
Type B
Accident Investigation Board Report
On the February 25, 2009
Abdominal Injury
To a Passenger in an Electric Cart
Waste Isolation Pilot Plant
Carlsbad, New Mexico



April 2009

U.S. Department of Energy
Carlsbad Field Office

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**U.S. Department of Energy
Carlsbad Field Office**

This report is a product of an Accident Investigation Board appointed by David C. Moody, Manager, Carlsbad Field Office, Department of Energy, on March 4, 2009.

The Board was appointed to perform a Type B Investigation of this accident and to prepare an investigation report in accordance with DOE Order 225.1A, *Accident Investigations*.

The discussion of facts, as determined by the Board, and the views expressed in this report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

On March 4, 2009, I established a Type B Accident Investigation Board to investigate the injury of a waste handler at the Waste Isolation Pilot Plant located near Carlsbad, New Mexico.

The Board's responsibilities have been completed with respect to this investigation. The analysis process; identification of direct, contributing and root causes; and development of Judgments of Need during the investigation were done in accordance with DOE Order 225.1A, *Accident Investigations*.

I accept the findings of the Board and authorize the release of this report for general distribution.

A handwritten signature in black ink, appearing to read "David C. Moody". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

David C. Moody
Manager
Carlsbad Field Office

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TABLE OF CONTENTS

Acronyms	ix
I. EXECUTIVE SUMMARY	1
A. Introduction	1
B. Accident Description.....	1
C. Direct, Contributing, and Root Causes	1
D. Conclusions and Judgments of Need	2
II. INTRODUCTION	5
A. Appointment.....	5
B. Facility Description	5
C. Scope, Purpose and Methodology.....	8
III. FACTS AND BOARD CONCLUSIONS	9
A. Background	9
Waste Handling.....	9
B. Accident Chronology	11
Emergency Response	15
Hospitalization	16
C. WTS Occurrence Reporting and Processing System Evaluation.....	16
D. Electric Carts.....	19
Spotters Use of Electric Carts	22
Post-accident Electric Cart Stand-down.....	23
Electric Cart Testing	24
Maintenance	25
Electric Cart Action Requests	25
Vehicle Safety Program	26
Job Hazard Analysis.....	26
E. Family Day.....	27
F. DOE Oversight.....	28
G. Contractor Oversight.....	28
H. Previous Incidents	29
Vehicle Incidents.....	29
Occurrence Reporting	30
2004 Type B Accident Investigation.....	30
IV. ANALYSIS.....	31
A. Causal Factor Analysis.....	31
Barrier Analysis	31
Change Analysis.....	31
Events and Causal Factor Analysis	32
Root Cause Analysis	32
B. Requirements Verification Analysis	33

C.	Integrated Safety Management System.....	33
	Define the Work.....	34
	Analyze the Hazards	34
	Develop and Implement Controls	35
	Perform Work Safely	35
	Feedback and Improvement	35
V.	CONCLUSIONS AND JUDGMENTS OF NEED	37
VI.	BOARD MEMBERS, ADVISORS, AND STAFF	41
	Appendix A – ORPS Report of the Accident	43
	Appendix B – Type B Investigation Board Appointment Memorandum.....	53
	Appendix C – Barrier Analysis.....	53
	Appendix D – Change Analysis.....	61
	Appendix E – Events and Causal Factors Chart	67

LIST OF FIGURES

Figure 1:	WIPP Operations.....	6
Figure 2:	WIPP Surface Facilities.....	7
Figure 3:	Schematic of the Accident Scene	13
Figure 4:	Seat Deflection	14
Figure 5:	Shirt Worn by Injured Worker (cut/torn as part of primary medical care)	14
Figure 6:	Schematic of Passenger’s Injuries.....	17
Figure 7:	Taylor-Dunn Cart Involved in Accident (showing angle related to trailer).....	19
Figure 8:	Taylor-Dunn Cart Involved in Accident (from the front of the trailer).....	20
Figure 9:	Cart Accelerator Pedal.....	21
Figure 10:	Integrated Safety Management System Steps for Use of Electric Carts	34

Acronyms

CBFO	Carlsbad Field Office
CH	contact handled
DOE	Department of Energy
JHA	Job Hazard Analysis
RH	remote handled
TRU	transuranic
TRUDock	Transuranic Waste Handling Dock
TRUPACT	Transuranic Package Transporter
WIPP	Waste Isolation Pilot Plant
WTS	Washington TRU Solutions, LLC

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I. EXECUTIVE SUMMARY

A. Introduction

A Type B Accident Investigation Board was established to review an accident that resulted in an abdominal injury to a passenger in an electric cart at the U.S. Department of Energy Waste Isolation Pilot Plant.

B. Accident Description

The accident occurred at approximately 8:30 a.m. on February 25, 2009, at the Waste Isolation Pilot Plant. A Washington TRU Solutions LLC (WTS) employee was pinned between the light bar of a TRUPACT trailer and the front seat of an electric cart.

The injured employee was transported to the medical center in Carlsbad, NM, and after initial examination was airlifted to the University Medical Center in Lubbock, TX, for treatment of a lacerated liver. The injured employee remained in intensive care for six days before being released, and is recovering at home. The injured employee is currently under the care of a liver specialist and is also undergoing physical therapy for a shoulder injury that resulted from the accident.

C. Direct, Contributing, and Root Causes

The direct cause of the accident was the electric cart moving under the TRUPACT trailer, resulting in the employee being pinned between the TRUPACT trailer and the front seat of the electric cart.

The contributing causes of the accident were:

- A Job Hazard Analysis was not performed for electric cart use on the surface.
- Training was not formal or complete.
- Formal inspections of electric carts were not required.
- Previously identified issues with the accelerator pedal activation were not communicated.
- Effectiveness of past corrective actions, including vehicle issues, was not evaluated.
- Oversight of vehicular safety has not been conducted by WTS or the Carlsbad Field Office (CBFO).
- Family Day (term used for Wednesdays when both Crews A and B are onsite) resulted in unrecognized safety concerns.

The Board determined that the root causes of this incident were:

- The designed location of the electric cart acceleration pedal allowed a front seat passenger to engage the accelerator.
- Maintenance of electric carts did not meet the manufacturer's recommendation.
- Because WTS determined that the electric cart activity was low-risk and short-term, no hazard analysis was performed, controls were not implemented, and there was a lack of oversight. The Board determined this to be a systemic root cause. A systemic root cause is a deficiency in a management system that, if corrected, would prevent the occurrence of a class of accidents, not just those associated with electric carts.

D. Conclusions and Judgments of Need

Conclusions	Judgments of Need
<p>The designed location of the electric cart acceleration pedal contributed to the accident.</p>	<p>WTS needs to install the manufacturer's approved retrofit for the electric cart accelerator to prevent inadvertent engagement by the passenger.</p>
<p>Maintenance of the electric carts did not include the periodic drive chain adjustment, as well as the semi-annual and annual maintenance items established by the manufacturer.</p> <p>The combination of the accelerator being depressed and the existing conditions of Electric Cart 75-C-136 (loose drive chain and worn brake linings) resulted in an override of the braking system.</p>	<p>WTS needs to incorporate and implement the manufacturer's recommendations in the maintenance and servicing of the electric carts.</p>
<p>A Job Hazard Analysis has not been performed for surface electric cart use and, as a result, the appropriate controls were not implemented.</p> <p>Spotter activities were not analyzed for the hazards associated with the task to ensure appropriate controls were implemented, and were performed for some 34 months past the WTS documented endpoint.</p> <p>Overall implementation of Integrated Safety Management Systems for the use of electric carts was insufficient.</p>	<p>WTS needs to enhance its job hazard process to analyze task-level activities based on a formal risk-based approach, as a part of its Integrated Safety Management System program.</p> <p>WTS needs to evaluate the continued need for the spotter activities. (This Judgment of Need is consistent with the WTS recommendation from its initial investigation.)</p>
<p>The training of workers in electric cart use is not provided by the Training Department and is not part of the Waste Handling Technician's Qualification Card.</p> <p>The qualifications for electric cart drivers as defined in ANSI B56.8-2006 are not incorporated in the Vehicle Safety Program.</p>	<p>WTS needs to establish a formal training and qualification process for electric cart operators to meet the manufacturer's and ANSI B56.8-2006 requirements.</p>
<p>The WTS Vehicle Safety Program did not incorporate the needed requirements for surface use of the electric carts, similar to those developed for underground use.</p> <p>The pre-operation and/or pre-use inspections of electric carts were not performed consistently.</p> <p>A Job Hazard Analysis has not been performed for surface electric cart use and, as a result, the appropriate controls were not implemented.</p> <p>Assessments of vehicle safety have not been a part of the WTS oversight systems.</p>	<p>WTS needs to improve the Vehicle Safety Program to include information from 10 CFR 851, the manufacturer's requirements, ANSI B56.8-2006, and other related standards in establishing the onsite requirements for inspection and the resulting procedures.</p>
<p>Prior knowledge of the accelerator pedal should have been identified as a near miss so that corrective actions could be addressed.</p>	<p>WTS needs to provide and continue to reinforce the expectation to report routine safety occurrences through the WIPP Form, and close call program.</p>

Conclusions	Judgments of Need
<p>Family Day creates additional tasking issues, supervisory challenges, and unrecognized safety concerns when all the workers are present.</p>	<p>WTS needs to evaluate the effects of Family Day on work activities.</p>
<p>WTS oversight has not been extended to the safety and health programs to establish that they include the technical requirements for the work activities and to determine effective implementation of requirements at the worker task level.</p> <p>WTS implementation of corrective actions from past incidents and assessments has not been fully reviewed to determine if the corrective actions were effective and sustainable to preclude recurrence.</p> <p>Assessments of vehicle safety have not been a part of the WTS oversight systems.</p>	<p>WTS needs to enhance its oversight program to meet the contractor requirements documented in DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>, to ensure that completed corrective actions are effective and sustainable.</p>
<p>CBFO has not effectively ensured that the WTS has a credible, rigorous, and robust oversight program as outlined in DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>.</p> <p>Assessments of vehicle safety have not been a part of the CBFO oversight systems.</p>	<p>CBFO needs to improve its contractor oversight program to ensure that WTS meets DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>.</p>
<p>The Board concludes that the overall emergency response was timely, proficient, and executed in an exemplary manner.</p>	<p>None</p>
<p>WTS site readiness and accident scene preservation generally met the intent of DOE O 225.1A, <i>Accident Investigations</i>.</p>	<p>None</p>

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II. INTRODUCTION

A. Appointment

On February 25, 2009, at approximately 8:30 am, a WTS employee participating in a TRUPACT trailer spotter activity at the Waste Isolation Pilot Plant (WIPP) site was pinned between a TRUPACT trailer and the front seat of an electric cart. The injured worker was hospitalized for 6 days in the intensive care unit and was released March 3, 2009. The occurrence report for this accident is provided in Appendix A.

On March 4, 2009, David C. Moody, Manager of the Carlsbad Field Office (CBFO), appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 255.1A, *Accident Investigations*. A potential conflict of interest with one Board Member was identified on March 10, 2009, and a new Board Member was assigned. In addition, the Board added a technical advisor from Sandia National Laboratories. The revised appointment memorandum was issued on March 12, 2009 (Appendix B).

B. Facility Description

The United States Department of Energy (DOE) was authorized by Public Law 96-164, Department of Energy National Nuclear Security and Military Applications of Nuclear Energy Authorization Act of 1980, to provide a research and development facility for demonstrating the safe, permanent disposal of transuranic (TRU) wastes from national defense activities and programs of the United States exempted from regulations by the U.S. Nuclear Regulatory Commission. The WIPP, located in southeastern New Mexico near Carlsbad, was constructed to determine the efficacy of an underground repository for disposal of TRU wastes. Disposal operations began in 1999 and are scheduled to continue for 35 years.

The site is operated by Washington TRU Solutions, LLC (WTS), and managed by the DOE CBFO. The facility is under the programmatic direction of the DOE Office of Environmental Management.

Contact-handled and remote-handled transuranic (CH-TRU and RH-TRU) wastes are disposed of in the 100-acre (.04 km²) disposal area on a horizon located 2,150 ft (655m) beneath the surface in a deep, bedded salt formation. Waste is transferred from the surface to the disposal horizon through a waste shaft using a hoisting arrangement. On October 16, 2006, the Secretary of the New Mexico Environment Department issued a revised Hazardous Waste Facility Permit allowing the WIPP facility to receive RH-TRU mixed waste. RH-TRU waste allowable at the WIPP facility has a surface dose rate greater than or equal to 200 mrem per hour and up to 1,000 rem per hour. The RH-TRU waste handling area includes a shipping and receiving area and a shielded cell for unloading, inspection, and loading prior to transfer underground.

Vertical shafts, including the waste shaft, the salt handling shaft, the exhaust shaft, and the air intake shaft, extend from the surface to the underground horizon, as shown in Figure 1. These shafts are lined from the shaft collar to the top of the salt formation, approximately 850 ft (259m) below the surface, and are unlined through the salt formation.

The WIPP underground consists of waste disposal area, construction area, north area, and waste shaft station area. Structures on the surface and location of the accident are shown in Figure 2.

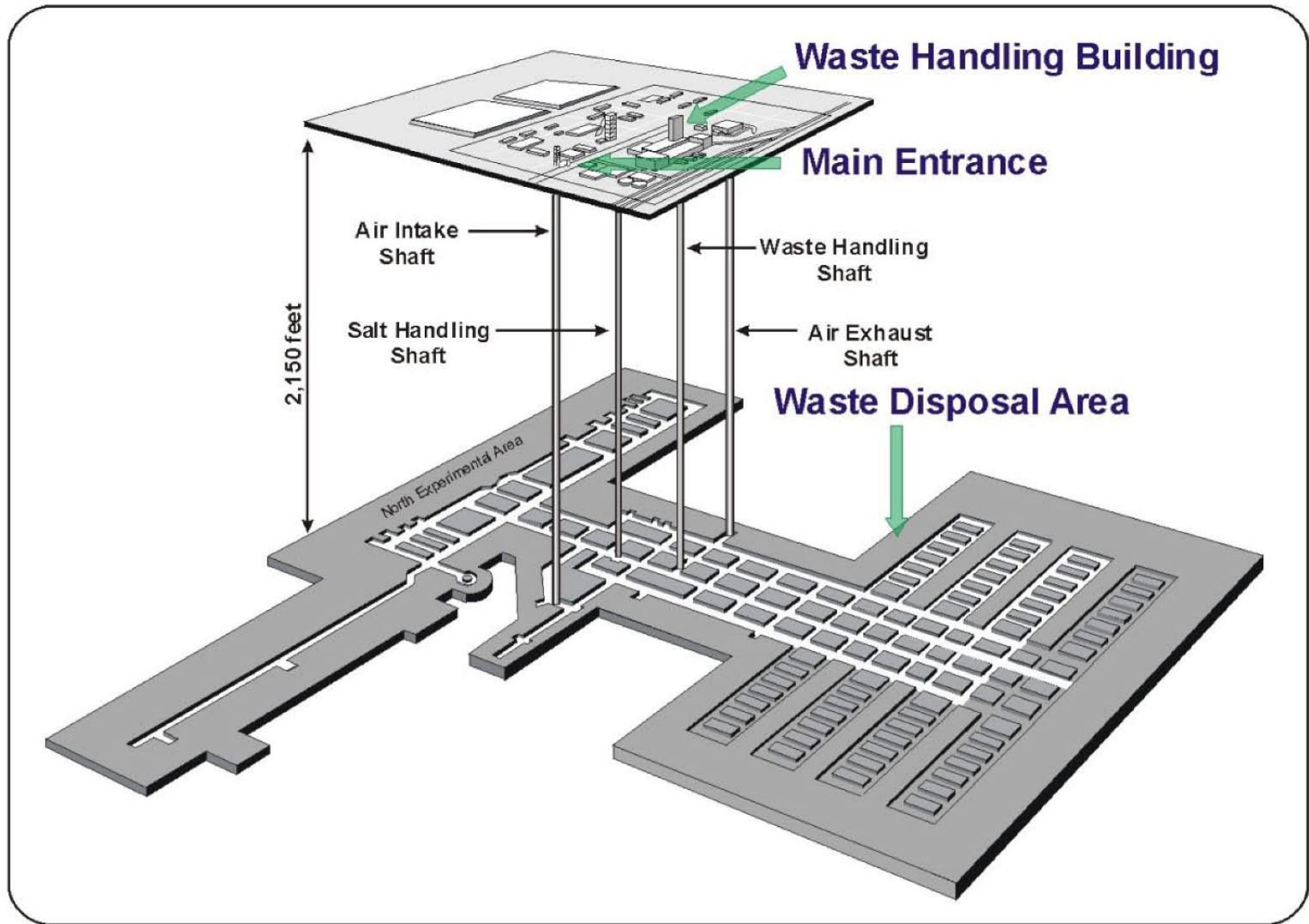


Figure 1: WIPP Operations



Figure 2: WIPP Surface Facilities

The principle CH waste operations at the WIPP involve (1) the receipt and disposal of TRU waste, and (2) the mining of underground rooms in which the waste is disposed. In the underground, the waste containers are removed from the waste hoist conveyance, placed on the underground transporter, and moved to a disposal room. In the disposal rooms, the CH waste containers are removed from the transporter and placed in the waste stack. RH waste is placed in boreholes in the walls (ribs) of the disposal rooms.

The site has 55 permanent buildings and four temporary buildings (trailers) in operation, one temporary building (lab trailer) in excess status, and various connexes (used for storage). The site buildings provide a total of 358,647 square feet of office and industrial space. Additional leased office space, the Skeen-Whitlock Building, is located in Carlsbad. Approximately 800 workers are assigned to the WIPP, representing the CBFO, the management and operating contractor, the security subcontractor, the warehouse, the document services subcontractor, the information technologies subcontractor, the CBFO Technical Assistance Contractor, Los Alamos National Laboratory-Carlsbad, Sandia National Laboratories-Carlsbad, and the New Mexico Environment Department-Carlsbad. Prominent features of the WIPP site include:

- Waste Handling Building. This structure provides a confinement barrier. Ventilation is operated to maintain a negative pressure with high-efficiency particulate air filtration.
- Waste Hoist. The Waste Hoist is designed to prevent an uncontrolled fall or descent of the waste conveyance into the waste shaft.
- Radiation Monitoring. Consists of continuous air monitoring and fixed air samplers.
- Central Monitoring Room. Provides a monitoring function and must be staffed and operational, with the ability to shift underground ventilation to filtration.
- Waste Handling Equipment. Selected items are designated safety class or safety significant.
- Emergency Services Bay. Houses the ambulance, rescue truck, and fire engine.
- Guard and Security Building. Houses the security monitoring and alarm systems.
- Parking Lot. The east portion of the front parking lot is used for employee parking, and the two west rows of the lot are designated for trailer storage and staging of empty TRUPACTs for DOE carrier transport to the generator sites and trailer maintenance facility (location of the accident – see Figure 2).

C. Scope, Purpose and Methodology

The Accident Investigation Board began its activities on March 9, 2009, and completed its investigation on April 7, 2009. The scope of the Board's investigation was to identify relevant facts; analyze the facts to determine the direct, contributing, and root causes of the event; develop conclusions; and determine Judgments of Need for actions that, when implemented, should prevent recurrence of the accident. The investigation was performed in accordance with DOE Order 225.1A, *Accident Investigations*, using the following methodology:

- Facts relevant to the event were gathered through interviews and reviews of documents and other evidence, including photographs and visits to the event scene.

- Facts were analyzed to identify the causal factors using event and causal factors analysis, barrier analysis, change analysis, root cause analysis, regulatory compliance analysis, and Integrated Safety Management analysis.
- Judgments of Need for corrective actions to prevent recurrence were developed to address the causal factors of the event.

Accident Investigation Terminology

- A **causal factor** is an event or condition in the accident sequence that contributes to the unwanted result. There are three types of causal factors: **direct cause(s)**, which is the immediate event(s) that caused the accident; **root cause(s)**, which is the causal factor that, if corrected, would prevent recurrence of the accident; and **contributing causal factors**, which are the causal factors that collectively with the other causes increase the likelihood of an accident but which did not cause the accident. The causal factors related to weaknesses in the five core functions of **Integrated Safety Management** are analyzed.
- **Event and causal factors analysis** includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the event to occur), and the use of deductive reasoning to determine the events or conditions that contributed to the accident.
- **Barrier analysis** reviews the hazards, the targets (people or objects) of the hazards, and the controls or barriers that management systems put in place to separate the hazards from the targets. Barriers may be physical or administrative.
- **Change analysis** is a systematic approach that examines planned or unplanned changes in a system that cause(s) the undesirable results of the accident.
- **Root cause analysis** is a technique that identifies the underlying deficiencies that, if corrected, would prevent the same or similar accidents from occurring.
- **Judgments of Need** are managerial controls and safety measures necessary to prevent or minimize the probability or severity of recurrence of an accident.
- **Requirements verification analysis** is a forward/backward analysis process to ensure that all portions of the report are accurate and consistent from the flow of facts to analysis to conclusion and Judgments of Need.

III. FACTS AND BOARD CONCLUSIONS

A. Background

Waste Handling

The typical day for waste handling operations begins with a preshift briefing to discuss equipment status, planned activities, special instructions, TRUPACT containers to be processed, and waste packages currently being staged for downloading to the WIPP underground. Briefings are attended by the Waste Handling Technicians, Radiological Control Technician leads and/or Superintendent, the Waste Handling Engineers assigned as team leads for the Waste Handling Technicians, and the Radiological Technician Supervisors. The planned activities are developed the previous day, and includes the technician duty assignments for the next day.

Waste Handling Technicians may be assigned underground and surface duties. The two primary surface operational duties for Waste Handling Technicians include Dock Operations, and Floor and Yard operations. This accident involved Floor and Yard Operations exclusively.

Dock Operations

Two individuals perform Dock Operations at the WIPP. The Crane Operator conducts preoperational checks on the crane and operates the crane during processing, and the Transuranic Waste Handling Dock (TRUDock) Operator assists the Crane Operator with general dock operations.

In Dock Operations, commonly referred to as “processing,” package assemblies of radioactive waste are removed from TRUPACTs using the overhead crane, and empty TRUPACTs are prepared for their next planned usage through cleaning, inspection for damage, and maintenance.

Floor and Yard Operations

Multiple types of work activities are involved in the general Floor and Yard Operations at the WIPP. A log keeper documents daily work activities in the operational log book (one for the surface and one for the underground areas). A 13-ton Forklift Operator performs pre-operational checks and operates the forklift, assisted by a spotter, who is present during movement of waste packages and TRUPACTs. A Trailer Jockey Operator performs pre-operational checks and operates the trailer jockey, and is assisted by a spotter, during movement of empty trailers and trailers loaded with TRUPACTS to the parking lot. The Trailer Jockey Spotter uses an electric cart to escort the trailer jockey. Waste Handling Technicians also perform general duties such as housekeeping, area inspections both for surface and underground, tying down waste packages on facility pallets, and tying down TRUPACTs after they are placed on the trailer.

The Floor and Yard Operations involve pre-operational inspections of equipment, pre-operational area inspections for both surface and underground, movement of waste packages to storage, downloading waste packages to the WIPP underground, emplacement of waste packages in the underground, moving the TRUPACTs to the TRUDock for processing, and moving the TRUPACTs after processing to either storage or to a trailer for loading in the Parking Area Unit located behind the Waste Handling Building.

During Floor and Yard Operations, a 13-ton forklift is used to move waste packages on facility pallets to storage, move facility pallets loaded with waste packages to the waste hoist for downloading to the WIPP underground, move loaded TRUPACTs from the trailer to the TRUDock, and move empty TRUPACTs from the TRUDock to the storage area or to the Parking Area Unit for loading on the trailers. The trailer jockey (tractor) is used to move empty trailers to the parking lot located outside the personal protection area (fenced area). This is also the area where empty trailers are stored prior to use or while waiting for pickup by the interstate carriers.

A spotter uses an electric cart to escort the trailer jockey and trailer to and from the parking lot. The spotter ensures that the rear wheels on the trailer turn when the trailer is moved forward, spots during back-up activities, and can assist the Trailer Jockey Operator with disconnecting the air lines from the trailer and placing glad hand covers on the air lines. This was intended to be a temporary task, but has become a permanent part of moving the trailers between the parking lot and the Parking Area Unit.

B. Accident Chronology

On February 25, 2009, the Waste Handling Technicians began their normal workday before 6:00 a.m.. At 6:00 a.m., the pre-shift meeting was held where safety topics and details of the day's work activities were provided for the Dock Operations and the Floor and Yard Operations personnel. This activity was conducted on a Wednesday, when both Crew A and Crew B are present. This is commonly referred to as "Family Day." Fourteen Waste Handling Technicians were assigned to Floor and Yard Operations on the day of the accident, where a team of three to seven are usually present on other days of the week.

The preoperational checks of the 13-ton forklift and the trailer jockeys were performed and formally documented as required by procedure. However, the daily and pre-use inspections of electric carts are not proceduralized and results are not recorded.

At approximately 8:00 a.m., the Waste Handling Technicians were tasked to move an empty trailer (tan in color with an unknown trailer number) from the Parking Area Unit located behind the Waste Handling Building to the west of the fenced property protection area (referred to as the parking lot in this report). The Trailer Jockey Operator was then to pick up empty Trailer 373 from the parking lot and transport it to the Parking Area Unit for TRUPACT loading.

Typically, a Trailer Jockey Operator and a spotter driving the electric cart are used for this activity. The spotter monitors that the trailer tires are turning, thus preventing damage to the tires. The spotter also assists the Trailer Jockey Operator when backing the trailer. On this day, the team consisted of four Waste Handling Technicians: the Trailer Jockey Operator, the Electric Cart Driver, the Front Passenger (who was a Waste Handling Technician trainee), and the Rear Passenger.

The trailer jockey was coupled to the empty trailer located in the Parking Area Unit, and after the required two-minute wait to allow air pressure equalization between trailer and jockey, the trailer jockey, accompanied by an electric cart, traveled to the security gate. The passengers left the electric cart and proceeded through security while the two drivers moved the vehicles through the security gate before proceeding through security themselves. The drivers and passengers returned to their vehicles and continued to an empty parking space in the row of parking slots furthest west row of slots in the parking lot. The Electric Cart Driver parked the electric cart perpendicular, about four feet away from the trailer jockey. The Electric Cart Driver dismounted the electric cart, spotted for the Trailer Jockey Operator as the trailer was backed into the space, disconnected the air lines from the trailer, and installed the glad hand covers. These latter two activities are normally a Trailer Jockey Operator responsibility per the procedure, but the Electric Cart Driver or passengers may assist on occasion. During this time, the two passengers remained in the electric cart.

The Electric Cart Driver then returned to the electric cart and backed up approximately 6 feet from the trailer jockey. The Electric Cart Driver made a looping turn to the right to travel to Trailer 373, which was four spaces to the south. An illustration of these activities is found in Figure 3. When completing the looping turn, the Electric Cart Driver was heading straight onto Trailer 373, as illustrated in the figure. About 6 feet from the trailer, the Electric Cart Driver attempted to stop the cart by pressing the brake pedal. The electric cart slowed, but the accelerator seemed to stick and

the Electric Cart Driver pressed harder on the brakes. The electric cart started to jerk and make slipping/clicking noises. The Electric Cart Driver attempted to turn left to avoid the trailer, but was too close to avoid the front of the trailer. Finally, the Electric Cart Driver attempted to stop the electric cart by raising his arms and pushing forcefully against the trailer's light bar. The Electric Cart Driver is a weight lifter capable of bench pressing some four hundred pounds, but was unable to stop the electric cart from proceeding partially under the trailer. As a result, the Front Seat Passenger was pinned between the trailer's light bar of the TRUPACT trailer and the front seat of the electric cart. This resulted in the front seat deflecting approximately 2.25 inches, as shown in Figure 4, and the injuries to the Front Seat Passenger.

A couple of seconds later, the Electric Cart Driver was able to push the electric cart back approximately 2 feet. After the electric cart was pushed back, the Front Seat Passenger exited the electric cart. The Passenger complained of pain, stumbled, and fell onto the parking lot area. The Electric Cart Driver noted the Front Seat Passenger was having difficulty breathing and the Rear Seat Passenger, a trained Mine Rescue Responder, began primary medical care.

A second electric cart, containing three Waste Handling Technicians, was escorting another trailer jockey into the same area of the parking lot when they noticed the injured Front Seat Passenger lying on the parking lot area between two trailers. They were told that the Passenger had been pinched between the electric cart and the Trailer 373 and to summon help. Two of the Waste Handling Technicians on the second electric cart traveled to the security gate house to call for help. One Waste Handling Technician called the injured worker's supervisor and the other called a Shift Contact-handled Waste Handling Engineer. The information provided was that there was an injury in the parking lot and the Front Seat Passenger was "pinched." The third Waste Handling Technician from the second electric cart used the Trailer Jockey Operator's personal cell phone that he retrieved from his personal car located near the accident scene and called the Central Monitoring Room at 234-8111.

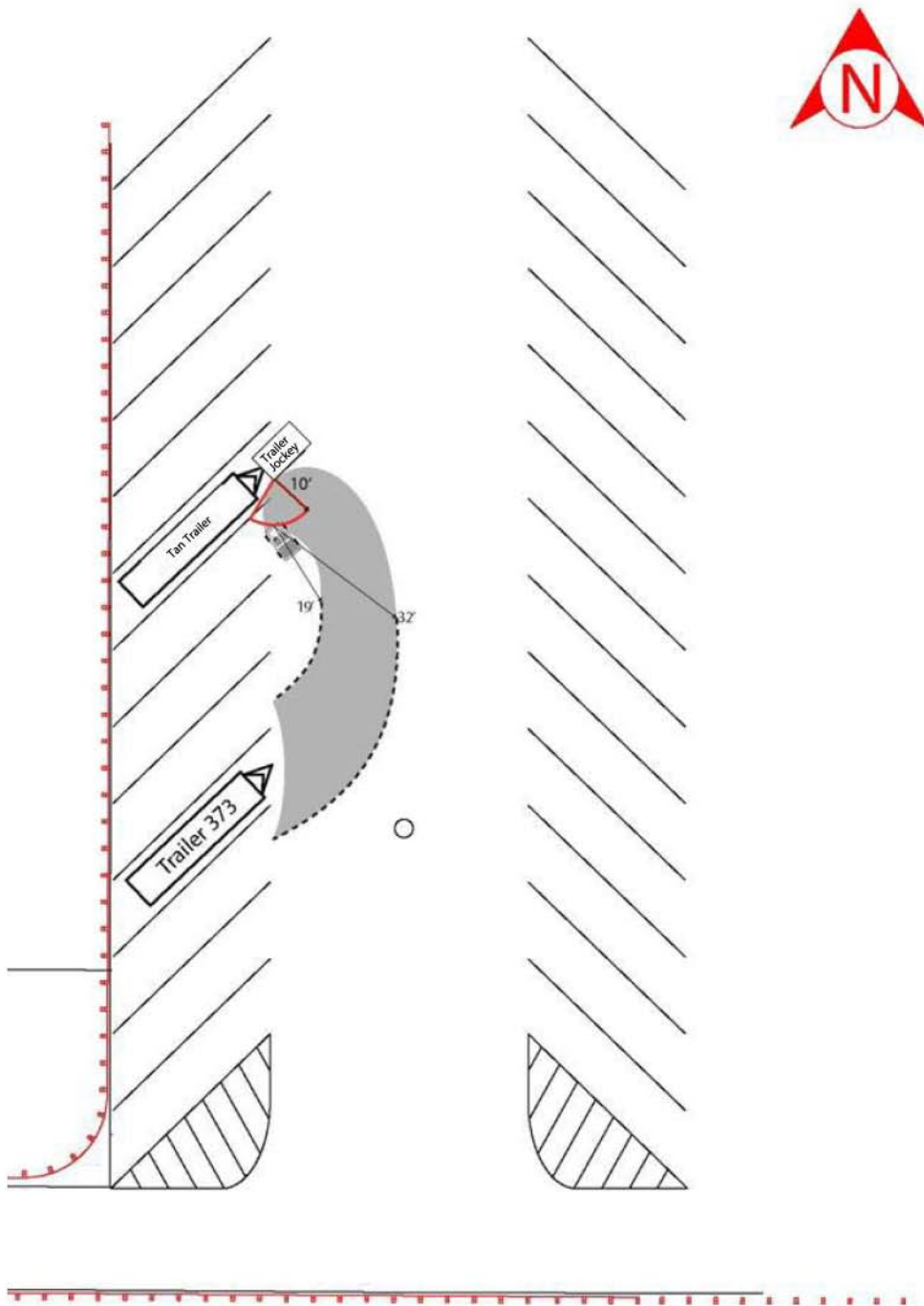


Figure 3: Schematic of the Accident Scene



Figure 4: Seat Deflection

One of the Waste Handling Technicians from the second electric cart left the gate house and returned to the accident scene and the other Waste Handling Technician stayed at the gate house to give the site ambulance directions to the accident scene.

Figure 5 shows the injured worker's shirt, with grease marks just below the front pocket resulting from being pressed against the light bar.



Figure 5: Shirt Worn by Injured Worker (cut/torn as part of primary medical care)

Emergency Response

At 8:40 a.m., the Central Monitoring Room Operator received a call on the emergency call number (234-8111) that an accident with injuries had occurred in the parking area west of the fenced property protection area. The Shift Manager and the Emergency Service Technicians were notified via radio, and a site-wide announcement was made concerning an accident with injuries in the front parking lot. The ambulance, manned by three Emergency Service Technicians and two Emergency Response Team members, was dispatched to the accident scene. A second call to the Central Monitoring Room was received from the second electric cart group at the security gate at 8:43 a.m. to also inform them of the accident and request emergency assistance.

Upon arrival at 8:46 a.m., the Emergency Service Technicians initiated their assessment of the injured worker, who was complaining of severe pain in the upper abdomen and chest areas. They removed the injured worker's shirt, provided oxygen via mask, and prepared to secure the injured worker to a back board for transport to the local hospital in Carlsbad, which is approximately 46 miles from the site. The ambulance team requested an intercept with the Carlsbad Fire Department ambulance, which is the standard procedural process for serious medical emergencies or accident victims with unknown injuries. The site ambulance departed the parking lot at 8:55 a.m. in route to the medical center. The Central Monitoring Room was notified of the ambulance's departure at 9:01 a.m. An intravenous fluid line was started on the injured worker and oxygen was continued during the transport. The injured worker was described as alert, with stable vital signs, responsive, and complaining of pain during the transport. The Emergency Service Technician's notes ranked the injured worker's pain as a 10 on a 1 to 10 scale. The ambulance intercept occurred approximately 16 miles from the WIPP site along the four-lane Highway 62-180, which has wide shoulders and could support the safe transfer of the injured worker. The patient was stable, and was transferred to the Carlsbad Fire Department ambulance. If a patient is unstable, the paramedic(s) and associated medical equipment are transferred to the site ambulance, which then continues to the local hospital. The site ambulance returned to the site at 9:46 a.m. The Carlsbad Fire Department ambulance arrived at the hospital at 9:49 a.m., where the injured worker was admitted to the emergency room for evaluation and treatment.

During the transport, the site ambulance encountered problems communicating with the Central Monitoring Room Operator from 8:55 a.m. to 9:01 a.m. However, radio communication with the Emergency Services base radio was maintained throughout the transport and important information was then communicated to the Central Monitoring Room Operator. A similar communication issue was encountered approximately three weeks prior when the WIPP site Emergency Response Team responded to an offsite emergency call as part of Memorandum of Understanding agreements with the surrounding communities. The site ambulance had difficulty communicating with Carlsbad Emergency Services. A WIPP site Action Request was submitted to evaluate and correct this issue, which apparently resulted when Eddy County and Lea County moved to new radio frequencies that are not supported by the repeaters in some areas. WTS has submitted a request to DOE to change the frequencies used by WIPP Emergency Communications to be consistent with the new county frequencies. In the interim, per the Memorandum of Understanding with Eddy County, WIPP will utilize these frequencies beginning April 14, 2009, until their co-licenses are finalized.

<p>The Board concludes that the overall emergency response was timely, proficient, and executed in an exemplary manner.</p>

Hospitalization

The injured worker was evaluated in the emergency room of the Carlsbad Medical Center and was diagnosed with a lacerated liver. At approximately 2:00 p.m., the injured worker was prepared for air transport to the University Medical Center in Lubbock, TX, where there was access to more medical specialists and advanced monitoring equipment.

As an immediate action, the WTS management requested that the site nurse, a Waste Handling Manager, and a Human Resources representative be present at the Carlsbad Medical Center to provide case management services for the injured worker and to serve as an interface between the medical staff, the injured worker, and the injured worker's family. The site nurse contacted the WTS Occupational Physician to provide information on the accident and the condition of the injured worker. When the injured worker was transferred to Lubbock, the site nurse traveled to and remained at the hospital for the first three days after the accident. During the entire hospitalization, a WTS manager remained in Lubbock to interface with the injured worker and the family and to support all of their needs. The site nurse prepared the schematic in Figure 6, which shows the bruising and red marking on the injured worker's torso.

At the University Medical Center in Lubbock, the injured worker was further evaluated to define the extent of the lacerated liver and the required follow-on treatment. The injured worker was admitted to the intensive care unit and remained there until discharge on Tuesday, March 3, 2009. The injured worker could have been moved from intensive care to a regular hospital room on Monday, March 2, 2009, but no rooms were available.

The WIPP site nurse and occupational physician have visited the injured worker at home, supported all the required medical needs, and arranged for a local liver specialist to follow the worker's recovery. After returning home, the injured worker had continued shoulder pain resulting from the accident. The worker is undergoing physical therapy to treat this injury and continuing to recuperate at home.

C. WTS Occurrence Reporting and Processing System Evaluation

While the Emergency Service Technicians were treating the injured worker, the local security team secured the accident scene to limit access, to document those entering the scene and to preserve evidence. Immediately after the site ambulance departed, photographs were taken, and initial witness statements were obtained. The evidence was secured until the Type B Accident Investigation Board arrived, with the exception of Trailer 373, which was inadvertently moved by a DOE contract carrier at approximately 2:00 a.m. March 8, 2009, even though an Out-of Service tag stating "Do Not Move" was posted on the trailer. Trailer 373 had been scheduled for routine maintenance and the communication of the out-of-service status was lost between shift changes with the contract carrier central dispatch office. On March 9, 2009, Trailer 373 was returned to the exact space in the parking lot where it had been at the time of the accident. The position and height of the front of the trailer was confirmed from photographs and measurements taken at the time of the accident.

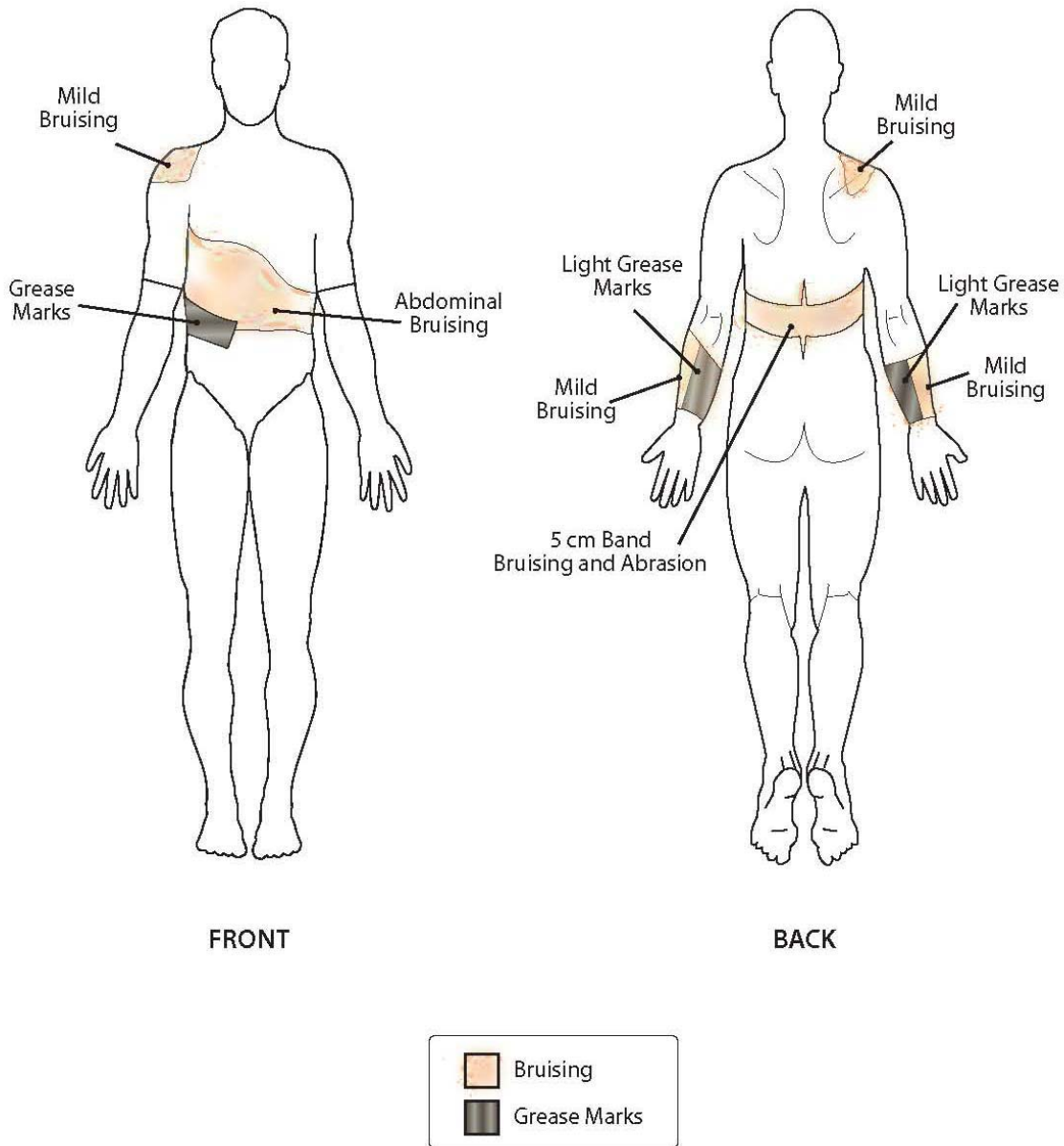


Figure 6: Schematic of Passenger's Injuries

WTS immediately performed the required testing of the Electric Cart Driver, which validated that the Electric Cart Driver was fit for duty.

WTS initiated a stand-down of electric cart usage immediately after the accident until a pre-operation inspection was conducted of all 143 electric carts onsite. As a result, 12 units were found to have deficiencies and were taken out of service and Action Requests were initiated. Trailer movements were also suspended until it was assured that the trailers were not instrumental in the accident. WTS initiated an Occurrence Reporting and Processing System evaluation within four hours of the accident.

WTS performed a critique on February 26, 2009. The WTS evaluation team completed a series of tests on the electric cart to determine the operability of the brakes, steering, and acceleration. The evaluation team was able to recreate the noise, lurching, and lack of braking when the accelerator and brakes were engaged at the same time. WTS maintenance personnel completed an evaluation of the electric cart, examining the brakes, throttle, and steering linkages. The electric cart manufacturer was contacted for follow-up on the brake override, and indicated that no issues have been previously brought to their attention. The WTS critique, tests, and maintenance evaluation, resulted in the following notations:

- No evidence of electric cart malfunction
- No evidence of excessive speed
- Communications in parking area were less than adequate
- Escort/spotter duties were not fully understood
- Qualification to operate electric cart was not fully understood
- The practice of approaching trailers head-on was not formalized
- Emergency response was prompt and professional

Recommendations included:

- 1) Evaluate requirements for the continued practice of trailer escort function
- 2) Ensure all electric cart operators are qualified to perform assigned tasks
- 3) Use radio communications when applicable
- 4) Ensure all electric cart operators are aware of the accelerator pedal configuration
- 5) Evaluate site requirements for electric cart use

The WTS evaluation efforts were terminated when the DOE Type B Accident Investigation Board was established. WTS results and supporting data, to date, were documented and provided to the Board.

The Board concludes that the site readiness and accident scene preservation generally met the intent of DOE Order 225.1A, <i>Accident Investigations</i> .
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A URS Washington Division Safety Expert performed a corporate review on March 5 and 6, 2009, to assess the accident and evaluate the site response performed by WTS. The following draft recommendations were made:

- Issue a job hazard analysis (JHA) for above ground operations of electric carts
- Expedite an engineering solution for the accelerator pedal
- Modify job performance measure to cover the potential for a passenger's foot to accidentally contact the accelerator pedal
- Consider a physical verification for electric cart qualification.

All recommendations were initiated and/or completed on March 6, 2009. The draft report was provided to the Type B Accident Investigation Board.

WTS immediately initiated discussions with Taylor-Dunn to determine if they had had similar reports with passengers engaging the accelerator pedals, and if they had a retrofit to prevent a passenger from inadvertently contacting the accelerator. The manufacturer indicated that they have not had reports of similar events. WTS has had continued discussions with the manufacturer, who has approved a retrofit to install a plate between the accelerator and the passenger. WTS has ordered the retrofit parts for all the electric carts on site and has asked for expedited delivery.

On March 24, 2009, the WTS Deputy General Manager issued an alert limiting the use of electric carts to activities that directly support work, requiring electric cart operators to be qualified, and restricting the use of the front passenger seat until the engineered retrofit can be implemented.

D. Electric Carts

The electric cart involved in the accident, 75-C-136, was a Taylor Dunn Model B0-210 36 Burden Master. This electric burden and personnel carrier, shown in Figures 7 and 8, was obtained in 1999. There are about 143 electric carts on the site, with approximately 50 operated on the surface. Some of the units have a cab and cowl configuration; however, 75-C-136 did not have the cab and cowl option. Without that option, the electric cart can potentially travel under any protruding loads or, in this case, a TRUPACT trailer. This type of electric cart presents a potential caught between hazard for any obstacle that is 45 inches or higher.



Figure 7: Taylor-Dunn Cart Involved in Accident (showing angle related to trailer)



Figure 8: Taylor-Dunn Cart Involved in Accident (from the front of the trailer)

The safety features/controls associated with these electric carts are: accelerator, brake, parking brake, horn, lights, automatic seat brake (which shuts off the electric cart motor when the driver gets up from the seat) and reverse beeper. Some of the older carts onsite are not equipped with a reverse beeper. The WTS evaluation team performed a visual inspection and ordered a maintenance inspection of the electric cart under Work Order 0901738S. The backshift maintenance team performed the inspection on February 25, 2009, and found that the acceleration system was in good working condition and there was no indication that the accelerator had stuck open. However, it was discovered that one of the disk brake pads was not attached to the backing plate, but was held in contact with the braking system by the brake pad pins. New brake pads are held to the backing plate with adhesive and the pad pins. It was also noted that the automatic seat brake switch was out of alignment and would not interrupt power. Also, the backup alarm was not functioning because a wire was not connected to the electrical terminal.

One design feature of the electric cart is that the accelerator pedal extends off-center into the passenger's foot area. The electric cart width is 42 1/2 inches and the bottom of the pedal is located on the passenger's side, 19 1/2 inches from the edge of the passenger's side. The top of the pedal extends further into the passenger's side. In discussions, many of the workers stated they have witnessed and even placed their own foot on the accelerator pedal while riding as passengers in the electric carts. However, this information was not brought formally to management prior to this accident. Figure 9 is photo of the pedal arrangement in the electric carts.

The Board concludes that the designed location of the electric cart accelerator pedal contributed to the accident.



Figure 9: Cart Accelerator Pedal

Based on the Taylor Dunn Operations Manual, MB-210-07, vehicle operational guidelines include the following:

- only qualified and trained operators may drive,
- drive slowly when making a turn,
- stay in your driving lanes under normal conditions,
- maintain a safe distance from all objects, and
- keep a clear view ahead at all times.

Per ANSI B56.8-2006, Safety Standards for Personnel and Burden Carriers, operators should also be qualified as to visual, auditory, physical and mental ability to safely operate the electric carts. There is no mention of this qualification as part of the WTS authorization for electric cart use. Training for electric cart drivers is comprised of a checklist/evaluation checklist (CAR-101) and also requires a review of the WIPP Electrical Cart User's Handbook, May 20, 2002, and WP 12-IS.01, Revision 4, December 20, 2008. The handbook discusses pre-operation inspections done at the beginning of each shift. There is no mention of back-up alarm inspection. It is noted that the automatic seat brake function will be checked as part of the quarterly preventative maintenance. The handbook provides details for equipment operations and parking requirements for both the surface and the underground.

The Board concludes that the qualifications for electric cart drivers as defined in ANSI B56.8-2006 are not incorporated in the Vehicle Safety Program.

The CAR-101 course was developed as a corrective action to a 1994 Type B accident investigation involving an underground electric cart. The course is not based on a qualification card, as is other heavy equipment, but rather on a checklist process. The course is not associated with the WTS Training Department. Four underground controllers administer the electric cart training based on their designation as Subject Matter Experts using the on-the-job training process. This course is a one-time requirement. Some workers have had the course once since its inception in 1994, and others have taken it multiple times because of missing training records. In discussion with electric cart drivers, they indicated there are no instructions or requirements on how to approach the parked trailers, whether head-on or perpendicular to the trailer. The workers on Electric Cart 75-C-136 all indicated they have never used the electric cart as a work surface to remove the glad hand covers. In other interviews, workers identified that some electric cart drivers do not follow procedures, for example, failing to sound the horn when backing. In reviewing the training records of the Electric Cart Driver, no documentation of training for CAR-101 was found.

The Board concludes that the training of workers in electric cart use is not provided by the Training Department and is not part of the Waste Handling Technician Qualification Card.

Spotters Use of Electric Carts

In late 2006 and 2007, the DOE carrier contractors, responsible for the transport of empty trailers, trailers with empty TRUPACTs, and trailers with loaded TRUPACTs between the waste generator sites and the WIPP site, were experiencing tire damage from movement of the trailers with the air brakes engaged. During this time period WTS communicated with CBFO and the contract carriers to develop corrective actions to prevent any tire damage that might be occurring during waste handling operations at the WIPP site.

Two mitigating actions were put in place by WTS to prevent tire damage on the trailers:

1. On March 20, 2007, Standing Instruction 07-002 was issued to require the use of a spotter during the movement of empty and loaded packaging trailers. This instruction required that a spotter watch the trailer tires during movements around the parking unit area and to staging areas in the parking lot outside of security parameters of the site. The Waste Handling Technicians began using electric carts for personnel conveyance during the spotting activity.

The Board observed electric carts performing this activity with one worker and with two workers. On the day of the accident there were two electric carts in the parking lot carrying three workers each. Only one worker is required for the spotter task, but the practice has evolved into having other passengers accompanying the spotter, particularly on Family Day (Wednesdays when both Crews A and B are onsite). Trailer Jockey Operators in training are required to be accompanied by a fully qualified Waste Handling Technician and trainer. In those instances, the qualified Waste Handling Technician and trainer usually ride as passengers on the electric cart and both the Trailer Jockey Operator and qualified observer are required to have radios.

2. On May 3, 2007, Standing Instruction 07-003 was issued to require operators of the trailer jockey to wait two minutes after attaching the tractor air supply to the trailer and prior to moving a trailer after the fifth wheel is raised or lowered. The two-minute requirement was imposed to allow the brake system air pressure to stabilize.

Since implementing the two-minute requirement, there has not been one instance of the trailer wheels not rotating during the onsite movements. This two-minute wait had been implemented several months prior to the issuance of the formal Standing Instruction 07-003.

An April 24, 2007, memorandum from the Assistant General Manager, WTS, to the Contracting Officer, CBFO, requested that the Management Plan to track damage to a trailer be modified to allow spotters to identify any “inappropriate engagement of the braking system,” and that this spotting activity continue until “at least two months have passed with no further instances of damage noted.” WTS already had one month of “no damage” performance when this memorandum was issued, following the implementation of Standing Instruction 07-002 on March 20, 2007.

Although originally planned as a two-month, limited duration activity, the use of spotters to ensure all wheels are turning freely on the TRUPACT trailers has continued for the last 36 months. The work practice has become part of the accepted process for moving TRUPACT trailers at the WIPP site. Due to the supposed limited duration of this activity, a JHA was not conducted. One questioning WTS manager challenged the continued process after the three months expired, but was instructed by senior management to continue.

The Board concludes that the spotter activities were not completely analyzed for the hazards associated with the task to ensure appropriate controls were implemented, and were performed for some 34 months past the WTS documented end point.

Post-accident Electric Cart Stand-down

After the accident, there was a stand-down of electric cart usage until a pre-operation inspection was conducted. As a result, 12 electric carts were found to have deficiencies and were taken out of service. It is not clear how so many electric carts could have deficiencies if the daily and operability checks required by the CAR-101 training were being performed. Of further note, Electric Cart 75-C-135, which was selected by the Board on March 16, 2009, for performance comparison to Electric Cart 75-C-136, had non-functioning rear lights and back-up alarm.

The Board concludes the pre-operations and/or pre-use inspections of electric carts were not performed consistently.

On March 13, 2009, an electric cart injury awareness presentation was initiated on behalf of the WTS Site Operations and Disposal Manager. Viewgraphs concerning the accident and general electric cart use awareness were prepared and distributed by the WTS Manager of Site Operations and Disposal, to the senior management team for presentation and discussion with their staff. The WTS Manager of Site Operations and Disposal followed up on this request and received responses

from the WTS Management Team on their actions. This follow-up request required a second submission from the managers to get the expected rigor and detail.

A laminated yellow card was also attached to all of the electric carts on the site to reinforce safe operating and inspection requirements. The electric carts are to be inspected at the beginning of the shift and before being used. The inspection, detailed on the yellow card, includes checking tires, horn, headlights, taillights, brakes (service and parking), steering, and backup alarm (if applicable). This card was created in conjunction with the general electric cart JHA to define criteria warranting the electric cart to be tagged out of service. Both of these were completed March 6, 2009.

Electric Cart Testing

After the accident, the WTS investigation was able to reproduce the reported slipping/clicking sound and jerking of the electric cart, as described by the Electric Cart Driver and Passengers. This was found by applying the brake and activating the accelerator at the same time. Based on this test, it was confirmed that depressing the accelerator can override the braking system on Electric Cart 75-C-136.

On March 16, 2009, the Type B Investigation Board again performed the electric cart tests and witnessed the same conditions. The Board also tried to observe the same evolution on a similar Electric Cart 75-C-135, to ensure this condition resides with like models, but Electric Cart 75-C-135 did not duplicate the results. The Board decided to have both electric carts fully charged and conducted the testing again on March 18, 2009. Also on March 18, 2009, a third electric cart, 75-C-137, was tested. All three electric carts stopped without accelerator override; however, there was still noise coming from Electric Cart 75-C-136.

The chain drive of Electric Cart 75-C-136 was subsequently inspected and it was found that the chain was loose on the gear drive and could not be adjusted. WTS replaced the chain, the brakes, and the steering column top bearing on Electric Cart 75-C-136, and repeated the above electric cart tests on April 1, 2009. The results of these tests identified that the electric cart came to a complete stop when the cart was accelerating at low, medium, and high speeds and the brake was engaged. Based on information provided by the manufacturer, “The brake performance is not changed by a misadjusted or worn out drive chain. Additionally, the drive cannot develop any more torque with a misadjusted or worn out drive chain than with a correctly maintained drive chain. The truck [sic] would not lurch due to a misadjusted or worn out drive chain if the brake pedal is held firm.”

Based on the electric cart tests conducted, the Board could not definitely determine the exact reason for the brake override. However, the non-braking and slipping/clicking noises were corrected by the replacement of the brakes and drive chain. The final tests conducted on April 1, 2009, verified that the brakes on the electric cart fully engaged and produced the same type of skid marks observed with the other electric carts tested by the Board.

<p>The Board concludes that the combination of the accelerator being depressed and the existing conditions of Electric Cart 75-C-136 (loose drive chain and worn brake linings) resulted in an override of the braking system.</p>
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Maintenance

Preventive maintenance of the electric carts is performed on a quarterly basis per PM000003, Revision 7, *Electric Carts*; PM074116, Revision 1, *Electric Carts* (underground); and MWI00011, *Repair of Electric Cart*, Revision 4. The maintenance is conducted on a quarterly basis; however, the manufacturer establishes a monthly, quarterly, semi-annual, and annual maintenance schedule based on hours of use. In discussion with the WTS Maintenance Manager, the equipment owner's manual was reviewed to establish the maintenance activities and maintenance frequencies. The manufacturer's semi-annual and annual requirements include checking motor brushes and wheel bearings, changing rear axle oil, and repacking front wheel bearings, which are not performed by WTS. In addition, the drive chain is to be adjusted per manufacturer's recommendations on a schedule based on hours and normal running conditions. The first adjustment is at 100 hours, the second at 150, the third at 250 hours, and then every 400 hours thereafter.

Procedure PM000003 requires maintenance to inspect cords for nicks and cuts, check integrity of wheels, inspect steering, inspect drive train components, and ensure proper operation of brakes, lights, horn and automatic seat brake (as required). There is no mention of checking the parking brake or back-up alarm. The last quarterly inspection of Electric Cart 75-C-136 was conducted on January 7, 2009. There were no issues identified during this inspection. However, as noted above, the automatic seat brake and back-up alarm devices did not work during the post-accident inspection. Also, inspection of the electric cart by the Type B Accident Investigation Board noted that the power cord to the charger was damaged.

<p>The Board concludes that the maintenance of the electric carts did not include the periodic drive chain adjustment, as well as the semi-annual and annual maintenance items as established by the manufacturer.</p>
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Electric Cart Action Requests

WTS uses an Action Request process to identify and schedule required work and maintenance on equipment and other infrastructure. A review of the work history that was executed under the Action Requests for Electric Carts 75-C-136 (the electric cart involved in the accident) and 75-C-135 (like model to the electric cart in question) was performed by the Type B Accident Investigation Board.

The WTS Occurrence Reporting and Processing System Evaluation Team (hereafter called the WTS evaluation team) collected the maintenance data between the June 1, 1999, and January 7, 2009, for Electric Cart 75-C-136. There were 36 maintenance work orders performed. These were identified as 24 quarterly preventative maintenance work orders and 12 corrective maintenance work orders. Of the corrective maintenance work orders, three were related to brake work, one was related to accelerator repair, one was a steering wheel replacement, and nine were general in nature, such as flat tires, battery repairs or general electrical work.

In addition, the Type B Accident Investigation Board collected two years of historical data of all Action Requests associated with electric carts. During the review, the Board found that the batteries for Electric Cart 75-C-136 had been replaced on February 19, 2009.

The Board also collected the maintenance data for Electric Cart 75-C-135 between the May 27, 1999, and October 23, 2008. This electric cart was used in testing by the Board to get like model performance. There were 37 maintenance work orders performed, 10 for corrective maintenance and the remaining 27 for quarterly preventive maintenance. Of these, 30 skill of the craft work packages were performed, five of them related to brake work, one related to accelerator repair, and the other 24 were of a general nature, such as flat tires, battery repairs, or general electrical work.

The Type B Accident Investigation Board also reviewed the Action Requests for the total WTS electric cart inventory for the last two years. In this time period, there was a total of 837 skill of the craft work orders performed. Of these work orders, the following number of electric cart systems were repaired: 66 involving brakes, 29 involving parking brakes, ten involving steering, and two involving accelerators.

Vehicle Safety Program

The Vehicle Safety Program required by 10 CFR 851 is documented in the WP 12-IS.01-3, *Industrial Safety Program – Equipment and Tools*, as part of the *Worker Safety and Health Program Description*, WP 15-GM.02, Revision 1, October 14, 2008. In the program, electric carts requirements are found in a separate section from the rest of Vehicle Safety Program. Section 5 describes the responsibilities, general requirements, training and qualifications, maintenance, travel and loading for electric carts. The section also references training topics that should include “manufacturer’s restrictions and requirements.” However, these requirements are not provided in the training CAR-101.

<p>The Board concludes that the WTS Vehicle Safety Program did not incorporate the needed requirements for surface use of the electric carts, similar to those found for the underground use.</p>

Job Hazard Analysis

Job Hazard Analyses are developed using WTS Procedure WP12-IS3002, Revision 0, *Job Hazard Analysis Development*, November 21, 2008. The manager is responsible for determining the jobs for which a JHA should be conducted. The guidance in the procedure states that JHAs should be generated for jobs with particular task-specific hazards. Based on interviews, electric cart usage on the surface was considered to be a “low hazard” activity that did not have task-specific hazards; therefore, no JHA was performed.

Job Hazard Analysis JHA 30 was developed on November 2, 2004, for the Electric Cart Operations in the Underground. However, no JHA was performed for the surface operations that included the spotter activities. In the Underground Operations JHA, the potential hazard of being caught between the electric cart and the rib, which had occurred in the underground in 1994, was identified. The safe job procedures that addressed these hazards are the inspection of the electric carts and the parking requirements. The potential of an electric cart driving near or under protruding equipment was not addressed in this JHA.

On March 6, 2009, a JHA for Electric Cart Operations for the General Site (i.e., TRUPACT trailer) was developed, GEN-01. In this iteration, the use of an electric cart as a work platform is addressed, but a separate JHA for this new job task is required. There are no directions for integrating these task-specific JHAs into the general site JHA. Also, the electric cart driver is to remind the passenger to stay away from the accelerator. The caught between hazard associated with the electric cart and trailers or other protruding equipment was still not analyzed.

The Board concludes that a Job Hazard Analysis was not performed of the surface electric cart use and as a result, the appropriate controls were not implemented.

E. Family Day

Work schedules for both surface and underground work are divided into two work crews, Crew A and Crew B. Each work crew works a 4-day schedule. Crew A works Monday through Wednesday and every other weekend, and Crew B works Wednesday through Friday and every other weekend opposite the weekend worked by Crew A. As identified above, both work crews are on site on Wednesdays, and this is referred to as Family Day.

Waste Handling Technicians and the Contact-handled Waste Handling Engineers, who provide supervisory responsibilities for the Waste Handling Technicians, identified that Family Days can be used to provide training to both crews at once, while maintaining operability. Family Day also provides the opportunity to share lessons learned between the crews. Family Days have been described as “hectic,” with both crews on site to assign tasks, and to ensure all Waste Handling Technicians have enough directed work to complete. Also, individual crews generally develop their own ways of operating when operating separately, and it can be a challenge when working together. Employees have also developed a sense of teamwork to get assigned work completed. Some individuals expressed the opinion that Family Day is “highly inefficient,” that the day can be like “a zoo going on,” and can be “interesting.” However, some individuals thought there was a benefit to having both crews on site at the same time.

February 25, 2009, was a Wednesday, and planned activities, which show general area assignments, for the day shift identified 14 individuals assigned to Floor and Yard Operations. Floor and Yard Operations include movement of the TRUPACT trailers to and from the trailer parking area in the west parking lot. There are generally three to seven individuals assigned to Floor and Yard on a normal workday. No crew training was scheduled for that day. The Contact-handled Waste Handling Engineer on duty that day provided direction to take a trailer out to the parking area and bring back Trailer 373. The Electric Cart Driver and Trailer Jockey Operator were both from Crew B, as was the injured individual who was a passenger in the electric cart. A second passenger in the electric cart was from Crew A. Although three people were in the electric cart, only the driver of the electric cart and the driver of the trailer jockey participated in moving the empty trailer. There was no indication on the planned activities that any on-the-job training was to be conducted that day. This would have required a trainer and a spotter, equipped with radios, to be present during this training activity.

The Board concludes that Family Day creates additional tasking issues, supervisory challenges, and unrecognized safety concerns.

F. DOE Oversight

The last DOE/HQ independent safety oversight was conducted in 2002. However, several Voluntary Protection Program validations have been conducted by the DOE Headquarters Office of Health, Safety and Security. At the time of the accident, a Voluntary Protection Program validation was on-going.

CBFO contractor oversight is established in the CBFO *Contractor Oversight Plan*, DOE/CBFO 04-3299, Revision 1, August 2005. CBFO oversight includes operations reviews and the daily Facility Representatives site reviews. CBFO has an on-going Assessment schedule from fiscal year 2008 and for fiscal year 2009 as part of their Integrated Evaluation Plan. For fiscal year 2009, CBFO has scheduled assessments for fall protection, confined spaces, electrical safety, JHA, mining, and HAZCOM. However, there were no programmatic assessments of the contractor safety programs in fiscal year 2008. Fiscal year 2008 included one fire protection review and one continuous air monitoring review. The remaining fiscal year 2008 assessments focused mainly on characterization reviews, areas at the site, and generator site reviews.

In January and February 2009, the CBFO Facility Representative conducted 15 assessments or reviews of the following topics: required reading, construction activities relating to fire water pipe installation, pre-jobs briefings and incident critiques. The Facility Representative's assessment and review activities are well documented in the Carlsbad Field Office Operational Assessment Report. The reports are submitted to WTS for any required corrective actions or response from the contractor. The assessments are focused on conduct of operations and fire protection, but there was some indication that safety is reviewed in the walk-arounds.

The Board concludes that CBFO has not effectively ensured that the WTS has a credible, rigorous, and robust oversight program as outlined in DOE O 226.1A, *Implementation of Department of Energy Oversight Policy*.

G. Contractor Oversight

Contractor oversight consists of individual assessments as established by the WTS assessment program and an annual Integrated Safety Management System assessment. The 2008 management assessments involving safety and health programs were limited to audits of Lockout/Tagout and Mine Safety and Health Administration quarterly inspections. There was one assessment of machine guarding resulting in three Opportunities for Improvement. In addition, management performed assessments for retrieval, characterization, and transportation activities at the host sites (i.e., Los Alamos National Laboratory, Idaho National Laboratory, and the Savannah River Site). At the host sites, safety walk-downs were conducted and documented.

The WTS 2009 Management Assessment Schedule includes safety programmatic topics such as fall protection, lockout/tagout, and confined space. In discussion with the WTS Acting Safety and Health Manager, these topics were selected because of compliance requirements. Some schedule slippage has occurred, but the WTS Acting Safety and Health Manager indicated that the assessment schedule is expected to be completed by September 2009.

The WTS Expert Review was conducted in July 2008 by independent technical experts within the URS Washington Division to evaluate overall performance of the organization. The assessment team focused on a range of technical issues including Safety Significant Systems, Components and Structures, Nuclear Safety Culture, and components of Integrated Safety Management guiding principles and core functions. The team concluded that WTS program reflects DOE orders, the Occupational Safety and Health Administration, the Mine Safety and Health Administration and other regulatory requirements. However, the team identified that many feedback and improvement processes are not effectively described, institutionalized, or implemented. The recommendations to WTS included the following:

- Incorporate cross-functional assessments into the Management Assessment Program,
- Implement a WIPP Corrective Action Review Board to provide management with ES&H issues,
- Establish an expectation that root cause analysis include extent of conditions and extent of cause.

All the corrective actions are completed and the first effectiveness review is scheduled to be completed by June 30, 2009.

The URS Washington Division also conducted the 2008 Integrated Safety Management System assessment in August 2008. Twenty Opportunities for Improvement were identified in the assessment report and included flow-down of requirements to subcontractors, training issues, and line direction and involvement in safety. In the report, there are Opportunities for Improvement for enhancing assessment activities such as:

- 1) tracking regulatory assessments,
- 2) documentation of field activities, and
- 3) additional staffing to provide oversight on back shifts.

There were also identified issues associated with JHA in that the developers use the JHA checklist randomly. Also, the procedures for JHA do not provide detailed direction. The Opportunities for Improvement were submitted through the WTS Issues Management Program. The corrective actions are to be completed by June 30, 2009.

<p>The Board concludes that WTS oversight has not been extended to the safety and health program level to establish that it includes the technical requirements for the work activities and to determine effective implementation of requirements at the worker task level.</p>

H. Previous Incidents

Vehicle Incidents

In late 2004, a WTS vehicle incident team was formed to review and make corrective actions due to an increase in moving vehicle accidents. Only one injury occurred during that time, but there was a concern that more serious injuries and property damage might occur. There were 32

incidents in the two years. The corrective actions by Waste Handling and Mining Operations were to evaluate tight handling spaces, conduct a walk-through of Automated Guided Vehicle operations and magnesium oxide storage, to reinforce “Time Out for Safety,” and to post electric cart access and parking signage. This Type B Accident Investigation Board reviewed the 2008 WIPP Forms and found seven incidents. These incidents were caused when forklifts struck other objects, an electric cart struck other electric carts or in one case, when an electric cart ran over a worker’s foot. As a result of these incidents, corrective actions were developed and closed.

As identified previously, many of the workers stated they have witnessed and even placed their own foot on the accelerator while riding as passengers in the electric carts. However, this information was not brought formally to management prior to this accident, so that the issue could be evaluated and appropriate corrective action could be developed.

Occurrence Reporting

In 2008 and 2009, twenty Occurrence Reporting and Processing System reports have been generated. Because of an increase in Occurrence Reporting and Processing System reports, a conduct of operations pause was initiated by WTS management in August 2008. Some of management’s initial expectations were to focus on following procedures and “looking for the little things – they have the habit of turning into big things.” A management control plan was developed with a corrective action plan

There was another Conduct of Operations Improvement Plan issued on February 15, 2008. Actions included management training on conduct of operations, improvement of the critique process, ensuring implementation of procedures, enhancing expectations, and ensuring operator and operational performance to meet expectations. As a result, a management self-assessment schedule was developed on March 14, 2008, to further address the identified needs.

2004 Type B Accident Investigation

A Type B Accident Investigation was conducted at WIPP in 2004 entitled *Type B Accident Investigation Board Report – On the August 25, 2004 Head Injury to Miner, Waste Isolation Pilot Plant, Carlsbad, New Mexico*. In the report, the following six Judgments of Need were identified:

- WTS needs to establish a program to provide a formal Person in Charge Program
- WTS needs to strengthen its Integrated Safety Management System program
- WTS needs to better communicate work scope involving multiple work groups
- WTS needs to adhere to the training requirements in 30 CFR 49.8
- WTS needs to focus attention on hazard identification
- WTS needs to assess the effectiveness of hazard recognition

Corrective actions were developed and completion of the corrective actions was confirmed by the CBFO Acting Manager in a memorandum to the Principal Deputy Assistant Secretary for Environmental Management dated March 18, 2005.

Two of the above Judgments of Need are germane to this accident:

- 1) Focusing attention on hazard identification through the JHA
- 2) Assessing the effectiveness of the hazard recognition process through self assessments

The corrective actions for these Judgments of Need were to review the JHA to ensure it covers the work, to make any improvements, and to provide training to managers, supervisors, and union leadership in planning and managing safely to reduce injuries to zero. WTS is relying on their new metric “days since a lost work day incident” to measure overall effectiveness of the corrective action for the Type B Judgment of Need. The overall effectiveness of the corrective actions was evaluated during the 2005 annual WTS Integrated Safety Management System review.

The Board concludes that the WTS implementation of the corrective actions from past incidents and assessments have not been fully reviewed to determine if they were effective and sustainable to preclude recurrence.

The Board further concludes that prior knowledge of the accelerator pedal should have been identified as a near miss so that corrective actions could be addressed.

IV. ANALYSIS

A. Causal Factor Analysis

Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all accidents/events. Barriers are developed into a system or work process to protect personnel and equipment from hazards. For an accident/event to occur, there must be a hazard that comes into contact with the target (worker) because the barriers or controls were not in place, not used, or failed. A hazard is the potential for unwanted energy flow to result in an accident or other adverse consequence. A target is a person or object that a hazard may damage, injure, or fatally harm. A barrier is any means used to control, prevent, or impede the hazard from reaching the target, thereby reducing the severity of the resultant accident or adverse consequence. The results of the barrier analysis are used to support the development of the causal factors. The Board’s analysis is presented in Appendix C.

Change Analysis

Change is anything that disturbs the “balance” of a system that is operating as planned. Change is often the source of deviations in system operations. Change can be planned, anticipated, and desired, or it can be unintentional and unwanted. Change analysis examines planned or unplanned changes that caused undesired results or outcomes related to the event. The process analyzes the difference between what is normal (or “ideal”) and what actually occurred. The results of the change analysis are used to support the development of the causal factors. The Board’s analysis is presented in Appendix D.

Events and Causal Factor Analysis

An events and causal factors analysis was performed in accordance with the DOE Workbook Conducting Accident Investigations. The events and causal factors analysis requires deductive reasoning to determine which events and/or conditions contributed to the accident/event. Causal factors are the events or conditions that produced or contributed to the occurrence of the accident/event, and they consist of direct, contributing, and root causes.

The direct cause is the immediate event(s) or condition(s) that caused the accident/event. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the event but which did not cause this event. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar events.

The Board identified that the direct cause of this accident was the electric cart moving under the TRUPACT trailer, resulting in the employee being pinned between the TRUPACT trailer and the seat of the electric cart.

The Board identified the following seven contributing causes for this event:

- Job Hazard Analysis was not performed for the electric cart use on the surface.
- Training was not formal or complete.
- Formal inspections of electric carts were not required.
- Previously identified issues with the accelerator pedal activation were not communicated.
- Effectiveness of past corrective actions, including vehicle issues, was not evaluated.
- Oversight of vehicular safety has not been conducted by WTS or CBFO.
- Family Day resulted in unrecognized safety concerns.

The Events and Causal Factors Chart is provided in Appendix E.

Root Cause Analysis

Root cause analysis is a systematic process that uses the facts and results of the core analytic techniques to determine the most important reasons for the accident. The intent of the analysis is to address only those root causes that can be controlled within the system being investigated, excluding events or conclusions that cannot be reasonably anticipated or controlled, such as some natural disasters. Root cause analysis is primarily performed to resolve the question, “Why?”

The Board determined that the root causes of this incident were:

- The designed location of the electric cart acceleration pedal allowed a front seat passenger to engage the accelerator.
- Maintenance of electric carts did not meet the manufacturer's recommendation.
- Because WTS determined that the electric cart activity was low-risk and short-term, no hazard analysis was performed, controls were not implemented, and there was a lack of oversight. The Board determined this to be a systemic root cause. A systemic root cause is a deficiency in a management system that, if corrected, would prevent the occurrence of a class of accidents, not just those associated with electric carts.

Of these three root causes, the Board found that WTS's determination that the cart activity was low risk was the overarching and systemic root cause for this accident.

B. Requirements Verification Analysis

Requirements verification analysis is conducted after all the analytical techniques are completed and a draft of the report has been prepared. The analysis ensures that all portions of the report are accurate and consistent and verifies that the conclusions are consistent with the facts and judgments of need. The verifications analysis determines whether the flow from facts to analysis, conclusion, and judgments of need is logical. The conclusions and judgments of need are traced back to locate the facts to support the conclusions. The goal is to eliminate conclusions that are not based on facts. One approach is to compare the facts, analysis, conclusions, causes, and judgments of need on a wall chart, and then validate the continuity of facts through the analysis and conclusion to the judgments of need. This method also identifies any misplaced facts, insufficient analyses, and unsupported conclusions or judgments of need. This analysis tool was used by the Board; however, it is not included as part of the report.

C. Integrated Safety Management System

WTS has not applied Integrated Safety Management System core functions and guiding principles in the use of electric carts for performing work on the surface. Figure 10 provides a schematic of the Integrated Safety Management System steps that should have been in place for the use of electric carts with the surface activities at WIPP as they relate to the accident.

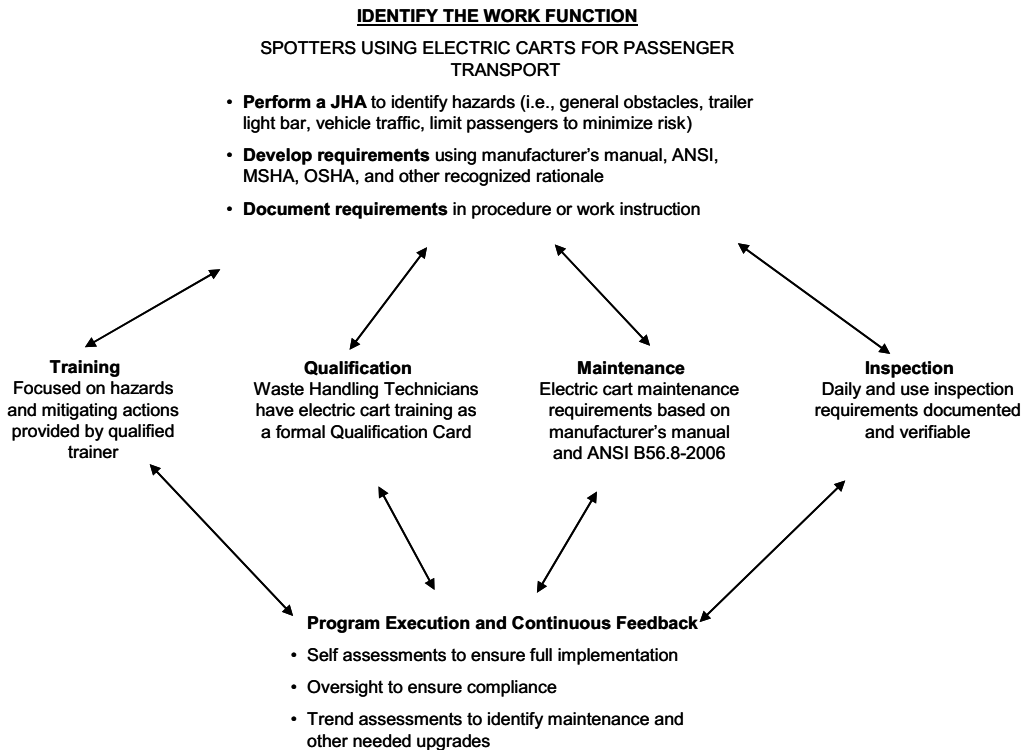


Figure 10: Integrated Safety Management System Steps for Use of Electric Carts

Define the Work

In 1994, an electric cart accident in the underground resulted in an occupational injury and the site responded by focusing on safety requirements for the use of electric carts in the underground. A JHA was developed for the use of electric carts in the underground and the resulting requirements were codified in the work instructions or work packages for the work activities being executed. The focus on the underground only is further evidenced by the fact that the electric cart training was initiated in 1994 and is performed by the Underground Controllers, versus the WTS Training Department.

Use of electric carts on the surface has not been a focus, and no hazard evaluations have been performed. As identified in the Facts and Board Conclusion Section, the spotter activity requiring the use of the electric cart was planned to be a temporary activity. As such, WTS did not identify the need to walk down the usage of the electric carts; however, the process became a permanent work step for moving trailers between the Parking Area Unit and the parking lot. The original purpose for the spotter was lost with time. After a period of 36 months, the spotters have become a part of the normally accepted process for moving TRUPACT trailers at the WIPP site.

Analyze the Hazards

Due to the WTS documented position in 2007 that the spotters were to be used for a three-month period, a job hazard analysis was not conducted. Some hazards are identified in the training for the use of electric carts in the CAR-101 course, but the use of the electric cart for spotter activities has

not been walked down to identify hazards associated with their use in moving the trailers and watching for inappropriate activation of the breaking system on the trailers. The hazard of traveling under the light bar of Trailer 373 could have been identified and mitigated by requiring the electric carts to slowly approach the TRUPACT trailers and to only park parallel to the light bar or on the side of the trailer.

Develop and Implement Controls

Without the analysis of hazards, adequate controls could not be established. In fact, during the Board interviews it was indicated that no procedural requirements have ever been documented for the spotters due to the “short term” need for their function.

Perform Work Safely

The observation of work activities by supervision is a key element in ensuring a safe workplace. In discussions with the Board, the WTS Waste Handling Technicians and management indicated that supervisors seldom if ever go to the front parking lot. This further demonstrates that the electric cart use was perceived as a low risk and below the threshold for management review and attention. The WTS General Manager indicated during the August 2008 Conduct of Operations stand down that “the little things – they have the habit of turning into big things.” The expressed expectation was that the WTS management team would focus on these low hazard activities.

The daily and use inspection of electric carts is informal and is not documented. Multiple data points indicate that these inspections do not have the required rigor. The Electric Cart 75-C-136 involved in the accident had a automatic seat brake switch that did not work and a non-functioning back-up alarm. When Electric Cart 75-C-135 was selected by the Board for use as a like model, the brake light and the back-up alarm were not working. On the day of the accident, WTS initiated a stand down of electric cart usage until a pre-operation inspection was performed. Twelve of the estimated 143 electric carts on site were found to have deficiencies and were taken out of service. It is not clear how all these deficiencies were missed in the daily inspection process.

Feedback and Improvement

Multiple workers indicated that they have experienced placing their foot too far to the left while in the front passenger seat of the electric carts, or that while driving their passenger began to accelerate the electric cart. No reports of this information were presented to management or on the WIPP Forms process.

One WTS manager challenged the continuation of the spotters after the 2-month period. The previous WTS Operations Manager made the decision to continue without assessing the hazards and risk of this activity and the resource expenditures.

Vehicle safety has not been an oversight topic for the CBFO or for WTS for several years. In 2004, WTS implemented a Vehicle Incident Team to assess any moving vehicle. This team focused on parking and storing of vehicles and also addressed electric cart access parking requirements. No effectiveness reviews have been performed to document the implementation of the corrective actions. In August 2008, WTS executed a conduct of operations stand down due to forklift and

other vehicle incidents. This further illustrates the ineffective implementation of the previous corrective actions. These trends and ineffective implementation have not been adequately considered by CBFO and WTS in their oversight program assessment formulations.

CBFO oversight has included programmatic reviews conducted by program managers and Facility Representatives daily site reviews. However, the 2008 assessments only included one Fire Protection review and one continuous air monitoring review, and does not demonstrate a comprehensive review of the contractor's safety and health functions. In 2009 there are assessments scheduled for fall protection, confined space, electrical safety, Job Hazard Analysis, mining and HAZCOM. This new schedule demonstrates some improvement in the review of the contractor's safety related areas but it is important that full execution of these scheduled assessments take place to ensure continued improvement. However, assessments of vehicle safety need to be considered.

In 2008 the WTS oversight consisted of multiple individual organization assessments that were further supplemented by the WTS Expert Review to evaluate overall performance of the organization. Lockout/Tagout and several Mine Safety and Health Administration quarterly inspections were the only safety topics reviewed in 2008. This oversight performance for 2008, combined with the limited DOE oversight, does not ensure that all of the programmatic safety functions are being evaluated to identify areas for continuous improvement.

In 2009 the WTS Management Assessment Schedule includes safety programmatic topics such as fall protection, lockout/tagout, and confined space. The Acting Manager for Environment, Safety and Health indicated to the Board that this schedule was compliance-based and focused on needs identified through operating experience and performance. No documented basis was provided. The 2009 schedule has already experienced some delays and postponements.

It is therefore critical that both CBFO and WTS continue to increase their oversight of safety-related areas in order to provide for continuous improvement and enhanced feedback and improvement, especially in the area of vehicle safety.

The Board concludes that assessments of vehicle safety have not been a part of the WTS and CBFO oversight systems.
--

The feedback processes associated with the electric carts and with the ongoing DOE and WTS oversight have areas for improvement to meet the Integrated Safety Management System expectations.

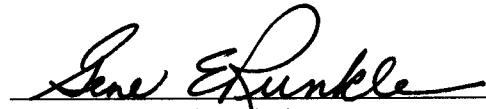
The Board concludes that overall implementation of the Integrated Safety Management System for the use of electric carts was insufficient.
--

V. CONCLUSIONS AND JUDGMENTS OF NEED

Conclusions	Conclusions
<p>The designed location of the electric cart acceleration pedal contributed to the accident.</p>	<p>WTS needs to install the manufacturer's approved retrofit for the electric cart accelerator to prevent inadvertent engagement by the passenger.</p>
<p>Maintenance of the electric carts did not include the periodic drive chain adjustment, as well as the semi-annual and annual maintenance items established by the manufacturer.</p> <p>The combination of the accelerator being depressed and the existing conditions of Electric Cart 75-C-136 (loose drive chain and worn brake linings) resulted in an override of the braking system.</p>	<p>WTS needs to incorporate and implement the manufacturer's recommendations in the maintenance and servicing of the electric carts.</p>
<p>A Job Hazard Analysis has not been performed for surface electric cart use and, as a result, the appropriate controls were not implemented.</p> <p>Spotter activities were not analyzed for the hazards associated with the task to ensure appropriate controls were implemented, and were performed for some 34 months past the WTS documented endpoint.</p> <p>Overall implementation of Integrated Safety Management Systems for the use of electric carts was insufficient.</p>	<p>WTS needs to enhance its job hazard process to analyze task-level activities based on a formal risk-based approach, as a part of its Integrated Safety Management System program.</p> <p>WTS needs to evaluate the continued need for the spotter activities. (This Judgment of Need is consistent with the WTS recommendation from its initial investigation.)</p>
<p>The training of workers in electric cart use is not provided by the Training Department and is not part of the Waste Handling Technician's Qualification Card.</p> <p>The qualifications for electric cart drivers as defined in ANSI B56.8-2006 are not incorporated in the Vehicle Safety Program.</p>	<p>WTS needs to establish a formal training and qualification process for electric cart operators to meet manufacturer's and ANSI B56.8-2006 requirements.</p>
<p>The WTS Vehicle Safety Program did not incorporate the needed requirements for surface use of the electric carts, similar to those developed for underground use.</p> <p>The pre-operation and/or pre-use inspections of electric carts were not performed consistently.</p> <p>A Job Hazard Analysis has not been performed for surface electric cart use and, as a result, the</p>	<p>WTS needs to improve the Vehicle Safety Program to include information from 10 CFR 851, the manufacturer's requirements, ANSI B56.8-2006, and other related standards establishing the onsite requirements for inspection and the resulting procedures.</p>

Conclusions	Conclusions
<p>appropriate controls were not implemented.</p> <p>Assessments of vehicle safety have not been a part of the WTS oversight systems.</p>	
<p>Prior knowledge of the accelerator pedal should have been identified as a near miss so that corrective actions could be addressed.</p>	<p>WTS needs to provide and continue to reinforce the expectation to report routine safety occurrences through the WIPP Form, and close call program.</p>
<p>Family Day creates additional tasking issues, supervisory challenges, and possible safety concerns when all the workers are present.</p>	<p>WTS needs to evaluate the effects of Family Day on work activities.</p>
<p>WTS oversight has not been extended to the safety and health programs to establish that they include the technical requirements for the work activities and to determine effective implementation of requirements at the worker task level.</p> <p>WTS implementation of corrective actions from past incidents and assessments has not been fully reviewed to determine if the corrective actions were effective and sustainable to preclude recurrence.</p> <p>Assessments of vehicle safety have not been a part of the WTS oversight systems.</p>	<p>WTS needs to enhance its oversight program to meet the contractor requirements documented in DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>, to ensure that completed corrective actions are effective and sustainable.</p>
<p>CBFO has not effectively ensured that the WTS has a credible, rigorous, and robust oversight program as outlined in DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>.</p> <p>Assessments of vehicle safety have not been a part of the CBFO oversight systems.</p>	<p>CBFO needs to improve its contractor oversight program to ensure that WTS meets DOE O 226.1A, <i>Implementation of Department of Energy Oversight Policy</i>.</p>
<p>The Board concludes that the overall emergency response was timely, proficient, and executed in an exemplary manner.</p>	<p>None</p>
<p>WTS site readiness and accident scene preservation generally met the intent of DOE O 225.1A, <i>Accident Investigations</i>.</p>	<p>None</p>

BOARD SIGNATURES



Gene E. Runkle, Chairperson
DOE Accident Investigation
Board Chairperson
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington D.C.



Don Galbraith
DOE Accident Investigation
Member
U.S. Department of Energy
Carlsbad Field Office



Erin Preciado
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Member
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Carlsbad Field Office



Nathan Morley, CQA, CMQOE
DOE Accident Investigation
Analyst/Member
U.S. Department of Energy
National Nuclear Security Administration/
Service Center

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VI. BOARD MEMBERS, ADVISORS, AND STAFF

Chairperson	Gene Runkle, DOE RW-9
Accident Investigator/Member	Don Galbraith, DOE CBFO
Accident Investigator/Member	Erin Preciado, DOE CBFO
Analyst/Member	Nathan Morley, CQA, NNSA/SC
Advisor	Ralph Fevig, Sandia National Laboratories
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WTS Liaison	Mary Ann Mullins, WTS
	Amy Navarrete-Boyea, CDI
Administrative Support	Danette Harvill, CTAC
United Steel Workers 12-9477 Interface	Juan Garza III
	Pedro (Pete) Navarrete
	Justin Kirkes, Safety Representative

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Appendix A – ORPS Report of the Accident

Occurrence Report After 2003 Redesign

Waste Isolation Pilot Plant

(Name of Facility)

Nuclear Waste Operations/Disposal

(Facility Function)

Carlsbad Field Office

Washington TRU Solutions, LLC.

(Site)

(Contractor)

Name: Knox, Jeff W.

Title: TECHNICAL COORDINATOR

Telephone No.: (575) 234-8462

(Facility Manager/Designee)

Name: LONG, MARK L

Title: OPERATIONS ENGINEER

Telephone No.: (575) 234-8170

(Originator/Transmitter)

Name:

Date:

(Authorized Classifier (AC))

1. Occurrence Report Number: EM-CAFO--WTS-WIPP-2009-0003

Employee Injured While Riding in an Electric Cart

2. Report Type and Date: UPDATE

	Date	Time
Notification:	02/27/2009	18:58 (ETZ)

Initial Update:	03/04/2009	15:51 (ETZ)
Latest Update:	03/25/2009	13:20 (ETZ)
Final:		(ETZ)

3. Significance Category: 2

4. Division or Project: WTS/WIPP

5. Secretarial Office: EM - Environmental Management

6. System, Bldg., or Equipment: Facility 200

7. UCNI?: No

8. Plant Area: Site Parking Area

9. Date and Time Discovered: 02/25/2009 12:17 (MTZ)

10. Date and Time Categorized: 02/25/2009 12:48 (MTZ)

11. DOE HQ OC Notification:

Date	Time	Person Notified	Organization
NA	NA	NA	NA

12. Other Notifications:

Date	Time	Person Notified	Organization
02/25/2009	12:48 (MTZ)	Facility Shift Manager	WTS
02/25/2009	13:03 (MTZ)	Facility Representative	DOE/CBFO
02/25/2009	12:17 (MTZ)	Facility Manager Designee	WTS
02/25/2009	12:17 (MTZ)	Facility Manager	WTS

13. Subject or Title of Occurrence:

Employee Injured While Riding in an Electric Cart

14. Reporting Criteria:

2A(6) - Any single occurrence resulting in a serious occupational injury. A serious occupational injury is an occupational injury that:

- (a) Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received;
- (b) Results in a fracture of any bone (except simple fractures of fingers, toes, or nose, or a minor chipped tooth);
- (c) Causes severe hemorrhages or severe damage to nerves, muscles, or tendons;
- (d) Damages any internal organ; or
- (e) Causes second- or third-degree burns, affecting more than five percent of the body surface.

10(1) - Any event resulting in the initiation of a Type A or B investigation as categorized by DOE O 225.1A, ACCIDENT INVESTIGATION.

Note: This reporting criterion may raise the significance category of an occurrence already reported under separate criteria. Multiple reporting criteria should be noted when appropriate.

15. Description of Occurrence:

On February 25, 2009, at approximately 0830, a WIPP Waste Handling (WH) technician sustained internal injuries when he was riding in an electric cart.

Four WH personnel were moving trailers, loaded with empty waste containers, to the WIPP Site parking lot and preparing unloaded waste shipment trailers for transport from the parking lot to the Parking Area Unit (PAU). The four WH personnel consisted of a Trailer Jockey Operator and three WH technicians that were performing equipment escort and spotter duties. After assisting the Trailer Jockey Operator with the movement and placement of a loaded trailer, the three WH Technicians proceeded down the trailer line in an electric cart (75-C-136) to prepare the next empty/unloaded trailer (Trailer 373) for transport to the PAU for empty container loading. The three WH Technicians on the electric cart were located in the driver, front passenger and rear seats.

As the cart approached the front of Trailer 373, the driver began applying the brakes in order to slow down and stop in front of the trailer. Approximately six feet from the front of the trailer, the driver stated that the cart acted like the accelerator was stuck so he applied more pressure to the brake pedal. The additional pressure did not stop the cart. The driver attempted to turn away from the trailer (left turn)

when he realized the cart would not stop. The short distance between the cart and trailer did not allow the entire cart to avoid the trailer and the front passenger was caught between the front of the trailer and the cart's seat back. The cart continued to push forward for approximately 2-3 seconds before it stopped. The cart driver used his hands and arms to push the cart backwards. Once the cart was pushed back, the front seat passenger exited the cart and relayed that he was in pain before dropping to the ground. The driver noticed that the injured passenger was having difficulty breathing. The injured (front seat) passenger laid down on the asphalt and the rear seat passenger, a trained Mine Rescue Responder, began primary patient care.

A second cart, containing WH Technicians, arrived at the scene to see if there was a problem. Those WH Technicians began making the initial notifications to the Central Monitoring Room, site Emergency Services and the WH Manager.

Emergency Services personnel were dispatched to the scene and provided on-scene treatment and preparation for transport to the local hospital. The local hospital was notified and a request was made to transfer the patient in-route. At approximately 0901, the site ambulance left the site and proceeded towards town. The WIPP ambulance met the local hospital (Carlsbad Medical Center) ambulance in route and the transfer was made.

At 1217 hours, the WTS Facility Manager was notified that the injured employee had sustained internal injuries (liver). At 1248 hours, the Facility Manager categorized this incident as Group 2, Subgroup A(6) 3(d). NOTE: This categorization could change as additional information becomes available.

Doctors at the Carlsbad Medical Center determined that the patient should be transported by air to the University Hospital in Lubbock, Texas for additional observation and availability of better medical equipment. The employee was transferred at approximately 1230 hours on 02/25/2009.

UPDATE 3/4/09: The injured employee was discharged from the University Hospital in Lubbock, Texas at approximately 1645 hours on March 3, 2009.

The Carlsbad Field Office (CBFO) has verbally notified the contractor (Washington TRU Solutions, LLC (WTS)) that a Type B investigation will be conducted based on the requirements identified in DOE Order 225.1A and that the CBFO Appointing Official is in the process of selecting an Accident Investigation Board.

This occurrence was initially categorized as a 2A(6)3 in the Notification Report based on known information at that time (damage to internal organ and hospitalization for more than 48 hours). The categorization has been upgraded to a 10(1)2 due to the Type B Investigation determination.

WTS has contacted the electric cart manufacturer (Taylor-Dunn) to discuss any observed problems with the Taylor-Dunn, Model B2-10 electric cart and to gain additional information that might pertain to this occurrence.

UPDATE 3/25/09: This update is to clarify that the WIPP ambulance was met by the Carlsbad dispatched (Carlsbad Fire Department) ambulance in route and the transfer of the patient was made.

16. Is Subcontractor Involved? No

17. Operating Conditions of Facility at Time of Occurrence:

Does not apply

18. Activity Category:

03 - Normal Operations (other than Activities specifically listed in this Category)

19. Immediate Actions Taken and Results:

Provided on-site primary care to the injured employee.

Cart driver was taken to site nurse for medical evaluation.

Secured and photographed the accident scene.

Employee statements were taken and follow-up interviews were conducted.

WTS Waste Handling manager, Human Resources representative and Health Services nurse provided support at Carlsbad Medical Center.

WTS Management dispatched a manager and site nurse to the medical facility in Lubbock, Texas to assist patient and patient's family.

Suspended all cart use until inspections were conducted. Cart inspections included operability checks on brakes, throttle mechanisms, control switches, etc.

On-scene examination of cart 75-C-136 was performed.

Cart 75-C-136 was transported to the Maintenance Shop for thorough evaluation.

An Event Critique was held at 0800 on 02/26/09 to establish timelines, gather information, develop immediate corrective actions and discuss the event.

WTS Management created an Accident Investigation Team to gather additional incident information.

20. ISM:

- 2) Analyze the Hazards
- 3) Develop and Implement Hazard Controls
- 4) Perform Work Within Controls

21. Cause Code(s):

22. Description of Cause:

23. Evaluation (by Facility Manager/Designee):

An Event Critique was held at 0800 on 02/26/09 to establish timelines, gather information, develop immediate corrective actions and discuss the event.

The event description and timelines identified during the Critique are identified in the Description of Occurrence section of this report.

Event causes identified during the Critique are listed below:

- 1) Hazards not recognized.
- 2) Employees unfamiliar with the Job Hazard Analysis (JHA) for this evolution.
- 3) JHA was less than adequate and did not include cart escort as part of the evolution.

Corrective Actions identified during the Critique are listed below:

- 1) A Stand-down was issued for trailer moving activities until the JHA can be reviewed and appropriate revisions are incorporated.
- 2) Perform an Extent of Condition for JHA review and implementation process.
- 3) Review and verify electric cart operators qualifications.
- 4) Evaluate the need for carts used as vehicle escorts.
- 5) Develop Lessons Learned and conduct briefings for the following:
 - 5a.) Importance of detailed logkeeping in order to reconstruct event timelines;
 - 5b.) Incident Scene organization and security;
 - 5c.) Mobile equipment operators concerning body placement, pinch points and visual awareness of work area;
 - 5d.) Reinforcement of Notification requirements.
- 6) Evaluate the condition and operability of Waste Handling radios.
- 7) Perform a Root Cause Analysis for this event.

The causes and corrective actions listed above were identified in the Critique and are not listed in the Cause, Description of Cause and Corrective Actions section of this report. The causes, appropriate cause codes, corrective actions and site tracking numbers will be incorporated in this report after the Root

Cause Analysis has been conducted and the Corrective Action Plan has been approved.

UPDATE 3/4/09: The injured employee was discharged from the University Hospital in Lubbock, Texas at approximately 1645 hours on March 3, 2009.

The Carlsbad Field Office (CBFO) has verbally notified the contractor (Washington TRU Solutions, LLC (WTS)) that a Type B investigation will be conducted based on the requirements identified in DOE Order 225.1A and that the CBFO Appointing Official is in the process of selecting an Accident Investigation Board.

This occurrence was initially categorized as a 2A(6)3 in the Notification Report based on known information at that time (damage to internal organ and hospitalization for more than 48 hours). The categorization has been upgraded to a 10(1)2 due to the Type B Investigation determination.

The WTS Accident Investigation Team that was formed on 02/25/09, is finalizing a written report. The final report will be submitted to the Type B Accident Investigation Board before they begin the Type B investigation.

WTS has contacted the electric cart manufacturer (Taylor-Dunn) to discuss any observed problems with the Taylor-Dunn, Model B2-10 electric cart and to gain additional information that might pertain to this occurrence.

24. Is Further Evaluation Required?: Yes

If YES - Before Further Operation? No

By whom? Operations

By when?

25. Corrective Actions

(* = Date added/revised since final report was approved.)

26. Lessons Learned:

27. Similar Occurrence Report Numbers:

[EM-ALO--WWID-WIPP-1994-0003](#)

[EM-ALO--WTS-WIPP-2004-0011](#)

[EM-RP--BNRP-RPPWTP-2007-0014](#)

28. User-defined Field #1:

29. User-defined Field #2:

30. HQ Keyword(s):

08D--OSHA Reportable/Industrial Hygiene - Injury
10B--Transportation - Vehicle Accident
12H--EH Categories - Injuries Requiring Medical Treatment Other Than First Aid
13A--Management Concerns - HQ Significant (High-lighted for Management attention)
13C--Management Concerns - Accident Investigation - Type B
14L--Quality Assurance - No QA Deficiency

31. HQ Summary:

On February 25, 2009, a WIPP Waste Handling technician sustained internal injuries when he was riding in an electric cart that went out of control and hit an unloaded trailer. The technician who was in the front seat was caught between the front of the trailer and the seat back. An ambulance took the injured technician to the Carlsbad Medical Center where doctors diagnosed internal injuries (liver). The technician was later transported by air to the University Hospital in Lubbock, Texas for additional observation and availability of better medical equipment. The technician was one of three people in the electrical cart. As the driver applied the brakes in order to slow down and stop in front of the trailer, the cart acted as if the accelerator was stuck. Additional brake pressure failed to stop the cart and the short distance between the cart and trailer did not allow the entire cart to avoid hitting the trailer. All cart use was suspended until inspections are conducted. A critique was held and, after five days of hospitalization for the injured worker, a Type B Accident Investigation was convened.

32. DOE Facility Representative Input:

33. DOE Program Manager Input:

Appendix B – Type B Investigation Board
Appointment Memorandum

United States Government

Department of Energy

memorandum

Carlsbad Field Office
Carlsbad, New Mexico 88221

DATE: March 12, 2009

REPLY TO
ATTN OF: CBFO:OOM:VD:AAC:09-0006:UFC1100.00

SUBJECT: Type B Accident Investigation-Employee Injured While Riding in an Electric Cart, Final Board

TO: Gene E. Runkle, DOE Office of Civilian Radioactive Waste Management

You are hereby appointed Chairperson of the Type B Investigation Board (Board) to investigate the subject accident that occurred at the Waste Isolation Pilot Plant in Carlsbad, New Mexico on February 25, 2009. I have determined this accident meets the requirements established for a Type B accident investigation in the Department of Energy (DOE) DOE Order 225.1A, ACCIDENT INVESTIGATIONS, dated September 29, 1997. After your arrival, we have established that the Board will be comprised of the following members:

- Nathan Morley, NNSA Service Center, Analyst/Member
- Ralph Fevig, Sandia National Laboratories, Technical Advisor/Member
- Don Galbraith, Carlsbad Field Office, Accident Investigator/Member
- Erin Preciado, Carlsbad Field Office, Accident Investigator/Member

The Board will be assisted by advisors and consultants and by other support personnel, as you deem necessary. If additional resources are required to assist you in completing this task, please let me know and they will be provided.

The accident investigation will be conducted consistent with DOE O 225.1A, *Accident Investigations*, and DOE G 225.1A-1, *Implementation Guide for Use with DOE Order 225.1A, Accident Investigations*. The scope will include the review of the information developed by the WIPP Contractor Washington TRU Solutions (WTS) on the accident prior to the notification that DOE would conduct a Type B investigation, causal factors, an independent site investigation, interviews, and analysis as necessary.

The Board should provide me and the Deputy Manager, Vernon Daub, with weekly informal reports on the status of the investigation, but shall not include any conclusions until an analysis of all the causal factors have been completed. Draft copies of the factual portion of the investigation report should be submitted to my office and WTS for factual review prior to report finalization.

The final investigation report should be provided to me on or before April 1, 2009. Any proposal to change this date should be justified and sent to this office. Discussions of the investigation and copies of the draft report should be controlled until I authorize release of the final report. For additional information on this occurrence, please reference the ORPS Report Number EM-CAFO-WTS-WIPP-2009-0003, titled *Employee Injured While Riding in an Electric Cart*. If you have any questions, please contact Vernon Daub at (575) 234-7303.

Thank you for agreeing to assist the Carlsbad Field Office and WTS in this important matter.



David C. Moody
Manager

cc:

G. Podonsky, HS-1	*ED
C. Lewis, HS-31,	ED
D. Pegram, HS-31	ED
R. Goldsmith, EM-62	ED
N. Morley, NNSA	ED
V. Daub, CBFO	ED
D. Galbraith, CBFO	ED
J. Ford, CBFO	ED
CBFO M&RC	

*ED denotes electronic distribution

Appendix C – Barrier Analysis

Barrier Analysis

Hazard: Caught between Trailer and Electric Cart			Target: Waste Handler
What were the barriers?	How did each barrier perform?	Why did the barrier fail?	How did the barrier affect the accident?
A guard to prevent accessibility of the accelerator pedal by passenger.	There is no guard between the driver and the passenger preventing passenger access to the accelerator pedal.	The design of the equipment did not take into account this issue. According to the manufacturer, there have been no issues associated with this design	<ul style="list-style-type: none"> The passenger inadvertently stepped on the accelerator while the driver was braking. The accelerator overrode the brake and caused a jerking motion without bringing the electric cart to a complete stop.
The cab option installed on the electric cart.	The cab was not installed.	The electric carts are mainly used underground, where the cab option would keep the workers from inspecting the back of the mine. The cab option is not designated for passenger protection; however, it could have slowed the electric cart.	The cab option would have lessened the speed of the electric cart.
A designated space between the trailers and electric cart travel.	The designated space was not identified.	A JHA was not conducted for this task with the electric carts operating around the protruding trailers.	Without restricting the electric cart access to parts of the trailer while parking, the driver and passenger were exposed to being caught beneath the trailer should the electric cart fail to stop.
Training of the drivers.	The Electric Cart Drivers were not trained or qualified per ANSI B56.8 to meet WTS requirements.	<p>Training was not formal, as is the heavy equipment training.</p> <ul style="list-style-type: none"> The training did not include the requirements established by the manufacturer. No qualification card for drivers. One time only. No refresher training required. 	<ul style="list-style-type: none"> Training did not keep the electric cart drivers proficient in the recognition of hazards. Training did not keep the electric cart drivers knowledgeable of WTS requirements for inspections and operations of electric carts.
Maintenance of the electric cart per manufacturer's requirements.	Maintenance is performed quarterly.	The manufacturer's manual was not reviewed prior to establishing the required frequency.	The brake and drive train systems were not fully maintained, to manufacturer's manual possibly causing operating issues.

Barrier Analysis

Hazard: Caught between Trailer and Electric Cart		Target: Waste Handler	
What were the barriers?	How did each barrier perform?	Why did the barrier fail?	How did the barrier affect the accident?
Pre-operations/pre-use inspections.	Inspections are not thorough.	No formal requirement or checklist provided to conduct inspections.	Safety deficiencies are not found and corrected.
Procedures established.	Operations near equipment were not well defined.	The manufacturer's manual was not reviewed to develop safety requirements and procedures.	The driver was not aware of the hazards present in the parking lot and around other protruding equipment areas.
Hazard Analysis	JHA was not performed for the electric cart activity on the surface. The JHA for the electric cart activity underground did not analyze the "caught between" hazard.	The activity was to be short-duration. The manufacturer's manual was not reviewed to assist in the JHA development.	<ul style="list-style-type: none"> • Work was not assessed to identify changes and hazards. • The analysis should have considered the barriers to keep the electric carts from traveling under the trailers, other equipment, and structures.
Oversight	Oversight was not performed.	Oversight was focused on high-level corporate programs such as Integrated Safety Management, conduct of operations. The oversight did not look at programmatic areas such as vehicle safety.	Oversight of vehicular safety at the worker level could have identified unsafe driving actions as well as possible safety issues (protruding equipment).
Lessons Learned	Lessons learned are developed from incidents, but follow-up was not incorporated. Incidents concerning passengers inadvertently stepping on the accelerator were not given to management.	A vehicle incident team was formed in 2004 to follow up on vehicular incidents, but sustainability was not incorporated.	Without the continued follow-up, it was not known if the corrective actions were successful and effective.

Appendix D – Change Analysis

Change Analysis

Accident Situation	Prior, Ideal, or Accident Free Situation	Difference	Evaluation of Effect
Electric cart would not stop before going under trailer.	Electric cart stops before trailer.	<ul style="list-style-type: none"> • Electric cart did not stop as expected 	<ul style="list-style-type: none"> • Front of electric cart slides under trailer.
Electric cart arrived perpendicular to trailer.	Electric cart arrives parallel to trailer.	<ul style="list-style-type: none"> • Electric cart can slide under trailer if cart fails to stop. 	<ul style="list-style-type: none"> • Electric cart slid under trailer before stopping.
Electric cart left rear break pad loose.	Electric cart break pad securely fastened.	<ul style="list-style-type: none"> • Electric cart breaking system not correct. 	<ul style="list-style-type: none"> • Electric cart did not stop before sliding under the trailer crushing the Passenger.
Electric cart drive chain loose.	Electric cart drive chain tight	<ul style="list-style-type: none"> • Chain intermittently engaged. • Electric cart stopped correctly after replacing drive chain and brakes. 	<ul style="list-style-type: none"> • Electric cart jerking and makes noise. • Electric cart did not stop before crushing the Passenger.
Electric cart receives quarterly preventative maintenance.	Electric cart receives annual and semi-annual as suggested by the manufacturer, in addition to the quarterly preventative maintenance.	<ul style="list-style-type: none"> • Electric cart only receives quarterly preventative maintenance identified by WTS personnel. 	<ul style="list-style-type: none"> • Electric cart may not be in full operable condition.
Electric cart left outside since 1999.	Electric cart kept out of the elements to the extent possible.	<ul style="list-style-type: none"> • Electric carts exposed to rain, snow, dust, and the salt environment. • Parts on electric carts rusted and show signs of wear. 	<ul style="list-style-type: none"> • Electric cart may not be in adequate condition.
Backup alarm disconnected.	Backup alarm connected and functioning.	<ul style="list-style-type: none"> • Personnel did not realize backup alarm not working. • There is no procedure to inspect backup 	<ul style="list-style-type: none"> • Electric cart may not be in adequate condition. • Promotes laissez-faire attitude in ensuring electric carts can be operated safely.
Automatic seat brake switch inoperable.	Automatic seat brake switch operable.	<ul style="list-style-type: none"> • Automatic seat brake switch not available to stop cart. • Automatic seat brake switch not required to be a part of daily inspection. 	<ul style="list-style-type: none"> • Electric cart slid under trailer before cart would stop. • Automatic seat brake switch not known to be operable.

Change Analysis

Accident Situation	Prior, Ideal, or Accident Free Situation	Difference	Evaluation of Effect
Job hazard analysis did not address all hazards.	Hazard analysis completely addresses all hazards.	<ul style="list-style-type: none"> • Use of electric carts treated as low hazard • Process does not address hazards associated with an open electric cart. • Hazard of pulling up perpendicular to trailer not addressed. • Complacent attitude on use of electric carts. 	<ul style="list-style-type: none"> • Process does not prevent pulling up perpendicular to the front of the trailer. • Electric cart could not stop before sliding under trailer.
No radios present.	Operable radios present at site.	<ul style="list-style-type: none"> • Radios could not be used to call for assistance. • Personal cell phone had to be retrieved from employee's car to call Central Monitoring Room Operator. • 2nd set of Waste Handling Technicians had to return to guard station. • Radios are required for training purposes only. 	<ul style="list-style-type: none"> • Waste Handling Technicians needed to find and use a persons cell phone and could not call for assistance immediately. • Emergency response may have been delayed. • Effect limited because a personal cell phone was quickly made available and used to call Central Monitoring Room Operator.
2 nd set of Waste Handling Technicians called Supervisor first.	Waste Handling Technicians call Central Monitoring Room Operator.	<ul style="list-style-type: none"> • All Waste Handling Technicians did not remember to call Central Monitoring Room Operations first. 	<ul style="list-style-type: none"> • Emergency response may have been delayed. • Effect limited because Central Monitoring Room Operator was able to be contacted using a personal cell phone.
Accelerator pedal easily reachable by Passenger.	Accelerator pedal not reachable by Passenger.	<ul style="list-style-type: none"> • Passenger able to engage accelerator without any knowledge of driver or passenger. 	<ul style="list-style-type: none"> • Passenger engaged accelerator while driver trying to stop the electric cart. • Electric cart could not stop before crushing passenger between the trailer and the electric cart seat.

Change Analysis

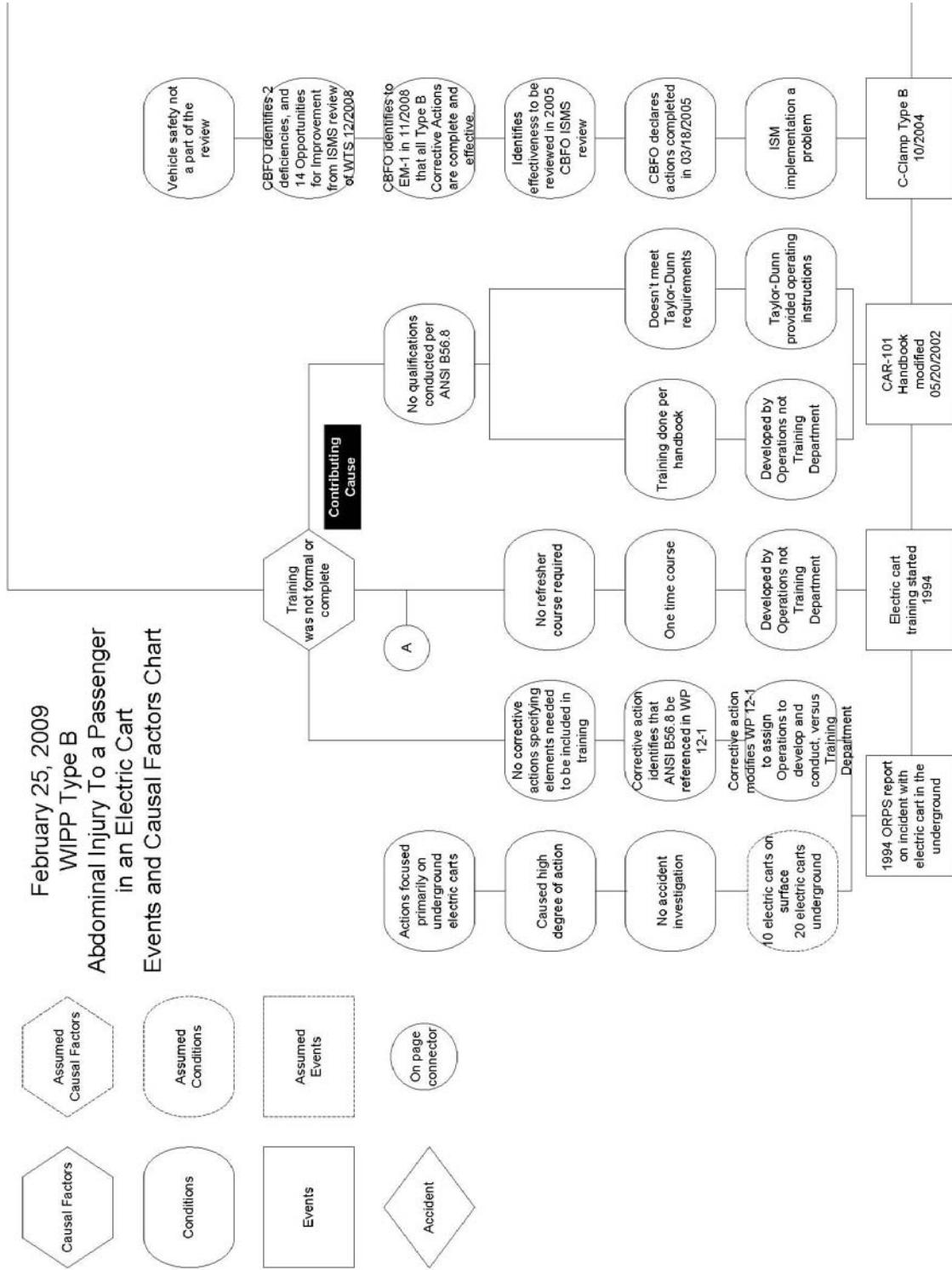
Accident Situation	Prior, Ideal, or Accident Free Situation	Difference	Evaluation of Effect
Lesson plan did not address manufacturer's recommendations	Lesson plan addresses manufacturer's recommendations.	<ul style="list-style-type: none"> Training did not address all the potential issues identified by the manufacturer. Site identifies only those hazards determined to be applicable to the site. 	<ul style="list-style-type: none"> All important controls addressing potential hazards were not made known to the electric cart drivers.
No formal pre-op inspection of electric cart activity associated before use	Pre-ops on electric carts formally defined and utilized before use.	<ul style="list-style-type: none"> Problem with automatic seat brake switch not detected. Could not override accelerator. Problem with backup alarm not detected. 	<ul style="list-style-type: none"> Possible mechanical problems not identified Electric cart slid under trailer.
Back in trailer parking.	Pull through trailer parking.	<ul style="list-style-type: none"> Need spotter to backup some trailers into position. Easier to pull through versus backing up. Spotter needed to go with Trailer Jockey Operator. 	<ul style="list-style-type: none"> A spotter using an electric cart is needed, exposing a worker to the hazard. Accident would not have occurred. Electric cart slid under trailer.
Spotter activity for locked tires continued for 36 months.	Spotter activity to be discontinued following 3 months of no locked tire issues.	<ul style="list-style-type: none"> Electric carts not needed to spot for locked tires. Spotter activity became the norm. WTS not being active in identifying cut offs for limited duration activity. 	<ul style="list-style-type: none"> Individuals continued to be exposed to a hazard for a task that was no longer needed. Spotter unnecessarily exposed to hazard. Electric cart slid under trailer. Accident would not have occurred.
One time training required.	Refresher training required.	<ul style="list-style-type: none"> Drivers of electric carts are not reminded of their responsibilities while operating electric carts. Drivers of electric carts are not provided updates to WTS electric cart regulations and practices. Updates in CAR-101 Handbook are not given to electric cart drivers. 	<ul style="list-style-type: none"> Electric cart drivers are not up to date on current WTS safety practices for use of electric carts.

Change Analysis

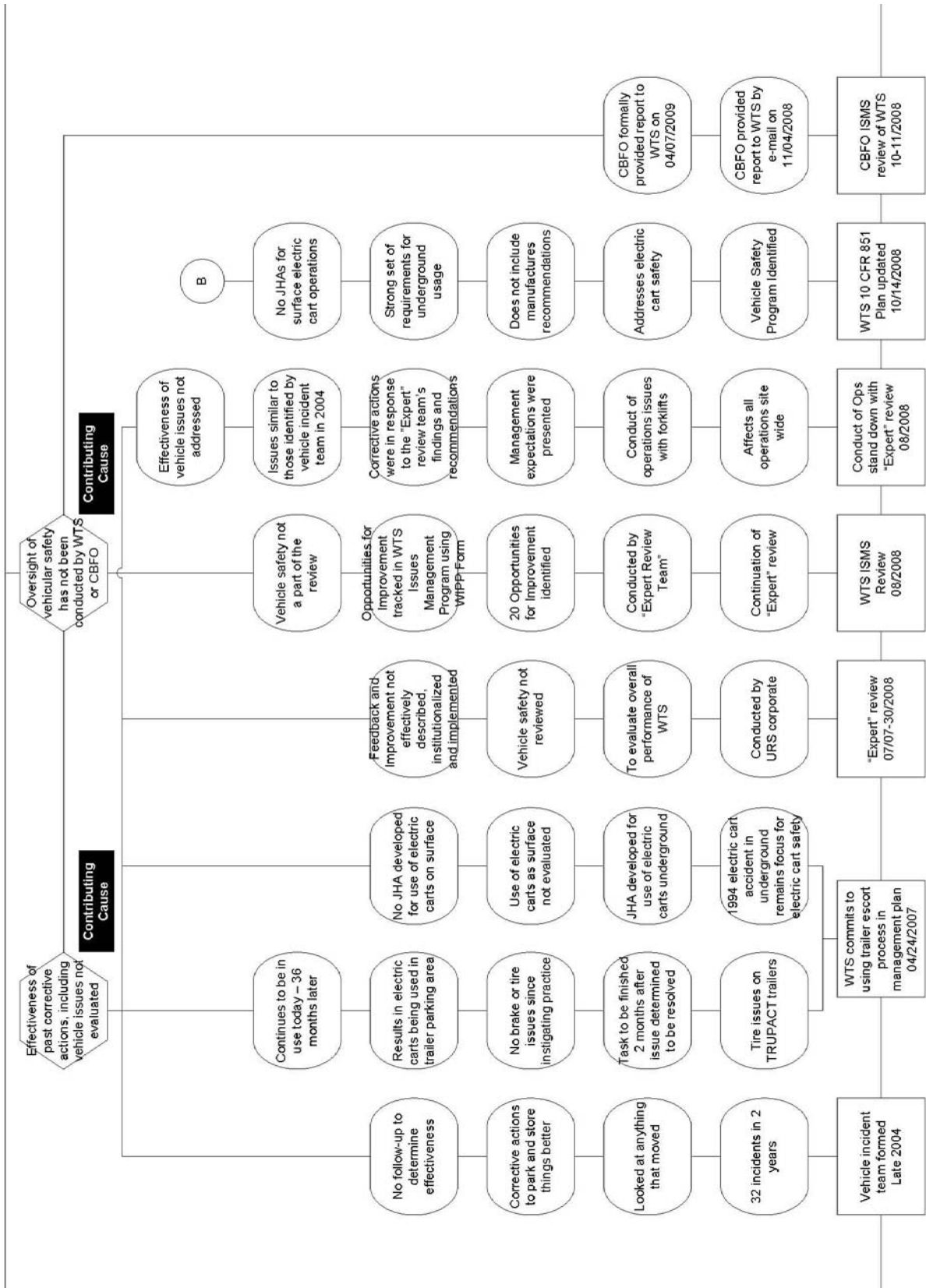
Accident Situation	Prior, Ideal, or Accident Free Situation	Difference	Evaluation of Effect
No electric cart qualifications per ANSI 56.8	Electric cart qualifications established.	<ul style="list-style-type: none"> There is no formal mechanism to ensure users of electric carts have the latest information involving the safe use of electric carts as a part of job performance. 	<ul style="list-style-type: none"> Electric cart drivers are not up to date on current WTS safety practices for use of electric carts pertaining to their positions.
Vehicle safety training developed and conducted by the Operations Department with little involvement from the Training Department.	The Training Department is involved in vehicle safety training to ensure the training meets its requirements for course development and implementation.	<ul style="list-style-type: none"> Training course requirements identified for other on-site training are not required for CAR-101. Training Department cannot assure that CAR-101 meets site training requirements. 	<ul style="list-style-type: none"> CAR-101 not identified as official training.

Appendix E – Events and Causal Factors
Chart

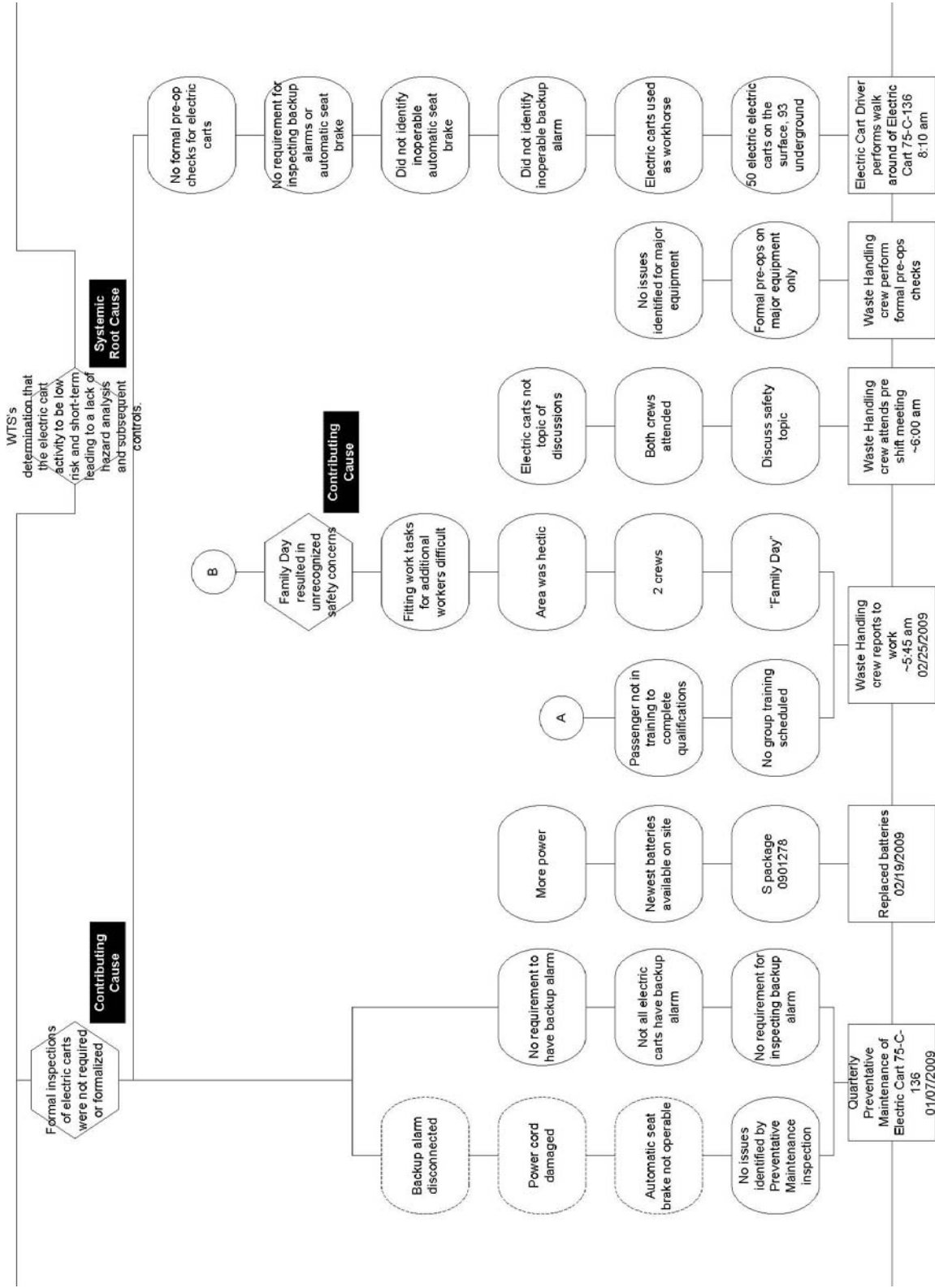
Events and Causal Factors Chart



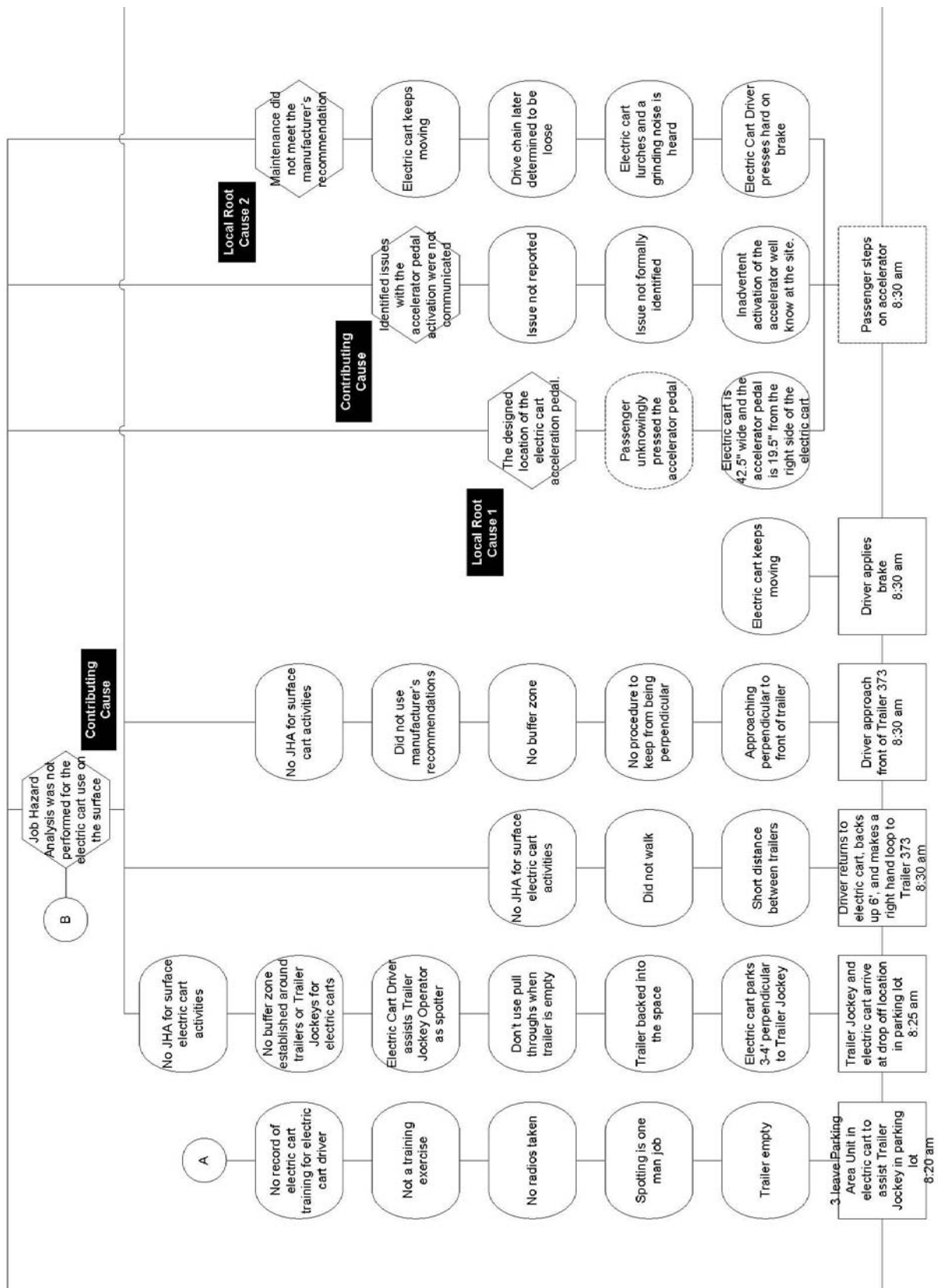
Events and Causal Factors Chart



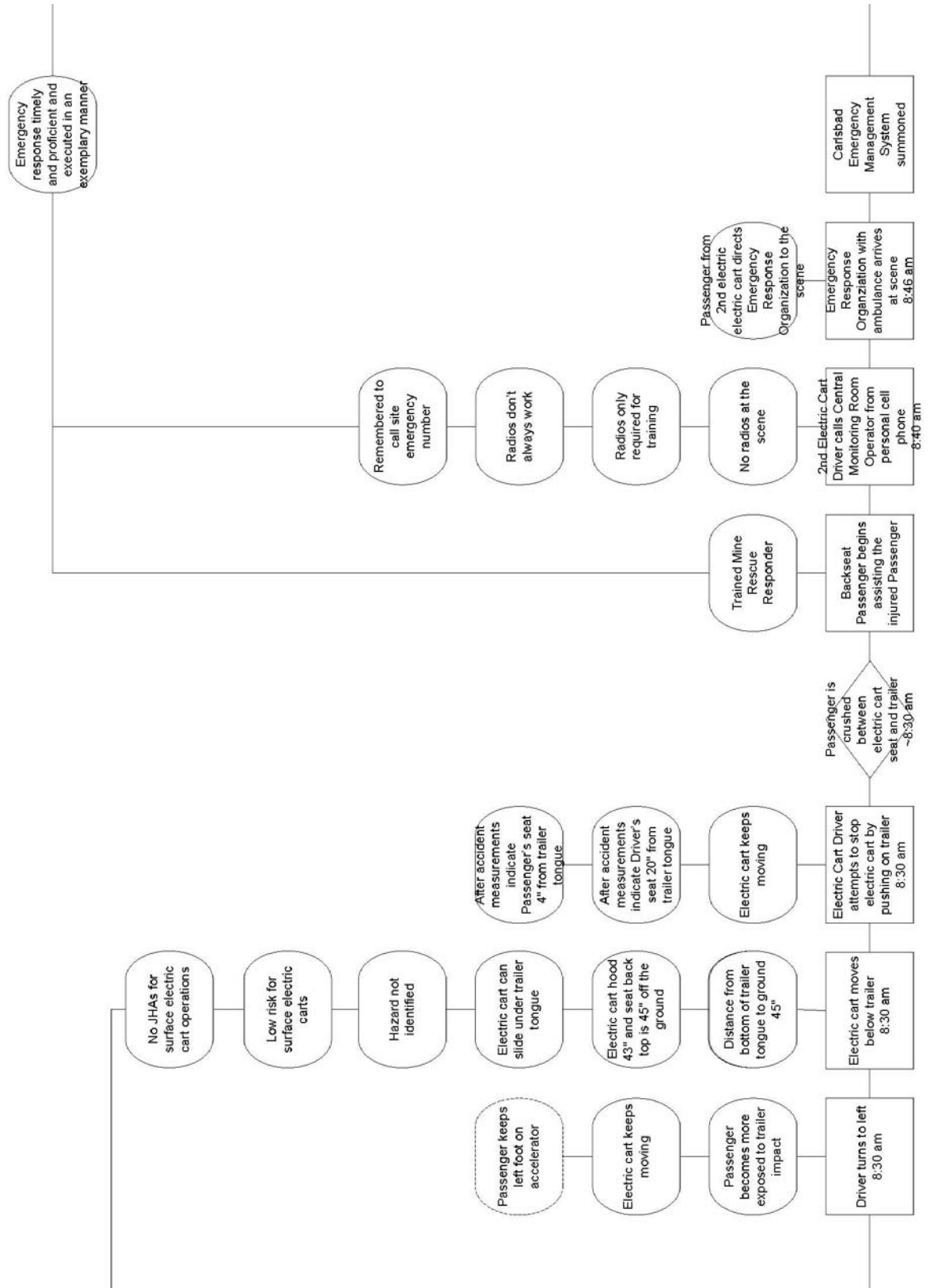
Events and Causal Factors Chart



Events and Causal Factors Chart



Events and Causal Factors Chart



Events and Causal Factors Chart

