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Management and Disposal of Vehicles Following a Wide Area Incident: Literature Review and Stakeholder Workshop

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Management and Disposal of Vehicles Following a Wide Area Incident: Literature Review and Stakeholder Workshop

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TABLE OF CONTENTS

DISCLAIMER

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LIST OF TABLES AND FIGURES

ACRONYMS AND ABBREVIATIONS

AL	Active Learning
CBRN	Chemical, Biological, Radiological and Nuclear
CDL	Commercial Driver's License
CESQG	Conditionally Exempt Small Quantity Generators
DED	Detailed Equipment Decontamination
DHS	U.S. Department of Homeland Security
DND	Canadian Department of National Defense
DOD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GPM	Gallon(s)-per-minute
HHW	Household Hazardous Waste
HSRP	Homeland Security Research Program
HTH	High-test Hypochlorite
JAEA	Japan Atomic Energy Agency
LDS	Lightweight Decontamination System
MPDS	Multipurpose Decontamination System
MSW	Municipal Solid Waste
NHSRC	National Homeland Security Research Center
OEM	Original Equipment Manufacturer
ORCR	Office of Resource Conservation & Recovery
ORD	Office of Research and Development
PDDA	Power-driven Decontamination Apparatus
R&D	Research and Development
SDS	Sorbent Decontamination System
SME	Subject Matter Expert
STB	Super Tropical Bleach
SWANA	Solid Waste Association of North America
TEPCO	Tokyo Electric Power Co.
UAV	Unmanned Aerial Vehicle
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VHR	Very High Resolution
WCB	Waste Characterization Branch
WEST	Waste Estimation Support Tool

EXECUTIVE SUMMARY

Large-scale natural disasters have the potential to generate a significant amount of waste. Man-made chemical, biological, radiological and nuclear (CBRN) incidents, either by way of terrorism, war, or accident, have the potential to generate as much or more waste. Furthermore, following a wide-area incident, it is assumed that a large number of vehicles will be damaged and/or contaminated to varying degrees and left unattended within the impacted area. The resource demand required to manage (gather, transport, store, treat/decontaminate, recycle, or dispose of) these contaminated vehicles may overwhelm local, state, and federal recovery efforts. Therefore, research efforts to reduce the cost and time associated with assessing, collecting, and recycling or disposing of contaminated vehicles resulting from a wide-area incident are necessary.

This report details the results of a literature review and stakeholder workshop conducted to begin to synthesize existing knowledge and research related to vehicles impacted following a wide-area CBRN incident. The literature review sought to identify relevant articles, reports, and other information related to methods for quantifying, assessing, collecting and managing (recycling and/or disposal of) contaminated vehicles.

From the perspective of emergency planning and response, the ability to quickly identify and estimate the numbers and types of vehicles that may be impacted in a wide-area response would allow planners and responders to generate waste estimates and project resource requirements. Methods of interest for these estimates include remote sensing, modeling, and inventory data derived from modeling software, property records, insurance companies, and vehicle title databases.

Vehicles of all types contain hundreds, if not thousands, of components that vary depending on the type of vehicle. Many of these components may be contaminated to some degree during a wide-area CBRN event. A broad spectrum of materials exists, and the efficacy of decontamination methods and strategies for various material types will need to be evaluated and considered in the context of the anticipated final disposition of the vehicles (i.e., reuse, recycling, and/or disposal decisions).

Many challenges were identified from past natural disaster incidents related to the collection and transport of large numbers of impacted vehicles. Vehicles and vessels may be in various states of operability, damage, and/or contamination level. Following a CBRN incident, contaminated vehicles pose a unique challenge to the response/recovery effort in terms of accessing the vehicle, transporting the vehicle, and managing its decontamination and disposition.

The U.S. Departments of Defense (DOD) and Agriculture (USDA) have established procedures for the decontamination of vehicles following CBRN events, Ebola Virus Disease contamination, and animal-disease contamination. Those procedures, especially those developed by DOD, are focused on returning operational assets to a suitable state of readiness as quickly as practicable. However, differences exist in the risk assessment and risk management when evaluating the return to use of decontaminated vehicles in: (1) a military operational theatre, versus (2) a civilian setting where vehicles may be returned to private residential areas in urban environments, or managed or disposed of as (potentially) contaminated waste. Furthermore, deficiencies exist in validated and exercised approaches for civilian vehicle decontamination, and only very generic guidance exists for civilian vehicle decontamination of CBRN hazards. Following wide-area contamination events, decision makers will need to consider the ultimate vehicle end-use when evaluating available and appropriate decontamination procedures. There appear to be opportunities to commercialize decontamination technologies used to remediate agricultural, health, and military facilities, vehicles, and equipment for civilian applications, and to identify, promote and integrate emerging technologies into decontamination approaches for civilian vehicles.

EPA's National Homeland Security Research Center (NHSRC) coordinated a one-day workshop on Vehicle Waste Management and Disposal, which was held on Monday, November 13, 2017, at EPA's Potomac Yard South located in Arlington, Virginia. The workshop brought together officials from federal, state, and local governments, as well as researchers and experts from the automotive recycling, scrap recycling, waste management, and insurance industries, to discuss research, operational, and waste management considerations related to the characterization, management, reuse/resale, recycling, and disposal of vehicles following a wide-area man-made or natural incident. Many of the observations discussed and presented in this report are consistent with the challenges that were identified in the literature review. The workshop participants identified numerous information needs, gaps, and areas for future investigation and research related to vehicle management following wide-area incidents.

Results of the literature review and insights gained through the stakeholder workshop validate that while there are many valuable lessons learned from natural disaster responses and work by other federal agencies to address decontamination of valuable vehicle assets to leverage, many questions remain unanswered. Additional research is needed to gain a full appreciation of the impact managing vehicles from a wide-area CBRN event may have, as well as guidance and support to aid decontamination and waste management strategies. The table below summarizes the needs that were identified. A qualitative magnitude of needs was identified based on an analysis of the literature review results and input obtained from workshop participants.

Topic	**Information/Needs Category**		
	Scientific/ Technology	**Operational**	**Policy**
Vehicle Identification	◆	◆	N/A
Identification of Vehicle Material Contamination	◆	◆	◆
Vehicle Decontamination Technologies	◆	◆	N/A
Reuse, Recycling, and Disposal Criteria	N/A	◆	◆
Private Industry Considerations	N/A	◆	◆
Communication and Transparency	N/A	◆	◆

Red = Greatest need; Yellow = Moderate need; N/A = Not applicable

Conducting additional research to understand these key issues will further preparedness efforts for handling large numbers of vehicles resulting from a wide-area event.

1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is designated as a coordinating Agency, under the National Response Framework, to prepare for, respond to, and recover from a threat to public health, welfare, or the environment caused by actual or potential oil and hazardous materials incidents. Hazardous materials may include chemical, biological, and radiological or nuclear (CBRN) substances, whether accidentally or intentionally released. EPA can also have responsibilities to address debris and waste through decontamination, removal, and disposal operations. This project supports the mission of the EPA's Office of Research and Development's (ORD's) Homeland Security Research Program (HSRP) by providing expertise and guidance on issues related to management, recycling, and disposal of vehicles resulting from a wide-area incident, including considerations related to selection and implementation of decontamination methods and complexities related to waste handling activities that are expected to impact recovery resource demands.

Large-scale disasters have the potential to generate a significant amount of waste. For example, Hurricane Katrina and the Joplin, Missouri, tornado resulted in 100 million and 1.5 million cubic yards of waste, respectively. Man-made CBRN incidents, either by way of terrorism, war, or accident, have the potential to generate as much or more waste. Furthermore, both natural and man-made incidents may also generate some amount of hazardous waste. Once designated as hazardous waste, the segregation, identification of staging and storage facilities, logistics, and resource demands associated with managing such waste can be an arduous undertaking. Past agency experiences, including exercises dealing with biological and radiological contamination, and more recently the Tokyo Electric Power Co. (TEPCO) Fukushima nuclear accident in Fukushima, Japan, have highlighted the fact that vehicles could constitute a significant part of the waste stream, and viable options for managing those contaminated vehicles do not yet exist [1].

Following a wide-area incident, it is assumed that numerous vehicles will be damaged and/or contaminated to varying degrees and left unattended within the impacted area. Furthermore, given the contaminant and the state of the vehicle at the time of contaminant release (e.g., on/off, windows open/closed), various internal components of the vehicles may also be contaminated. For one hypothetical radiological contamination incident in a downtown urban area, EPA estimated that approximately 56,000 vehicles would be impacted[1]. The resource demand required to manage (gather, transport, store, treat/decontaminate, recycle, or dispose of) these contaminated vehicles may overwhelm local, state, and federal recovery efforts. Therefore, research efforts to reduce the cost and time associated with assessing, collecting, and recycling or disposing of contaminated vehicles resulting from a wide-area incident are necessary.

[1] The estimate was derived using vehicle data from the Federal Emergency Management Agency's (FEMA's) *Hazus* software coupled with geographic data from EPA's Waste Estimation Support Tool (WEST). The hypothetical scenario was EPA's Liberty RadEx exercise held in April 2010 in Philadelphia, PA.

The objectives of this study were threefold: (1) conduct a literature review to identify relevant articles, reports, and other information related to methods for quantifying, assessing, collecting, and managing (recycling and/or disposal) contaminated vehicles; (2) convene a workshop to bring together a broad range of stakeholders representing government; state and local agencies and emergency planning/response personnel; and private industry, insurance industry, and recycling industry to discuss and identify waste management, recycling, and disposal challenges that may arise when dealing with wide-area incidents involving large quantities of vehicles; and (3) document findings in a report. From this study, EPA gained a better understanding of the magnitude of impacts that could occur following a large-scale contamination incident. The resulting number of contaminated vehicles will have significant implications for response and recovery activities, and strategies to alleviate these issues should be developed. This study also identified numerous informational gaps that need to be addressed to develop sound guidance and response strategies.

This assessment report is structured in the following manner:

- Chapter 2 summarizes the results of the literature review;
- Chapter 3 summarizes the outcomes and results from the stakeholder workshop; and
- Chapter 4 discusses the observations and conclusions reached as a result of this study and needs for future research.

2 QUALITY ASSURANCE/QUALITY CONTROL

The purpose of this study was to synthesize existing knowledge and research related to vehicles impacted following a wide-area CBRN incident. The work and conclusions presented as part of this study were empirical and observational – no scientific experiments were performed. Technical area leads evaluated the quality of the information collected by this effort (i.e., secondary data), and based on their expert opinion, determined if the information should be documented within the literature review. Collected literature was evaluated according to the "Literature Review Scoring Criteria" as shown in Appendix B. All supporting documentation of the secondary data considered worthy for inclusion were cited. However, no experimental confirmation of secondary data (e.g., accuracy, precision, representativeness, completeness, and comparability) was conducted as part of this study.

3 LITERATURE REVIEW

A literature review was conducted to identify relevant articles, reports, and other information related to methods for quantifying, assessing, collecting and managing (recycling and/or disposal) contaminated vehicles. Targeted search terms were developed to focus literature retrieval (Appendix A).

Each piece of literature was read, assessed, and documented based on several criteria. To standardize this process, a Literature Assessment Questionnaire form was used to document the overall quality of the literature. Upon completion of entry via the form, the reviewer's evaluation was stored in a spreadsheet to document the assessment. The resulting spreadsheet was used to summarize key research findings.

Relevant articles were defined as those crucial to answering research questions pertaining to the management of vehicles following a wide-area event. Each article was evaluated based on the seven criteria: applicability and utility, soundness, clarity and completeness, uncertainty and variability, evaluation and review, focus, and verity (Appendix B). Literature deemed at least moderately relevant to meeting the objectives of this study was then summarized, and relevant information is included in this report. A total of 98 sources were identified through the targeted search, and 40 of the 98 were selected for further evaluation. Of those 40, only 13 sources were identified as having information relevant to address the research topics identified for this project.

The remaining sections present findings addressing the following topics:

- Identification and estimation of the number and type of vehicles present in a geographical area;
- Vehicle materials characterization;
- Collection and transportation of large numbers of inoperable vehicles;
- Vehicle decontamination;
- Vehicle reuse, recycling, and disposal considerations; and
- Waste management.

3.1 Identification and Estimation of the Number and Type of Vehicles Present in a Geographical Area

From the perspective of emergency planning and response, the ability to quickly identify and estimate the number and types of vehicles that may impact a wide-area response would allow planners and responders to generate waste estimates and project resource requirements. Methods of interest that enable forming estimates from two primary mechanisms were identified: 1) Remote sensing using visual data from satellite imagery, and 2) Models and records using projected estimates from modeling algorithms and inventory data derived from modeling software, property records, insurance companies, and vehicle title databases.

3.1.1 Remote Sensing

Several recent studies related to the development of remote sensing techniques to identify and estimate the numbers of vehicles in a given geographic location were identified [2-8]. One study evaluated aimed to develop methods based on intensity, chromaticity (i.e., quality of color), and lane-based methods to quickly determine the operating conditions of roadways from satellite images by detecting the presence of debris and the blockage of roads and vehicle flows. The article describes efforts to automatically identify traffic lanes, a prerequisite for determining blockages of debris, and for detecting vehicles from satellite images. The study found that the method was able to eliminate interferences from dark vehicles and shadows. The method was also able to detect vehicles with small intensity contrast with the pavement and maintain the shapes. The study concluded that vehicle detection rates can be improved by combining information on traffic lane locations and the color tones of vehicles. The method can be used for roadway and traffic assessment after a disaster, as well as transportation applications such as traffic data collection, traffic flow monitoring, and transportation infrastructure management [9].

A second study presented a two-level Active Learning (AL) classification method for the interactive detection of earthquake-induced debris via the synergetic use of post-disaster Very High Resolution (VHR) satellite and local decimeter-resolution aerial images. The method supports creating accurate maps of post-disaster debris using low and high-resolution satellite imagery with the objective of producing accurate maps with the fewest images taken (thereby reducing cost and time). The study discussed the use of unmanned aerial vehicles (UAVs) to collect imagery, while cautioning that UAVs have limited flying time. The authors claimed that the best maps are derived using an iterative surveying approach, with subsequent surveys directed towards progressively smaller areas of interest that are identified by first examining the large-scale images. The use of satellite imagery and UAV imagery may be very helpful in accurately identifying and mapping the extent of debris occurrence in a geographical area to inform the organization of recovery/collection efforts [10].

3.1.2 Models and Records

In addition to remote sensing techniques, additional models and databases can be utilized to estimate the number of potentially impacted vehicles following a wide-area incident. Models such as FEMA's *Hazus* software [11] include state databases of vehicle counts by Census tract and Census block. The vehicle counts can easily be queried for a known list of Census tracts and include daytime and nighttime vehicle counts for cars, light duty trucks and heavy-duty trucks.

Other academic studies and models may also be useful. One study considered routing and scheduling considerations for handling freight in disasters through the development of a mathematical model. Although the study focused on routing relief supplies to people in need after a disaster, the model could also inform coordinating disaster debris (including vehicles) removal [12].

Insurance and title records are another potential source for vehicle information. States maintain insurance and titling information records and databases that can be used to identify owners of abandoned vehicles, identify insurance carriers, and quantify vehicles insured and titled in a given jurisdiction. Title information can also be obtained from the National Motor Vehicle Title Information System [13].

3.2 Vehicle Materials Characterization

Vehicles of all types contain hundreds, if not thousands, of components that vary depending on the type of vehicle. Many of these components may be contaminated to some degree during a wide-area CBRN event. A 2010 report by Argonne National Laboratory presented the relative percentage of vehicle materials for both a 2004 Toyota Prius and a 2004 Ford Taurus. Those percentages are presented in Table 1 [14]. As shown in Table 1, metals, followed by plastics, represent the greatest proportion of the overall material composition. It is assumed that most metal and elastomer materials within a vehicle are found within the vehicle body, chassis, and the numerous engine and exhaust components. Plastics and other materials likely comprise most of the interior components.

Table 1. Breakdown of Materials for Mid-Size Vehicles

Materials	2004 Toyota Prius		2004 Ford Taurus	
	Mass (lb)	%	Mass (lb)	%
Ferrous Metals	1,713	60.6	2,223	70.4
Nonferrous Metals	507	17.9	312	9.9
Plastics	341	12.1	340	10.8
Elastomers	87	3.1	152	4.8
Inorganic Materials	77	2.7	90	2.9
Other	62	2.2	38	1.2
Organic Materials	42	1.5	4	0.1
Vehicle Mass (Less Fluids)	2,829	100.0	3,159	100.0

The identification and material characterization of vehicle components is necessary to inform the selection of appropriate decontamination methods and strategies. As Table 1 illustrates, a broad spectrum of materials exists, and the efficacy of decontamination methods and strategies for various material types will need to be evaluated and considered in the context of the anticipated final disposition of the vehicles (i.e., reuse, recycling, and/or disposal decisions).

3.3 Collecting and Transporting Large Numbers of Inoperable Vehicles

Many challenges were identified from past incidents related to the collection and transport of large numbers of impacted vehicles. Vehicles and vessels may be in various states of operability, damage, and/or contamination level. Historically, there are very few wide-area CBRN incidents to evaluate. Therefore, past experiences and lessons learned from natural disasters serve as a starting point for understanding how, in general, vehicles were collected and managed following a wide-area event.

Within the first month of recovery efforts in response to Hurricane Katrina, Louisiana State Police estimated that more than 200,000 cars were damaged beyond recovery in Louisiana [15]. Vehicular debris included automobiles, trucks, buses, campers, motorcycles, and golf carts. Marine vessels were also problematic and included boats, trailers, and jet skis. For vehicles and vessels, the debris management process consisted of: (1) vehicle pickup; (2) hauling vehicles/vessels (using an appropriate transporter); (3) temporary storage; and (4) transfer to a recycler or release to owner.

Vehicles and marine vessels frequently blocked roads and access points needed by recovery teams. For example, in the Pass Christian area, 350 vehicles and 358 marine vessels were removed as part of the debris removal mission. All vehicles and vessels were towed by commercial towing contractors to designated staging locations. Scrap metal from reduced vehicles and vessels was also recycled [16].

Another challenge relates to the legality of handling vehicles or vehicle debris. Frequently, owners might abandon vehicles if they relocate or due to the amount of damage the vehicle may have suffered. However, private vehicles must be carefully handled as there are often legal processes to follow before an entity can remove or destroy a privately-owned vehicle. Vehicles and vessels that are insured must be documented, and their recovery or loss should be reported to insurers. Titled property such as vehicles and vessels, if authorized for removal, should be taken to a secure storage location managed by the local government [17]. The Solid Waste Association of North America (SWANA) noted some lessons learned from state and local governments related to managing vehicle debris during the response to Hurricane Katrina include [18]:

- Establish multiple staging areas;
- Site vehicle processing close to Port of New Orleans;
- Ensure availability of tow trucks;
- Designate local neighborhoods as staging areas for insurance processing;
- Prioritize material recycling and re-use as a secondary consideration;
- Establish zones for collection and waste processing;
- Ensure viable markets for waste streams are in place;
- Quickly establish tax credits and other financial incentives; and
- Hazardous materials may be handled as Household Hazardous Waste (HHW) or Conditionally Exempt Small Quantity Generator (CESQG) wastes in coordination with State waste management officials.

Additional hazards generally associated with vehicle removal include [19]:

- General heavy equipment operation (tow trucks and cranes);
- Leaking fuels, oils, and battery acid;
- Contact with downed lines and live electrical equipment and other utilities (e.g., gas, water);
- Exposure to contaminated water and/or floodwaters;
- Welding, cutting, and burning;
- Discovery of human or animal remains; and
- Discovery of other unknown chemicals.

Following a natural disaster, the vehicle itself and most of its material components will not likely be hazardous, and other known hazards (e.g., fuels, oils, and battery acid) can be managed, However, following a CBRN incident, contaminated vehicles pose a unique challenge to the response/recovery effort in terms of accessing the vehicle, transporting the vehicle, and managing its decontamination and disposition.

In disaster situations, logistics infrastructure (roads, bridges, warehouses, seaports, airports) are often compromised, thereby complicating distribution and collection activities (routing, travel times). In addition, the dynamics of the situation (e.g., time constraints, vehicle breakdowns, new information on clusters) may require that distribution/collection activities be reprioritized. Therefore, strategies should be agile and able to easily adapt to updated information [12].

3.4 Vehicle Decontamination

As discussed, it is assumed that a large number of vehicles may be contaminated at various levels following a wide-area incident. Vehicle decontamination procedures and methods are needed to guide mass decontamination efforts with consideration given to anticipated end use. As described below, several federal agencies have guidance and procedures in place for vehicle decontamination. However, none of these procedures have been validated and exercised for civilian vehicle decontamination applications, and many may not reasonably be scaled without significant modification. While the procedures discussed below are useful for informing vehicle decontamination procedures, the procedures are designed to return limited numbers of operational assets to a suitable state of readiness as quickly as practicable. Further considerations will be needed for the application or potential adaptation of these procedures in a civilian environment following a wide-area contamination incident affecting many thousands of vehicles.

The U.S. Departments of Defense (DOD) and Agriculture (USDA) have established procedures for the decontamination of vehicles following CBRN events [20], Ebola Virus Disease contamination [21], and animal disease contamination [22]. Foreign governments also have guidance and procedures for vehicle decontamination, including New South Wales (Australia) [23] and the Canadian Department of National Defense (DND).

The DOD procedures for vehicle decontamination (detailed in *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination*) following a CBRN event are comprehensive. In checking for chemical contamination under the DOD procedures, M8 chemical agent detector paper is used. For radiological contamination, a RADIAC detector (for obtaining dose rates) is used. If a vehicle has only isolated areas of contamination, then the M100 Sorbent Decontamination System (SDS) is used to decontaminate those areas. M100 SDS consists of two 0.7-lb packs of reactive sorbent powder, two applicators, a carrying case, and two straps. For more extensive exterior and interior vehicle contamination (i.e., "thorough decontamination"), weathering should be employed first to remove contamination as the need for a thorough decontamination may be eliminated. Additional active decontamination consists of the Detailed Equipment Decontamination (DED) process, which employs a vehicle wash down through a series of stations.

The DED process for chemical and biological contamination is comprised of five stations (Figure 1, [24]) and is intended to return a vehicle to a state of operational readiness as quickly as possible. For radiological contamination, the DED uses all but Station 2. Stations are normally 50 meters apart. A limiting factor is the availability of water as a typical vehicle will require about 500 gallons of water during the process.

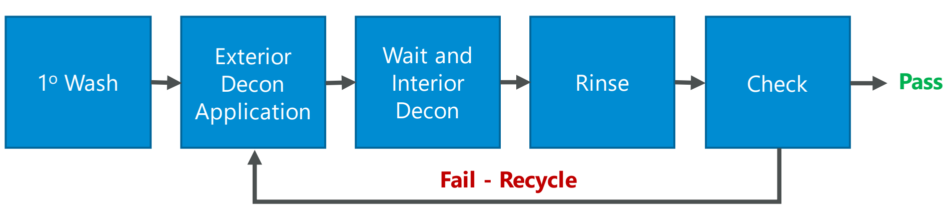

Figure 1. Detailed Equipment Decontamination (DED) Process Diagram

Station 1 is a primary wash where gross contamination and dirt are removed from the vehicle using hot water, cold water, hot or cold soapy water, or steam. The type of wash used can vary by surface type and material and at varying degrees of effectiveness (p. V-20). This station uses approximately 250 gallons of water per vehicle. The runoff from this station should be contained and analyzed to determine if it is contaminated, how it is classified, and from that what the reuse or waste management options may be. This station requires high water pressure systems (M12A1 power-driven decontamination apparatus [PDDA], M17 lightweight decontamination system [LDS], or multipurpose decontamination system [MPDS]) rather than low water volume systems (65-gallon-per-minute [GPM] pumps).

Station 2 applies the decontaminant to the entire vehicle. Super tropical bleach (STB) slurry, STB dry mix (if the temperature is below 0 °F), or another approved decontaminant is applied starting at the top of the vehicle and working toward the undercarriage.

Station 3 ensures the decontaminant is allowed to completely neutralize the chemical agent and is where the interior of the vehicle is decontaminated. A 30-minute contact time is allowed whereby there should be no desorption for most chemical agents. The interior of the vehicle is inspected for liquid contamination and M8 chemical agent detector paper is used to check for chemical contamination.[2] The best decontamination solution for use in the interior of vehicles is a 5 percent solution of high-test hypochlorite (HTH) or STB. All reasonably accessible surfaces are wiped with a rag or sponge soaked in the HTH or STB solution. Once the interior decontamination is complete, covers are placed over the seats and floor of the vehicle. For radiological contamination, a RADIAC detector is used to determine the extent and location of contamination inside the vehicle. If the contamination is greater than 0.33 centigrays (cGy), the interior of the vehicle must be decontaminated using a wet sponge to wipe the interior of the vehicle.[3]

Station 4 is the rinse station where the decontaminant is removed from the vehicle. Water is sprayed over the vehicle from top to bottom including the undercarriage using high water pressure systems (M12A1 PDDA, M17 LDS, or MPDS) or large-volume water pumps (65- and 125-GPM). This station uses approximately 200 gallons of water per vehicle. Plastic or other material (if present) covering the seats and floor is removed and disposed as hazardous waste.[4]

Station 5 is the check station where the vehicle is checked to see if it has a negligible contamination level or if it still has significant contamination remaining. Detection procedures will vary depending on the type of contamination. If significant contamination is found on the vehicle then the vehicle is returned to Station 2 for further chemical decontamination or to Station 1 for further radiological decontamination.

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[2] This DOD procedure may not be applicable in a civilian environment.
[3] This is a DOD action level and may not be applicable in a civilian environment.
[4] This DOD procedure may not be applicable in a civilian environment.

Appendix C of *Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination* contains a detailed matrix of available decontaminants and their preparations, and Appendix D provides a listing of decontamination methods for specific surface types and materials and is based on the type of contaminant.[5]

Recently, the Canadian DND procured six vehicle and personnel CBRN decontamination systems. For vehicles, the decontamination line includes a wash station, decontamination station, and rinse station. Washing and rinsing is performed using high pressure heated water and a mechanism to treat all exterior vehicle surfaces, a single vehicle at a time.

Other commercially developed vehicle decontamination systems are available that employ the same three-stage decontamination process (wash, decontamination, rinse).[6] These systems are designed and constructed to decontaminate a single vehicle at a time and are not expected to be a viable option for mass decontamination operations.

EPA has recognized that recent radiological exercises and contamination events have not evaluated civilian vehicle decontamination, and this remains a significant gap. In response to the TEPCO nuclear accident in Fukushima, Japan, traditional car washing techniques performed on a Japan Atomic Energy Agency (JAEA) radiation detection vehicle did not remove all exterior contamination [1]. This finding was consistent with results from a 2015 joint EPA/Department of Homeland Security (DHS) demonstration event in Columbus, Ohio. Low-tech washing methods failed to remove all surrogate contamination from a vehicle [25].

As evidenced through the literature review, deficiencies exist for validated and exercised approaches for civilian vehicle decontamination, and only very generic guidance for civilian vehicle decontamination of chemical hazards exists. There appear to be opportunities to commercialize decontamination technologies used to remediate agricultural, health, and military facilities, vehicles, and equipment for civilian applications, and to identify, promote and integrate emerging technologies into decontamination approaches for civilian vehicles.

While not unique to chemical contamination events, the re-introduction of contaminants (via desorption or resuspension, etc.) remains an active threat following egress of a vehicle into a clean area or via insufficient decontamination. Adsorption and desorption of chemical agents in vehicles must be considered, and weathering can reduce the exposure risk. Gaps in the current approach to civilian vehicle decontamination include [26]:

- Decontamination objectives, material compatibility, and clearance protocols; and
- A roadmap for decontamination of civilian vehicles that focuses on vehicle conditions of use, including:
    - Vehicle functions, characteristics, and passenger populations;

[5] These DOD procedures, available decontaminants, and decontamination methods may not be applicable in a civilian environment.
[6] For example, the ESCORPIO 300 developed by Indra Company. https://www.indracompany.com/sites/default/files/Escorpio_300_v3.pdf. Last accessed June 25, 2018.

- Risk-based and value-based guidelines for decontamination objectives; and
- Leveraging related existing practices for vehicle cleaning and maintenance, and revision for chemical hazard decontamination.

Existing comprehensive vehicle decontamination procedures, especially those developed by DOD, are focused on returning operational assets to a suitable state of readiness as quickly as practicable. Following wide-area contamination events, EPA will also need to consider the ultimate vehicle end-use when evaluating available and appropriate decontamination procedures.

3.5 Vehicle Reuse, Recycling, and Disposal

General considerations regarding vehicle reuse following decontamination, recycling, and/or disposal include: removal of oils, gasoline, diesel fuel, antifreeze, and minerals prior to further processing vehicles for recycling, salvage, or destruction [17]. Additional information related to this topic is discussed in Sections 3.3 and 3.4.

3.6 Waste Management

Tens of thousands of vehicles and vessels were abandoned in the New Orleans area after Hurricane Katrina, including the associated fuel, motor oil, batteries, and tires. While vehicles and vessels can generally be recycled, gas tanks, mercury switches, batteries, and tires should be removed and managed separately [27]. Typically, auto-related wastes such as motor oil, gasoline, whole tires, and batteries are prohibited from municipal solid waste (MSW) landfills and preferably are recycled [28]. As part of the debris management process after Hurricane Katrina, tires were segregated and transported to recycling facilities. At least 42.53 metric tons of tires were recycled from Harrison County and documentation shows that, collectively, 162.6 metric tons of tires were recycled [16].

Whole car and truck bodies can be handled through establishment of additional processing areas. Non-hazardous household or consumer auto-type wastes can be handled safely enough through regular conventional waste collection. Automobile-related materials such as gasoline/diesel fuel, lubricating fluids, and cleaning agents, may be handled as household hazardous wastes (HHWs) or conditionally exempt small quantity generator (CESQG) wastes with appropriate coordination with state and local waste management officials. Most states have banned the disposal of lead-acid batteries, used motor oil, and whole tires from MSW landfills. Therefore, these items, as well as any other items that have been banned by the state where the MSW landfill is located, must be collected and managed separately [18].

4 VEHICLE WASTE MANAGEMENT AND DISPOSAL WORKSHOP

EPA’s National Homeland Security Research Center coordinated a one-day workshop on Vehicle Waste Management and Disposal, which was held on Monday, November 13, 2017, at EPA’s Potomac Yard South located in Arlington, Virginia. The workshop brought together officials from federal, state, and local governments, as well as researchers and experts from the automotive recycling, scrap recycling, waste management, and insurance industries, to discuss research, operational, and waste management considerations related to the characterization, management, reuse/resale, recycling, and disposal of vehicles following a wide-area man-made or natural incident. The morning session featured presentations on the latest vehicle decontamination and waste management Research and Development (R&D) efforts and lessons learned from Hurricane Sandy and the Fukushima nuclear incident. In the afternoon session, participants discussed decision-making processes to identify information gaps and policy implications associated with managing, decontaminating, and disposing of a large number of vehicles.

Many of the observations discussed are consistent with the challenges that were identified in the literature review. The workshop participants identified numerous information needs, gaps, and areas for future investigation and research related to vehicle management following wide-area incidents. The following sections describe those findings and observations.

4.1 General Observations

The following general observations were noted:

- Plans and procedures addressing how to label and track biologically, chemically, and radiologically contaminated vehicles, like tracking flooded vehicles, to keep contaminated vehicles out of the fleet and resale markets and how to designate and/or label effectively decontaminated vehicles may be needed.
- Laws governing vehicle titling are currently controlled at the state level, and there is no mechanism to designate a CBRN-contaminated vehicle in the titling process.
- Adjustments to cleanup level goals based on ultimate end use (e.g., disposal vs. reoccupation) should be considered.
- Remote sensing capability may be critical for determining situational awareness and for estimating the number of vehicles potentially contaminated by a CBRN incident. Potentially useful data sources may include: the U.S. Geological Survey's (USGS's) Earth Explorer Website and Orbital Insight -- Digital Globe's Big Data Archive, as well as other sources maintained by USGS's Land Remote Sensing Program.
- Municipalities and local governments might consider identifying, pre-qualifying and/or having pre-established contracts with heavy duty towing companies or in-house towing and storage resources well ahead of a potential incident.
- Coastal states/cities should plan for the removal of waste/debris from navigable waterways.
- Logistical planning and routing for large cities may be driven by physical constraints (e.g., truck clearance (top/sides), weight, sensitive areas).
- Enhance the transparency of emergency response permitting by specifying what permits authorize and to whom access should be granted across all cleanup and recovery phases.

4.2 Operational Considerations

Operational considerations include the logistics of transporting contaminated and/or damaged vehicles to a staging or storage site and/or disposal location. Considerations to address situations where damage/contamination to the local response vehicle fleet may require outside support in the immediately affected area is necessary. Following Hurricane Sandy in October 2012, vehicle removal and towing operations lasted for two months, though final disposal went on until May 2013. Initial recovery efforts required that 3,500 vehicles and 72 boats be removed since they were interfering with response operations.

Lessons learned from previous natural disaster response efforts can inform planning efforts and increase preparedness. Specifically:

- There are a limited number of responders with a Commercial Driver's License (CDL) license, and those that have one may not have the required health and safety training to operate in such situations or may have limited availability following a wide-area incident.
- City agencies with debris-clearing expertise typically may not be able to operate in a CBRN-type environment without appropriate worker health and safety training and potentially the use of personal protective equipment including respiratory protection. Additionally, stand-by contracts may not be realistic for 'hot zone' operations, and new contracts with the private sector may be required for many, if not most, cleanup operations after the emergency phase of an incident.
- Cities and states may need to plan for a 24/7 debris task force.
- Protocols for dealing with vehicle-driven events are critical, and the pre-identification of staging areas cannot be underemphasized. The shorter the distance waste needs to be transported, the quicker the recovery and at less cost.
- For large urban areas, space is at a premium (i.e., there is very little room to stage vehicles and other equipment). It is recommended that staging areas for vehicles and other property be kept close to owners.
- Leaching of contaminants from temporary storage sites is a concern.
- There will be intense pressure to re-open locations of high importance. Planning is greatly improved if a strategy/destination for the ultimate management of contaminated and decontaminated vehicles exists.
- Management of a large waste stream like vehicles involves planning to quantify estimated numbers of vehicles that will need to be managed and estimating how many vehicles can reasonably be managed per unit of time to inform recovery timelines.
- Effective "Pre-Incident Waste Management Planning" can help prevent it from becoming the "critical path" for reoccupying contaminated areas.

4.3 Decontamination

Very few vehicle-specific technologies and/or methods exist for decontaminating large quantities of vehicles in a timely and effective manner. Technologies and methods that are employed in other situations/applications (e.g., U.S. DOD, USDA, etc.) should serve as a starting point, where applicable procedures can be adapted and enhanced for CBRN scenarios. For example, important insights can be gained by examining technologies and procedures developed by USDA to clean contaminated farm vehicles and DOD to decontaminate military vehicles/planes.

Vehicle decontamination strategies developed should be holistic and address precursor steps and timeliness among other considerations. Methods should consider procedures for washing as a prior step to decontamination to both aid in capturing a significant portion of agent, as well as increasing the efficacy of decontamination methods by removing organic materials (i.e., dirt) that may compromise efficacy.

Evaluating how agencies handle decontamination of vehicles contaminated with methamphetamines and fentanyl could also provide additional insights, particularly impacts associated with further processing vehicle components for recycling/disposal. Vehicle components with high value in secondary parts and equipment markets may be prioritized when establishing decontamination priorities and developing corresponding methods (e.g., industry indicated transmissions and engines are the two most important parts). In addition, components that are known to be more problematic for decontamination may be identified and collection strategies may specify segregation for disposal rather than attempts at decontamination (e.g., tires and most rubber-based parts such as gaskets, seals, etc.).

Decontamination methods may also address upcoming or innovative vehicle design technologies that might promote or introduce additional hazards during collection or decontamination such as hybrid or battery-operated vehicles. Batteries found in these vehicles may be susceptible to fire or other hazards following increased temperatures.

4.4 Waste Management

There is general agreement that it is necessary to: 1) first, characterize the estimated contamination; and 2) quantify the number (mass/volume) of contaminated vehicles that will need to be managed. The magnitude of both parameters drives waste management options. The nature of the contamination may determine whether and where to decontaminate vehicles prior to storage for further processing (recycling/disposal). If recycling proves to be a viable option, consideration may be given to how mature local recycling programs are. EPA-reviewed case studies indicate a correlation between maturity of existing programs and rapid scale-up potential. Logistical constraints (e.g., lack of space, routes, etc.) may also impact locating and establishing staging and storage areas for processing contaminated vehicles to avoid spreading contamination.

A large municipality with experience in managing vehicles resulting from a natural disaster suggested that the short-term priority be on immediate clearance where disabled/abandoned vehicles are moved for first-response roadway access due to very limited space on streets. Doing so adds an intermediate step but is necessary not to impede recovery efforts. For long-term vehicle management, there is a need to identify temporary storage space for staging before eventual transportation to disposal site(s). Challenges of long-term management include: availability of open space for staging and/or treating large volumes of materials (many large areas are privately owned, in use, and/or located in a yet-to-be impacted community) and the potential to create a secondary contamination area if transportation is routed through residential areas.

4.5 Industry Considerations

Representatives from the vehicle and scrap recycling industries provided valuable and insightful perspectives and suggested several recommendations to consider when managing contaminated vehicles. Specific topics discussed that could be explored further include:

- Vehicle Life Cycle – Document and describe the life cycle of vehicle and parts from normal usage through end of life, including: resale, recycling, and parting out, to better understand the relationship among key stakeholders and illustrate the potential implication of key decision points and thresholds.

- Vehicle and Parts Tracking – The recycling industry maintains very elaborate parts inventory/tracking systems and relies on Original Equipment Manufacturer (OEM) part numbers for part history. It was suggested that leveraging block chain technology in tracking mechanisms could be very impactful in managing waste streams to the end of life.

- *De Minimis* Levels – Determine whether *de minimis* levels for radioactively-contaminated vehicles and vehicle parts can be established for components contaminated with very low levels to avoid rejection by radiation detection equipment in place at vehicle processing plants.

- Waste Classification – The automotive recycling and scrap recycling industries are not currently permitted to handle or move materials classified as hazardous waste. The classification of materials will dictate at what point stakeholders can become involved.

- Declaration of Clean – Automotive recycling and scrap recycling facilities may not accept contaminated vehicles or parts. There could be significant impacts to these recycling industries and their downstream customers, as well as their waste disposal facilities, if they were to accept contaminated vehicles, potentially jeopardizing a national inventory that could put workers and consumers at risk.

In addition to the physical handling of vehicles, important issues related to insured personal property were discussed. Specifically, a CBRN event brings new challenges related to how the insurance industry would handle CBRN-contaminated vehicles for salvage, reuse, and resale. Current business models are linked to the insurance company's ability to sell vehicle components in the secondary marketplace. Massive net losses would be expected if total loss vehicles cannot be further processed and sold in the secondary marketplace to recoup portions of total loss payments made to the insured.

In addition, insurance organizations would still likely require access or a method for gathering information from impacted vehicles. These activities are complicated in a CBRN event where providing physical access to vehicles may not be feasible. Therefore, alternative methods to collect similar information may need to be established.

Another complicating matter is handling uninsured vehicles that are abandoned in place. Past incidents have shown that many people do not want their uninsured vehicles and vessels back, and the burden for removal and disposal falls on municipalities. Preparedness plans should address such scenarios.

Lastly, nefarious sellers and parts distributors might take advantage of state law/procedures to clear (i.e., title wash) questionable vehicles as evidenced in recent hurricanes and large flooding events. A need for policies that address interstate movement of vehicles with "dirty titles" (particularly with CBRN) was identified.

5 DISCUSSION AND IDENTIFICATION OF RESEARCH NEEDS

Large numbers of vehicles will be damaged and/or contaminated to varying degrees following a wide-area CBRN incident. Additionally, numerous vehicles may be abandoned within the impacted area. The logistics and resource demand to gather, transport, store, decontaminate, recycle, or dispose of these vehicles may overwhelm local, state, and federal recovery efforts. Because of this, research efforts to reduce the cost and time associated with assessing, collecting, decontaminating, and recycling or disposing of contaminated vehicles resulting from a wide-area incident are necessary.

Results of the literature review and insights gained through the stakeholder workshop validate that while there are many valuable lessons learned from natural disaster responses and work by other federal agencies to address decontamination of valuable vehicle assets to leverage, many questions remain unanswered. Additional research is needed to gain a full appreciation of the impact that managing vehicles from a wide-area CBRN event may have, as well as guidance and support to aid in the resolution of decontamination and waste management issues. Table 2 below presents an overview of outstanding needs related to scientific/technology development, operational considerations, and policy guidance for several key topics that are important for managing vehicles from a wide-area event. A qualitative magnitude of needs was identified based on an analysis of the literature review results and input obtained from workshop participants.

Table 2. Matrix of Information and Needs

Topic	Information/Needs Category		
	Scientific/ Technology	**Operational**	**Policy**
Vehicle Identification			N/A
Identification of Vehicle Materials Contamination			
Vehicle Decontamination Technologies			N/A
Reuse, Recycling, and Disposal Criteria	N/A		
Private Industry Considerations	N/A		
Communication and Transparency	N/A		

Red = Greatest need; Yellow = Moderate need; N/A = Not applicable

Conducting additional research to understand these key issues will further preparedness efforts for handling large volumes of vehicles resulting from a wide-area event. Below is a summary of specific needs and considerations for each topic that were identified through this study.

1. Vehicle Identification
    - Develop methods to identify vehicles, including: vehicle counts, surface distribution, volume/mass of materials, and vehicle type.
    - Explore methods using remote sensing, tax/property records, and pre-existing modeling efforts.
    - Increase capacity for collaboration between industry and intelligence agencies to develop methods and strategies for locating vehicles via remote sensing.

2. Identification of Vehicle Materials Contamination
    - Develop metrics to identify whether a vehicle was contaminated in a wide-area CBRN release scenario. Address complications resulting from a covert CBRN release where a large number of vehicles might interact with the contaminant and egress the impacted area resulting in further spread of the contaminant.
    - Understand impact of vehicle state when subjected to contamination.
    - Identify quantitative information defining vehicle characteristics such as number of parts, material composition, distribution of materials, hazardous materials specific to vehicle type (i.e., sedan, truck, etc.).
    - Assess effectiveness of passenger cabin air filters to filter contaminant.
    - Understand the impact of contaminants on internal components of internal combustion engines.

3. Vehicle Decontamination Technologies
    - Determine how existing decontamination technologies employed by DOD or USDA might be leveraged to decontaminate privately owned civilian vehicles.
    - Develop a report/compendium summarizing viable decontamination methods (i.e., method summary, metrics, etc.) that are applicable to vehicles, vessels, planes, rail, and other transportation systems.
    - Develop practical technologies for mass decontamination of civilian vehicles.

4. Reuse, Recycling, and Disposal Criteria
    - Develop criteria for determining whether a vehicle (or vehicle type) is a candidate for decontamination/reuse or recycling/disposal depending on type of contamination and end use.
    - Establish *de minimis* acceptance levels and opportunities for detecting contamination.

5. Private Industry Considerations
    - Understand how private industry processes end-of-life vehicles and the full life cycle of recycled vehicle components and materials and vehicle waste.
    - Identify vehicle processing, recycling and waste management facilities.
    - Develop potential waste volume reduction methods.

- Understand impact on depollution of end-of-life vehicles.
- Develop guidelines to reduce worker exposure when managing and disposing of vehicle waste.
- Understand the business economics of secondary markets for recycled vehicle components and materials and issues related to resale/reuse of properly decontaminated vehicles.

6. Communication and Transparency
    - Improve communication and transparency with respect to identifying sources and venues for communicating between various stakeholders, as well as strategies for encouraging communication between federal agencies, state and local entities, and industry. Enhanced communication capabilities between government and industry might improve response and recovery capabilities. Transparency between the government and the public is critical, especially where private property is involved.

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APPENDIX A. LITERATURE SEARCH SOURCE CRITERIA AND KEYWORDS

1. Sources

Sources that were prioritized were those sources expected to contain the most relevant information and meet established quality standards, including:

- Information from sources that are considered recognized, reputable, and credible;
- Information sources from nationally and internationally recognized scientific, technical, or response organizations;
- Information from written text, publications, reports, subject-matter experts, and internet sites;
- Information sources included:
    - Peer-reviewed journals, scientific manuals, and other scientific publications;
    - Federal, state, and local agency web sites or publications;
    - University web sites or publications;
    - Professional society and organization web sites or publications;
    - Recognized international scientific/environmental organizations;
    - International government web sites and publications;
    - Military web sites and publications;
    - Industry providers of equipment and materials (i.e., vendors); and
    - Conference proceedings.

Other relevant sources included articles, reports, guidance documents, case studies, conference proceedings, national exercise materials and conclusions, after action reports, and EPA web sources that have sought to compile response and recovery guidance.

2. Search Criteria

A preliminary list of proposed search terms was developed (see Figure 1). To further focus the search, we consulted with subject matter experts (SMEs) who have expertise in vehicle decontamination and disposal issues to refine targeted search criteria and identify relevant data sources. As illustrated in Figure A-1, the primary and secondary terms identified aim to maximize retrieval of information related to:

- Identifying and estimating the number and type of vehicles present in a specified geographical area;
- Assessing whether a vehicle is a candidate for decontamination/reuse or recycling/disposal;
- Retrieving and transporting large numbers of inoperable vehicles (contaminated and non-contaminated); and
- Mass decontamination or disposal of large numbers of vehicles (both on- and off-site).

Chemical, biological radiological, nuclear, anthrax, CWA, TIC, CBRN, cesium-137, Cs-137, strontium-90, Sr-90, Bacillus anthracis, disaster, natural disaster, hurricane, earthquake, tornado, flood, Sandy, Katrina, Ike, Andrew, Wilma, Ivan, Irene
AND
Waste management, debris management, waste, debris, disposal, size reduction, scrap, recycling, claim, identification, insurance, transport, storage, treating, decontamination, treatment, decontamination
AND
Car, truck, automobile, bus, motor, boat, tire, vessel, ship, junk car, transportation, battery, cargo, locomotives, railroad cars, gas, freight cars, freight, 18-wheeler, semi, trailer truck

Figure A-1. Preliminary Search Terms

After the initial results were obtained, the literature review search strategy and keywords were refined as shown in Figure A-2:

ProQuest:
all(disaster OR natural disaster OR hurricane OR earthquake OR tornado OR flood OR Sandy OR Katrina OR Ike OR Andrew OR Wilma OR Ivan OR Irene OR Fukushima OR nuclear) AND all(Car OR truck OR automobile OR bus OR motor OR boat OR tire OR vessel OR ship OR "junk car" OR battery OR cargo OR locomotives OR "railroad cars" OR "freight cars" OR freight OR "18-wheeler" OR "trailer truck") AND all("Waste management" OR "debris management" OR waste OR debris)

Web of Science:
TS=(disaster OR natural disaster OR hurricane OR earthquake OR tornado OR flood OR Sandy OR Katrina OR Ike OR Andrew OR Wilma OR Ivan OR Irene OR Fukushima OR nuclear) AND TS=(Car OR truck OR automobile OR bus OR motor OR boat OR tire OR vessel OR ship OR "junk car" OR battery OR cargo OR locomotives OR "railroad cars" OR "freight cars" OR freight OR "18-wheeler" OR "trailer truck") AND TS=("Waste management" OR "debris management" OR waste OR debris)

Figure A-2. Refined Search Terms

APPENDIX B. LITERATURE REVIEW SCORING CRITERIA

To standardize the review process, a *Literature Assessment Questionnaire* was used to document the overall quality of literature. The *Literature Assessment Questionnaire* was developed using Google Forms, a secure online tool for publishing and conducting surveys. After the reviewer completed the form, the reviewer's evaluation was stored in a spreadsheet to document the assessment. The resulting spreadsheet was used to summarize key research findings.

1. General Observations

The relevancy to key questions, such as those listed below, were observed when assessing and summarizing articles:

- Identifying and estimating the number and type of vehicles present in a specified geographical area;
- Assessing whether a vehicle is a candidate for decontamination/reuse or recycling/disposal;
- Retrieving and transporting large numbers of inoperable vehicles (contaminated and non-contaminated);
- Mass decontamination or disposal of large numbers of vehicles (both on- and off-site);
- Impact of vehicle being on/off when subjected to contamination;
- Impact of vehicle windows being open/closed when subjected to contamination;
- Effectiveness of passenger cabin air filters to filter contaminants; and
- Impact of contaminants on internal components of internal combustion engines.

2. Literature Assessment

Relevant articles were defined as those crucial to answering research questions pertaining to handling recycling and disposal of vehicles following a wide-area event. Each article was evaluated and scored using a Likert scale (i.e., (1) Poor – (5) Excellent) based on the following seven criteria: applicability and utility, soundness, clarity and completeness, uncertainty and variability, evaluation and review, focus, and verity:

- ***Utility:*** The extent to which the information is relevant for the intended use.
- ***Clarity and Completeness:*** The degree of clarity and completeness with which the data, assumptions, methods, QA, and analyses employed to generate the information are documented.
- ***Uncertainty and Variability:*** The extent to which variability and uncertainty (quantitative and qualitative) related to results, procedures, measures, methods, or models are evaluated and characterized.
- ***Soundness****:* The extent to which the scientific and technical procedures, measures, methods, or models employed to generate the information is reasonable for, and consistent with, the intended application.
- ***Evaluation and Review:*** The extent of independent verification, validation, and peer review of the information or of the procedures, measures, methods, or models.

- ***Focus:*** The extent to which the work not only addresses the area of inquiry under consideration but also contributes to its understanding; it is germane to the issue at hand.
- ***Verity:*** The extent to which data are consistent with accepted knowledge in the field or, if not, the new or varying data are explained within the work. The degree to which data fit within the context of the literature and are intellectually honest and authentic.

Table B-1 shows the rubric for tallying articles.

Table B-1. Rubric for Tallying Articles

Overall Rating	Description
35—40	High quality article. Article shall be recorded and summarized accordingly.
25—34	Moderately high-quality article. Article shall be recorded and summarized accordingly.
15—24	Lower quality article but with some useful information. Article shall be recorded and summarized accordingly.
<15	Unacceptable/Do not use

Articles that scored higher or equal to 15 were deemed at least moderately relevant and were recorded and summarized accordingly; however, articles scoring less than 15 were discarded.

APPENDIX C. VEHICLE WASTE MANAGEMENT AND DISPOSAL WORKSHOP AGENDA

United States
Environmental Protection Agency
Office of Research and Development

Vehicle Waste Management and Disposal Workshop

U.S. Environmental Protection Agency
Potomac Yard South
2777 Crystal Drive, Room S1204/06
Arlington, VA 22202

November 13, 2017

Agenda

MONDAY, NOVEMBER 13, 2017

8:30 am **Check-in/Security**

9:00 am **Introductions** .... *Timothy Boe, EPA*

9:10 am **National Homeland Security Research Center (NHSRC) Overview** *Paul Lemieux, EPA*

9:30 am **Management and Disposal of Vehicles** .... *Colin Hayes, ERG*

9:50 am **National Civil Applications** .... *Daniel Opstal, USGS*

10:00 am **Vehicle Decontamination Research** .... *Timothy Boe, EPA*

- Vehicle Decontamination Studies by EPA
  - *Lukas Oudejans, EPA*
- Overview of Agriculture Emergency Response Decon Methods for Vehicles
  - *Lori Miller, USDA*
- Hot, Humid Air Decontamination of a C-130 Aircraft Contaminated with B. anthracis Surrogates
  - *Tony Buhr, DoD*
- Vehicle Decontamination Methods for Water Soluble and Inert Radioactive Contaminations
  - *Michael Kaminski, Argonne National Lab*

11:30 am LUNCH

MONDAY, NOVEMBER 13, 2017 (continued)

12:30 pm **Operational Considerations** .... *Worth Calfee, EPA*

- Hurricane Sandy: Removal of Damaged Vehicles and Vessels
  - *Keith Kerman, Stanley John, NYC DCAS*
- Considerations for Managing Wide-Area Vehicle Contamination
  - *Andrew Mark, Eliot Calhoun, NYC OEM*
- Fukushima Remediation Observations
  - *Sang Don Lee, EPA*

1:45 pm **Waste Management**.. *Paul Lemieux, EPA*

- Pre-Incident All-Hazards Waste Management Planning for Wide Area Incidents
  - *Mario Ierardi, EPA*
- Tools and Models for Decontamination and Waste Management
  - *Paul Lemieux/Timothy Boe, EPA*
- Large Volume Waste Transport
  - *Molly Rodgers, ERG*

2:45 pm BREAK

3:00 pm **Industry Perspective** .... *Lukas Oudejans, EPA*

- Vehicle Insurance Considerations
  - *James Whittle, American Insurance Association*
- Automotive Disposal and Recycling
  - *Michael Wilson, Automotive Recyclers Association*
  - *David Wagger, Institute of Scrap Recycling Industries*

3:40 pm **Topic Discussion** .... *Sang Don Lee/Timothy Boe, EPA*

4:20 pm **Parting Thoughts** .... *Timothy Boe, EPA*

4:30 pm ADJOURN

EPA
United States
Environmental Protection
Agency

PRESORTED STANDARD
POSTAGE & FEES PAID
EPA
PERMIT NO. G-35

Office of Research and Development (8101R)
Washington, DC 20460

Official Business
Penalty for Private Use
$300