NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

October 19, 2011

BNSF Ancillary Event Recorder Data Study

By Cassandra Johnson

1. EVENT SUMMARY

Location: Red Oak, Iowa
Date: April 17, 2011
Company: BNSF Railway
Train: BNSF Coal Train C-BTMCNM0-26
NTSB Number: DCA11FR002

On April 17, 2011 at about 6:55 a.m. central daylight time (CDT), eastbound BNSF coal train C-BTMCNM0-26, BNSF 9159 East, collided with the rear end of standing BNSF maintenance of way (MOW) equipment train U-BRGCRI-15, BNSF 9470 East, near Red Oak, Iowa. The accident occurred at milepost (MP) 448.4 on main track number two on the Creston Subdivision of the BNSF Nebraska Division. The striking coal train was travelling about 23 mph when it struck the standing MOW equipment train.

2. SUMMARY OF ANCILLARY EVENT RECORDER STUDY

This study provides alert alarm information from two sets of event recorder data when the accident crew of BNSF 9159 had previously operated locomotives in similar routes as taken on the day of the April 17, 2011 accident. For each set of event recorder data, table 1 lists the information BNSF provided to the NTSB's Vehicle Recorder Division including the BNSF locomotive identification number, locomotive type, locomotive wheel size, train size, train length, and the route taken.

Table 1. Ancillary event recorder information.

Locomotive Identification Number	Locomotive Type	Locomotive Wheel Size (inches)	Train Weight (tons)	Train Length (feet)	Train Route
BNSF 5897	GE[1] ES44AC	41.11	2,768	6,689	Creston, NE to Lincoln, NE
BNSF 9309	EMD[2] SD70ACE (same type of Locomotive as BNSF 9159)	42.60	2,945	5,277	Lincoln, NE to Creston, NE

2.1. Recording Description and Wheel Size

For most event recorders like the event recorder data from the GE locomotive, the actual speed and distance values are not recorded but rather the number of drive wheel rotations (or fraction thereof) is stored in memory. At the time the data is extracted, a wheel size is manually entered into the readout station or computer. Wheel size, number of rotations, and time are

[1] GE stands for General Electric.
[2] EMD stands for Electro-Motive Diesel, Inc.

then used by the program to calculate distance traveled, where the derived distance traveled does not account for any wheel skidding or slipping that could have occurred. Then the calculated distance traveled and time data are used to calculate speed. In contrast, EMD locomotives use ground radar to calculate speed and distance traveled and this information is recorded in the event recorders. Additionally, EMD locomotives keep track of wheel size which is also recorded by the event recorders. Therefore, the wheel size is not needed when extracting event recorder data from an EMD locomotive.

Using the wheel size of 41.11 inches as provided by BNSF, the BNSF 5897's event recorder data were extracted using the program Wabtec Railway Electronics Event Recorder Data Analysis Software. Additionally, using the same program, the event recorder data were extracted for the locomotive BNSF 9309. Only the data relevant to this study are provided in this report.

The data for these two sets of locomotive data are exported from the Wabtec Railway Electronics Event Recorder Data Analysis Software with a sampling rate of one second. Therefore, the data has an accuracy of +/- 1 second.

2.2. Parameters

BNSF 5897's event recorder and BNSF 9309's event recorder recorded different parameters. Tables A-1 and A-2 list the parameters from BNSF 5897's event recorder and from BNSF 9309's event recorder, respectively, that were verified and provided in this report.

2.2.1. Alert Alarm

The alert alarm parameter is the main focus of this report. In particular, how many alert alarms transitioned from "Off" to "On" for both sets of event recorder data, the duration of each alert alarm and if possible, what action turned the alert alarm off (from "On" to "Off"). For instance, there were four parameters recorded by BNSF 9159 that would turn off the alert alarm: vigilance acknowledgement (vig ack), bell, horn and throttle notch. Due to the different type of locomotives and different systems, only BNSF 9309's event recorder recorded these four parameters. BNSF 5897's event recorder did not record vigilance acknowledgement but did record bell, horn and throttle notch. Therefore, since vigilance acknowledgment was not recorded by BNSF 5897's event recorder, the actual action to turn off BNSF 5897's alert alarm is unknown.

2.3. Event Recorder Timing

The recorded data from both BNSF locomotives' event recorders are independently time stamped and no offset was applied to either set of data. Additionally, all times provided are as recorded by each event recorder.

2.4. BNSF 5897 Plots and Corresponding Tabular Data

Figures 1 through 8 contain BNSF 5897's event recorder parameters listed in table A-1 and cover the train movement from Creston, NE to Lincoln, NE.

Figure 1 contains the entire train movement from 23:28:00 on April 1, 2011 to 11:28:00 on April 2, 2011. Additionally, figure 1 has vertical lines indicating where every alert alarm transitioned from “Off” to “On”.

Figures 2 through 4 split the time covered in figure 1. Figure 2 covers the first 3 hours of data from 23:28:00 to 02:28:00, figure 3 covers the next 4 hours of data from 02:28:00 to 06:28:00 and lastly, figure 4 covers the last 5 hours of data from 06:28:00 to 11:28:00. These 3 figures have vertical lines associated when the alert alarm transitioned from “Off” to “On” including the recorded time each alert alarm occurred and the duration of each alert alarm.

Lastly, figures 5 through 8 are the same plots as figures 1 through 4, respectively, except the lines and labels were removed.

In summary, the BNSF 5897’s event recorder data indicated there were a total of 88 alert alarms that transitioned from “Off” to “On” between 23:28:00 on April 1, 2011 to 11:28:00 on April 2, 2011. Table 2 lists the 88 alert alarms including the time the train started and stopped movement, the time each alert alarm transitioned from “Off” to “On”, the duration of each alert alarm from “On” to “Off”, and, lastly, the time between events.

Table 2. Alert alarm information from BNSF 5897.

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Elapsed Time Since Previous Event (hh:mm:ss)
23:37:40	Start Movement	N/A	N/A
23:37:56	Alert Alarm 1	5	0:00:16
23:49:21	Alert Alarm 2	4	0:11:25
0:10:10	Alert Alarm 3	2	0:20:49
0:13:25	Alert Alarm 4	2	0:03:15
0:16:03	Stop Movement	N/A	0:02:38
0:31:50	Start Movement	N/A	0:15:47
0:32:07	Alert Alarm 5	5	0:00:17
0:47:15	Alert Alarm 6	3	0:15:08
0:51:21	Alert Alarm 7	5	0:04:06
1:06:54	Alert Alarm 8	2	0:15:33
1:13:33	Alert Alarm 9	2	0:06:39
1:14:30	Alert Alarm 10	3	0:00:57
1:15:32	Alert Alarm 11	2	0:01:02
1:16:32	Alert Alarm 12	3	0:01:00
1:20:49	Alert Alarm 13	6	0:04:17
1:22:13	Alert Alarm 14	3	0:01:24
1:23:08	Alert Alarm 15	3	0:00:55
1:24:06	Alert Alarm 16	2	0:00:58
1:27:16	Alert Alarm 17	2	0:03:10
1:28:09	Alert Alarm 18	3	0:00:53
1:29:09	Alert Alarm 19	3	0:01:00

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Elapsed Time Since Previous Event (hh:mm:ss)
1:30:05	Alert Alarm 20	3	0:00:56
1:31:18	Alert Alarm 21	3	0:01:13
1:51:01	Alert Alarm 22	3	0:19:43
1:53:05	Alert Alarm 23	3	0:02:04
1:54:02	Alert Alarm 24	4	0:00:57
1:57:13	Alert Alarm 25	4	0:03:11
2:00:07	Alert Alarm 26	3	0:02:54
2:01:04	Alert Alarm 27	3	0:00:57
2:02:03	Alert Alarm 28	3	0:00:59
2:03:04	Alert Alarm 29	2	0:01:01
2:08:03	Alert Alarm 30	4	0:04:59
2:18:41	Stop Movement	N/A	0:10:38
3:04:23	Start Movement	N/A	0:45:42
3:10:59	Alert Alarm 31	3	0:06:36
3:27:23	Alert Alarm 32	2	0:16:24
3:31:53	Stop Movement	N/A	0:04:30
3:37:28	Start Movement	N/A	0:05:35
3:54:43	Alert Alarm 33	3	0:17:15
3:58:48	Alert Alarm 34	2	0:04:05
4:05:27	Alert Alarm 35	2	0:06:39
4:06:46	Alert Alarm 36	7	0:01:19
4:13:48	Alert Alarm 37	1	0:07:02
4:15:11	Alert Alarm 38	2	0:01:23
4:23:14	Alert Alarm 39	2	0:08:03
4:27:02	Alert Alarm 40	3	0:03:48
4:30:20	Alert Alarm 41	2	0:03:18
4:37:14	Alert Alarm 42	3	0:06:54
4:38:35	Alert Alarm 43	3	0:01:21
4:40:51	Alert Alarm 44	1	0:02:16
4:54:51	Stop Movement	N/A	0:14:00
4:58:32	Start Movement	N/A	0:03:41
5:00:56	Alert Alarm 45	3	0:02:24
5:11:08	Alert Alarm 46	2	0:10:12
5:15:51	Alert Alarm 47	3	0:04:43
5:18:28	Alert Alarm 48	3	0:02:37
5:21:06	Stop Movement	N/A	0:02:38
5:27:20	Start Movement	N/A	0:06:14
5:32:43	Alert Alarm 49	3	0:05:23
5:35:54	Alert Alarm 50	3	0:03:11
5:46:27	Alert Alarm 51	3	0:10:33

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Elapsed Time Since Previous Event (hh:mm:ss)
5:48:33	Alert Alarm 52	2	0:02:06
5:56:51	Alert Alarm 53	3	0:08:18
6:09:18	Stop Movement	N/A	0:12:27
7:03:15	Start Movement	N/A	0:53:57
7:03:28	Alert Alarm 54	3	0:00:13
7:10:55	Alert Alarm 55	2	0:07:27
7:16:20	Alert Alarm 56	3	0:05:25
7:22:09	Alert Alarm 57	2	0:05:49
7:25:03	Alert Alarm 58	5	0:02:54
7:32:37	Alert Alarm 59	8	0:07:34
7:33:09	Stop Movement	N/A	0:00:32
8:39:42	Start Movement	N/A	1:06:33
8:39:58	Alert Alarm 60	4	0:00:16
8:42:26	Alert Alarm 61	3	0:02:28
8:44:38	Alert Alarm 62	7	0:02:12
8:47:36	Alert Alarm 63	4	0:02:58
8:48:46	Alert Alarm 64	3	0:01:10
8:49:50	Alert Alarm 65	7	0:01:04
8:50:59	Alert Alarm 66	2	0:01:09
8:57:47	Alert Alarm 67	4	0:06:48
8:59:09	Alert Alarm 68	8	0:01:22
9:00:01	Alert Alarm 69	4	0:00:52
9:01:09	Alert Alarm 70	3	0:01:08
9:02:19	Alert Alarm 71	6	0:01:10
9:03:09	Alert Alarm 72	3	0:00:50
9:06:25	Alert Alarm 73	3	0:03:16
9:08:10	Alert Alarm 74	2	0:01:45
9:09:34	Alert Alarm 75	1	0:01:24
9:10:50	Alert Alarm 76	2	0:01:16
9:12:32	Alert Alarm 77	4	0:01:42
9:14:12	Alert Alarm 78	2	0:01:40
9:17:33	Alert Alarm 79	2	0:03:21
9:19:52	Alert Alarm 80	3	0:02:19
9:20:59	Alert Alarm 81	1	0:01:07
9:28:59	Stop Movement	N/A	0:08:00
10:44:31	Start Movement	N/A	1:15:32
10:49:29	Alert Alarm 82	4	0:04:58
10:51:08	Alert Alarm 83	2	0:01:39
10:52:34	Alert Alarm 84	3	0:01:26
11:00:08	Alert Alarm 85	3	0:07:34

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Elapsed Time Since Previous Event (hh:mm:ss)
11:09:47	Stop Movement	N/A	0:09:39
11:10:44	Start Movement	N/A	0:00:57
11:12:47	Alert Alarm 86	3	0:02:03
11:14:56	Alert Alarm 87	4	0:02:09
11:18:07	Stop Movement	N/A	0:03:11
11:20:03	Alert Alarm 88	2	0:01:56

All of the corresponding tabular data used to create figures 1 through 8 are provided in electronic (.CSV) format as attachment 1 to this factual report.

Figure 1. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE with vertical lines for each alert alarm.

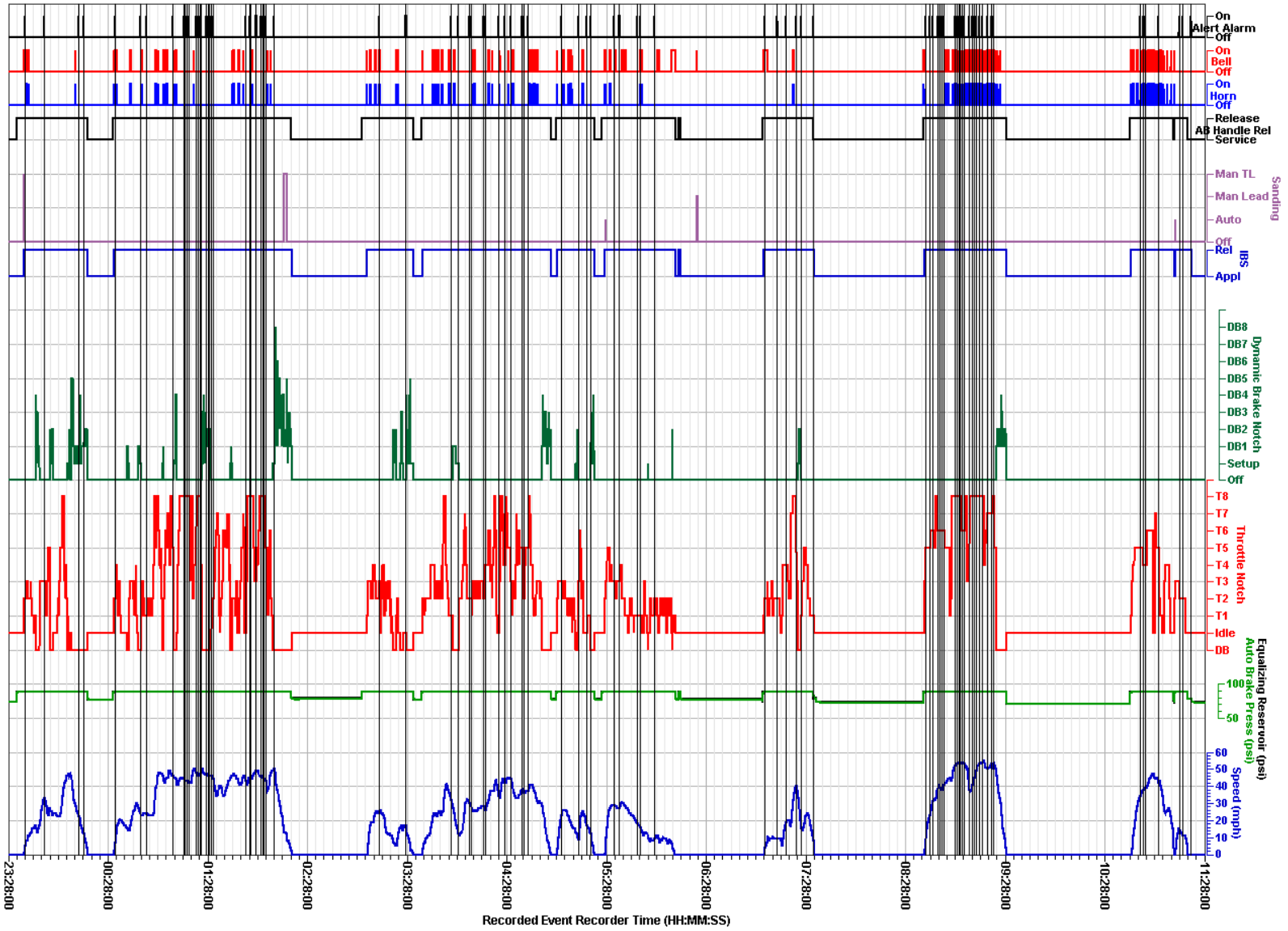
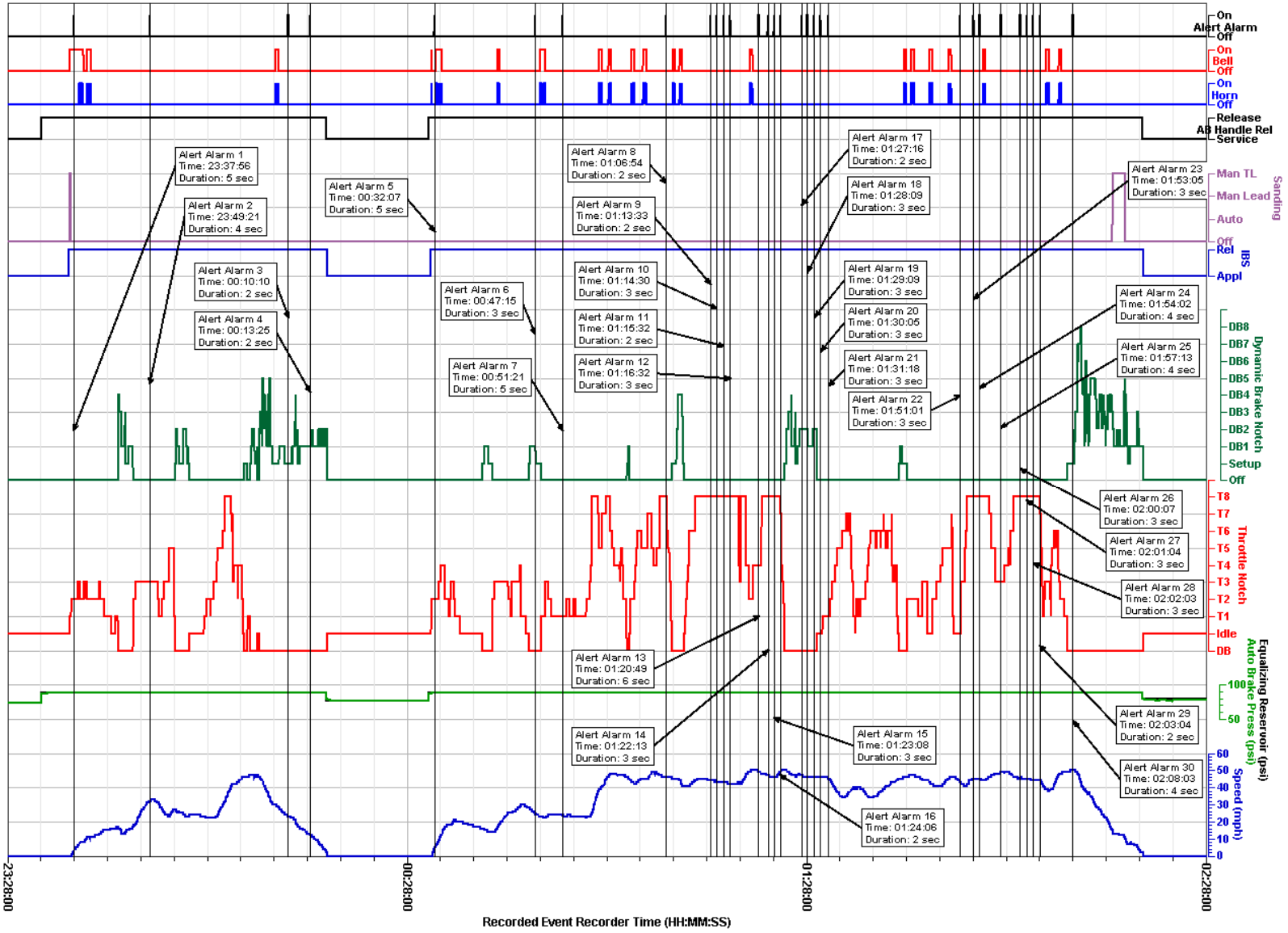


Figure 2. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 1 of 3).



Revised: 22 September 2011

BNSF 5897, 4/1/11-4/2/11 Creston to Lincoln (Expanded Scale 1/3)

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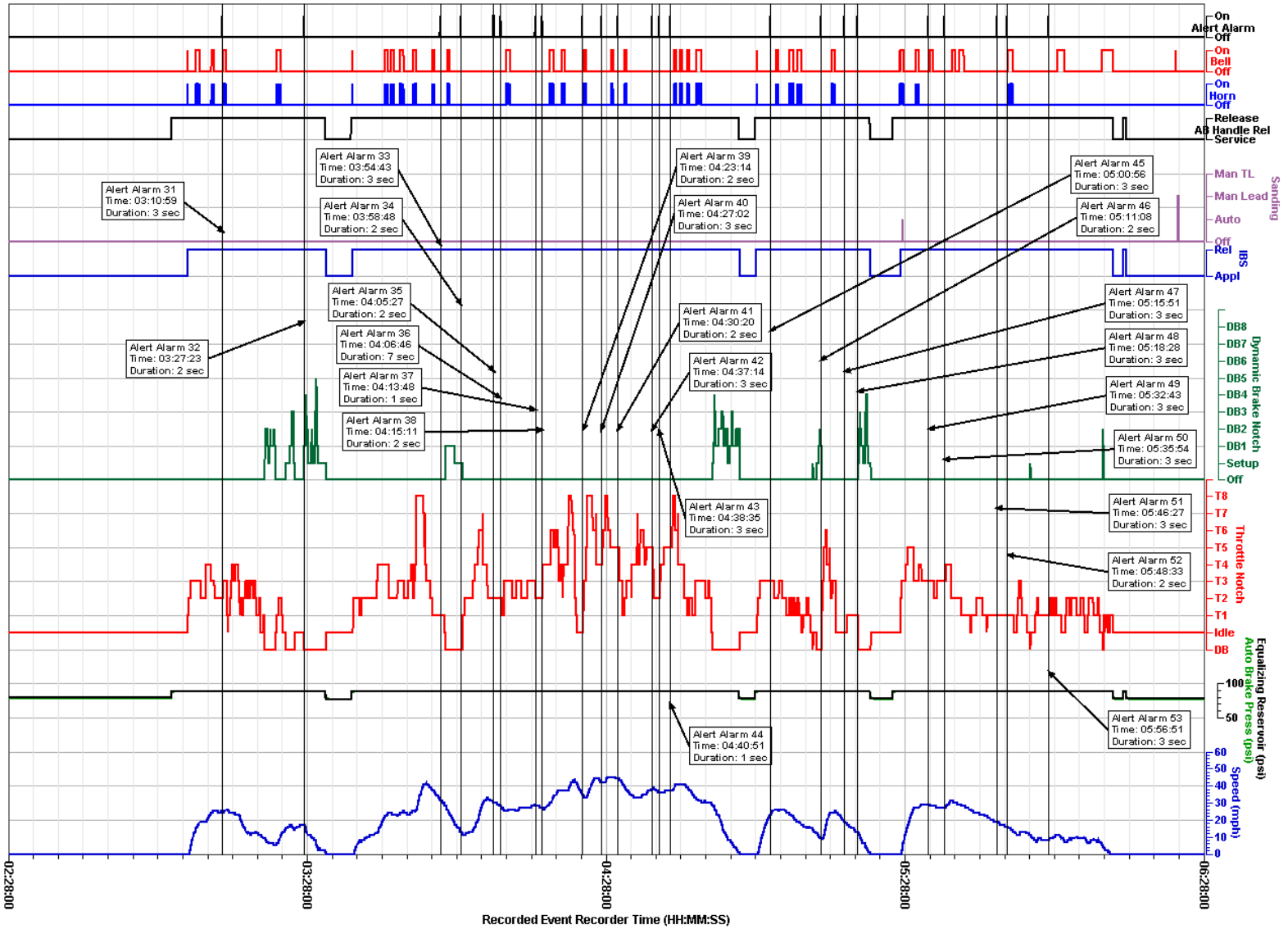
Figure 3. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 2 of 3).



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BNSF 5897, 4/1/11-4/2/11 Creston to Lincoln (Expanded Scale 2/3)

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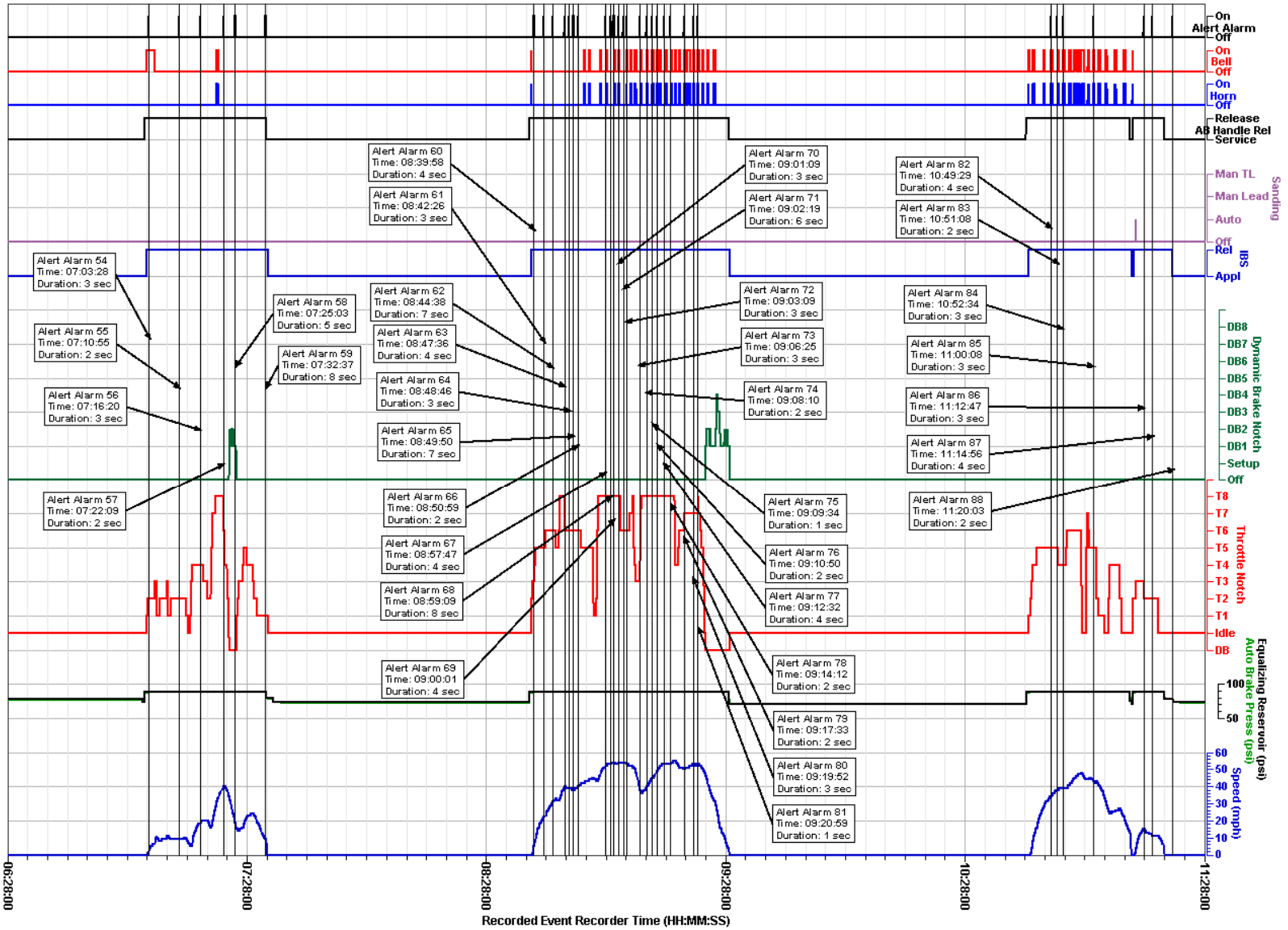
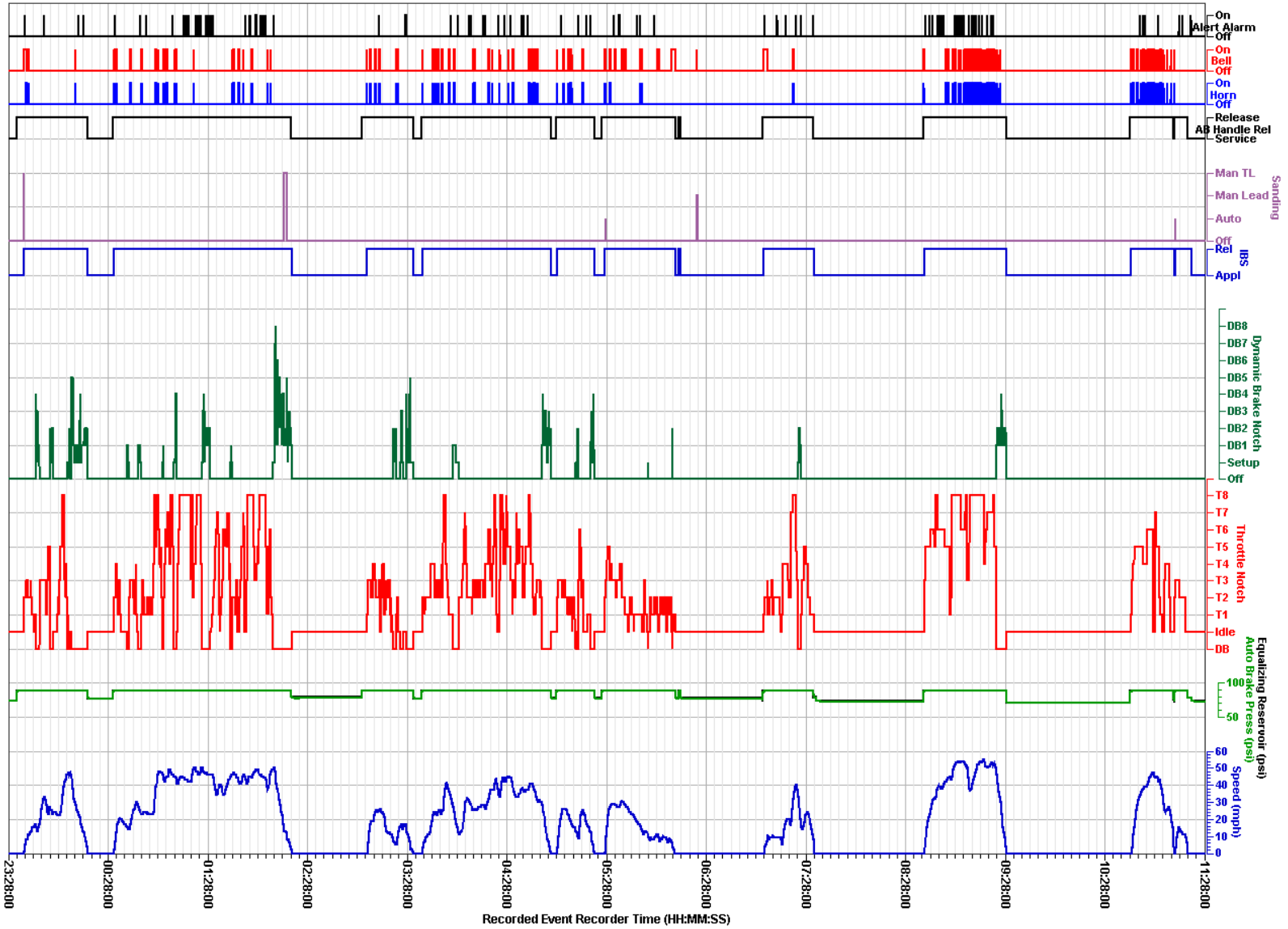
Figure 4. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 3 of 3).



Revised: 19 October 2011 BNSF 5897, 4/1/11-4/2/11 Creston to Lincoln (Expanded Scale 3/3) National Transportation Safety Board

Figure 5. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE without vertical lines.



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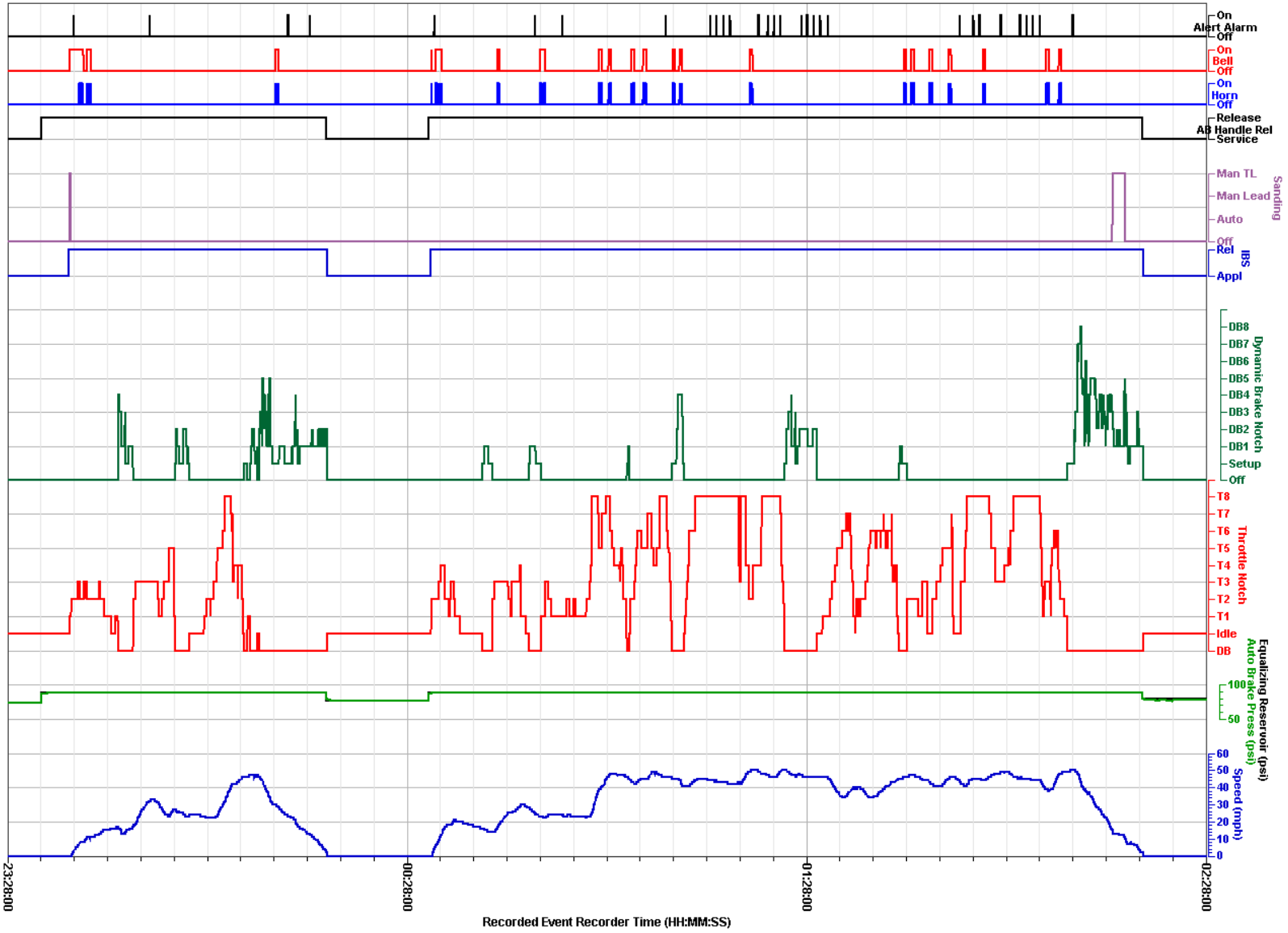
BNSF 5897, 4/1/11-4/2/11 Creston to Lincoln (No Alert Alarm Lines)

National Transportation Safety Board

Figure 6. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 1 of 3) without labels.

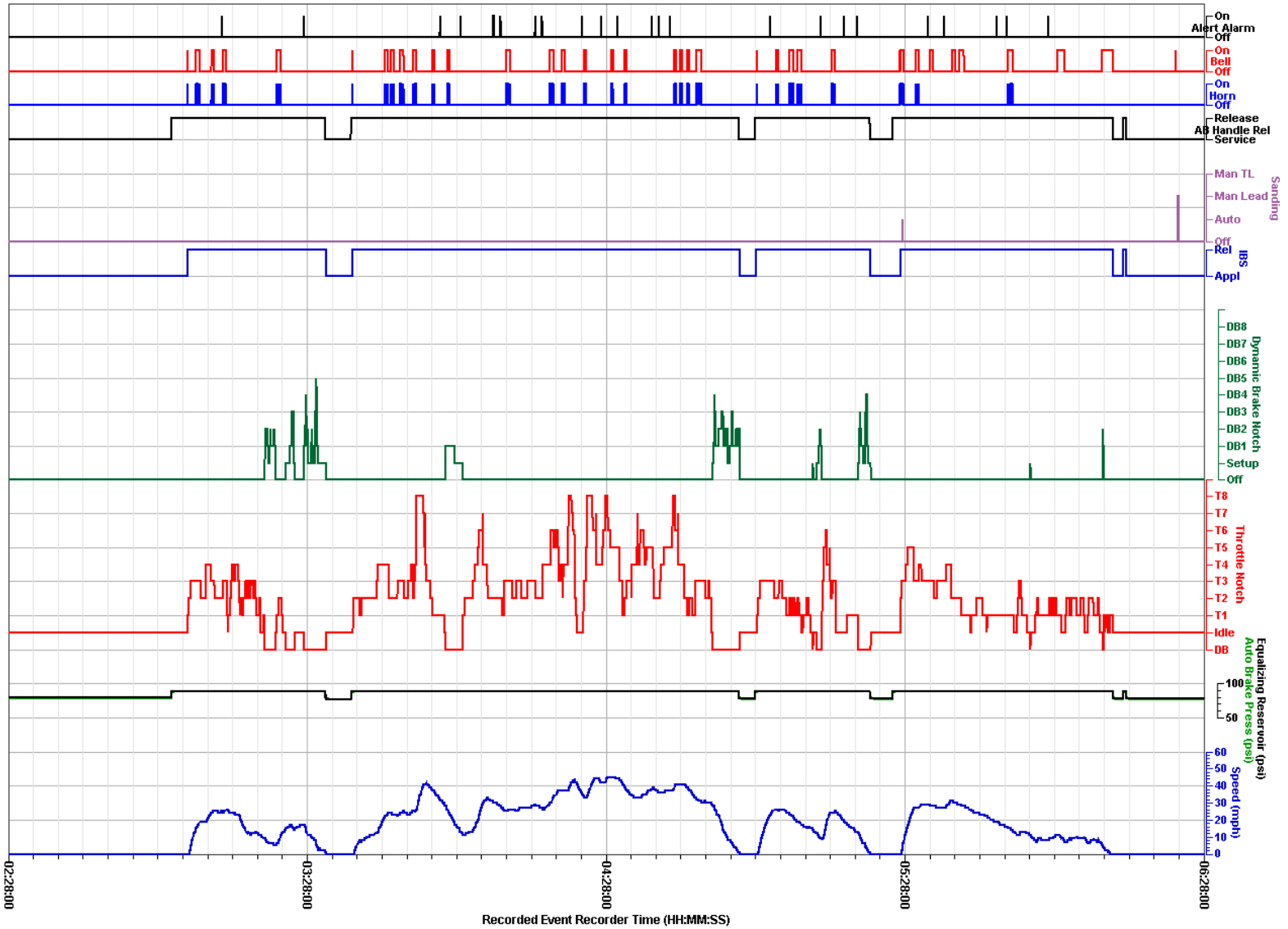


Revised: 22 September 2011

BNSF5897 4/1/11-4/2/11 Creston-Lincoln (Expanded Scale 1/3) No Labels

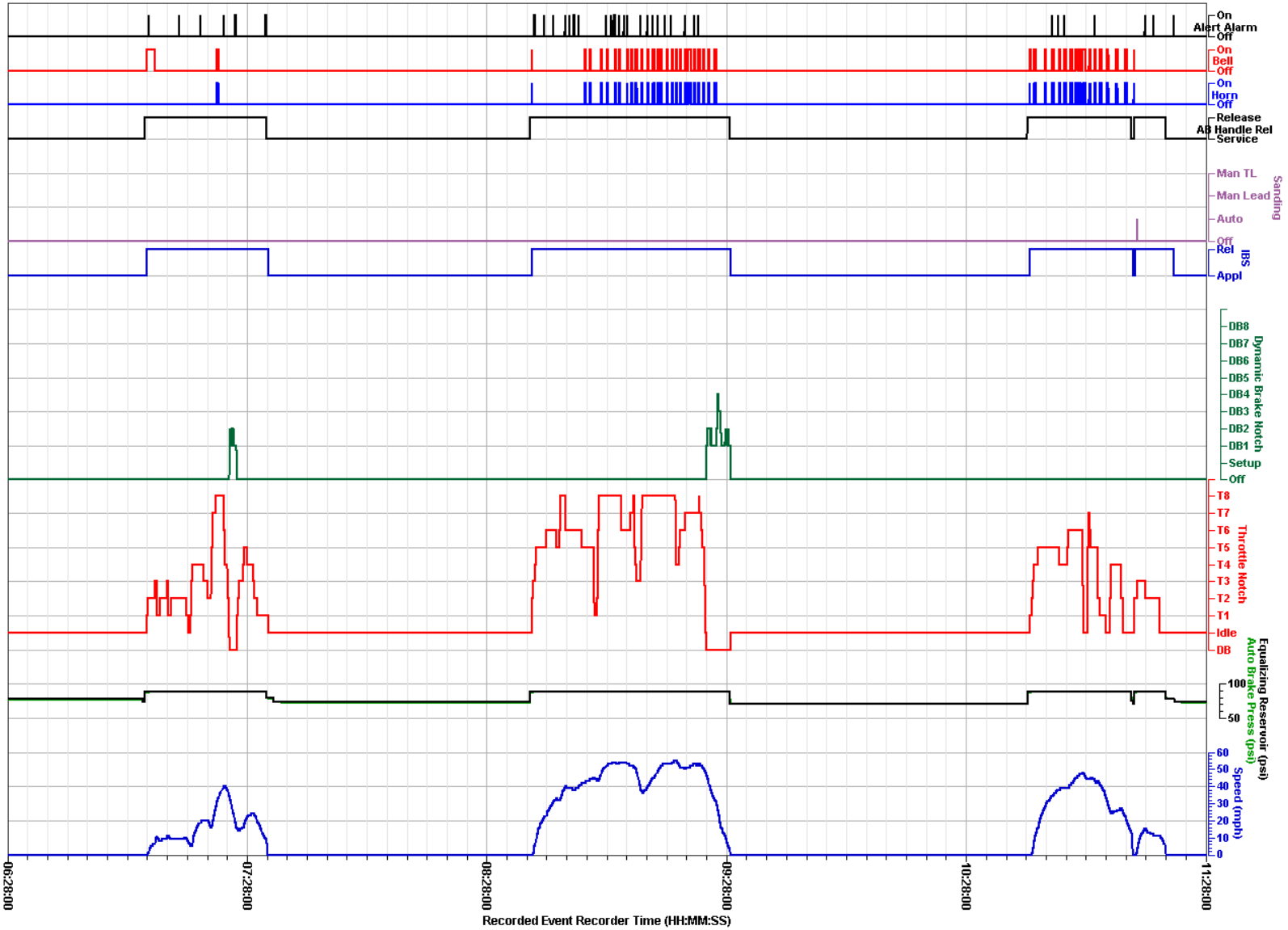
National Transportation Safety Board

Figure 7. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 2 of 3) without labels.



Revised: 22 September 2011 BNSF5897 4/1/11-4/2/11 Creston-Lincoln (Expanded Scale 2/3) No Labels National Transportation Safety Board

Figure 8. BNSF 5897 event recorder data from Creston, NE to Lincoln, NE (plot 3 of 3) without labels.



Revised: 22 September 2011

BNSF5897 4/1/11-4/2/11 Creston-Lincoln (Expanded Scale 3/3) No Labels

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2.5. BNSF 9309 Plots and Corresponding Tabular Data

Figures 9 through 14 contain BNSF 9309's event recorder parameters listed in table A-2 and cover the train movement from Lincoln, NE to Creston, NE. As stated in section 2.2.1 Alert Alarm, BNSF 9309 recorded the four actions (e.g. vigilance acknowledgement, bell, horn and throttle notch) that would turn the alert alarm off (from "On" to "Off"). Therefore, the action that turned off the alert alarm was recorded and is provided in this section.

Figure 9 covers the entire train movement from 19:12:00 on April 2, 2011 to 00:42:00 on April 3, 2011. Additionally, figure 9 has vertical lines indicating where every alert alarm transitioned from "Off" to "On".

Figures 10 and 11 split the time covered in figure 9. Figure 10 covers the first 2 hours and 45 minutes from 19:12:00 to 21:57:00 and figure 11 covers the next 2 hours and 45 minutes 21:57:00 to 00:42:00. These 2 figures have vertical lines indicating when the alert alarm transitioned from "Off" to "On" including the recorded time each alert alarm occurred, the duration of each alert alarm and the action that turned off the alert alarm.

Lastly, figures 12 through 14 are the same plots as figures 9 through 11, respectively, except the lines and labels were removed.

In summary, the BNSF 9309 event recorder data indicated there were a total of 37 alert alarms that transitioned from "Off" to "On" between 19:12:00 on April 2, 2011 to 00:42:00 on April 3, 2011. Table 3 lists the 37 alert alarms including the time the train started and stopped movement, the time each alert alarm transitioned from "Off" to "On", the duration of each alert alarm from "On" to "Off", the time between the events, and lastly, the parameter that turned the alert alarm off.

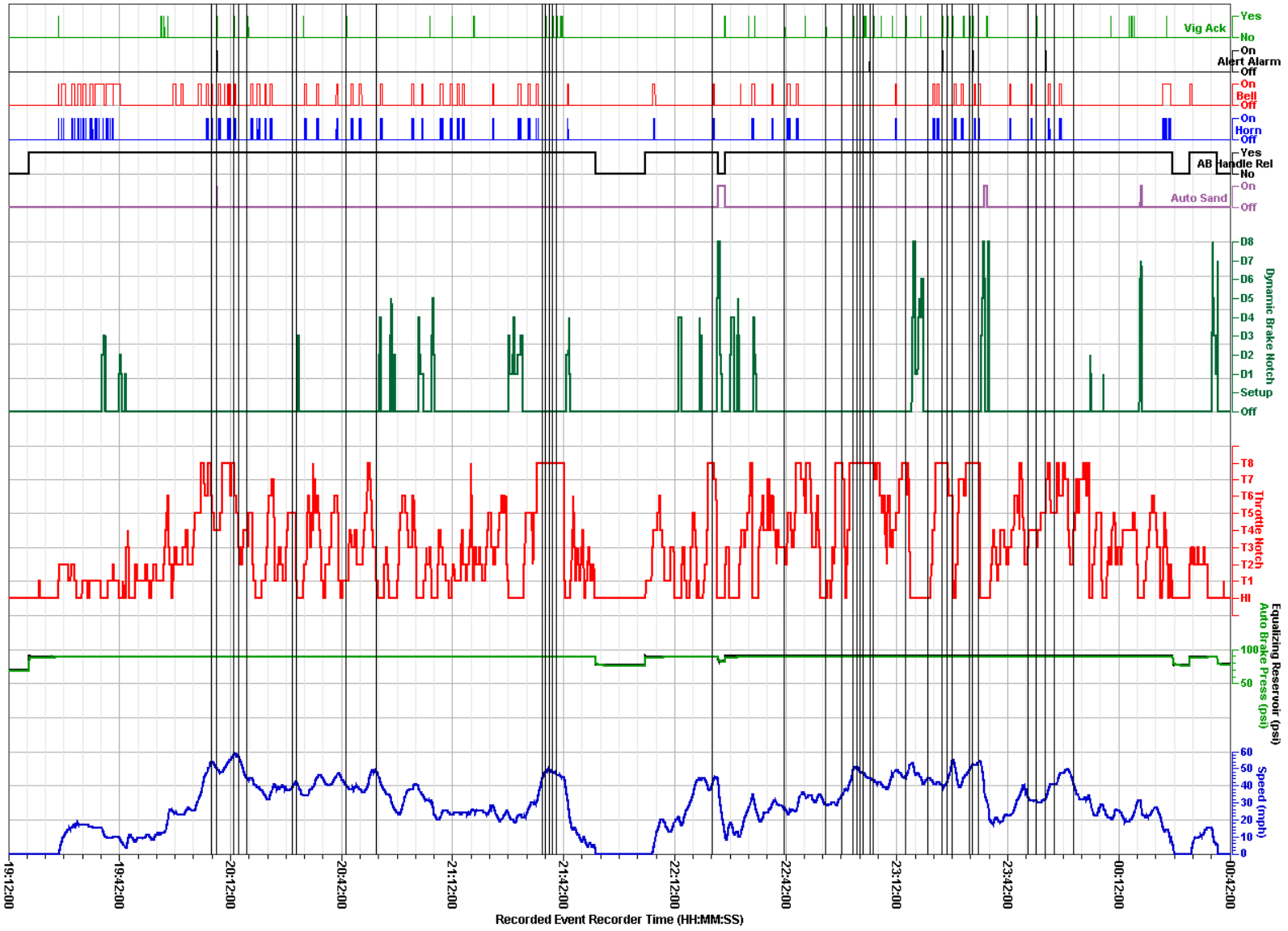
Table 3. Alert alarm information from BNSF 9309.

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Triggered the Alert Alarm Off	Elapsed Time Since Previous Event (hh:mm:ss)
19:25:47	Start Movement	N/A	N/A	N/A
20:06:45	Alert Alarm 1	1	Vig Ack	0:40:58
20:08:18	Alert Alarm 2	4	Vig Ack	0:01:33
20:12:53	Alert Alarm 3	1	Vig Ack	0:04:35
20:14:16	Alert Alarm 4	1	Throttle Notch	0:01:23
20:16:20	Alert Alarm 5	2	Vig Ack	0:02:04
20:28:36	Alert Alarm 6	2	Vig Ack	0:12:16
20:29:41	Alert Alarm 7	2	Throttle Notch	0:01:05
20:43:10	Alert Alarm 8	2	Vig Ack	0:13:29
20:51:18	Alert Alarm 9	1	Vig Ack	0:08:08
21:36:07	Alert Alarm 10	5	Vig Ack	0:44:49
21:37:06	Alert Alarm 11	2	Vig Ack	0:00:59
21:38:02	Alert Alarm 12	1	Vig Ack	0:00:56
21:39:00	Alert Alarm 13	3	Vig Ack	0:00:58

Recorded Time (Ascending)	Event	Duration of Alert Alarm (seconds)	Triggered the Alert Alarm Off	Elapsed Time Since Previous Event (hh:mm:ss)
21:39:58	Alert Alarm 14	2	Vig Ack	0:00:58
21:50:49	Stop Movement	N/A	N/A	0:10:51
22:06:05	Start Movement	N/A	N/A	0:15:16
22:22:05	Alert Alarm 15	5	Vig Ack	0:16:00
22:41:35	Alert Alarm 16	2	Vig Ack	0:19:30
22:52:43	Alert Alarm 17	6	Vig Ack	0:11:08
22:57:04	Alert Alarm 18	2	Vig Ack	0:04:21
23:00:16	Alert Alarm 19	1	Vig Ack	0:03:12
23:01:10	Alert Alarm 20	2	Vig Ack	0:00:54
23:02:01	Alert Alarm 21	3	Vig Ack	0:00:51
23:02:54	Alert Alarm 22	4	Vig Ack	0:00:53
23:04:41	Alert Alarm 23	5	Vig Ack	0:01:47
23:05:41	Alert Alarm 24	2	Vig Ack	0:01:00
23:14:27	Alert Alarm 25	2	Vig Ack	0:08:46
23:20:20	Alert Alarm 26	6	Vig Ack	0:05:53
23:24:21	Alert Alarm 27	2	Vig Ack	0:04:01
23:25:31	Alert Alarm 28	2	Vig Ack	0:01:10
23:27:02	Alert Alarm 29	3	Vig Ack	0:01:31
23:31:36	Alert Alarm 30	3	Vig Ack	0:04:34
23:32:32	Alert Alarm 31	4	Vig Ack	0:00:56
23:34:07	Alert Alarm 32	2	Vig Ack	0:01:35
23:47:32	Alert Alarm 33	1	Throttle Notch	0:13:25
23:49:44	Alert Alarm 34	2	Vig Ack	0:02:12
23:52:14	Alert Alarm 35	2	Throttle Notch	0:02:30
23:54:35	Alert Alarm 36	2	Vig Ack	0:02:21
23:59:42	Alert Alarm 37	2	Vig Ack	0:05:07
0:27:01	Stop Movement	N/A	N/A	0:27:19

All of the corresponding tabular data used to create figures 9 through 14 are provided in electronic (.CSV) format as attachment 2 to this factual report.

Figure 9. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE with vertical lines for each alert alarm.



Revised: 22 September 2011

BNSF 9309, 4/2/11 to 4/3/11, Lincoln to Creston (Alert Alarm Lines Only)

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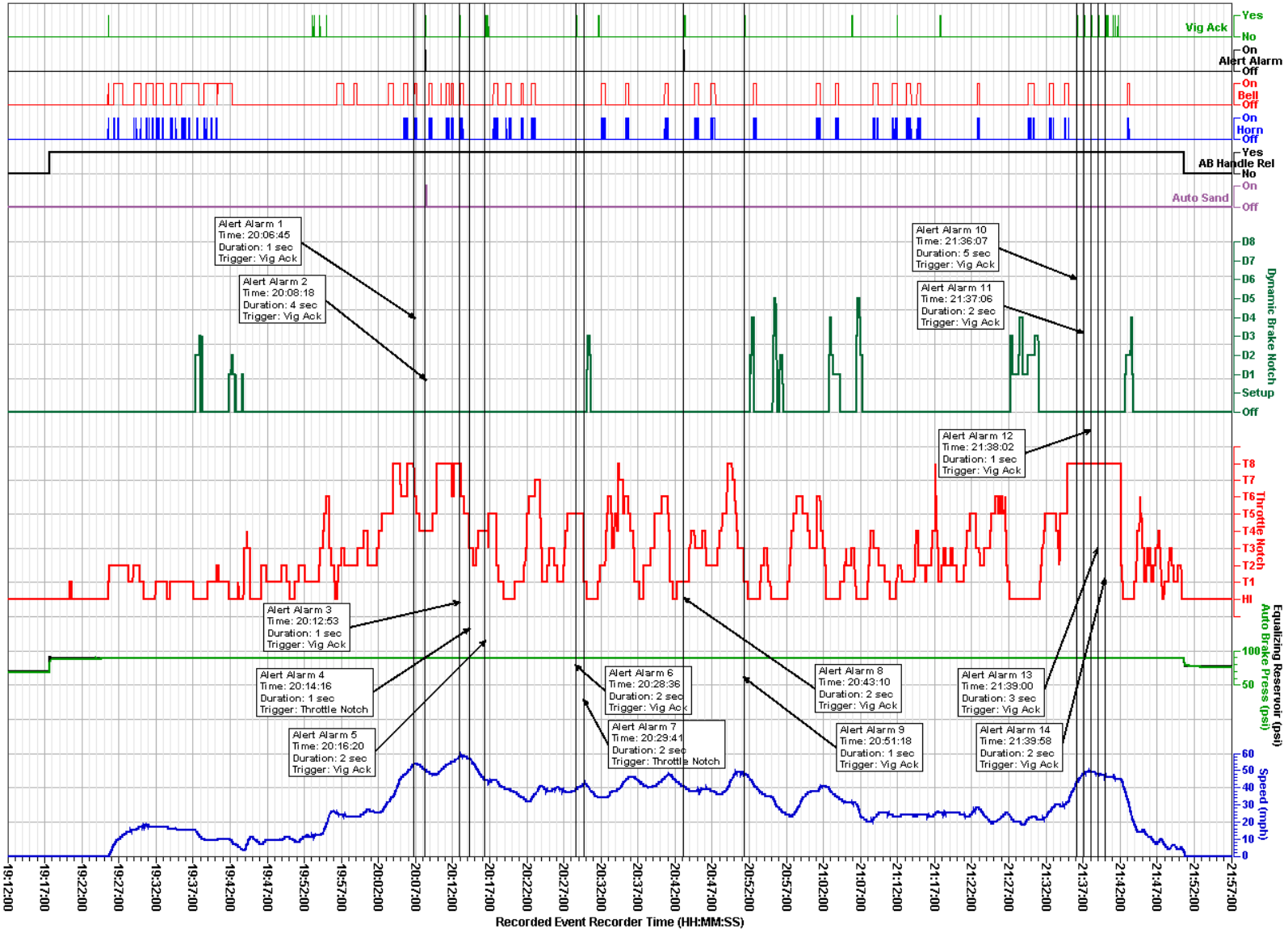
Figure 10. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE (plot 1 of 2).



Revised: 23 September 2011

BNSF 9309, 4/2/11, Lincoln to Creston (Expanded Scale 1/2)

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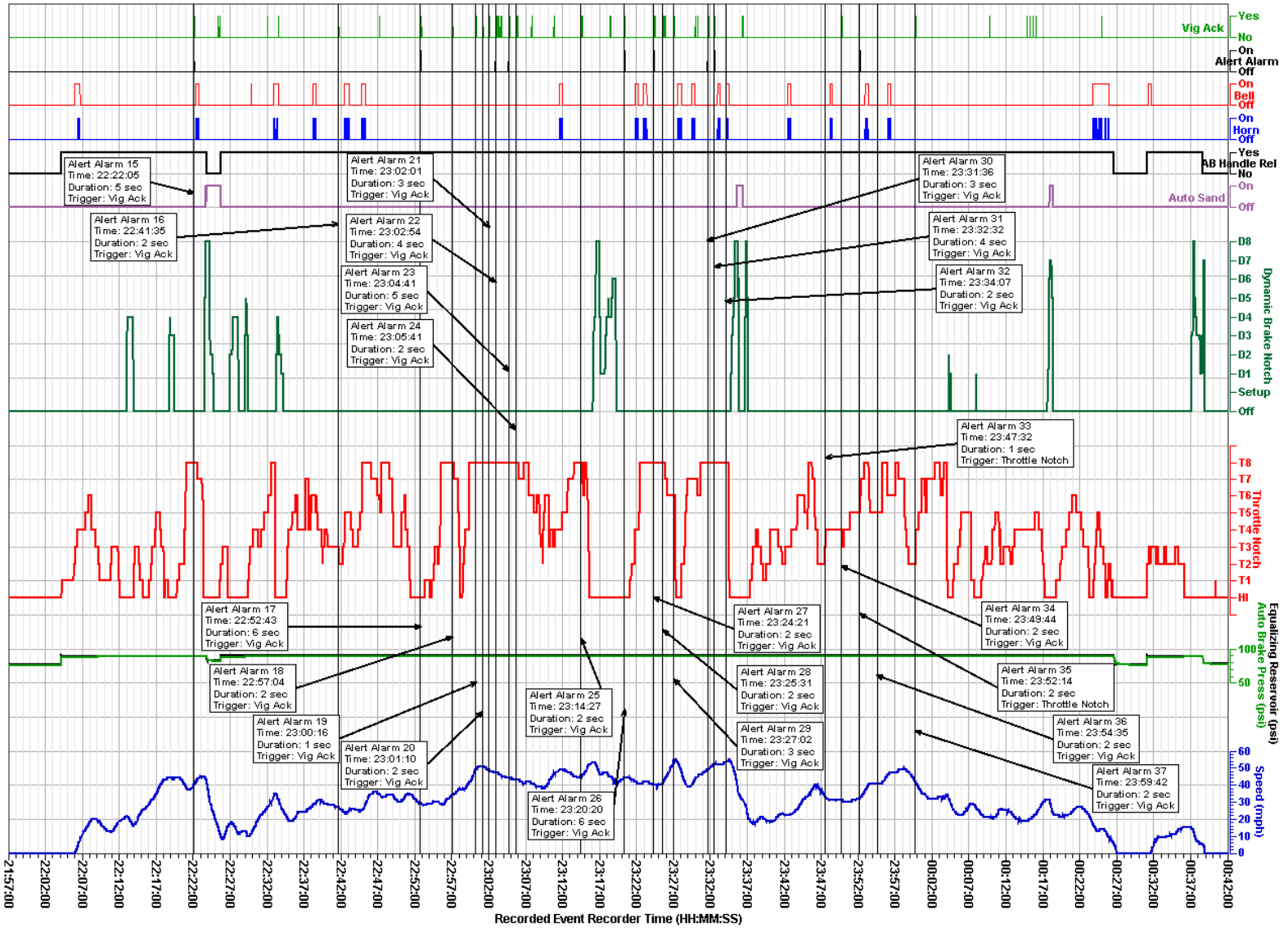
Figure 11. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE (plot 2 of 2).



Revised: 22 September 2011

BNSF 9309, 4/2/11 to 4/3/11, Lincoln to Creston (Expanded Scale 2/2)

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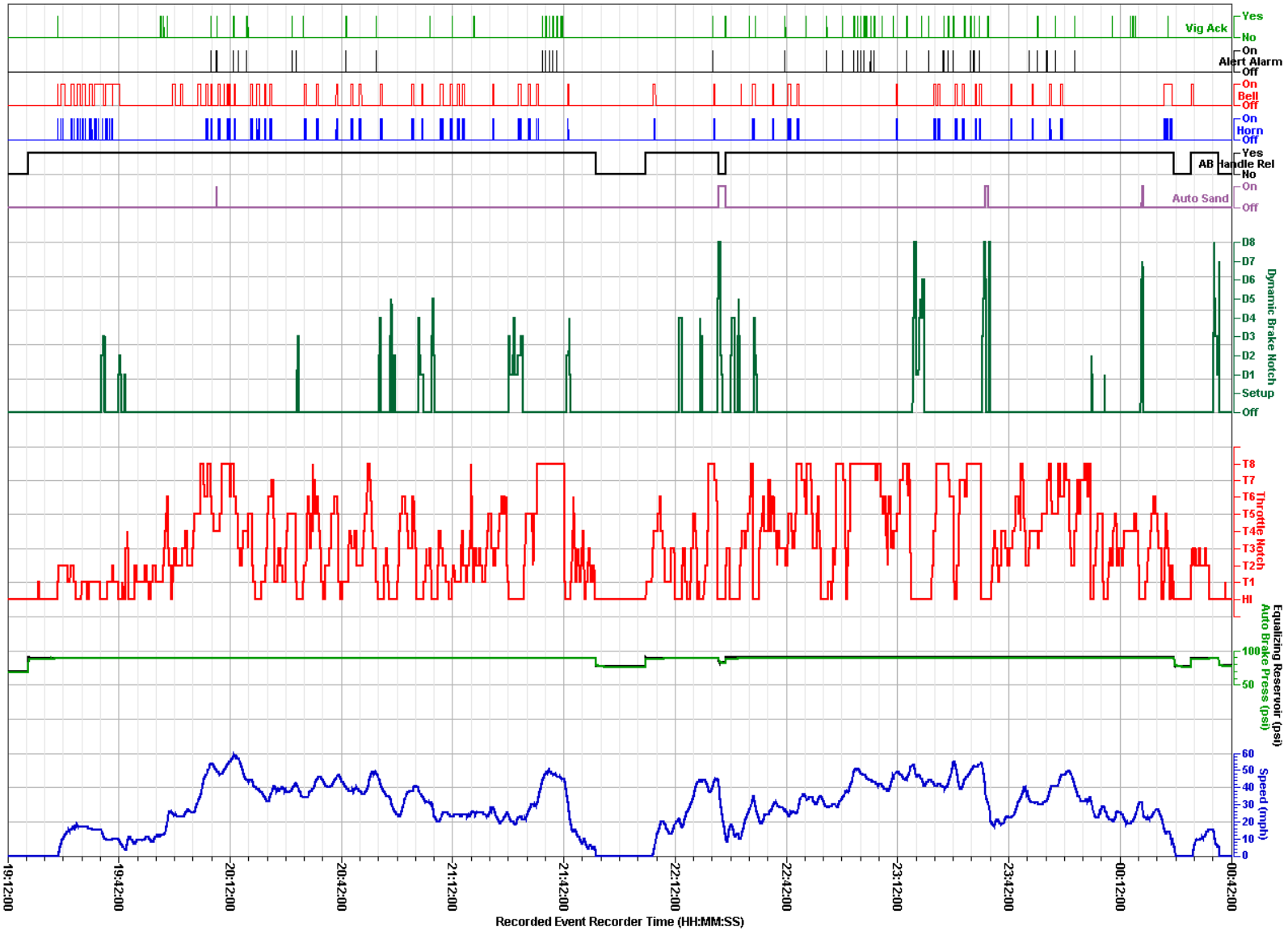
Figure 12. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE without vertical lines.

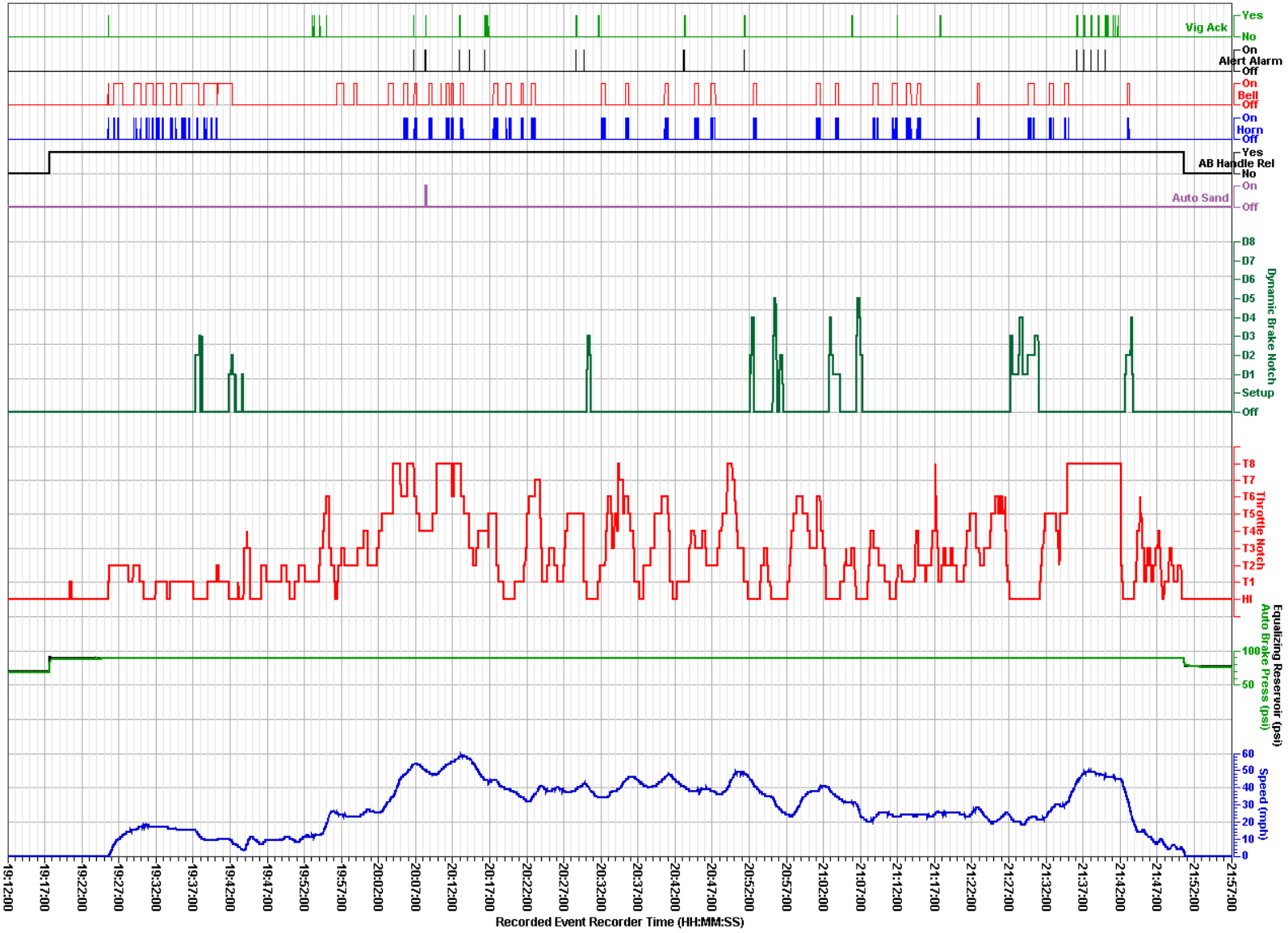


Revised: 22 September 2011

BNSF 9309, 4/2/11 to 4/3/11, Lincoln to Creston (No Alert Alarm Lines)

National Transportation Safety Board

Figure 13. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE (plot 1 of 2) no labels.

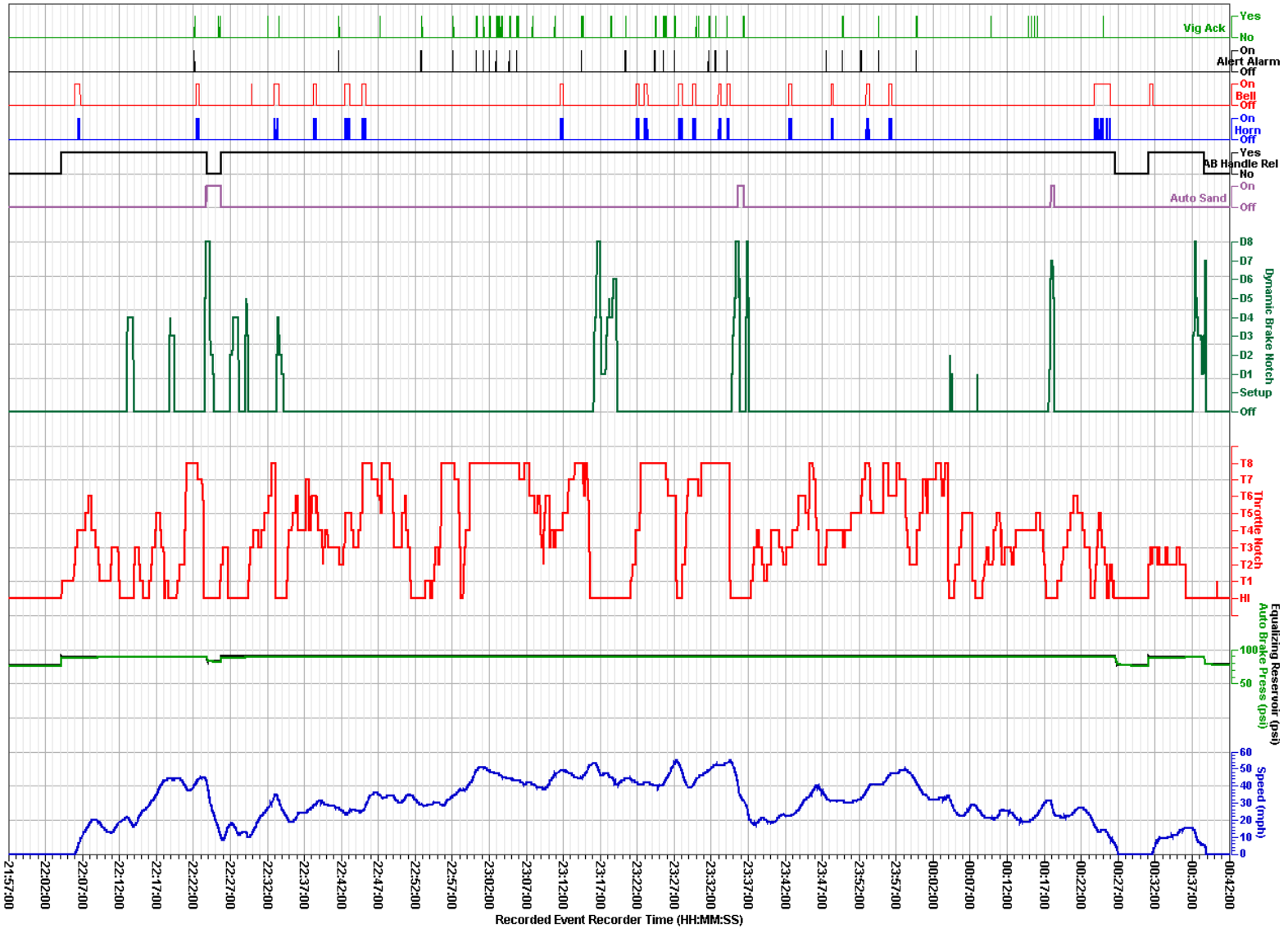


Revised: 23 September 2011

BNSF 9309, 4/2/11, Lincoln to Creston (Expanded Scale 1/2)

National Transportation Safety Board

Figure 14. BNSF 9309 event recorder data from Lincoln, NE to Creston, NE (plot 2 of 2) no labels.



APPENDIX A

This appendix describes the parameters provided and verified in this report. Tables A-1 and A-2 lists the parameters and table A-3 describes the unit abbreviations.

Table A-1. Verified and provided event recorder parameters from BNSF 5897.

Parameter Name	Parameter Description
1. AB Handle Rel (discrete)	Automatic Brake Handle Release
2. Alert Alarm (discrete)	Alert Alarm
3. Auto Brake Press (psi)	Automatic Brake Pressure
4. Bell (discrete)	Bell
5. Dynamic Brake Notch (discrete)	Dynamic Brake Notch
6. Equalizing Reservoir (psi)	Equalizing Reservoir
7. Horn (discrete)	Horn
8. IBS (discrete)	Independent Brake Switch
9. Sanding (discrete)	Sanding
10. Speed (mph)	Speed
11. Throttle Notch (discrete)	Throttle Notch

Table A-2. Verified and provided parameters from BNSF 9309.

Parameter Name	Parameter Description
1. AB Handle Rel (discrete)	Automatic Brake Handle Release
2. Alert Alarm (discrete)	Alert Alarm
3. Auto Brake Press (psi)	Automatic Brake Pressure
4. Auto Sand (discrete)	Auto Sand
5. Bell (discrete)	Bell
6. Dynamic Brake Notch (discrete)	Dynamic Brake Notch
7. Equalizing Reservoir (psi)	Equalizing Reservoir
8. Horn (discrete)	Horn
9. Speed (mph)	Speed
10. Throttle Notch (discrete)	Throttle Notch
11. Vig Ack (discrete)	Vigilance Acknowledgement

Table A-3. Unit abbreviations.

Units Abbreviation	Description
mph	miles per hour
psi	pounds per square inch

NOTE: For parameters with a unit description of discrete, a discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.