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April 25, 2024

VIA ELECTRONIC MAIL

Melanie Bachman
Executive Director
Connecticut Siting Council
10 Franklin Square
New Britain, CT 06051

> Re: Petition No. 1609 - TRITEC Americas, LLC notice of election to waive exclusion from Connecticut Siting Council jurisdiction, pursuant to Connecticut General Statutes §16-50k(e), and petition for a declaratory ruling, pursuant to Connecticut General Statutes §4-176 and §16-50k, for the proposed construction, maintenance and operation of a 0.999-megawatt AC solar photovoltaic electric generating facility located at 250 Carter Street, Manchester, Connecticut, and associated electrical interconnection. **Submission of Testimony and Evidence**

Dear Executive Director Bachman:

As a pending status Party, I hereby submit a Testimony document with respect to possible contamination of stormwater, groundwater and drinking water as a result of PE 1609. I expect to submit at least one additional testimony document separately. Also attached and enclosed are Evidence documents related to this Testimony. I am delivering fifteen (15) paper copies of the Testimony and the Evidence to the Siting Council offices.

I certify that I am including on the distribution of this emailed submission all the parties on the Service List shown on the Siting Council's website as of today as well as parties with pending applications for Party and/or Intervenor status.

Respectfully,

Raymond Welnicki

cc: cc John F. Sullivan, Attorney for Town of Manchester, Raymond Welnicki, Rachel and Dana Schnabel, Rosemary Carroll (on behalf of MARSD), Attorneys for the Petitioner: Paul R. Michaud, Bernadette Antaki, Dylan J. Gillis

TESTIMONY
Petition 1609
Submitted by Ray Welnicki, Party (status pending on date of submission)

This is testimony of Ray Welnicki, MAAA, who is a resident of 121 Amanda Drive, Manchester CT 06040. That property abuts 250 Carter St. in Manchester. I have filed for Party status with respect to Petition 1609 and I enter this testimony in that regard.

I am a Member of the American Academy of Actuaries and a past Fellow of the Society of Actuaries. While I am not testifying in my professional role as an actuary, I represent that my actuarial training and experience provides me with substantial and credible proficiency in evaluating risk in a wide variety of applications. This includes assessing factors that lead to reasonable conclusions regarding the potential for certain situations, events and conditions to occur or arise and the potential for them to produce significant adverse consequences. I certify that I have applied my risk assessment skills and proficiency in developing this testimony.

Potential Contamination of Stormwater, Groundwater and Drinking Water

Based on the information in Petition 1609 and evidence that I have submitted it is clear that the Petitioner has not met their burden of proof that no substantial adverse environmental effects will result from their proposed development of a solar electrical generating facility at 250 Carter St. in Manchester, CT.

In summary, my analysis shows that there is a real potential for leaching of toxic substances from the solar panels and that those substances can realistically migrate to aquifers that private wells in the area draw from and to an aquifer that at least one of Manchester's public drinking water supply wells draws from. My conclusion based on this analysis is that the Petitioner has not proven that there will be no contamination whatsoever of stormwater, groundwater and any private or public drinking water supply. Below, I present a detailed analysis of this with respect to the potential contribution of this facility to contamination of public and/or private drinking water supplies.

1) An environmental hazard posed by solar facilities is that toxic substances contained in the solar panels may leach out of the panels onto the soil and mix with stormwater and groundwater. The consequences resulting from this hazard can be particularly acute when those substances migrate into public and/or private water sources used for drinking water.
2) The burden of proof is on the Petitioner to demonstrate that the hazard described in (1) above will not result in any substantial adverse environmental effects. Accordingly, the Petitioner must prove one of the following:
    a) Scenario 1: There are no toxic substances in the solar panels;
    b) Scenario 2: The probability of leaching of toxic substances from the solar panels is so low that the risk is inconsequential; or

c) Scenario 3: Some toxic leaching may occur, but the resulting environmental consequences are insignificant.

3) I contend that the Petitioner cannot prove any one of these scenarios with reasonable certainty. Let's analyze each of the scenarios based on available evidence.

4) **Scenario 1**. The Product Information in Appendix E of the Petition indicates that the solar panels were tested for a variety of toxic substances. The TCLP testing showed measurable leaching for one substance: barium. While leaching of other toxic substances was below minimum detection levels, the manufacturer did not claim that these substances are not present at all in the solar panels. Consequently, the Petitioner cannot prove that Scenario 1 is applicable, and, in fact, the Petitioner does not appear to be claiming this. So, this eliminates Scenario 1 from consideration.

5) **Scenario 2.** The Petitioner appears to rely on the TCLP testing of the panels as shown in Appendix E- Product Information of the Petition to contend that the probability of measurable levels of toxic substance leaching from the panels is negligible. I do not believe that these test results should be accepted as proof that no substantial adverse environmental effects would occur as a result of deploying these solar panels for two basic reasons:

   a. Reason 1. It is my understanding that federal and state TCLP testing standards require a test period ranging from 18 hours (federal) to 48 hours (California). But toxicity studies submitted as Evidence indicate that much longer testing periods (some suggest up to one year) are at a minimum desirable if not necessary in order to mirror real world experiences. For example:

   - The study *A Review of Toxicity Assessment Procedures of Solar Photovoltaic Modules* states in Section 4.4 regarding CdTe (Cadmium telluride): "For instance, a year-long leaching study (using 5 cm x 5 cm sample pieces) revealed that approximately 62 % of the Cd in CdTe commercial module pieces leached out under simulated acid rain conditions with a pH of 3, employing citric acid as the leaching agent (Nover et al., 2017)."
   - That same study in Section 4.5 indicates "Regulatory leaching tests universally specify the use of room temperature (20–25 ◦C) throughout the fluid agitation and extraction steps. Elevated temperatures can accelerate the diffusion rate of metals, leading to a greater release of toxic elements into the solution (Collins and Anctil, 2017)." Solar panels in actual installed arrays will reach temperatures much greater than used in testing and will therefore leaching of toxic substances is likely to be greater in the field than that shown by the TCLP test results.
   - The study *Leaching via Weak Spots in Photovoltaic Modules* states in its Abstract as submitted into Evidence: "Our long-term experiments clearly demonstrate that it is possible to leach out all, or at least a large amount, of the (toxic) elements from the photovoltaic modules. It is therefore not sufficient to carry out experiments just over 24 h and to conclude on the stability and environmental impact of photovoltaic modules."

   Additionally, no details are provided in Appendix E of the Petition regarding how the samples used in the TCLP testing were taken. Without this information, we simply do not know whether the test results are representative of leaching potentials throughout the solar panels. In this regard, we call attention to the article published in EPRI Journal on June 8, 2022 as submitted in Evidence (see "Why Consistent Sampling Is Key to Solar Module Toxicity Testing"). Based on studies and discussions with researchers, the article points out that significant variability in TCLP test results can occur depending on how the solar panel sample was obtained. As that article points out, "The result is that a sample from a crystalline silicon module could comprise only material with no lead, like pieces of aluminum frame and cell areas with little metallization. Using such a sample, a TCLP lab would deem the module non-hazardous. But another sample from the very same module—say, from the solar cell interconnect ribbon areas, where there typically are significant amounts of lead—could be designated as hazardous."

Thus, Scenario 2 (i.e., low probability of toxic leaching) cannot be proven unless the solar panels are tested over a much longer time period (e.g., a year) than standard TCLP testing (e.g., 18 – 48 hours), and the solar panel samples submitted for testing are verified to be representative of the entire panel. The Petitioner has not provided evidence on these two testing aspects and, therefore, has not shown that TCLP testing proves that there is a low probability of toxic leaching

b. <u>Reason 2</u>. The TCLP testing is designed primarily to model potential leaching of panels in landfills and not potential leaching resulting after damage sustained at the solar facility as a result of fire, windstorms (including tornados), hurricanes, hailstorms, vandalism and other real life occurrences. Consider the following:
    - In 2019, a hailstorm in west Texas caused $70 – 80 million in damages to a solar facility according to an article submitted as Evidence titled "Solar Farm Hail Damage: The Perfect Storm".
    - The insurance industry is concerned about escalating claims costs at storm damaged renewable energy projects including solar facilities, according to this article submitted as Evidence: "Baseball-Size Hail Makes Insuring Solar and Wind Farms Pricier".
    - In 2016, an EF-1 tornado (second lowest of 6 categories of tornados) damaged a quarter of the 97 rows of solar panels at a National Guard camp on Minnesota, according to an article submitted in Evidence titled "Tornado damages National Guard camp's new solar energy project". The tornado with maximum winds of 90 miles per hour did this extensive damage despite the fact that, according to the article, "The array was designed and built to American Society of Civil Engineers structural codes to withstand 105 mph winds".
    - In 2019, Hurricane Dorian severely damaged a solar facility at Grandy, NC, according to a news report submitted as Evidence: "Newly-built Currituck solar farm damaged by Hurricane Dorian".
    - A 2022 article submitted into Evidence entitled *Fire a major hidden danger for solar farms* states that: "A recent report by Firetrace International found that the solar industry is potentially underestimating the risk of fire at solar farms,

partly due to a shortage of data on solar farm fires. The report also said that research into the issue has given rise to suspicions that fires at solar farms have been under-reported."

- A report from the International Renewable Energy Agency (IRENA) cited by Tescol, a French solar consultancy and submitted into Evidence states that over 7% of solar farms worldwide were vandalized in 2022, an increase of 10% from 2021. (see "Photovoltaic parks are new targets for vandalism" dated Nov. 26, 2023 submitted in Evidence.)

Given the above, it should be clear that solar panels may be severely damaged as a result of a variety of events. Taken separately, the risk that a particular one of these events in a given year at a certain site may be small but the cumulative risk that one or more of these events will occur at some point over the next 20 years cannot be ignored. While we may not be able to precisely quantify that probability, we know that the cumulative 20-year probability is not zero and it is not likely to insignificant. Consider:

- The Hartford area has experienced hurricanes in the past and is likely to sustain hurricane damage in the future.
- Connecticut experiences multiple tornados a year on average and 9 tornados touched down in Connecticut in 2018 (see CT Post article "With 9 tornadoes this year, state has new record" submitted in Evidence).
- Severe thunderstorms with high winds and often hail occur every year in Connecticut. As recently as 1995 a supercell dropped baseball size hail in Manchester according to "Remembering the 1995 Hail Storm" submitted in Evidence.
- According to an excerpt submitted into Evidence from the 2022 Annual Crime Report published by the Connecticut Department of Emergency Services and Public Protection, there were 16,345 incidents in Connecticut in 2022 that were categorized as "Destruction/Damage/Vandalism".

When solar panels are damaged in an event such as described above the toxic substances in the panels will almost certainly become exposed or dislodged and if any rain occurs, some of those substances are likely to mix with the precipitation and move with the resulting stormwater flows or infiltrate into the ground and contaminate the groundwater. The Petitioner has not shown that damage to solar panels from natural and human events will not result in toxic substances leaching into stormwater and groundwater. This is the second reason why the Petitioner falls short of proving that the probability of leaching of toxic substances would be negligible.

6) **Scenario 3.** The only remaining argument the Petitioner might offer to prove no significant adverse environmental effects would be to contend that some leaching of toxic substances may occur but the resulting consequences would be insignificant. In order to prove this, the Petitioner would need to establish that the amount of toxic

substances that would reach private or public drinking water supplies would be at or below tolerable allowances. In this regard, please consider:

a) The Petitioner has not provided any information or studies of the groundwater flows and aquifer recharge related to the private wells of the residences along Blue Ridge Drive. More importantly, the Petitioner has not provided any demonstration or evidence proving that no substances leaching from the solar panels will find their way into the aquifers drawn by the private wells along Blue Ridge Drive.
b) The proposed site lies within the Lower Hockanum River Watershed as documented in submitted Evidence. As it does now, stormwater runoff and groundwater sourced at the proposed site would migrate downslope, cross Amanda Drive via existing storm drains, and continue on to Birch Mountain Brook which connects to Hop Brook and ultimately to the Hockanum River. Along the way, Birch Mountain Brook comes within 100 yards of a public water drinking supply well at the eastern end of Charter Oak Park.
c) The Petitioner has not provided any demonstration or evidence proving that no substances leaching from the solar panels will find their way into Birch Mountain Brook and ultimately into the public drinking water supply sourced from the well at Charter Oak Park. (Consider that there will be two stormwater sources emanating from the site: PDA-1A via overflows from the infiltration basin and PDA-1B which will no longer have tree interception and absorption of stormwater. Additionally, contaminated groundwater infiltration will also be possible with respect to both PDA-1A and PDA-1B.)
d) Therefore, the Petitioner has not proven Scenario 3 – i.e., that while some leaching of toxic substances may occur, the resulting consequences would be insignificant. That's because the Petitioner has not analyzed the potential that some toxic substances may find their way into aquifers feeding private wells on Blue Ridge Drive and/or migrate to Birch Mountain Brook and then to a public drinking water aquifer source within the Lower Hockanum River Watershed.

Consequently, there is a distinct and worrisome potential for dangerous amounts of toxic substances from the almost 3,000 solar panels to contaminate either or both of private and public drinking water sources in Manchester. This risk assessment reflects the cumulative risk over time rather than a static point in time risk. This is necessary given the fact that this facility is proposed to be in operation for twenty years or more. The Petitioner clearly has not met its burden of proof that substantial adverse environmental effects with respect to stormwater, groundwater and drinking water contamination will not occur. I believe that by itself, this is sufficient grounds for the Siting Council to deny with prejudice the petition for a declaratory ruling.

Completed by Ray Welnicki, April 23, 2024

PETITION 1609

EVIDENCE RELATED TO:

POSSIBLE CONTAMINATION OF STORMWATER, GROUNDWATER & DRINKING WATER

Submitted by Ray Welnicki, Party

April 25, 2024

an average of 8, based on an assessment of eighteen commercial HWLs in the U.S. (Pavelka et al., 1993).

In regulatory leaching procedures, the leaching agent is determined by a preliminary evaluation based on the pH measurement of the solid waste in reagent water (US EPA, 1992). There are two primary leaching solutions used in the EPA TCLP Method 1311. If the measured pH of the waste is less than 5.0, a mixture of sodium acetate and acetic acid with a pH of 4.93 ± 0.05 (fluid #1) is used. Conversely, if the pH of the waste is more than 5.0, a mixture of sodium acetate and acetic acid with a pH of 2.88 ± 0.05 (fluid #2) will be used instead. Both extraction fluids are notably more acidic than rainwater (pH 5.2–6.2) and may infiltrate landfills. Rainwater seldom represents the range of potential pH values measured in real landfills (National Atmospheric Deposition National Atmospheric Deposition Program, 2021).

Recent investigations on PV devices have further expanded testing of leachate pH, encompassing a much broader range from 3 to 11, depending on specific conditions. These studies demonstrated a significant pH dependence on the leaching behavior of toxic and heavy metals, from which three distinct patterns emerged: the oxoanionic pattern, the cationic pattern, and the amphoteric pattern. An oxoanionic pattern was observed with GaAs modules. As the pH increased within a narrow range of 6.8–8.5, there was a notable increase in the dissolution of Ga and As (Ramos-Ruiz et al., 2018). Under acidic conditions, a cationic pattern emerged. In this scenario, ionic species with a positive charge (cations) were significantly leached. For instance, Cd, Te, Cu, and Zn exhibited decreasing leaching concentrations within a pH range of 3–7 or 3.5–9.9 or 3–9 due to metal precipitation, particularly the formation of insoluble cadmium hydroxide (Allen et al., 2010; Sharma et al., 2021; Zeng et al., 2015). The third pattern, referred to as the "amphoteric pattern," is characterized by a decrease followed by an increase in leaching concentrations of Pb, Al, or Ag with the rising pH of the solution, such as a mixture of nitric acid and sodium hydroxide (Nover et al., 2017; Sharma et al., 2021). The lowest leaching levels were typically observed under neutral pH conditions. This phenomenon, resembling a V-shaped curve, has been observed not only in PV waste but also in other lead-containing solid materials like lead-based paint and soil amendments (Dubey and Townsend, 2004; Wadanambi et al., 2008). These distinct leaching patterns underscore the critical role of pH in governing the release of toxic metals and provide valuable insights for environmental assessments and waste management practices.

Furthermore, the use of redox potential-pH diagrams has proven valuable for defining equilibrium states and reactions involving elements, ions, and compounds in aqueous solutions as pH varies. These diagrams have been established for elements like lead (Kraft et al., 2015), silver (Delahay et al., 1951), and compounds such as CdTe (Fthenakis and Wang, 2004) and CdSe (Zeng et al., 2015).

It is important to note that these insights from research testing can inform the highest efficiency leaching methods, or better characterize certain scenarios. However, at this point in time, there are no known planned modifications to regulatory leach testing procedures under consideration.

4.4. Impact of testing duration on test result variability

Though various regulatory leaching tests last only hours, typically 18 or 48 h as required by U.S. jurisdictions, researchers have extended the leaching duration to days, months, and longer to better understand the potential impacts on leachate concentrations. Prolonging the test duration, essentially increasing the contact time between waste and leaching agent, is expected to yield more substantial leaching and consequently higher metal concentrations in the resulting leachate.

In encapsulated PV modules, characterized by impermeable or less permeable superstrate and substrate materials, a slower leaching behavior is observed compared to non-encapsulated materials (e.g., printed circuit boards). This has led some researchers to believe that comprehending long-term leaching behavior concerning the relationship between metal solubility and pH may be valuable from a perspective of total leaching potential, although not necessarily for regulatory compliance purposes. However, limited data is available on this topic, as summarized in Table 5. The table presents selected studies, standards or procedures, sample sources, particle sizes, sampling methods, leaching solutions, pH levels, test temperatures, test durations, sample technologies, and major findings. Several studies have observed substantial Cd leaching from CdTe modules over extended periods. For instance, a year-long leaching study (using 5 cm x 5 cm sample pieces) revealed that approximately 62 % of the Cd in CdTe commercial module pieces leached out under simulated acid rain conditions with a pH of 3, employing citric acid as the leaching agent (Nover et al., 2017). In another 30-day study using a synthetic leachate composed of volatile fatty acids, which resulted in a final pH of 4.67, 73 % of Cd and 21 % of Te were released into the leachate in simulating the acidic phase of a landfill (Ramos-Ruiz et al., 2017). While a neutral aqueous environment can inhibit Cd mobility initially, over time (e.g., 56 days or 360 days), concentrations may eventually surpass regulatory limits if this methodology appropriately reflects landfill conditions (Nover et al., 2017; Zapf-Gottwick et al., 2015). One study observed a time-dependent increase in CdTe samples following a power-law trend ($t^{0.43}$) (Zapf-Gottwick et al., 2021).

Significant Cd leaching, such as 30 % of total Cd or 3–3.5 mg/L, has been detected from the CdS buffer layer in CIGS modules, varying in sample size from millimeters to centimeters, after months of leaching, exceeding permissible levels (Collins and Anctil, 2017; Zapf-Gottwick et al., 2015). In contrast, other elements like In, Ga, Mo and Se present in CIGS modules have demonstrated stability and relatively low solubility in aqueous solutions (Nover et al., 2017; Zapf-Gottwick et al., 2015; Zimmermann et al., 2013).

The long-term leaching behavior of lead in silicon modules, including a-Si, multi-crystalline silicon (mc-Si), and c-Si technologies, exhibits significant variation due to factors such as sample piece size, experimental parameters, and the evolving composition of module components toxic substances (Collins and Anctil, 2014, 2017; Kayla Kilgo et al., 2022). Given the disparities in sample piece preparation and leach testing methodologies and conditions, it is imperative to exercise caution when comparing results across various studies, regardless of the PV technologies tested.

4.5. Impact of testing temperature on test result variability

Regulatory leaching tests universally specify the use of room temperature (20–25 °C) throughout the fluid agitation and extraction steps. Elevated temperatures can accelerate the diffusion rate of metals, leading to a greater release of toxic elements into the solution (Collins and Anctil, 2017). Furthermore, elevated temperatures can increase the rate of chemical reactions and enhance the solubility of most solid compounds, altering the direction of reversible reactions (Faraji et al., 2020). However, the effects of elevated temperatures on metals leached from PV modules in an actual MSW landfill environment, where in-situ temperatures range from 30 °C to 65 °C due to anaerobic decomposition (US EPA, 2006), have not been systematically investigated. MSW landfills have been observed to have higher temperatures compared to the surrounding air, likely due to biological decomposition activity, making it imperative to conduct further research on its influence on leaching behavior (Jafari et al., 2017). If there is a need to design a new leaching method, considering the temperature effect on leachability could be a crucial parameter or relationship to explore.

5. Research gaps

This review paper identifies four research gaps and challenges in assessing the toxicity levels and regulatory compliance of PV modules. The research gaps are related to leaching risks for new cell materials, sampling procedures specific to PV module design for leach testing,

energies

Article

Leaching via Weak Spots in Photovoltaic Modules

Jessica Nover [1], Renate Zapf-Gottwick [1,*], Carolin Feifel [2], Michael Koch [2] and Juergen Heinz Werner [1]

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Abstract: This study identifies unstable and soluble layers in commercial photovoltaic modules during 1.5 year long-term leaching. Our experiments cover modules from all major photovoltaic technologies containing solar cells from crystalline silicon (c-Si), amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS). These technologies cover more than 99.9% of the world market. We cut out module pieces of 5 × 5 cm^2 in size from these modules and leached them in water-based solutions with pH 4, pH 7, and pH 11, in order to simulate different environmental conditions. Unstable layers open penetration paths for water-based solutions; finally, the leaching results in delamination. In CdTe containing module pieces, the CdTe itself and the back contact are unstable and highly soluble. In CIGS containing module pieces, all of the module layers are more or less soluble. In the case of c-Si module pieces, the cells' aluminum back contact is unstable. Module pieces from a-Si technology also show a soluble back contact. Long-term leaching leads to delamination in all kinds of module pieces; delamination depends strongly on the pH value of the solutions. For low pH-values, the time dependent leaching is well described by an exponential saturation behavior and a leaching time constant. The time constant depends on the pH, as well as on accelerating conditions such as increased temperature and/or agitation. Our long-term experiments clearly demonstrate that it is possible to leach out all, or at least a large amount, of the (toxic) elements from the photovoltaic modules. It is therefore not sufficient to carry out experiments just over 24 h and to conclude on the stability and environmental impact of photovoltaic modules.

Keywords: leaching; long term; photovoltaic modules; delamination; solubility

Citation: Nover, J.; Zapf-Gottwick, R.; Feifel, C.; Koch, M.; Werner, J.H. Leaching via Weak Spots in Photovoltaic Modules. *Energies* **2021**, *14*, 692. https://doi.org/10.3390/en14030692

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1. Introduction

Photovoltaic (PV) modules are not a niche product anymore. The market started with an installed capacity of 20 MW in the early 1990s and increased up to 635 GW of total installed PV modules worldwide at the end of 2019 [1]. By assuming an average lifetime of 30 years, we have to deal with an increasing amount of waste from PV modules of up to 1.7 million tonnes until 2030 [2].

In principle, photovoltaics are a green technology; however, some PV modules contain toxic elements such as lead in the solder ribbons and metalization pastes, or even worse, such as in CdTe technology, the toxic elements Cd and Te in the photoactive layer itself. Many modules using copper indium gallium diselenide (CIGS) also contain cadmium in the so-called CdS buffer layer of the CIGS cells. This situation is mainly possible because PV modules are still excluded from the EU Directive on the restriction of hazardous substances (ROHS 2) in electrical and electronic equipment. This exclusion will remain until the next review of the RoHS 2, which is planned for 2021 [3]. For all other electric and electronic equipment (EEE) on the EU market, the tolerated maximum concentrations by weight in homogeneous materials for lead (Pb) and cadmium (Cd) are 0.1% and 0.01%, respectively. Clearly, in the case of the compounds CdS or CdTe, with 50% of the mass being Cd,

Why Consistent Sampling Is Key to Solar Module Toxicity Testing

And why solar modules toxicity testing matters to utilities and the solar industry's reputation

By Chris Warren

Although the forecasts vary, there is little doubt that solar will provide an increasingly large percentage of the electricity used around the world. According to the research and consultancy group Wood Mackenzie, solar accounted for 46% of all new U.S. electricity generating capacity added in 2021. In its Solar Futures Study issued last year, the U.S. Department of Energy laid out a roadmap for solar to produce at least 37% of America's electricity by 2035—up from around 3% today.

Regardless of the exact proportion of electricity provided by solar, it's clear that the volume of solar modules that will need to be recycled or disposed of in the future will increase dramatically. According to a report produced by the International Renewable Energy Agency and the International Energy Agency's Photovoltaic Power Systems Program, the cumulative volume of waste photovoltaic (PV) modules globally could reach 1.7 million metric tons by 2030 and over 60 million metric tons by 2050—an amount that would represent about 10% of current e-waste volumes.

Given the rapidly accelerating growth of solar installations, the fact that PV modules typically have a 20- to 30-year lifespan, and the accumulation by some owners of modules experiencing early failures, it's important for plant owners and utilities to rapidly develop science-based approaches to manage PV modules that have reached the end of their useful life. One important reason to do this is that failure to develop transparent and environmentally responsible methods for handling large volumes of PV modules threatens the reputation of clean energy.

"All technologies have benefits and challenges. The fact that there can be trace amounts of toxic elements in PV modules, even if small in mass, is something that needs to be dealt with," said Stephanie Shaw, a technical executive at EPRI whose research focuses on assessing and reducing the environmental and health impacts of energy generation and storage. "There is an inaccurate narrative that says that PV is not environmentally friendly because we are swapping the harm of fossil fuels for the harm of toxic or critical materials. But there are already options to recycle and reuse those materials before they need to be disposed. We need to improve those options, make them more cost-effective, and incorporate them into the normal environmental management processes for all types of solar PV projects."

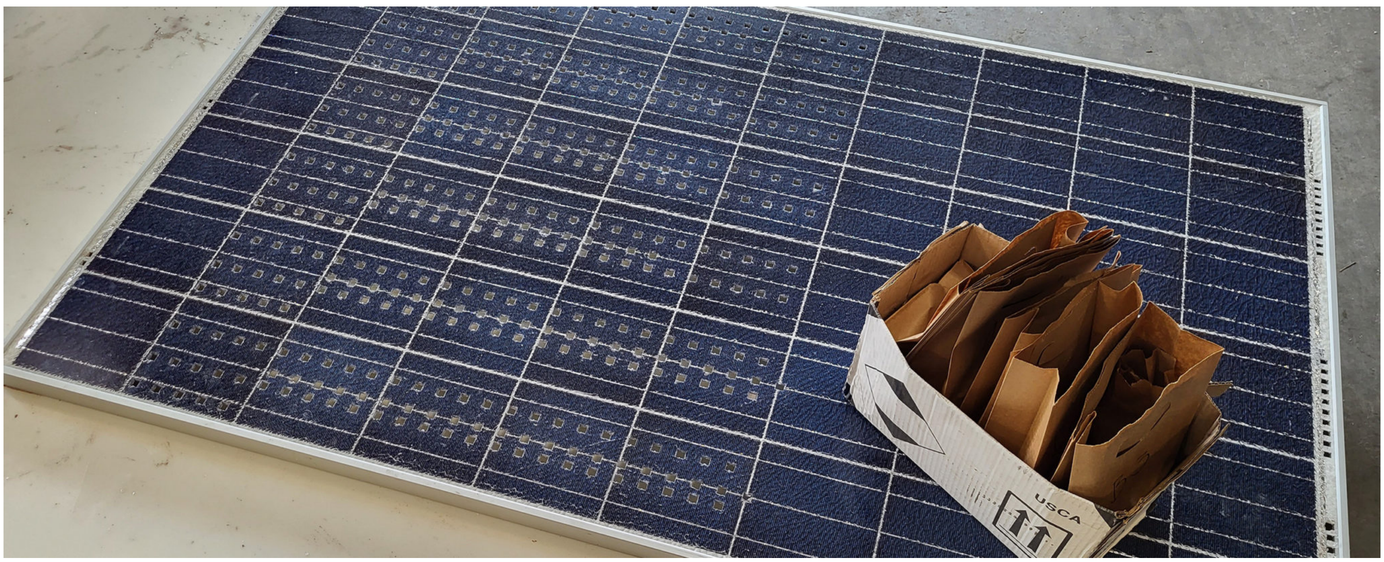


Photo courtesy Denver Waterjet

A New Standard for Sampling PV Modules

The recent release of an ASTM International standard practice represents an important step forward in providing a uniform and science-based approach to classifying solar modules for disposal. The practice is based on a standard operating procedure developed in EPRI projects, including *Assessing Variability in Toxicity Testing of Photovoltaic Modules*. More recently, EPRI and a number of utility and solar industry partners have collaborated on the supplemental project *Improving PV Sampling Methods for End-of-Life Leach Testing*. EPRI and the Photovoltaic Reliability Laboratory at Arizona State University (ASU) also presented PV Module Toxicity Methods and Results: A Literature Review at IEEE's 2022 Photovoltaic Specialists Conference (PVSC).

Co-led by Shaw and EPRI principal technical leader Cara Libby, this ongoing research began with the understanding that many PV modules contain hazardous materials, such as lead and cadmium. Both materials have the potential to leach into ground and surface water if they are not classified properly before being recycled or disposed of in a landfill.

Currently, PV modules in the United States have to pass the Toxicity Characteristic Leaching Procedure Test (TCLP) to be disposed of in a non-hazardous landfill. Modules that don't pass the TCLP are deemed hazardous waste and must be disposed of following far more stringent and expensive processes.

In the past, however, no uniform approach for extracting samples to be sent to TCLP labs existed. "EPA [Environmental Protection Agency] Method 1311 is the methodology used to determine how much material leaches out of an object ," Libby said. "Besides defining the maximum size and weight of the sample to be tested, it doesn't tell you how to obtain that sample. So, you could take a drill or a saw or a hammer to cut pieces from the module laminate, include pieces of the aluminum frame or the electronics, or send the entire module to the TCLP lab and let them figure it out."

The result is that a sample from a crystalline silicon module could comprise only material with no lead, like pieces of aluminum frame and cell areas with little metallization. Using such a sample, a TCLP lab would deem the module non-hazardous. But another sample from the very same module—say, from the solar cell interconnect ribbon areas, where there typically are significant amounts of lead—could be designated as hazardous. "We said, 'There has to be a way to do this more consistently to avoid biasing the results,'" Libby said.

Finding Ways to Reduce Variability

Working with ASU and other partners, EPRI began developing a standard sampling protocol by first understanding why test results vary so much and then examining ways to improve their consistency. As a start, EPRI and its partners worked with ASU to send identical samples to a number of testing labs to see how much the results varied. Results were repeatable within the labs, but they were not replicable between different labs without clear and consistent instructions to not crush the samples further.

In the effort to reduce the variability in test results, researchers first used a diamond bit drill to extract samples from the module laminate. They learned that mechanical cutting methods could not achieve reasonable variability. “We saw huge variations, including the same module either passing or failing, depending on the sample extraction method,” Libby said.

Instead of a drill, saw, or grinder, a water jet that shoots water at a very high force was used to cut samples from the modules. The improved precision of the water jet further reduced test variability because the pieces were less fragmented and cracked.

Perhaps the most important step in improving the consistency of test results was to preclude use of samples that are biased in terms of where they are collected within the module laminate. To do that, ASU came up with an approach that is now part of the ASTM standard. Samples include a total of about 100 grams of material from all four key sections of a module: the cell area, the cell ribbon area, the string ribbon area, and the non-cell and non-ribbon area.

The amount that comes from each area is proportional to that area’s relative size and weight in the overall module. “ASU has a calculation so that proportional numbers of pieces from each of the key sections of the module represent the mass distribution in a real module,” Shaw said. “Most of the sample is the cell.”

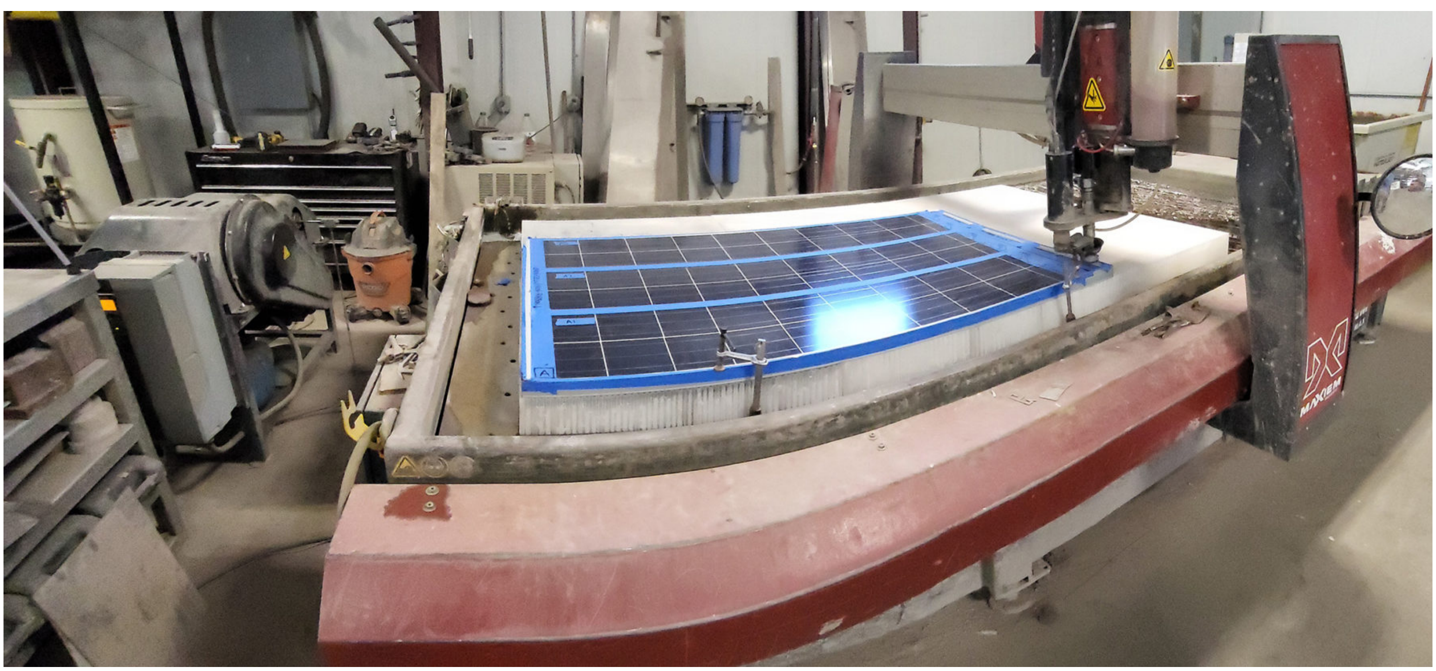


Photo courtesy Denver Waterjet

Delivering Consistency and Confidence

One potential benefit of the ASTM standard is its incorporation into procurement requirements when utilities source modules for solar installations. Facility owners already ask manufacturers for results of leach testing; now they can request use of the ASTM standard in collecting samples for the testing.

Consistent sampling can also lower risks and provide significant financial benefits at the end of a module's life. In the United States, responsibility for module end-of-life management typically rests with the PV plant owner. The plant can send a module to a water jet lab to extract samples, which are then sent to a TCLP lab.

Given the costs of classifying a module as hazardous or non-hazardous, it's important to be certain that test results are precise. "If you put in the effort to get a sample, you want to make sure you can trust the results," Shaw said. "If you improperly classify a large volume of modules as non-hazardous based on inaccurate tests, you could face fines or have to retrieve modules from landfills. Or you could spend a lot of money treating them as hazardous when they actually aren't." Besides offering potential financial benefits and risk mitigation, the standard helps utilities achieve their environmental stewardship objectives.

For ConEd, a funder of the research that ultimately led to the standard practice, there are potential benefits for both its regulated and its non-regulated businesses. ConEd's Clean Energy Businesses owns and operates solar power plants across the country.

Most of ConEd's solar projects are early in their life cycle, and any modules that need to be taken out of operation are recycled. But John Oldi, manager of environmental programs for Clean Energy Businesses, says now is the time to establish processes and standards to consistently and transparently recycle or dispose of a large volume of solar modules at the end of their useful life. "From a regulatory and larger sustainability point of view, understanding the composition and risks associated with modules as a waste stream is important for me from an operational standpoint," Oldi said.

More specifically, Oldi said, ConEd could develop a protocol for sampling modules using the ASTM standard. Having a consistent approach to sampling modules for toxicity testing is also important to William Slade, project specialist for ConEd's Environment, Health and Safety division. "Waste management is the number one place of risk for the company's reputation and liabilities," Slade said. "Making sure we have the right answers about characterizing waste is important."

Another potential benefit of the research that led to the ASTM standard is to inform any potential state regulations about the disposal of modules. In a state like New York, this is particularly important. "New York is committed to a huge build-out of modules and farms, and research shows there is a big bump of waste as the modules reach the end of their lives," Slade said. "We hope we can provide good data to help if rules about disposal are developed so that regulations are workable and make sense for the industry."

EPRI's work in this area will continue. One area of focus is creation of a database of TCLP results from a variety of manufacturers and module types to help identify whether there are common characteristics that lead to a pass or fail determination.

Other questions require additional investigation and testing. For example, little is known about how weathering from environmental impacts like ultraviolet light exposure, temperature changes, and wind could change the leaching behavior of a module over time. "A plant owner might require a manufacturer to provide TCLP results at the beginning of a project," Libby said. "But 30 years later, when the modules are taken out of service, will the results still hold? We want to make sure cracks, backsheet tears, and corrosion from moisture ingress don't affect TCLP results. That is something we are hoping to test this year."

EPRI Technical Experts:

Cara Libby, Stephanie Shaw

Solar Farm Hail Damage: The Perfect Storm

Hail the size of golf balls, softballs, and even grapefruit has always made weather news. Each spring and early summer, local weather stations and people across the United States share photos and videos on social media of hail, along with measurements, comparisons, and the damages sustained to their property. So, how has hail news become a hot topic in the insurance industry, specifically as it relates to solar farms? The following information may be of particular interest to insurance industry personnel, solar developers, risk managers, and owners and operators of solar facilities in the United States or with interests in the United States.

Impacts of Hail on Solar Farms

As the United States continues the transition to renewable energy to meet national climate goals, land that was previously not desirable or considered remote and undeveloped has been purchased or leased to install solar farms. Coincidentally, some of these undeveloped areas lie within historically severe weather across the United States but may not have historical hail data available due to their remote nature. Now that solar farms are being constructed or are operating in these largely remote areas, some of the largest renewable energy losses sustained in the United States are being reported as a result of hail. In 2019, the now infamous Midway Solar hail claim made insurance industry headlines with losses totaling approximately $70-80 million in west Texas because of hail more than two inches in size. Each year since, the insurance industry has continued to see reports of hail claims totaling $5 million to $80 million on solar farms and claims seem to be occurring with greater frequency. In 2022, the renewable energy insurance industry experienced recording breaking losses upward of $300-400 million related to hail damages. One likely contributor to the growth in frequency of hail claims year over year is the increased development of solar facilities in historically hail prone locations where hail was previously underreported.

Hail Damage in the Solar Industry

To better understand how and why the solar industry has seen, and will continue to see, large hail losses, this article will discuss:

- Weather analysis and prediction of hail.
- Some of the manufacturing requirements for solar modules that address hail.
- Research and development in the solar industry to combat hail.
- Microfractures, and testing for the same.
- Best practices after a hail event.

Weather Analysis & Prediction of Hail

The National Weather Service classifies hail as “severe” when it reaches one inch (25 mm) in diameter. Before the year 2010, “severe” hail was characterized once it reached 0.75-inches (19 mm) in diameter. An added classification of hail is “significant severe,” at two inches (50 mm), and “giant” at four inches (100 mm) in diameter. The NOAA Storm Events Database contains a collection of these reported hail events across the United States.

Despite the growing trend of reporting hail events and subsequent documentation in official weather archives, there are many significant limitations, including:

Baseball-size hail makes insuring solar and wind farms pricier

The Scottsbluff solar farm in western Nebraska was built to withstand most hailstones. But the icy pellets that rained down in late June were bigger than baseballs. The hail -part of a larger pattern of severe storms, heat and other extreme weather fiieled by climate change -smashed the bulk of ScottsblulTs glass panels. Designed to power more than 650 local homes, the facility remains out of commission over a month later. Its owner, private developer Arevon Energy, is still tallying the cost.

Solar plants and wind farms are crucial weapons in the battle against greenhouse gas emissions. So it's a cruel irony that their effectiveness is often hobbled by damage from storms, floods, wildfires and other disasters amplified by global warming. That's making them harder to insure. Property insurance premiums for U.S. solar facilities have soared as much as 50% over the past year, threatening to slow their rollout and derail global efforts to cut carbon emissions.

Extreme weather has "become a giant risk for the financing of these projects," said Jason Kaminskv, chief executive officer of solar data and climate insurance provider kWh Analytics. "Anything that increases costs could slow down the deployment of renewable power needed for the energy transition."

In areas particularly prone to natural disasters, some renewable energy companies have stopped developing projects altogether because of the cost to insure. Lightsource, a global solar developer halfowned by oil giant BP, has so far avoided building on the U.S. Gulf Coast near the shore because of hurricane threats. SB Energy, a renewable energy developer backed by Japan's SoftBank Group, has passed on signing leases or acquiring a few early-stage projects in the Midwest and Texas due to hail risk.

"Not every project is insurable anymore," said Kevin Christy, head of innovation and operational excellence in the Americas at Lightsource.

Major losses caused by recent U.S. natural disasters have pushed up the price of all types of property insurance, according to Marsh, an insurance broker. In California, some big insurers have gone so far as to recently stop providing new property and casualty insurance policies over wildfire risk. Farmers Insurance said last month that it will pull out of Florida due to risk exposure in the hurricane-prone state.

While insurance costs are rising across the board, there's a twist for renewable energy. As extreme weather makes solar and wind projects harder to build, it threatens, in turn, to prolong dependence on fossil fuels and contribute to the global warming that magnifies extreme weather in the first place.

Premiums for solar properties have risen even higher than the overall property insurance market, said Michael Kolodner, global renewable energy and U.S. power leader for Marsh. In Texas and the Southeast, claims have increased and premiums have risen as much as 50% in the past year, according to a survey by BloombergNEF. In high-risk areas, insurance companies are capping their coverage at $10 million, which means large projects must seek coverage from multiple insurers, according to law firm Norton Rose Fulbright.

The problem extends well beyond the U.S. Japan's average solar insurance costs are the highest in the world because of natural hazards, while extreme weather in Italy is also pushing up premiums there, according to BNEF.

Wind turbines are proving to be a bit more resilient to severe weather, Kolodner said. But they've also become more expensive to insure, even if the premiums haven't gone up as dramatically.

In June, a tornado damaged five transmission poles connected to a Texas wind farm owned by Ecofin US Renewables Infrastructure Trust, forcing the project to shut down while repairs are made. And a powerful storm last year pummeled an American Electric Power wind farm in Oklahoma -one of the world's largest -damaging a turbine and sparking a fire.

Insurers like FM Global are working to determine just how resilient renewable energy projects are to storms and other intense weather.

Inside a nondescript building on a research campus in Rhode Island, FM Global employees fire chunks of ice out of a cannon at solar panels, trying to find vulnerabilities. The company is testing panels to make recommendations to renewable energy developers about whether they'll be able to withstand the weather specific to a certain area. FM Global's facility can also simulate disasters like hurricanes, floods and fires.

"A lot of areas that are ripe for solar energy are vulnerable to hail," said Lou Gritzo, FM Global's chief science officer. The company has identified the Rocky Mountains east to the Great Plains and West Texas as a high-risk zone.

Clean energy developers are starting to factor higher insurance costs into their business plans. SB Energy used to model $3 a kilowatt to insure a typical U.S. solar farm, according to Jaime Carlson, head of commercialization. Now, the company is seeing closer to $4 to $5 a kilowatt for less coverage, Carlson said. But in areas particularly prone to natural disasters, the cost estimates can be five to six times as high.

Last summer, hailstorms caused nearly $300 million in losses in Texas, nearly twice the financial hit caused by severe storms, wildfires and flooding at notable U.S. wind and solar facilities since 2020, according to GCube, an underwriter of renewable energy projects.

At the same time, renewable energy developers across the U.S. are facing more restrictive terms with higher deductibles and less coverage for events like hailstorms.

Emerging clean energy sources such as carbon capture and hydrogen projects are also struggling to find adequate insurance coverage, said Aaron Ratner, a venture capitalist and co-founder of Climate Risk Partners, an insurance start-up. The lack of coverage is "one of the most critical bottlenecks in the sustainable energy transition," Ratner said.

The escalating insurance costs for green power come at a critical moment. The Biden administration is offering billions of dollars worth of incentives for clean energy projects to help speed up the country's transition away from fossil fuels. Meanwhile, climate scientists warn that the world must move quickly to reduce heat-trapping greenhouse gases to avoid the worst effects of global warming.

In areas where they're continuing to build, clean energy developers are taking steps to adapt to heightened climate risk. For its solar farms located in hail-prone areas, Lightsource has a team of people who monitor the weather and can remotely tilt panels to protect from hail in advance of major storms, Christy said. During a recent day ol exceptionally severe weather across the U.S. Southeast, the company was able to avoid hail damage to seven of its solar farms that way, he said.

In the U.S. West, insurers have imposed stricter standards for clearing grass and vegetation around solar facilities to reduce the risk of wildfires, Christy said. SB Energy said it now works with an insurance broker to analyze natural catastrophe risks before investing in a facility. The company also has weather monitors and remotely controlled panel trackers for its solar farms vulnerable to hail.

"Insurance was a checkthe-box exercise previously, where now it is something we think about at the very beginning of the project cycle," Carlson said.

Tornado damages National Guard camp's new solar energy project

Camp Ripley received damage to multiple buildings, including parts of a 60-acre solar field, built in cooperation with Minnesota Power, during a storm and tornado Sept. 7, 2016. (Photo courtesy of Minnesota National Guard: SSG Anthony Housey)

LITTLE FALLS, Minn. — A Wednesday night storm packing a small tornado damaged barracks buildings and set back the opening of a new solar panel array at the Minnesota National Guard's Camp Ripley near Little Falls.

Staff Sgt. Anthony Housey said the storm hit the central Minnesota camp beginning at about 10 p.m. Wednesday. Sometime between 10:30 and 11 p.m., the roof of a barracks building was blown off along with part of the roof from a billeting area.

The debris from the buildings in turn damaged the brand-new solar panel field under construction, the final panels of which were due to be installed the next day.

The dedication ceremony for the 10-megawatt solar array that was set for Sept. 16 was postponed until next spring, according to project developer Minnesota Power.

No injuries were caused by the storm, but trees were downed and both government-owned and personal vehicles were damaged. No soldiers were in the dormitory at the time its roof was blown off, Housey said.

The damage was still being assessed, so a dollar figure was not yet available, Housey said.

Multiple buildings on Camp Ripley, including those used for housing, training and maintenance, received damage during a late-night storm and small tornado that moved through Morrison County on Sept. 7, 2016. (Photo courtesy of Minnesota National Guard: SSG Anthony Housey)

The National Weather Service office in Chanhassen said Thursday night that a weak tornado, measuring EF-1 in intensity, caused the damage at Camp Ripley. The tornado, with maximum winds of 90 mph, was on the ground for 7 or 8 miles and was about 50 yards wide.

“We were extremely fortunate, all our people are safe,” Col. Scott St. Sauver, Camp Ripley garrison commander, said in the National Guard’s news release. “We can repair buildings and replace damaged equipment, but our people are irreplaceable.”

A release from Minnesota Power said a quarter of the 97 rows of solar panels sustained damage, including twisted and broken racks that hold the solar panels in place, broken solar panels and damaged wiring. The solar panels were crushed by a large storage container and other debris blown into the array by high winds, the release said.

“Minnesota Power had representatives at Camp Ripley this morning ensuring the site is physically and environmentally safe, contacting insurers and beginning to plan for repair or replacement of damaged components,” the company said.

The array was designed and built to American Society of Civil Engineers structural codes to withstand 105 mph winds and the panels are tested to withstand the impact of golf ball-size hail, the release said.

Newly-built Currituck solar farm damaged by Hurricane Dorian

GRANDY, N.C. — A recently completed North Carolina solar farm suffered a setback on Friday, after several panels were severely damaged by Hurricane Dorian.

The solar farm is located in the Grandy area of Currituck County, on the site of the old Goose Creek Golf Course. The array was completed over summer, but now will need repairs. The field the panels are located in was also flooded by an overflowing drainage ditch.

Resident Steven Brown saw the damage during the height of the storm, saying the floodwaters were being blown about into waves that would come up and crash down.

"This is our main concern, watching it all morning and wondering how well the system is going to hold up in a hurricane," Brown said. "And this was just a Category 1 hurricane offshore, not a direct hit."

RELATED: Outer Banks' Avalon Pier and Nags Head Pier are heavily damaged by Hurricane Dorian

RELATED: Dorian's floodwaters trap people in attics in North Carolina

Brown added that he and other residents are seeing their worst fears realized with how easy it seemed the panels were ripped from the ground by Dorian's winds.

"Before it was just a golf course, and trees which wasn't that big of a problem. But now with the proximity of the solar panels here, we're worried about wind picking these things up and crashing into our homes," Brown said.

Evidence Submission
Excerpt from article "Fire a major hidden danger for solar farms" published in Insurance Business Magazine online at https://www.insurancebusinessmag.com/us/risk-management/news/fire-a-major-hidden-danger-for-solar-farms-419868.aspx#:~:text=The%20Firetrace%20study%20highlighted%20three%20major%20causes%20of,the%20outbreak%20of%20around%2030%25%20of%20studied%20fires.

Risk Management News

By Gabriel Olano
Sep 08, 2022 / Share

Fire is one of the oldest and most omnipresent risks businesses face and is potentially one of the most devastating. Any business worth its salt has adequate fire safety measures and insurance in place.

However, in many emerging industries, risks are often harder to measure, leading to exposures and losses. One such industry is solar energy, which has been growing rapidly in recent years due to the shift to renewable energy.

A recent report by Firetrace International found that the solar industry is potentially underestimating the risk of fire at solar farms, partly due to a shortage of data on solar farm fires. The report also said that research into the issue has given rise to suspicions that fires at solar farms have been under-reported.

Tecsol blog

November 26, 2023

Photovoltaic parks are new targets for vandalism: BauWatch solutions

According to IRENA's report "The Global Solar Industry Year in Review 2022", 7.6% of the world's PV farms reported vandalism or theft in 2022. This represents a 10% increase from 2021. Solutions exist to overcome the problem. Let's talk about it!

Photovoltaic parks are particularly vulnerable to vandalism. They usually cover large areas of ground. The solar panels themselves can be the target of theft, as well as associated equipment, such as inverters and copper cables. Damage caused by theft attempts can often be costly in terms of repairs and lost production. Implementing security measures such as camera surveillance, alarms, and fencing are crucial.

photovoltaic parks; a cost of €10K to €50K per incident

Damage caused by theft or vandalism can cost on average between €10,000 and €50,000 per incident, depending on the size of the facility and the value of the equipment targeted. In addition, photovoltaic parks are usually located in remote areas, making squatting less likely. However, large ground-based facilities can sometimes be vulnerable to vandals or temporary squatters, especially when they are under construction or idle.

Artificial intelligence

Faced with the resurgence of these security incidents, BauWatch offers 2 solutions to protect against them, the BauWatch GreenLight tower to monitor sites even at night and the BauWatch Solar tower, an autonomous solution powered by solar panels. Designed using the latest technological advances, these solutions combine artificial intelligence and predictive analytics to anticipate threats and ensure optimal protection. Simple to deploy and suitable for a multitude of environments, these solutions are the perfect combination of innovation and efficiency, ensuring enhanced temporary security.

GreenLight, the video surveillance tower for site security, even at night

The protection offered by GreenLight is twofold. Its 2 green light projectors illuminate the entire site and deter potential intruders from taking action. At the slightest break-in attempt, intruders are immediately detected by its 3 cameras, thanks to its automatic detection algorithm.

Solar, the autonomous video surveillance tower, powered by solar panels

Thanks to its solar panels, its methanol fuel cell and its 3 HD cameras connected to its 24/7 alarm centre, the sites are constantly protected; without additional costs related to a generator or fuel and even at night, thanks to its infrared cameras. The Solar solution works in all weather conditions. If clouds obscure the sun, the system automatically switches to the built-in alternative power source.

For the 2 solutions, GreenLight and Solar, the CCTV images are analysed online by BauWatch's 24/7 alarm centre, its remote surveillance agents can view the images live, intervene via the tower's loudspeakers to put intruders to flight or notify the police directly.

08:30 | Permalink

With 9 tornadoes this year, state has new record

Damascus Road in Branford on Aug. 28, the morning after Branford was hard hit by a fierce storm with severe thunderstorms and high winds throughout the evening ripping down trees and wires. A majority of power outages were in the towns hit hardest by Thursday's storm: Branford, Hamden and North Haven. It is believed a tornado may have touched down.
Peter Hvizdak / Hearst Connecticut Media

Lines down on Pine Orchard Road on Aug. 28, the morning after Branford was hard hit by a fierce storm with severe thunderstorms and high winds throughout the evening ripping down trees and wires. A majority of power outages were in the towns hit hardest by Thursday's storm: Branford, Hamden and North Haven. It is believed a tornado may have touched down.
Peter Hvizdak/Hearst Connecticut Media

Thr brand new, just about finished synthetic turf field at East Haven High School was hit by a possible tornado on Aug. 27.
Contributed photo

Damascus Road in Branford on Aug. 28, the morning after Branford was hard hit by a fierce storm with severe thunderstorms and high winds throughout the evening ripping down trees and wires. A majority of power outages were in the towns hit hardest by Thursday's storm: Branford, Hamden and North Haven. It is believed a tornado may have touched down.
Peter Hvizdak / Hearst Connecticut Media

Indian Woods Road by Deer Path Road in Branford on Aug. 28, the morning after Branford was hard hit by a fierce storm with severe thunderstorms and high winds throughout the evening ripping down trees and wires. A majority of power outages were in the towns hit hardest by Thursday's storm: Branford, Hamden and North Haven. It is believed a tornado may have touched down.
Peter Hvizdak / Hearst Connecticut Media

Work crews clear storm debris amid deactivated power lines, Friday, Aug. 7, 2020, in Westport, Conn. A tornado was confirmed to have touched down in town during the storm.
John Minchillo / Associated Press

Power lines lie in a roadway beside a fallen tree caused by Tropical Storm Isaias, Friday, Aug. 7, 2020, in Westport, Conn. A tornado was confirmed to have touched down in town during the storm.
John Minchillo / Associated Press

Power lines and poles lie in a roadway beside a fallen tree brought down by Tropical Storm Isaias, Friday, Aug. 7, 2020, in Westport, Conn. A tornado was confirmed to have touched down in town during the storm.
John Minchillo / Associated Press

A now roofless home in the aftermath of a Tropical Storm Isaias tornado at 9 Surf Road in Westport, Conn. on Monday, August 10, 2020.
Brian A. Pounds / Hearst Connecticut Media

Bob Katchko, owner of Stamford-based Katchko & Sons, on Saturday began cleaning up the Surf Road area of Westport where a tornado briefly touched down Tuesday during Tropical Storm Isaias.
Jarret Liotta / For Hearst Connecticut Media

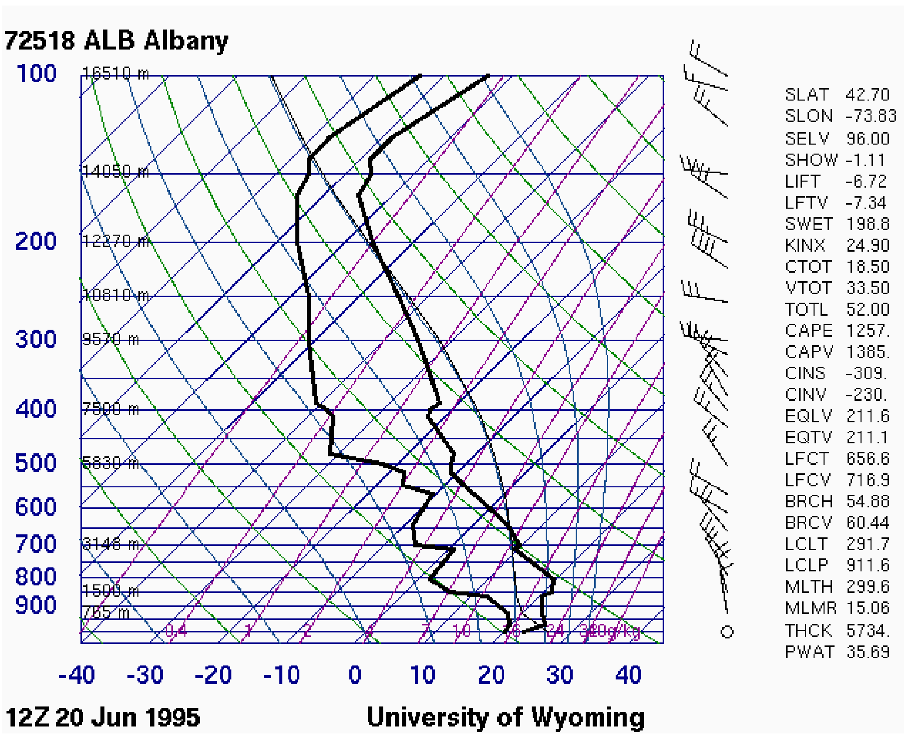
A now roofless home in the aftermath of a Tropical Storm Isaias tornado at 9 Surf Road in Westport on Monday.
Brian A. Pounds / Hearst Connecticut Media

The roof was ripped off a Surf Road home in the Saugatuck section of Westport when a tornado briefly touched down Tuesday during Tropical Storm Isaias.
Jarret Liotta / For Hearst Connecticut Media

Trees uprooted and snapped along West Norwalk Rd. in Norwalk on Wednesday October 3, 2018, after strong storms brought down trees and utilty poles causing power outages.

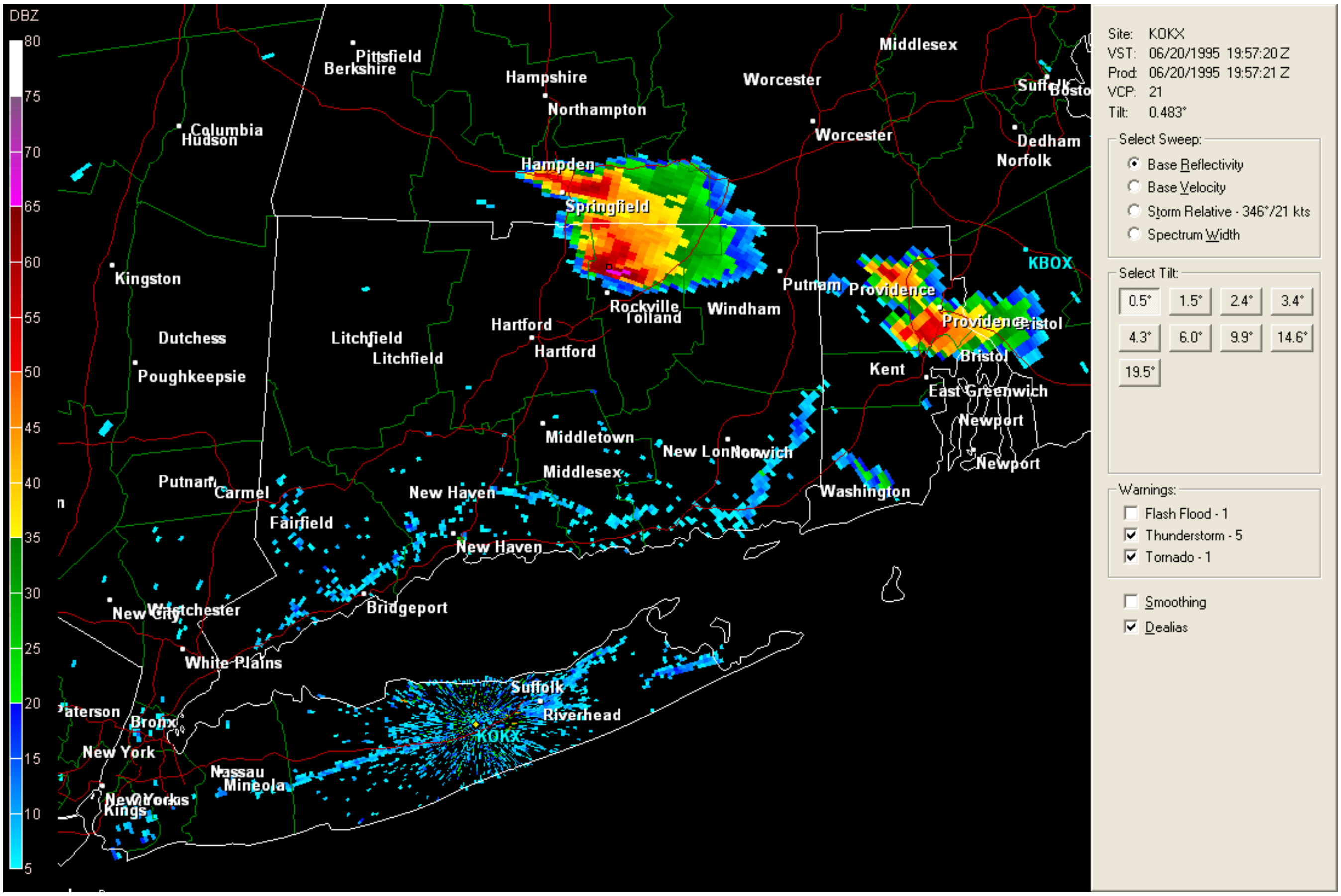
Remembering the 1995 Hail Storm

June 20, 1995 was a sultry and oppressive day. Temperatures in the 90s down to the water with dew points in the mid 70s drove heat index values above 100º. At the same time an elevated mixed layer (EML) moved overhead creating an exceptionally unstable and volatile air mass.



This weather balloon sounding from Albany shows the EML with very steep lapse rates between 650mb and 500mb. This means that the temperature above 10,000 feet was decreasing very rapidly with height (nearly 10ºC/km). With an oppressively hot and humid airmass in place the atmosphere was primed for a big explosion.

That explosion came north of the Massachusetts border when a supercell developed and began moving south.



What was remarkable about this storm was the amount of large hail it dropped during its trek through Connecticut. Baseball-sized hail was reported in 3 towns – Vernon, Manchester, and Deep River.

The relatively isolated storm (typical of EML days) continued to move due south and produced a gorgeous looking radar image. The outflow boundary of rain cooled air surged west across Hartford and Waterbury while a backdoor cold front that started near Boston around 10 a.m. finally caught up with the storm at the mouth of the Connecticut River.

Crimes Against Property Statewide Incident-Based Profile 2022

The data represent each offense that occurred within a reported crime incident

Crimes Against Property

Offenses Reported	88,523
Number of Victims	86,990
Percent Cleared	12.8
Rate per 10K	245.15
Total Arrests	10,163

Total Property Values

Stolen	**$283,203,205**
Recovered	**$68,969,223**

Victims by Type

Individual	63,605	73.1%
Business	21,899	25.2%
Government	878	1.0%
Other	222	0.26%
Financial Institution	149	0.17%
Unknown	132	0.15%
Religious Organization	105	0.12%

Distribution of Crimes Against Property by Offenses

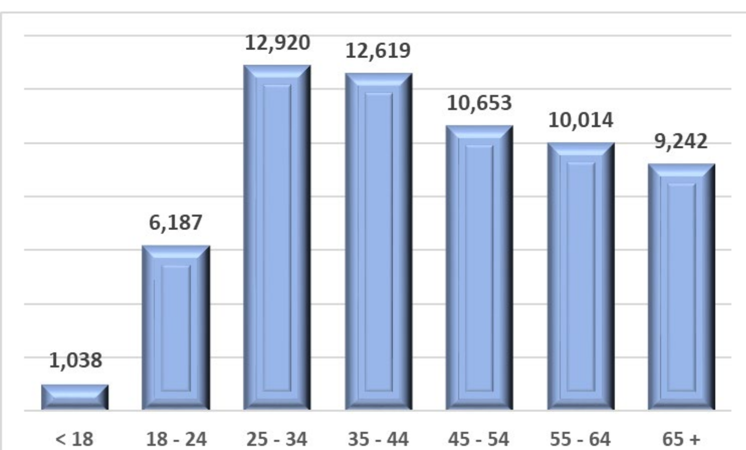
Larceny - Theft Offenses	43,109	48.7%
Destruction/Damage/Vandalism	16,345	18.5%
Fraud Offenses	11,890	13.4%
Motor Vehicle Theft	7,209	8.1%
Burglary/Breaking & Entering	4,658	5.3%
Counterfeiting/Forgery	1,924	2.2%
Robbery	1,637	1.8%
Stolen Property Offenses	1,102	1.2%
Extortion/Blackmail	266	0.3%
Arson	196	0.2%
Embezzlement	179	0.2%
Bribery	8	0.01%

Top 10 Property Items Stolen

Money	10,693	13.8%
Vehicle Parts/Accessories	9,485	12.2%
Other	8,902	11.5%
Automobiles	6,602	8.5%
Merchandise	6,567	8.5%
Identity Documents	3,562	4.6%
Purses/Handbags/Wallets	3,533	4.6%
Identity–Intangible	3,314	4.3%
Credit/Debit Cards	3,205	4.1%
Clothes/Furs	3,079	4.0%

10.7% of property crime arrestees were juveniles

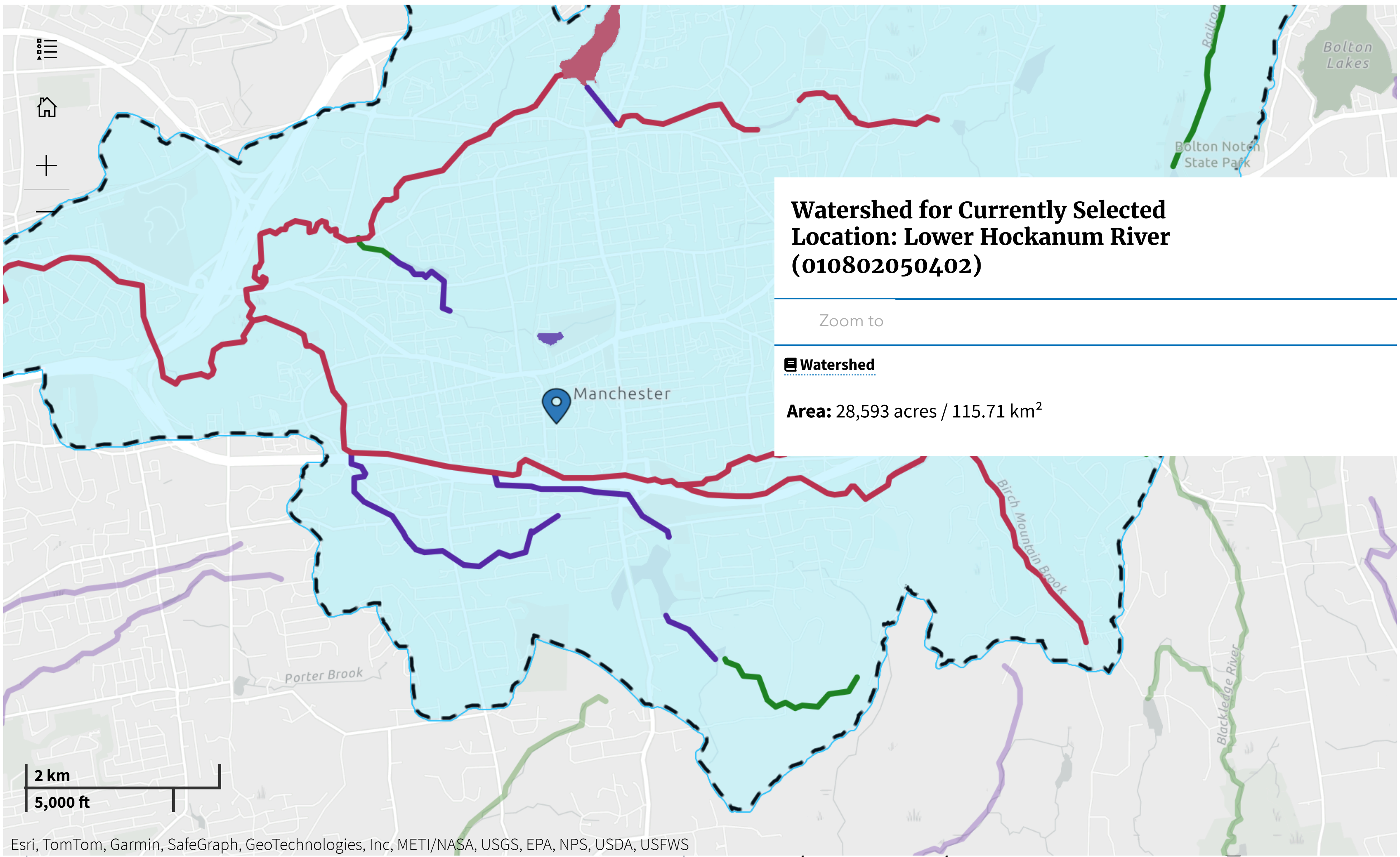
Number of 'Individual' Victims by Age Range



Age is unknown for 932 'individual' victims

14.5% of 'individual' property crime victims were age **65 or older**

Note on Property: NIBRS reporting connects property stolen, damaged, etc. to an incident, not an offense. If an incident has multiple offenses that involve property, there is no way to identify which offense is connected to which property. Therefore, property is presented aggregately in this report.



The **dashed outline on the map shows your watershed.**

Water quality is monitored for physical, chemical and biological factors. The monitoring results are assessed against EPA approved water quality standards or thresholds. Water can be impaired, meaning it is not able to be used for certain purposes.... **Show more**

DISCLAIMER

27	122	50
Waterbodies	Water Monitoring Locations	Permitted Dischargers

Waterbodies | Water Monitoring Locations | Permitted Dischargers

Waterbody Conditions:

Good | Impaired | Condition Unknown

Overall condition of **27** waterbodies in the *Lower Hockanum River* watershed.

Expand All

- **Averys Brook (Manchester/South Windsor)-01**
  State Waterbody ID: CT4500-09_01
- **Barrows Brook (Vernon/Tolland)-01**
  State Waterbody ID: CT4503-00-trib_01
- **Bigelow Brook (Manchester)-01**
  State Waterbody ID: CT4500-14_01
- **Bigelow Brook (Manchester)-02**
  State Waterbody ID: CT4500-14_02

Birch Mountain Brook (Manchester)-01
State Waterbody ID: CT4504-03_01

Center Spring Park Pond (Manchester)
State Waterbody ID: CT4500-14-1-L1_01

Watershed for Currently Selected Location: Lower Hockanum River (010802050402)

Watershed

Area: 28,593 acres / 115.71 km²

Hockanum River (Manchester)-03
State Waterbody ID: CT4500-00_03

Hockanum River-01
State Waterbody ID: CT4500-00_01

Hockanum River-04a
State Waterbody ID: CT4500-00_04a

Hop Brook (Manchester)-01
State Waterbody ID: CT4504-00_02

Lydall Brook (Manchester)-01
State Waterbody ID: CT4500-12_01

Lydall Brook (Manchester)-02
State Waterbody ID: CT4500-12_02

Lydall Brook (Manchester)-03
State Waterbody ID: CT4500-12_03

Porter Brook (Manchester)-01
State Waterbody ID: CT4504-01_01

Porter Brook (Manchester/Bolton)-02
State Waterbody ID: CT4504-01_02

Railroad Brook (Vernon/Bolton)-01
State Waterbody ID: CT4503-04_01

South Fork Hockanum River (Manchester)-01
State Waterbody ID: CT4504-00_01

Tankerhoosen River-01
State Waterbody ID: CT4503-00_01

Tankerhoosen River-02
State Waterbody ID: CT4503-00_02

Union Pond (Manchester)
State Waterbody ID: CT4500-00-3-L3_01

Unnamed tributary to Gages Brook (Vernon/Tolland)-01
State Waterbody ID: CT4503-02_01

Unnamed tributary to Hop Brook (Manchester)-01
State Waterbody ID: CT4504-04_01

Unnamed tributary to Hop Brook (Manchester)-02
State Waterbody ID: CT4504-04_02

Unnamed tributary to Hop Brook (Manchester)-03
State Waterbody ID: CT4504-04_03

2 km
5,000 ft

Watershed for Currently Selected Location: Lower Hockanum River (010802050402)

Watershed

Area: 28,593 acres / 115.71 km^2

2 km
5,000 ft

Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS