**Trinkaus Engineering, LLC**
114 Hunters Ridge Road
Southbury, Connecticut 06488
203-264-4558 (office & fax)
+1-203-525-5153 (mobile)
E-mail: strinkaus@earthlink.net
http://www.trinkausengineering.com

December 19, 2018

Ms. Leslie King, Esq.
Murtha Cullina
One Century Tower
265 Church Street
New Haven, Connecticut 06510

Re: Solar Farm – Grassy Hill Road
East Lyme, Connecticut

Dear Ms. King,

At your request, I have reviewed the following additional documents for the solar farm which was constructed on Grassy Hill Road in East Lyme.

1. Site plans prepared for Antares Solar Field by BL Companies, dated: October 9, 2012 and revised to July 16, 2013.
2. Stormwater Management Report prepared for Antares Solar Field by BL Companies, dated: July 16, 2013 (Stormwater Management Report)

None of the information found in these documents changes my conclusions and professional opinions regarding issues with the design of the stormwater management and erosion control plan for the East Lyme solar farm.

**Executive Summary of Opinions:**

1. The stormwater management report grossly under estimates both the peak rate and runoff volumes which are being generated by the project as it does not consider the solar panels to be impervious. The panels are situated above the ground surface, thus every raindrop which falls on a panel instantly becomes runoff.
2. The applicant failed to account for changes in soil compaction and porosity which resulted from the considerable regrading of the site. The substantial cuts and fills of the site resulted in a soil surface which will not infiltrate and thus will generate more runoff than the undisturbed pre-development conditions.

**Developers Stormwater Management Plan and Report:**

To further support the professional opinions stated in the executive summary regarding the increases in the peak rate and runoff volumes, I have performed calculations to show the significant increases in the peak rate of runoff and runoff volume are being generated by the existing solar farm on Grassy Hill Road in East Lyme.

I have calculated the changes in both the peak rate of runoff and runoff volumes for that portion of the solar farm which is tributary to the Bialowans property. Based upon the plans and Stormwater Management Report prepared by BL Companies, sub-watershed areas A-1, A-2, A-3, A-4, A-5 and B-1 identified therein were analyzed.

The Time of Concentration value used by BL Companies as well as their total sub-watershed area was used in my analysis. I made three modifications compared to the BL analysis. First, the area of the solar panels was considered as pervious by BL Companies and I considered them to be impervious as all rainfall which falls on the panels is converted to runoff. An impervious surface has a Runoff Curve Number (RCN) of 98. Each panel was shown on the site plan by BL Companies as a separate unit and measured 10' x 35'. To determine the impervious area, I counted the number of solar panels within each sub-watershed area.

The approved site plans BL Companies showed a gap between each panel in a row; however, in the field there is no gap between each panel, so the actual peak rate of runoff and runoff volumes would be higher than the values stated in Table #1 and #2 for Trinkaus #1 and Trinkaus #2. The calculated values for Trinkaus #1 and Trinkaus #2 are based upon a gap existing between the individual panels as shown on the BL Company site plans.

Secondly, the RCN for the gravel roads was changed from 89 to 96. In the HydroCAD Version of TR-55, there are two categories for a gravel road. First, a gravel road (with right of way) has an RCN of 89. This is the value used by BL Companies in their stormwater management plan and is not applicable in this case as the gravel road is simply located within the limits of the solar farm. A gravel road (w/o right of way) has a RCN of 96 according to the HydroCAD program and this condition reflects what was actually proposed by BL Companies and constructed in the field at the Antares Solar Farm.

Lastly, one analysis (Trinkaus #1) was done using a RCN for Lawn in Good Condition on a Class C soil (74) and the second analysis (Trinkaus #2) was done using a RCN for Lawn in Good Condition on a Class D soil (80). The Class D soil designation more accurately reflect the disturbed soil conditions on the site as a result of the regrading and compaction specifications on the approved plans by BL Companies.

Applying these three modifications, the peak rate of runoff for the 2-year rainfall event (3.4" per 24 hours as stated in the Stormwater Management Report by BL Companies) was analyzed; the results are shown in Table #1 below. Peak Rate of runoff is shown as cubic feet per second (cfs). Runoff volume for the two-year rainfall event is shown in Table #2. Runoff volume is measured in acre-feet. (An acre-foot is 1 foot of water over 1 acre of land (43,560 cubic feet of water).)

Table #1

| Post-Development Watershed Area | BL Companies | Trinkaus #1 | **Net Change/ Percent Change** | Trinkaus #2 | **Net Change** |
|---|---|---|---|---|---|
| Peak Rate | cfs | cfs | | cfs | |
| A-1 | 5.36 | 5.63 | **+0.27/5.0%** | 7.66 | **+2.30/22.9%** |
| A-2 | 5.52 | 6.49 | **+0.97/17.6%** | 8.25 | **+2.73/49.4%** |
| A-3 | 7.12 | 8.35 | **+1.23/17.3%** | 10.60 | **+3.48/48.9%** |
| A-4 | 5.11 | 5.97 | **+0.86/16.8%** | 7.53 | **+2.42/47.3%** |
| A-5 | 7.43 | 14.32 | **+6.89/92.7%** | 18.13 | **+10.70/144.0%** |
| B-1 | 3.40 | 4.15 | **+0.75/22.0%** | 4.97 | **+1.57/46.2%** |

Table #2

| Post-Development | BL Companies | Trinkaus #1 | **Net Change/ Percent Change** | Trinkaus #2 | **Net Change** |
|---|---|---|---|---|---|
| Runoff Volume | cubic feet | cubic feet | | cubic feet | |
| A-1 | 0.530 | 0.556 | **+0.026/4.9%** | 0.732 | **+0.202/38.1%** |
| A-2 | 0.545 | 0.629 | **+0.084/15.4%** | 0.786 | **+0.241/44.2%** |
| A-3 | 0.715 | 0.826 | **+0.111/15.5%** | 1.032 | **+0.317/44.3%** |
| A-4 | 0.542 | 0.624 | **+0.082/15.1%** | 0.776 | **+0.234/43.4%** |
| A-5 | 0.774 | 0.898 | **+0.124/16.0%** | 1.121 | **+0.347/44.8%** |
| B-1 | 0.312 | 0.375 | **+0.063/20.2%** | 0.446 | **+0.134/42.9%** |
| | | | | | |

The results shown in both Table #1 and Table #2 clearly show that both peak rate and runoff volumes are substantially higher when the solar panels are considered impervious.

The engineering standard for the design of a stormwater management is to consider any hard surface above ground or on the ground surface as impervious. The stormwater manuals of the States of Massachusetts, Minnesota, North Carolina and Maryland have sections which specifically address how to handle stormwater from large scale solar farms. Links to these sections are provided below.

State of Massachusetts: https://www.mass.gov/guides/massdep-wetlands-program-policy-17-1-photovoltaic-system-solar-array-review

State of Minnesota:
https://stormwater.pca.state.mn.us/index.php?title=Fact_sheet_on_stormwater_guidance_for_solar_farm_projects

State of North Carolina:
https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Stormwater/BMP%20Manual/E-6%20%20Solar%20Farms.pdf

State of Maryland:
https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Documents/ESDMEP%20Design%20Guidance%20Solar%20Panels.pdf

The common features in these four manuals is that solar panels themselves could be considered pervious if all of the following conditions are met. If any of conditions are not met, then the solar panels must be considered as impervious.

a. Minimize site disturbance,
b. Prevent compaction of the soils on the solar farm, particularly in the area of the panels and vegetated strips,
c. Prevention the removal of topsoil from the site or replace the topsoil prior to seeding,
d. Maintain or restore infiltrative capacity of the soil,
e. Prevent concentrated flow from occurring,
f. Establishment of a dense vegetated cover on the soil surface.

The Antares Solar Farm on Grassy Hill Road in East Lyme does not meet any of the conditions stated above, therefore the solar panels must be considered impervious in the design of the stormwater management systems.

At the field inspection of the site on October 5, 2018, it did not appear that topsoil was replaced on the site after being removed to permit the mass grading of the site to occur. This observation is based on a visual inspection of the ground surface which did not show dark brown organic soil on the surface. The ground under the rows of panels and between the rows was light brown and very compacted, whereas if topsoil was present, the surface would not be compacted due to the higher organic content found in topsoil.

There is clear evidence in the field that runoff from the solar panels are not infiltrating into the disturbed soils under the entire solar farm. This evidence of erosion and resultant sedimentation is shown in Figure 1 and Figure 2 below.

Figure 1 - Concentrated flow from runoff off solar panel

Figure 2 - Erosion & Sedimentation resulting from concentrated flow

On Sheet GN-1 by BL Companies with a revision date of 7/16/13 under Grading and Utility Notes, note #5 states the following: "The contractor shall compact fill in 8" maximum lifts under all building areas to 95% of the maximum dry density as determined by ASTM D1557 (Modified Proctor Test), or as directed by the Geotechnical Engineer." In my professional opinion, the term "all building areas", mean the entirety of the solar farm. The natural soils

were cut and filled substantially on the site, compacted to the ASTM D1557 standard, which easily and clearly explains why there is no infiltration occurring within the grass areas on the solar farm and more runoff is being created for all rainfall events.

Information on the ASTM D1557 standard can be found at this link: https://www.astm.org/Standards/D1557.htm . The following language was taken from this link and the sentence shown in bold is how the properties of the natural soil would be changed.

NOTE 3: The degree of soil compaction required to achieve the desired engineering properties is often specified as a percentage of the modified maximum dry unit weight as determined using this test method. If the required degree of compaction is substantially less than the modified maximum dry unit weight using this test method, it may be practicable for testing to be performed using Test Method D698 and to specify the degree of compaction as a percentage of the standard maximum dry unit weight. Since more energy is applied for compaction using this test method, the soil particles are more closely packed than when D698 is used. **The general overall result is a higher maximum dry unit weight, lower optimum moisture content, greater shear strength, greater stiffness, lower compressibility, lower air voids, and decreased permeability.** However, for highly compacted fine-grained soils, absorption of water may result in swelling, with reduced shear strength and increased compressibility, reducing the benefits of the increased effort used for compaction **(2)**. Use of D698, on the other hand, allows compaction using less effort and generally at a higher optimum moisture content. The compacted soil may be less brittle, more flexible, more permeable, and less subject to effects of swelling and shrinking. In many applications, building or construction codes may direct which test method, D698 or this one, should be used when specifying the comparison of laboratory test results to the degree of compaction of the in-place soil in the field.

**Corrective Action to Remediate the Stormwater Management System:**

In order to reduce the runoff being discharged from the solar farm, the existing stormwater management systems must be remediated to provide the Channel Protection Volume (CPV) as specified in the CT DEP 2004 Storm Water Quality Manual. The CPV requires developers to reduce the post-development peak rate of runoff from the 2-year rainfall event to 50% of the pre-development peak rate for the 2-year storm event. The intent of the CPV is to reduce the post-development peak rate, which will significantly increase the duration of flow directed to a receiving stream. By reducing the peak rate, the nominal flow depth in the receiving streams is lowered for the all rainfall event up to and equal to the 2-year rainfall event to the more naturally stable cross-sectional area of the stream, thus preventing adverse changes to the morphology of the stream channel. The following work must be done to the Antares Solar Field in order to have a stormwater remediation plan which provides the CPV:

1. An As-built survey of the entire solar farm done conforming to the following standards.

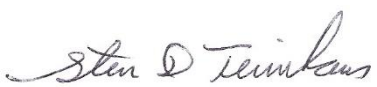
    a. Boundary work and survey location performed to a Class A-2 standards locating all buildings, solar panels, gravel roadways, stormwater management practices (ponds and swales),
    b. A two-foot topographic survey of the solar farm which meets Class T-2 standards. The area of the topographic survey needs to encompass all those areas within the fenced area of the solar farm, including the detention ponds and swales. The

limit of topographic survey must extend a minimum of fifty (50) feet beyond the eastern and southern limit of grading of the solar farm.

2. A revised stormwater management analysis and design encompassing the following parameters.
    a. All solar panels, all buildings or above ground equipment identified as impervious,
    b. The grass on all disturbed areas within the limits of the solar farm shall be considered as Grass (good condition on a Class D soil),
    c. Post-development watershed boundaries shall be established by the design engineer based upon current as-built conditions,
    d. Times of concentration shall be determined by the current field conditions,
    e. Runoff Curve Numbers (RCN) will be determined based upon current field conditions and the parameters stated above,
    f. Post-development peak rates of runoff and runoff volumes shall be determined by HydroCAD or a similar hydrologic model for the two-year rainfall event (3.4"/24 hours),
    g. The size and hydrologic outlets of all the existing stormwater ponds shall be redesigned to provide the Channel Protection Volume (CPV) as specified in the CT DEP 2004 Storm Water Quality Manual as well as attenuate the peak rate of runoff for the 10-year rainfall event. An appropriate overflow spillway shall be incorporated into the design of all stormwater ponds for all rainfall events larger than the 10-year event up to and including the 100-year rainfall event,
    h. A revised site plan showing the modifications to all the stormwater ponds shall be prepared. The site plans shall include all construction details for each stormwater pond and their respective outlet structures,
    i. An erosion control plan, conforming to the CT DEP 2002 Guidelines for Soil Erosion and Sediment Control shall be prepared for the modifications of the stormwater ponds,
    j. A revised stormwater management report shall be prepared with all calculations and pond routing analyses.

The above modifications to the stormwater management plan for the solar farm must be reviewed and approved by a third-party engineering consultant which expertise in stormwater management prior to its implementation. No cost for the implementation of the stormwater pond modifications can be determined until an actual design has been made.

Respectfully Submitted,
Trinkaus Engineering, LLC



Steven D. Trinkaus, PE