



WASHINGTON STATE PATROL
STATE FIRE MARSHAL'S OFFICE

ELECTRIC VEHICLE FIRE STUDY

JANUARY 2025



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ACKNOWLEDGEMENTS

The Washington State Patrol (WSP), through the State Fire Marshal's Office (SFMO), led the efforts to conduct a study of electric vehicle fires in accordance with Substitute Senate Bill 5812 (SSB 5812, 2024 Legislature).

SSB 5812 directed the WSP to secure relevant stakeholders from each of four areas: 1) Department of Ecology, 2) local fire protection districts, 3) the towing and recovery industry, and 4) other entities. The WSP-SFMO successfully secured more than 20 stakeholders representing each of these areas who served as the SSB 5812 technical workgroup to develop this study. The technical workgroup was chaired by Deputy State Fire Marshal Scott Lancaster of the WSP, SFMO. Workgroup members include:

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John Geppert, Department of Labor and Industries
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Karen Grove, Seattle Fire Department and Washington State Association of Fire Marshals
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The sponsors of SSB 5812 are members of the Senate Committee on Transportation, and the bill was originally sponsored by Senators Wilson, Nguyen, Lovick, and McCune.

SECTION 1: EXECUTIVE SUMMARY

Substitute Senate Bill 5812 (SSB 5812) called for the WSP to “conduct a study of electric vehicle fires reviewing the following: impacts to the environment and proximate residential areas and health impacts to responding firefighters; best practices for fire response; and best practices regarding cleanup and disposal efforts.” This legislative direction is an important complement to Washington State’s transportation electrification strategy, which together with federal infrastructure funding, is requiring and incentivizing a rapid transition from internal combustion engines to electric or battery powered vehicles. This legislative direction recognizes that new technologies present different risks to firefighters and communities. As we make this transition, it is important that the fire service and other responders be prepared to effectively protect and rescue the public. In addition, the legislative direction recognizes the importance of incorporating protections for first responders and the environment into planning for response to electric vehicle fires.

In the first five months of 2023, electric vehicles (EVs) or plug-in hybrid electric vehicles (PHEVs) represented 16% of vehicles sold in Washington State, making Washington a recognized leader in the work to electrify transportation (Interagency Electric Vehicle Coordinating Council, 2024). EV cars will soon represent a large percentage of passenger vehicles and light trucks on Washington State’s roads and will also come to represent a similar proportion of vehicle crashes and fire responses. California’s Advanced Clean Cars II rule requires 100% of new passenger vehicles to be electric by 2035 (California Air Resource Board, 2024). Revised Code of Washington (RCW) 43.392.020 establishes a target that 100% of passenger vehicles and light duty vehicles sold, purchased, or registered in Washington State be electric by 2030. The Washington State Legislature adopted California’s vehicle emissions standards, including Advanced Clean Cars I and II (ACC I and II) (Chapter 173-432 WAC , 2021).

The transformation of energy and transportation in Washington State from carbon-based to electric is one of the most important contributions the state can make to reduce carbon dioxide emissions and help slow climate change. This transformation also represents the most substantial changes in the transportation sector since the start of the 20th century, when steam engines and horse drawn vehicles were replaced by petroleum-based internal combustion engines.

Batteries are an integral part of electrification, as they allow electricity to travel with a moving vehicle. Battery technologies are evolving quickly and have been identified as posing new and different challenges for first responders. Battery fires pose the following risks:

- Battery cells burn at a slightly higher temperature than internal combustion engine fires.
- Additional toxic gases, including heavy metal particulates are released when lithium-ion batteries go into thermal run away.
- Gases generated during thermal run away may build up in enclosed spaces such as garages, vehicle compartments, and shipping containers which can result in an explosion. The explosion can result in death or serious injury to those in proximity to the location of the fire.
- Significantly more water and time is generally necessary to extinguish the fire.
- Control and evacuation zones may be larger due to the toxic gases that are emitted during the combustion of the EV.
- EV fires may cause impacts to traffic due to the extended amount of time that may be required to stabilize the incident.
- Damaged batteries can reignite hours or days after they are initially extinguished.
- EVs involved in collisions may ignite or reignite while in transport or in storage.
- Environmental impact concerns need to be considered due to contaminants and run off present during an EV fire.

Currently, most public and private agencies with emergency response duties in Washington State indicate that they are insufficiently prepared to handle the new challenges posed by EVs.

To accomplish the objectives of SSB 5812, the State Fire Marshal's Office convened a technical workgroup including:

- Department of Ecology
- Department of Commerce
- Department of Labor and Industries
- Towing industry representatives
- Commissioned Washington State Patrol personnel
- Washington Fire Chiefs
- Washington Metro Fire Chiefs
- Washington State Council of Fire Fighters
- Washington State Fire Fighters' Association
- Washington Fire Commissioners Association
- Washington State Association of Fire Marshals
- Many local fire departments including volunteers, fire districts, and municipal fire departments

This technical workgroup surveyed the state's fire service and law enforcement agencies as well as the towing industry in Washington State; reviewed best literature on impacts to firefighter health from national agencies and research institutes, the environment and proximate residential areas; researched existing national best practices regarding fire response, firefighter health, clean up and disposal efforts, and also identified gaps in those areas; and interviewed fire service personnel in charge of specific incidents in Washington State to better understand the risks and needs. We distilled our findings into recommendations for best practices for training as well as checklists that will provide an achievable and impactful set of next steps for legislators and policymakers to support.

Section 1.1 Summary of Recommendations

The technical workgroup focused on identifying specific, immediate steps that can be taken, with a goal of developing funding requests to increasing the levels of readiness in Washington State to respond to EV fires, protecting crash victims, nearby properties, first and second responders, and the environment. In response to SSB 5812, we have compiled eighteen recommendations outlined in this report. The recommendations are based on national models and best practices and include additional recommendations specific to Washington State needs and framework. They represent an implementable and pragmatic approach that allow policy recommendations.

It is important to note that the information contained in this report is based on the available information gathered by the workgroup up to this point. Anywhere in this report where EV or hybrid vehicles are mentioned, the information is intended to encompass electric vehicles, plug-in hybrid vehicles, and hybrid vehicles. Incidents involving lithium-ion batteries are unique and evolving. As new information becomes available, it will be necessary to continually evaluate and validate the recommendations included in this report.

Best Practices for Fire Agency Response to EV Fires Recommendations

- **Recommendation Firefighter Training/Response 1:** Establish a program in the SFMO for emerging innovations in Washington State such as the technologies related to electrifying the state and risks concerning fire and life safety for responders and our communities. In accordance with RCW 43.43.930, the WSP SFMO is the state agency identified to assist all local fire jurisdictions with fire service-related training to ensure their personnel are adequately trained to discharge their responsibilities (2010). This new program would research emerging technologies, develop and implement training programs based on best practices, and contribute to the national and state codes and standards designed to keep responders and the public safe. It is essential that the SFMO work in partnership with the Department of Ecology, Department of Commerce, State Military Department's Emergency Management Division, local governments, and industry to ensure a comprehensive approach is taken towards prevention, mitigation, and recovery.

Recommendation Firefighter Training/Response 2: Due to the importance of this training, by September 30, 2025, the WSP SFMO should advise fire agencies in Washington about the importance of training on EV fires. The SFMO should identify free or low-cost options available through the National Fire Protection Association (NFPA), UL-Fire Service Rescue Institute, Texas A & M Engineering Extension Services (TEEX), and other quality training programs, and share the information with the response community.

- **Recommendation Firefighter Training/Response 3:** Training for firefighters related to EV awareness and/or response should be incorporated into the nationally recognized standards for firefighting. The SFMO and the fire service should work to influence NFPA standards to incorporate best practices. In accordance with WAC 296-305-0552 "employers must provide training, education and ongoing development for all members commensurate with those duties and functions that members are expected to perform" (2022). Training duration needs to be sufficient to provide for life safety, property conservation, and environmental protection.
- **Recommendation Firefighter Training/Response 4:** The WSP, through the SFMO, should develop best practices for EV fire response and an EV fire interagency coordination checklist available to all fire agencies in Washington.

Health Impacts to Responding Firefighters Recommendations

- **Recommendation Firefighter Health 1:** The legislature should provide one time funding for a grant program to be administered by the SFMO for small, rural, or volunteer fire agencies to purchase particulate hoods and respiratory protection. In addition, there is a need for funding to replace personal protective equipment, including: particulate hoods, gloves, up to 200 turnout coats and pants, helmets, respiratory protection and protective clothing. There are approximately 10,000 volunteer firefighters in Washington State.
- **Recommendation Firefighter Health 2:** Before September 30, 2025, the WSP, through the SFMO, should disseminate information to all fire departments regarding the importance of using self-contained breathing apparatus (SCBA) with a face piece and full personal protective equipment (PPE) when responding to an EV fire, and the importance of following standard decontamination procedures for SCBA or PPE that have been used in an EV fire before the gear is worn again, consistent with Chapter 296-824 WAC.

PPE should be isolated, taken out of service, and cleaned before further use. PPE may need to be replaced when exposed to an EV fire. Studies are underway to provide further guidance on the proper cleaning methods for PPE after exposure to an EV fire. Testing of firefighting PPE conducted by Texas A & M Engineering Extension (2024) confirms “high concentrations of lithium, nickel, cobalt, manganese and copper were detected during each Li-ion thermal runaway event, with lithium being the most dominant.” “Several metals, such as cobalt, manganese and lithium, remained in the gear regardless of the cleaning method used” (Texas A & M Engineering Extension Service, 2024).

Towing Industry Recommendations

- **Recommendation Tow Operator Training 1:** Revise Chapter 46.55 RCW to require the employer-provided training for tow truck operators. Training related to EV response for tow truck operators should be administered by the SFMO. Content of the training should include safe towing and storage practices for EV and hybrid vehicles, hazard identification, proper use of PPE, decontamination procedures, and environmental considerations. Individuals who are properly trained should be on a separate rotational list for WSP and law enforcement agencies. Tow operators who wish to opt-out of EV towing should be allowed to do so without penalty, while the standard letter of authority is in effect.
- **Recommendation Tow Operator Training 2:** Due to the importance of this training, beginning on September 30, 2025, the Department of Licensing should advise all tow truck operator personnel about training on EV fires. Free or paid options are available through the National Fire Protection Association, Alternative Fuel Vehicle Second Responder Series, West Virginia University, and the Energy Security Agency.
- **Recommendation Tow Operator Training 3:** To help tow truck operators with EV-related tows, WSP through the SFMO should develop best practices for EV multi-discipline response and an EV multi-discipline interagency coordination checklist that provides guidance to the towing industry.
- **Recommendation Tow Operator Training 4:** To further help ensure best practices and safety for tow truck operators, Washington State should administer a grant program that covers the

cost of PPE for tow truck operators. There are over 400 registered tow truck operator companies in Washington State, with approximately 2,800 tow operators.

Impacts to Environment, Clean Up and Disposal Efforts Recommendations

- **Recommendation Environment 1:** Recommend that first responders and partner agencies strengthen notification procedures that include notifications to Department of Ecology as required by WAC 173-303-145, RCW 90.48.080, and Chapter 70A.305 RCW for releases of hazardous substances to the environment.
- **Recommendation Environment 2:** Recommend development of a formal interagency taskforce or workgroup to continue development and understanding of the impacts to human health and the environment in the event of EV fire events.
- **Recommendation Environment 3:** Identify who is the generator of waste, who is responsible for waste reporting, and how Resource Conservation Recovery Act Identification numbers are assigned in the event an EV battery fire results in generation of hazardous waste in the public space in accordance with Chapter 173-303 WAC and 42 U.S.C. §6901.

Other Recommendations

- **Recommendation Other 1:** Training for law enforcement officers needs to be developed to address life safety, property conservation, and environmental protections. This training needs to be incorporated into basic academies and reoccurring training through the WSP and the Criminal Justice Training Commission. Law enforcement officers need to be equipped with appropriate respiratory protection, personal protective equipment, and equipment to do their job.
- **Recommendation Other 2:** WSP through the SFMO should develop best practices for EV multi-discipline response and an EV multi-discipline interagency coordination checklist that provides guidance to the towing industry.
- **Recommendation Other 3:** Funding should be established to provide the WSP with the appropriate PPE and equipment necessary to perform their duties. There are needs for respiratory protection, retrofitting of bull pens to meet the separation distances or create barrier isolations, and for other technology used for identification and safety.
- **Recommendation Other 4:** Data sharing and incident tracking are valuable and should be promoted. Existing data infrastructure should be leveraged by encouraging fire agencies to comply with RCW 43.44.060 by providing incident data to SFMO. SFMO should publicize SFMO/United States Fire Administration incident coding guidelines. Law enforcement agencies and Department of Ecology should be encouraged to document EVs and PHEVs incidents.
- **Recommendation Other 5:** Conduct a hazard assessment by an industrial hygienist for first and secondary responders to ensure the appropriate PPE has been identified for various mitigation measures.

Section 1.2 Budgetary Recommendations

Budget Request 1: Establish a work unit within the SFMO to address the following recommendations:

Firefighter Training/Response 1
Firefighter Training/Response 2
Firefighter Training/Response 3
Firefighter Training/Response 4
Tow Operator Training 1
Tow Operator Training 2
Tow Operator Training 3
Other 1
Other 2

Estimated cost: \$1.346 million first biennium, and \$768,000 in ensuing biennia.

Description: Create a work unit within the SFMO to study and develop training for emerging technologies related to the electrification of Washington State. This work unit will develop training to meet the needs of the fire service, law enforcement, registered tow truck operators, and the public with the purpose of increasing the knowledge and awareness of the risks associated with EV fires and other emerging technologies. This work unit will advise the responder community in Washington about the importance of training on EV fires by identifying free or low-cost options available through other entities who provide training. In addition, this work unit will develop the best practices resources for the responder community.

A new work unit within the SFMO will include one Chief Deputy State Fire Marshal and one Deputy State Fire Marshal to focus on studying, developing, and delivering training for emerging technologies related to the electrification of Washington State. The existing Hazardous Materials training coordinator DSFM would join this section.

Funding for professional service contracts is needed to enable the SFMO to hire companies that specialize in training on emerging technologies. The estimated cost is \$340,000 per biennium.

It is estimated that 2,000 responders could be trained per year through this delivery method.

Budget Request 2: Establish a one biennium grant program with staffing to address the following recommendations:

Firefighter Health 1
Tow Operator Training 4

Estimated cost: \$6,617,600 first biennium, and \$202,000 in ensuing biennia.

Description: Funding is needed to help fire agencies and registered tow truck operators to purchase or replace equipment.

Add one Deputy State Fire Marshal to the SFMO to oversee a grant program to reimburse agencies and industry for equipment purchases. This position would be redirected to support training after the grant period ends.

Examples of equipment needs:

Fire Service needs: particulate hoods and personal protective equipment

Towing industry: respiratory protection and personal protective equipment

	Estimated Cost	Estimated Personnel	Cost
Level C Suits (For Incident Clean Up)	\$100	14,800	\$1,480,000
Chemical Boots	\$3	14,800	\$44,400
Respiratory Protection	\$178	4,800	\$854,400
Cartridges	\$9	14,800	\$133,200
Turn Out Gloves	\$135	200	\$27,000
Turn Out Coat	\$4,300	200	\$860,000
Turn out Pants	\$2,800	200	\$560,000
Helmet	\$580	200	\$116,000
Boots	\$323	200	\$64,600
Particulate Hoods	\$200	10,000	\$2,000,000
Estimated Cost			\$6,139,600

Budget Request 3: Equipment needed for Washington State Patrol

Meeting the following recommendations:

Recommendation Other 3

Description: Funding is needed to purchase respiratory protection cartridges, retrofit bull pens to meet the separation distances or create barrier isolations, and thermal imaging devices.

	Estimated Cost	Items needed	Cost
Cartridges	\$50	1,100	\$55,000
Barrier isolation	\$15,000	75	\$1,125,000
Thermal Imaging Device	\$500	15	\$7,500
Estimated Cost			\$1,187,500

SECTION 2: THE NATURE OF ELECTRIC VEHICLE FIRES

There is wide agreement among national organizations that EV fires pose new risks and complex challenges that the fire service, other first and second responders, and environmental agencies must be equipped to address.

In testimony to the U.S. House of Representatives Committee on Homeland Security and Governmental Affairs, the President of the International Association of Fire Chiefs (IAFC), John S. Butler, highlighted an “urgent need” to address the increasing fire hazards posed by lithium-ion batteries (International Association of Fire Chiefs, 2024). The IAFC’s position is that lithium-ion

batteries “not only pose significant risks to public safety but also present unique challenges for fire and emergency services due to their intensity, duration and the toxic smoke they produce. The National Transportation Safety Board (2020) has reported “emergency responders faced safety risks related to electric shock, thermal runaway, battery ignition and reignition, and stranded energy” in incidents involving crashed and non-crashed EV vehicles.

Lithium-ion is the most popular chemistry used in rechargeable batteries today. It has a higher voltage than many other battery types, so that it can store more energy and discharge more power, which is important for driving a car at high speeds. Lithium-ion batteries are also relatively long lasting, and studies show that many can be recharged over 1,000 times without losing their capacity (Climate Portal MIT, 2024). The technology has many unusual attributes including:

- **Stranded energy** – when electrical energy remains in a battery, and effective options to remove the energy are not available. This often occurs when a battery is damaged and can lead to thermal runaway.
- **Thermal runaway** – “one of the primary risks related to lithium-ion batteries...in which the lithium-ion cell enters an uncontrollable, self-heating state” (UL Research Institute, 2021). Thermal runaway often causes fire, smoke, extremely high temperatures, release of toxic gases, and ejection of gas or shrapnel (violent cell venting).
- **Rekindling of lithium-ion fires** – can occur when stranded energy from a damaged battery causes the battery to reignite hours, days and even weeks after the original fire was extinguished.
- **Shock hazard** – exposure to high-voltage connections can occur when an EV is involved in a crash and the “safety features such as protective covers and circuit fuses are defeated” (National Transportation Safety Board, 2020).

These challenges require first responders to have knowledge and to use response tactics that differ from their current training, including:

- **Fire suppression** – fires involving the battery may require copious amounts of water which exceeds the amounts normally used in internal combustion related fires. Some manufacturers recommend allowing the fire to burn itself out rather than trying to actively extinguish it. Some fire agencies are also exploring options to move burning EV vehicles to reduce the risk of secondary exposures such as other parked vehicles, buildings, or even wildlands such as grasses and forests.
- **Rescue of victims** – Access to vehicle occupants/victims may be challenging. If an EV loses power, doors and windows may not open without manual intervention. EVs have laminated glass on the front and side windows which makes access more difficult and requires different tools. Vehicle stabilization is complicated and adds time to the rescue operations. Vehicle extrication processes may be more difficult due to hardened frame materials. The electrical system of the vehicle complicates vehicle extrication techniques. Caution must be taken when performing auto extrication due to the possible placement of the battery pack. Any damage or penetration during an auto extrication may result in an unexpected thermal runaway event.
- **Overhaul after the fire** – There is risk of rekindle/reignition when a damaged EV or hybrid vehicle is towed. Fires related to these vehicles have occurred on tow trucks, in tow yards, in recycling facilities, and on trucks or ships transporting damaged EVs and hybrid vehicles to bulk recycling. Due to the configuration of battery units within EVs and hybrid vehicles, there may be stranded energy within the unit that may result in thermal runaway which can result in reignition. The regenerative braking system in these vehicles require all tires to be off the ground when the vehicle is towed to prevent energy generation.

- Environmental mitigation is necessary to reduce and manage exposures such as heavy metal particulates contaminating the surrounding areas and getting into waterways.

EV fires also cause the release of toxic gasses and metal particulates that can cause short-term and long-term health risks to responders, including firefighters, law enforcement and tow truck employees. The use of PPE and SCBA can help reduce exposure to toxic gasses and metals, when combined with proper decontamination prior to their next use.

Finally, the toxic gasses and metals released in an EV fire pose hazards to the environment and communities near an EV fire. Incident Commanders need to be familiar with how to properly initiate required mitigations for the public and engagement with the Department of Ecology.

Due to these characteristics of lithium-ion batteries, manufacturers are continuing to explore safer technologies. It is possible that other technologies may join and possibly replace lithium-ion batteries for use in electric vehicles. However, any battery technology – including those currently under development – will present similar challenges for our first responders, towing industry, communities, and the environment. The SSB 5812 technical workgroup intends that the framework recommended for EV fires today is flexible enough to be used as battery technologies continue to evolve.

SECTION 3: MAINTAINING FIRST RESPONDER READINESS AS THE TRANSPORTATION SECTOR TRANSFORMS

In response to legislative direction in SSB 5812, the technical workgroup reviewed national best practices for fire response to EV fires. Overall, the consensus of best practices for fire response include training on EVs before an incident; availability of best practices checklists during an incident; coordination with tow companies after an incident; establishing protocols for transitioning the incident command from the fire agency (for the fire emergency) to the environmental lead agency (for the hazmat incident); and clarity among first responders regarding the PPE required for these new response types. Within the best practices model, it is essential that communications occur between fire service, law enforcement, towing industry, and environmental personnel to ensure continuity of operations in mitigating the incident.

The United States Bureau of Alcohol, Tobacco, Firearms, and Explosives published a technical bulletin titled “Best Practices for the Safe Handling of Lithium Cells and Batteries” which provides an overview of the typical battery cell geometrics, explains the problems that can be “caused by electrical, mechanical, or thermal abuse, as well as poor design or maintenance, and manufacturing defects” (United States Bureau of Alcohol, Tobacco, Firearms and Explosives, 2024). This bulletin also provides fire suppression considerations and post-suppression stabilization, fire/explosion scene investigation considerations, packaging, transportation, storage, and disposal considerations as well as other valuable information for the response community. The United States Environmental Protection Agency published an informational bulletin titled “2023 Maui Wildfires Damaged Lithium-Ion Battery Management Guide for Electric Vehicles and Mobility Devices” that describes the hazards, provides handling and transportation guidance, and staging requirements for battery mitigation (United States Environmental Protection Agency, 2023). Incidents involving lithium-ion batteries present unique challenges that must be handled cautiously and with care.

Section 3.1 Firefighter Training

As part of this study, a survey was conducted of Washington’s fire agencies, law enforcement agencies, and the towing industry. Of 120 responses received, the majority assessed themselves as underprepared for EV fire responses. Respondents were asked to answer the question “How

prepared, overall, do you feel your department is to handle electric vehicle (EV) incidents?”, where 1 represented not prepared at all, a 3 represented neither prepared nor unprepared, and 5 represented well prepared. The average rating across Washington State was 2.2, indicating Washington State fire agencies assess themselves to be unprepared to respond to EV fires.

Training before the incident is an accepted best practice in emergency response. Washington State has a framework for preparing firefighters to best protect the public and keep themselves safe during responses; however, there is a need to enhance training to incorporate methods for effectively mitigating EV fires.

- **Firefighter Training/Response 1:** Establish a program in the SFMO for emerging innovations in Washington State such as the technologies related to electrifying the state and risks concerning fire and life safety for responders and our communities. In accordance with RCW 43.43.930, the WSP SFMO is the state agency identified to assist all local fire jurisdictions with fire service-related training to ensure their personnel are adequately trained to discharge their responsibilities (2010). This new program would research emerging technologies, develop and implement training programs based on best practices, and contribute to the national and state codes and standards designed to keep responders and the public safe. It is essential that the SFMO work in partnership with the Department of Ecology, Department of Commerce, State Military Department’s Emergency Management Division, local governments, and industry to ensure a comprehensive approach is taken towards prevention, mitigation, and recovery.

Section 3.1.1: Review of Best Available Firefighter EV Training Provided by or Recommended by National Organizations and Federal Government Agencies

Many national organizations have taken steps to address the challenges of EV fires by providing training and safety information for first responders. However, there are specific training courses and materials that rise to the top in terms of the frequency with which they are recommended and cited by national organizations.

The **National Fire Protection Association (NFPA)** has created multiple trainings including a four-hour overview covering the basics from size up to overhaul; more specialized trainings for jurisdictions with specific needs including tunnels or parking garages; basic training focused on tow and salvage challenges; and information for public education and emergency management (National Fire Protection Association, 2024). The basic four-hour overview course for firefighters has been widely recommended and reposted by numerous national agencies including the IAFC and the United States Department of Energy Alternative Fuels Data Center (International Association of Fire Chiefs, 2024, United States Department of Energy Energy Efficiency and Renewable Energy, n.d.) The training is available online and costs \$31 per student. The NFPA received a \$225,000 grant from General Motors to deliver this training for free to 12,000 volunteer and underserved fire departments throughout the U.S (Virginia State Firefighters Association, 2022). NFPA’s more specific training, for example for parking garages and tow companies, is also recommended by the Fire Department of New York and other leading agencies (National Fire Protection Association, n.d.) This training represents good basic training that could be available at a low cost to any Washington State fire agency. As of 2024, these training options are roughly three years old and may not remain relevant much longer.

The **Underwriters Laboratories Fire Safety Research Institute (UL/FSRI)** has created a one-hour course focusing on foundational research about lithium-ion batteries, thermal runaway, and how fire

and explosion hazards develop. This course is referenced and recommended for firefighters by many other reputable organizations, including the IAFC and the National Volunteer Firefighter Council (UL Fire Safety Research Institute Fire Safety Academy, 2023). This course, titled “The Science of Fire and Explosion Hazards from Lithium-Ion Batteries,” is one hour in length and available at no cost.

UL/FSRI is currently completing a multi-year study that will represent advanced research into EV dangers and training recommendations for response, disposal, and firefighter safety. This study is expected to be completed in 2025 to include possible training for first responders. When new UL/FSRI training becomes available, it should be evaluated as a replacement for the NFPA four-hour course referenced above.

Finally, Texas A & M Engineering Extension Service (TEEX), which delivers many classes in partnership with the federal Department of Homeland Security, as well as many National Fire Academy courses, offers a 2.5 hour class called Electric Vehicle (EV) Safety for the First Responder (Texas A & M Engineering Extension Service, 2024).

The National Fire Protection Association (NFPA) urges that “education and outreach are...needed so that more fire departments understand the risks of products powered by large lithium-ion batteries and the potential they have to seriously injure firefighters” (Roman, 2024).

- **Firefighter Training/Response 2:** Due to the importance of this training, by September 30, 2025, the WSP SFMO should advise fire agencies in Washington State about the importance of training on EV fires. The State Fire Marshal’s Office should identify free or low-cost options available through the NFPA, UL-Fire Service Rescue Institute, and TEEX and other quality training programs and share the information with the responding community.

Washington State, like many other states, helps support a basic level of operational safety and readiness in the fire service by enumerating minimum required training for firefighters. This training is maintained in WAC 296-305-0552. Historically, as new risks have been identified, the WAC training requirements have been updated. The technical workgroup recommends that the state require employer-provided firefighter training beginning in 2025, consistent with the state’s approach to other hazards.

- **Firefighter Training/Response 3:** Training for firefighters related to EV awareness and/or response should be incorporated into the nationally recognized standards for firefighting. The SFMO and the fire service should work to influence NFPA standards to incorporate best practices. In accordance with WAC 296-305-0552 “employers must provide training, education and ongoing development for all members commensurate with those duties and functions that members are expected to perform” (2022). Training duration needs to be sufficient to provide for life safety, property conservation, and environmental protection.

The men and women of the fire service respond to emergency incidents to suppress fire, rescue and extricate patients, and provide lifesaving medical aid. Fire agencies and departments help equip their firefighters to be effective by ensuring they have the training and operational knowledge needed.

[Section 3.1.2: Best Practices for Fire Response – Best Practice Checklists](#)

National best practice research indicates that checklists can help improve outcomes during emergency response. Checklists distill hours of classroom training into short, actionable lists that can be drilled on before an incident and referred to during an incident. The technical workgroup

members include national leaders in EV response tactics. Based on their knowledge of other organizations and agencies checklists, the technical workgroup identified that nationally there is not a clear standard for an EV fire response checklist. In addition, the technical workgroup identified a need for interagency coordination in developing a Washington State-specific EV fire checklist.

There are over 400 fire agencies in Washington State and approximately 18,000 firefighters who need guidance on how to respond to EV fire incidents. In addition, emergency communication centers provide essential information to responders, and the telecommunicators need to know what questions to ask when taking calls relating to EV incidents. A best practice checklist can help guide responders through the mitigation process.

- **Firefighter Training/Response 4:** The WSP, through the SFMO, should develop best practices for EV fire response and an EV fire interagency coordination checklist available to all fire agencies in Washington.

Section 3.2: Firefighter Health

The technical workgroup reviewed several scientific documents and reports on health and toxicity related to lithium-ion batteries which are referenced throughout this report. The literature shows that all lithium-ion battery fires produce both toxic gases and toxic metal contamination.

The toxic gases produced, both asphyxiants and irritants, are well documented, and they can produce immediate dangers to exposed personnel, as well as long-term health concerns and environmental damage. The toxic components of main concern from a thermal runaway battery fire are Carbon Monoxide, Hydrogen Fluoride, Hydrogen Chloride, Hydrogen Chloride Cyanide, Nitrogen Oxides, and Sulfur Oxide (Bugryniec, et al., 2024). Inhalation of these gasses can cause dizziness, headache, loss of consciousness, coma, or death. The best recommendations are to stay out of the plume and remain upwind when possible while wearing appropriate PPE and protecting our respiratory system. Exposed gear and equipment should be considered contaminated and appropriate treatment and handling is recommended post-fire. Environmental remediation and clean-up may be necessary after a large lithium-ion battery fire.

Metal contamination is not as well understood or discussed as the toxic gases but published scientific papers highlighting these concerns. It is important to understand that a large percentage of a battery's total mass consists of the cathode metals, including heavy metal nanoparticles. These cathode materials are typically nickel, cobalt, manganese, iron, aluminum, and other metals with known toxicity profiles and very low exposure limits per OSHA/NIOSH in an industrial workplace. Battery cells also contain additional metals such as copper or aluminum as well as other components that may be vaporized during a combustion event based on testing (often present as "foils" inside cells) due to the extreme heat and pressures that may develop.

The same recommendations to protect from unnecessary exposure to the gases listed above are also recommended to avoid toxic metal exposures. The various metals' toxicities cause different adverse health effects. For example, cobalt's "systemic health effects are characterized by a complex clinical syndrome, mainly including neurological (e.g. hearing and visual impairment), cardiovascular and endocrine deficits" (Leyssen, Vinck, Van Der Straeten, Wuyts, & Maes, 2017). Elevated exposure to cobalt can affect heart, thyroid, liver, and kidneys. Repeated exposure to cobalt dust can cause scarring of the lungs (fibrosis) even if no symptoms are noticed. Like cobalt, nickel is another known sensitizer and causes respiratory issues including asthma like allergic reactions. Nickel and nickel compounds are classified Group 1 carcinogens (Klein & Costa, 2015). Aluminum

compounds have been linked to asthma, obstructive pulmonary disease, heart disease, and adverse neurological conditions (Sjögren, Iregren, Montelius, & Yokel, 2015).

Based on the toxic hazards, it is important that first and secondary responders have access to appropriate training and education, personal protective equipment (PPE), and respiratory protection when facing both direct and indirect exposures to these fires. With that said, standard structural firefighting PPE including an SCBA is appropriate for both EV/HEV and ICE vehicle fires.

WAC 296-824-60005 Table 9 already requires employers to provide, at no cost to the employee, SCBA if the employee is in situations with inhalation hazards, including vehicle fires whether gas powered, hybrid electric, or full EV. The NFPA Standard 1970 is being updated to include requirements for particulate-blocking hoods as part of the firefighting ensemble. “NFPA 1970 also includes a section outlining a range of new test methods for evaluating the whole ensemble for thermal protection, heat stress impact, and protection from particulates and gases” (United States Fire Administration, 2023).

- **Firefighter Health 1:** The legislature should provide one time funding for a grant program to be administered by SFMO for small, rural, or volunteer fire agencies to purchase particulate hoods and respiratory protection. In addition, there is a need for funding to replace personal protective equipment including: particulate hoods, gloves, up to 200 turn out coats and pants, helmets, respiratory protection and protective clothing. There are approximately 10,000 volunteer firefighters in Washington State.
- **Firefighter Health 2:** Before September 30, 2025, the WSP through the SFMO should disseminate information to all fire departments regarding the importance of using self-contained breathing apparatus (SCBA) with a face piece and full personal protective equipment (PPE) when responding to an EV fire, and the importance of following standard decontamination procedures for SCBA or PPE that have been used in an EV fire before the gear is worn again consistent with Chapter 296-824 WAC.

SECTION 4: TOWING INDUSTRY CONSIDERATIONS

The tow truck industry is regulated by federal and state laws to include the fees that can be charged for towing and storing a vehicle. In accordance with RCW 46.55 the Department of Licensing and the WSP regulate the fee schedule established for tow truck operators. The fee schedules need to be updated to reflect the circumstances and hazards associated with towing and storing EVs or hybrid vehicles. The current fee schedule does not take into account the fire risk associated with towing or storing EVs or hybrid vehicles. WAC 204-91A-140 establishes the fees for registered tow truck operators with current Letter of Appointment (LOA) with the WSP and established truck rates and daily storage rates. WAC 204-91A-140 (3)(a) sets the basic storage rate fee calculation to be used as bumper-to-bumper measurements for vehicles; (b) the rate must be calculated on a twenty-four-hour basis and must be charged to the nearest half day from the time the vehicle arrives at the secure storage area. Vehicles stored over twelve hours on any given day within the twenty-four-hour period may be charged a full day's storage. Vehicles stored less than twelve hours on any given day, may only be charged for twelve hours of storage, (c) must be the same for all three and four-wheel vehicles twenty feet or less in length, (d) or vehicles or combinations exceeding twenty feet, the storage fee must be computed by multiplying each twenty feet of vehicle length, or any portion thereof, by the basic storage fee. The National Highway Traffic Safety Administration (2014) states “do not store a severely damaged vehicles with lithium-ion batteries inside a structure or within 50 feet of any structure, vehicle, or combustibles.” SAE International (2019) recommends a barrier isolation on three sides of the vehicle made of “earth, steel, concrete, or solid masonry design to

contain the fire from a stored vehicle from extending to adjacent vehicles.” “It is not recommended to fully enclose the vehicle in a structure due to the risk of post-incident fire extending to the structure and the possibility of trapped explosive or harmful gasses; therefore, a roof is not recommended for the barrier construction” (SEA International, 2019). The location of a tow yard may be in proximity of residential, educational, or other inhabited areas, which should be taken into consideration when taking a damaged EV or hybrid vehicle to a tow yard. Most tow yards in Washington State are not set up to implement these recommendations without financial assistance.

When a tow truck is requested by the WSP, the tow truck operator needs to be informed the vehicle is EV or hybrid, so the appropriate equipment and personnel can be dispatched. A hook type tow truck cannot be used to tow an EV or hybrid vehicle based on manufacturer's specifications. Flatbed or dollies need to be used. There are several factors that need to be taken into consideration, to include:

- Make and model of the vehicle
- Condition of the vehicle
- Weight of the vehicle
- State of charge of the vehicle

The NFPA has established a free website that actively maintains a collection of Emergency Response Guides for alternative fuel vehicle manufacturers: [AFV Emergency Response Guides](#). This website is recommended for use by the towing industry to ensure employees safety.

In accordance with Chapter 204-91A WAC a rotational list is maintained by the WSP. There is a need to amend this WAC to create a list of registered tow truck operators prepared to tow and store EVs and hybrid vehicles. The location of tow yards within proximity to residential, educational, or other inhabited locations should be considered when determining where to store a damaged EVs and hybrid vehicle. The list should not impact the existing towing procedures or rotational position established for internal combustion vehicles.

The towing industry should work in conjunction with law enforcement and the fire service to notify the Department of Ecology of fire incidents involving EV or hybrid vehicles.

Section 4.1: Towing Operator Training

A survey was conducted as part of this study of fire agencies, law enforcement agencies, and the towing industry in Washington state. The majority of tow truck operators have very little training on the hazards associated with towing EV or hybrid vehicles.

Training on EVs and hybrid vehicles should be required for tow operators including tow operators who do not hold a LOA and do not tow for law enforcement (non-registered tow truck operators) who currently are exempt from annual WSP inspections and training requirements. RCW 46.55 needs to be revised to require tow truck employers to provide training to their employees. This will promote better safety across the industry and reduce incidents while EVs or hybrids are being transported. Secondary tows (vehicles moved after being towed to the first location) should be included in the training as well as awareness to the exposures of hazards therein and better protect the general public. Some free and paid training options are available to include:

- **Electric Vehicle Safety Online Training: Tow and Salvage Edition** – Online course offered by the NFPA that provides training specific to vehicle recovery, towing, and post-incident storage of EVs (National Fire Protection Association, 2024).

- **Tow Truck Operator Alternate Fuel Vehicle Safety Training** – Course offered by AFV Educate that provides information on alternative fuels and alternative fuel vehicles, as well as information related to towing, immobilizing, and storage of alternative fuel vehicles (Alternative Fuel Vehicle Second Responder Series, 2023).
- **Alternative Fuel Vehicle Towing and Roadside Assistance Training** – Online course developed by National Alternative Fuels Training Consortium in conjunction with the U.S. Department of Energy that provides information on alternative fuels and alternative fuel vehicles, as well as proper procedures for towing—or providing roadside assistance to—EVs or alternative fuel vehicles (West Virginia University, 2024).
- **Energy Security Agency (ESA) – Tow Recovery Training Programs** - The Energy Security Agency offers training programs for tow and recovery professionals that interact with high voltage battery systems. This training is advertised as providing multiple levels of Awareness and Operations safety training through online, in-person, or at the ESA training facility. ESA indicates their training is up-to-date and industry relevant thanks to their close relationships with vehicle manufacturers (Energy Security Agency, n.d.).

A multi-discipline training for the first and secondary responders should be developed and administered in Washington state through the SFMO. The towing industry needs access to training that covers safe towing and storage practices for EV and hybrid vehicles, hazard identification, proper use of PPE, decontamination procedures, and environmental considerations. Training developed by the SFMO should incorporate multi-discipline, interagency coordination to include fire, law enforcement, and tow operators to promote best practices and train responders on the established state action plan/checklist. These recommendations and procedures should be established by state agencies with input and adoption by industry.

- **Recommendation Tow Operator Training 1:** Revise Chapter 46.55 RCW to require the employer-provided training for all registered tow truck operators. Training related to EV response for tow truck operators should be administered by the SFMO. Content of the training should include safe towing and storage practices for EV and hybrid vehicles, hazard identification, proper use of PPE, decontamination procedures, and environmental considerations. Individuals who are properly trained should be on a separate rotational list for WSP and law enforcement agencies. Tow operators who wish to opt-out of EV towing should be allowed to do so without penalty, while the standard letter of authority is in effect.
- **Recommendation Tow Operator Training 2:** Due to the importance of this training, beginning on September 30, 2025, the Department of Licensing should advise all tow truck operator personnel about the need for training on EV fires. Free or paid options are available through the National Fire Protection Association, Alternative Fuel Vehicle Second Responder Series, West Virginia University, and the Energy Security Agency.

Best practices need to be developed for transportation of EVs and hybrid vehicles that have been involved in a fire or collision. Damaged batteries or batteries exposed to water have the potential to experience catastrophic failure. This situation is more likely to occur when the vehicle is in transit post-fire suppression due to water that might be in the battery pack. Fire service escort may be necessary during the transportation of a damaged EV or hybrid.

- **Recommendation Tow Operator Training 3:** To help tow truck operators with EV-related tows, WSP, through the SFMO, should develop EV multi-discipline response best practices and an

EV multi-discipline interagency coordination checklist that provides guidance to the towing industry.

Section 4.2: Towing State Supported Grant for the Purchase of PPE

The tow truck industry does not currently have established requirements for PPE acceptable for EV-related incidents. Recommendations for PPE for the towing industry need to be developed based on best practices like other responders doing similar work. A grant program that would assist tow operators purchase PPE would enable industry to come into alignment with PPE recommendations. The towing industry does not have access to the same grants and programs that equip state or local agencies.

The towing industry is concerned about employee health and safety and any potential injury claims that involving thermal runaway incidents and fires related to EVs. The towing industry should work in partnership with Labor and Industries to minimize risk and avoid violations.

The towing industry needs to develop a decontamination process from start to finish and a cost recovery mechanism to be able to continue to tow EV vehicles.

- **Recommendation Tow Operator Training 4:** To further help ensure best practices and safety for tow truck operators, the state should administer a grant program that covers the cost of PPE for tow truck operators. There are over 400 registered towing companies in Washington state with approximately 2,800 tow operators.

Section 4.3: RCW and WAC Updates Required

There is a need to adopt and/or revise existing RCWs and WACs related to the towing industry to adapt to the electrify Washington policies. Chapter 46.55 RCW needs revised to incorporate EV and hybrid vehicles. Working in partnership, the towing industry, WSP, Department of Licensing (DOL), Department of Ecology, and Labor and Industries need to assess current policy to determine the responsible party for cleanup costs should an EV or hybrid fire occur. Consideration for increasing towing fees is needed due to the difficulties and hazards in EV and hybrid vehicle towing that are far beyond the current scope of work. Consideration is needed for increasing storage fees to enable tow yards to comply with NTSB recommended safe storage standards as defined in SAE International J2990 (SEA International, 2019). Changes to the Registered Tow Truck Operator Official Fees Sheet by managed by DOL to enable tow operators to add additional fees/expenses related to EV towing and storage that the current form does not include. Possibly including an additional section addressing EV related towing and storage fees and applicable expenses. May need to include costs for decontamination or replacement of PPE and trucks. Changes to this form and charging outside of what is listed is prohibited by current statute. Additional costs of monitoring these vehicles in towing company possession and care will exist.

An evaluation of the regulatory liability of the towing industry is needed to assess the industry's risks and liabilities associated with the towing and recovery of EVs and hybrid vehicles. The towing industry is concerned about the potential risks associated with towing and storing EV and hybrid vehicles, especially as it relates to the environmental impacts. The towing industry may need assistance with processing and disposing of EVs and hybrid vehicles if a vehicle is abandoned at a tow yard. There are concerns that the cost of disposal or recycling will be the financial burden of the tower. Further research is needed to determine the liabilities for damage to other vehicles and/or other personal property should an EV or hybrid fire incident occur in a tow yard.

In accordance with Chapter 204-91A WAC, a rotational list is maintained by the WSP. There is a need to amend this WAC to create a list of registered tow truck operators prepared to tow and store EVs and hybrid vehicles. Zoning/location of tow yards with proximity to residential, educational, or other inhabited locations should be considered when storing damaged EVs and hybrid vehicles. The list should not impact the existing towing procedures or rotational position established for internal combustion vehicles. Tow operators who wish to opt-out of EV towing should be allowed to do so without penalty, while the standard letter of authority is in effect.

There is a need to revise Chapter 46.55 RCW to allow storage of EVs or hybrid vehicles beyond the current 90 days. There is a need for funding for the Department of Ecology or other agencies to conduct an environmental assessment when an EV or hybrid incident occurs while the vehicle is in the possession of a towing company. Vehicle insurance policies may not have adequate coverage for clean-up or storage costs. Insurance policies may need to be increased to cover these expenses.

Current WAC 204-91A-140(b) states tow operators must carry two gallons of absorbent to effectively clean up one gallon of spilled liquids. This WAC may need to be revised to address EVs and hybrid vehicle hazardous materials spills. Procedures need to be established along with funding to clearly define roles and responsibilities of the towing industry and the Department of Ecology at the incident and in the tow yard.

The towing industry, working in partnership with the SFMO, fire service, Department of Ecology, Labor and Industries, and other interested parties should continue to research and inform the guidance on the proper use and decontamination procedures for PPE and tow equipment. As this report is being developed and published, information from national research institutions is indicating it may not be possible to eliminate the heavy metal nanoparticles present after lithium-ion battery-related fires. This contamination may necessitate further remediation of environmental hazards such as removal of soil and/or other materials (see Section 5: Environmental).

Section 4.4: General Concerns/Considerations/Requests related to the Towing Industry

The tow truck industry encourages the state to facilitate ongoing research and establish standards or guidelines to ensure all first and second responders can operate safely to minimize the health and environmental impact. Very little is known currently about the long-term effects, and there is a need to review safe practices on a regular basis, but no less than annually or biannually.

The towing industry is concerned about environmental contamination created by EV towing and storage as it relates to risks and liabilities. State and federal policies and guidelines need to be established to help towing companies understand the mitigation requirements and strategies to protect health and the environment. The towing industry requests the legislature to fund an environmental response unit to assess hazards and provide clean up at incidents with no additional expense to the tow operator, so long as policies and procedures were followed.

The towing industry encourages the legislature to establish an emergency point of contact to assist first and second responders with assessing the volatility of an EV or hybrid vehicle that has sustained damage to determine what precautions need to be taken to reduce the risk of fire, explosion, off gassing, or other hazards.

The towing industry encourages the legislature to require EVs and hybrid vehicles sold in Washington State to be equipped with a warning system capable of notifying vehicle occupants and the responding community of thermal runaway. Early notification can help identify the dangers associated with thermal runaway. All EVs involved in a collision should be handled with care, and

responders and the public need to be aware of the potential of fire or explosion that could ensue immediately following impact or even hours or days later. A warning system would increase the safety of tow operator in relocating the vehicle especially when vehicles are transferred from one tow operator to the next (a vehicle's possession may transfer between tow companies due to various circumstances such as insurance purposes). A warning system that notifies the responding community that a thermal runaway situation is occurring will allow immediate action to be taken to protect life, property, and the environment.

The use of a universal marker/identifying sticker that could be affixed to EVs or hybrid vehicles involved in a collision is recommended to be implemented. This would be helpful for all first and secondary responders to include fire service, law enforcement, ecology, and towing. The universal marker/ sticker would be initiated at the incident and be recognizable as the vehicle is moved from location to location. EVs and hybrid vehicles need to be transported and monitored on scene, in transport, at the tow yard, and ongoing until the hazard has been eliminated.

The towing industry recommends the legislature to establish a cost recovery mechanism for the fire service, Department of Ecology, and towing industry to cover the cost of a fire event or secondary reignition for EV or hybrid related incidents. Insurance policies held by the owner of the vehicle may not be high enough to cover the clean up or response costs. Insurance policies held by the towing company may be cancelled if claims adversely impact the insurance company.

There is a need to evaluate the towing industry's regulatory liability for recovering EVs. This includes performing the recovery to transporting the vehicle to storing EVs. The towing industry sees a potential need for exemptions or authorities being granted.

The towing industry recommends the legislature to implement a grant program to assist with retrofitting tow yards to be compliant with SAE International J2990 and NTSB specifications. Tow storage facilities may need to be modified to meet requirements for proper EV barrier isolation as defined and recommended by SAE International J2990 and NTSB. This will include use of non-combustible storage containers, ecological blocks containment bays, or other acceptable methods where space is limited, and tow operators are unable to safely position vehicles 50 feet away from all other buildings and vehicles in the towing company's possession.

SECTION 5: ENVIRONMENTAL

The technical workgroup reviewed scientific literature on the environmental impacts and disposal pathways of fire-damaged vehicle batteries. The literature shows that fires involving EV batteries present new challenges for first responders, recyclers, and waste handlers. These fires have distinct environmental risks that need to be managed to limit potential negative impacts (Mrozik, Ali Rajaeifar, Heidrich, & Christensen, 2021).

Section 5.1: Impacts to Environment

Based on findings in scientific literature, pollutants from EV fires have several possible release routes from the battery to the environment. Each is unique to the specific chemistry and design of the battery involved, and the specifics of the incident (Mrozik, Ali Rajaeifar, Heidrich, & Christensen, 2021). Incident specifics include the type and extent of damage to the battery and its state of charge at the time of the incident. Environmental impacts from EV fires include emissions of fire-related pollutants to air, contamination of soil or surface water at or near the site of the fire, and transport of pollutants in firefighting runoff to nearby waterbodies.

Emission pathways from a burning vehicle battery to air and impacts on a surrounding community can include particulates, along with toxic and potentially explosive gases. There are ongoing studies to better define air pathway exposure hazards. Incident commanders and public health officials need to observe and monitor smoke plume movement and judge potential impacts on surrounding communities when considering fire suppression options and public health decisions during a fire. Protocols may need to be adjusted as further knowledge and understanding of the hazards associated with EV battery fires is gained over time and as EV battery technology evolves (Mrozik, Ali Rajaeifar, Heidrich, & Christensen, 2021).

Soil contamination resulting from an EV fire is subject to assessment against the Model Toxics Control Act (MTCA) (Chapter 70A.305 RCW). The metals content of batteries depends on their design, size, and chemistry. A typical EV battery contains:

- 0.05–0.37 kg cobalt per kilowatt hour (kW h)
- 0.25–0.86 kg nickel per kW h
- 0.46–0.9 kg lithium per kW h.222–225

Metals present in these quantities translate to tens of kilograms of materials in EV battery packs that could potentially be released to the environment during fires or, if improperly disposed of, could pose threats to human health and the environment (Quant, Willstrand, Millian, & Hynynen, 2023). Other inorganic contaminants beyond the primary metals used for battery construction may also be present in lower concentrations (such as arsenic, chromium, and antimony) and warrant evaluation against MTCA cleanup levels.

Washington State Department of Ecology supported WSP and North Mason Regional Fire Authority on an EV fire in Mason County, Washington on May 22, 2024. Soil sampling from the site indicated metals contamination at levels that would exceed MTCA cleanup limits – although the sampling was exploratory and only intended to identify the presence of possible contaminants. The results, shown below in Table 1, indicate the need for greater understanding of soil impacts and remediation options following EV fires.

The contaminants listed in Table 1 were selected for analysis because they are known to be either 1) components of lithium-ion battery chemistries and/or 2) released when those batteries burn. Sample results for five distinct samples collected at the site of the EV fire are provided. Results that exceed MTCA cleanup levels are highlighted in red. All thresholds and results are provided in mg/kg. Please note that these results represent only what was found at a single incident and may not be representative of potential releases from other fires involving lithium batteries.

Table 1: Potential hazards: Soil sampling at the site of one EV event in Mason County, Washington collected in May 2024.

Contaminant	Cleanup Threshold (mg/kg)	Sample Results (mg/kg)				
Mercury	2.0 (Method A)	0.0609	ND	ND	ND	ND
Lithium	160	39.1	2770	1180	4.96	7.31
Silver	400	0.093	0.103	0.468	0.077	0.05
Arsenic	0.67	4.85	3.38	2.88	4.89	2.53
Beryllium	160	0.385	0.5	0.368	0.38	0.268
Cadmium	80	0.297	0.279	0.205	0.222	0.191
Cobalt	24	67.5	4380	2200	15.1	10.8
Chromium	NA	50	47.1	77.8	56.4	39.5
Copper	3,200	202	1670	1820	36.9	33.1
Manganese	3,700	649	1080	468	662	461
Nickel	1,600	359	23900	12300	55.5	35.7
Lead	250 (Method A)	25.7	43.6	34.6	21.1	30.3
Antimony	32	4.52	75.9	67.7	0.36	0.358
Selenium	400	0.125	0.093	0.078	0.13	0.068

Runoff of contaminated firefighting water can negatively affect water quality in surface and groundwaters. Water used to extinguish EV fires contains a higher concentration of nickel, cobalt, lithium, manganese, and fluoride compared with extinguishing water samples from a conventional vehicle fire (Quant, Willstrand, Millian, & Hynynen, 2023).

Firefighting activities can cause discharges to stormwater systems and could enter waters of the state. However, discharges during emergency firefighting activities are authorized under federal rule. All municipal separate storm sewer system (MS4) permits in Washington State include provisions authorizing emergency discharges to prioritize safety of first responders and the public when fighting fires. Incident commanders determine appropriate application and control measures for fire suppression water at the time of an EV battery fire.

Post emergency clean-up procedures to reduce pollutant discharges to waters of the state are required under MS4 permits issued by Ecology. Permit requirements apply to the permittee, which are typically local governments or the Washington State Department of Transportation. These requirements may result in additional procedures for any parties involved in post emergency clean-up since discharge of polluting matter to waters of the state is prohibited (RCW 90.48.090). No permittee is expected to deploy control measures during an emergency.

Section 5.2: Best Practices for Clean-up and Disposal Efforts

Waste EV battery components are subject to waste designation in accordance with the Washington State Dangerous Waste Regulations (Chapter 173-303 WAC). Although several EV battery chemistries exist on the market, a majority are lithium-ion based and likely to designate as dangerous waste for reactivity (D003), ignitability (D001), or both. A person who generates dangerous waste is called a dangerous waste generator. In most circumstances, generators have the option to recycle dangerous waste batteries under the less stringent universal waste standards in

option to recycle dangerous waste batteries under the less stringent universal waste standards in WAC 173-303-573, rather than managing them as fully regulated dangerous waste (2020).

Burned or severely fire-damaged batteries no longer meet the definition of a battery in WAC 173-303-040 and must be managed as dangerous waste unless analytical testing demonstrates otherwise (WAC 173-303-040, 2020). In general, dangerous waste EV batteries must be:

- Stored safely in containers that are in good condition and made of material that is compatible (i.e. won't react) with the battery. For instance, waste EV batteries may be disassembled into individual cells and placed into a 55-gallon steel drum for temporary storage.
- Placed in closed containers unless temporary venting is required to prevent dangerous situations such as the build-up of extreme pressure. In these circumstances, the container may be stored in a satellite accumulation area where regulations allow temporary venting. Department of Ecology recognizes the risk of vapors and off-gassing when a battery catches on fire; therefore, closed containers may not always be the safest management option (Washington State Department of Ecology, 2024).
- Labeled in accordance with the dangerous waste labeling requirements (Washington State Department of Ecology). Additionally, Ecology recommends labeling or clearly marking damaged or defective battery containers with the words "Damaged/defective lithium-ion battery." The label should be visible and legible from 25 feet, or the lettering size must be a minimum of 0.5-inch in height (Washington State Department of Ecology, 2024).
- Shipped to a permitted treatment, storage, and disposal facility using a uniform hazardous waste manifest (EPA Form 8700-22) following U.S. Department of Transportation hazardous materials shipping requirements for damaged, defective, or recalled batteries (United States Department of Transportation Pipeline and Hazardous Materials Safety Administration, 2023).

Ongoing efforts to study EV battery fire hazards will likely result in updated guidelines for managing damaged, defective and recalled batteries. Department of Ecology's Dangerous waste basics webpage provides information about other dangerous waste regulatory requirements (Washington State Department of Ecology).

- **Recommendation Environment 1:** Recommend that first responders and partner agencies strengthen notification procedures that include notifications to Department of Ecology as required by WAC 173-303-145, RCW 90.48.080, and Chapter 70A.305 RCW for releases of hazardous substances to the environment.
- **Recommendation Environment 2:** Recommend development of a formal interagency taskforce or workgroup to continue development and understanding of the impacts to human health and the environment in the event of EV fire events.
- **Recommendation Environment 3:** Identify who is the generator of waste, who is responsible for waste reporting, and how Resource Conservation Recovery Act Identification numbers are assigned in the event that an EV battery fire results in generation of hazardous waste in the public space in accordance with Chapter 173-303 WAC and 42 U.S.C. §6901.

SECTION 6: OTHER THEMES AND RECOMMENDATIONS RELATED TO SCOPE OF SSB5812

Training for law enforcement personnel is needed to ensure they are prepared to take the necessary actions at an EV related incident. Law enforcement officers may need to establish traffic control measures, make rescue of victims, or other mitigating actions prior to fire agency personnel arrival.

- **Recommendation Other 1:** Training for law enforcement officers needs to be developed to address life safety, property conservation, and environmental protections. This training needs to be incorporated into basic academies and reoccurring training through the WSP and the Criminal Justice Training Commission. Law enforcement officers need to be equipped with appropriate respiratory protection, PPE, and other equipment to do their job.

When a vehicle related incident occurs, law enforcement, fire service, Department of Transportation, and towing industry often work together to clear the roadways. If there are hazardous materials involved in the incident, Department of Ecology needs to be notified. Incidents involving EVs involve similar considerations as ICE vehicles.

- **Recommendation Other 2:** WSP, through the SFMO, should develop EV multi-discipline response best practices and an EV multi-discipline interagency coordination checklist that provides guidance to the towing industry.

The WSP has 15 bull pens across Washington State. The bull pens store vehicles held in evidence. EVs that experience thermal runaway and catch on fire may damage other vehicles or equipment being stored in or near the bull pens. Commissioned staff may also need to rescue victims inside an EV which will require the appropriate level of PPE and respiratory protection.

- **Recommendation Other 3:** Funding should be established to provide the WSP with the appropriate PPE and equipment necessary to perform their duties. There are needs for respiratory protection, retrofitting of bull pens to meet the separation distances or create barrier isolations, and for other technology used for identification and safety.

In an effort to better understand the incidents involving EVs and plug-in hybrid electric vehicles, fire agencies, law enforcement agencies, and the Department of Ecology should be encouraged to document and report incidents in a standardized manner. The agencies should be encouraged to work together to better understand the incident experience, so that risk reduction measures can be developed and implemented.

- **Recommendation Other 4:** Data sharing and incident tracking are valuable and should be promoted. Existing data infrastructure should be leveraged by encouraging fire agencies to comply with RCW 43.44.060 by providing incident data to SFMO. SFMO should publicize SFMO/United States Fire Administration incident coding guidelines. Law enforcement agencies and Department of Ecology should be encouraged to document EVs and PHEVs incidents.

This report has included recommendations for PPE for fire service, law enforcement, and towing industry based on the current available information. Mitigating incidents involving lithium-ion batteries is evolving, and new information is coming out on a regular basis. There is a need for a hazard assessment by an industrial hygienist for first and second responders to include Department of Ecology and Department of Transportation. Department of Labor and Industries may be the state

agency best equipped to provide direction and subject matter expertise consistent with Chapter 296-824 WAC.

- **Recommendation Other 5:** Conduct a hazard assessment by an industrial hygienist for first and secondary responders to ensure the appropriate PPE has been identified for various mitigation measures.

SECTION 7: CONCLUSION

As Washington State moves toward the electrification of vehicles, the emergency responders and partner organization need to be prepared to respond to incidents involving EVs and PHEVs. The legislature is encouraged to evaluate the potential hazards to responders, the communities, and the environment.

We would like to thank the SSB 5812 sponsors, WSP, SFMO, Department of Ecology, Department of Commerce, Department of Labor and Industries, many local fire departments including volunteers, fire districts, and municipal fire departments, towing company representatives, Washington Fire Chiefs, Washington Metro Fire Chiefs, Washington State Council of Fire Fighters, Washington State Fire Fighters' Association, Washington Fire Commissioners Association, Washington State Association of Fire Marshals, and the WSP commissioned personnel who contributed to this report. The technical workgroup reviewed literature from national agencies and research institutes on impacts to firefighter health, the environment and proximate residential areas; researched existing national best practices regarding fire response, firefighter health, clean up and disposal efforts, and also identified gaps; interviewed fire service personnel in charge of specific incidents in Washington to better understand the risks and needs; and distilled our findings into recommendations for best practices for training as well as checklists that will provide an achievable and impactful set of next steps for legislators and policymakers to support.

The recommendations contained in this report will provide the legislature with items to consider for implementation. The work group members have benefited from the discussions resulting from this study. Members were able to share knowledge across discipline lines for the betterment of Washingtonians. The recommendations contained in this report were developed based on the information known at the time this report was compiled. The emerging hazards that have been showcased throughout this report will not be isolated to lithium-ion batteries. As new or changing technologies get introduced to the marketplace, it would be beneficial for the technical workgroup to continue their research and studies.

Appendix 1: Fire Service, Law Enforcement, and Towing Industry Survey

Fire Agencies/First Responders Section

Question #1: How prepared, overall, do you feel your department is to handle electric vehicle (EV) incidents?

On a scale of 1-5 - Mean Average Response: 2.3

Question #2: How many EV incidents has your agency responded to in the past two years?

The answers ranged from none up to 300. To validate this information, a study would need to be conducted.

Question #4: In terms of response planning and tactics, how prepared is your department or organization?

On a scale of 1-5 - Mean Average Response: 2.4

Question #3: In terms of personal protective equipment (PPE), how prepared is your department or organization with the appropriate PPE?

On a scale of 1-5 - Mean Average Response: 1.9

Question #5: How prepared do you feel with decontamination procedures?

On a scale of 1-5 - Mean Average Response: 1.9

Question #6: How prepared do you feel with post-response actions?

On a scale of 1-5 - Mean Average Response: 2.3

Question #7: On those incidents, did you work with:

- | | |
|-----------------------|-----|
| • Towing and Recovery | 46% |
| • WSP | 35% |
| • Ecology | 17% |
| • Others | 27% |

Question #8: What types of training or education has your agency received on EVs?

- None
- Reading
- Training with TRAW
- ESA Classes
- Four of us took an EV class.

Question #9: What kind of training would you like to see regarding EV incidents?

- Tactical/Operational 71%
- In-person 62%
- Awareness
- Virtual/pre-recorded
- Manufacturer specific

Question #10: Has your agency recently changed or increased PPE requirements when responding to an EV incident?

- No 84%
- Yes 8%

Question #11: Is your department:

- Career 59%
- Volunteer 13%
- Hybrid 28%

Question #12: Would you characterize your department's service area as:

- City 28%
- Suburban 24%
- Rural 48%

Question #13: How many hours a month does your agency dedicate to training?

- 6-10 38%
- 2-5 29%
- 0-1 13%

Question #14: What are the barriers to training/education your agency faces?

- No EV classes for fire
- Towing industry is a private industry.
- Cost and availability
- Educated SME
- Lack of personal experience in subject matter
- Funding-Time
- "Ignorance-That is a Hazmat Problem"
- Scheduling
- Volunteer FD-Staffing and time restraints.

Question #15: What is your agency's main concern when responding to an EV incident?

- Safety, Fire, Clean-up
- Reigniting
- Putting out the fire

- Keeping traffic moving
- Available volunteers
- Exposure and decontamination

Question #16: Does your agency have a system in place to identify EV vehicles that have an accident? If so, what do you do?

- Yes, call ESA.
- NO
- Not yet, working on standard app to use for consistency.
- Yes, but limited.

Question #17: Are there any other comments you'd like to leave for the SSB 5812 Workgroup?

- Would be nice to have all agencies on same page.
- Would like to know how to disconnect all power supplies to vehicle, if not they will be separated from anything that can catch fire.
- This subject needs to be pushed to the front of the line, we are behind the curve.
- Responses create a lack of resources overall.

Law Enforcement/First Responders Section

Question #18: How prepared, overall, do you feel your department is to handle electric vehicle (EV) incidents.

On a scale of 1-5 - Mean Average Response: 1.4

Question #19: How many incidents has your agency responded to in the past two years?

- Actual response information is a little crazy. See survey information.

Question #20: In terms of personal protective equipment (PPE), how prepared is your department or organization with the appropriate PPE?

On a scale of 1-5 - Mean Average Response: 1.5

Question #21: In terms of response planning and tactics, how prepared is your department or organization?

On a scale of 1-5 - Mean Average Response: 1.3

Question #22: How prepared do you feel with decontamination procedures?

On a scale of 1-10 - Mean Average Response: 0.8

Question #23: How prepared do you feel for post-response actions?

On a scale of 1-5 - Mean Average Response: 1

Question #24: On those incidents, did you work with:

- Towing 65%
- Others 30%
- None 15%
- WSP 20%

Question #25: What types of training or education has your agency received on EVs?

- None
- Lithium-Ion battery training and EV towing certification
- Very little
- Awareness

Question #26: Has your agency recently changed or increased PPE requirements when responding to an EV incident?

- No 68%
- Yes 16%
- Other comments 16%

Question #27: What kind of training would you like to see regarding EV incidents?

- Awareness Level 68%
- Tactical/Operations 63%
- Virtual 53%
- In-person 53%
- WSP Provided, similar to Hazmat training 58%

Question #28: Is your department:

- Career 89%
- Volunteer 11%

Question #29: Would you characterize your department's service area as:

- City 26%
- Suburban 32%
- Rural 42%

Question #30: How many hours a month does your agency dedicate to training?

- 0-1 21%
- 2-5 58%
- 6-10 21%

Question #31: What are the barriers to training/education your agency faces?

- No EV training available
- Cost and opportunity

- Personnel to attend training and funding to provide training.
- Money and time
- Should not be any.

Question #32: What is your agency's main concern when responding to an EV incident?

- Safety, Fire
- Secondary incidents and contamination
- Employee safety on scene and safe storage of vehicles as evidence
- Disposal
- Personal safety and traveling public.
- Employee exposure

Question #33: Does your agency have a system in place to identify EV vehicles that have been in an accident? If so, what do you do?

- Evaluate Access Contact ESA and make action plan accordingly??
- NO
- Don't know.

Question #34: Are there any other comments you'd like to leave for the SSB-5812 workgroup?

- No
- We need to be following a recommended national safety standard. We need a state plan. We need PPE and general public/industry understanding. We need to know how to get PPE and how to decontaminate.
- Please no more unfunded mandates and training expectations!!
- Please make available resources for responding.

Towing and Recovery Section

Question #35: How prepared, overall, do you feel your company is to handle electric vehicle (EV) incidents?

On a scale of 1-5: Mean Average Response: 1.9

Question #36: In terms of personal protective equipment (PPE), how prepared is your department or organization with the appropriate PPE?

On a scale of 1-5: Mean Average Response: 1.4

Question #37: In terms of response planning and tactics, how prepared is your department or organization?

On a scale of 1-5: Mean Average Response: 2.1

Question #38: How prepared do you feel with decontamination procedures?

On a scale of 1-5: Mean Average Response: 1.3

Question #39: How prepared do you feel for post-response actions?

On a scale of 1-5: Mean Average Response: 1.6

Question #40: On those incidents, did you work with:

- Others 48%
- WSP 40%
- Local Fire 35%
- Ecology 8%
- None 24%

Question #41: What types of training or education has your company received on EVs?

- Two meetings, getting all information.
- None
- Reading up on any articles we come across. Towing industry is on top of the training.
- Zero
- ESA EV training May 2024
- Self-education
- Very little

Question #42: What kind of training would you like to see regarding EV incidents?

- In-person 67%
- WSP Training similar to Hazmat training 55%
- Awareness Level 52%
- Tactical/Operations 52%
- Virtual/pre-recorded 52%

Question #43: If there was no penalty to your Letter of Appointments, would your company opt out of towing/recovering EVs?

- Yes 54%
- Other 26%
- No 19%

Question #44: As of 6-2024, the current NTSB recommendation for EV storage is 50-feet in either direction. Do you meet the current recommendation for EV storage in your tow yard?

- No 46%
- Yes 23%
- Other 31%

Question #45: Have you made any alterations to your standard response for vehicle fires when you arrive to an EV fire?

- Increased precautions when handling EV incidents 54%
- Reconfigured tow yard to accommodate storage of EVs 38%

- Others 33%
- Purchased equipment to accommodate storage of EVs in tow yards 13%
- Changed or increase PPE 8%

Question #46: Does your company have a system in place to identify EV vehicles that have been in an accident such as tracking system, identification stickers, etc.? if so, what do you do?

- No 62%
- Yes 8%

Question #47: would you consider your company storage area as:

- City 77%
- Suburban 12%
- Rural 12%

Question #48: How many hours a month can your company dedicate to EV training?

- 0-1 54%
- 2-5 35%
- 6-10 8%

Question #49: What is the main concern when responding to an EV incident?

- Storage
- Safety
- Damage to the battery! I wish we could plug something into the vehicle to discharge the battery.
- Fire
- That we get paid for the services we provide.
- Liabilities
- Heavy metal contamination on truck and driver
- Reoccurring fire start-ups.
- Disposal
- Lack of space in impound yard.

Question #50: Are there any comments you'd like to leave for the SSB-5812 workgroup?

- Yes, the public needs to know what can happen when possessing an EV.
- Education
- As a tow company we mostly don't get notified it's an EV before we arrive on scene. We have no funds for the PPE and not even sure what we need. As well as costs of all this and not being able to charge to recoup our costs.

APPENDIX 2: LIST OF NEWS ARTICLES

[Semi-truck carrying lithium batteries catches fire, blocks traffic along I-90 near Issaquah – KIRO 7 News Seattle](#)

[Belfair woman dies in crash - Shelton-Mason County Journal](#)

[Sue Lani Madsen: EV challenges no longer hypothetical in Fairfield | The Spokesman-Review](#)

[Deadly Tesla crash in Spokane County used as a test case to fight electric vehicle fires | The Spokesman-Review](#)

[Crash, fire involving Tesla in Medina raises questions about electric vehicle safety – KIRO 7 News Seattle](#)

[Fire destroys Lynnwood home, causes Tesla's to explode in driveway – KIRO 7 News Seattle](#)

[Tesla says car fire began in battery | king5.com](#)

[UPDATE. A Tesla Model X Catches Fire in Front of a Garage Full of Ammunition - autoevolution](#)

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