Vineyard Wind Blade Event – Initial Environmental Analysis

Executive Summary

Introduction

Following the blade event at the Vineyard Wind project on July 13, 2024, GE Vernova retained Arcadis US, Inc., a global engineering and environmental consultancy firm, to perform an initial assessment of environmental considerations associated with the presence of the blade debris in the water and along the shoreline. Arcadis used a common and widely accepted methodology (called a Conceptual Site Model or CSM), consistent with Massachusetts guidance, that evaluates 1) locations and characteristics of the blade debris, 2) potential receptor groups (human and aquatic) and pathways for contact/uptake of the materials, and 3) an indication of potential adverse conditions or risks. The analysis also considered the Material Safety Data Sheets (MSDSs) for the blade constituents.

Initial Findings

Based on their initial evaluations, the Arcadis report notes:

- The current primary potential risk is injury to people who may physically contact the blade debris, (such as shards of fiberglass) on public beach and shoreline areas.
- The blade materials and debris in their final product state are considered inert, non-soluble, stable, and non-toxic, akin to materials that can be found in textiles, boat construction and the aviation industry. This applies to debris that has been observed on shore and which remains submerged at this time.
- The same final state materials do not require any specific environmental management and are considered non-hazardous and classified for landfill disposal, when retired. (For the blade at issue here we will work with Vineyard Wind to identify a specific disposal plan.)
- The report notes there are no PFAS containing materials used in the manufacture of the blade itself or in the foam, fiberglass, wood or coating. There are multiple small Aerodynamic add-ons attached to the root end of the exterior of the blade (a common application in the industry) that contain PTFE, commonly referred to as Teflon, which is one of a broad set of chemicals categorized as PFAS and approved by the FDA for use in contact with food, potable water, and pharmaceutical products. The PFAS content in the aerodynamic add-ons account for 0.00005% of the total weight of the blade. At least 67 of 240 add-ons are visible as attached to the blade, and additional add-ons may be present on parts of the blade that are not currently visible.
- To safeguard against contact with the debris, a dedicated Hotline (833-609-5768) and Online reporting (click here) tool are operational, allowing members of the public to report debris sightings, enabling safe collection and support accurate inventorying of the materials.

Anticipated Next Steps

The report identifies further evaluations concurrent with continued debris recovery efforts to advance the overall Conceptual Site Model initial risk assessment outcomes, including:

- Ongoing debris recovery measures near the turbine itself, as well as along the shoreline
- A detailed inventory of the debris recovered to date, focusing on the type, weight, and size of the materials.
- Expansion of the CSM consistent with standard planning and assessment activities for human health and ecological risk assessments, in terms of potential current and future receptors, exposure routes, and pathways. As part of this, supplemental data needs may be identified and will be addressed, possibly including additional material testing.

We are also coordinating with Resolve Marine, a global leader in maritime response and recovery, on efforts to detach the remaining segment of the affected blade from the main turbine. This initiative would be done in coordination with Vineyard Wind, the Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE), and state and local officials.

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Vineyard Wind Blade Event – Initial Environmental Analysis
Prepared by Arcadis US, Inc.

1. Introduction

Concurrent with the immediate actions implemented following the blade event at Vineyard Wind on July 13, 2024, GE Vernova engaged Arcadis US, Inc. (Arcadis) to support an initial assessment of environmental considerations associated with the presence of the blade debris in the environment. Arcadis is a global engineering and consultancy firm with a significant presence in the environmental market in the US.

This document provides a preliminary summary of the activities and findings and will be supplemented as the blade recovery continues, and additional environmental assessment and evaluation activities are advanced.

2. Objective

Based on available information, initial assessment activities considered potential near-term effects to human health, public welfare, safety and the environment related to the discharge of blade components, materials, and debris into the environment. Information related to the blade event incident and response actions, specifications related to the products used in the manufacture of blades (including safety and environmental data), and the overall environmental setting and current uses has been considered.

3. Methodology

3.1 A common and widely accepted approach to evaluate a release to the environment is to use a Conceptual Site Model (CSM). This is a management tool cited in the Massachusetts Contingency Plan (MCP 310 CMR 40.000), with the following definition:

"*… a site-specific description of how contaminants entered the environment, how contaminants have been and may be transported within the environment, and routes of exposure to human and environmental receptors that provides a dynamic framework for assessing site characteristics and risk, identifying and addressing data gaps and managing uncertainty, eliminating or controlling contaminant sources, developing and conducting response action strategies, and evaluating whether those strategies have been effective in achieving desired endpoints…*"

3.2 The initial CSM provides a framework to organize available information, establish initial hypotheses, and guide ongoing and future evaluation and mitigation activities as needed. It is a non-static document and will evolve as more information becomes available.

3.3 To initially construct the CSM a variety of data sources were considered, including:

- Understanding the nature of the debris released to the environment and subsequent movement and dispersion.
- The overall physical site setting of the areas affected by the debris.
- Engineering and technical information to understand the types and weights of materials used to manufacture the blade.
- Manufacturer/Supplier-issued Material Safety Data Sheets (MSDSs) for the materials used during blade manufacture; and blade sampling and analysis performed in September 2012 of a final end product the blade to support waste disposal decision making. The blade was located at the Gaspe, Canada manufacturing site (where the Vineyard Wind blade also originated). In 2018 a retired blade at the LM Wind facility in Grand Folks, ND (slightly different in size and composition compared to the Vineyard Wind blades, but still representative of a typical blade construction) was characterized to

support landfill disposal. A copy of the waste profile form prepared and executed by LM Wind Power supporting disposal of the blade as non-hazardous solid waste is included in Appendix C.

4. Blade Construction

4.1 The final weight of this particular 107-meter-long blade is approximately 52,000kg. A cross-section view of a typical turbine blade is provided in Appendix A.

4.2 There are 33 different materials involved in the production of a turbine blade, from the most basic common household adhesives to the more complex industrial materials used to build the blade. Safety Data Sheets (SDSs) for the blade materials have been compiled and will be provided by GE Vernova under separate cover.

4.3 During the blade manufacturing process, as indicated on the SDSs, some of these materials require specialized engineering and safety controls to produce the final end-state blade. The end-state blade itself is considered inert with a construct including fiberglass, semi-rigid foam, and polyester resins. The materials used in blade production are also materials that are commonly found in textiles, boat construction and the aviation industry as shown in Appendix B. These stable physical and chemical properties are also the basis for the acceptance of the blades for landfill disposal once retired, as non-toxic, non-hazardous, solid waste materials. (https://astswmo.org/files/Resources/Hazardous_Waste/2022-11-Wind-Turbine-Blades-Fact-Sheet.pdf)

5. Preliminary EHS Assessment Findings

The initial CSM is provided in Table 1 at the conclusion of this report. The manufactured blade materials, in their end-product state (and those materials that have been and will be recovered going forward) are considered inert, stable, non-toxic, and non-hazardous. Further evaluations will consider the potential for degradation of the residual blade materials that remain in the environment and potential exposure routes and other fate and transport mechanisms. Section 7 below identifies further evaluation steps concurrent with debris recovery efforts (e.g., literature review, data collection, and modeling) to advance the overall CSM and risk assessments.

As the CSM advances, potential effects on human health and the environment will be considered and advanced, likely including scientific literature review, research, site-specific data collections and evaluations.

6. Assessment of PFAS

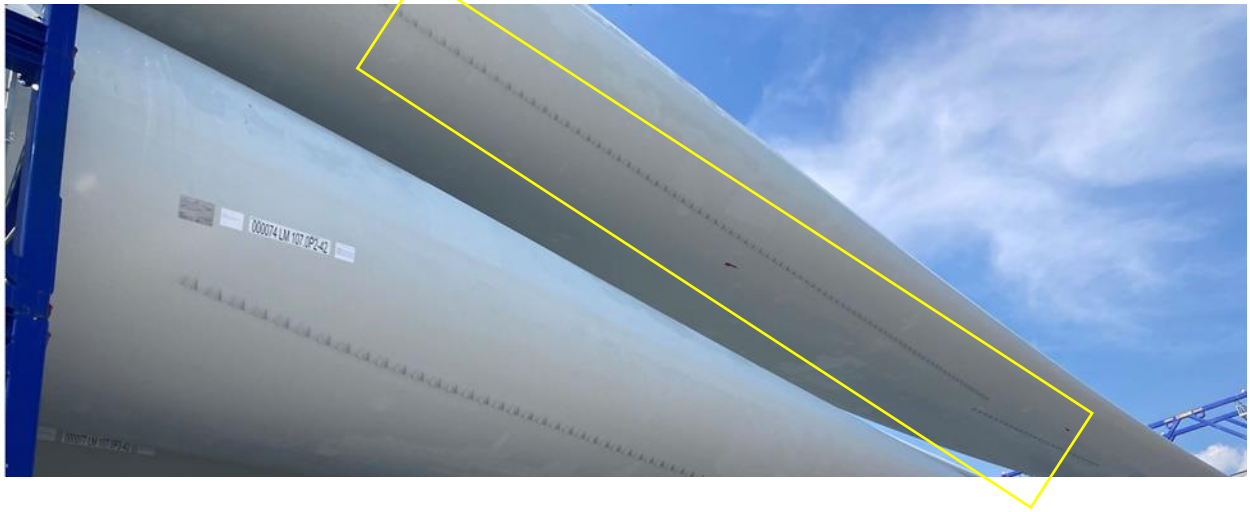
There are no PFAS-containing materials used in the manufacture of the blade itself. However, there are small Aerodynamic add-ons attached to the root end of the exterior of the blade (a common application in the industry) that contain PTFE, commonly referred to as Teflon, which is one of a broad set of chemicals categorized as PFAS. PTFE is a large molecular weight material that is highly stable and won't degrade under typical environmental processes. The USEPA does not regulate PTFE like it does other smaller molecular weight PFAS and the material is approved by the FDA for use in contact with food, potable water, and pharmaceutical products. Additionally, scientists have evaluated PTFE and found it to be safe as compared to other PFAS in other products. (https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.4035).

Further:

- The Aerodynamic add-ons are injection-molded thermoplastic pieces approximately 15cm x 20cm in size. The PFAS material is contained within the thermoplastic piece.
- The Aerodynamic add-ons are included to improve efficiency performance of the blade. They are a common feature on blades across not only the wind industry but also the aviation industry.

On this blade there are a total of 240 Aerodynamic add-ons. They are located between 0 and 43m from the root end. They are in one row; 184 units weigh 45g and 56 units weigh 20g. Total weight of the thermoplastic add-ons is 9.4kg, of which PFAS content is 28.2g, accounting for 0.00005% of the total blade weight.

The provided picture (next page) is a representation of the layout on the blade in question.



There is drone footage taken on July 19, 2024 that shows some of the Aerodynamic add-ons are in place. An initial 67 units shown on the drone picture (28% of the total) have been visually counted as evidenced in Appendix D. These 67 are not expected to fall due to their location and stability of this section of the blade at the upright, 12 o'clock position.

Of the remaining 173 units, it is not yet possible to confirm how many remain adhered to the outer blade due to not only the folded section of the remaining blade piece. It is possible that some may have fallen from the blade, have landed either on the working platform of the tower or equally into the sea, and/or have already been collected in the debris from the shoreline or by the salvage vessels.

7. Anticipated Next Steps

Several activities have been identified to support the overall assessment of the blade event and the evaluation of potential effects of remaining blade debris on human health, public welfare, safety, and the environment. Thus far, the following activities have been identified:

- Continuing debris recovery measures localized to the turbine itself (where safe to do so) as well as along the shoreline with regular public communications and status updates.
- Performing a detailed inventory of the debris that has been recovered to date, focusing on the type, weight, and size of the materials. This will support assessments related the extent of blade recovery that has occurred to date. Further, the rate of debris recovery will be tracked going forward to assess potential trends and influences in the amount of debris recovery.
- Expansion of the CSM consistent with standard planning and assessment activities for human health and ecological risk assessments, in terms of potential current and future receptors, exposure routes, and pathways. As part of this, supplemental data needs may be identified and will be addressed, possibly including additional material testing.

Table 1. Nantucket Turbine Blade Event - Conceptual Site Model (CSM) [1]

Turbine Blade Debris in the Environment		Potential Human Exposure Routes		Potential Aquatic Exposure Routes		Physical / Environmental Fate and Transport		
		Direct Contact	Uptake Mechanisms[2]	Physical Contact	Uptake Mechanisms[2]	Dispersion	Degradation	Dissolution
Present Scenario [3]	Shoreline Debris	Moderate [5]		Low [5]	Low [5]	Low [5]		
	Floating Materials			Low [5]	Low [5]			
	Deeper Deposits							
Potential Future Conditions [4]	Remaining Debris	Further evaluations will consider the potential for degradation of the residual blade materials that remain in the environment. Section 7 of the Initial Environmental Analysis identifies further evaluation steps concurrent with debris recovery efforts (e.g., literature review, data collection, and modeling) to advance the overall CSM and risk assessments.						
	Degradation Byproducts							
	Micro-Scale Particles							

Available information (debris characteristics, physical setting, product literature) suggests that potential receptors, exposure pathways, and fate and transport mechanisms are not sufficient to result in an adverse risk condition at present time. As additional information is obtained, the CSM will be refined as appropriate.

Notes

1. The CSM considers 1) locations and characteristics of the blade debris in the physical environment, 2) potential receptor groups (human and aquatic) and pathways for contact/uptake of the materials, and 3) an indication of a potential adverse condition or risk. This initial CSM provides a framework to organize available information, and guide ongoing and future evaluation and mitigation activities as needed.

2. Potential human uptake mechanisms include ingestion of debris. Potential aquatic uptake mechanisms include debris ingestion and adsorption.

3. Present Scenario is considered the period of time from July 13, 2024 until substantial completion of shoreline and water debris recovery.

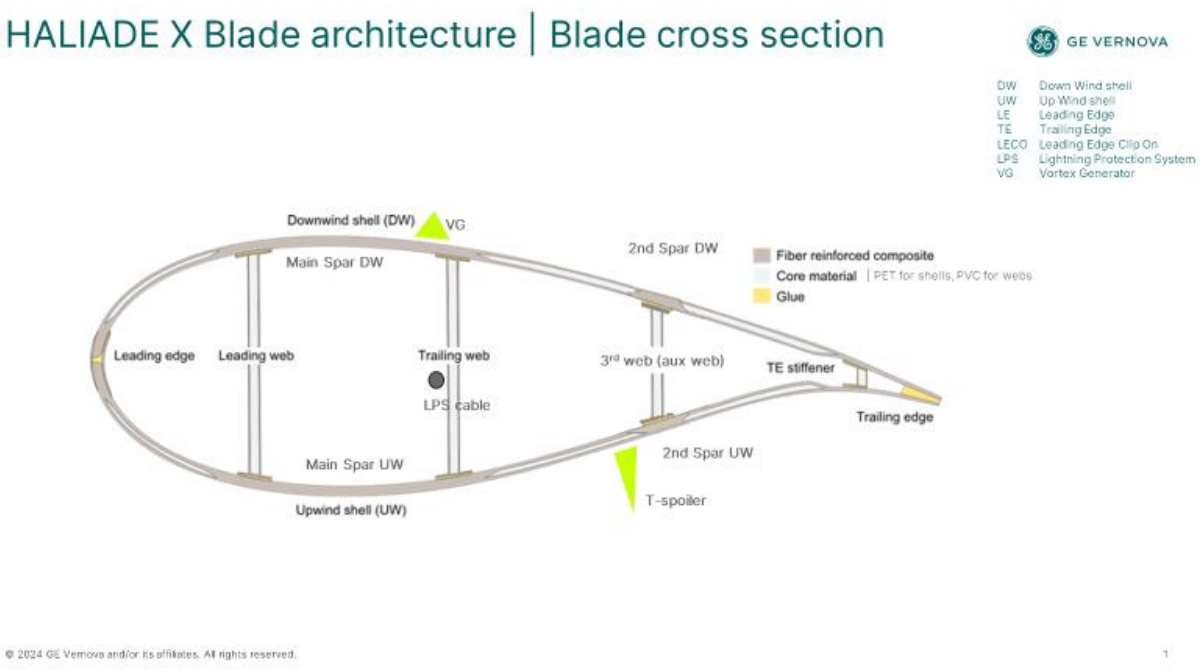
4. Product safety information indicates that manufactured blade components in their end-product form are inert and environmentally stable. Further evaluations will consider the potential for degradation of the residual blade materials that remain in the environment.

5. Considering the available information and within the context of this initial CSM, the current risk concern is the potential for physical contact of debris by child and adult recreational users of public beach and shoreline areas, currently mitigated by the ongoing/future program to recovery debris.

Appendices

- **Appendix A:** Typical Turbine Blade Cross Section
- **Appendix B:** Blade Composition and Common Industry Comparisons
- **Appendix C:** Waste Disposal Profile (2018) – Grand Forks, ND
- **Appendix D:** Drone footage of the Aerodynamic Add Ons, taken 19th July 2024

Appendix A: Typical Turbine Blade Cross Section



Appendix B: Blade Composition and Common Industry Comparisons

Material	Primary ingredient	Blade Component	Functional purpose in blade	Weight [% of total blade]	Density [kg/m^3]	Other industry application
Glass fiber & Polyester resin composite	Silica (silicon and Oxygen) with polyester (carboxylic acid, alcohol and water)	Blade shell, Leading edge and Trailing Edge, 2nd spar, Web skin.	Provide aerodynamic shape with structural stability on deflection and torsion	64.1%	1800-2000	Boats, construction
Glass fiber & Epoxy resin composite	Silica (silicon and oxygen) with epoxide polymers	LECO	Tip leading edge with erosion protection	0.3%	1500-1800	Standard turbine blades, electrical insulations
Carbon planks	Carbon (graphite) with epoxide polymers	Main spar	Main deflection load carrying component	12.2%	1600	Airplane, textile,
Adhesive and Coatings	Coating: Adhesive: Vinylester GT60 glue	Coating: Shells Adhesive: Shell-shell, shell-web	Coating: protect structural materials against environment and UV Adhesives: bond blade components together (shells and webs)	4.1%	(Coating included in shell) Adhesive: 1200-1400	
PET foam & polyester resin	polyethylene terephthalate (Carbon, hydrogen, Oxygen)	Shell panels	Reinforce blade shells against buckling	10.5%	150-400	Textile, packaging (i.e. bottles), waterproof film protection
PVC foam & polyester resin	Poly vinyl chloride (carbon, hydrogen, chlorine)	webs	Provide blade stability against buckling	4.2%	100-250	Pipes, electric cables insulation, packaging, healthcare
Balsa wood & polyester resin	Balsa	Reinforced shell sections	Handling locations in blade shells are reinforced with balsa instead of PET	0.3%	250-350	boats
Metals in Bushings	Steel (Chromium, Molybdenum)	Blade root connection	Metallic insert embedded in the blade to receive the hub bolts and create mechanical connection to the hub	3.9%	8000	Multiple
Metals in Lightning protection system	Copper	Lightning protection system	Capture and conduct lightning impacts on the blade	0.2%	9000	Multiple
Plastics	T-Spoiler: Polyurethane (PUR) VG: Polycarbonate	Add on components (VG and T-spoiler)	Enhance blade root aerodynamic performance to gain torque and Power.	0.2%	1100-1200	Multiple plastic injected or molded applications, non structural

Appendix C: Waste Disposal Profile (2018) – Grand Forks, ND

GRAND FORKS

CITY OF GRAND FORKS LANDFILL
GENERATOR'S WASTE PROFILE FORM

Grand Forks Public Works Department
724 North 47th Street
Grand Forks, ND 58203
Telephone: 701.738.8740
Fax: 701.738.8749

City Use Only

Profile Number: _____

Technical Approval By: _____ Expiration Date: _____

Management Approval By: _____ Approval Date : _____

Limitations, Precautions, or Special Handling Procedures (City of Grand Forks use only):

In order for us to determine whether we can lawfully and safely manage your waste material, we must obtain certain information about the chemical and physical properties of the waste, and its chemical composition and regulatory status. Please answer each question as completely as possible by circling **"YES" or "NO", checking the appropriate boxes, or listing in the blanks, or attaching additional sheets as necessary.** An ink pen or typewriter must be used. The Generator or Authorized Representative must sign the form. **All related analyses must be included with the form and if future analyses differ from what was submitted, it must be sent to us immediately.** ***Originals must follow fax copies.***

A. WASTE GENERATOR INFORMATION

1. **Generator:**	LM Wind Power	2. SIC Code:	3511
3. Facility Street Address:	1580 S. 48th Street	4. Phone:	(701) 780-9910
5. Facility City:	Grand Forks	6. State/Province	ND
7. Zip/Postal Code:	58201	8. Generator USEPA/Fed ID#:	NDR000 002 576
9. County:	Grand Forks	10. State/Province ID #:	
11. **Hauler Name:**	Countywide Sanitation	12. Hauler Phone:	( )
13. Hauler Contact:		14. Hauler e-mail:	

B. PROCESS GENERATING WASTE (Based on 40 CFR Part 261)

Waste Name: Demo Debris

Mode of Shipment: ☒ Bulk Solid ☐ Drums ☐ Other Roll offs

Process Generating Waste: plastic film is removed from turbine after curing process has been completed

Estimated Quantity: 130 gallons, pounds, yd, (tons), drums / week (circle one)

Describe the Business of Generator: Builds wind tower turbine blades

Frequency Per: ☒ Day ☐ Month ☐ Year ☐ One Time ☐ Project Other:

Code of Federal Regulations (CFR) may be found at http://www.gpoaccess.gov/cfr/retrieve.html

C. WASTE PROPERTIES

Profile #

Appearance:
Color: Various
Odor:
- [x] None
- [ ] Mild
- [ ] Strong
- [ ] _____ Other

Phases:
- [x] Singled
- [ ] Bi-layered
- [ ] Multi-layered

Corrosivity:
- [ ] < or equal to 2
- [ ] 2.1 - 7
- [ ] 7 - 12.4
- [ ] > or equal to 12.5
- [x] N/A-Solid
- [ ] *Corrodes steel*

Viscosity:
(Similar to)
- [x] Solid
- [ ] Tar
- [ ] Honey
- [ ] Motor Oil
- [ ] Water

Specific Gravity:
- [ ] < 0.8
- [ ] 1.0 - 1.7
- [ ] > 1.7
- [ ] _____ actual
- [x] N/A

Total Suspended Solids (% wt):
- [ ] < 0.5
- [ ] 0.5 - 2.0
- [ ] 2 - 5
- [ ] 6 - 20
- [ ] > 20
- [ ] _____ actual
- [x] N/A

Physical State:
- [ ] oil
- [ ] liquid (water)
- [ ] sludge
- [ ] damp solid
- [x] dry solid
- [ ] powder
- [ ] filter cake
- [ ] soil
- [ ] concrete
- [x] debris
- [ ] lab pack
- [ ] ash
- [ ] gas

Ignitability:
(closed cup)
- [ ] Non-ignitable solid
- [ ] <140° F
- [ ] 140°- 200°F
- [x] >200° F
- [ ] _____ actual
- [ ] Oxidizer
- [ ] *Carcinogenic*
- [ ] *Pyrophoric*
- [ ] *Infectious*
- [ ] *Explosive*
- [ ] *Shock Sensitive*
- [ ] *Reactive*
- [ ] *Radioactive*

D. REGULATORY QUESTIONS

(Based On 40 CFR Part 261)

Is the waste a hazardous waste as defined by Part 261 Sections 261.31 (F Code), 261.32 (K Code), 261.33 (P or U Codes)?	Yes (No)
Is the waste characteristically hazardous per Part 261 Section 261.21-.24 (D Codes)? (Attach analysis if applicable)	Yes (No)
Is the waste from an UST corrective action under 40 CFR Part 280?	Yes (No)
Is the waste specifically excluded from hazardous waste regulations per Part 261 Section 261.4? If so, attach an explanation including the applicable portion of the regulation.	Yes (No)
Is the waste being legally treated for a single hazardous characteristic? If so, attach a copy of the Agency notification and a certification that no Underlying Hazardous Constituents (UHC's) are present.	Yes (No)
Is the waste from a CERCLA project, in response to a Compliance Order, or a hazardous waste in another State or subject to Land Disposal Restrictions?	Yes (No)
Does the waste contain regulated quantities of radioactives or PCBs? (Attach analyses if applicable)	Yes (No)

E. HANDLING REQUIREMENTS

List any special handling instructions/personal protection equipment recommended for handling and disposal of this waste.

F. AUTHORIZED SIGNATORY

I hereby certify that I am the generator or authorized by the Generator identified herein to provide the information submitted in this form and any attached documents and to enter into this Agreement on the Generator's behalf. I have made a complete and thorough investigation of all matters relevant to completion of this form. This investigation included laboratory analysis, where applicable, and was performed in accordance with 40 CFR Part 261 Section 261.20 (c) on a representative sample of the ("Waste"). All required information concerning the Waste, including the results of all laboratory analyses has been provided in this and the attached documents. Such information is complete and accurate and that all known or suspected hazardous constituents/characteristics or safety hazards associated with the Waste have been disclosed herein. If I become aware that the analysis is not representative, that the waste has changed, or that the process has changed such that the waste characteristics are substantially different I will notify the landfill facility and the hauler and I will amend the Generator's Waste Profile Sheet as soon as practicable.

Print: Dana Paulson Signature:

Date: 8-6-18 Title: EHS Manager

Company: LM Windpower

FORM 408
REVISED 1/1/09

Appendix D: Drone footage of the Aerodynamic Add-Ons, taken 19th July 2024