions. The primary change to hydrologic characteristics under the proposed conditions of the Site is the amount and location of recharge which will enter the groundwater system due to the conversion of mature forest to meadow underlying the solar panels. The overall amount of rainfall falling on the area will not be affected by the clearing and development of the solar installation; however, how much of the precipitation transpires versus running off will affect the amount of aquifer recharge. Transpiration is expected to decrease significantly as mature trees are removed and replaced with a grass meadow cover. As a corollary, runoff is expected to increase because of this land cover change, as shown in the HydroCAD models. The proposed Site design includes detention basin stormwater management measures intended to address the anticipated increase in runoff. The detention basins are not designed for infiltration and the Applicant has taken no credit for infiltration from them. However, the basins have not been specifically designed to be impermeable and, therefore, some infiltration will likely occur beneath them. For the purposes of this groundwater mounding analysis, infiltration is assumed to occur beneath the detention basins to provide a conservative assessment of potential groundwater impacts.

Therefore, with regards to recharge, the primary changes from existing conditions to the proposed conditions model are the locations and amounts of recharge that occur because of the increased surface runoff, which is expected based on the stormwater modeling described in Section 4 of this report. Slightly less recharge is anticipated to occur beneath the panels due to increased runoff. Significantly more recharge is anticipated to occur beneath the two stormwater detention basins where that excess runoff is directed and detained.

HydroCAD modeling of storm events indicates that runoff on the cleared Site areas will increase during all storm events of approximately one inch or greater (see Stormwater Section 4). Due to Site land cover conditions, rainfall events of approximately less than one inch do not generate runoff under either existing or proposed conditions and, therefore, do not impact recharge. HW's HydroCAD models document runoff volume increases of 48% during the one-year storm event, 47% during the two-year storm event, and 27% during the 10-year storm event. Over a 10-year period, these three storm frequencies result in an approximately 75% volume increase per year. While the larger storms (greater than one-year frequency) generate more runoff, they occur less frequently and therefore only represent a small percentage of the total rainfall that occurs on Site. Studies of rainfall frequency occurrence have documented that no more than 10% of the total rainfall for any given site occurs in these larger storms (Schueler, 1987). Since larger storms are estimated to increase volumetric runoff from the Site by 75% under proposed conditions but those large storms represent only 10% of the typical, annual rainfall volume, the result is a 7.5% increase in long-term, average annual rainfall volume. The estimated 7.5% increase in runoff volume per year directly correlates to a 7.5% decrease in recharge across the cleared area (excluding the detention basins). That excess runoff directed to the detention basins results in a corresponding increase in recharge under those basins.

Horsley Witten Group
Sustainable Environmental Solutions

Path: H:\Projects\2021\21134 Fearing Hill Solar Farm Wareham\GIS\Maps\Figure 3 - Model Results.mxd




Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset,

Date: 5/17/2022
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

*This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.*

- Site Locus
- Groundwater Mound Contours (0.05')
- Wareham Tax Parcels
- Monitoring Wells
- NeighborParcels
- Model Grid

**Adjusted Recharge**

- 9.25 in/year
- 10 in/year (unchanged)
- 21.34 in/year

Figure **8**
Proposed Conditions Mounding Analysis

While the detention basins contain overflow pipes of varying sizes at different elevations, the model conservatively assumes that the increased runoff conveyed to each detention basin would lead to an increase of the same volume of water recharging to the aquifer beneath the detention basins (i.e., overflow exiting the detention basins is not accounted for). This is a reasonably conservative assumption for two primary reasons:

- Detention Basin 2, on the southwest slope of the hill, is the basin closest to neighboring properties of potential concern for groundwater impacts and the overflows from that basin are directed to the railroad grade/ drainage ditches along the western Site boundary that are closer to the neighboring properties of primary concern. Further, the only way for water to exit the railroad grade/ drainage ditches is through a small culvert or culverts beneath Fearing Hill Road of unknown condition or conveyance capacity. The hydraulic capacity of the railroad grade/ drainage ditches south of Fearing Hill Road is similarly unknown. Because much of the water that overflows from Detention Basin 2 may well be detained and ultimately infiltrate at the railroad grade/ drainage ditches, it is appropriate to consider the infiltration of the entirety of the excess runoff volume to Detention Basin 2 as increased recharge.
- The primary objective of this mounding assessment is to identify if there is a significant concern regarding groundwater impacts to neighboring properties from the proposed Site conversion. Given that goal, and the uncertainty regarding how much infiltration may occur beneath these detention basins, it is appropriate to begin the assessment using conservative assumptions.

Based on the above-discussed methodology for assessing proposed conditions changes in recharge, the change in recharge rates and annual volumes are described in Table 14.

**Table 14: Existing to proposed conditions change in long term average recharge rates**

| | Area ($ft^2$) | Existing Recharge Rate (in/year) | Existing Recharge Volume ($ft^3$/year) | Proposed Recharge Rate (inches/year) | Proposed Recharge Volume ($ft^3$/year) |
|---|---|---|---|---|---|
| **Clearing Area*** | 1,084,555 | 10 | 903,795 | 9.25 | 836,011 |
| **Detention basin area** | 71,945 | 10 | 59,955 | 21.31 | 127,762 |
| **Total** | 1,156,500 | -- | 963,750 | -- | 963,750 |

*Excluding detention basin area

Figure 9 visually depicts the proposed conditions distribution of recharge rates, as described above. Figure 9 also depicts contours of the model-simulated, proposed Site conditions, and the change in steady state water table elevation for the Site area (i.e., groundwater mounding). The groundwater mounding represents the proposed conditions water table contours minus the existing conditions contours and, therefore, represents the estimated changes in long-term average water table elevations likely to develop because of the proposed changes to Site recharge distribution. The Figure 9 estimated groundwater mound is useful for visualizing the estimated change in long-term water table elevations at key locations of potential Site impact, like neighboring properties. As a planning tool, this model-estimated change in long-term average groundwater conditions is a useful means of evaluating how much risk there is for impacts to neighboring septic systems or basements from the proposed Site development. Table 15 lists the model-estimated change in long-term average groundwater conditions for each neighboring property of potential concern.

**Table 15: Steady state groundwater mound heights at neighboring properties under proposed recharge conditions as modeled by HW MODFLOW model**

| Address | Mound Height (ft) |
|---|---|
| **20 Helen Street** | 0.030 |
| **22 Helen Street** | 0.037 |
| **24 Helen Street** | 0.034 |
| **26 Helen Street** | 0.031 |
| **28 Helen Street** | 0.015 |
| **30 Helen Street** | 0.055 |
| **32 Helen Street** | 0.060** |
| **3 Old Fearing Hill Road** | 0.042 |
| **121 Fearing Hill Road** | 0.060 |

| Address | Mound Height (ft) |
|---|---|
| **116 Fearing Hill Road** | 0.036 |
| **114 Fearing Hill Road** | 0.029 |
| **112 Fearing Hill Road** | 0.017 |
| **110 Fearing Hill Road** | 0.009 |
| **106 Fearing Hill Road** | 0.000 |
| **104 Fearing Hill Road** | 0.000 |
| **102 Fearing Hill Road** | 0.000 |
| **94 Fearing Hill Road** | 0.000 |
| **95 Fearing Hill Road** | 0.000 |

The estimated long-term average increases in groundwater elevations from the proposed Site conditions are relatively minimal; a maximum of ¾ of an inch of increase at any neighboring property.

In addition to the long-term average increases, temporary groundwater mounding changes from less frequent storm events must also be considered. As described above in the Stormwater Management section of this report, the HydroCAD simulated changes in runoff from larger storm events were proportionally scaled downward when estimating the long-term average changes in recharge likely to occur for the purposes of the steady state groundwater model due to the low return frequency of these larger storm events. However, potential short-term impacts from those less frequent storm events must also be evaluated and that evaluation is discussed below. The cumulative potential groundwater mounding impact at any neighboring property is the steady state, long-term-average mound plus the short-term mound for each storm event of concern.

## 5.2 Hantush Method for Storm Events Groundwater Mounding Assessment

Hantush originally published analytical equations to predict the rise (mounding) of groundwater beneath infiltration areas in 1967. In the decades following, refinements and advancements to the math were developed by Hantush and others. More recently, during the age of the personal computer, various spreadsheet applications have been developed to simplify the application of the complicated mathematical equations to solve for any analysis on a Site scale. The USGS (USGS SIR 2010-5102) developed an effective spreadsheet application used here to estimate the groundwater mounding that develops beneath stormwater infiltration basins. This spreadsheet-based analytical evaluation is a relatively simplistic means to quickly evaluate the anticipated groundwater mound at different distances from an infiltration facility. In situations such as this one, with multiple infiltration sites, the distance-variable results from one Site must be superimposed atop the results from the other sites to estimate the total mound at any given location.

The key inputs for the Hantush Method, USGS stormwater mounding spreadsheet are:

- Size of the Infiltration Areas: These quantities were calculated from the Applicant's HydroCAD model for the area beneath the emergency overflow spillway.
- Hydraulic Conductivity (K): K values used as calculated for the MODFLOW groundwater model and described above.
- Aquifer Thickness (feet): The distance from the water table down to bedrock. Calculated based on Site monitoring well borings.
- Specific Yield (SY): The unitless transmittable storage capacity of the aquifer between sediment grains. Expressed as a percentage and estimated based upon observed geology from Site monitoring wells and professional judgment.
- Recharge (R): The volume of water added to each infiltration area for each storm event divided by the infiltration area through which that volume must infiltrate. Results in units of length/ time (feet/ day). Volumes were obtained from HydroCAD results for each storm event and each detention basin as discussed in the Stormwater Management section of this report above.
- Time (days): The time over which infiltration occurs. HW used three days for this because the Massachusetts Stormwater Manual requires infiltration basins to dewater within three days. Therefore, were these detention basins in fact infiltration basins, the total volume of water added during any storm event would be required to infiltrate within three days.

Hantush mounding calculations using the USGS spreadsheet were conducted for the 2-, 10-, 25-, and 100-year return frequency storm events. USGS mounding calculation spreadsheets for each detention basin and all storm events are included here as Appendix B. To conservatively assess the conditions most likely to exhibit increased mounding from the proposed project the Hantush-method mounding results for the 100-year storm event at the locations of the nearest neighbors are shown below in Table 16.

**Table 16: Groundwater mounds resulting from a 100-year storm event**

| Address | Distance From Center of Stormwater Basin 1 (ft) | Distance From Center of Stormwater Basin 2 (ft) | Basin 1 Mound Height (ft) | Basin 2 Mound Height (ft) | Total Mound Height at Property (ft) |
|---|---|---|---|---|---|
| **20 Helen Street** | 1096 | 1098 | 0.011 | 0.009 | 0.02 |
| **22 Helen Street** | 1012 | 936 | 0.011 | 0.009 | 0.02 |
| **24 Helen Street** | 952 | 782 | 0.011 | 0.009 | 0.02 |
| **26 Helen Street** | 917 | 623 | 0.011 | 0.009 | 0.02 |
| **28 Helen Street** | 917 | 245 | 0.011 | 0.059 | 0.07 |
| **32 Helen Street** | 974 | 245 | 0.011 | 0.059 | 0.07 |
| **3 Old Fearing Hill Road** | 1108 | 372 | 0.011 | 0.009 | 0.02 |
| **121 Fearing Hill Road** | 1003 | 249 | 0.011 | 0.052 | 0.063 |
| **116 Fearing Hill Road** | 1112 | 465 | 0.011 | 0.009 | 0.02 |
| **114 Fearing Hill Road** | 1071 | 465 | 0.011 | 0.009 | 0.02 |
| **112 Fearing Hill Road** | 997 | 497 | 0.011 | 0.009 | 0.02 |
| **110 Fearing Hill Road** | 970 | 531 | 0.011 | 0.009 | 0.02 |
| **106 Fearing Hill Road** | 940 | 577 | 0.011 | 0.009 | 0.02 |
| **104 Fearing Hill Road** | 940 | 690 | 0.011 | 0.009 | 0.02 |
| **102 Fearing Hill Road** | 941 | 744 | 0.011 | 0.009 | 0.02 |
| **94 Fearing Hill Road** | 995 | 975 | 0.011 | 0.009 | 0.02 |
| **95 Fearing Hill Road** | 903 | 888 | 0.011 | 0.009 | 0.02 |

As was the case for the estimated long-term average groundwater impacts, the estimated short-term mounding impacts from the proposed Site conditions are relatively minimal; a maximum of less than an inch of increase at any neighboring property during and immediately following the 100-year storm event. Note that these estimated groundwater mounding changes are those that are specifically related to the proposed Site conditions and would occur in addition to whatever prevailing flooding conditions may already occur under existing conditions for any given storm event.

Table 17 combines the estimated steady-state groundwater mounding with the estimated 100-year storm event mounding to list the maximum estimated groundwater mound for neighboring properties of potential impact concern.

**Table 17: Combined total steady-state and 100-year storm event maximum groundwater mounding**

| Address | Distance From Center of Stormwater Basin 1 (ft) | Distance From Center of Stormwater Basin 2 (ft) | Steady State Mound Height (ft) | 100-Year Mound Height at Property (ft) | Total Mound Height at Property (ft) |
|---|---|---|---|---|---|
| **20 Helen Street** | 1096 | 1098 | 0.030 | 0.02 | 0.057 |
| **22 Helen Street** | 1012 | 936 | 0.037 | 0.02 | 0.054 |
| **24 Helen Street** | 952 | 782 | 0.034 | 0.02 | 0.051 |
| **26 Helen Street** | 917 | 623 | 0.031 | 0.02 | 0.085 |
| **28 Helen Street** | 917 | 245 | 0.015 | 0.07 | 0.125 |
| **32 Helen Street** | 974 | 245 | 0.055 | 0.07 | 0.08 |
| **3 Old Fearing Hill Road** | 1108 | 372 | 0.060 | 0.02 | 0.105 |
| **121 Fearing Hill Road** | 1003 | 249 | 0.042 | 0.063 | 0.08 |
| **116 Fearing Hill Road** | 1112 | 465 | 0.060 | 0.02 | 0.056 |
| **114 Fearing Hill Road** | 1071 | 465 | 0.036 | 0.02 | 0.049 |
| **112 Fearing Hill Road** | 997 | 497 | 0.029 | 0.02 | 0.037 |
| **110 Fearing Hill Road** | 970 | 531 | 0.017 | 0.02 | 0.029 |
| **106 Fearing Hill Road** | 940 | 577 | 0.009 | 0.02 | 0.02 |
| **104 Fearing Hill Road** | 940 | 690 | 0.000 | 0.02 | 0.057 |
| **102 Fearing Hill Road** | 941 | 744 | 0.000 | 0.009 | 0.02 |
| **94 Fearing Hill Road** | 995 | 975 | 0.000 | 0.009 | 0.02 |
| **95 Fearing Hill Road** | 903 | 888 | 0.000 | 0.009 | 0.02 |

Estimated combined mounding impacts from the proposed Site conditions are relatively minimal overall; with a maximum of less than two inches of increase at any neighboring property during and immediately following the 100-year storm event. As stated above, these estimated groundwater mounding changes are those that are specifically related to the proposed Site conditions and would occur in addition to whatever prevailing flooding conditions may already occur under existing conditions for any given storm event.

Also, please note that any culvert or culverts beneath Fearing Hill Road, if they exist and have effective hydraulic capacity, would begin to drain water southward away from the railroad grade. If there is effective hydraulic drainage across Fearing Hill Road and away from the Site, potential groundwater mounding impacts to neighboring properties would likely be less than estimated here. To our knowledge, the Applicant has not conducted an assessment of the hydraulic capacity of the railroad grade drainage ditches or any culverts that may exist.

While these estimated groundwater impacts are relatively minimal, HW understands that many Site neighbors already experience high groundwater and flooding concerns under existing conditions. With these estimated change magnitudes in hand, it is for the town to evaluate to what extent relatively minor increases in groundwater levels may or may not exacerbate existing concerns relative to separation from groundwater for septic systems, basements, or other infrastructure.

# 6) NON-HYDROLOGIC CONSIDERATIONS

## 6.1 MADEP Solar Guidance

Massachusetts guidance for solar facilities is general in nature. The Applicant has stated that the site has been designed and evaluated with respect to MADEP's 2017 solar facility guidance. We recommend that the town confirm specifics with the Applicant regarding the following criteria:

- The required analysis of alternatives has been submitted for siting, types of panels, or other methods to reduce impact.
- "Topsoil is preserved or supplemented sufficient to maintain vegetation cover."
- "Solar panel rows are spaced in a manner to allow sunlight penetration sufficient to support vegetation between the solar panel rows.
- "No conveyances or outfalls are constructed."

## 6.2 RIDEM Solar Guidance

As previously stated, this project does not fall under RIDEM jurisdiction. However, RIDEM guidance is considerably more specific than Massachusetts guidance and, therefore, provides a useful comparison to current best practices for ground-mounted solar arrays in the region. Therefore, we have included RIDEM guidance in our analysis for information purposes. This project fails to meet the following RIDEM recommendations:

- Avoid forested sites and instead utilize existing disturbed space;

- Provide sufficient topsoil for vegetation growth (currently unspecified by the Applicant to HW's knowledge); and
- Space panels apart at least by the width of each panel.

## 7) CONCLUSIONS

Based on our review of available information, new field data collected as part of this project, and the surface water and groundwater analyses conducted, we offer the following conclusions regarding the potential impacts from the proposed Site development:

- Since the proposed Site stormwater management system will discharge excess runoff generated from the southwest side of the hill to the railroad grade/drainage ditches at the western edge of the Site, and that outflow from that drainage ditch is limited by passage beneath Fearing Hill Road through an unconfirmed 12-inch dimeter culvert (or culverts), and the close proximity of neighboring properties (at which high groundwater is already a concern under existing conditions), our assessment of estimated impacts from the proposed Site development are focused on this area.
- Because the northeast side of the hill drains to a large wetland complex with connectivity to the Weweantic River, and that there are few or no close proximity neighboring homes between the Site and this northeastern wetland, no significant hydrologic impacts are anticipated in this direction.
- Because of the use of less conservative input factors, the Applicant's Pre-Development HydroCAD model overestimates the amount of runoff currently generated onsite and the Post-Development HydroCAD model underestimates the amount of runoff predicted to occur on site. These over (pre-development) and under (post-development) estimates compound each other such that the Applicant has likely underestimated the anticipated changes in runoff under proposed conditions. As a result, the state stormwater standards for the proposed development may not have been met and both stormwater basins may be undersized and to manage proposed conditions stormwater runoff.
- Undersized detention basins would result in more overflow from those basins to the receiving areas of the railroad grade/drainage ditches at the west side of the Site and the forested wetland complex at the northeast side of the Site. Potential erosion at both of those overflows is a general concern to be further evaluated. Hydrologic/hydraulic impacts from the additional overflow to the western railroad grade location are of likely greater concern due to the proximity of neighboring houses to that railroad grade and the proposed (to HW's understanding) future conversion of that railroad grade to a rail trail.

- MODFLOW modeling of the long-term average changes in water table conditions indicate relatively minor increases in elevation of less than an inch at neighboring properties, relative to existing conditions.
- Analytical evaluations of the short-term groundwater mounding impacts during and immediately following storm events indicate relatively minor increases in water table elevations of less than an inch at neighboring properties, relative to existing conditions.
- Combined long-term average changes in water table conditions with 100-year storm event mounding indicate relatively minor total increases in elevation of less than two inches at neighboring properties, relative to existing conditions.
- Current Massachusetts guidance for ground-mounted solar facilities is only general in nature. It is unclear, based on material reviewed by HW, if the Applicant has met the alternatives analysis requirements.
- While not a regulatory requirement for the Site because it is not located in Rhode Island, the proposed Site design does not meet more recent Rhode Island guidance for ground-mounted solar facilities, which do not allow solar developments on forested areas, or with the panel spacing as designed for the current Site proposal.

# 8) RECOMMENDATIONS

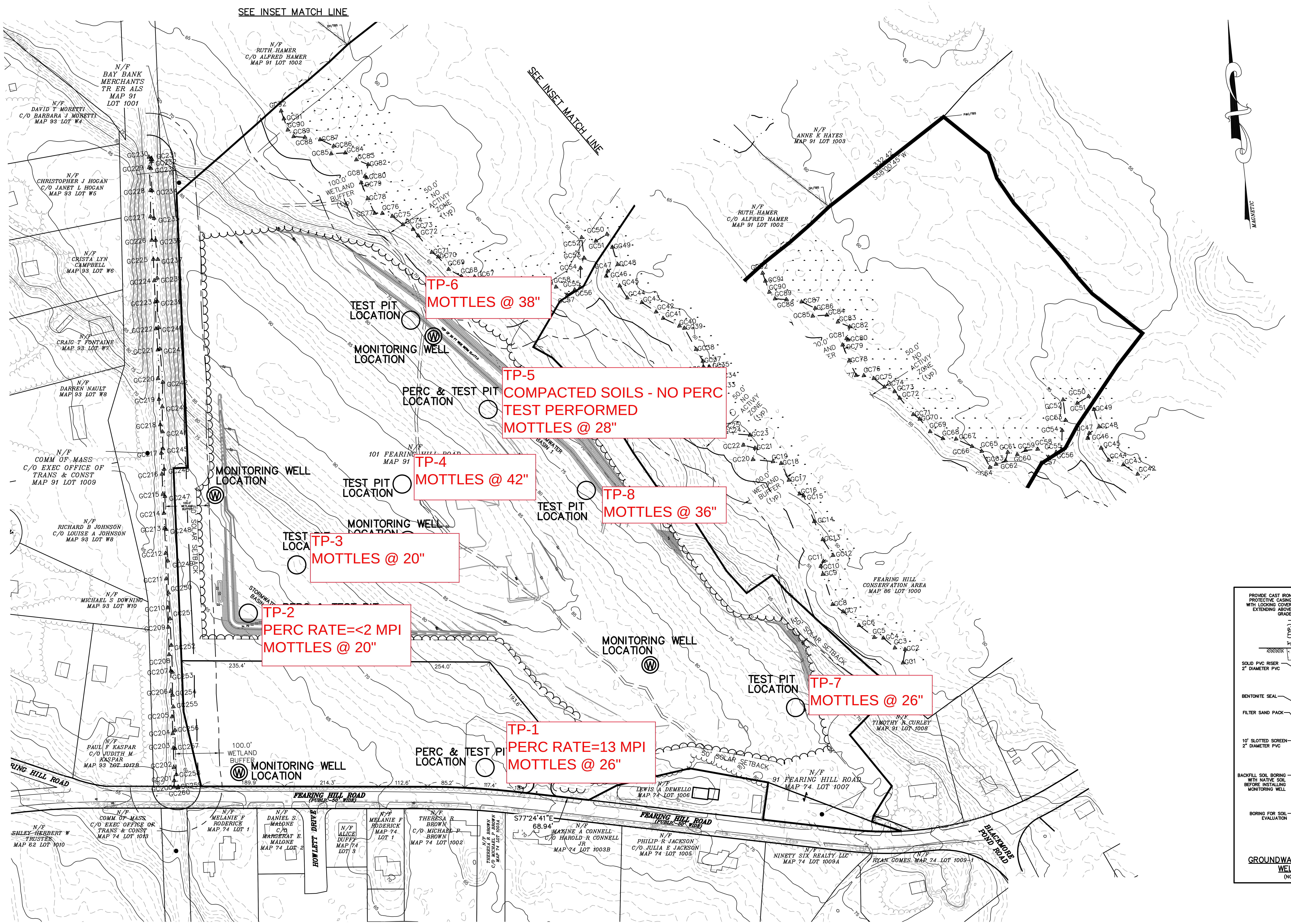
Due to the projected increases in stormwater runoff from the proposed Site, and the existing conditions high water level concerns of nearby neighbors, we recommend that the Applicant consider some elements of redesign for Site layout and stormwater management.

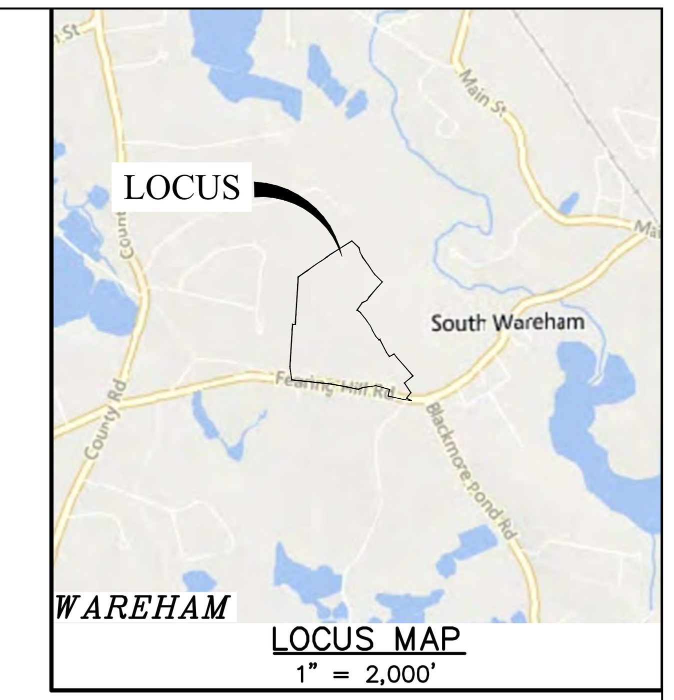
- While the Site compliance with current Massachusetts guidance for ground-mounted solar facilities is uncertain, it does not meet all the newer guidance standards of the Rhode Island guidance. Significantly, the current Rhode Island guidance calls for a minimum spacing between rows of panels of at least equal to the width of those panels, and the proposed Site development does not meet that criterion. This is important because a wider spacing between panels would better allow for a healthy grass or meadow ground cover to establish. While a healthy meadow still allows for more runoff than does an intact forest, it would reduce the volume and rate of runoff generated from the proposed development relative to the current design. The Site is obviously not in Rhode Island and, as such, we mention this newer Rhode Island guidance as informational for Town consideration.
- The HydroCAD Pre- and Post-Development models should be updated to more accurately and conservatively reflect the existing Time of Concentration and proposed ground cover (and by extension, Curve Numbers). These changes will necessitate increasing the size of the stormwater detention basins. In addition, the offsite impacts

of the basin overflows should be assessed to ensure no negative effects downstream of the basins, including erosion.

- The Applicant's current stormwater modeling assessment does not include the western railroad grade/drainage ditch and its assumed outlet culvert beneath Fearing Hill Road, or any other offsite areas. In addition to the proximity of this drainage ditch to abutting neighbors, we understand that there is a potential plan to establish a rail trail along this railroad grade easement. If stormwater is to continue to be directed in this direction, the Applicant should undertake additional field survey and HydroCAD modeling to better assess how stormwater will be retained in the ditch and/or transferred through the culvert to the south. This HydroCAD assessment should include not just an evaluation of peak runoff rates, but also a quantification of the volume of excess runoff likely to be generated to the ditch, retained in the ditch, and infiltrated beneath the ditch. Potential impacts to both neighbors and the use of the railroad easement as a rail trail should be evaluated.
- To the extent practical, and as necessary to avoid the potential impacts to the railroad grade and its neighbors discussed above, stormwater runoff and stormwater infiltration should be minimized along the southwestern slope of the hill where impact concerns are highest. Due to the potential hydrologic concerns associated with the western drainage ditch and impacts to abutting neighbors, it would be preferable if all or nearly all stormwater runoff could be managed to avoid the southwestern slope and instead overflow and/or infiltrate on the opposite, northeastern slope of the hill. Such a design would require gravity conveyance of stormwater around the hill from the southwestern side to the northeastern side and lining of conveyance channels/detention facilities on the southwestern side of the hill. Gravity conveyance of runoff around the hill would likely require the elimination of some panels from the lower elevations on the southwestern side of the hill.
- Construction and post-construction monitoring should be required to ensure that stabilization has occurred for the Site in general and, specifically for the detention basin outfall areas.

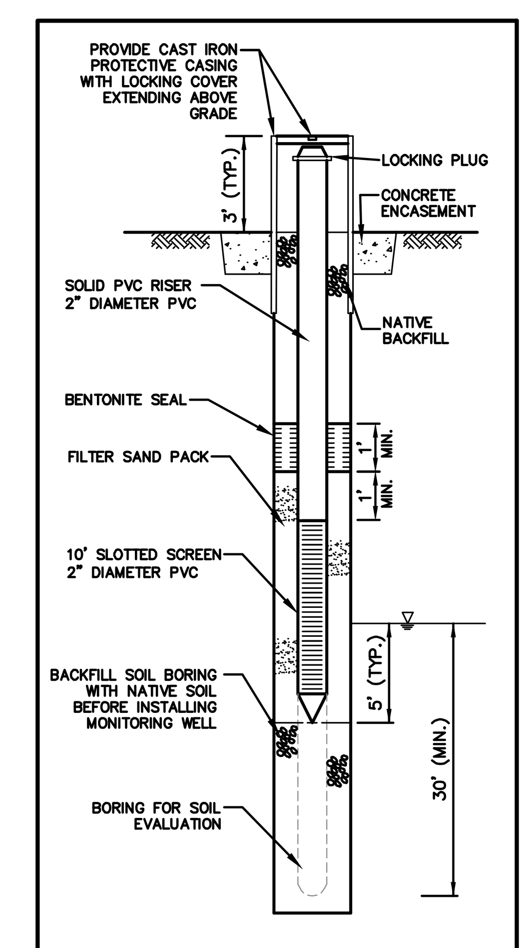
# APPENDIX A: FIELD WORK DOCUMENTATION




## LEGEND

- EXISTING CONTOUR LINE
- EXISTING WATER LINE (APPROX. LOCATION)
- EXISTING OVERHEAD WIRE
- EXISTING STONE RETAINING WALL
- EXISTING HYDRANT
- EXISTING WATER GATE VALVE
- EXISTING LIGHT POST
- EXISTING SIGN
- EXISTING EDGE OF PAVEMENT
- WETLAND FLAG
- EXISTING WETLAND LINE
- EXISTING 100' WETLAND BUFFER
- EXISTING TREE LINE
- EXISTING TREE
- EXISTING MAILBOX
- EXISTING UTILITY POLE
- EXISTING SURVEY MONUMENT
- EXISTING FENCE




GROUNDWATER MONITORING WELL DETAIL
(NOT TO SCALE)

FILE: 3055.02-SITE-STAKEOUT

**Atlantic® DESIGN ENGINEERS, INC.**
P.O. Box 1051, Sandwich, MA 02563 (508) 888 – 9282

Designed by :
Drawn by :
Checked by :
Survey chk. by :
Approved by :

SCALE
SCALE 1" = 100'
0 25 50 100 200

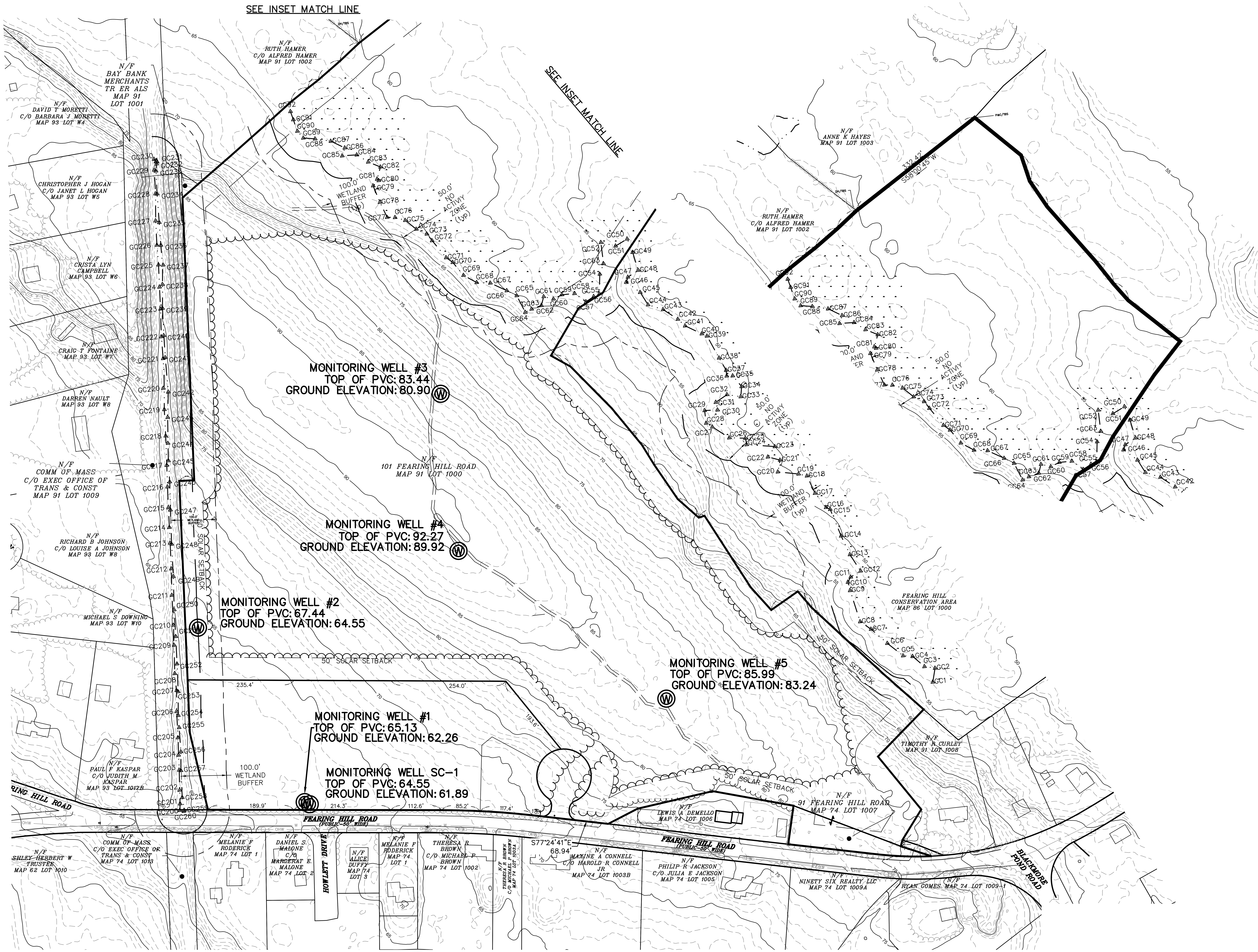
DATE

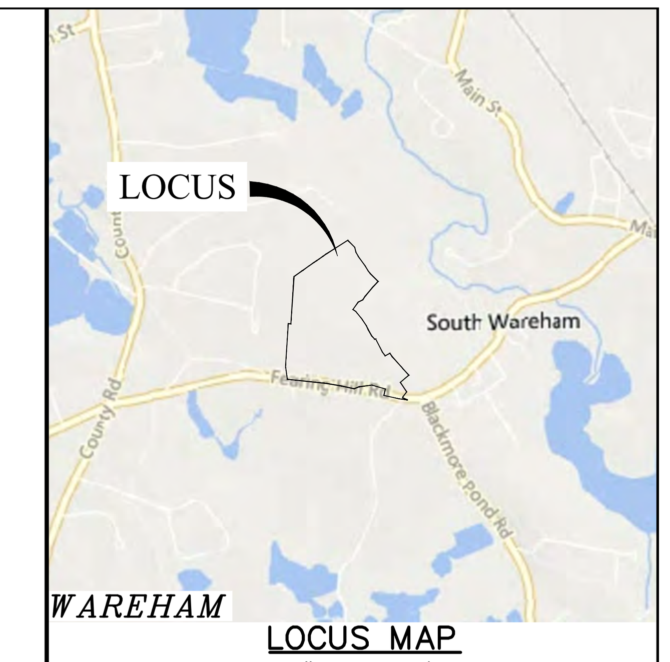
| NO. | BY | DATE | REVISION |
|---|---|---|---|

APPLICANT:
WAREHAM MA 3, LLC
100 SUMMIT LAKE DRIVE, SUITE 210
VALHALLA, NY 10595

ONSITE SOIL TESTING LOCATION WORKSHEET
FOR
FEARING HILL ROAD SOLAR PROJECT
WAREHAM MA 02576
NOVEMBER 16, 2021

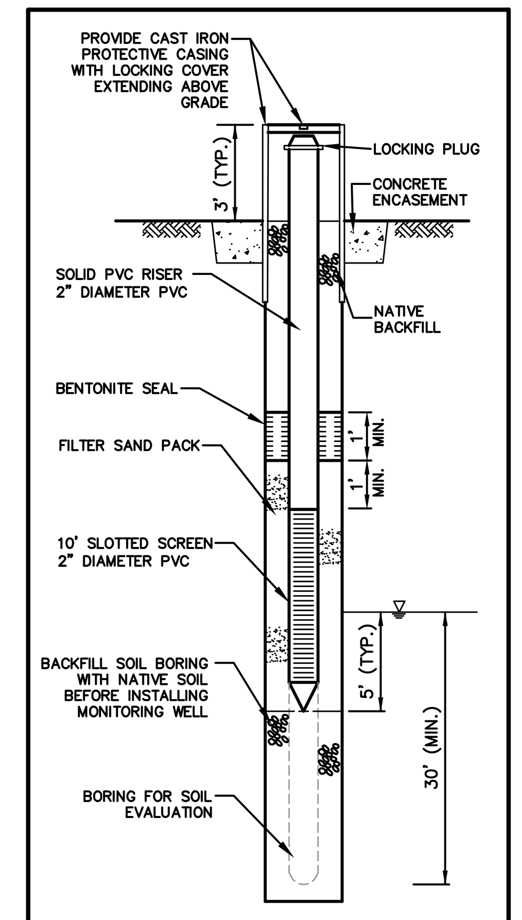
Sheet 1 of 1
JOB NUMBER 3055.02




LOCUS MAP
1" = 2,000'

| LEGEND |
| --- |
| EXISTING CONTOUR LINE |
| EXISTING WATER LINE (APPROX. LOCATION) |
| EXISTING OVERHEAD WIRE |
| EXISTING STONE RETAINING WALL |
| EXISTING HYDRANT |
| EXISTING WATER GATE VALVE |
| EXISTING LIGHT POST |
| EXISTING SIGN |
| EXISTING EDGE OF PAVEMENT |
| WETLAND FLAG |
| EXISTING WETLAND LINE |
| EXISTING 100' WETLAND BUFFER |
| EXISTING TREE LINE |
| EXISTING TREE |
| EXISTING MAILBOX |
| EXISTING UTILITY POLE |
| EXISTING SURVEY MONUMENT |
| EXISTING FENCE |




GROUNDWATER MONITORING WELL DETAIL
(NOT TO SCALE)

FILE: 3055.02-SITE-MW LOCATION PLAN

Atlantic® DESIGN ENGINEERS, INC.
P.O. Box 1051, Sandwich, MA 02563 (508) 888 - 9282

Designed by :
Drawn by :
Checked by :
Survey chk. by :
Approved by :

SCALE
SCALE 1" = 100'
0 25 50 100 200

DATE

| NO. | BY | DATE | REVISION |
| --- | --- | --- | --- |

APPLICANT:
WAREHAM MA 3, LLC
100 SUMMIT LAKE DRIVE, SUITE 210
VALHALLA, NY 10595

MONITORING WELL LOCATION PLAN
FOR
FEARING HILL ROAD SOLAR PROJECT
WAREHAM MA 02576
FEBRUARY 15, 2022

Sheet 1 of 1
JOB NUMBER
3055.02

# On-Site Review
## Form 11 & 12
### Wareham, Massachusetts

Site Address/Parcel ID **101 Fearing Hill Rd / Map 91 Lot 1000** Owner Name Ninety-Six Realty, LLC

New Construction ☒ Upgrade ☐ Repair ☐

Soil Survey Available? Yes ☒ No ☐ Source NRCS Web Soil Survey Soil Map Unit 320A

Soil Name Birchwood Sand Parent Material Sandy eolian deposits Landform Till plains

Land Use Woodland Slope (%) 0-8% Surface Stones Some Vegetation Trees

Current Water Resource Conditions (USGS): Date: 11/17/21 Range: Above Normal

Deep Hole Number **TP-1** Date 12/8/2021 Time 10 am Weather cloudy 35°

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☒ No ☐ If Yes: Depth to Weeping 58" Depth to Standing None

Estimated Depth to High Groundwater Mottles @ 26"

**SOIL LOG**

| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
|---|---|---|---|---|---|
| 0-7 | O/A | Sandy Loam | 10YR 2/2 | | Friable |
| 7-28 | B | Loamy Sand | 10YR 5/6 | @26" | Friable |
| 28-114 | C | Loamy Sand | 2.5Y 5/3 | | Firm in place |

**PERCOLATION TEST**

| Date: 12/8/2021 | Time: 10:14 am | |
|---|---|---|
| Deep Hole Number | TP-1 | |
| Depth of Perc. | 34"-52" | |
| Start Pre-Soak | 10:14 | |
| End Pre-Soak | 10:29 | |
| Time at 12" | 10:29 | |
| Time at 9" | 10:46 | |
| Time at 6" | 11:25 | |
| Time (9"-6") | 39 Min. | |
| Rate (Min./Inch) | 13 MPI | |

Witnessed By: Neal Price (Horsley Witten Group)

Performed By: Nyles Zager SE2781 Exp. 6/20/2022

Signature [signature] Date 1-7-22

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**3 Main St Lakeville, MA Tel# 508-947-4208**

# On-Site Review
# Form 11 & 12
# Wareham, Massachusetts

Site Address/Parcel ID **101 Fearing Hill Rd / Map 91 Lot 1000** Owner Name Ninety-Six Realty, LLC

New Construction ☒ Upgrade ☐ Repair ☐

Soil Survey Available? Yes ☒ No ☐ Source NRCS Web Soil Survey Soil Map Unit 321B

Soil Name Birchwood Sand Parent Material Sandy eolian deposits Landform Till plains

Land Use Woodland Slope (%) 8-15% Surface Stones Some Vegetation Trees

Current Water Resource Conditions (USGS): Date: 12/15/21 Range: Normal

Deep Hole Number **TP-2** Date 1/5/2022 Time 9 am Weather clear 35°

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☒ No ☐ If Yes: Depth to Weeping 44" Depth to Standing 68"

Estimated Depth to High Groundwater Mottles @ 20"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-12 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 12-20 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 20-58 | C1 | MS | 2.5Y 5/3 | @20" | Loose |
| 58-96 | C2 | MCSG | 2.5Y 7/2 | | Loose |

Deep Hole Number **TP-3** Date 1/5/2022 Time 9 am Weather clear 35 °

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☒ No ☐ If Yes: Depth to Weeping 52" Depth to Standing None

Estimated Depth to High Groundwater Mottles @ 20"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-6 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 6-18 | B | Loamy Sand | 10YR 5/6 | | Friable |
| 18-56 | C1 | MS | 2.5Y 5/3 | @20" | Loose |
| 56-100 | C2d | Loamy Sand | 2.5Y 7/2 | | Compact |

| PERCOLATION TEST | | |
|---|---|---|
| Date: 1/5/2022 | Time: 9:33 am | |
| Deep Hole Number | TP-2 | |
| Depth of Perc. | 20"-38" | |
| Start Pre-Soak | 9:33 | |
| End Pre-Soak | 9:48 | |
| Time at 12" | 9:48 | |
| Time at 9" | 9:52 | |
| Time at 6" | 9:57 | |
| Time (9"-6") | 5 min | |
| Rate (Min./Inch) | <2 MPI | |

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# On-Site Review
# Form 11 & 12

## Wareham, Massachusetts

Site Address/Parcel ID **101 Fearing Hill Rd / Map 91 Lot 1000** Owner Name Ninety-Six Realty, LLC

New Construction ☒ Upgrade ☐ Repair ☐

Soil Survey Available? Yes ☒ No ☐ Source NRCS Web Soil Survey Soil Map Unit 301B

Soil Name Montauk fine sandy loam Parent Material Sandy lodgment till Landform Drumlins

Land Use Woodland Slope (%) 3-8% Surface Stones Some Vegetation Trees

Current Water Resource Conditions (USGS): Date: 12/15/21 Range: Normal

Deep Hole Number **TP-4** Date 1/5/2022 Time 10 am Weather clear 35 °

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☐ No ☒ If Yes: Depth to Weeping None Depth to Standing None

Estimated Depth to High Groundwater Mottles @ 42"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-8 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 8-26 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 26-42 | C1 | Sandy Loam | 2.5Y 5/2 | | Firm |
| 42-96 | C2d | Sandy Loam | 2.5Y 5/2 | @42" | Compact |

Deep Hole Number **TP-5** Date 1/5/2022 Time 12 pm Weather clear 35 °

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☐ No ☒ If Yes: Depth to Weeping None Depth to Standing None

Estimated Depth to High Groundwater Mottles @ 28"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-8 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 8-18 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 18-92 | C1d | Sandy Loam | 2.5Y 5/2 | @ 28" | Compact |

**3 Main St Lakeville, MA Tel# 508-947-4208**

**Wareham, Massachusetts**

Site Address/Parcel ID **101 Fearing Hill Rd / Map 91 Lot 1000** Owner Name Ninety-Six Realty, LLC
New Construction ☒ Upgrade ☐ Repair ☐
Soil Survey Available? Yes ☒ No ☐ Source NRCS Web Soil Survey Soil Map Unit 301C
Soil Name Montauk fine sandy loam Parent Material Sandy lodgment till Landform Drumlins
Land Use Woodland Slope (%) 8-15% Surface Stones Some Vegetation Trees
Current Water Resource Conditions (USGS): Date: 12/15/21 Range: Normal

Deep Hole Number **TP-6** Date 1/5/2022 Time 1 pm Weather clear 35 °
Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+
Property Line 10'+ Drinking Water Well 100'+ Other None
Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐
Groundwater Observed? Yes ☐ No ☒ If Yes: Depth to Weeping None Depth to Standing None
Estimated Depth to High Groundwater Mottles @ 38"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-8 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 8-24 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 24-118 | C1d | Sandy Loam | 2.5Y 5/2 | @38" | Compact |

Deep Hole Number **TP-7** Date 1/5/2022 Time 2 pm Weather clear 35 °
Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+
Property Line 10'+ Drinking Water Well 100'+ Other None
Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐
Groundwater Observed? Yes ☐ No ☒ If Yes: Depth to Weeping None Depth to Standing None
Estimated Depth to High Groundwater Mottles @ 26"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-8 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 8-26 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 26-96 | C1d | Sandy Loam | 2.5Y 5/2 | @26" | Compact |

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# On-Site Review
# Form 11 & 12

Site Address/Parcel ID **101 Fearing Hill Rd / Map 91 Lot 1000** Owner Name Ninety-Six Realty, LLC

New Construction ☒ Upgrade ☐ Repair ☐

Soil Survey Available? Yes ☒ No ☐ Source NRCS Web Soil Survey Soil Map Unit 301C

Soil Name Montauk fine sandy loam Parent Material Sandy lodgment till Landform Drumlins

Land Use Woodland Slope (%) 8-15% Surface Stones Some Vegetation Trees

Current Water Resource Conditions (USGS): Date: 12/15/21 Range: Normal

Deep Hole Number **TP-8** Date 1/6/2022 Time 9 am Weather clear 40 °

Distance From: Open Water Body 400'+ Drainage Way 100'+ Wetlands 100'+

Property Line 10'+ Drinking Water Well 100'+ Other None

Unsuitable Material Present? Yes☐ No ☒ If Yes: Disturbed Soil ☐ Fill Material ☐ Bedrock ☐

Groundwater Observed? Yes ☐ No ☒ If Yes: Depth to Weeping None Depth to Standing None

Estimated Depth to High Groundwater Mottles @ 36"

| SOIL LOG | | | | | |
|---|---|---|---|---|---|
| Depth (in) | Soil Horizon/ Layer | Soil Texture | Soil Color (Munsell) | Mottles | Other (Structure, Stones, Boulders, Consistency, % Gravel) |
| 0-8 | O/A | Sandy Loam | 10YR 3/2 | | Friable |
| 8-22 | B | Sandy Loam | 10YR 5/6 | | Friable |
| 22-110 | Cd | Sandy Loam | 2.5Y 5/2 | @36" | Compact, 20% Stones |

Witnessed By: Manny Guerzon (Horsley Witten Group)

Performed By: Will Connelly SE14360 Exp. 7/1/2022

Signature [signature] Date 1/7/22

ZCE
Zenith Consulting Engineers, LLC

**3 Main St Lakeville, MA Tel# 508-947-4208**

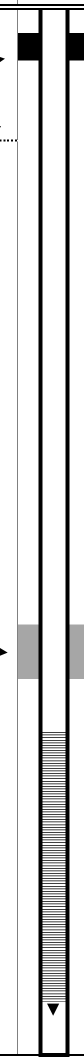
Horsley Witten Group
*Sustainable Environmental Solutions*
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

# BORING LOG — MW-1

**Project:** Proposed Fearing Hill Solar Facility
**Client:** Town of Wareham
**Boring Contractor:** Northern Drill Service, Inc.
**Boring Equipment:**

**Date:** 1/10/2022
**Completion Depth:** 36'
**Elevation:**
**Inspector:**

| Depth Feet | Description | Sample Interval | Penetra./ Recovery | Blow Count | USCS Code | USCS Color | USGS Angularity | Comments | Well Details | Depth Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | stick up protective casing with locking cap | | |
| 0 | | | | | | | | Concrete Seal | | 0 |
| | | | | | | | | Water Table ~ 3' | | |
| 5 | f SAND, so silt | 5-7 | 2/2 | | | Gy-Br | | | | 5 |
| 10 | m-c SAND, tr gravel | 10-12 | 2/2 | | | Gy-Br | | | | 10 |
| 15 | f-m SAND, tr gravel | 14-16 | 2/2 | | | Gy-Br | | | | 15 |
| | | | | | | | | Bagged sand to concrete @ ground surface | | |
| 20 | f-m SAND, tr gravel | 19-21 | 2/2 | | | Gy-Br | | | | 20 |
| | | | | | | | | 2' Bentonite seal | | |
| | | | | | | | | Bagged sand | | |
| 25 | f-m SAND | 24-26 | 2/2 | | | Gy-Br | | | | 25 |
| | | | | | | | | Slotted 2" PVC 26-36' | | |
| 30 | GRAVEL (GW), so m sand, tr c sand, tr silt | 29-30 | 1/1 | | | Yl-Br | | | | 30 |
| | | | | | | | | Bedrock @ 34' | | |
| | | | | | | | | | | 35 |
| | | | | | | | | Well set @ 36' | | |



**Proportions Used:**

| | |
|---|---|
| trace (tr) | 0 - 10% |
| little (li) | 10 - 20% |
| some (so) | 20 - 35% |
| and | 35 - 50% |

**Abbreviations:**

| Color | | Angular | Misc. | Size | |
|---|---|---|---|---|---|
| Blue (Bl) | Tan (T) | Round (rnd.) | Fragments (frag.) | Fine = (f) | Fine to Coarse = (f-c) |
| Red (R) | Gray (Gy) | Angular (ang.) | Cement (cem.) | Medium = (m) | Very = (v) |
| Light (lt) | Brown (Br) | | Well-Graded Sand (SW) | Coarse = (c) | More/Less = (+/-) |
| Dark (dk) | Yellow (Yl) | | Poorly-Graded Sand (SP) | Dark = (dk) | |
| | | | Well-Graded Gravel (GW) | | |
| | | | Poorly-Graded Gravel (GP) | | |
| | | | Below Land Surface (BLS) | | |
| | | | Not Available (N/A) | | |

# BORING LOG MW-2

Horsley Witten Group
*Sustainable Environmental Solutions*
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

**Project:** Proposed Fearing Hill Solar Facility
**Client:** Town of Wareham
**Boring Contractor:** Northern Drill Service, Inc.
**Boring Equipment:**

**Date:** 1/11/2022
**Completion Depth:** 14'
**Elevation:**
**Inspector:**

| Depth Feet | Description | Sample Interval | Penetra./ Recovery | Blow Count | USCS Code | USCS Color | USGS Angularity | Comments | Well Details | Depth Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | stick up protective casing | | |
| 0 | | | | | | | | with locking cap | | 0 |
| | | | | | | | | Concrete Seal | | |
| | | | | | | | | Water Table ~ 3.5' | | |
| 5 | f-m SAND, li silt, tr gravel | 4-6 | 2/2 | | | Gy-Br | | 2' Bentonite Seal | | 5 |
| | | | | | | | | Slotted 2" PVC 4-14' | | |
| 10 | m-c SAND, and gravel, so f sand | 9-11 | 2/2 | | | Gy-Br | | | | 10 |
| | | | | | | | | Well set @ 14' | | |
| 15 | f-m SAND, so c sand | 14-16 | 2/2 | | | Gy-Br | | | | 15 |
| | | | | | | | | Backfilled bagged sand to 14' | | |
| 20 | f-m SAND, so c sand, tr gravel | 19-21 | 2/2 | | | Gy-Br | | | | 20 |
| 25 | f-m SAND, so c sand, tr gravel | 24-25 | 1/1 | | | Gy-Br | | | | 25 |
| 29 | f-m SAND, so c sand, so GW | 29-29.5 | 0.5/0.5 | | | Yl-Br | | | | |
| | | | | | | | | | | 30 |
| | | | | | | | | Bedrock @ 31' | | |
| | | | | | | | | | | 35 |

**Proportions Used:**

| | |
|---|---|
| trace (tr) | 0 - 10% |
| little (li) | 10 - 20% |
| some (so) | 20 - 35% |
| and | 35 - 50% |

**Abbreviations:**

| Color | | Angular | Misc. | Size | |
|---|---|---|---|---|---|
| Blue (Bl) | Tan (T) | Round (rnd.) | Fragments (frag.) | Fine = (f) | Fine to Coarse = (f-c) |
| Red (R) | Gray (Gy) | Angular (ang.) | Cement (cem.) | Medium = (m) | Very = (v) |
| Light (lt) | Brown (Br) | | Well-Graded Sand (SW) | Coarse = (c) | More/Less = (+/-) |
| Dark (dk) | Yellow (Yl) | | Poorly-Graded Sand (SP) | Dark = (dk) | |
| | | | Well-Graded Gravel (GW) | | |
| | | | Poorly-Graded Gravel (GP) | | |
| | | | Below Land Surface (BLS) | | |
| | | | Not Available (N/A) | | |

# BORING LOG  MW-3

Horsley Witten Group
*Sustainable Environmental Solutions*
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

**Project:** Proposed Fearing Hill Solar Facility
**Client:** Town of Wareham
**Boring Contractor:** Northern Drill Service, Inc.
**Boring Equipment:**

**Date:** 1/12/2022
**Completion Depth:** 16.5'
**Elevation:**
**Inspector:**

| Depth Feet | Description | Sample Interval | Penetra./ Recovery | Blow Count | USCS Code | USCS Color | USGS Angularity | Comments | Well Details | Depth Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | stick up protective casing with locking cap | | |
| 0 | | | | | | | | Concrete Seal | | 0 |
| 5 | f SAND, tr gravel | 4-6 | 2/2 | | | T | | 2' Bentonite Seal | | 5 |
| | | | | | | | | Slotted 2" PVC 6.5-16.5' | | |
| | | | | | | | | Water Table ~ 10' | | |
| 10 | f-m SAND, tr gravel | 9-11 | 2/2 | | | T | | | | 10 |
| 15 | f SAND, so gravel | 14-16 | 2/2 | | | T | | Well set @ 16.5' | | 15 |
| 20 | f-m SAND, so gravel | 19-21 | 2/2 | | | T | | Backfilled bagged sand to 16.5' | | 20 |
| 25 | f-m SAND, and gravel | 24-26 | 2/2 | | | T | | | | 25 |
| 30 | f SAND, and silt | 29-31 | 2/2 | | | Br-Gy | | Bedrock @ 33' | | 30 |
| | | | | | | | | | | 35 |

**Proportions Used:**

| | |
|---|---|
| trace (tr) | 0 - 10% |
| little (li) | 10 - 20% |
| some (so) | 20 - 35% |
| and | 35 - 50% |

**Abbreviations:**

| Color | | Angular | Misc. | Size | |
|---|---|---|---|---|---|
| Blue (Bl) | Tan (T) | Round (rnd.) | Fragments (frag.) | Fine = (f) | Fine to Coarse = (f-c) |
| Red (R) | Gray (Gy) | Angular (ang.) | Cement (cem.) | Medium = (m) | Very = (v) |
| Light (lt) | Brown (Br) | | Well-Graded Sand (SW) | Coarse = (c) | More/Less = (+/-) |
| Dark (dk) | Yellow (Yl) | | Poorly-Graded Sand (SP) | Dark = (dk) | |
| | | | Well-Graded Gravel (GW) | | |
| | | | Poorly-Graded Gravel (GP) | | |
| | | | Below Land Surface (BLS) | | |
| | | | Not Available (N/A) | | |

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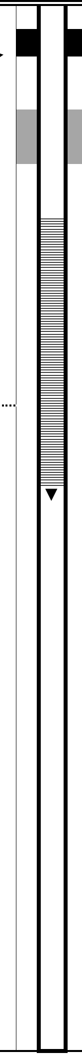
# BORING LOG MW-4

**Project:** Proposed Fearing Hill Solar Facility
**Client:** Town of Wareham
**Boring Contractor:** Northern Drill Service, Inc.
**Boring Equipment:**

**Date:** 1/13/2022
**Completion Depth:** 17'
**Elevation:**
**Inspector:**

| Depth Feet | Description | Sample Interval | Penetra./ Recovery | Blow Count | USCS Code | USCS Color | USGS Angularity | Comments | Well Details | Depth Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | stick up protective casing | | |
| 0 | | | | | | | | with locking cap | | 0 |
| | | | | | | | | Concrete Seal | | |
| | | | | | | | | Bagged sand to concrete | | |
| 5 | f-m SAND, tr gravel | 4-6 | 2/2 | | | T | | 2' Bentonite Seal | | 5 |
| | | | | | | | | Slotted 2" PVC 7-17' | | |
| 10 | f-m SAND, and gravel | 9-11 | 2/2 | | | T | | | | 10 |
| | | | | | | | | Water Table ~ 13.5' | | |
| 15 | f SAND, and gravel | 14-16 | 2/2 | | | T | | | | 15 |
| | | | | | | | | Bedrock @ 16.5' | | |
| | | | | | | | | Well set @ 17' | | |
| | | | | | | | | | | 20 |
| | | | | | | | | | | 25 |
| | | | | | | | | | | 30 |
| | | | | | | | | | | 35 |



**Proportions Used:**

| | |
|---|---|
| trace (tr) | 0 - 10% |
| little (li) | 10 - 20% |
| some (so) | 20 - 35% |
| and | 35 - 50% |

**Abbreviations:**

| Color | | Angular | Misc. | Size | |
|---|---|---|---|---|---|
| Blue (Bl) | Tan (T) | Round (rnd.) | Fragments (frag.) | Fine = (f) | Fine to Coarse = (f-c) |
| Red (R) | Gray (Gy) | Angular (ang.) | Cement (cem.) | Medium = (m) | Very = (v) |
| Light (lt) | Brown (Br) | | Well-Graded Sand (SW) | Coarse = (c) | More/Less = (+/-) |
| Dark (dk) | Yellow (Yl) | | Poorly-Graded Sand (SP) | Dark = (dk) | |
| | | | Well-Graded Gravel (GW) | | |
| | | | Poorly-Graded Gravel (GP) | | |
| | | | Below Land Surface (BLS) | | |
| | | | Not Available (N/A) | | |

# BORING LOG MW-5

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

| | | | |
|---|---|---|---|
| **Project:** | Proposed Fearing Hill Solar Facility | **Date:** | 1/13/2022 |
| **Client:** | Town of Wareham | **Completion Depth:** | 17' |
| **Boring Contractor:** | Northern Drill Service, Inc. | **Elevation:** | |
| **Boring Equipment:** | | **Inspector:** | |

| Depth Feet | Description | Sample Interval | Penetra./ Recovery | Blow Count | USCS Code | USCS Color | USGS Angularity | Comments | Well Details | Depth Feet |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | stick up protective casing | | |
| 0 | | | | | | | | with locking cap | | 0 |
| | | | | | | | | Concrete Seal | | |
| | | | | | | | | Bagged sand to concrete | | |
| | | | | | | | | 2' Bentonite Seal | | |
| 5 | f-m SAND, tr gravel | 4-6 | 2/2 | | | Br | | | | 5 |
| | | | | | | | | Water Table ~ 7' | | |
| | | | | | | | | Slotted 2" PVC 7-17' | | |
| 10 | f-m SAND, tr gravel | 9-11 | 2/2 | | | T | | | | 10 |
| 15 | f-m SAND, so gravel | 14-16 | 2/2 | | | T | | | | 15 |
| | | | | | | | | Well set @ 17' | | |
| | | | | | | | | Bagged sand backfill to 17' | | |
| | | | | | | | | Bedrock @ 19' | | |
| | | | | | | | | | | 20 |
| | | | | | | | | | | 25 |
| | | | | | | | | | | 30 |
| | | | | | | | | | | 35 |

| **Proportions Used:** | | **Abbreviations:** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Color** | | **Angular** | **Misc.** | **Size** | |
| trace (tr) | 0 - 10% | Blue (Bl) | Tan (T) | Round (rnd.) | Fragments (frag.) | Fine = (f) | Fine to Coarse = (f-c) |
| little (li) | 10 - 20% | Red (R) | Gray (Gy) | Angular (ang.) | Cement (cem.) | Medium = (m) | Very = (v) |
| some (so) | 20 - 35% | Light (lt) | Brown (Br) | | Well-Graded Sand (SW) | Coarse = (c) | More/Less = (+/-) |
| and | 35 - 50% | Dark (dk) | Yellow (Yl) | | Poorly-Graded Sand (SP) | Dark = (dk) | |
| | | | | | Well-Graded Gravel (GW) | | |
| | | | | | Poorly-Graded Gravel (GP) | | |
| | | | | | Below Land Surface (BLS) | | |
| | | | | | Not Available (N/A) | | |

# Well Driller

**Please specify work performed:**
New Well

**Please specify well type:**
Monitoring

**Number Of Wells:**
6

**Well Location**

**In public right-of-way:**
○ Yes ◉ No

**Subdivision/Property/Description:**
WOODED PROPERTY

**Property Owner:**
WAREHAM MA, LLC

**Engineering Firm:**
ATLANTIC DESIGN ENGINEERS, INC.

**Address at well location:**

| Street Number: | Street Name: |
|---|---|
| 101 | FEARING HILL RD |
| Building Lot#: | Assessor's Map #: |
| | |
| Assessor's Lot#: | ZIP Code: |
| | 02576 |

**City/Town:**
WAREHAM

**GPS** (GPS for the deepest well)

| North: | West: |
|---|---|
| 41.76718 | 70.76576 |

**Mailing Address:**
☐ click here if same as well location address

| Street Number: | Street Name: |
|---|---|
| 101 | SUMMIT LAKE DRIVE |
| City/Town: | State: |
| VALHALLA | NEW YORK |
| ZIP Code: | |
| 10595 | |

**Board of health permit obtained:**
○ Yes ◉ Not Required

Permit Number: Date Issued:

**Massachusetts Department of Environmental Protection**
Bureau of Resource Protection – Well Driller Program
*Well Completion Reports(Monitoring)*

# Well Driller - Monitoring Form

**DRILLING METHOD**

**Overburden** Dirve and Wash **Bedrock** -- Choose Bedrock --

**WELL LOG OVERBURDEN LITHOLOGY**

| From(ft) | To(ft) | Code | Color | Comment | Drop in drill stem | Extra fast or slow drill rate | Loss or addition of fluid |
|---|---|---|---|---|---|---|---|
| 0 | 5 | Silty Sand And Gra | Brown | | YES NO | Fast Slow | Loss Addition |
| 5 | 25 | Sand And Gravel | Brown | | YES NO | Fast Slow | Loss Addition |
| 25 | 36 | Till | Light Gray | | YES NO | Fast Slow | Loss Addition |

**PERMIT INFORMATION**

DEP 21E RTN # DEP Groundwater Discharge #

**ADDITIONAL WELL INFORMATION**

| | | | |
|---|---|---|---|
| Developed | Yes (•) No | Are these wells nested? | Yes (•) No |
| Surface Seal Type | Concrete | Area of group (sq. ft) | 10000 |
| Total Well Depth | 36 | Depth to Bedrock | |

**CASING**

☑ Is Casing above ground? From:3To:3

| From | To | Type | Thickness | Diameter |
|---|---|---|---|---|
| 3 | 26 | Polyvinyl Chloride | Schedule 40 | 2 |
| 3 | 4 | Polyvinyl Chloride | Schedule 40 | 2 |
| 3 | 6.5 | Polyvinyl Chloride | Schedule 40 | 2 |
| 3 | 7 | Polyvinyl Chloride | Schedule 40 | 2 |
| 3 | 7 | Polyvinyl Chloride | Schedule 40 | 2 |

**SCREEN** ☐ No Screen

| From"> | To | Type | Slot Size | Diameter |
|---|---|---|---|---|
| 26 | 36 | Slotted PVC | 0.010 | 2 |
| 4 | 14 | Slotted PVC | 0.010 | 2 |
| 6.5 | 16.5 | Slotted PVC | 0.010 | 2 |
| 7 | 17 | Slotted PVC | 0.010 | 2 |
| 7 | 17 | Slotted PVC | 0.010 | 2 |
| 3 | 5 | Slotted PVC | 0.010 | 2 |

**WATER-BEARING ZONES**

**Massachusetts Department of Environmental Protection**
Bureau of Resource Protection – Well Driller Program
*Well Completion Reports(Monitoring)*

| From | To | Yield (gpm) |
|---|---|---|
| 5.8 | 36 | 1 |
| 6.1 | 14 | 1 |
| 12.7 | 16.5 | 1 |
| 16.4 | 17 | 1 |
| 16.9 | 17 | 1 |
| 3.3 | 5 | 1 |

**ANNULAR SEAL / FILTER PACK**

| From | To | Material 1"> | Weight | Material 2 | Weight | Water (gal) | Batches | Method Of Placement |
|---|---|---|---|---|---|---|---|---|
| 24 | 36 | Sand | | Bentonite Chips/Pellets | | | | Gravity |
| 2 | 14 | Sand | | Bentonite Chips/Pellets | | | | Gravity |
| 4.5 | 16.5 | Sand | | Bentonite Chips/Pellets | | | | Gravity |
| 5 | 17 | Sand | | Bentonite Chips/Pellets | | | | Gravity |
| 5 | 17 | Sand | | Bentonite Chips/Pellets | | | | Gravity |
| 1 | 5 | Sand | | Bentonite Chips/Pellets | | | | Gravity |

**WATER LEVEL**

| Date Measured | Static Depth BGS (ft) | Flowing Rate (gpm) |
|---|---|---|
| 01/13/2022 | 5.8 | 1 |

**COMMENTS**

**WELL DRILLERS STATEMENT**

This well was drilled or altered under my direct supervision, according to the applicable rules and regulations, and this report is complete and accurate to the best of my knowledge.

Driller JON BEIRHOLM Registration # 942 Monitoring [M] Supervising Driller Signature DEVILLERS, CHRISTOPHER,

Firm NORTHERN DRILL SEVICE, INC. Rig Permit # 0501 Date Job Complete 01/13/2022

NOTE: Well Completion Reports must be filed by the registered well driller within 30 days of well completion.

# Well Driller - Addendum Form

**WELL COMPLETION ADDENDUM FORM MONITORING WELLS**

| Well ID | Well Depth | Screen Interval FROM | Screen Interval TO | GPS Coordinates (WGS 1984) Degree Decimals | |
|---|---|---|---|---|---|
| MW1 | 36 | 26 | 36 | North: 41.76732 | West: 70.76585 |
| MW2 | 14 | 4 | 14 | North: 41.76799 | West: 70.76710 |
| MW3 | 16.5 | 6.5 | 16.5 | North: 41.76863 | West: 70.76519 |
| MW4 | 17 | 7 | 17 | North: 41.76812 | West: 70.76522 |
| MW5 | 17 | 7 | 17 | North: 41.76762 | West: 70.76407 |
| SC1 | 5 | 0 | 5 | North: 41.76736 | West: 70.76583 |

NOTE: Well Completion Reports must be filed by the registered well driller within 30 days of well completion.

# APPENDIX B: HYDROCAD DOCUMENTATION

**NOAA Atlas 14, Volume 10, Version 3**
**Location name: West Wareham, Massachusetts, USA***
**Latitude: 41.769°, Longitude: -70.7649°**
**Elevation: 86.73 ft****
* source: ESRI Maps
** source: USGS

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.295** (0.237-0.362) | **0.366** (0.293-0.449) | **0.482** (0.385-0.592) | **0.578** (0.459-0.714) | **0.710** (0.548-0.911) | **0.808** (0.613-1.06) | **0.913** (0.676-1.23) | **1.04** (0.722-1.41) | **1.23** (0.821-1.71) | **1.38** (0.908-1.96) |
| 10-min | **0.418** (0.336-0.513) | **0.518** (0.416-0.636) | **0.682** (0.545-0.839) | **0.818** (0.651-1.01) | **1.00** (0.777-1.29) | **1.14** (0.868-1.50) | **1.29** (0.958-1.75) | **1.47** (1.02-2.00) | **1.74** (1.16-2.42) | **1.96** (1.29-2.78) |
| 15-min | **0.492** (0.395-0.603) | **0.610** (0.489-0.748) | **0.803** (0.642-0.987) | **0.963** (0.765-1.19) | **1.18** (0.914-1.52) | **1.35** (1.02-1.76) | **1.52** (1.13-2.06) | **1.73** (1.20-2.35) | **2.04** (1.37-2.85) | **2.31** (1.51-3.26) |
| 30-min | **0.704** (0.565-0.863) | **0.872** (0.700-1.07) | **1.15** (0.918-1.41) | **1.38** (1.10-1.70) | **1.69** (1.31-2.17) | **1.93** (1.46-2.52) | **2.18** (1.61-2.94) | **2.48** (1.72-3.36) | **2.92** (1.96-4.07) | **3.30** (2.16-4.67) |
| 60-min | **0.916** (0.735-1.12) | **1.14** (0.911-1.39) | **1.49** (1.20-1.84) | **1.79** (1.43-2.21) | **2.20** (1.70-2.83) | **2.51** (1.90-3.28) | **2.83** (2.10-3.83) | **3.22** (2.24-4.37) | **3.80** (2.55-5.30) | **4.29** (2.82-6.07) |
| 2-hr | **1.23** (0.991-1.49) | **1.53** (1.23-1.86) | **2.02** (1.63-2.47) | **2.43** (1.95-2.98) | **3.00** (2.33-3.82) | **3.41** (2.61-4.44) | **3.87** (2.89-5.20) | **4.42** (3.10-5.94) | **5.25** (3.55-7.25) | **5.97** (3.95-8.36) |
| 3-hr | **1.44** (1.17-1.75) | **1.79** (1.46-2.18) | **2.37** (1.91-2.88) | **2.84** (2.29-3.48) | **3.50** (2.74-4.45) | **3.98** (3.06-5.15) | **4.51** (3.39-6.03) | **5.15** (3.63-6.89) | **6.12** (4.16-8.41) | **6.96** (4.63-9.70) |
| 6-hr | **1.89** (1.54-2.27) | **2.31** (1.88-2.78) | **3.00** (2.44-3.62) | **3.57** (2.89-4.33) | **4.36** (3.43-5.48) | **4.94** (3.82-6.33) | **5.57** (4.21-7.36) | **6.32** (4.49-8.38) | **7.46** (5.11-10.1) | **8.42** (5.65-11.6) |
| 12-hr | **2.40** (1.98-2.88) | **2.88** (2.36-3.45) | **3.65** (2.99-4.38) | **4.29** (3.49-5.17) | **5.17** (4.09-6.44) | **5.83** (4.53-7.38) | **6.53** (4.95-8.50) | **7.33** (5.26-9.63) | **8.50** (5.88-11.4) | **9.47** (6.41-12.9) |
| 24-hr | **2.90** (2.40-3.44) | **3.44** (2.84-4.09) | **4.32** (3.56-5.15) | **5.05** (4.14-6.04) | **6.05** (4.82-7.46) | **6.81** (5.32-8.52) | **7.60** (5.78-9.76) | **8.48** (6.14-11.0) | **9.73** (6.79-13.0) | **10.7** (7.33-14.5) |
| 2-day | **3.33** (2.77-3.93) | **3.96** (3.30-4.68) | **5.00** (4.14-5.92) | **5.85** (4.83-6.96) | **7.04** (5.64-8.61) | **7.93** (6.24-9.84) | **8.86** (6.79-11.3) | **9.89** (7.22-12.7) | **11.4** (8.00-15.0) | **12.5** (8.64-16.8) |
| 3-day | **3.65** (3.05-4.29) | **4.32** (3.61-5.08) | **5.41** (4.51-6.38) | **6.32** (5.24-7.48) | **7.57** (6.09-9.21) | **8.51** (6.72-10.5) | **9.49** (7.30-12.0) | **10.6** (7.75-13.5) | **12.1** (8.56-15.8) | **13.3** (9.22-17.7) |
| 4-day | **3.93** (3.30-4.61) | **4.62** (3.87-5.42) | **5.74** (4.79-6.75) | **6.67** (5.54-7.87) | **7.95** (6.41-9.64) | **8.92** (7.06-11.0) | **9.92** (7.64-12.5) | **11.0** (8.10-14.0) | **12.5** (8.90-16.3) | **13.7** (9.56-18.2) |
| 7-day | **4.68** (3.95-5.46) | **5.40** (4.55-6.30) | **6.57** (5.52-7.68) | **7.54** (6.30-8.84) | **8.87** (7.19-10.7) | **9.89** (7.86-12.0) | **10.9** (8.44-13.6) | **12.0** (8.91-15.2) | **13.5** (9.65-17.4) | **14.6** (10.2-19.2) |
| 10-day | **5.39** (4.56-6.26) | **6.13** (5.18-7.12) | **7.33** (6.18-8.54) | **8.34** (6.99-9.74) | **9.71** (7.90-11.6) | **10.8** (8.59-13.0) | **11.8** (9.16-14.6) | **12.9** (9.63-16.3) | **14.3** (10.3-18.4) | **15.4** (10.9-20.1) |
| 20-day | **7.48** (6.37-8.63) | **8.29** (7.06-9.58) | **9.63** (8.17-11.1) | **10.7** (9.07-12.5) | **12.3** (10.0-14.5) | **13.5** (10.8-16.1) | **14.6** (11.3-17.7) | **15.7** (11.8-19.6) | **17.1** (12.4-21.7) | **18.1** (12.8-23.3) |
| 30-day | **9.22** (7.89-10.6) | **10.1** (8.64-11.6) | **11.6** (9.85-13.3) | **12.8** (10.8-14.8) | **14.4** (11.9-17.0) | **15.7** (12.7-18.7) | **17.0** (13.2-20.4) | **18.1** (13.7-22.4) | **19.5** (14.2-24.6) | **20.4** (14.6-26.1) |
| 45-day | **11.4** (9.81-13.1) | **12.4** (10.6-14.2) | **14.0** (12.0-16.1) | **15.3** (13.0-17.6) | **17.1** (14.1-20.0) | **18.6** (15.0-21.9) | **19.9** (15.6-23.8) | **21.1** (16.1-26.0) | **22.5** (16.6-28.3) | **23.4** (16.8-29.8) |
| 60-day | **13.3** (11.4-15.1) | **14.3** (12.3-16.4) | **16.0** (13.8-18.4) | **17.5** (14.9-20.1) | **19.4** (16.1-22.6) | **21.0** (17.0-24.7) | **22.5** (17.6-26.7) | **23.7** (18.1-29.0) | **25.1** (18.5-31.4) | **26.0** (18.7-32.9) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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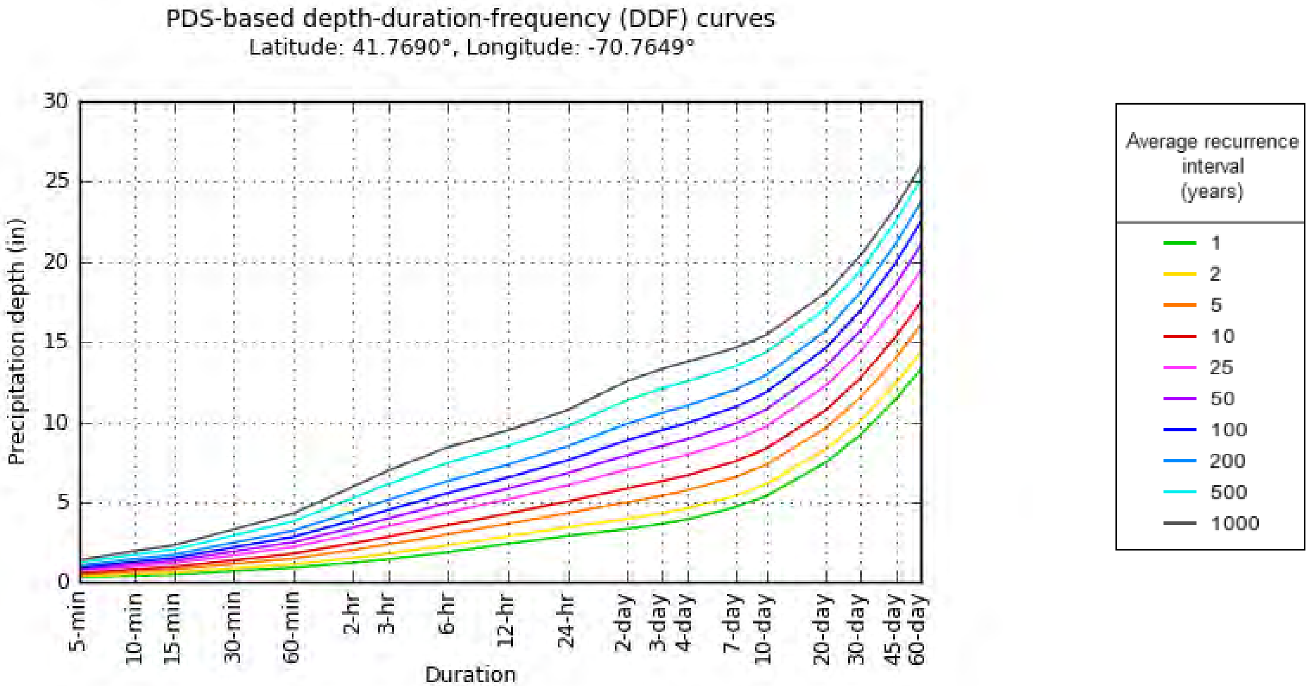
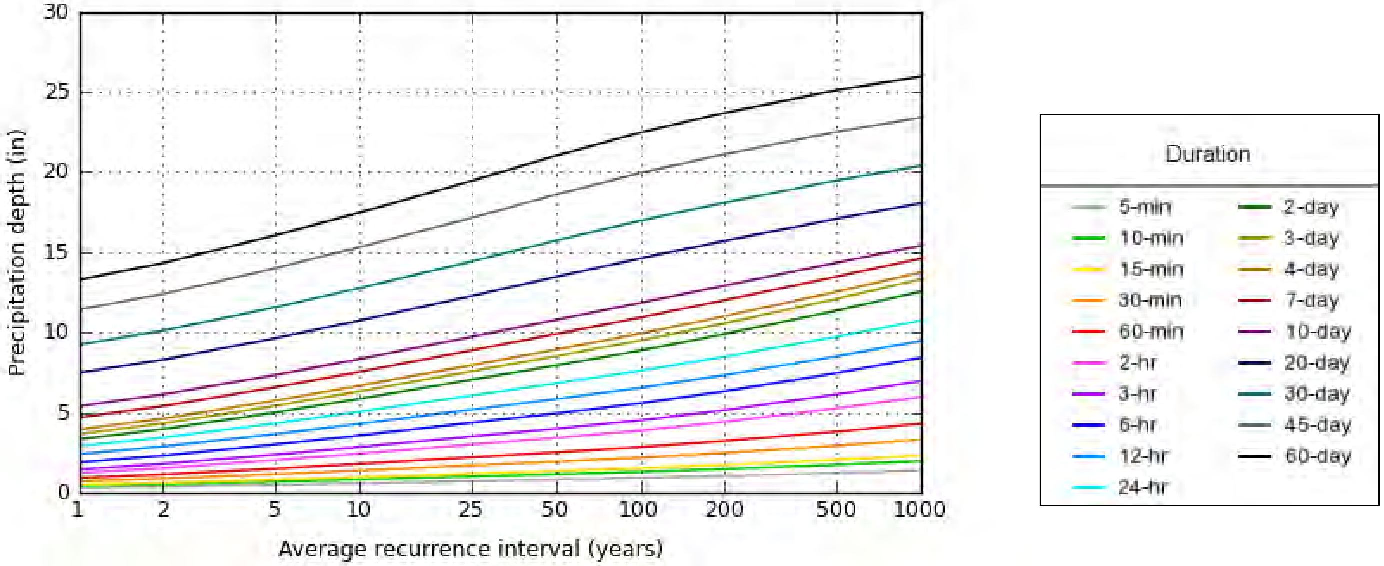
## PF graphical




NOAA Atlas 14, Volume 10, Version 3 Created (GMT): Thu Mar 31 04:02:18 2022

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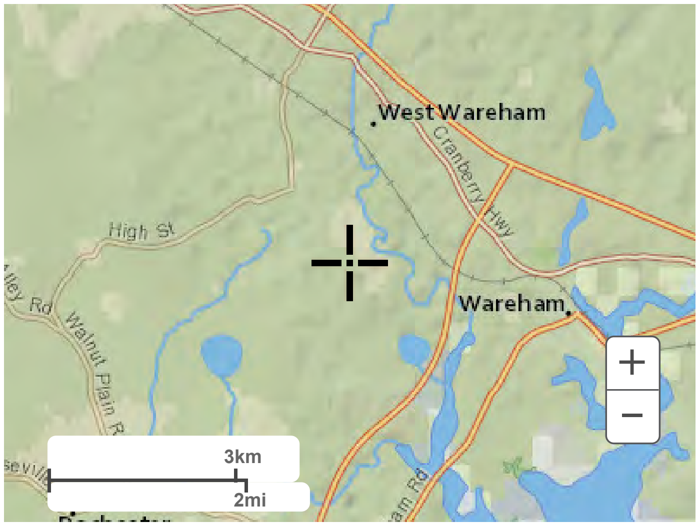
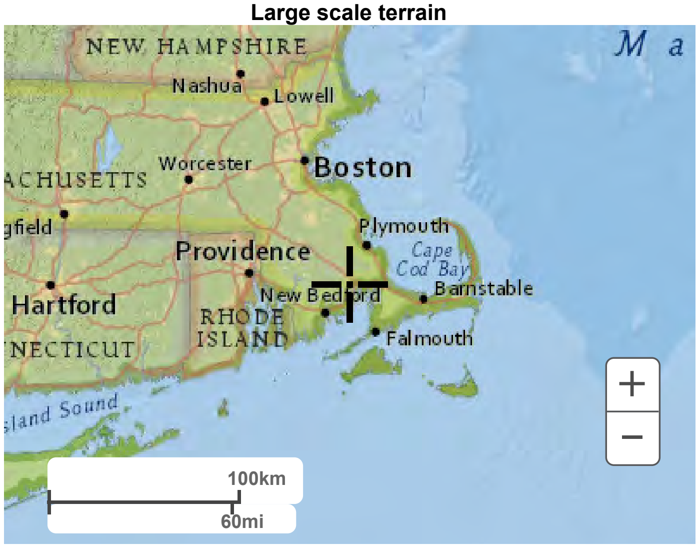
## Maps & aerials

**Small scale terrain**




**Large scale terrain**




**Large scale map**


**Large scale aerial**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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov


| LEGEND | |
|---|---|
| 1P | STORMWATER BASIN |
| 1S | SUBCATCHMENT AREA |
| DP1 | DESIGN POINT |
| —·—► | Tc PATH |
| —— | SUBCATCHMENT AND UNDISTURBED AREA BOUNDARY |
| 32A "D" | HYDROLOGIC SOIL GROUP AND BOUNDARY |

GRID NORTH NAD83

FILE: 3055.02-WSHD

**Atlantic® DESIGN ENGINEERS, INC.**
P.O. Box 1051, Sandwich, MA 02563 (508) 888 – 9282

Designed by: ________
Drawn by: ________
Checked by: ________
Survey chk. by: ________
Approved by: ________

SCALE
SCALE 1" = 120'
0 60 120 240

DATE

| NO. | BY | DATE | REVISION |
|---|---|---|---|

APPLICANT:
WAREHAM MA 3, LLC
100 SUMMIT LAKE DRIVE, SUITE 210
VALHALLA, NY 10595

PRE DEVELOPMENT WATERSHED PLAN
FOR
FEARING HILL ROAD SOLAR PROJECT
WAREHAM, MA 02576
MAY 17, 2021

Sheet 1 of 1
JOB NUMBER 3055.02


LEGEND

| | |
|---|---|
| 1P | STORMWATER BASIN |
| 1S | SUBCATCHMENT AREA |
| DP1 | DESIGN POINT |
| → | Tc PATH |
| —— | SUBCATCHMENT AND UNDISTURBED AREA BOUNDARY |
| 32A "D" | HYDROLOGIC SOIL GROUP AND BOUNDARY |

FILE: 3055.02-WSHD

**Atlantic® DESIGN ENGINEERS, INC.**
P.O. Box 1051, Sandwich, MA 02563 (508) 888 – 9282

Designed by :
Drawn by :
Checked by :
Survey chk. by :
Approved by :

SCALE
SCALE 1" = 120'
0 60 120 240

DATE

| NO. | BY | DATE | REVISION |
|---|---|---|---|

APPLICANT:
WAREHAM MA 3, LLC
100 SUMMIT LAKE DRIVE, SUITE 210
VALHALLA, NY 10595

# POST DEVELOPMENT WATERSHED PLAN
FOR
# FEARING HILL ROAD SOLAR PROJECT
WAREHAM, MA 02576
MAY 17, 2021

Sheet 1 of 1
JOB NUMBER 3055.02