BONNEVILLE
POWER ADMINISTRATION

Level I Accident Investigation Report

Tice Electric Company Employee Fatality near Patrick's Knob Radio Station, October 1, 2013

Report Date:
November 22, 2013

DISCLAIMER

This report is an independent product of the Level I Accident Investigation Board appointed by Brad Bea, Chief Safety Officer, Bonneville Power Administration. The Board was appointed to perform a Level I Accident Investigation and to prepare an investigation report in accordance with *Bonneville Power Administration Manual*, Chapter 181, *Accident Investigation and Reporting.*

The discussion of the facts, as determined by the Board, and the views expressed in the 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.

RELEASE AUTHORIZATION

On October 2, 2013, an Accident Investigation Board was appointed to investigate the fatality of a Tice Electric Company Crew employee while operating a material handler near Patrick's Knob Radio Station near Plains, Montana, on October 1, 2013. The Board's responsibilities have been completed with respect to this investigation. The analysis and the identification of the causal factors and the Findings and Recommendations resulting from this investigation were performed in accordance with *Bonneville Power Administration Manual*, Chapter 181, "Accident Investigation and Reporting."

The report of the Accident Investigation Board has been accepted and the authorization to release this report for general distribution has been granted.

Brad A. Bea

Brad Bea
Chief Safety Officer, Bonneville Power Administration

11-25-13

Date

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Personnel Legend

TLE	Tice Lead Electrician
TL	Tice Lineman
TMHE	Tice Material Handler Employee
ECSW	Electrical Construction Safety Watch/Escort
COTR	BPA Contracting Officer Technical Representative
CSM	BPA Control System Monitor

Acronyms

BPA	Bonneville Power Administration
CPR	Cardiopulmonary Resuscitation
DOE	Department of Energy
EC	Electrical Construction Company
EG	Emergency Generator
EMS	Emergency Medical Services
Gradall	Gradall Model 534D9-45 Material Handler
PMA	Power Marketing Administrations
SSSP	Site Specific Safety Plan
Tice	Tice Electric Company
THA	Task Hazard Analysis

SCOPE OF INVESTIGATION

On October 2, 2013, at the request of the Bonneville Power Administration (BPA) Chief Safety Officer, a Level I Accident Investigation was convened to investigate an accident that resulted in the fatality of a Tice Electric Company Crew employee while operating a Gradall material handler on the access road from Patrick's Knob Radio Station near Plains, Montana, on October 1, 2013.

The purpose of the investigation was to determine the cause of the accident and to develop recommendations for corrective actions to prevent recurrence.

The scope of the investigation included gathering and documenting all relevant facts of the accident; conducting interviews; reviewing employee statements, work procedures, management systems; and other elements factoring into the incident. The scope also included the Bonneville Power Administration's programs and oversight activities.

EXECUTIVE SUMMARY

Introduction

On October 1, 2013, a Tice Electric Company (Tice) employee was fatally injured while operating a Gradall Material Handler (Gradall) on Forest Service Road 7592 approximately four miles from Patrick's Knob Radio Station near Plains, Montana.

On October 2, 2013, the Chief Safety Officer for Bonneville Power Administration (BPA) appointed a Level 1 Accident Investigation Board (the Board) to investigate the accident, in accordance with the requirements of *Bonneville Power Administration Manual*, Chapter 181, "Accident Investigation and Reporting."

Description of the Work

Tice was contracted by BPA to replace the Patrick's Knob Radio Station Emergency Generator under Master Contract Number 57634, Release 003, with project-specific instructions and technical specification. Tice started on-site work at the Patrick's Knob Radio Station the week of September 23, 2013. The work entailed the replacement of the existing EG, building renovation, minor structural modifications, and replacement of other electrical equipment and fixtures.

Accident Description

On the afternoon of October 1, 2013, a Tice Lead Electrician (TLE) was fatally injured in a vehicle rollover accident while enroute from a remote mountain top BPA Radio Station to an established transport pickup point for the Gradall. The TLE was driving the Gradeall down Forest Service Road 7592 from the worksite to the drop-off point on Forest Service Road 508. About four miles from the worksite, at approximately 1530, the Gradall left the roadway, rolled down an embankment, and over the driver.

The accident was witnessed by a Tice Lineman (TL) following behind in a pickup truck. TL witnessed TLE attempt to steer the Gradall back onto the road, which ended with the machine mostly off the road and its right side leaning extremely to the down side of the hill. TL saw TLE attempt to exit the Gradall from the up-hillside as it rolled off the road edge and out of sight.

The Gradall was equipped with a Roll Over Protection Structure (ROPS) and included the safety restraints as part of the ROPS System.

Emergency Response

Immediately following the accident, at approximately 1531, TL went down the embankment on foot while ECSW called 911. TL found TLE down the embankment about 45 feet from the roadway. Upon completing the call, the Electrical Construction Safety Watch/Escort (ECSW) grabbed a first aid kit and proceeded to the accident scene. TL checked for but could not locate a pulse and ECSW called 911 again at 1538 to provide additional accident site details and report

that TLE had no pulse. TL and ECSW attempted Cardiopulmonary Resuscitation (CPR) but were not able to provide rescue breaths due to a blocked airway.

First Emergency Responders from Plains, Montana Rural Fire Department (Rescue 1) arrived on accident scene approximately 38 minutes after the accident at 1608. The Rescue 1 Incident Commander requested the Sanders County, Montana, Coroner through the 911 dispatcher at 1615. At 1627, the Rescue 1 Incident Commander also contacted Search and Rescue to assist in recovery of TLE from the location below the road. Between 1633 and 1905, Rescue 1, Search and Rescue, and the Coroner all completed their tasks and all were cleared of the scene by 1905.

Results of the Investigation (Findings and Recommendations)

The Board determined the facts of the accident and analyzed the facts to determine what happened, why it happened, and what needs to be done to prevent recurrence. The Board used Barrier Analysis and Causal Factors Analysis to arrive at Findings and Recommendations, which if implemented, should prevent a similar accident.

As part of the investigation, skill level, physical, and administrative/management prevention barriers were analyzed. Although a direct cause for the fatality was determined, the Board did not have sufficient evidence to make any conclusions as to why the Gradall left the roadway, and found the root cause to be undetermined at this time. Because of this, the Board could not develop any recommendations for preventing the root cause of the accident which was the Gradall leaving the roadway. The investigation did uncover areas where changes in management prevention barriers would help improve safety in the work environment for the type of work being performed, and these are listed in the findings and recommendations.

The Board concluded the **direct cause** of the accident was exposure to fatal blunt force trauma during rollover of Gradall Material Handler.

The Board concluded the **root cause** of the accident was the Gradall Material Handler leaving the roadway and the operator attempting to exit the machine when it rolled over.

The Board identified one **contributing cause** to the accident as the narrow roadway with brushy overgrowth and steep embankments.

Table ES-1: Findings and Recommendations

Findings	Recommendations
Accident	
F1: The Board found that the Gradall left the road creating an equipment rollover situation.	No recommendation. There was no factual evidence available to the Board to explain why the Gradall left the roadway.
F2: The Tice (Tice) Electric Company Lead Electrician (TLE) attempted to exit Gradall prior to roll over. This would have defeated the safety restraint component of the rollover protection system that includes safety restraints in addition to the Roll Over Protection Structure (ROPS).	**R1**: The Board determined that the ROPS includes the safety restraints as part of the ROPS System and recommends that, if applicable, future training for equipment operators includes detailed explanation of the ROPS and safety restraints and what to do during a rollover event.
F3: Use of seatbelt while operating the Gradall Material Handler is undetermined.	No recommendation. There was no factual evidence available to the Board to determine if seatbelt was or was not utilized while operating the Gradall.
Emergency Response	
F4: The Board found that the crew's rescue effort was performed in a safe and timely manner. Response by professional emergency medical services was timely.	No recommendation.
Investigative Readiness	
F5: The Board found that conflicting views between contractor's management and BPA created difficulties with collecting evidence, conducting additional follow-up witness interviews, and obtaining some of the information requested, limiting the investigation process. Conflicting views were in the areas of authority to conduct an accident investigation, limitations of the investigation scope and concerns over legal implications of releasing facts.	**R2**: The Board recommends that BPA evaluate the need to include information in contract packages informing contractors of BPA's accident reporting and investigating process. Contract additions and addendums should convey BPA accident investigation protocol and provide applicable copies of BPA accident investigation standards and protocol. Information should convey a clear demarcation for when an accident would include investigation by BPA.

Findings	Recommendations
Medical Analysis/Fitness for Duty	
F6: The Board requested but was not provided with medical information to base any conclusions on TLE's medical state, fitness for duty or official cause of death.	**R3**: The Board recommends that BPA's Medical Officer assess the medical information for TLE if received. **R4**: The Board recommends that BPA's Contracting Office insert language into all master contracts and contract releases that explicitly states that if requested, BPA's Medical Officer is to be provided with all relevant medical information as soon as it becomes available in the event of a BPA Contractor injury or fatality.
Training	
F7: The Board was provided sufficient evidence to determine that TLE had been provided training to operate material handlers.	No recommendation.
Tice Electric Company Safety Management Processes – Site Specific Safety Plan	
F8: The Board found that a Site Specific Safety Plan (SSSP) was developed for the job, but was not conveyed to all workers at the worksite. **F9**: The Board determined that the fragmentation of expectations for communicating the SSSP to workers is a weakness in executing management safety barriers.	**R5**: The Board recommends that contract language, Notice to Proceed, and SSSP contain expectations for conveying the site safety elements of the plan to all contractor workers including subcontractors. Expectations for how to convey the SSSP to workers should be included on the cover page of each SSSP. The site foreman or manager should brief each worker, and all additional workers, on SSSP contents before starting any work on the site.
F10: The Board found there was a delay in activating a blood borne pathogen protocol.	**R6**: Tice should evaluate performance on executing a blood borne pathogen protocol for this accident.

Findings	Recommendations
Job Hazard Analysis and Job Briefings	
F 11: The Board found the Site Specific Safety Plan (SSSP) was not clear on expectations for conducting both weekly safety meetings and daily job briefing (toolbox meetings).	**R7**: The language in the SSSP for expectations in conducting both weekly safety meetings and daily job briefing should be revised to make the expectations clearer. The Board recommends that Tice should evaluate the language for safety meetings and job briefings in their SSSP, and revise to make the instructions and expectations for weekly and daily meetings to be individually clear on expectation and documentation requirements. BPA contracting and safety office should evaluate and determine if documenting daily job briefings should be a standard requirement for contracted projects and include this expectation in contract language and verify inclusion in future contractor SSSPs with availability for inspection on request .

1. INTRODUCTION

1.1. About Bonneville Power Administration

The Bonneville Power Administration (BPA) is a U.S. Federal agency based in the Pacific Northwest. BPA was created by an act of Congress in 1937 to market electric power from the Bonneville Dam located on the Columbia River and to construct facilities necessary to transmit that power. Congress has since designated BPA to be the marketing agent for power from all of the Federally-owned hydroelectric projects in the Pacific Northwest. BPA is one of four regional Federal Power Marketing Administrations (PMA) within the U.S. Department of Energy (DOE) and is headquartered in Portland, Oregon.

The BPA owns power transmission and communications facilities for their transmission network, which are constructed and refurbished as either internal or contracted projects as required to meet business needs.

1.2. Tice Electric Company

Tice Electric Company (Tice) offers contract electrical services and electrical construction. They are a BPA approved contractor for providing contract electrical construction including construction in electrical power substations. For BPA, they have completed emergency generator (EG) replacement, fiber optics installation, battery replacement, and facility construction projects.

1.3. Electrical Construction Company

Electrical Construction Company (EC) offers contract electrical services and labor for electrical construction. They are a BPA-approved contractor for providing safety watchers for work on BPA facilities.

2. FACTS AND ANALYSIS

2.1. Description of Work Activity

BPA's Patrick's Knob Radio Station was being upgraded with an emergency generator (EG) replacement under a single project plan. The EG set replacement was a high priority project due to generator set damage experienced earlier in the year and upcoming station accessibility issues during winter.

Figure 1: Patrick's Knob Radio Station

Tice was contracted by BPA to replace the Patrick's Knob Radio Station EG under Master Contract Number 57634, Release 003, with project-specific instructions and technical specification. BPA approved Tice's Site Specific Safety Plan (SSSP) and provided the Notice to Proceed (NTP) on September 9, 2013. The NTP was accepted by Tice on September 10, 2013.

Tice started on-site work at the Patrick's Knob Radio Station the week of September 23, 2013. The work entailed the replacement of the existing EG, building renovation, minor structural modifications, and replacement of other electrical equipment and fixtures. The work crew assigned to the EG work on the day of the accident consisted of Tice Lead Electrician (TLE), Tice Lineman (TL), Tice Material Handler Employee (TMHE) and the Electrical Construction Company Safety Watch (ECSW).

Figure 2: Gradall Model 534D9-45 Material Handler

To facilitate the removal of the old EG and placement of the new EG, Tice arranged for the rental of a Gradall Model 534D9-45 Material Handler (Gradall). On the morning of October 1, 2013, Midway Rentals delivered the Gradall to a location about 11.5 miles from the Patrick's Knob Radio Station on Forest Service Road 508 per TLE's instructions. The location was referred to as the "second cattle guard." TLE

took delivery of the Gradall and drove it from the "second cattle guard" location to the Radio Station site, traveling up Forest Service Roads (FSR) 508 and 7592 to the Radio Station. The SSSP noted sections of road within the last four miles to the site where the road had reduced width without space to move off the road for vehicle bypass, and vehicle speeds needed to be less than five miles per hour in this section of road.

Figure 3: Location of Patrick's Knob near Plains, Montana

During the course of the day[1], Tice workers completed various jobs for the work specified in the contract Technical Specifications. The interior of EG room was painted; the old EG was disconnected and removed; the new EG was set on rollers in the EG room; and the old EG was loaded onto the flatbed truck for return to BPA by TMHE.

During removal of the old EG and setting the new EG in the generator room, the Gradall was operated several times during the day by TL with no abnormal mechanical conditions experienced.

After lunch, the workers discussed returning the Gradall to the "second cattle guard" delivery site on Forest Service Road 508 for pick up by Midway Rental. TLE planned to leave the

[1] Times stated in this report are Mountain Daylight Time.

worksite first in the Gradall and then return to the worksite to retrieve another work vehicle following the drop-off.

TMHE was to remain at the worksite to load some additional materials onto the flatbed before leaving. The workers agreed that at some point TMHE would need to pass TLE on the road. TMHE was instructed to "honk" when approaching and TLE would move over to allow TMHE to pass. TLE departed the worksite at about 1434. ECSW assisted TMHE with loading the additional materials and TMHE left the worksite about 1450 in the flatbed truck.

TL loaded some rigging slings and other materials into a pickup truck and left the worksite about 1500. TL caught up to TLE in the Gradall. TMHE had already passed TLE. TL remained about three to five truck lengths behind the Gradall while going down the road. To maintain a speed commensurate with the speed of the Gradall, TL operated his vehicle in four-wheel drive, low range, and first gear.

After the other workers left the worksite, ECSW set up some supplemental heat in the building to help ensure proper curing of the freshly painted interior. At 1509, ECSW contacted the BPA Control System Monitor to activate the security alarm, locked the facility, traveled down the road, and caught up to TL following TLE. ECSW followed behind TL about three to five truck lengths for approximately 5 minutes before the accident occurred.

2.2. Description of the Accident

On the afternoon of October 1, 2013, TLE was fatally injured in a vehicle accident while enroute from a remote mountain top BPA Radio Station to an established transport pickup point for the Gradall Material Handler. The TLE was driving from the worksite down Patrick's Knob access road, which consists of Forest Service Roads (FSR) 7592 and 508, to the drop-off point on FSR 508. About four miles from the worksite, at approximately 1530, the Gradall left the roadway of FSR 7592 and rolled down an embankment, and over the TLE. The accident was witnessed by TL following behind in a pickup truck.

Figure 4: Location of Accident near Patrick's Knob

TL witnessed TLE attempt to steer the Gradall back onto the road, which ended with the machine mostly off the road and its right side leaning extremely to the down side of the hill. TL also saw TLE attempt to exit the Gradall from the up-hillside as it rolled off the road edge and out of sight. There was no factual evidence available to the Board to determine if the seat belt was or was not utilized while operating the Gradall prior to going off the roadway, but the Board determined that TLE was not belted in while the Gradall was rolling over.

Gradall had traveled approximately four miles in 56 minutes putting the average speed at approximately four miles per hour. The Forest Service roads were dry, hardened gravel, and in good condition with less than two percent grade at accident location. The drivable road width is 12 feet with total shoulder to shoulder width of 14 feet 10 inches and generally straight with a slight bend at the accident location. The weather at the time was dry with temperatures in the mid-40 ºF.

The Gradall was equipped with a Roll Over Protection Structure (ROPS) and included the safety restraints as part of the ROPS System. Following the accident, the Gradall ROPS was inspected by BPA and it was determined that there was no structural damage to the ROPS. The Board reviewed all available evidence and the scene but could not determine any explanation for the Gradall to have left the roadway. However, the Board determined that if the seatbelt had been in use during the rollover and TLE stayed within the ROPS, the fatal injuries may not have occurred as the ROPS was found to be intact and fully functional.

Finding 1: Gradall left the road, creating an equipment rollover situation.

Finding 2: Tice Electric Company Lead Electrician attempted to exit Gradall prior to roll over. This would have defeated the safety restraint component of the rollover protection system that includes safety restraints in addition to the Roll Over Protection Structure (ROPS). (**R1**)

Finding 3: Use of seatbelts while operating the Gradall Material Handler is undetermined.

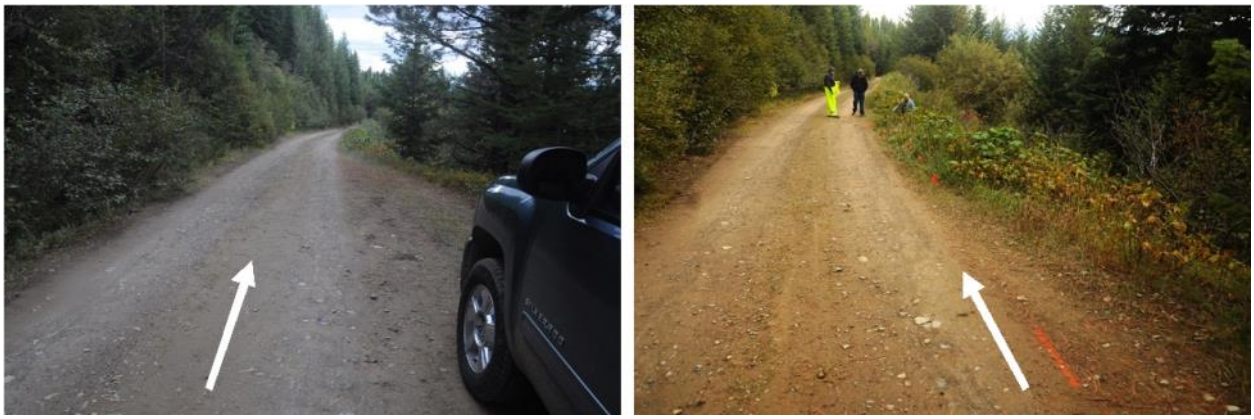


Figure 5: Direction of Travel of the Gradall on Forest Service Road 7592 (Patrick's Knob Road)

Figure 6: Forest Service Road 7592 Marked Indicating Tire Tracks Leaving Roadway to Point of Rollover

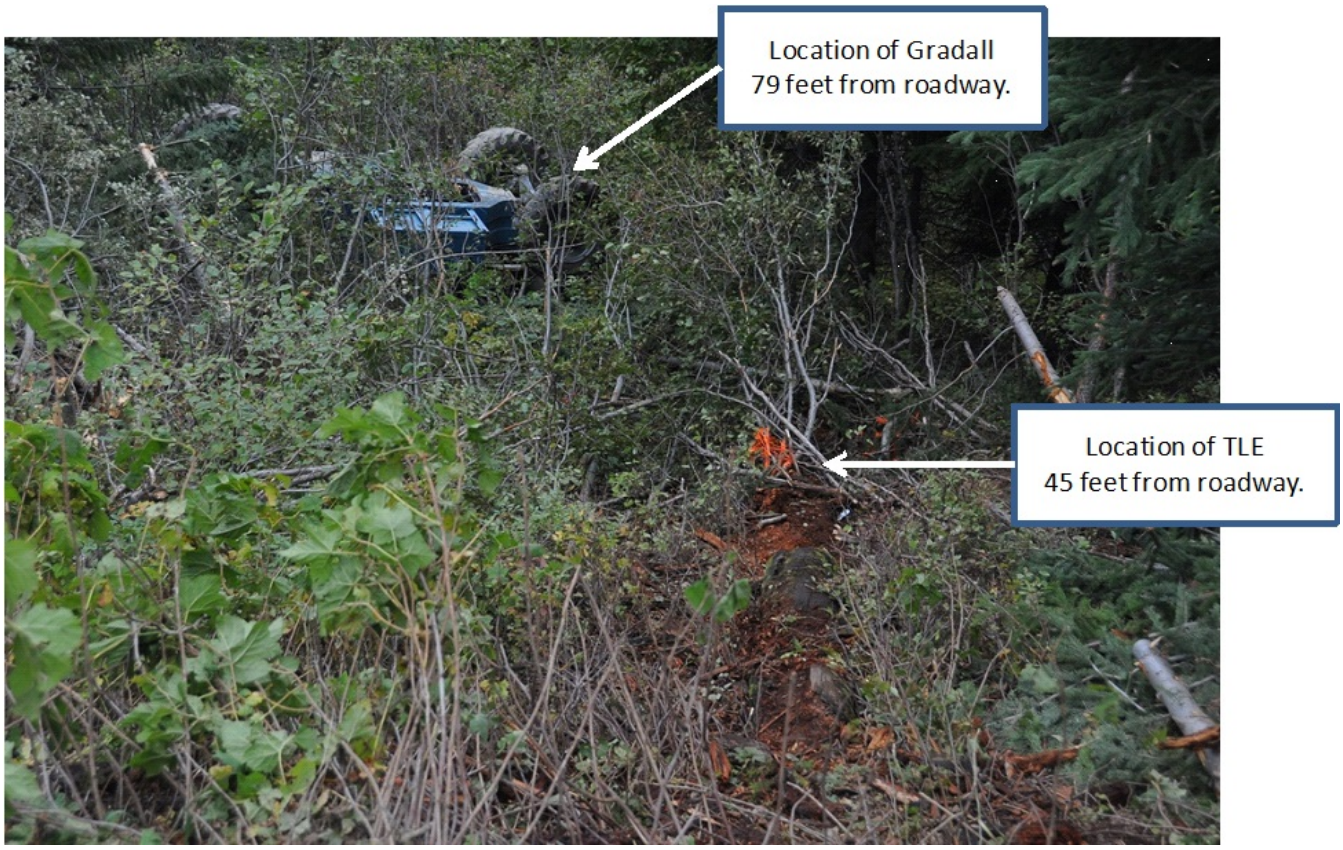


Figure 7: Positions of TLE and Gradall on Hillside

Figure 8: Gradall Position down the Hillside

Figure 9: The Photo on the Left is the view from the Roadway to the Location of Gradall on the Hillside; the Photo on the Right is from the Location of Gradall up to Roadway

Table 1 provides a brief chronology of significant events leading up to the accident.

Table 1: Chronology of the Accident

Time	Significant Events Leading to the Accident of October 1, 2013
09/25/2012	Master contract 57634 awarded to Tice.
07/22/2013	Technical specifications issued by BPA (Release 003)
09/09/2013	Notice To Proceed Issued by BPA.
09/23/2013	Tice Electric Company (Tice) began work under Release 003.
09/30/2013	ECSW first day on job.
10/01/2013 ~0900	Gradall scheduled for delivery by Midway Rental to “second cattle guard” site.
10/01/2013	TLE operated the Gradall from delivery point to worksite.
10/01/2013	TL drove the Gradall around the worksite during the workday.
10/01/2013	After lunch, group discussed returning the Gradall to the delivery location.

Time	Significant Events Leading to the Accident of October 1, 2013
10/01/2013 ~1434	TLE departed worksite in Gradall.
10/01/2013 ~1450	TMHE departed the worksite in the flatbed truck.
10/01/2013 ~1500	TL departed worksite in pickup truck to catch up and follow TLE to the "second cattle guard" delivery site.
10/01/2013 1509	ECSW called CSM and locked the building.
10/01/2013 ~1514	ECSW left the worksite.
10/01/2013 ~1525	ECSW caught up with TL and TLE.
10/01/2013 ~1530	TL saw TLE heading toward the edge of the road.
10/01/2013 ~1530	TL saw TLE drive off the edge of the road.
10/01/2013 ~1530	TL saw TLE try to correct steering by swinging rear steering end downhill.
10/01/2013 ~1530	TL saw TLE trying to exit the Gradall before rolling over.
10/01/2013 ~1530	TL saw Gradall roll over and out of sight.
10/01/2013 ~1530	ECSW saw the Gradall leave the road and drop out of view.
10/01/2013 ~1530	TL stopped in roadway.
10/01/2013 ~1530	ECSW stopped behind TL's vehicle.
10/1/2013 ~1530	**Gradall roll over occurred.**

2.3. Emergency Response

Immediately following the accident, at approximately 1531, TL went down the embankment on foot while ECSW called 911. TL found TLE down the embankment about 45 feet from the roadway. Upon completing the call, ECSW grabbed a first aid kit and proceeded to the accident scene on foot. TL checked for but could not locate a pulse and ECSW called 911 again at 1538 to provide additional accident site details and report that TLE had no pulse. TL and ECSW attempted Cardiopulmonary Resuscitation (CPR) but were not able to provide rescue breaths due to a blocked airway.

At 1542, the 911 dispatcher alerted Life Flight and Life Flight responded with an estimated arrival to the scene of 33 minutes. First Emergency Responders from Plains, Montana Rural Fire Department (Rescue 1) arrived on the accident scene approximately 38 minutes after the accident at 1608. Emergency personnel evaluated TLE and considered application of Automated External Defibrillator, but they determined that resuscitation was not viable. Rescue 1 Incident Commander stood down Life Flight and requested the Sanders County, Montana, Coroner through the 911 dispatcher at 1615. At 1627, the Rescue 1 Incident Commander also contacted Search and Rescue to assist in recovery of TLE from the location below the road. Between 1633 and 1905, Rescue 1, Search and Rescue, and the Coroner all completed their tasks and all were cleared of the scene by 1905. A Montana State Patrol Officer cleared the scene at 1923, and ECSW left shortly after.

Table 2 provides the chronology of actions immediately following the accident and the emergency response.

Table 2: Chronology of Rescue Activities

Date/Time	Rescue Activities
10/01/2013 ~1531	TL went down the hillside on foot towards the Gradall location.
10/01/2013 ~1532	TL told ECSW to call “911.”
10/01/2013 ~1532	ECSW called “911.”
10/01/2013 ~1532	TL located TLE on hillside.
10/1/2013 ~1533-1535	ECSW obtained first aid kit and CPR barrier and brought both to TL/TLE location.
10/01/2013 1534	911 first page to Plains, Montana, ambulance.
10/01/2013 1536	911 second ambulance page and page to Plains, Montana, Rural Fire Department.

Date/Time	Rescue Activities
10/01/2013 ~1538	ECSW called 911 a second time to report status and no pulse.
10/01/2013 ~1538	ECSW and TL attempted CPR.
10/01/2013 1542	Life Flight alerted.
10/01/2013 1547	Life Flight reports to 911 arrival ETA 33 minutes.
10/01/2013 1608	Plains, Montana, Fire Department (Rescue 1) on the scene.
10/01/2013 1615	The Rescue 1 Incident Commander requested the Sanders County, Montana, Coroner and Life Flight to stand down.
10/01/2013 1618	The Sanders County, Montana, Deputy Coroner was enroute to accident site.
10/01/2013 1627	The Rescue 1 Incident Commander paged Search and Rescue to scene for assistance.
10/01/2013 1631	Search and Rescue Team Leader acknowledged page and responded.
10/01/2013 1631	Montana State Patrol Officer arrives at accident site.
10/01/2013 1633	Sanders County, Montana, Deputy Coroner arrived at accident site.
10/01/2013 1706	The Plains, Montana, Rural Fire Department cleared the scene.
10/01/2013 1711	The Deputy Coroner leaves the scene.
10/01/2013 1905	Search and Rescue clears the scene.
10/01/2013 1923	Montana State Patrol Officer leaves the scene.
10/01/2013 ~1923	ECSW leaves the scene.

Finding 4: The crew's rescue effort was performed in a safe and timely manner. The response time by professional emergency medical services was timely.

2.4. Investigative Readiness

The Board fully investigated this accident under and within the scope of BPA accident investigation policy and practices summarized in the following.

Per the Bonneville Power Administration Manual, Chapter 181, "Accident Investigation and Reporting, 181.1 "Policy."

> *It is BPA policy to thoroughly investigate all serious accidents and near misses. The purpose of the investigation is to establish the facts related to the accident, determine the factors that directly caused or contributed to the accident, and recommend steps to be taken to prevent a recurrence. Investigation results shall be reported without attributing individual fault or proposing punitive measures. The investigation report constitutes an accurate and objective record that provides complete and accurate details and facts pertaining to the accident. Analytical results, causes of the accident, conclusions reached, and recommendations to correct deficiencies that should have or could have prevented the accident shall be identified.*

Per the BPA Safety and Health Program Handbook, Section C. "Accident Investigation and Reporting," Chapter 1, "Accident Reporting and Investigation Process."

> *Level I: Any occurrence that results in a fatality, serious occupational illness or injury to three or more employees and/or contractors in the same occurrence; or members of the public involving a BPA operation; or violations of Accident Prevention Manual life or death rules from which there is a substantial probability that death or serious physical harm could have resulted.*
>
> *Accident Investigation Response: All accidents shall be reported to their line management as soon as possible. Line management has the responsibility to report the occurrence to the Safety Office where the Chief Safety Officer will determine the level of investigation required. In the event that investigation is called for, the Safety Office will immediately dispatch a Safety Manager to respond to the accident site to begin an initial investigation. Accident investigation board members will be contacted and are to report to the accident site within 24 hours following notification. The Chief Safety Officer shall establish an accident investigation board within two working days of notification of an occurrence.*

Immediately following the accident, Tice notified the BPA Contracting Officer Technical Representative (COTR) on October 1, 2013, at approximately 1620. The BPA COTR notified the BPA Safety Office 10 minutes later at approximately 1630. A Safety and Occupational Health Manager was assigned immediately after notification to Safety Office, and was dispatched to accident site and to arrive as soon as possible to make sure it was secure and safe.

A Level I Accident Investigation Board was appointed on October 02, 2013 to investigate the accident per the *Bonneville Power Administration Manual*, Chapter 181, "Accident Investigation and Reporting, 181.1 "Policy.

The first member of the Accident Investigation Board (Board), a Safety and Occupational Health Manager, arrived at the site at approximately 0800 on October 2, 2013. The BPA Kalispell District Manager was notified October 1, 2013, and responded to accident site on the morning of October 2, 2013, to verify a secure scene and collect information.

On October 2, 2013, at approximately 1400, the remaining Board members arrived at accident site to conduct preliminary interviews with witnesses and collect evidence.

The Montana Highway Patrol, U.S. Forest Service, and local OSHA authority all collected information and witness statements from TL and ECSW following the accident.

The Board encountered difficulties with collecting evidence and conducting witness interviews due to conflicting views between contractor's management, and BPA regarding the authority to conduct an accident investigation, limits of investigation scope and legal implications of releasing evidence. Prior to leaving the scene of the accident, the Board had obtained a verbal agreement with a Tice Safety Manager to share witness statements from Tice employees to facilitate the BPA investigation. Following the return to the office, and upon advice of Tice legal counsel, Tice did not provide the witness statements Tice had obtained on-site. The Board also determined that follow-up interviews would be necessary, but were not granted access to the witnesses by Tice management.

Finding 5: The Board found that conflicting views between contractor's management and BPA created difficulties with collecting evidence, conducting additional follow-up witness interviews, and obtaining some of the information requested, limiting the investigation process. Conflicting views were in the areas of authority to conduct an accident investigation, limitations of the investigation scope and concerns over legal implications of releasing facts. (**R2)**

2.5. Medical Analysis/Fitness for Duty

The Board requested but did not receive information regarding toxicology analysis performed following the accident. The Board was unable to affirm TLE's Fitness for Duty based upon such results, if they existed.

Finding 6: The Board requested but was not provided medical information to base any conclusions on Tice Electric Company (Tice) Lead Electrician medical state, fitness for duty or official cause of death. (**R3, R4**)

3. WORK PROCESSES AND CONTROLS

3.1. Training and Certification

The Board reviewed TLE's training and certification records provided by Tice, which documented that TLE was trained, demonstrated proficiency, and was certified to operate the Gradall material handler in accordance with Tice requirements.

Finding 7: The Board was provided sufficient evidence to determine that TLE had been provided training to operate material handlers.

3.2. Site Specific Safety Plan

The SSSP was reviewed and the Board determined it was complete and adequate for the work to be performed. In addition, the BPA Safety Office had reviewed and approved the SSSP prior to issuing the NTP.

Expectations for the handling and conveyance of the SSSP information to workers at the jobsite were provided in fragmented fashion and not as a single set of instructions. The NTP specified that the SSSP must be on site for review by workers, and BPA's safety office conveyed additional expectations in the September 9, 2013, email message used to transmit the NTP to Tice. BPA Safety Office expectations stated that the Contractor is to have all workers become familiar with the contents of the SSSP. The Board found from interviews that not all workers were aware of the SSSP at the worksite.

In investigating emergency response for this fatal accident, the Board found an area of concern in executing a blood borne pathogen protocol. There was a delayed response to conducting an exposure assessment and no follow up on possible exposure to blood. OSHA requirements are for immediate activation of the protocol upon exposure and this is captured in Tice's safety manual as a within 24 hours requirement. Based on Tice's blood borne pathogen incident/accident report, a medical referral was not implemented and exposure assessment by Tice did not occur until 3 days after the accident. The protocol is covered in the Tice's Safety Manual. The Board found that exposure to blood was present, and that at least one worker may have been exposed because rescue breaths were attempted in the presence of blood. Even though a barrier was utilized, there was a significant presence of blood which could have been contacted.

Finding 8: The Board found that a Site Specific Safety Plan (SSSP) was developed for the job, but was not conveyed to all workers at the worksite. (**R5**)

Finding 9: The Board determined that the fragmentation of expectations for disseminating information in the SSSP to all workers is a weakness in management barriers for accident prevention and a gap in assuring adequate and effective safety processes and controls. (**R5**)

Finding 10: The Board found there was a delay in activating a blood borne pathogen protocol. (**R6**)

3.3. Job Hazard Analysis

The Board reviewed the Contract and the Tice Safety Manual to determine applicability of JHA to the work performed. A JHA is a comprehensive evaluation of a work site and intends to identify all potential hazards that exist. This is done in advance of starting a job, and is typically more encompassing of worksite safety issues than what would be covered by routine jobsite briefings (which are typically described as job briefings, tool box meetings, tail gate meetings, or a task hazard analysis). Job briefings are conducted in advance of performing daily work and also during execution of work when the work presents new hazards. The Board determined that the SSSP developed by Tice, and approved by BPA, demonstrated and documented a JHA for this contract work and it identified the general jobsite hazards associated with the work to be performed.

3.3.1. Daily Job Briefings

The Board reviewed the Contract, SSSP, and Tice's Safety Manual to determine applicability of job briefings (toolbox meetings) to the work performed. The Board found the instructions in the SSSP to be confusing for daily documented safety meetings and job briefings. This confusing language represents a weakness in management barriers for accident prevention and a potential gap in assuring adequate and effective worksite safety processes and controls.

The Tice SSSP – *Responsibilities and Accountability for Foreman* - states:

> *Conduct weekly and daily toolbox safety meetings and recorded prior to each work shift. Safety topic as part of the daily job briefing.*

The Board requested copies of the documented daily job briefings for the work performed, but was not provided with physical copies of these briefings. The Board did receive a letter from Tice stating job briefings were conducted. There was no factual evidence available to the Board to conclude job briefings were compliant with expectations of the SSSP, but concluded that verbal briefings were adequate for the work being performed.

Finding 11: The Board found the Site Specific Safety Plan (SSSP) was not clear on expectations for conducting both weekly safety meetings and daily job briefing (toolbox safety meetings). (**R7**)

4. ANALYSIS

This investigation was conducted using the processes described in the *Bonneville Power Administration Manual*, Chapter 181, "Accident Investigation and Reporting" and the *DOE Handbook, Accident Investigation and Prevention* Volume 1 – Accident Analysis Techniques (DOE-HDBK-1208-2012) which provides guidance on the core analytical methods identified in DOE Order 225.1B, *Accident Investigations*. Evidence was gathered through interviews and reviews of documentation and physical evidence to determine the facts of the accident. The facts were analyzed using barrier analysis, change analysis, events and causal factors analysis, and root cause analysis. The results of those analyses were validated through verification analysis.

4.1. Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any management or physical means used to control, prevent, or impede the hazard from reaching the target (i.e., persons or objects that a hazard may damage, injure, or harm). The results of the barrier analysis are integrated into the events and causal factors chart to support the development of causal factors.

While the Board identified a number of barrier failures, 3 key barriers were major contributors to the accident:

B1 Maintaining the Gradall on the roadway;

B2 Attentive driving;

B3 Seat belt usage

Appendix A contains the complete Barrier Analysis of physical and management barriers identified by the Board.

4.2. Change Analysis

Change analysis examines planned or unplanned changes that caused undesirable results related to the accident. This process analyzes the difference between what is normal, or expected, and what actually occurred before the accident. The results of a change analysis are typically integrated into the events and causal factors chart to support the development of causal factors. The Board examined the evidence, witness statements, and photographs and determined that change analysis could not be applied to this accident.

4.3. Events and Causal Factors Analysis

The Events and Causal Factors Analysis is a systematic process that uses methods to determine Causal Factors of an accident. Causal factors are the significant events and conditions that produced or contributed to the **Direct Cause**, the **Contributing Causes** and the **Root Cause**(s) of the accident.

The direct cause of an accident is the immediate events or conditions that caused the accident. The Board concluded the **direct cause** of the accident was:

- Exposure to fatal blunt force trauma during rollover of Gradall Material Handler.

Root causes are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults. The Board determined the **root causes** of the accident were the following:

- The Gradall Material Handler leaving the roadway;
- TLE attempting to exit the machine when it rolled over.

Contributing causes are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur.

The Board identified the following **Contributing Cause** (CC):

- Narrow roadway with brushy overgrowth and steep embankments.

5. EXAMINATION OF EVIDENCE

5.1. Findings and Recommendations

The Board determined the facts of the accident and analyzed the facts to determine what happened, why it happened, and what needs to be done to prevent recurrence. The Board used Barrier Analysis and Causal Factors Analysis to arrive at Findings and Recommendations, which if implemented should prevent a similar accident.

Table 3: Findings and Recommendations

Findings	Recommendations
Accident	
F1: The Board found that the Gradall left the road creating an equipment rollover situation.	No recommendation. There was no factual evidence available to the Board to explain why the Gradall left the roadway.
F2: The Tice (Tice) Electric Company Lead Electrician (TLE) attempted to exit Gradall prior to roll over. This would have defeated the safety restraint component of the rollover protection system that includes safety restraints in addition to the Roll Over Protection Structure (ROPS).	**R1**: The Board determined that the ROPS includes the safety restraints as part of the ROPS System and recommends that, if applicable, future training for equipment operators includes detailed explanation of the ROPS and safety restraints and what to do during a rollover event.
F3: Use of seatbelt while operating the Gradall Material Handler is undetermined.	No recommendation. There was no factual evidence available to the Board to determine if seatbelt was or was not utilized while operating the Gradall.
Emergency Response	
F4: The Board found that the crew's rescue effort was performed in a safe and timely manner. Response by professional emergency medical services was timely.	No recommendation.

Findings	Recommendations
Investigative Readiness	
F5: The Board found that conflicting views between contractor's management and BPA created difficulties with collecting evidence, conducting additional follow-up witness interviews, and obtaining some of the information requested, limiting the investigation process. Conflicting views were in the areas of authority to conduct an accident investigation, limitations of the investigation scope and concerns over legal implications of releasing facts.	**R2**: The Board recommends that BPA evaluate the need to include information in contract packages informing contractors of BPA's accident reporting and investigating process. Contract additions and addendums should convey BPA accident investigation protocol and provide applicable copies of BPA accident investigation standards and protocol. Information should convey a clear demarcation for when an accident would include investigation by BPA.
Medical Analysis/Fitness for Duty	
F6: The Board requested but was not provided with medical information to base any conclusions on TLE's medical state, fitness for duty or official cause of death.	**R3**: The Board recommends that BPA's Medical Officer assess the medical information for TLE if received. **R4**: The Board recommends that BPA's Contracting Office insert language into all master contracts and contract releases that explicitly states that if requested, BPA's Medical Officer is to be provided with all relevant medical information as soon as it becomes available in the event of a BPA Contractor injury or fatality.
Training	
F7: The Board was provided sufficient evidence to determine that TLE had been provided training to operate material handlers.	No recommendation.
Tice Electric Company Safety Management Processes – Site Specific Safety Plan	
F8: The Board found that a Site Specific Safety Plan (SSSP) was developed for the job, but was not conveyed to all workers at the worksite. **F9**: The Board determined that the fragmentation of expectations for communicating the SSSP to workers is a weakness in executing management safety barriers.	**R5**: The Board recommends that contract language, Notice to Proceed, and SSSP contain expectations for conveying the site safety elements of the plan to all contractor workers including subcontractors. Expectations for how to convey the SSSP to workers should be included on the cover page of each SSSP. The site foreman or manager should brief each worker, and all additional workers, on SSSP contents before starting any work on the site.

Findings	Recommendations
F10: The Board found there was a delay in activating a blood borne pathogen protocol.	**R6**: Tice should evaluate performance on executing a blood borne pathogen protocol for this accident.
Job Hazard Analysis and Job Briefings	
F 11: The Board found the Site Specific Safety Plan (SSSP) was not clear on expectations for conducting both weekly safety meetings and daily job briefing (toolbox safety meetings).	**R7**: The language in the SSSP for expectations in conducting both weekly safety meetings and daily job briefing should be revised to make the expectations clearer. The Board recommends that Tice should evaluate the language for safety meetings and job briefings in their SSSP, and revise to make the instructions and expectations for weekly and daily meetings to be individually clear on expectation and documentation requirements. BPA contracting and safety office should evaluate and determine if documenting daily job briefings should be a standard requirement for contracted projects and include this expectation in contract language and verify inclusion in future contractor SSSPs with availability for inspection on request .

6. BOARD OF AUTHORITY MEMORANDUM

DOE F 1325.8e Electronic Form Approved by Forms Mgmt. 04/26/2012
(08-89)

United States Government **Department of Energy**

memorandum **Bonneville Power Administration**

DATE: October 2, 2013

REPLY TO ATTN OF: NF-WHSE-E

SUBJECT: Level I Accident Investigation Board

TO: Claudia Andrews, Acting Chief Operating Officer – K-7

This memorandum is to confirm the appointment of the individuals listed below to Bonneville Power Administration's Level I Accident Investigation Board. The purpose of the Board is to investigate the fatality of a contract worker while operating a material handler at Patrick's Knob Radio Station near Plains, Montana on October 1, 2013.

Richard Becker	Supervisory Electrical Engineer - TES Board Chairperson
Tom Race	Safety and Health Manager - NF Board Member
Rod Leetch	Equipment Pool Services Manager - NSSP Board Member
Tom Rhew	Client Services Manager - NSS Board Member

The incident shall be thoroughly investigated and a report prepared in a manner consistent with BPA's Manual Chapter 181. During the investigation, the team shall review the incident site, equipment, work procedures, management systems, and other elements that are possible factors in the incident. Bonneville's final report shall include the facts, analysis of facts and conclusions with findings and recommendations. The report shall be forwarded to the Chief Safety Officer within 30 calendar days.

Brad A. Bea
Chief Safety Officer

cc:
C. Andrews – K-7
J. Hairston- N-4
L. Bekkedahl – T/Ditt-2
R. Furrer – TF/Ditt-2

R. Shaheen - TE/Ditt-2
T. Oleson – NS/Ditt-2
J. Cramer – NF/Pasco
Official File – NF

6.1. Bonneville Power Administration Safety Notice

Bonneville Power Administration

SAFETY NOTICE!

Subject: **Contractor Fatality While Operating Material Handler**

Issue Date: **10-01-2013** ***Alert Number:*** **SAN2013-10-01**

The following notice from the Safety Office is intended for the timely, system wide dissemination of information on safety issues, topics, and events in order to promote a safer work environment. Please distribute the following information to appropriate members of your work groups.

On Tuesday October 1st an employee of Tice Electric was fatally injured in a roll over incident while operating a material handler (forklift) at Patrick's Knob Radio Station near Plains, Montana. The other members of the crew immediately notified EMS and attempted to aid the victim. A Level I Accident Investigation has been convened.

BPA Safety Office (360) 418-2397 Safety Notices are available on Safety's Web Page:

http://internal.bpa.gov/Policy/Safety/Pages/SafetyHome.aspx

Page 1 of 1

7. BOARD MEMBERS' SIGNATURES

Richard Becker
Board Chairperson
Bonneville Power Administration
Substation Engineering Manager, Transmission and Engineering Technical Services

Rodney Leetch
Board Member
Bonneville Power Administration
Equipment Pool Services Manager, Internal Business Services

Tom Race
Board Member
Bonneville Power Administration
Safety and Occupational Health Manager, Internal Business Services

Tom Rhew
Board Member
Bonneville Power Administration
Client Services, Internal Business Services

BOARD MEMBERS, ADVISORS AND CONSULTANTS

Board Members

Board Chairperson	Richard Becker Bonneville Power Administration Substation Engineering Manager Transmission and Engineering Technical Services
Board Member	Rodney Leetch Bonneville Power Administration Equipment Pool Services Manager Internal Business Services
Board Member	Tom Race Bonneville Power Administration Safety and Occupational Health Manager Internal Business Services
Board Member	Tom Rhew Bonneville Power Administration Client Services Internal Business Services

Advisors/Consultant

Advisor/Consultant:	William McQuiston, MAS Consultants

Administrative Coordinator

Consultant/Technical Editor	Susan Keffer, Project Enhancement Corporation

Appendix A. Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with all tasks. A barrier is any means used to control, prevent, or impede a hazard from reaching a target, thereby reducing the severity of the resultant accident or adverse consequence. A hazard is the potential for an unwanted condition 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. Barrier analysis determines how a hazard overcomes the barriers, comes into contact with a target (e.g., from the barriers or controls not being in place, not being used properly, or failing), and leads to an accident or adverse consequence. The results of the barrier analysis are used to support the development of causal factors.

Table A-1: Barrier Analysis

	Barrier Analysis Worksheet	
	Hazard: Injury from Gradall material handler roll over	**Target:** Driver/Operator

	What Were the Barriers?	**How Did Each Barrier Perform?**	**Why Did the Barrier Fail?**	**How Did the Barrier Affect the Accident?**
B1	Maintaining the Gradall on roadway.	Failed	Unknown	The Gradall was driven off the edge of the road and then rolled over.
B2	Attentive driving.	Failed	Unknown	The Gradall was driven off the edge of the road and then rolled over.
B3	Seat Belt usage	Failed - Operator trying to exit Gradall Material Handler (Seat belt not used at time of roll over).	Unknown	The Gradall was driven off the edge of the road and then rolled. Continued seat belt use as part of the Roll Over Protection Structure (ROPS) system may have mitigated serious injury and death.

	What Were the Barriers?	How Did Each Barrier Perform?	Why Did the Barrier Fail?	How Did the Barrier Affect the Accident?
B4	Roll Over Protection Structure (ROPS).	The ROPS remained intact.	Did not fail	Remaining restrained within the ROPS may have mitigated serious injury and death.
B5	Poor road conditions were identified in SSSP.	Accident did not occur on the section of road identified as poor in the SSSP.	Did not fail	
B6	Equipment operators are certified on and demonstrate proficiency on heavy equipment prior to in service use.	TLE was trained and documented as certified to operate the Gradall.	Did not fail	

Appendix B. Events and Causal Factor Chart

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 those events and/or conditions that contributed to the accident. Causal factors are the events or conditions that produced or contributed to the accident, and they consist of direct, contributing, and root causes. The direct cause is the immediate event(s) or condition(s) that caused the accident. The contributing causes are the events or conditions that, collectively with the other causes, increased the likelihood of the accident, but which did not solely cause the accident. Root causes are the events or conditions that, if corrected, would prevent recurrence of this and similar accidents. The causal factors are identified in Table B-1: Events and Causal Factors Analysis Chart.

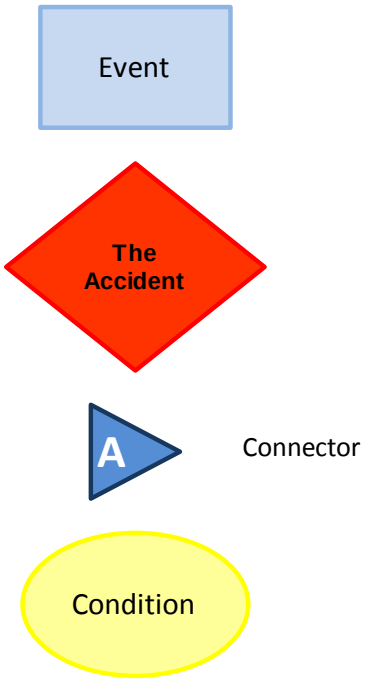
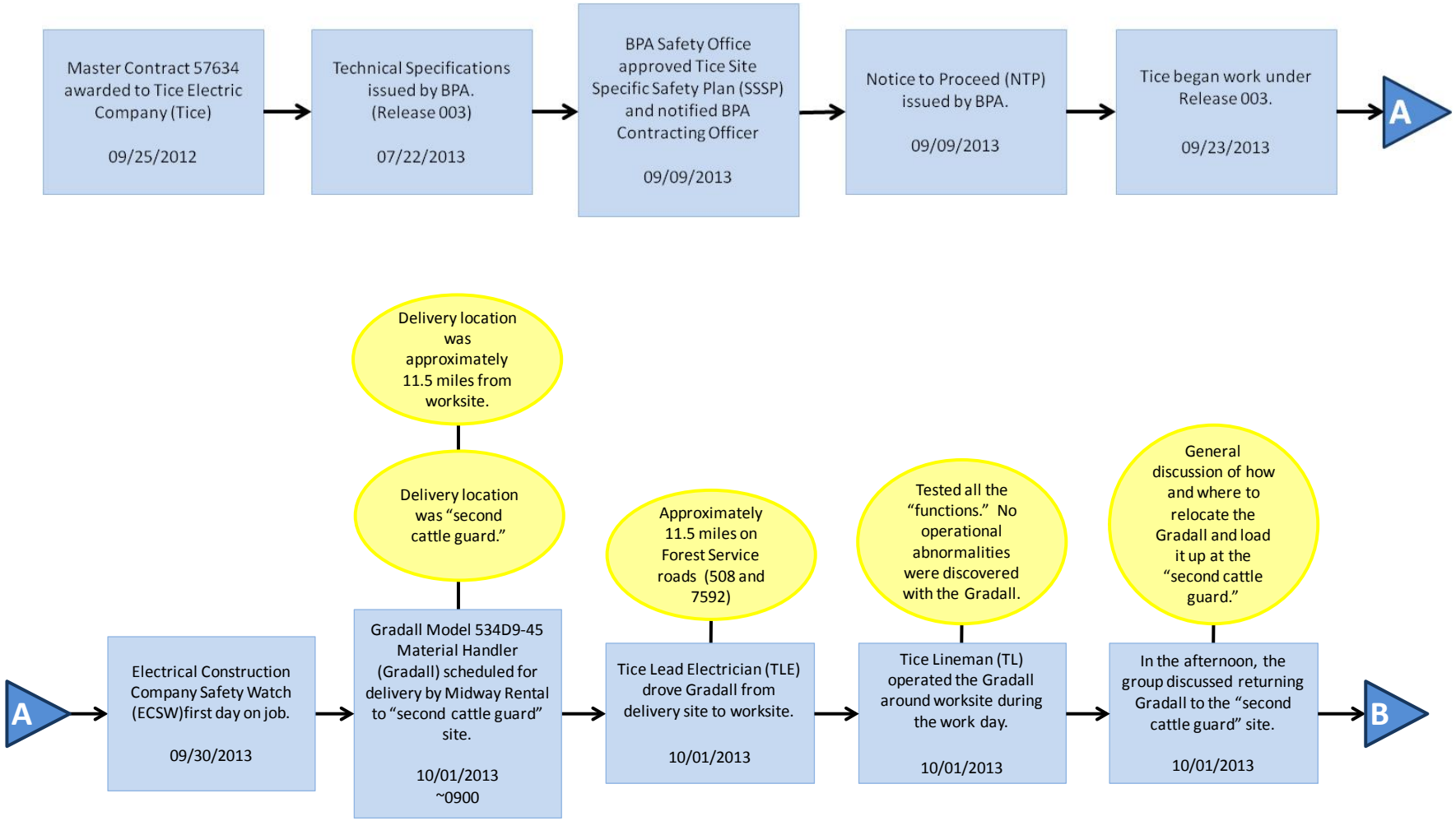
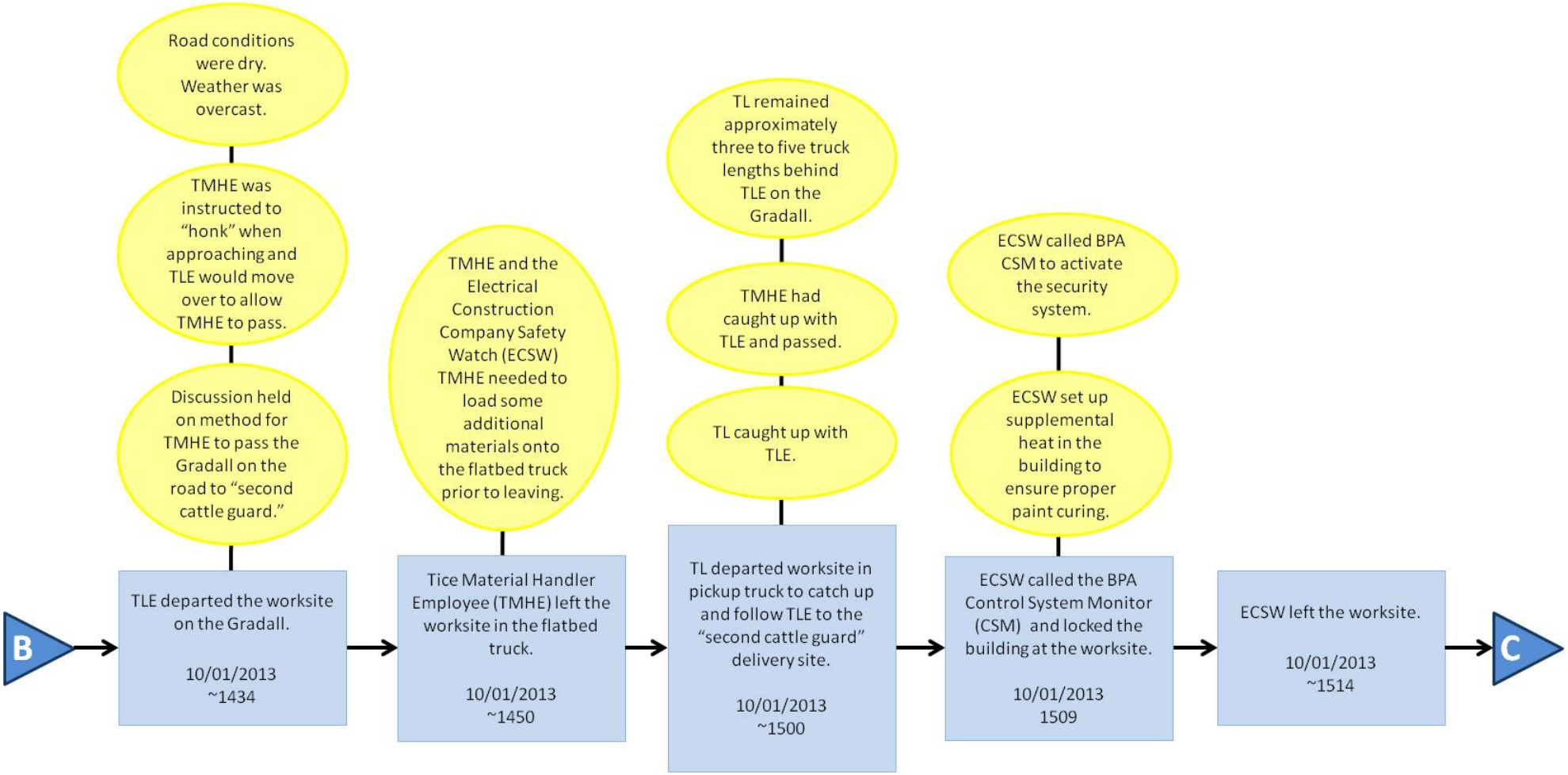
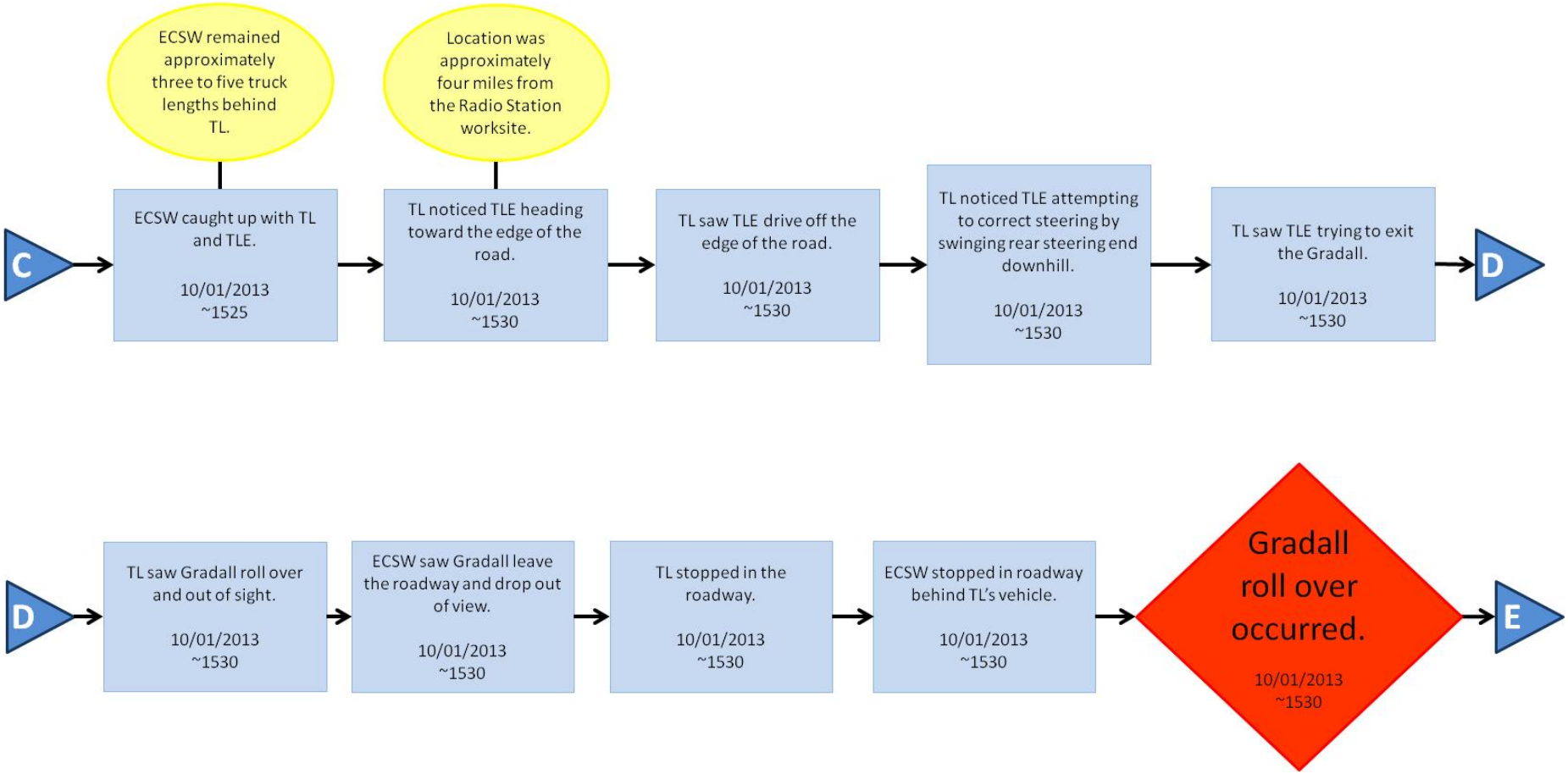
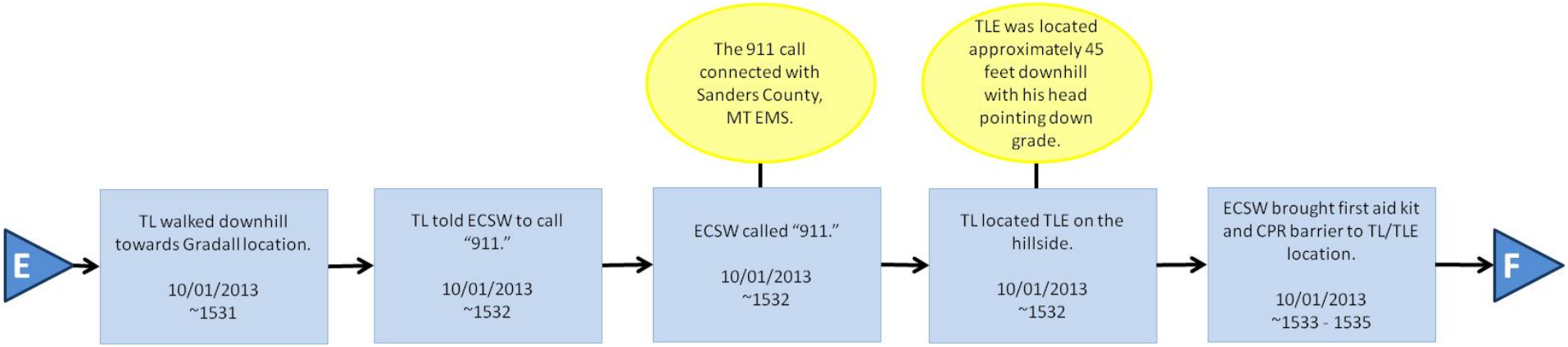


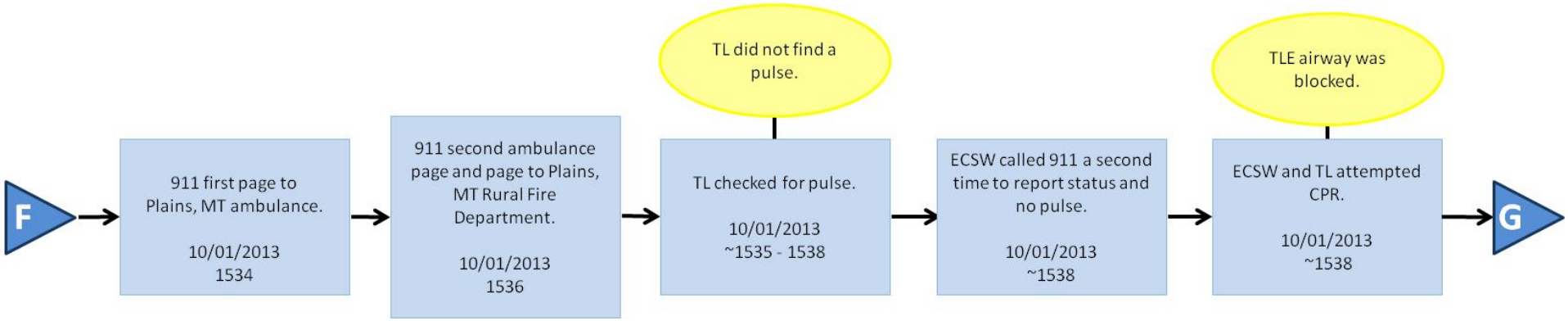
Table B-1: Events and Causal Factors Chart

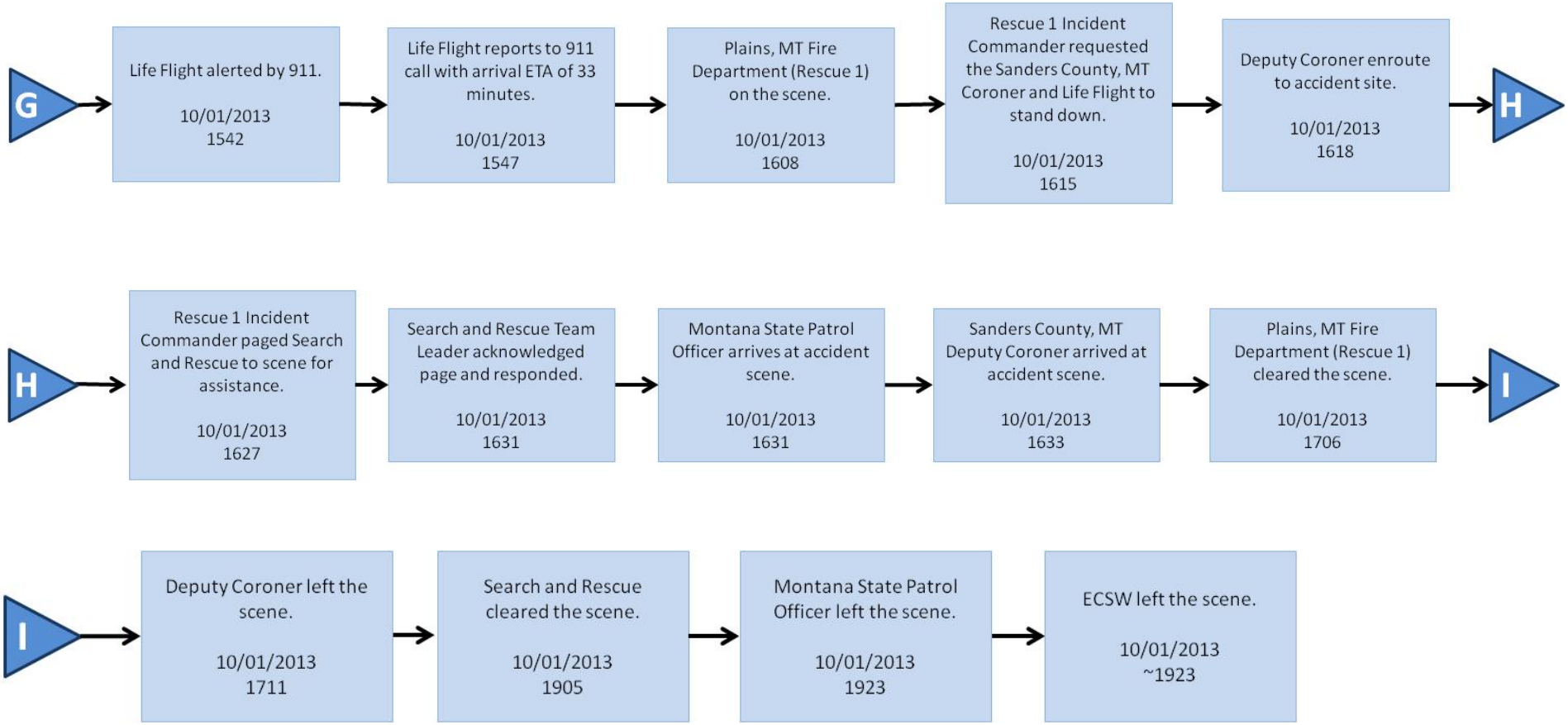



B
Road conditions were dry. Weather was overcast.
TMHE was instructed to "honk" when approaching and TLE would move over to allow TMHE to pass.
Discussion held on method for TMHE to pass the Gradall on the road to "second cattle guard."
TLE departed the worksite on the Gradall.
10/01/2013
~1434
TMHE and the Electrical Construction Company Safety Watch (ECSW) TMHE needed to load some additional materials onto the flatbed truck prior to leaving.
Tice Material Handler Employee (TMHE) left the worksite in the flatbed truck.
10/01/2013
~1450
TL remained approximately three to five truck lengths behind TLE on the Gradall.
TMHE had caught up with TLE and passed.
TL caught up with TLE.
TL departed worksite in pickup truck to catch up and follow TLE to the "second cattle guard" delivery site.
10/01/2013
~1500
ECSW called BPA CSM to activate the security system.
ECSW set up supplemental heat in the building to ensure proper paint curing.
ECSW called the BPA Control System Monitor (CSM) and locked the building at the worksite.
10/01/2013
1509
ECSW left the worksite.
10/01/2013
~1514
C


ECSW remained approximately three to five truck lengths behind TL.
Location was approximately four miles from the Radio Station worksite.
C
ECSW caught up with TL and TLE.
10/01/2013 ~1525
TL noticed TLE heading toward the edge of the road.
10/01/2013 ~1530
TL saw TLE drive off the edge of the road.
10/01/2013 ~1530
TL noticed TLE attempting to correct steering by swinging rear steering end downhill.
10/01/2013 ~1530
TL saw TLE trying to exit the Gradall.
10/01/2013 ~1530
D
D
TL saw Gradall roll over and out of sight.
10/01/2013 ~1530
ECSW saw Gradall leave the roadway and drop out of view.
10/01/2013 ~1530
TL stopped in the roadway.
10/01/2013 ~1530
ECSW stopped in roadway behind TL's vehicle.
10/01/2013 ~1530
Gradall roll over occurred.
10/01/2013 ~1530
E


E
TL walked downhill towards Gradall location.
10/01/2013
~1531
TL told ECSW to call "911."
10/01/2013
~1532
The 911 call connected with Sanders County, MT EMS.
ECSW called "911."
10/01/2013
~1532
TLE was located approximately 45 feet downhill with his head pointing down grade.
TL located TLE on the hillside.
10/01/2013
~1532
ECSW brought first aid kit and CPR barrier to TL/TLE location.
10/01/2013
~1533 - 1535
F


F
911 first page to Plains, MT ambulance.
10/01/2013
1534
911 second ambulance page and page to Plains, MT Rural Fire Department.
10/01/2013
1536
TL did not find a pulse.
TL checked for pulse.
10/01/2013
~1535 - 1538
ECSW called 911 a second time to report status and no pulse.
10/01/2013
~1538
TLE airway was blocked.
ECSW and TL attempted CPR.
10/01/2013
~1538
G


G
Life Flight alerted by 911.
10/01/2013
1542
Life Flight reports to 911 call with arrival ETA of 33 minutes.
10/01/2013
1547
Plains, MT Fire Department (Rescue 1) on the scene.
10/01/2013
1608
Rescue 1 Incident Commander requested the Sanders County, MT Coroner and Life Flight to stand down.
10/01/2013
1615
Deputy Coroner enroute to accident site.
10/01/2013
1618
H
H
Rescue 1 Incident Commander paged Search and Rescue to scene for assistance.
10/01/2013
1627
Search and Rescue Team Leader acknowledged page and responded.
10/01/2013
1631
Montana State Patrol Officer arrives at accident scene.
10/01/2013
1631
Sanders County, MT Deputy Coroner arrived at accident scene.
10/01/2013
1633
Plains, MT Fire Department (Rescue 1) cleared the scene.
10/01/2013
1706
I
I
Deputy Coroner left the scene.
10/01/2013
1711
Search and Rescue cleared the scene.
10/01/2013
1905
Montana State Patrol Officer left the scene.
10/01/2013
1923
ECSW left the scene.
10/01/2013
~1923

Appendix C. Additional Photographs from Accident Scene

Figure C-1: Additional Markings of Gradall Track Direction off the Side of the Roadway

Figure C-2: Views of Gradall on the Hillside

Figure C-3: Views of Damage to the Gradall

Figure C-4: Model and Serial Number Information from Gradall

Figure C-5: Measurements of Gradall Seat Belt

Figure C-6: Gradall Loaded on Flatbed for Transport Following Recovery from Accident Scene

Appendix D. Accident Investigation Terminology

Table D-1: Accident Investigation Terminology

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), root cause, and the contributing causal factors. The **direct cause** of an accident is the immediate events or conditions that caused the accident. Typically, the direct cause of the accident may be constructed or derived from the immediate, proximate event and conditions next to or close by to the accident on the Events and Causal Factors Chart. **Root causes** are the causal factors that, if corrected, would prevent recurrence of the same or similar accidents. Root causes may be derived from or encompass several contributing causes. They are higher-order, fundamental causal factors that address classes of deficiencies, rather than single problems or faults. **Contributing causes** are events or conditions that collectively with other causes increased the likelihood of an accident but that individually did not cause the accident. Contributing causes may be longstanding conditions or a series of prior events that, alone, were not sufficient to cause the accident, but were necessary for it to occur. Contributing causes are the events and conditions that "set the stage" for the event and, if allowed to persist or re-occur, increase the probability of future events or accidents. **Event and causal factors analysis** includes charting, which depicts the logical sequence of events and conditions (causal factors that allowed the accident 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.