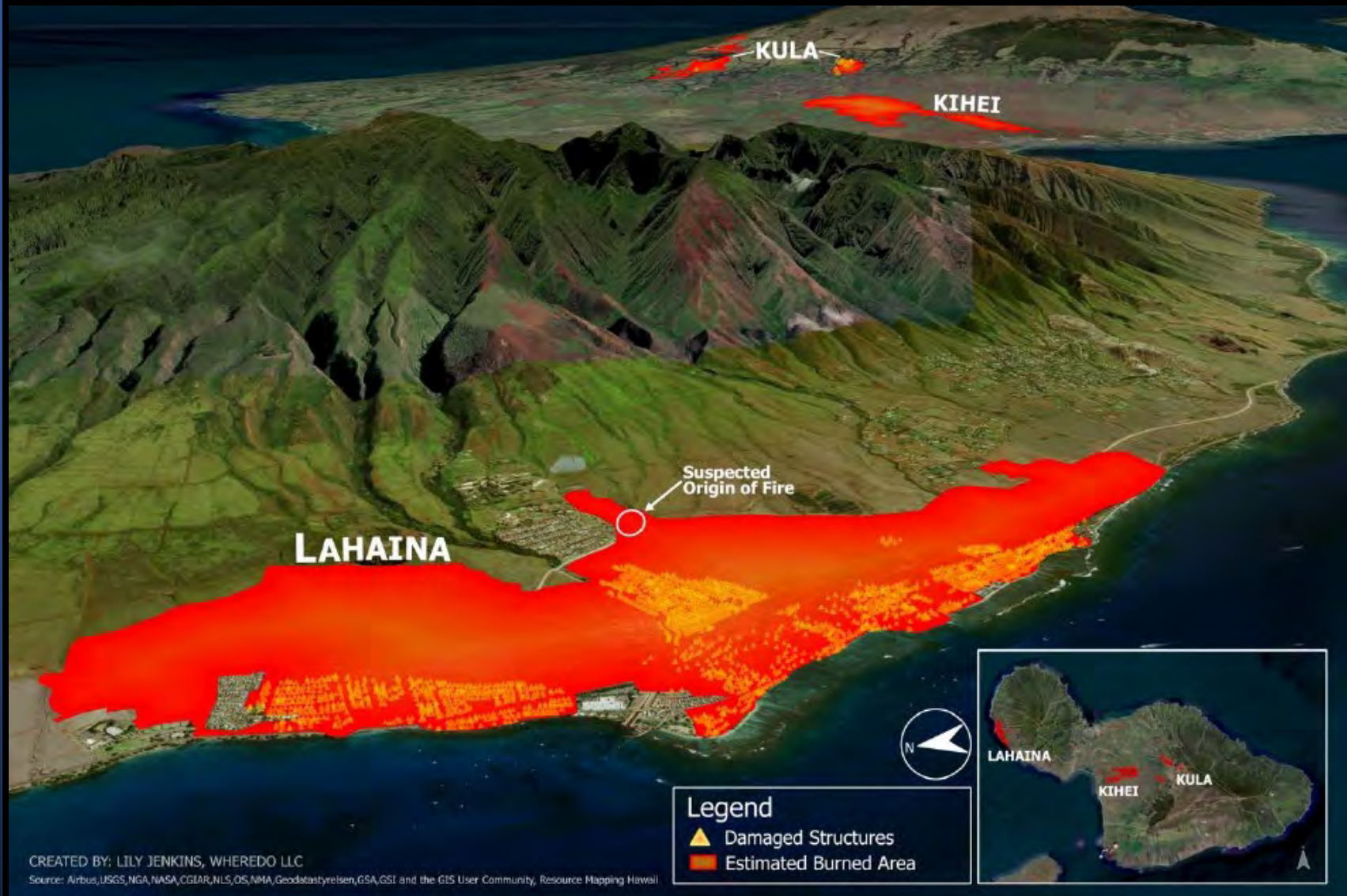




Lithium-Ion Battery Case Study: Maui Wildfire Response



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November 2024 Clean Gulf Conference and Exhibition

Learning Outcomes / Project Challenges



- Unpredictable battery behavior
- Concerns over safety of personnel and public
- Not a lot of guidance on how to handle them once impacted by fire
- Shipping via DDR is cost prohibitive and limited by shipping co.
- Shipping Companies do not like DDRs
- Little on-island resources for managing DDR/waste
- Processing in the field was only option
- How to take DDR Batteries to “Not Batteries”
- Disposal (Recycling)
- Few national experts



Contributors

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Bryan Vasser: USEPA Region 4 On-Scene Coordinator

Leon Wirschem: San Diego County DEHQ – Hazmat Division/Emergency Response

USEPA START and ERRS Contract Support

State and Local Resources



FEMA MATO: Address Li-ion Batteries



Primary Sources:

- Battery Energy Storage Systems (BESS)
- Electric Vehicles (Cars, go-carts, golf carts, etc)

Secondary Sources:

- Limited mobility devices (bikes, scooters)
- Power tools
- Computers





Reconnaissance of Residential BESS

Intel Obtained from:

- Tesla Database
- HEPCO
- Owner Self-Assessment
- Ground Truth – EPA Teams

Different Brand = Different Battery Chemistry



Reconnaissance of Residential BESS



Removal/Recovery of Residential BESS

Step 1:
Force
Removal



Step 2:
Move



Removal/Recovery of Residential BESS



Tyvek &
Fire Blanket

Step 3: "Lau Lau" Wrap

Step 4: Buffalo Convoy /
Relocate to Staging



Reconnaissance - EVs

- Maui County Data
- Motor Vehicles Data
- National Insurance Crime Bureau
- Owner Self-Assessment & Re-entry Forms
- Hotline, Commercials, PSAs
- Ground Truth – EPA Teams

No resources on-island for investigating battery health



Reconnaissance - Community Outreach EVs



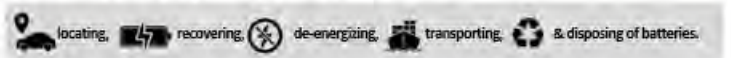
Maui Wildfire Recovery

Safely Removing Electric and Hybrid Vehicle Batteries
October 31, 2023



Maui gives so much to the world. As guests we are honored to give our support back.

The Federal Emergency Management Agency tasked EPA to remove lithium-ion batteries from electric and hybrid vehicles affected by the Maui wildfires. The process includes:



The batteries should be considered extremely dangerous, even if they look intact. Disturbing lithium-ion batteries can cause:



DO NOT:

- attempt to start, repair, charge, or sit in electric and hybrid vehicles
- remove vehicle batteries

If you have an electric or hybrid vehicle in the burn zone, please call the EPA hotline at: **808-539-0555** or the County of Maui's Abandoned Vehicle and Metals Office at: **808-270-6102**.

To watch a video of EPA's electric and hybrid vehicle battery removal process, use this QR code.

808-539-0555

R9Wildfiresinfo@epa.gov

epa.gov/maui-wildfires



Search

Electric and Hybrid Vehicle Battery Handling Informational



Electric and Hybrid Vehicle Battery Deconstruction on Maui

EPA Regions logo with 697 subscribers.

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MAUI NOW

Sections Maui News Wildfires & Recovery Business

EPA processing hundreds of thousands of lithium-ion batteries from Maui fires for recycling in Nevada

By [Cammy Clark](#)
November 15, 2023 · 10:00 AM EST
* Updated November 15, 2023 · 11:57 AM

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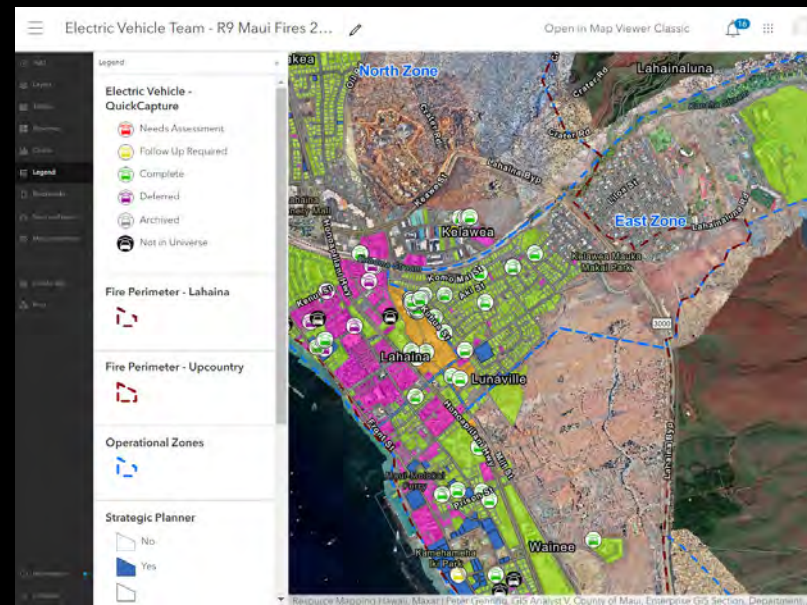
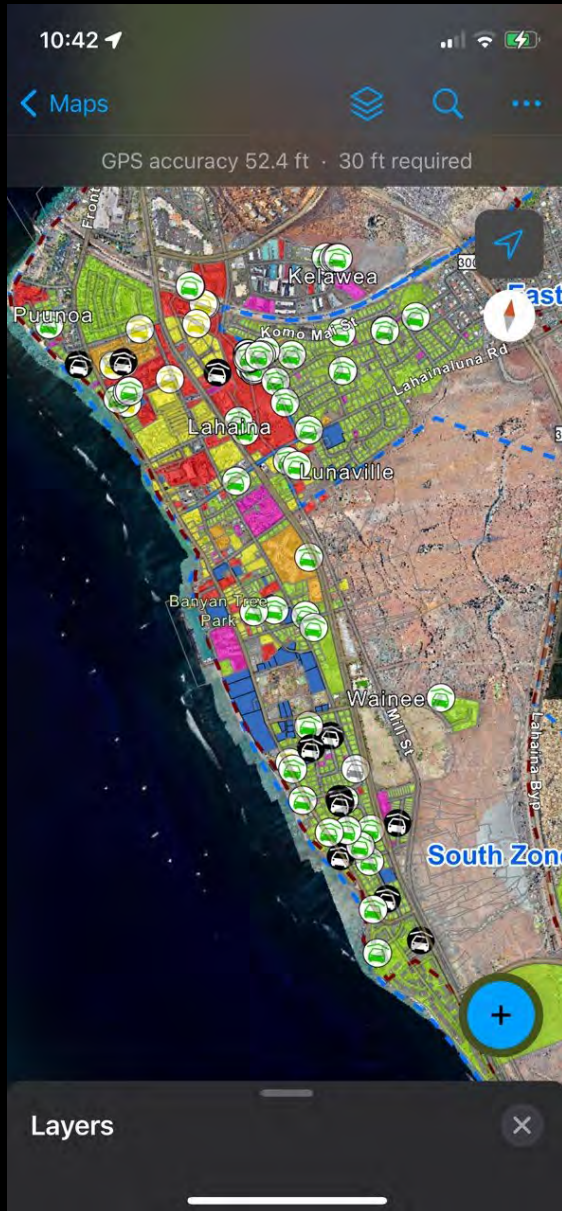
A photograph showing workers at an EPA temporary processing site in Olowalu. They are using a large yellow drum roller to crush lithium-ion batteries from the Lahaina burn site. The site is outdoors with a dirt ground and some vegetation in the background.

Workers at an EPA temporary processing site in Olowalu use a drum roller to crush lithium-ion batteries from the Lahaina burn site before they are shipped to the mainland for recycling of rare metals and disposal of what's left. PC: Cammy Clark

Reconnaissance - EVs


Data Management

- Assessment Info
- Point Collection in App
- Vehicle Research
- Battery Condition/Type



10:44

Cancel Collect Submit

 **Electric Car: Needs Assess...**
No location

Needs Assessment ☒

Follow Up Required ☐

Not in Universe ☐

Denied ☐

Electric Vehicle Status Comment

Ford escape hybrid

EV Make

Ford

EV Model

Escape

Electric Vehicle VIN

VIN287651976

EV License Plate

HPL 287

Battery Recovery/Removal - EVs

To gain an understanding of battery type, important to know:

- Make
- Model
- Year
- Option

This was a luxury if available.





Battery Recovery/Removal - EVs

Different Make = Different Battery
Different Model = Different Battery
Different Year = Different Battery
Different Option = Different Battery

National Fire Protection Association
Emergency Response Guides\Tech Ref



Battery Recovery/Removal – EVs (Tesla)



Step 1: Cut Roof/Access Points



Step 2: Flip Vehicle

Battery Recovery/Removal – EVs (Tesla)



Step 3: Remove Fasteners & Central Strip

Battery Recovery/Removal – EVs (Tesla)



Battery Recovery/Removal – EVs (Tesla)

Step 4: Cell Harvest



Battery Recovery/Removal – EVs (Nissan Leaf)



Battery Recovery/Removal – EVs (Toyota Prius)



Battery Recovery/Removal – EVs (Subaru)

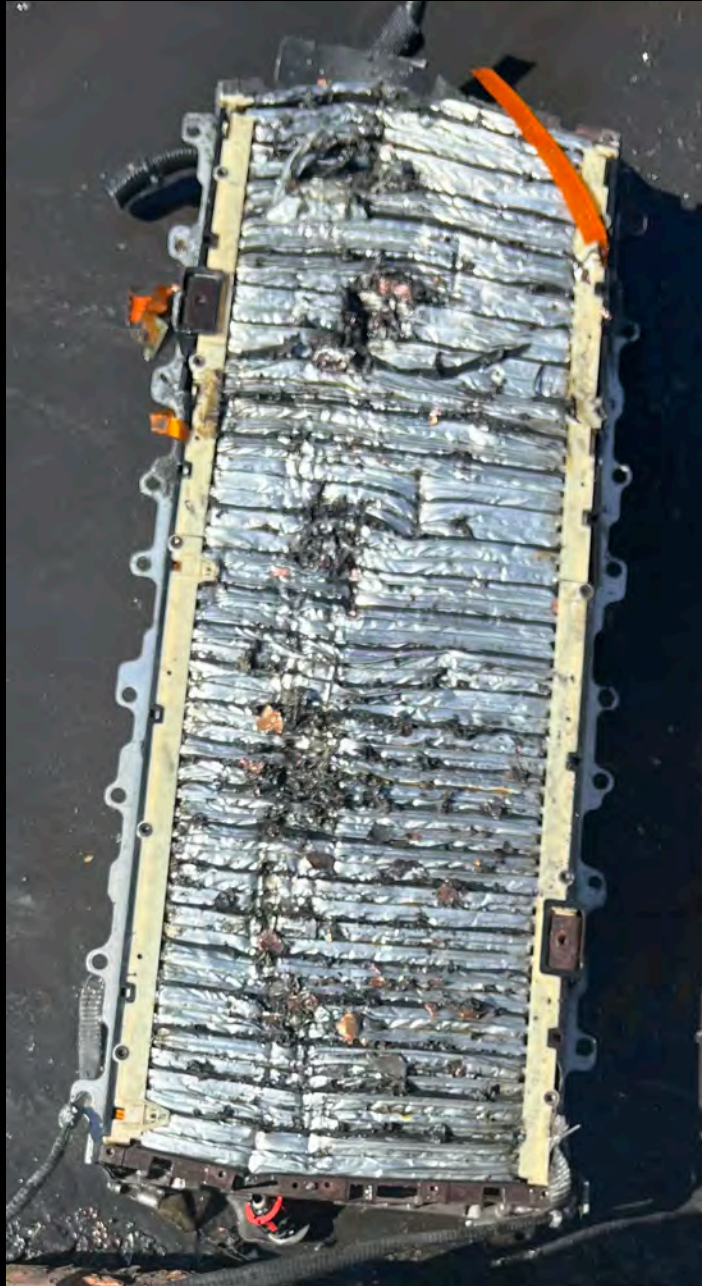


Battery Recovery/Removal – EVs (BMW i3)



Battery Recovery/Removal – EVs (Difficulty w/ Insurance/Auction)







Health and Safety - EVs

Electrician
Temperature Checks
Air Monitoring
PPE

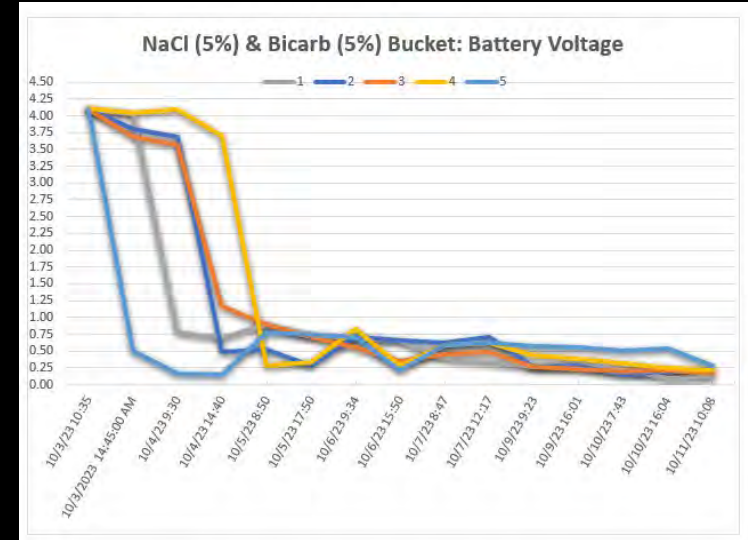


Health and Safety - Dust, Toxic Vapors, and Fire Hazards



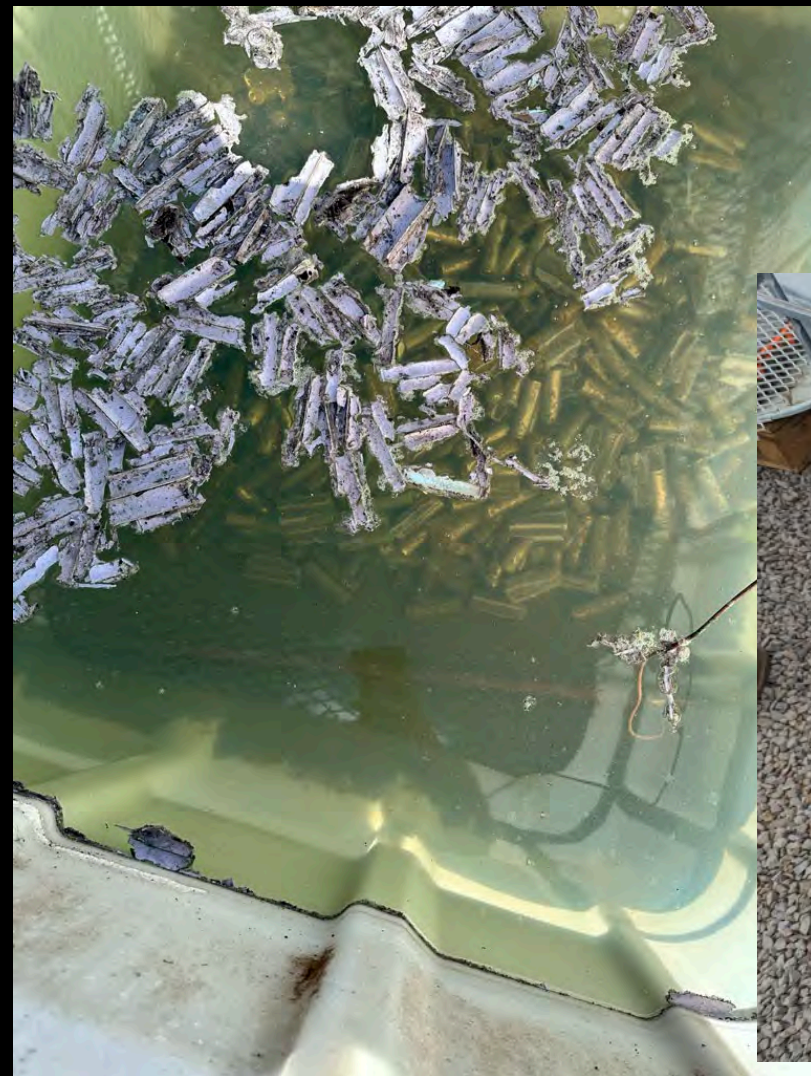
Water/Pump and Hose Line in Place, PPE On

Battery Processing – De-Energizing





Battery Processing – De-Energizing



Battery Processing – Crushing



What is it?

Battery? HazMat? Scrap Metal?





Waste Determination and Transportation

- Material still observed to generated very limited toxic and flammable gases (Electrolysis, hydrolysis, oxidation, and/or decomposition)
- Material moved in packaging that provides:
 - Ventilation
 - Particulate Control
 - Water Intrusion Control
- Packaging transported in open top containers



Waste Determination and Transportation

Battery Packaging



Battery Packaging







**SUPERFUND TECHNICAL ASSESSMENT RESPONSE TEAM
STANDARD OPERATING PROCEDURE FOR RECONNAISSANCE OF
ELECTRIC VEHICLES
2023 MAUI WILDFIRE RESPONSE
DRAFT OCTOBER 27, 2023**

1. OBJECTIVE

This Standard Operating Procedure (SOP) describes the process to determine the presence and location of hybrid and electric vehicles (EVs) impacted by fire. Identification of EVs in a burn zone is necessary to ensure the proper handling and recycling/disposal of lithium ion and nickel-metal hydride battery packs. The objective is to identify and log all hybrid and EVs within the burn zone. This includes vehicles with partial or no visible impacts by fire since temperatures as low as 150 degrees Fahrenheit can compromise the batteries. The purpose of the battery reconnaissance (recon) is to:

- 1) Understand the scope of the EV project and collect specific data in the site database which can then be queried for information;
- 2) Assist the battery recovery process;
- 3) Inform EPA's discussions of the disposition of EVs with interested third parties such as owners, insurance companies, local police and city officials, local auto recovery companies;
- 4) Plan battery processing activities; and
- 5) Plan disposal of EV batteries.

The Battery Recon Team will be followed by the Battery Removal Team which will be responsible for assessing the condition of the vehicle and the battery, if the battery should be removed, or if the owner of the vehicle or insurance company should be contacted (e.g., if the vehicle appears not to be impacted). The Battery Recon Team will typically be made up of 2-3 START personnel with oversight by an Federal On-Scene Coordinator.

2. SUMMARY OF METHOD

Recon is done by a team of trained hazmat responders familiar with vehicle manufacturers, models, and mechanical and battery technology. Teams will survey burned areas looking for vehicles with either hybrid or all electric drivetrains. Once a vehicle is positively identified with hybrid or EV technology, it is marked physically with paint or grease pencil, with a blue colored lightning bolt (typically paint can be used on burned vehicles and the grease pencil on non-burned vehicles on the windshield or glass) and digitally entered into electronic field collection and mapping software (QuickCapture via Field Maps). Additional methodology can be found in the Maui Wildfires 2023 Damaged Lithium-Ion Battery Management Guide for Electric Vehicles.

SOPs - EVs

**Maui Wildfires 2023
Damaged Lithium-Ion Battery Management Guide for Electric Vehicles
Version: November 2, 2023**

1. OBJECTIVE

The handling of damaged lithium-ion batteries inherently presents significant hazards to response personnel. This Guide has been established as a set of general guidelines for the proper handling of lithium-ion batteries to protect all response personnel. The purpose of this procedure is to outline the minimum requirements for safe handling, transportation, and the disposal process considerations for fire damaged lithium-ion batteries through a process of hazard identification and exposure control practices resulting in risk mitigation (Hazard x Exposure = Risk). This Guide is geared towards the following categories of lithium-ion batteries: Battery Energy Storage Systems (BESS), electric and hybrid vehicles (EVs), micromobility devices (e-bikes and scooters), and small batteries (vaping devices, computers, cell phones, etc.)

2. HAZARDS

Thermally insulted, burned or partially damaged lithium-ion batteries are susceptible to thermal runaway. This chemical reaction produces self-sustaining high temperatures that can result in the release of toxic and flammable/explosive vapors with the potential for fire (Figure 1). In addition to combustion products, the vapor produced during thermal runaway and fire can include the following hazardous and toxic and flammable/explosive vapors:

- Hydrogen (30%-50%)
- Carbon monoxide (CO)
- Hydrogen fluoride (HF)
- Hydrogen chloride (HCl)
- Hydrogen cyanide (HCN)
- Phosphoryl fluoride (POF₃)
- Organic solvent droplets
- Ethane, methane, and other hydrocarbons



Figure 1: Diagram depicting a cascading thermal runaway event.

Burned or damaged batteries are unpredictable and cannot be considered fully discharged or free of hazards. Reignition from propagation or thermal insult to other cells within a battery is common and can occur 30 to 90 days from an initial thermal runaway event. During transportation, extreme temperatures and mechanical damage (such as puncturing or jostling) can trigger additional thermal runaway events. Batteries, groups of cells, or individual cells that have suffered significant fire damage may be present as a mass of melted or consumed material that must be evaluated by the Electric Vehicle Task Force to determine if the article has the remaining potential to be a functional cell or battery. When in doubt, the fire damaged article(s) in question must be rendered safe by the Electric Vehicle Task Force (eliminate the hazard) to effectively manage any risks associated with any necessary future steps, such as: local ground movement transportation, disposal or remediation, and long-distance shipping by ground or vessel, etc.

JHA – Battery Energy Storage Systems



2023 Maui Wildfires

U.S. Environmental Protection Agency, Region 9

Emergency Response Section

JOB HAZARD ANALYSIS #7: Power Walls / Lithium Batteries

JHA			
JHA #: 007	Name of Task: Power Walls / Lithium Batteries	Location: 2023 Maui Wildfires	
Task Description: Managing power wall- and lithium batteries		Task Duration: Daily	

Physical Hazards							
Hazard	Source	Control Measures:	Exposure Potential				
			H	M	L	UnE	N/A
Stored Energy (Electricity) / Fire and Explosion	1. Electro/Power supply lines 2. Power walls (Tesla and other brands or homemade versions) 3. Lithium batteries	1. Ensure all electrical power has been shut off/disconnected from the power wall: a. Licensed/certified electrician to verify power status. 2. Ensure no backfeeding in the power wall (i.e., solar panels or any other device that could potentially be feeding energy to or drawing energy from power wall). 3. Isolate the energy storage system (i.e., power wall) after verification that all energy to the system has been shut off or disconnected. 4. Prepare power wall for transportation: ▪ Partially burned, Partially insulated, intact, but suspected damaged power walls: - Use SCBA for respiratory protection along with Flame-Resistant (FR) clothing. Completely charred or Completely charred and bulged power walls: - Use organic vapor/acid gas filters along with Flame-Resistant (FR) clothing. ▪ Wrap powerwall in fireblankets, (e.g., Bridgefill). ▪ If any reaction occurs during handling, immediately drop the power wall and vacate the area to a safe place. ▪ Place in transport vehicle and secure in place using straps or other equipment. ▪ Ensure fire extinguisher and pressurized water sprayers are available during transport. 5. Transport power wall to secure staging area for further processing: ▪ Coordinate with local fire department prior to transport. ▪ If reaction occurs during transport, park vehicle immediately in a location with minimal fire risk (to the extent possible, call fire department (dial 911) immediately for assistance.					

		<ul style="list-style-type: none"> Maintain fire readiness (fire extinguishers and pressurized water sprayers in and container during transport in the event of reaction/fire situations). 					
Chemical Exposure:	By-product of fires involving lithium batteries	See Chemical Hazards section below					

Biological Hazards				Exposure Potential				
Hazard	Source	Control Measures:		H	M	L	UnE	N/A
COVID-19 Exposure	Unknown	Follow COVID-19 protocols						

Chemical & Radiological Hazards				Exposure Potential				
Hazard	Source	Control Measures:		H	M	L	UnE	N/A
Hydrogen Fluoride	By-product of fires involving lithium batteries	<ol style="list-style-type: none"> Partially burned, partially insulated, intact, but suspected damaged power walls: - SCBA required for respiratory protection while handling power walls. - Completely charred or completely charred and bulged power walls: organic gas/acid gas filters required for respiratory protection. FR clothing required for potential fires. In the event a reaction occurs during handling, immediately drop the power wall and vacate the area to safety. Notify the fire department (dial 911). 						

PPE				
Level A	Level B	Level C	Level D Mod	Level D
	Fully encapsulating, chemically resistant, hood with integrated communication system, SCBA, and gloves.	Completely charred or completely charred and bulged power walls: (Organic gas/acid gas filters required for respiratory protection combined with FR clothing.)		

Other	
Notes:	

JHA – EV Battery Removal & Transport



2023 Maui Wildfires

U.S. Environmental Protection Agency, Region 9
Emergency Response Section

JOB HAZARD ANALYSIS #8: EV Battery Removal and Transport

JHA		
JHA #: 088	Name of Task: EV Batteries	Location: 2023 Maui Wildfires
Task Description: Managing EV batteries	Task Duration: Daily	

Physical Hazards – EV Battery Removal							
Hazard	Source	Control Measures	Exposure Potential				
			S	M	L	Unk	N/A
Overhead Hazards	Burned out structure debris	Situational awareness, Hard hat					
Tripping Hazards	Burned out structure debris	Situational awareness, test footing prior to stepping on unknown area					
Electrocution	Intact power lines, Charged EV battery	Avoiding all electric lines and appliances are energized. Evaluate EV battery prior to handling.					
Traffic	Vehicles traveling in work areas	Situational Awareness, High visibility vests					
Fall Hazard	Open septic field or tree root/bush out	Situational Awareness, Mark deep fall hazards with caution tape and orange spray paint					
Falling Trees	Burned out trees	Situational Awareness, Observe Adjacent markings trees, Avoid hazardous tree fall zones, Cease work until wind speeds of 20mph.					
Puncture Risk	Sharp objects in debris	Situational Awareness, Leather work gloves					
Heavy Equipment	Crush zones during vehicle rotation	Situational Awareness, Spotter usage					
Pinch Points	Cutting metal/laws of life	Situational Awareness, Use caution work gloves					
Heat Stress	Working in protective gear	Follow Work/Rest schedules, Stay hydrated					
Lifting Injuries	Lift heavy batteries and equipment	Use proper lifting techniques, Use two man lift for heavy objects, Do not carry heavy objects far distance					

Physical Hazards – EV Batteries							
Hazard	Source	Control Measures	Exposure Potential				
			S	M	L	Unk	N/A
Stored Energy (Electricity) + Fire and Explosion	1. Electric/Power supply lines 2. EV high-voltage and low-voltage batteries	1. Ensure all electrical power has been shut off/disconnected from EV vehicle. a. Licensed/certified electrician to verify power status. 2. Ensure no back feeding to the EV vehicle (i.e., solar panels or any other device that could potentially be feeding energy to or drawing energy from EV vehicle). 3. Isolate the energy storage system (i.e., EV battery) after verification that all energy to the vehicle has been shut off					

		<ul style="list-style-type: none"> or disconnected. Remove EV battery from vehicle using methods identified in the SOP; methods may include rotating vehicle (on side or completely flipped over) using heavy equipment, cutting metal using "Jaws of Life", removing bolts or other metal fasteners (see physical hazards above). Prepare EV battery for transportation. <ul style="list-style-type: none"> Active thermal event or poorly ventilated area - SEBA required for respiratory protection along with Flame-Resistant (FR) clothing OR Standard EV battery removal - organic gas/acid gas filters required for respiratory protection along with Flame-Resistant (FR) clothing. Wrap EV battery in fireblankets (e.g., Bridgell) or place loose material in drum with bung off. If any reaction occurs during handling: immediately drop the EV battery and vacate the area to a safe place (upwind). Place in transport vehicle and secure in place using straps or other equipment. Secure the extinguisher and pressurized water sprayers are available during transport. Transport EV battery to secure staging area for further processing. <ul style="list-style-type: none"> Notify local fire department if thermal or other event occurs that requires a response. If reaction occurs during transport, pack vehicle immediately in a location with minimal fire risk (to the extent possible); call fire department (dial 911) immediately for assistance. Maintain fire readiness (fire extinguishers and pressurized water sprayers to cool container during transport in the event of reaction/fire situation). 					
Chemical Exposure	By-product of fires involving lithium batteries	See Chemical Hazards section below					

Biological Hazards							
Hazard	Source	Control Measures	Exposure Potential				
			S	M	L	Unk	N/A
COVID-19 Exposure	Unknown	Follow COVID-19 protocols					

Chemical & Radiological Hazards							
Hazard	Source	Control Measures	Exposure Potential				
			H	M	L	Unk	N/A
Alkaline Ash and Battery	Remnants of burned car	Personal Data Rain worn by perimeter personnel. Multifac monitoring by screening team. P100 respirators on EV					

Materials	Structures and battery materials	Battery removal crew					
Aesthetics	Remnants of burned car structures	Personal Data Rain worn by perimeter personnel. Multi-face monitoring by screening team. P100 respirators on EV battery removal crew.					
Flammable and Combustible gases	Batteries	Well-ventilated area. P100 respirators and proper eye protection (i.e., goggles). If ventilation concerns, switch to SCBA.					
Acid gases	Batteries	P100 respirators, acid-proof gloves					
Lead acid	Batteries	Tyvek suits, acid-proof gloves					
Hydrogen fluoride	By-product of fires involving lithium batteries	1. Active thermal event or poorly ventilated area - SEBA required for respiratory protection (OR Standard EV battery removal - organic gas/acid gas filters required for respiratory protection). 2. FR clothing required for potential fires. 3. In the event a reaction occurs during handling, immediately drop the EV battery and vacate the area to safety. 4. Notify the fire department (dial 911).					

PPE				
Level A	Level B	Level C	Level D Mod	Level D
	Active thermal event or poorly ventilated area. (SCBA for respiratory protection combined with FR clothing)	Completely contained or properly sealed and bagged EV battery. (Organic chemical gas filter required for respiratory protection combined with FR clothing)		
Other				
None				

NOTES:

From draft SOP on EV Reconnaissance – Hazards and required PPE are listed as: Many hazards exist when performing reconnaissance of burned vehicles. Some of these hazards include sharp edges, broken glass, puncture hazards, structurally unsafe walls, beams, and roofs, high voltage hazards, toxic dust, compromised trees, heat/cold stress, and many more. The recommended PPE for this task is: long sleeve pants and shirts, hardhat, safety toe boots with steel shank, cut resistant gloves, eye protection, high visibility vests, and a dust mask or respirator. Higher level PPE such as Tyvek and boot covers is recommended when conditions require entry into ash footprint.

From draft SOP on EV Battery Removal – Hazards and required PPE are listed as: Numerous chemical and physical hazards are present during vehicle battery recovery. Chemical hazards include acid gases and occasional lead-acid. Physical hazards are heavy lifting of responder tools, sharp metal, fire, heat, ash and dehydration. The PPE level utilized is Level C with half-face respirator utilizing acid gas/P100 dual cartridge, flame retardant clothing (FRC), cut resistant gloves, hard hat and safety glasses. Tyvek suits are only utilized during lead acid battery removal.



Maui Wildfire Recovery

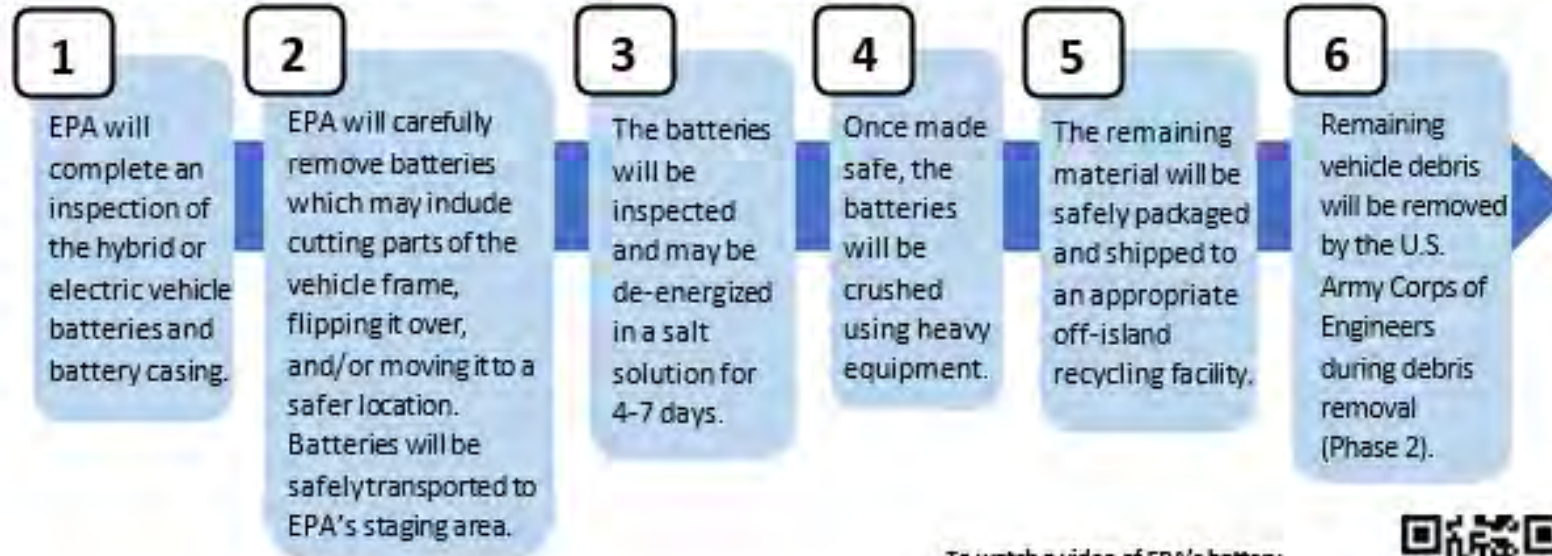
Steps to Safely Removing Electric and Hybrid Vehicle Batteries

October 31, 2023



Maui gives so much to the world. As guests we are honored to give our support back.

The Environmental Protection Agency (EPA) and the County of Maui are locating hybrid and electric vehicles in the burn zone. If you own a hybrid or electric vehicle, please call EPA's hotline at: [808-539-0555](tel:808-539-0555) or the County of Maui Abandoned Vehicle and Metals Office at: [808-270-6102](tel:808-270-6102).



808-539-0555



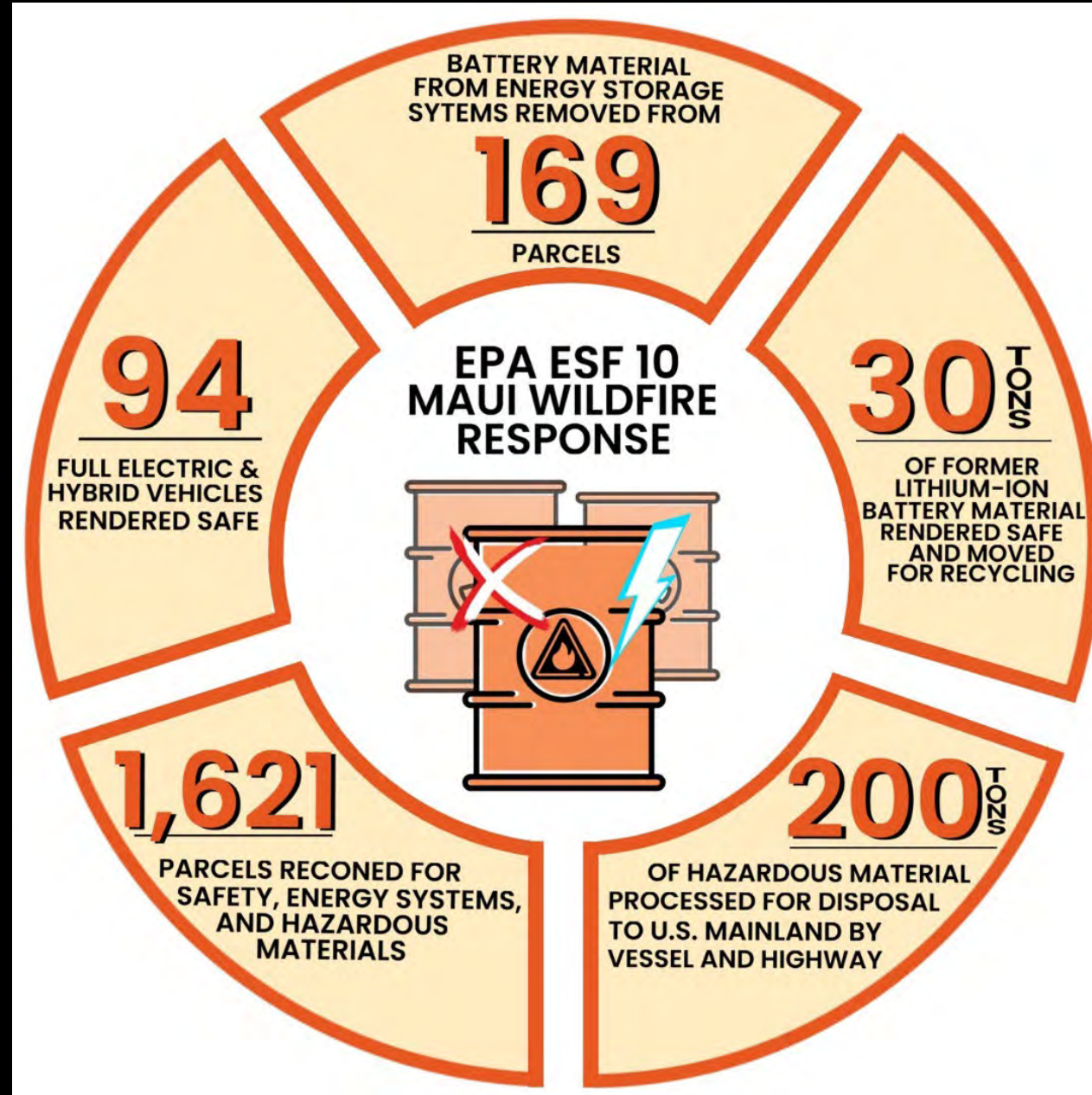
R9Wildfiresinfo@epa.gov



epa.gov/maui-wildfires

To watch a video of EPA's battery removal process, scan this QR code:





Questions?



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November 2024 Clean Gulf Conference and Exhibition