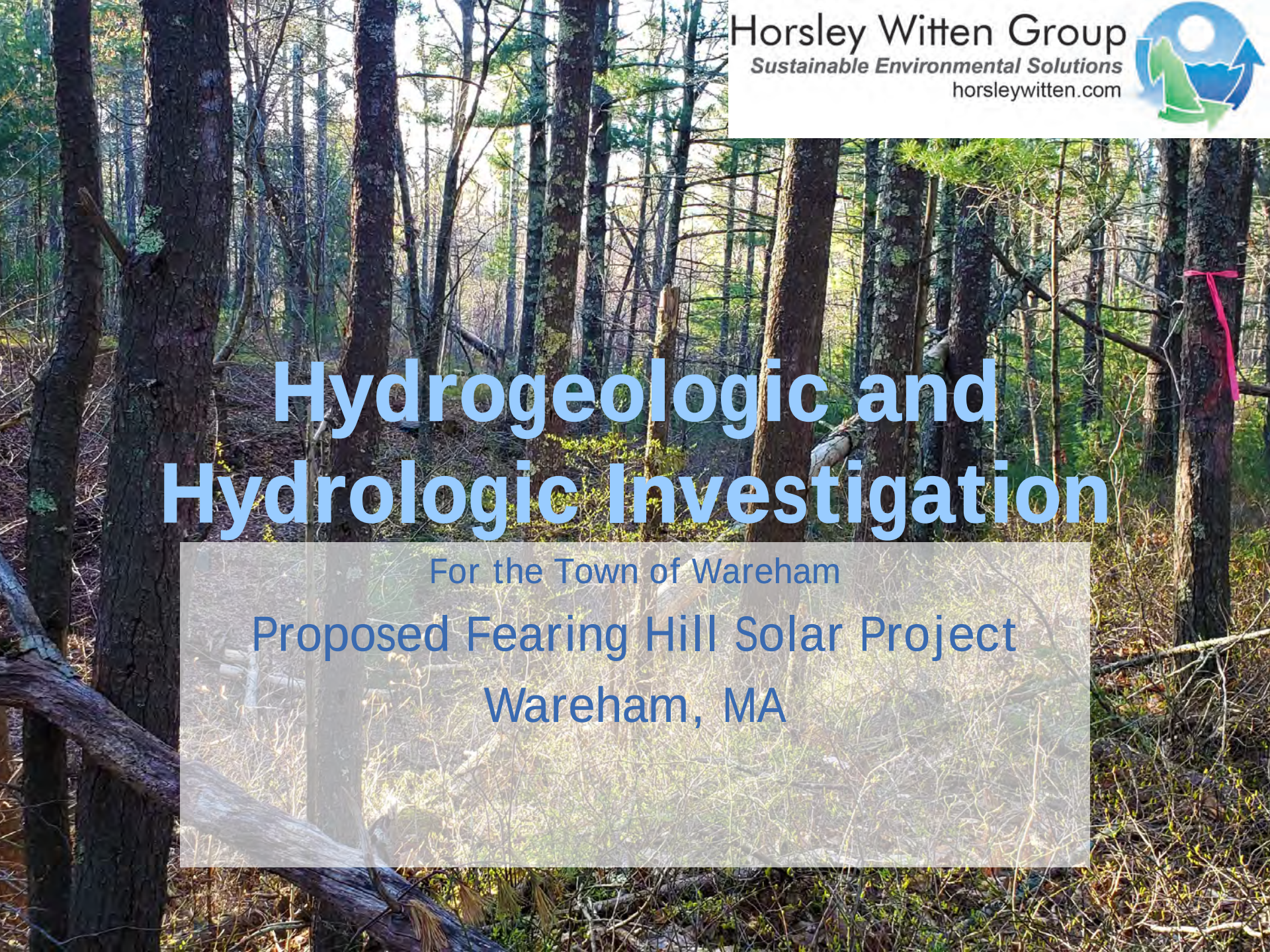


Horsley Witten Group
Sustainable Environmental Solutions
horsleywitten.com

Hydrogeologic and Hydrologic Investigation

For the Town of Wareham

Proposed Fearing Hill Solar Project

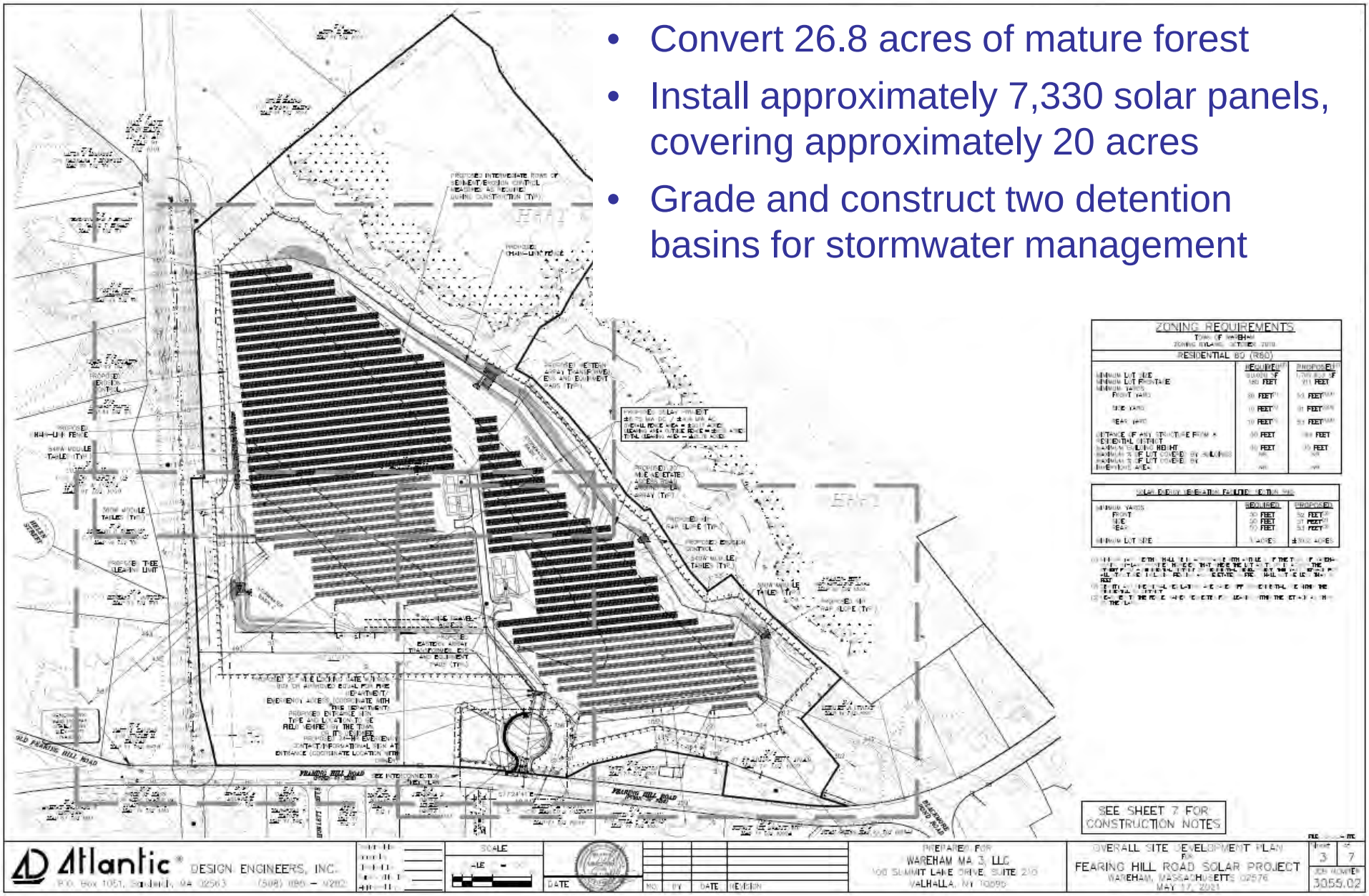
Wareham, MA

Agenda

- Overview of H&H investigation by HW
- Recommendations from H&H
- Applicant responses to Date
- Outstanding items
- Revised plans presented by Atlantic Design Engineers (Rich Tabaczynski)

Proposed Design at Time of Study

- Convert 26.8 acres of mature forest
- Install approximately 7,330 solar panels, covering approximately 20 acres
- Grade and construct two detention basins for stormwater management



Scope of Investigation

- Groundwater & Stormwater quantity only
  - Not a formal regulatory review
  - Significant water quality impacts unlikely

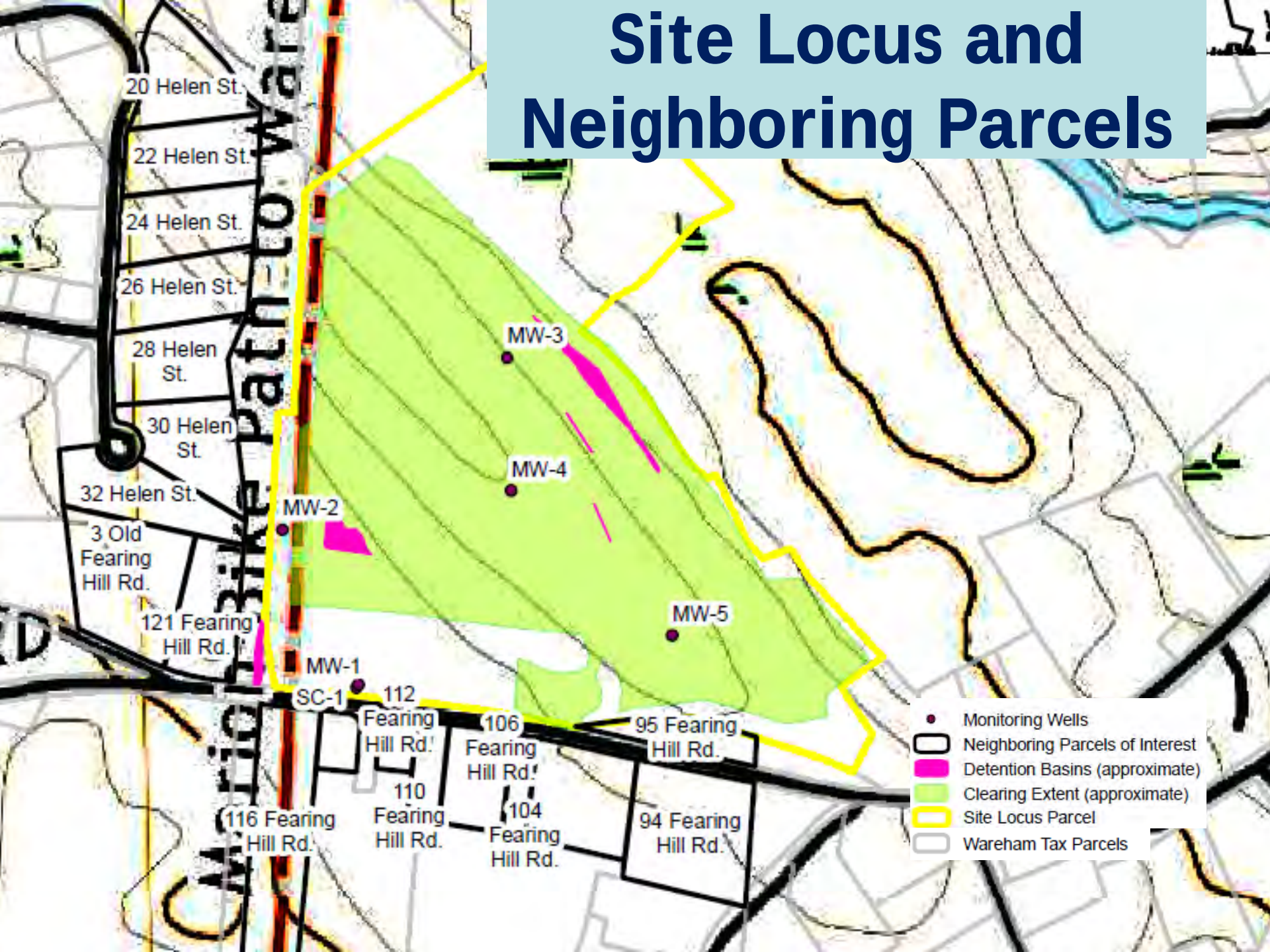
- No consideration of other factors
  - Net greenhouse gas emissions
  - Impacts to habitat
  - Non-hydro impacts to neighbors

Investigation Overview

- Field investigations (with Applicant):
  - Well drilling, groundwater monitoring, test pits, percolation tests
- Stormwater Modeling
  - HydroCAD pre- and post-development
- Groundwater Modeling
  - Steady state modeling in MODFLOW
  - Event-based modeling using Hantush equation
- Conservative and reasonable assumptions
  - Opposite assumptions for Groundwater vs. Stormwater

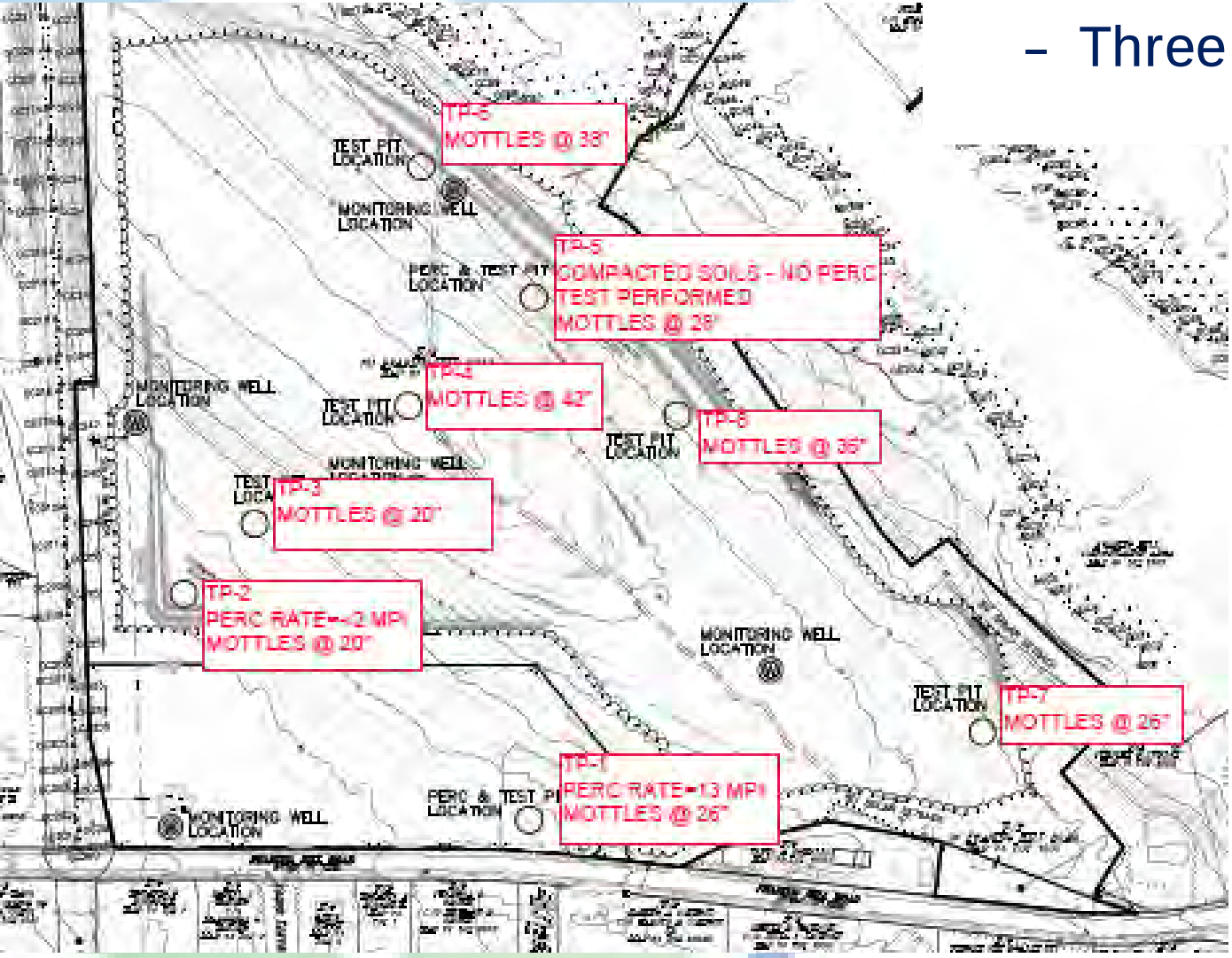
USGS Geology

Site Locus and Neighboring Parcels



Eight Test Pits

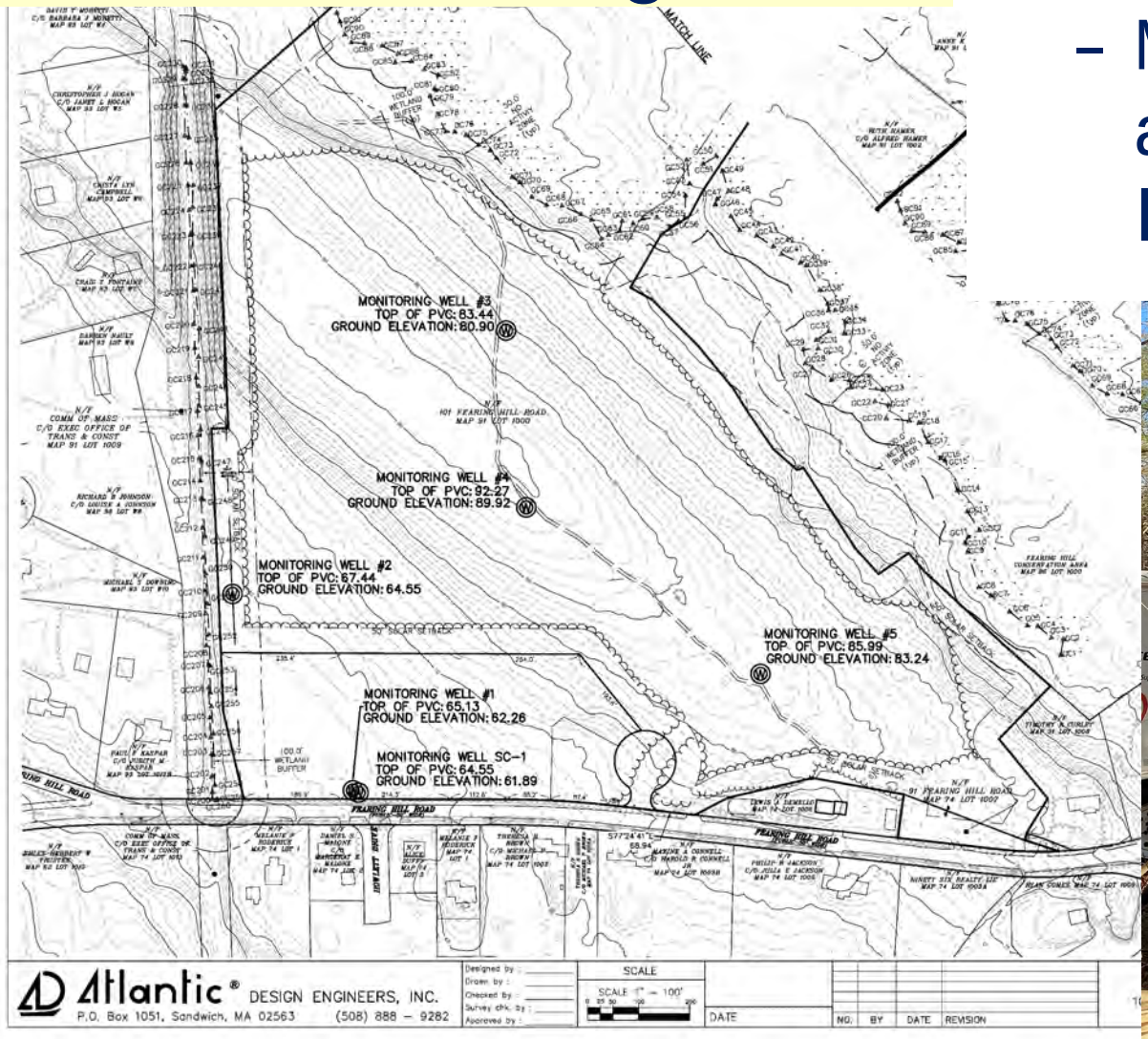
- Three percolation tests



Horsley Witten Group, Inc.

Six Monitoring Wells

- Surveyed
- Manual (4) and automated water level measurements



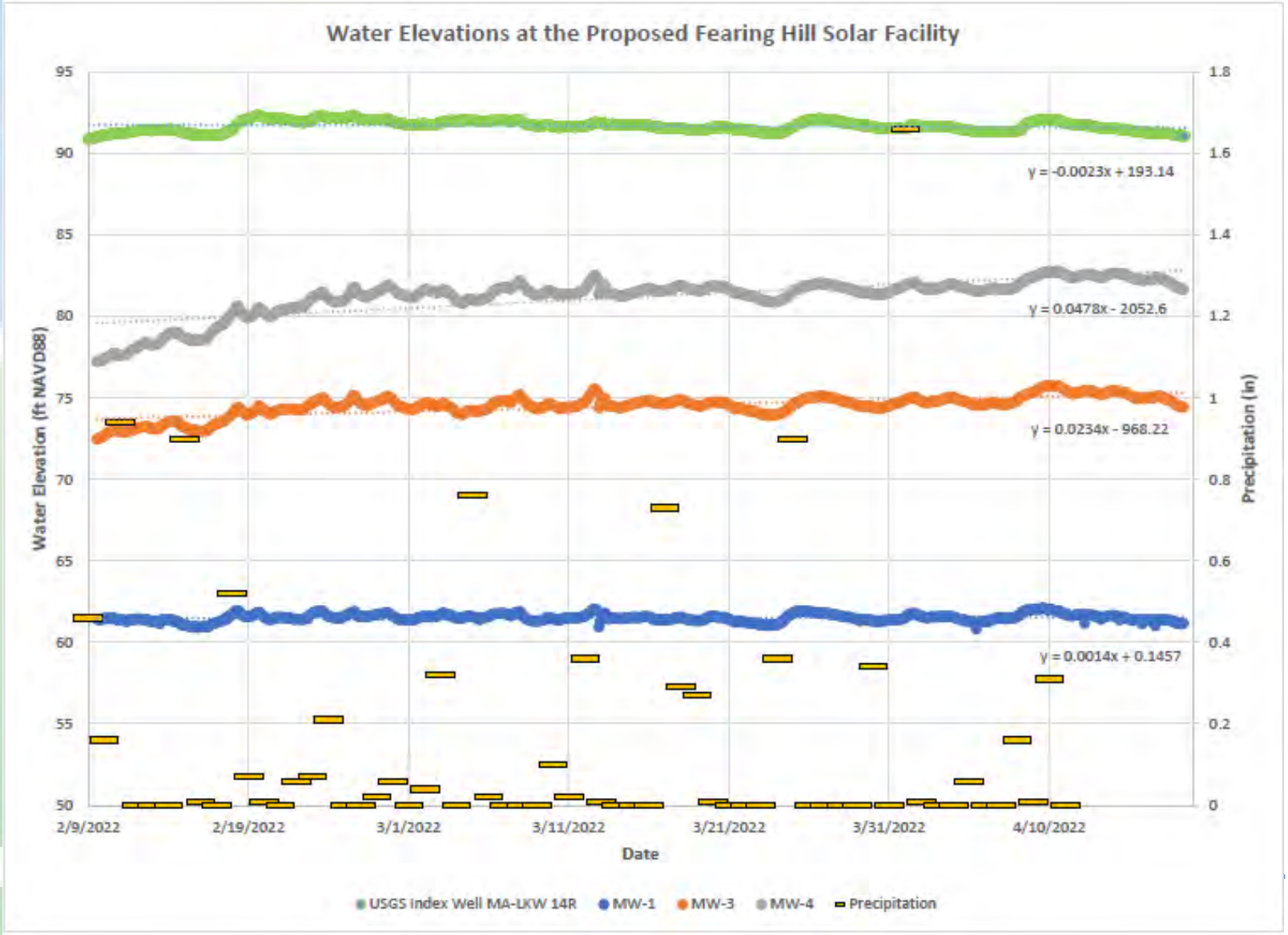
Test Pits and Borings

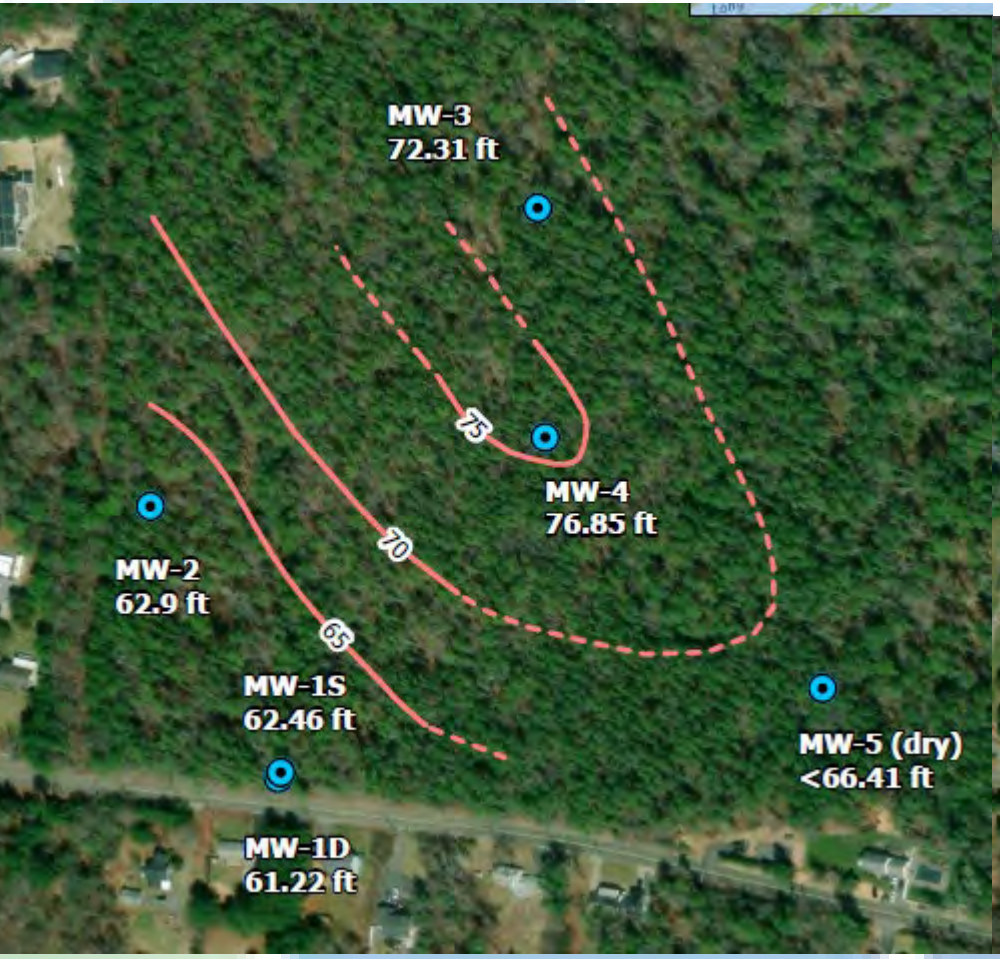
- Sandy loam/ compact till
  - Low percolation rate on Fearing Hill deposits
  - High percolation rate (≤2 min/in) at TP-2
- Shallow Depth to SHGW Water (20-42”)
- Fearing Hill drumlin has a shallow bedrock core (~16 feet bgs)

Field Investigations: Groundwater Monitoring

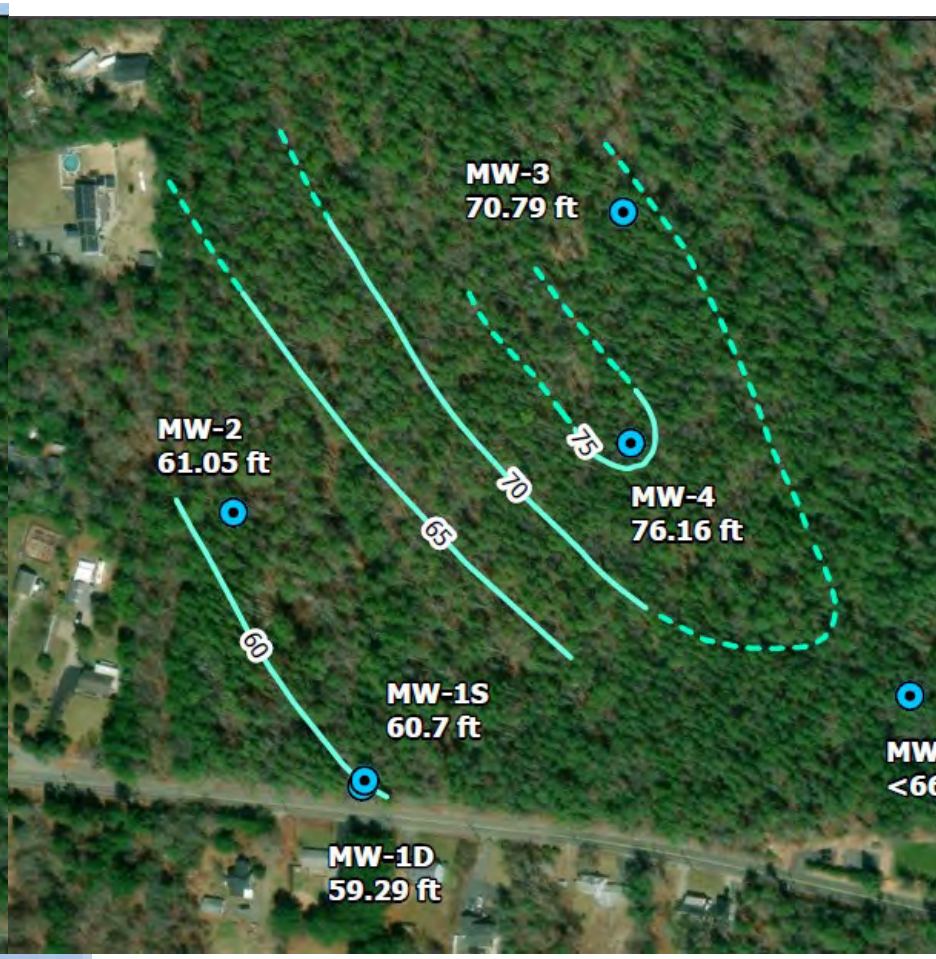
- Boring observation, manual water level measurement, water table mapping
- Automatic long-term water level measurement
- Comparison to USGS reference well

Observed GW Levels





February 9th, 2022



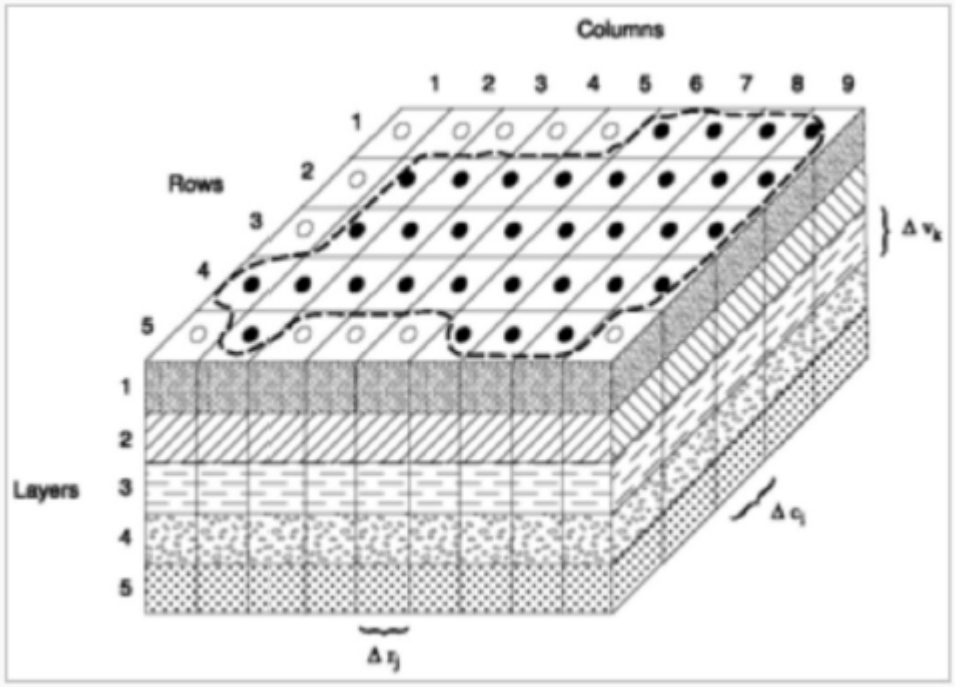
January 26th, 2022

Water Table Contours From Field Observations

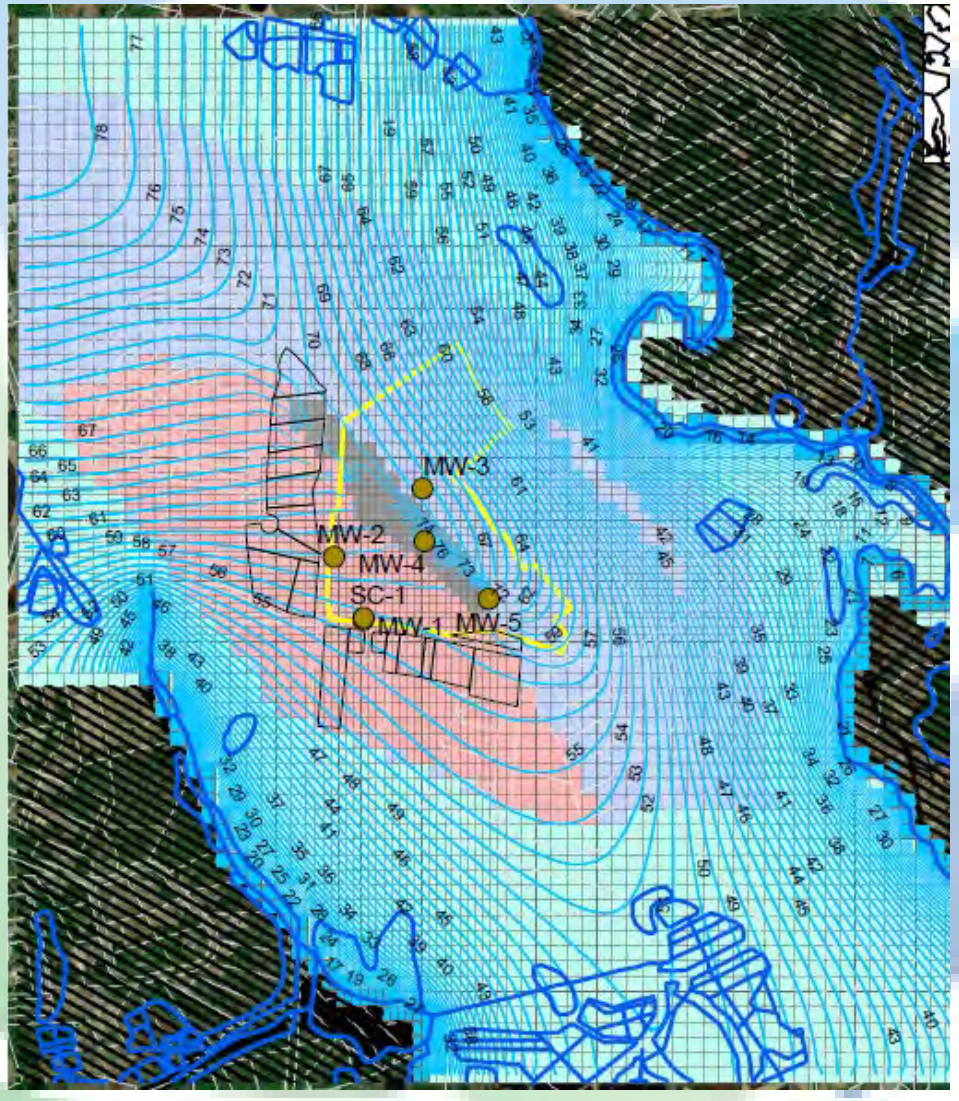
MODFLOW Groundwater Model

A new model was developed by HW to evaluate the long-term, steady state impacts of the proposed development

Groundwater models represent hydraulic properties in a 3D grid, then compute the behavior of groundwater in that virtual environment



Existing Conditions Model



Boundaries:

- Weweantic River to east
- Cranberry bog system to south/west
- Model extends 2,000 – 3,000 feet from site in other directions
- Recharge from the top
- Bedrock (no-flow) at model bottom

20 vertical layers

50 X 50 ft cell size at Site

Hydraulic Parameters

Hydraulic Conductivity:

- 7 ft/day surrounding area
- 8.5 ft/day southwest slope of hill
- 4 ft/day northeast slope of hill
- 1 ft/day weathered upper layer of bedrck

Recharge

- 10 in/year

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

Baseline Model Calibration

Hydraulic conductivity values based on USGS figures, adjusted based on field observations and model results

Calibrated to field-observed water levels

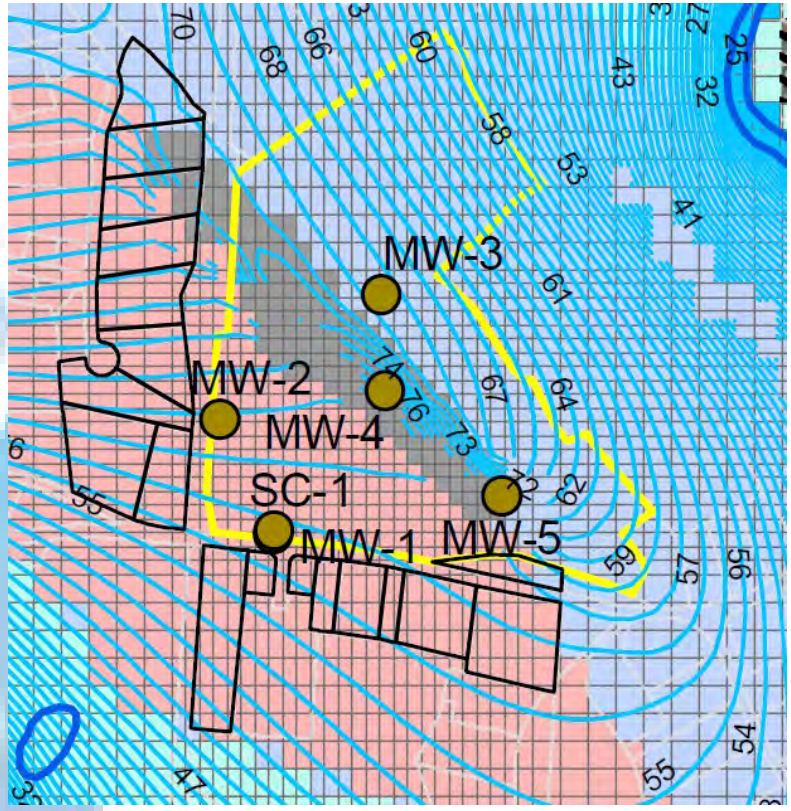


Table 13: MODFLOW Model calibration report

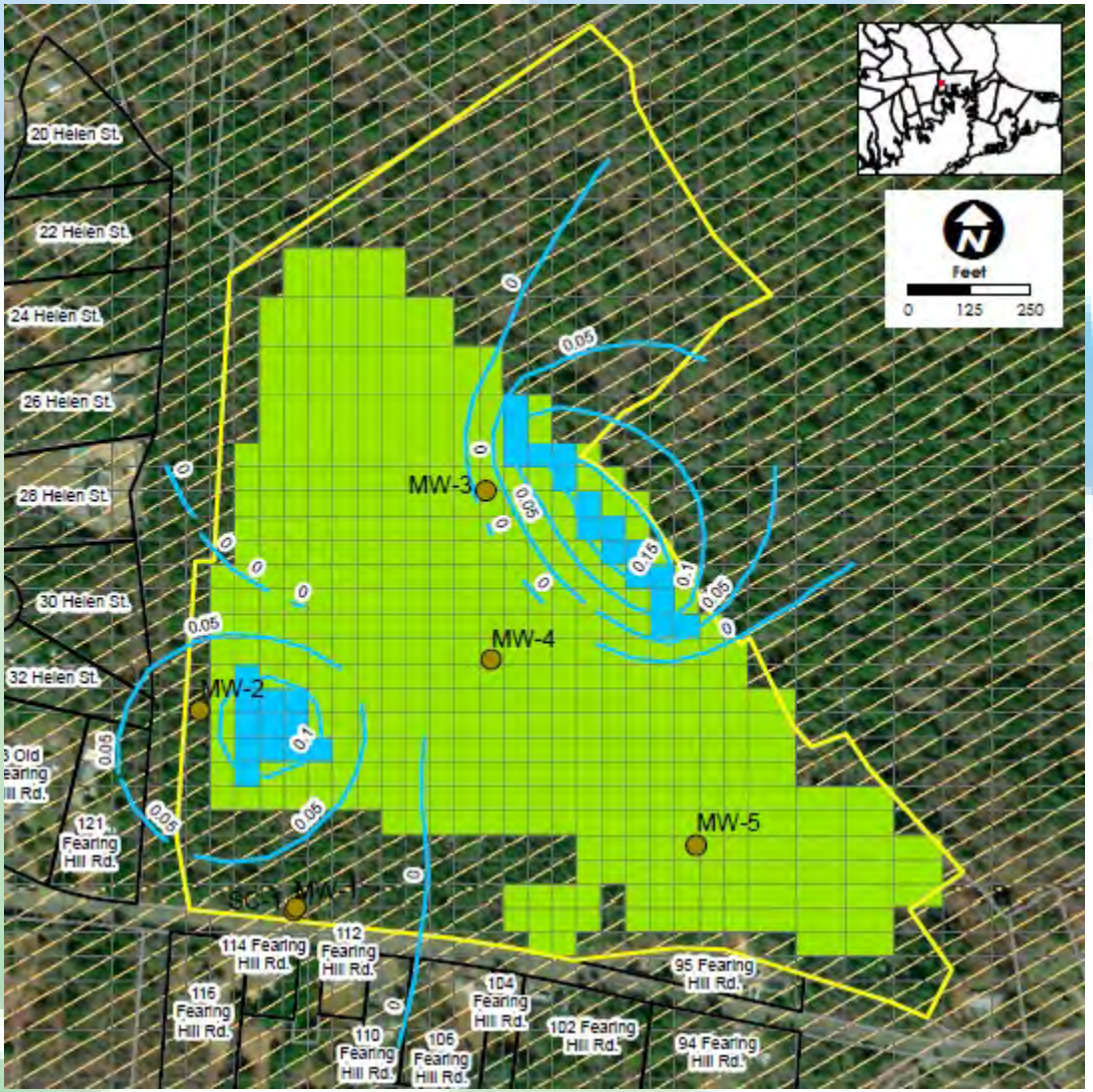
Well	Observed water table elevation January 26, 2022 (ft NAVD88)	Calculated water table elevation (ft NAVD88)	Residual (ft)
MW-1	56.80	56.32	0.48
MW-2	58.63	58.57	0.06
MW-3	68.44	68.34	0.10
MW-4	74.50	74.75	-0.25

Proposed Conditions Model

Assumptions:

- No net change in recharge
  - Approximately balanced loss of transpiration versus increased evaporation, runoff
- Relocation of recharge from hill crest to detention basins
  - Assumed 7.5% of recharge in the previously wooded areas will become runoff and will recharge at the detention basins
  - Though not infiltration basins, infiltration will likely occur at the detention basins
  - Most rainfall occurs in storm events smaller than the 2-year storm

Proposed Conditions Results



Green cells (clearing area) have 7.5% reduced recharge

Blue cells (detention basins) have increased recharge equal to the volume reduced

Maximum mounding at 32 Helen St. of 0.06 feet (approximately ¾ inch) is unlikely to cause detrimental impacts

Hantush Groundwater Modeling

Calculates groundwater mound from infiltration at a basin over shorter time

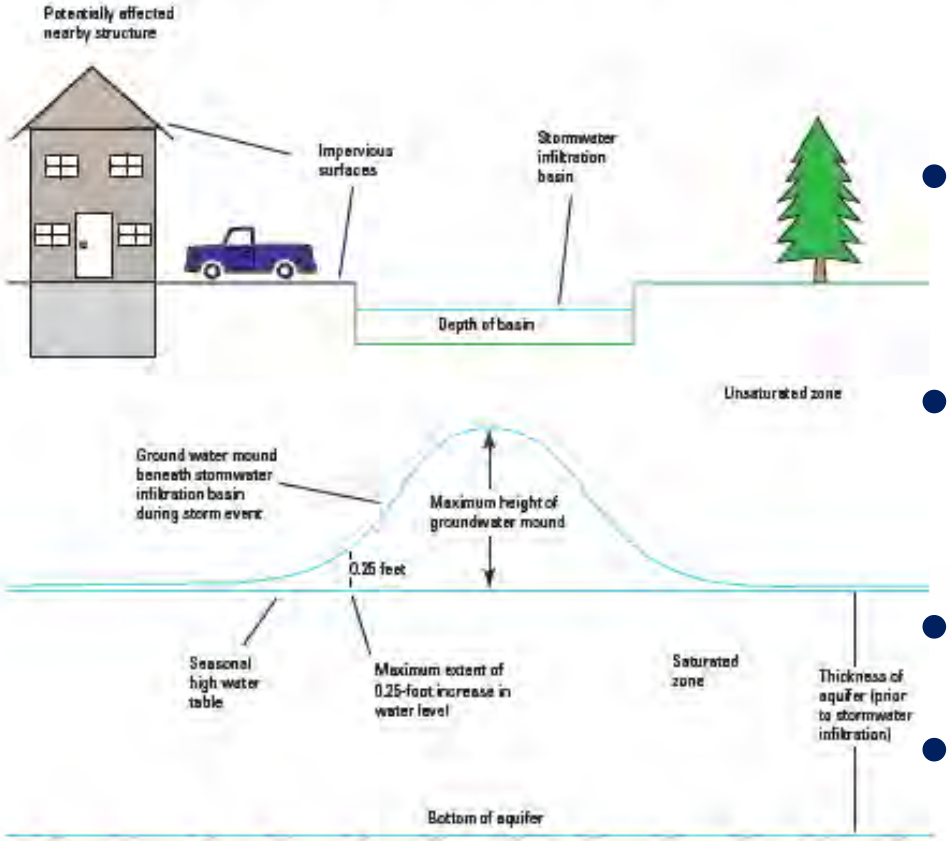
One dimensional – distance from the basin

- Effects from multiple basins must be superimposed

Mound for a single storm event

Stormwater Event Mounding (Hantush Method)

Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins



Scientific Investigations Report 2010–5102

- Size of infiltration area (feet^2)
- Hydraulic Conductivity (K)
- Aquifer Thickness (feet)
- Specific Yield (Sy)
- Recharge (R)
- Time (days)

Hantush Modeling Result (100-year storm)

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

Total Combined 100-yr Event GW 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

Stormwater Runoff Assessment

Event-based HydroCAD modeling of stormwater runoff impacts (e.g. peak discharge and flooding management)

- 2-, 10-, 25-, 100-year storm events

Conservative modifications to HydroCAD models provided by Atlantic

- Increased precipitation overall
- decreased pre-development runoff
- increased post-development runoff

Recommended Changes to Stormwater Model

Pre-Development

- Decreased runoff due to increased time of concentration
  - Surface updated from "light underbrush" to "dense underbrush"
  - Increased flow path as needed

Post-Development

- Increased runoff due to increased curve number for grass area
  - Grass areas updated to "fair" condition instead of "good" condition, based on RI DEM guidance for solar facilities

- Both scenarios: NOAA+ rainfall estimates instead of older values used by Atlantic

Stormwater Model Results

"Change" is change in flow or volume for post- vs pre- development scenarios, not HW versus Atlantic modeling.

As proposed, the stormwater basins are undersized to manage this amount of runoff.

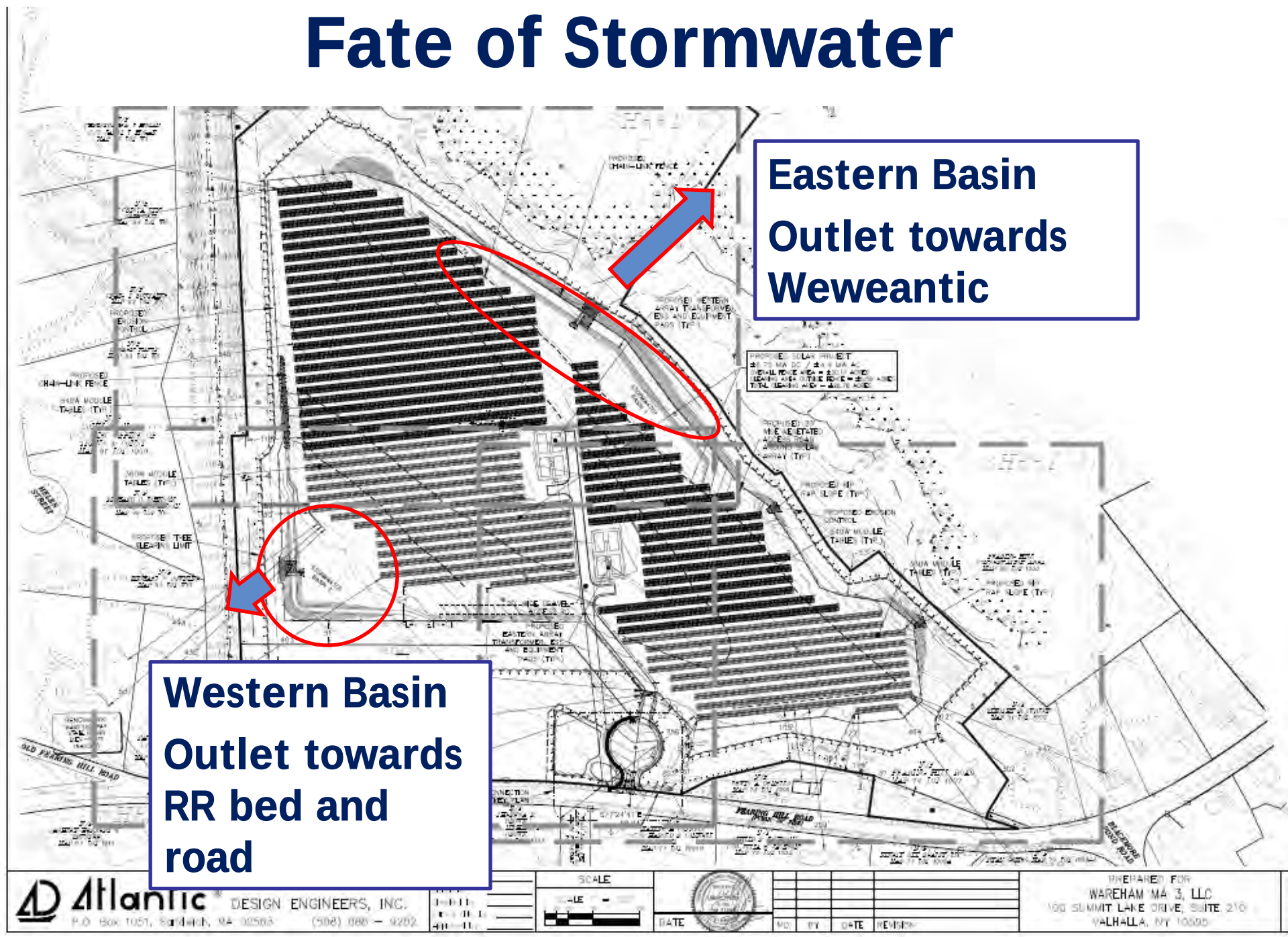
Table 11: Pre- and post-development flows for HW Models

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%

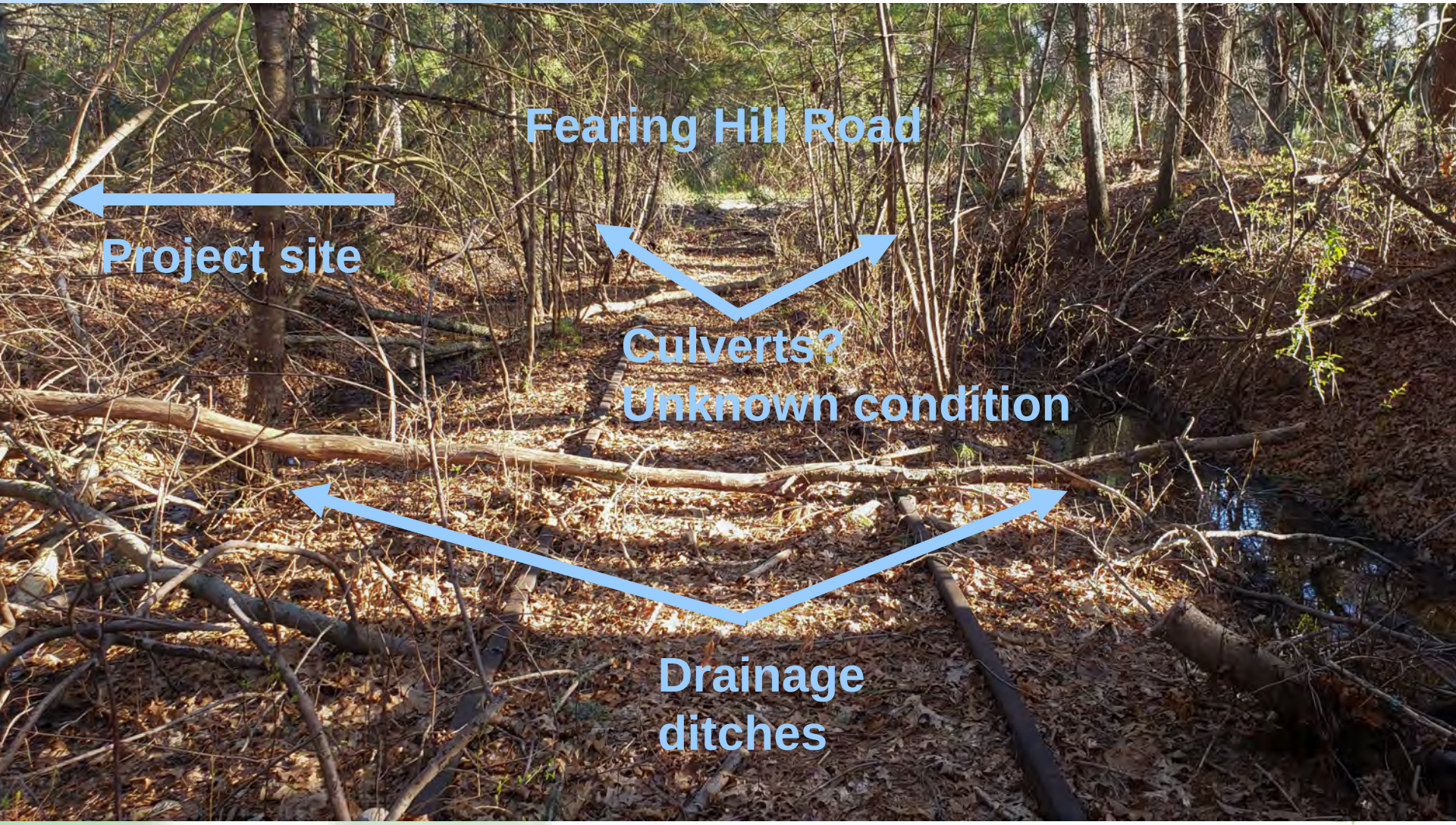
DP2	West Wetland					
Event	*Pre-development (HW)*		*Post-development (SW)*		Change	
	Flow, *cfs*	Volume, *a-f*	Flow, *cfs*	Volume, *a-f*	Flow	Volume
2-yr	7.82	1.200	12.21	1.800	56%	50%
10-yr	20.76	2.800	30.10	3.600	45%	29%
25-yr	31.67	4.100	43.24	5.100	37%	24%
100-yr	51.03	6.500	65.83	7.700	29%	18%

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%

Fate of Stormwater



Abandoned Rail Grade West of Project Site



Stormwater Conclusions

- The detention basins appear undersized and will not meet state stormwater standards as proposed.
- Stormwater draining to the north flows to the Weweantic River with no negative impacts anticipated.
- Stormwater draining to the south flows to drainage ditches along an abandoned railroad bed, which pass under Fearing Hill Road.
- Further evaluation is needed to assess the impacts to the drainage ditches, railroad bed, and Fearing Hill Road, culvert(s)

Recommendations

Massachusetts has basic guidance for ground-mounted solar facilities. Rhode Island has more updated guidance. The proposed facility does not meet Rhode Island's guidance regarding minimum panel spacing, which improve the health of meadow plants surrounding the panels, decreasing stormwater impacts.

Atlantic has provided greater than 50% grass cover inside the limit of work & also increased depth of topsoil and improved seeding mix to be eligible for "good" conditions land cover.

Recommendations

The HydroCAD pre- and post-development models should be updated with the NOAA+ rainfall amounts, and more accurate and conservative Time of Concentration and Ground Cover. These changes will necessitate larger detention basins.

Atlantic has updated the rainfall amounts and TC and GC values. The two basins were expanded and a third basin was added.

Recommendations

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

The basins are designed with level spreaders and rip rap aprons to prevent erosion. Atlantic will provide sizing information for those erosion control measures.

Recommendations (con't)

To the extent practical, stormwater runoff and infiltration should be minimized along the southwestern edge of the site to avoid potential impacts to the railroad grade, Fearing Hill Road, and neighbors in this area.

Atlantic has added a trench to divert stormwater from the west side of the hill to the wetland on the east side, where there is less groundwater impact.

Recommendations (con't)

The Applicant should undertake additional field survey and HydroCAD assessment of the drainage ditch and culvert system. The assessment should include a quantification of excess volume as well as peak runoff rates.

Atlantic further surveyed the culvert under Fearing Hill Road and has incorporated it in the HydroCAD modeling.

Recommendations

This railroad grade has been identified by the Town as a potential rail trail and impacts to this potential use should be evaluated.

Issue for Town evaluation. Revised design and analyses by Atlantic indicate no to minimal H&H impacts

Updated Project Design

- Presentation by Rich Tabaczynski from Atlantic.
- HW & Atlantic have been in communication on revised design.
- Few minor details on diversion trench and outfalls to work through.
- Overall revised design appears to address all H&H concerns.
- This evening ends HW's Scope of Work