Short-range Seismic and Acoustic Signature Measurements Through Forest

Stephen N. Decato, Donald G. Albert, Frank E. Perron Jr., and David L. Carbee

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ABSTRACT: The effect of forests on low frequency military noise propagation is unknown. As part of a joint project, ERDC-CERL and ERDC CRREL conducted measurements at the Lone Star Army Ammunition Plant located in Texarkana, Texas, to investigate these effects. In this report, the short-range measurements conducted by ERDC-CRREL are documented. Blast noise waveforms produced by C4 explosions at distances from 30 to 567 m were recorded and are presented in this report. In all, 42 different explosions were recorded, producing 314 high quality pressure waveforms for analysis. Additional reports documenting the long-range measurements and analyzing the recorded data are in preparation.

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PREFACE

This report was prepared by Stephen N. Decato, Physical Science Technician, Donald G. Albert, Research Geophysicist, Frank E. Perron Jr., Physical Science Technician, and David L. Carbee, Physical Science Technician, Geophysical Sciences Branch, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory.

In recent years the increase of civilian populations living on the outskirts of U.S. Army installations has led to more frequent noise complaints. While the Army normally uses forest management techniques to ensure the health of the forests on its installations, a question that has arisen is whether these forest practices, including tree harvesting, might adversely impact the noise problem by reducing the noise absorption characteristics of the forested land. Underlying this question is the assumption that forests absorb noise. While this is certainly true at high frequencies (in the kHz band), little work has been done at the lower frequencies (below 100 Hz) often produced by Army demolition and training activities. As a result of this lack of knowledge, ERDC, under the direction of Dr. Larry Pater, ERDC-CERL, is embarking on a study of the low frequency noise attenuation by forests. As part of this study, a joint measurement program involving two ERDC Laboratories, CERL and CRREL, was conducted at the Lone Star Army Ammunition Plant in Texarkana, Texas. The purpose of this report is to document the CRREL measurements. Additional reports will document the CERL measurements and analyze the experimental data to determine the effect of the forest on low frequency military blast noise.

Field personnel during this test included Don Albert, Steve Decato, and Frank Perron from CRREL, and Larry Pater, Mike White, Richard Racioppi, Jeff Mifflin, George Swenson, Brent Miller, and Achal Modi from CERL. The authors especially thank Dave Self, Jesse Stewart, and all the other Lone Star Army Ammunition Plant personnel for their assistance during these measurements. They thank Tom Vorac, U.S. AMC Installations and Security Activity (now with the U.S. Army Environmental Center, Natural Resources), and Dr. Larry Pater, U.S.A ERDC-CERL, for funding this research. Finally, they thank Dr. Pater, Project Leader for Military Noise Management, for the invitation to participate in this project.

This report was prepared under the general supervision of Dr. Richard Detsch, Chief, Geophysical Sciences Branch; and James Wuebben, Acting Director, CRREL.

The Commander of the Engineer Research and Development Center is COL James R. Rowan, EN. The Director is Dr. James R. Houston.
Short-range Seismic and Acoustic Signature Measurements Through Forest

STEPHEN N. DECATO, DONALD G. ALBERT, FRANK E. PERRON JR., AND DAVID L. CARBEE

1 INTRODUCTION

This report documents the measurements and presents the signals recorded during the Blast Noise Propagation Through Forest Test conducted by the U.S. Army ERDC Construction Engineering Research Laboratory and the U.S. Army ERDC Cold Regions Research and Engineering Laboratory. The measurements were conducted at the Lone Star Army Ammunition Plant in Texarkana, Texas, from 23 July through 25 July 2002 to determine the properties of blast noise wave propagation through a forested area. This report contains the recordings made by CRREL; the CERL recordings will be published in a separate report. Use of this and other data sets will assist the Army in determining methods of improving blast noise attenuation in populated areas and enhance forest management techniques.

The blast waves were produced by detonating charges of M112 C4 explosive at various heights and locations. Sledge hammer blows on an aluminum plate and .45 caliber blank rounds were also recorded to provide additional ground and air characterization. Pressure sensors, microphones, and geophones were configured in a straight-line array on the ground and 1.5 m above the ground surface.

The intent of this report is to provide documentation of the CRREL measurements that will accompany the transmittal of the recorded data on CD-ROM to the test participants and sponsor. This report includes a list of the records obtained during the tests, documentation of the sensor array, a table of sensors used, environmental characterization, and a description of the data reduction. Plots of all the signatures are provided, and the signatures themselves are included on a CD-ROM in ASCII format. An analysis report of the signatures shown here will be published separately.
2 OVERVIEW OF TEST

The Lone Star Army Ammunition plant routinely detonates obsolete munitions as a method of disposal. On a typical day, as many as 48 shots, each consisting of about 95 lb (43 kg) of explosives, may be detonated. Although these charges are buried 10 to 15 ft (3 to 5 m) deep in a sandy/silty soil, the shots always “blow out,” sending debris high into the air producing a loud blast wave. In recent years, private homes are being built close to the AAP and other Army facilities’ boundary lines. This has resulted in concerns about noise complaints from new residents. As the current demolition area at the AAP is surrounded by forest, a scientifically unanswered question is what is the effect of this forest on the noise produced by the explosions? If the trees are cut or thinned as a part of normal forest management plan, will the noise complaints increase? To answer this question, the measurements in this report were conducted.

The measurements were conducted at the (new) Demolition Range at the Lone Star AAP. Figure 1 shows an aerial photograph of the test site with the shot locations (marked TC = Test Charge) and sensor locations. The CRREL sensor array was located in the forest south of TC 3. Figure 2 shows a schematic of the CRREL sensor locations and a typical test charge (C-4) shot. Details of the sensor array are given in Section 3 of this report.

Data Recording and Reduction

A Geometrics NZ digital seismograph (Fig. 3) was used to record the signature data from the sensor arrays. We used an 8-kHz sampling rate (0.125 ms) per channel, providing a 3-dB recording bandwidth of 1.75 Hz to 3.3 kHz. Twenty-four sensor channels were recorded for each test charge.

Because of a malfunction with the CRREL blaster box, the actual shot instant could not be recorded and the recorder could not be automatically started as we normally do. Instead, the recordings were started manually and the shot instant was determined afterwards from the blast wave arrival times. This correction procedure is discussed in Section 6.

The seismograph produces binary data files in an industry standard format called SEG-2. These binary files contain the raw voltage output of the sensors, but contain no other information. We converted these binary files into ASCII files using the MATLAB program listed in Appendix B. The ASCII files have the correct physical units, time information, and sensor location details. The signature plots presented in Appendix A were produced by the MATLAB program.
listed in Appendix C from the ASCII data files. Additional data analysis will be performed using only the ASCII data files.

Figure 1. View of the Lone Star AAP test range, with approximate locations of test charge and sensor locations.
Figure 2. Test Charge Site 2 (TC 2) and a sketch of the test array.
List of Signature Records

The measurements were conducted without interfering with the normal demolition operations. This meant that the forest testing was delayed and personnel were evacuated from the test site when demolition shots were fired. While we did take advantage of this opportunity to record some of these demolition shots using a separate small sensor array located in the safety zone, those recordings are not of client interest to this study and are not included in this report. They do, however, affect the numbering of the records and files recorded by the digital seismograph.

The following list contains the types of data recorded for the Blast Noise Propagation Test and is included on the CD. NZ file names like “1.dat” through “199.dat” have been converted to multichannel ASCII files with the correct physical units. File names like “TX02002.asc” through “TX02046.asc” are files numbered so that they correspond to CERL’s C4 shot numbers. Munition demolition records have been omitted from this report. Table 1 contains the list of signature records. Figures 4 and 5 show our C4 charges and .45-calibre pistol.
Table 1. Signature records.

<table>
<thead>
<tr>
<th>File Numbers</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.dat – 19.dat</td>
<td>.45 cal. blank</td>
</tr>
<tr>
<td>20.dat – 27.dat</td>
<td>Microphone calibration</td>
</tr>
<tr>
<td>28.dat – 30.dat</td>
<td>Demolition of munitions</td>
</tr>
<tr>
<td>39.dat – 44.dat</td>
<td>C4</td>
</tr>
<tr>
<td>45.dat</td>
<td>Noise Record</td>
</tr>
<tr>
<td>46.dat – 56.dat</td>
<td>Demolition of munitions</td>
</tr>
<tr>
<td>57.dat – 58.dat</td>
<td>Noise Record</td>
</tr>
<tr>
<td>59.dat</td>
<td>Demolition of munitions</td>
</tr>
<tr>
<td>60.dat – 68.dat</td>
<td>C4</td>
</tr>
<tr>
<td>69.dat</td>
<td>Noise Record</td>
</tr>
<tr>
<td>70.dat – 74.dat</td>
<td>C4</td>
</tr>
<tr>
<td>75.dat – 81.dat</td>
<td>Demolition of munitions</td>
</tr>
<tr>
<td>82.dat – 91.dat</td>
<td>Calibration</td>
</tr>
<tr>
<td>92.dat</td>
<td>Noise Record</td>
</tr>
<tr>
<td>93.dat – 113.dat</td>
<td>C4</td>
</tr>
<tr>
<td>114.dat – 199.dat</td>
<td>Calibration</td>
</tr>
</tbody>
</table>

Specifications for Sources used in Measurements

**C4**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ brick</td>
<td>0.63 lb (0.28 kg)</td>
</tr>
<tr>
<td>1 brick</td>
<td>1.25 lb (0.57 kg)</td>
</tr>
<tr>
<td>2 bricks</td>
<td>2.50 lb (1.23 kg)</td>
</tr>
<tr>
<td>4 bricks</td>
<td>5.00 lb (2.27 kg)</td>
</tr>
<tr>
<td>5 bricks</td>
<td>6.25 lb (2.84 kg)</td>
</tr>
<tr>
<td>8 bricks</td>
<td>10.00 lb (4.55 kg)</td>
</tr>
<tr>
<td>10 bricks</td>
<td>12.50 lb (5.67 kg)</td>
</tr>
</tbody>
</table>

**.45 cal. blank**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Length</td>
<td>0.89 in. (22.6 mm)</td>
</tr>
<tr>
<td>Case Length</td>
<td>0.89 in. (22.6 mm)</td>
</tr>
<tr>
<td>Cartridge Weight</td>
<td>7.6 g</td>
</tr>
<tr>
<td>Case Weight</td>
<td>5.8 g</td>
</tr>
<tr>
<td>Powder Weight</td>
<td>31 g</td>
</tr>
<tr>
<td>Powder Type</td>
<td>Black, FFFFG, CCI</td>
</tr>
<tr>
<td>Primer Type</td>
<td>Magnum</td>
</tr>
<tr>
<td>Manufacture</td>
<td>Custom made</td>
</tr>
</tbody>
</table>

**10-lb (4.5-kg) sledge hammer**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Length</td>
<td>34 in. (86.7 cm)</td>
</tr>
<tr>
<td>Overall Weight</td>
<td>11.68 lb (5.30 kg)</td>
</tr>
<tr>
<td>Head Weight</td>
<td>10.0 lb (4.55 kg)</td>
</tr>
<tr>
<td>Strike Plate Material</td>
<td>6061T6 Aluminum</td>
</tr>
<tr>
<td>Strike Plate Area</td>
<td>103.1 in.² (668 cm²)</td>
</tr>
<tr>
<td>Strike Plate Thickness</td>
<td>1 in. (2.54 cm)</td>
</tr>
<tr>
<td>Strike Plate Weight</td>
<td>10.36 lb. (4.70 kg)</td>
</tr>
</tbody>
</table>
Figure 4. .45-caliber calibration pistol firing blanks at a 1-m height.

a. C4 being formed into a 5-lb (2.25-kg) spherical charge.

Figure 5. Making the C4 charges.
b. A 1.25-lb (0.68-kg) brick of C4.

c. C4 spherical charge being suspended at TC 3.

Figure 5 (con't). Making the C4 charges.
3 CRREL SENSOR CONFIGURATION

The sensor configuration installed by CRREL consisted of a linear array with multi-sensor stations. The array was located in the forest between TC 3 and TC 4. It extended from 30 to 151.3 m magnetic south of TC 3. The goal of this sensor array was to obtain a detailed view of the blast waves as they propagated into the forest.

CERL also installed and recorded signatures from their own independent sensor array. This array was located both inside and outside of the forest on a true north-south line. This array was designed to obtain a complete overview of the blast wave propagation at the site as well as details of the blast wave generation by the source.

Table 2 lists the distances between the CRREL and CERL locations. This difference was due to a 3.5 degree east deviation between true north and magnetic north.

Figures 6 through 11 show the locations of the CRREL instrument stations. Table 3 details the sensors used in the CRREL Blast Wave Propagation Array. Table 4 notes any sensor changes made to that array, during the measurements.

Figure 12 shows the CRREL array used to record the large munitions demolition shots. Further discussion of this array is omitted from this report.

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 meters</td>
<td>1.83</td>
</tr>
<tr>
<td>60 meters</td>
<td>3.66</td>
</tr>
<tr>
<td>90 meters</td>
<td>5.49</td>
</tr>
<tr>
<td>120 meters</td>
<td>7.32</td>
</tr>
<tr>
<td>150 meters</td>
<td>9.15</td>
</tr>
</tbody>
</table>
Figure 6. 30 meter sensor locations.
Figure 7. 60 meter sensor locations.
Figure 8. 90 meter sensor locations.
Figure 9. 120 meter sensor locations.
Figure 10. 150 meter sensor locations.
Figure 11. 153.1 meter sensor locations.
Figure 12. CRREL munitions demolition array. This array was located approximately 600 to 900 m from the demolition charges, with Station 4 closest to the charges.
### Table 3. Wave propagation sensor array.

#### Array Cable 1

<table>
<thead>
<tr>
<th>Location</th>
<th>Channel Number</th>
<th>Sensor</th>
<th>Serial Number</th>
<th>Height (m)</th>
<th>Calibrated Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Meter</td>
<td>1</td>
<td>Radial geophone</td>
<td>H13</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>30 Meter</td>
<td>2</td>
<td>Vertical geophone</td>
<td>V23</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>30 Meter</td>
<td>3</td>
<td>PCB 102A07</td>
<td>15972</td>
<td>0.0</td>
<td>1.28E-02 mV/Pa</td>
</tr>
<tr>
<td>30 Meter</td>
<td>4</td>
<td>PCB 102A07</td>
<td>15973</td>
<td>1.5</td>
<td>1.24E-02 mV/Pa</td>
</tr>
<tr>
<td>60 Meter</td>
<td>5</td>
<td>Radial geophone</td>
<td>H2</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>60 Meter</td>
<td>6</td>
<td>Vertical geophone</td>
<td>V11</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>60 Meter</td>
<td>7</td>
<td>PCB 102A07</td>
<td>15971</td>
<td>0.0</td>
<td>1.30E-02 mV/Pa</td>
</tr>
<tr>
<td>60 Meter</td>
<td>8</td>
<td>PCB 106B50</td>
<td>6693</td>
<td>1.5</td>
<td>6.74E-02 mV/Pa</td>
</tr>
<tr>
<td>90 Meter</td>
<td>9</td>
<td>Radial geophone</td>
<td>H18</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>90 Meter</td>
<td>10</td>
<td>Vertical geophone</td>
<td>V4</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>90 Meter</td>
<td>11</td>
<td>PCB 106B50</td>
<td>3259</td>
<td>0.0</td>
<td>8.17E-02 mV/Pa</td>
</tr>
<tr>
<td>90 Meter</td>
<td>12</td>
<td>PCB 106B50</td>
<td>6695</td>
<td>1.5</td>
<td>7.16E-02 mV/Pa (uncal)</td>
</tr>
</tbody>
</table>

#### Array Cable 2

<table>
<thead>
<tr>
<th>Location</th>
<th>Channel Number</th>
<th>Sensor Number</th>
<th>Sensor S/N</th>
<th>Height (m)</th>
<th>Calibrated Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 Meter</td>
<td>13</td>
<td>Radial geophone</td>
<td>H28</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>120 Meter</td>
<td>14</td>
<td>Transv. geophone</td>
<td>H19</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>120 Meter</td>
<td>15</td>
<td>Vertical geophone</td>
<td>V6</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>120 Meter</td>
<td>16</td>
<td>B&amp;K 4938 - 3</td>
<td>2239255</td>
<td>0.0</td>
<td>1.15E-3 mV/Pa</td>
</tr>
<tr>
<td>150 Meter</td>
<td>17</td>
<td>Radial geophone</td>
<td>H20</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>150 Meter</td>
<td>18</td>
<td>Transv. geophone</td>
<td>H21</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>150 Meter</td>
<td>19</td>
<td>Vertical geophone</td>
<td>V28</td>
<td>0.0</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>150 Meter</td>
<td>20</td>
<td>B&amp;K 4938 - 2</td>
<td>2239254</td>
<td>0.0</td>
<td>1.32E-3 mV/Pa</td>
</tr>
<tr>
<td>151.3 Meter</td>
<td>21</td>
<td>Radial geophone</td>
<td>H10</td>
<td>1.5</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>151.3 Meter</td>
<td>22</td>
<td>Transv. geophone</td>
<td>H9</td>
<td>1.5</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>151.3 Meter</td>
<td>23</td>
<td>Vertical geophone</td>
<td>V?</td>
<td>1.5</td>
<td>32.2 V/m/s</td>
</tr>
<tr>
<td>151.3 Meter</td>
<td>24</td>
<td>B&amp;K 4938 - 1</td>
<td>2239253</td>
<td>1.5</td>
<td>1.20E-3 mV/Pa</td>
</tr>
</tbody>
</table>

All geophones are Mark Products L-15, 4.5 Hz
All B&K microphones had 1:1000 attenuation.
Table 4. Changes to wave propagation sensor array.

The PCB sensor at the 60 m location failed and was replaced after CRREL binary file number 44, or CERL shot number 6.

<table>
<thead>
<tr>
<th>Location</th>
<th>Channel</th>
<th>Sensor Number</th>
<th>Sensor S/N</th>
<th>Height (m)</th>
<th>Calibrated Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Meter</td>
<td>7</td>
<td>PCB 106B50</td>
<td>3260</td>
<td>0.0</td>
<td>7.16E-02 mV/Pa</td>
</tr>
<tr>
<td>60 Meter</td>
<td>7</td>
<td>PCB 102A07</td>
<td>15971</td>
<td>0.0</td>
<td>1.30E-02 mV/Pa</td>
</tr>
</tbody>
</table>

A = Binary records 45 - 199  
B = Binary records 1 - 44  

The B&K 4938 microphones at locations 120 m and 150 m were replaced with B&K 4165 microphones for blank pistol shots 5 - 19, ascii files 105 - 119, plus the associated calibration files.

<table>
<thead>
<tr>
<th>Location</th>
<th>Channel Number</th>
<th>Sensor Number</th>
<th>Sensor S/N</th>
<th>Height (m)</th>
<th>Calibrated Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 Meter</td>
<td>16 A</td>
<td>B&amp;K 4938 - 3</td>
<td>2239255</td>
<td>0.0</td>
<td>1.15 E-3 mV/Pa</td>
</tr>
<tr>
<td>120 Meter</td>
<td>16 B</td>
<td>B&amp;K 4165 - 5</td>
<td>1881043</td>
<td>0.0</td>
<td>0.75 E-3 mV/Pa</td>
</tr>
<tr>
<td>150 Meter</td>
<td>20 A</td>
<td>B&amp;K 4938 - 2</td>
<td>2239254</td>
<td>0.0</td>
<td>1.32 E-3 mV/Pa</td>
</tr>
<tr>
<td>150 Meter</td>
<td>20 B</td>
<td>B&amp;K 4165 - 6</td>
<td>1857571</td>
<td>0.0</td>
<td>0.73 E-3 mV/Pa</td>
</tr>
</tbody>
</table>

A = Binary records 39 - 199  
B = Binary records 5 - 27  
The 4165 microphones had too low of a calibration value, so may not be reliable.
4 SENSOR CALIBRATION

Tables 3 and 4 list the sensitivities used to convert the voltages recorded by the seismograph to physical units. These two tables also contain the calibration values for all sensors used. The sensitivities were determined as follows:

- **Geophones**: The sensitivity provided by the manufacturer was used. From past experience at CRREL, these sensors are usually accurate to about 10%, but they can occasionally vary more than this range because of differences in coupling to the ground.

- **Pressure Sensors** (solid state): The PCB pressure sensors were calibrated in situ using a Trig-Tek Model 402H calibrator (Fig. 13). This model calibrator provides sound pressure levels of 120 to 160 dB in 10-dB increments. We used levels of 140, 150, and 160 dB for these calibrations to match the expected blast noise levels. It has selectable internal low frequency outputs of 62.5, 125, 250, 500 and 1000 Hz. We relied mostly on the lower frequencies, 62.5–250 Hz, for these calibrations.

- **Microphones (¼ and ½ inch B&K)**: The B&K ¼ inch Model 4938 microphones were also calibrated using the Trig-Tek Model 402H calibrator at 140 and 150 dB.

![Figure 13. Typical sensor calibration using the Trig-Tek Model 402H calibrator.](image)
The B&K ½ inch Model 4165 microphones were calibrated using a GenRad Type 1562-A sound level calibrator. This type of calibrator provides a sound pressure level of 114 dB. It has selectable internal frequency outputs of 125, 250, 500, 1000 and 2000 Hz.
5 FOREST ENVIRONMENT

Figures 13 through 19 show typical views of the conditions within the forest. The understory vegetation limited visibility to about 30–60 m within the forest. Details of the tree species and density are to be provided by forest measurements already conducted as part of the land management at the Lone Star AAP.

Ground conditions usually consisted of a layer of needles a few inches thick, as seen in the photographs. The weather during the tests was very hot and humid, with air temperatures typically near 100°F (38°C).

Figure 14. Vegetation at 30 meter site.
Figure 15. Vegetation at 60 m site.

Figure 16. Vegetation at 90 m site.
Figure 17. Vegetation at 120 m site.

Figure 18. Vegetation at 150 m site.
151.3 Meter Site looking south towards TC 4.

Figure 19. Vegetation at 151.3 m site.
6  TEXAS 2002 TIME BREAK CORRECTIONS AND ACOUSTIC VELOCITIES

Because of a malfunction with the blaster box, good time breaks were not obtained. The seismograph recordings were started manually during the countdown, so the blast wave arrivals occur at different times within the binary file.

Before writing the ASCII files, the true time break was found by finding the blast wave arrival times and the correct zero time from the acoustic velocity. These corrections are listed below. In the ASCII files, the blast wave arrivals occur at the true arrival time.

In this listing, the shot number is the original CRREL binary file (xx.dat) recorded by the NZ seismograph. For C4 shots, the ASCII file name with the time break corrections applied is tx020xx.asc, where xx is the CERL number given below. For pistol shots, the

- ASCII file name is tx021xx.asc, where xx is the CRREL shot number.
- (For shot 40, the binary file is 40.dat and the ascii file is tx2002.asc.)
- (For shot 1, the binary file is 1.dat and the ascii file is tx2101.asc.)

The acoustic velocities listed below for the pistol shots are higher than the true velocities because of the offset of the pistol from the line of the sensors. As the pistol was only 2 m away from the nearest sensor, this did not affect the time break correction.

The records are sorted by shot location below.

Shot 60 TC2 CERL 7 Velocity = 349.7 m/s TB corr = -0.0465 7-24-02
Shot 62 TC2 CERL 9 Velocity = 348.0 m/s TB corr = -2.5717 7-24-02
Shot 66 TC2 CERL 13 Velocity = 348.2 m/s TB corr = 0.0052 7-24-02
Shot 70 TC2 CERL 3B Velocity = 347.4 m/s TB corr = -1.2592 7-25-02
Shot 71 TC2 CERL 4B Velocity = 347.3 m/s TB corr = -1.0796 7-25-02
Shot 72 TC2 CERL 5B Velocity = 348.2 m/s TB corr = -1.3115 7-25-02
Shot 73 TC2 CERL 6B Velocity = 348.7 m/s TB corr = -1.2592 7-25-02
Shot 74 TC2 CERL 7B Velocity = 348.6 m/s TB corr = -1.0384 7-25-02
Shot 94 TC2 CERL 17 Velocity = 349.6 m/s TB corr = -0.3061 7-25-02
Shot 97 TC2 CERL 21 Velocity = 350.7 m/s TB corr = -0.2621 7-25-02
Shot 101 TC2 CERL 25 Velocity = 350.5 m/s TB corr = -0.5556 7-25-02
Shot 105 TC2 CERL 29 Velocity = 351.0 m/s TB corr = -0.6646 7-25-02
Shot 108 TC2 CERL 32 Velocity = 352.3 m/s TB corr = -0.8483 7-25-02
Shot 109 TC2 CERL 33 Velocity = 352.7 m/s TB corr = -1.2742 7-25-02
Shot 110 TC2 CERL 34 Velocity = 351.8 m/s TB corr = -1.5879 7-25-02
Shot 111 TC2 CERL 35 Velocity = 352.4 m/s TB corr = -1.0272 7-25-02
Shot 112 TC2 CERL 36 Velocity = 351.9 m/s TB corr = -0.9628 7-25-02
Shot 113 TC2 CERL 37 Velocity = 351.5 m/s TB corr = -1.2390 7-25-02

Shot 61 TC1 CERL 8 Velocity = 350.2 m/s TB corr = 1.2226 7-24-02
Shot 65 TC1 CERL 12 Velocity = 348.6 m/s TB corr = 0.2675 7-24-02
Shot 93 TC1 CERL 16 Velocity = 352.9 m/s TB corr = -0.4247 7-25-02
Shot 96 TC1 CERL 20 Velocity = 348.7 m/s TB corr = -0.2756 7-25-02
Shot 100 TC1 CERL 24 Velocity = 351.5 m/s TB corr = -0.6963 7-25-02
Shot 104 TC1 CERL 28 Velocity = 351.0 m/s TB corr = -0.8121 7-25-02

Shot 40 TC3 CERL 2 Velocity = 350.4 m/s TB corr = -0.2134 7-24-02
Shot 41 TC3 CERL 3 Velocity = 349.0 m/s TB corr = -0.2179 7-24-02
Shot 42 TC3 CERL 4 Velocity = 350.5 m/s TB corr = -0.2174 7-24-02
Shot 67 TC3 CERL 14 Velocity = 348.7 m/s TB corr = 0.0880 7-24-02
Shot 98 TC3 CERL 22 Velocity = 350.6 m/s TB corr = -1.4086 7-25-02
Shot 102 TC3 CERL 26 Velocity = 350.4 m/s TB corr = -0.7076 7-25-02
Shot 106 TC3 CERL 30 Velocity = 350.9 m/s TB corr = -0.4905 7-25-02

Shot 64 TC4 CERL 11 Velocity = 353.1 m/s TB corr = -0.8379 7-24-02
Shot 68 TC4 CERL 15 Velocity = 353.3 m/s TB corr = -1.0028 7-24-02
Shot 95 TC4 CERL 19 Velocity = 355.0 m/s TB corr = -1.1580 7-25-02
Shot 99 TC4 CERL 23 Velocity = 355.2 m/s TB corr = -1.2413 7-25-02
Shot 103 TC4 CERL 27 Velocity = 355.4 m/s TB corr = -1.5833 7-25-02
Shot 107 TC4 CERL 31 Velocity = 355.7 m/s TB corr = -2.0720 7-25-02

**Blank Pistol Shots**
(The velocity is an apparent phase velocity, not the true acoustic velocity, because the source was offset from the sensor line.)

Shot 1 30m Velocity = 362.3 m/s TB corr = 0.8091 7-23-02
Shot 2 30m Velocity = 362.5 m/s TB corr = 0.5928 7-23-02
Shot 3 30m Velocity = 362.8 m/s TB corr = 0.9599 7-23-02
Shot 4 30m Velocity = 363.9 m/s TB corr = 1.2268 7-23-02
Shot 15 30m Velocity = 362.3 m/s TB corr = 0.9330 7-24-02
Shot 16 30m Velocity = 362.0 m/s TB corr = 1.2151 7-24-02
Shot 17 30m Velocity = 362.0 m/s TB corr = 1.3954 7-24-02
Shot 18 30m Velocity = 362.0 m/s TB corr = 1.1648 7-24-02
Shot 19 30m Velocity = 362.3 m/s TB corr = 1.1863 7-24-02
Shot 5 90m Velocity = 356.9 m/s TB corr = 1.4087 7-24-02
Shot 6 90m Velocity = 359.0 m/s TB corr = 1.4700 7-24-02
Shot 7 90m Velocity = 358.2 m/s TB corr = 1.0701 7-24-02
Shot 8 90m Velocity = 358.5 m/s TB corr = 1.0898 7-24-02
Shot 9 90m Velocity = 359.0 m/s TB corr = 1.2376 7-24-02

Shot 10 60m Velocity = 364.2 m/s TB corr = 1.2334 7-24-02
Shot 11 60m Velocity = 364.5 m/s TB corr = 1.2090 7-24-02
Shot 12 60m Velocity = 364.5 m/s TB corr = 1.2828 7-24-02
Shot 13 60m Velocity = 364.5 m/s TB corr = 1.0293 7-24-02
Shot 14 60m Velocity = 364.5 m/s TB corr = 1.3029 7-24-02
7 SIGNATURE RECORDINGS AND DATA QUALITY

This section provides plots of all of the C4 test charges and all of the .45 caliber pistol shots recorded by the CRREL sensor array. The plots were produced using the ASCII data files and the MATLAB plot program listed in Appendix C.

Table 5 lists the events recorded during the tests. As explained in Appendix B, the binary data file names were changed to agree with the CERL Test Charge numbering system. Also, to avoid duplicate file names, the .45 caliber shot files were renumbered in the range 101–119.

Table 6 gives an assessment of the data quality of each trace, based on the plots in this section. The table lists “good” data suitable for additional analysis. “Bad” data should not be used, at least not without further processing. The data might be bad because of sensor failure or too high a noise level.

Nine pressure sensor channels were recorded for each of the C4 shots. For the 42 C4 shots detonated during the test, five shots were not recorded because of a failure with the time break signal. Four other channels were unusable, while 15 were usable but noisy.

Appendix A shows each individual record that was made.
## Table 5. Chronology of recorded events.

<table>
<thead>
<tr>
<th>CRREL File Name</th>
<th>CRREL Shot #</th>
<th>Date</th>
<th>Local Time</th>
<th>Source</th>
<th>Source Ht. m (ft/in.)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.dat TX02101.asc</td>
<td>TX02101</td>
<td>07/23/02</td>
<td>1545</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>2.dat TX02102.asc</td>
<td>TX02102</td>
<td>07/23/02</td>
<td>1553</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>3.dat TX02103.asc</td>
<td>TX02103</td>
<td>07/23/02</td>
<td>1555</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>4.dat TX02104.asc</td>
<td>TX02104</td>
<td>07/23/02</td>
<td>1556</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>5.dat TX02105.asc</td>
<td>TX02105</td>
<td>07/24/02</td>
<td>0749</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m west of 90 m site</td>
</tr>
<tr>
<td>6.dat TX02106.asc</td>
<td>TX02106</td>
<td>07/24/02</td>
<td>0753</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m west of 90 m site</td>
</tr>
<tr>
<td>7.dat TX02107.asc</td>
<td>TX02107</td>
<td>07/24/02</td>
<td>0754</td>
<td>0.45 cal. blank</td>
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<td>Shot 2m west of 90 m site</td>
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<td>8.dat TX02108.asc</td>
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<td>0755</td>
<td>0.45 cal. blank</td>
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<td>Shot 2m west of 90 m site</td>
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<td>9.dat TX02109.asc</td>
<td>TX02109</td>
<td>07/24/02</td>
<td>0756</td>
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<td>Shot 2m west of 90 m site</td>
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<tr>
<td>10.dat TX02110.asc</td>
<td>TX02110</td>
<td>07/24/02</td>
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<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 60 m site</td>
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<td>07/24/02</td>
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<td>07/24/02</td>
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<td>0.45 cal. blank</td>
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<td>13.dat TX02113.asc</td>
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<td>07/24/02</td>
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<td>0.45 cal. blank</td>
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<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 60 m site</td>
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<td>0817</td>
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<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>16.dat TX02116.asc</td>
<td>TX02116</td>
<td>07/24/02</td>
<td>0818</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
</tr>
<tr>
<td>17.dat TX02117.asc</td>
<td>TX02117</td>
<td>07/24/02</td>
<td>0818</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
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<td>0819</td>
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<td>07/24/02</td>
<td>0819</td>
<td>0.45 cal. blank</td>
<td>1.0 (3/3)</td>
<td>Shot 2m east of 30 m site</td>
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<td>07/24/02</td>
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<td>07/24/02</td>
<td>1014</td>
<td>Munition Demo</td>
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<td>TX02149</td>
<td>07/24/02</td>
<td>1218</td>
<td>C4 (1 brick)</td>
<td>1.9 (6/3)</td>
<td>TC2 (See Note 1)</td>
</tr>
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<td>TX02153</td>
<td>07/24/02</td>
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<td>C4 (1 brick)</td>
<td>3.8 (12/6)</td>
<td>TC2</td>
</tr>
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<td>07/24/02</td>
<td>1345</td>
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<td>TC2</td>
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<td>07/24/02</td>
<td>1356</td>
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<td>TC2 (See Note 1)</td>
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<td>0.6 (2/0)</td>
<td>TC2 (See Note 1)</td>
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<td>59.dat TX02195.asc</td>
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<td>07/24/02</td>
<td>1532</td>
<td>Munition Demo</td>
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</tr>
</tbody>
</table>

Note 1. CRREL shotbox sent early time break. No ascii file.
Table 5 (cont’d). Recorded events.

<table>
<thead>
<tr>
<th>CRREL File Name</th>
<th>CERL Shot #</th>
<th>ASCII File Name</th>
<th>Date</th>
<th>Local Time</th>
<th>Source</th>
<th>Source Ht. m (ft/in.)</th>
<th>Comments</th>
</tr>
</thead>
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<td>60.dat 7</td>
<td>TX02007.asc</td>
<td>07/24/02 1550</td>
<td>C4 (1 brick)</td>
<td>0.3 (1/0)</td>
<td>TC2</td>
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</tr>
<tr>
<td>61.dat 8</td>
<td>TX02008.asc</td>
<td>07/24/02 1613</td>
<td>C4 (1 brick)</td>
<td>1.9 (6/3)</td>
<td>TC1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>62.dat 9</td>
<td>TX02009.asc</td>
<td>07/24/02 1614</td>
<td>C4 (1 brick)</td>
<td>1.9 (6/3)</td>
<td>TC2</td>
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<td>TX02010.asc</td>
<td>07/24/02 1615</td>
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<td>1.9 (6/3)</td>
<td>TC3</td>
<td>(See Note 1)</td>
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</tr>
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<td>TX02011.asc</td>
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<td>1.9 (6/3)</td>
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<td>TX02012.asc</td>
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<td>07/24/02 1633</td>
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<td>TX02015.asc</td>
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<td>69.dat</td>
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<td>70.dat 43</td>
<td>TX02043.asc</td>
<td>07/25/02 0859</td>
<td>C4 (1 brick)</td>
<td>3.8 (12/6)</td>
<td>TC2</td>
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<td>TX02044.asc</td>
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<td>C4 (1 brick)</td>
<td>3.8 (12/6)</td>
<td>TC2</td>
<td>Repeat of CERL shot # 4</td>
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</tr>
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<td>TX02045.asc</td>
<td>07/25/02 0933</td>
<td>C4 (1 brick)</td>
<td>3.0 (10/0)</td>
<td>TC2</td>
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Note 2. Time break failed. No binary or ascii file.

Note 3. All C-4 charges detonated to create files 96.dat through 113.dat were done using spherical charges, not preformed bricks.
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### Table 6. Data quality.

TX 2002 Forest Test
Sensors - Channel numbers

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Shot box TB failed for CERL shots 1, 5, 6, 10. No ascii files.
TB failure for CERL shot 18, no binary or ascii file.
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O = Good  
X = Bad  
N = Noisy data - but usable  
R = Ringing sensor  
C = Crosstalk

### BLANK PISTOL SHOTS

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<td>11 P-90-0</td>
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<td>X</td>
<td>X</td>
<td>O</td>
<td>O</td>
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<td>N</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20 P-150-0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>N</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>24 P-152T-1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

For records 105-119, channels 16, 20 used B&K 4165 microphones.

O = Good  
X = Bad  
N = Noisy data - but usable  
R = Ringing sensor  
C = Crosstalk
APPENDIX A: SIGNAL DATA PLOTS

The following signal data plots show the response of the 24 sensors recorded during each test. The plots are normalized so that each channel is the same size. The maximum amplitude is shown in the label for each channel. Figure A1 describes the plot layout, labels and descriptions used for each record made during the test. The plots are normalized so that each channel is the same size. The maximum amplitude is shown in the label for each channel.

Figure A1. Description of the signal data plots.
TX02 -- TX02003.asc -- TC3  0.6 kg C-4  3.8 m agl --  30–152 m

Pressure Sensors

P–30–1 565.1
P–30–0 603.3
V–30 1.3E-3
R–30 2.7E-3
P–60–1 390.7
P–60–0 76.4
V–60 0.27E-3
R–60 2.9E-3
P–90–1 283.3
P–90–0 320.3
V–90 0.88E-3
R–90 1.4E-3

P–120–0 250.1
V–120 0.83E-3
R–120 1.0E-3
T–120 0.45E-3
P–150–0 239.8
P–150–1 98E-3
R–150 0.72E-3
T–150 0.41E-3
P–152T–1 216.9
V–152T 1.1E-3
R–152T 2.6E-3
T–152T 0.67E-3

0 0.2 0.4 0.6 0.8
Time, sec

0 0.2 0.4 0.6
Time, sec

Seismic and Acoustic Signature Measurements Through Forest
<table>
<thead>
<tr>
<th>TX02</th>
<th>TX02007.asc</th>
<th>TC2</th>
<th>0.6 kg C-4</th>
<th>0.3 m agl</th>
<th>91-213 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-30-1</td>
<td>388.2</td>
<td>P-30-0</td>
<td>586.3</td>
<td>P-40-1</td>
<td>316.5</td>
</tr>
<tr>
<td>21.5</td>
<td>V-120</td>
<td>0.78E-3</td>
<td>R-120</td>
<td>0.68E-3</td>
<td>R-120</td>
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<tr>
<td>P-120</td>
<td>171.1</td>
<td>V-120</td>
<td>0.68E-3</td>
<td>R-120</td>
<td>0.48E-3</td>
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<tr>
<td>P-20-0</td>
<td>586.7</td>
<td>P-20-0</td>
<td>586.7</td>
<td>P-40-0</td>
<td>368.0</td>
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<tr>
<td>R-20</td>
<td>316.5</td>
<td>R-20</td>
<td>316.5</td>
<td>R-20</td>
<td>316.5</td>
</tr>
<tr>
<td>V-20</td>
<td>2.4E-3</td>
<td>V-20</td>
<td>2.4E-3</td>
<td>V-20</td>
<td>2.4E-3</td>
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<td>V-40</td>
<td>2.4E-3</td>
<td>V-40</td>
<td>2.4E-3</td>
</tr>
</tbody>
</table>

Seismic and Acoustic Signature Measurements Through Forest
TX02 -- TX02008.asc -- TC1 0.6 kg C-4 1.9 m agl -- 445–567 m

Pressure Sensors

Time, sec

1.2 1.4 1.6

P-30-1 100.1
P-30-0 98.0
V-30 0.20E-3
R-30 0.24E-3
P-60-1 98.0
P-60-0 101.9
V-60 41.8E-6
R-60 0.49E-3
P-90-1 96.4
P-90-0 90.0
V-90 0.20E-3
R-90 0.39E-3

1.4 1.6 1.8 2

P-120-0 94.1
V-120 0.24E-3
R-120 0.28E-3
T-120 0.11E-3
P-150-0 96.0
V-150 0.30E-3
R-150 0.28E-3
T-150 0.17E-3
P-152T-1 95.2
V-152T 0.34E-3
R-152T 0.84E-3
T-152T 0.19E-3

1.2 1.4 1.6

P-30-1 100.1
P-30-0 98.0
V-30 0.24E-3
R-30 0.28E-3
P-60-1 98.0
P-60-0 101.9
V-60 41.8E-6
R-60 0.49E-3
P-90-1 96.4
P-90-0 90.0
V-90 0.20E-3
R-90 0.39E-3

Pressure Sensors

Time, sec

1.2 1.4 1.6
Seismic and Acoustic Signature Measurements Through Forest
Seismic and Acoustic Signature Measurements Through Forest

TX02 -- TX02025.asc -- TC2 2.3 kg C-4 1.9 m agl -- 91-213 m

Pressure Sensors
TX02 -- TX02028.asc -- TC1 2.3 kg C-4 1.9 m agl -- 445–567 m

[Graphs and data readings]

Pressure Sensors

P~30-0 150.6
P~30-0 161.2
V~30 0.30E-3
R~30 0.38E-3
P~60-0 133.1
P~60-0 148.7
V~60 46.8E-6
R~60 0.41E-3
P~90-0 104.0
P~90-0 137.2
V~90 0.24E-3
R~90 0.46E-3
P~120-0 108.7
V~120 0.27E-3
R~120 0.31E-3
T~120 0.17E-3
P~150-0 95.8
V~150 0.30E-3
R~150 0.31E-3
T~150 0.19E-3
P~152T-1 89.9
V~152T 0.33E-3
R~152T 0.36E-3
T~152T 0.32E-3
P~120-0 108.7
P~150-0 92.8
P~152T-1 89.0
TX02 -- TX02029.asc -- TC2  2.3 kg C-4  1.9 m agl --  91–213 m

Pressure Sensors

Time, sec

0.2  0.4  0.6  0.8  1
TX02 -- TX02030.asc -- TC3  2.3 kg C-4  1.9 m agl --  30-152 m
TX02 -- TX02032.asc -- TC2 2.3 kg C4 1.9 m agl -- 91–213 m
Seismic and Acoustic Signature Measurements Through Forest

TX02 — TX02046.asc — TC2 0.6 kg C-4 1.2 m agl — 91–213 m

TX02 — Pressure Sensors

Time, sec
Seismic and Acoustic Signature Measurements Through Forest
TX02 -- TX02114.asc -- 60m Pistol 1.0 m -- 2-92 m

Pressure Sensors

P-30-1 3.54
P-30-0 75.5
V-30 8.8E-6
R-30 11.8E-6
P-60-1 152.1
P-60-0 2.7k
V-60 68.2E-6
R-60 0.20E-3
P-90-1 36.0
P-90-0 9.97
V-90 53.7E-6
R-90 88.1E-6

P-120-0 175.4
V-120 10.5E-6
R-120 21.5E-6
T-120 13.0E-6
P-150-0 50.1
V-150 3.4E-6
R-150 5.8E-6
T-150 7.9E-6
P-152-0 26.2
V-152T 16.5E-6
R-152T 14.2E-6
T-152T 4.1E-6

P-30-1 3.54
P-30-0 75.5
V-60 2.7k
R-90 152.1
P-90-0 2.7k
P-90-0 152.1
V-90 36.0
R-90 9.97
P-120-0 175.4
V-120 50.1
R-120 50.1
T-152T 26.2
Seismic and Acoustic Signature Measurements Through Forest

TX02 -- TX02119.asc -- 30m Pistol 1.0 m -- 2–122 m

Pressure Sensors

P-30-1 178.9
P-30-0 124.0
V-30 5.0E-3
V-30-1 25.3
P-60-1 9.46
P-60-0 5.4E-6
P-30-0 1.98
P-120-0 7.43
P-120-1 46.1
P-120-2 27.0
P-152-1 3.6E-6

Time, sec

0.2 0.4 0.6
APPENDIX B: MATLAB PROGRAMS TO READ AND PLOT BINER DATA FROM NZ SEISMOGRAPH AND TO WRITE MULTICHANNEL ASCII DATA FILES.

This section provides a listing of the MATLAB programs used to read and plot the 24 binary data files recorded by the Geometrics NZ seismograph in SEG-2 format. The programs convert the seismograph voltages to physical units before plotting. The programs also correct errors in the shot time (due to a malfunction of the shot box) and write the corrected data to multichannel ASCII data files that can be plotted using the programs listed in the next section of this report. These ASCII files serve as the permanent archive format for the test data. The files that are listed in this section are:

1. **tx02doprocessnz.m**—Main program to read binary data files and write multichannel ASCII files. To use, set the desired binary file numbers in the variable “recs” and run the program. You may have to change the lines that construct the filenames to use the correct directory for your computer, and you may want to change the print options at the very end of this program to match your printer or delete the plot from the screen after plotting. The program will write an ASCII file with a new record number that either matches the CERL shot number (for C4 explosions) or a new pistol shot number between 101 and 119. Writes the pressure sensor info to text file TX02MikeLog.m. Calls the programs listed below.

2. **readnz.m**—Function to read the SEG-2 binary file produced by the NZ seismograph. Calls words.m. Writes info to the text file readnzlog.m.

3. **tx02cerlnum.m**—Function to select the CERL C4 shot number or new pistol shot number from the binary file number.

4. **tx02label.m**—Function to get all of the experimental details including which sensor was attached to which channel, voltage-to-physical-units conversion factors, sensor and shot point geometry and distances, which source used for each file, etc. Calls words.m.

5. **tx02plotnz.m**—Function to make a three-panel plot of the binary data in landscape orientation. The channels plotted in each of the panels are given by the contents of iplot1, iplot2, and iplot3. These plots show the uncorrected times in the binary files, i.e., when the recorder button was pushed, not when the shot was actually fired.

6. **tx02tbcorr.m**—Function to find the true time break (shot instant). This is done using the arrival times from the first and last sensor in the array to determine the acoustic wave velocity, and then projecting back to zero
distance to get the origin time. Writes the time break info to file Tx02TimeBreakLog.m and applies the correction to the multichannel ASCII data files.

7. **tx02writenchan.m**—Function to write multichannel ASCII data file with 12 line trace headers. The ASCII file name is tx02nnn.asc, where nnn is a new file number. nnn = CERL shot number if it was a C4 shot.

8. **words.m**—Function to separate a string into individual words by finding the blank characters.

---

tx02doprocessnz.m—Main program to plot binary data and write multichannel ASCII file

```matlab
% d:\DataWinNT\FY02LoneStarTX\Plot\tx02doprocessnz.m
% Processes TX02 NZ seismograph data:
% Reads NZ data (x) -- writes file info to readnzlog.m
% Converts to eng units (xx)
% Finds CERL rec number (nnn)
% Plots data - 3 panels
% Finds the true time break - writes in Tx02TimeBreakLog.m
% Writes pressure data info to Tx02MikeLog.m
% Writes multichannel ascii file to tx02nnn.asc
% Calls subroutines
  readnz words tx02cerlnum
  tx02plotnz tx02label tx02tbcorr
  tx02writenchan

% d:\DataWinNT\FY02LoneStarTX\Plot\tx02doprocessnz.m
% Reads NZ seismograph binary records, makes 3 panel plots of data
% Writes pressure sensor info to Tx02MikeLog.m
% Calls functions
% readnz.m - to read the SEG-2 binary data using the CRREL field record numbers
% words.m - to parse ascii header lines into words
% Writes info about the file to file readnzlog.m
% tx02cerlnum.m - selects CERL shot number or new pistol shot number
% calls no subroutines
% tx02label.m - to get sensor geometry, etc
% calls words.m
% tx02plotnz.m - 3 Panel plot of data
% calls no subroutines
% tx02tbcorr.m - Finds true time break (shot instant)
```
% from the arrival times at a few of the sensors
% Writes info to Tx02TimeBreakLog.m
% calls no subroutines
% tx02writenchan.m - writes multichannel ascii data with 12 line trace
% headers
% File name is tx02nnn.asc, where nnn is a new file number
% nnn = CERL Shot number if it was a C-4 shot
% calls no subroutines

% Don Albert dalbert@crrel.usace.army.mil
% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

% NZ binary record numbers; plot has new record number in title
% C-4 Records 39,44 were bad and are omitted
% recs = [65 66 67 68 5]; %TX02 C-4 examples and blank pistol shot
% example
% recs = [ 3 5 10 15]; %Blank pistol shot examples
% recs = [ 40:43 60:68 70:74 93:113 1:19]; %All C-4 39,44 bad and all
% blank pistol
% recs = [ 40:43 60:68 70:74 93:113 1:19]; %All C-4 39,44 bad and all
% blank pistol
% recs = [64 65];

% Loop to plot the files
for i = 1:length(recs); % **************************************************
  xx=[]; x=[];
  recnum = recs(i);
  shotnum = recs(i);
  fname = sprintf('d:\DataWinNT\fy02texas\%s.dat',num2str(recnum));

% read in data from NZ binary file - x
  [x,npts,deltat,nchan,delays,descalefact,...
   stackcount,acqdate,acqtime] = readnz(fname);
% sample rate
  srate = 1/deltat;%number of samples per second

% Get geometry and description for this experiment and record number
  [sensor,sensortype,rtype,sensorx,sensory,sensorz,...
   srcloc,srcloc,srctype,srcx,srcy,srcz,sourcez,...
   engfact,dist,sensor2,source2] = tx02label (x,shotnum,nchan);
% Convert from voltage to physical units (Pa or m/s)
xgain = descalingfact./(stackcount.*engfact); % recorder units to eng units
for iii = 1:nchan; xx(:,iii) = x(:,iii) * xgain(iii); end
xxmax = max(abs(xx)); % abs max for plotting

% get CERL record number for C-4 shots
cerlrec = 0;
[cerlrec ] = tx02cerlnum (shotnum); % If C-4 get CERL Shot Number for Plot

% 3 panel plot of nz data
iplot1 = [9 10 11 12 5 6 7 8 1 2 3 4]; % Channels for 1st (left) panel
iplot2 = [22 21 23 24 18 19 20 14 13 15 16 ]; % 2nd (center) panel
iplot3 = [24 20 16 11 12 7 8 3 4 ]; % Channels for 3rd (right) panel
tx02plotnz(shotnum,cerlrec,xx,iplot1,iplot2,iplot3,deltat,delayms,...
dist,sensor,sensorx,sensory,sensorz,...
srcloc,source,sizes,source,sizes,sourcez,...
srcx,srsy,srsz,source,sizes,source,sizes,sourcez); %

% Write pressure sensor data to text file
fid3=fopen('Tx02MikeLog.m','a');
for iii =1:nplot;
tttmax = delayms/1000 + (bb(iplot(iii)) )/srate; % times in seconds
cc(iplot(iii)) = min(xx); % set plot windows because manual TB
for iii =1:nplot;
fprintf(fid3,...
' %4.0f %3.0f %3.0f %3.1f %5.0f %3.1f %3.1f %6.1f %6.1f %6.4f %6.1f %6.4f %6.4f 
','
shotnum,iplot(iii),sensorx(iplot(iii)),sensorx(iplot(iii)),...
srcx,srsy,srsz,sizes,sizes,sizes); %
end
fclose(fid3);

% Find TB correction - writes to output file xxxTimebreaklog.m
% itimeTB is the TB (shot instant) index
% itime0 is the index to start the save (usually=TB)
% if the shot was at TC1, 1 second is added to itime0
% itime1 is the index 2 seconds after the TB
% time0 is the start time for saving the time series

[itimeTB,itime0,itime1,time0,xdist,xtime] = tx02tbcorr(shotnum,...
    cerlrec,xx,deltat,delayms,srcloc);

% Write engineering data to ascii file
tx02writenchan(shotnum,cerlrec,xx,npts,deltat,nchan,delayms,descalefactor,...
    stackcount,acqdate,acqtime,engfact,xgain,itime0,itime1,time0,...
    dist,sensor,rtype,sensory,sensorx,sensorz,sensor2,...
    srcloc,stype,sourcetype,source,srcx,srcy,srcz,source2);

% Print and delete
% print -dljetplus;
% print -dljetplus; pause(25); h=gcf; delete(h);
% print to PostScript file for conversion to PDF:
% print -dps -r150 -append tx02datafigs
% h=gcf; delete(h); end

fclose('all'); return

**tx02label.m—Provides info about sensor array and sources**

function [sensor,sensorType,rType,sensorX,sensorY,sensorZ,...
    srcloc,sourcetype,stype,srcx,srcy,srcz,source,source2] = tx02label (x,shotnum,nchan)

% d:\DataWinNT\FY02LoneStarTX\tx02label.m
% Returns channel ids for NZ seismograph used at FY02 TX test
% calls words.m - breaks string into individual words

% Don Albert dalbert@crrel.usace.army.mil
% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755
% Assign sensor coordinates
% sensorx = (1:nchan)*1; sensorz(1:nchan) = 0;
sensorx = (1:nchan)*0; sensory = (1:nchan)*0; sensorz = (1:nchan)*0;
sensorx = [30,30,30,30, 60,60,60,60, 90,90,90,90, ... 120,120,120,120, 150,150,150,150, 152,152,152,152];

height15 = [4,8,12,24]; sensorz(height15) = 1.5;
height2 = [3,7,11]; sensorz(height2) = 0.08;
height3 = [16,20]; sensorz(height3) = 0.22;

% Assign sensortype
for i = 1:nchan; sensortype(i)='P'; end
senv = [2 6 10 15 19 23 ]; sensortype(senv)='V';
senr = [1 5 9 13 17 21 ]; sensortype(senr)='R';
sent = [ 14 18 22 ]; sensortype(sent)='T';

sss = ['R-30 V-30 P-30-0 P-30-1 R-60 V-60 P-60-0 P-60-1 ' ... 'R-90 V-90 P-90-0 P-90-1 ' ... 'R-120 T-120 V-120 P-120-0 R-150 T-150 V-150 P-150-0 ' ... 'R-152T T-152T V-152T P-152T-1 '];
%sss = ['1 2 3 4 5 6 7 8 9 10 11 12 ' ... '13 14 15 16 17 18 19 20 21 22 23 24 ' ... '25 26 27 28 29 30 31 32 33 34 35 36 ' ];
sensor = words(sss);

sss2 = ['MP-4.5Hz-geophone MP-4.5Hz-geophone PCB-102A07-15972 PCB-102A07-15973 ' ... 'MP-4.5Hz-geophone MP-4.5Hz-geophone PCB-106B50-3260 PCB-106B50-6693 ' ... 'MP-4.5Hz-geophone MP-4.5Hz-geophone PCB-106B50-3259 PCB-106B50-6695 ' ... 'MP-4.5Hz-geophone MP-4.5Hz-geophone MP-4.5Hz-geophone B&K-4939-1 ' ... 'MP-4.5Hz-geophone MP-4.5Hz-geophone MP-4.5Hz-geophone B&K-4939-2 ' ... 'MP-4.5Hz-geophone-in-tree MP-4.5Hz-geophone-in-tree ' ... 'MP-4.5Hz-geophone-in-tree B&K-4939-3-in-tree '];
sensor2 = words(sss2);

% rtype 1 = Microphone, 2 = PCB, 5= Vert, 6 = Horiz, 7 = Accel
rtype = [6 5 2 2 6 5 2 2 6 6 5 1 6 6 5 1 6 6 5 1 ];
% engfact = units per mV
% mV = data_value*descal_fact/stack_count
% phys_units = data_value*descale_fact / (stack_count*engfact)

% Starting nominal values:
engfact = [ ... 
32.2*1000 32.2*1000 100/6895 100/6895 ...
32.2*1000 32.2*1000 500/6895 500/6895 ...
32.2*1000 32.2*1000 500/6895 500/6895 ...
32.2*1000 32.2*1000 32.2*1000 -1.2/1000 ...
32.2*1000 32.2*1000 32.2*1000 -1.2/1000 ...
32.2*1000 32.2*1000 32.2*1000 -1.2/1000 ];

if(shotnum >=45);
engfact(7) = 100/6895; sensor2(7,:)='PCB102A07-15971 ';
end %102A07 15971 from Rec 45 on

% Actual calibrated values:
engfact = [ ... 
32.2*1000 32.2*1000 88.09/6895 85.75/6895 ...
32.2*1000 32.2*1000 500/6895 464.5/6895 ...
32.2*1000 32.2*1000 563.2/6895 500/6895 ...
32.2*1000 32.2*1000 32.2*1000 -1.15/1000 ...
32.2*1000 32.2*1000 32.2*1000 -1.32/1000 ...
32.2*1000 32.2*1000 32.2*1000 -1.20/1000 ];

% Adjust for changes in sensor array during test
if(shotnum >=45); engfact(7) = 89.72/6895; end %102A07 15971 from Rec 45 on
if(shotnum >=5 & shotnum <=27); %B&K mikes used for blank pistol shots
   engfact(16) = -0.7501/1000; sensor2(16,:)='B&K-4165-5 ';
   engfact(20) = -0.7436/1000; sensor2(20,:)='B&K-4165-6 ';
end %

% Assign source properties
% Default values
srcloc = 'SP1'; %Nominal value, actual TC locations below
srclocnum = 1; srcx = 0.0; srcy = 0.0; srcz = 1.5;
% stype 1 = C-4, 6 = 50 cal, 9 = 45 cal, 10 = noise
sourcetype = 'C-4'; stype = 1; sourcesize = 1;
% List of source heights used during tests
sht1 = 0.3048*(6*12+3)/12;
sht2 = 0.3048*(12*12+6)/12;
sht3 = 0.3048*(10*12+0)/12;
sht4 = 0.3048*(4*12+0)/12;
sht5 = 0.3048*(2*12+0)/12;
sht5 = 0.3048*(1*12+0)/12;
srcz = sht1; %default source height = 6 ft 3 = 1.9 m

% Assign C-4 source size
if(shotnum==40 | (shotnum>=96 & shotnum<=113) ) %4 bricks
    sourceSize = 4;
end

% Assign source height
if(shotnum==41 | shotnum==70 | shotnum==109 )
    srcz = sht2; %12-6 feet and inches
end
if(shotnum==42 | shotnum==71 | shotnum==110 )
    srcz = sht2; %10-0
end
if(shotnum==43 | shotnum==72 | shotnum==111 )
    srcz = sht3; %4-0
end
if(shotnum==44 | shotnum==73 | shotnum==112 )
    srcz = sht4; %2-0
end
if(shotnum==60 | shotnum==74 | shotnum==113 )
    srcz = sht5; %1-0
end

% Assign source locations
% TC3 is the origin, 30 m from the first CRREL sensor
if(shotnum==61 | shotnum==65 | shotnum==65 ... 
    | shotnum==93 | shotnum==96 | shotnum==100 ...
    | shotnum==104 ) %TC1
    srclocnum=1;srcloc='TC1';srcx=-414.7;source2='Open-field';
end
if(shotnum==60 | shotnum==62 | shotnum==66 ... 
    | (shotnum>=70 & shotnum<=74) | shotnum==94 ...)
| shotnum==97 | shotnum==101 | shotnum==105 ... |
| (shotnum>=108 & shotnum<=113) | %TC2 |
 srclocnum=2;srcloc='TC2';srcx=-60.5;source2='Open-field'; end

if((shotnum>=39 & shotnum<=44) | shotnum==63 ... |
| shotnum==67 | shotnum==98 | shotnum==102 ... |
| shotnum==106 ) | %TC3 |
 srclocnum=3;srcloc='TC3';srcx=0.0;source2='Edge-of-forest'; end

if(shotnum==64 | shotnum==68 ... |
| shotnum==95 | shotnum==99 | shotnum==103 ... |
| shotnum==107 ) | %TC4 |
 srclocnum=4;srcloc='TC4';srcx=311.0;source2='Edge-of-forest'; end

if(shotnum==39 | shotnum==69)
 srclocnum=5;srcloc='';srcx=0.0; sourcetype = 'Noise'; stype = 10; sourcesize = 0;source2='Noise'; end

% Assign source locations for blank pistol shots
if(shotnum<5) %30m
 srclocnum=5;srcloc='30m';srcx=30.0;srcy=2;srcz=1; sourcetype = 'Pistol'; stype = 9; sourcesize = 0;source2='In-forest'; end

if(shotnum>=5 & shotnum<10) %90m
 srclocnum=7;srcloc='90m';srcx=90.0;srcy=2;srcz=1; sourcetype = 'Pistol'; stype = 9; sourcesize = 0;source2='In-forest'; end

if(shotnum>=10 & shotnum<15) %60m
 srclocnum=6;srcloc='60m';srcx=60.0;srcy=2;srcz=1; sourcetype = 'Pistol'; stype = 9; sourcesize = 0;source2='In-forest'; end

if(shotnum>=15 & shotnum<20) %30m
 srclocnum=5;srcloc='30m';srcx=30.0;srcy=2;srcz=1; sourcetype = 'Pistol'; stype = 9; sourcesize = 0;source2='In-forest'; end

% Calculate source-to-sensor distances for this shot
srcx2 = srcx*srcx; srcy2 = srcy*srcy; srcz2 = srcz*srcz;
for i=1:nchan
    dist(i) = ((sensorx(i)-srcx).^2 + ...
                (sensory(i)-srcy).^2 + ...
                (sensorz(i)-srcz).^2 ) .^0.5;
end

return %----------------------------------------------------------

tax02cerlnum.m—Changes CRREL binary file numbers to CERL shot numbers

function [cerlrec ] = tx02cerlnum (shotnum)
% d:\DataWinNT\FY02LoneStarTX\tx02cerlnum.m
% Converts CRREL NZ seismograph file numbers for FY02 TX test
% For C-4, returns CERL Shot Num (1-39, with some "B" repeats)
% For blank pistol, assigns a number in the 100's
% For large Demo shots, assigns a number in the 300's
% Noise records 92-> 401
% Cal record numbers are omitted 20-27, 82-91, 114-199
% Don Albert dalbert@crrel.usace.army.mil
% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755
    cerlrec = ' ';    
    if(shotnum==39);cerlrec = ' 1';end
    if(shotnum==40);cerlrec = ' 2';end
    if(shotnum==41);cerlrec = ' 3';end
    if(shotnum==42);cerlrec = ' 4';end
    if(shotnum==43);cerlrec = ' 5';end
    if(shotnum==44);cerlrec = ' 6';end
    if(shotnum==60);cerlrec = ' 7';end
    if(shotnum==61);cerlrec = ' 8';end
    if(shotnum==62);cerlrec = ' 9';end
    if(shotnum==63);cerlrec = ' 10';end
    if(shotnum==64);cerlrec = ' 11';end
    if(shotnum==65);cerlrec = ' 12';end
    if(shotnum==66);cerlrec = ' 13';end
    if(shotnum==67);cerlrec = ' 14';end
    if(shotnum==68);cerlrec = ' 15';end
    % The next shots are repeats of Shots 3-7
    % We assign the CERL numbers 43-47
    if(shotnum==70);cerlrec = ' 43';end
    if(shotnum==71);cerlrec = ' 44';end
if(shotnum==72);cerlrec = ' 45';end
if(shotnum==73);cerlrec = ' 46';end
if(shotnum==74);cerlrec = ' 47';end
if(shotnum==93);cerlrec = ' 16';end
if(shotnum==94);cerlrec = ' 17';end
if(shotnum==95);cerlrec = ' 19';end
% missed CERL shot 18
if(shotnum==96);cerlrec = ' 20';end
if(shotnum==97);cerlrec = ' 21';end
if(shotnum==98);cerlrec = ' 22';end
if(shotnum==99);cerlrec = ' 23';end
if(shotnum==100);cerlrec = ' 24';end
if(shotnum==101);cerlrec = ' 25';end
if(shotnum==102);cerlrec = ' 26';end
if(shotnum==103);cerlrec = ' 27';end
if(shotnum==104);cerlrec = ' 28';end
if(shotnum==105);cerlrec = ' 29';end
if(shotnum==106);cerlrec = ' 30';end
if(shotnum==107);cerlrec = ' 31';end
if(shotnum==108);cerlrec = ' 32';end
if(shotnum==109);cerlrec = ' 33';end
if(shotnum==110);cerlrec = ' 34';end
if(shotnum==111);cerlrec = ' 35';end
if(shotnum==112);cerlrec = ' 36';end
if(shotnum==113);cerlrec = ' 37';end
% CRREL Blank Pistol Shots
if(shotnum== 1);cerlrec = '101';end
if(shotnum== 2);cerlrec = '102';end
if(shotnum== 3);cerlrec = '103';end
if(shotnum== 4);cerlrec = '104';end
if(shotnum== 5);cerlrec = '105';end
if(shotnum== 6);cerlrec = '106';end
if(shotnum== 7);cerlrec = '107';end
if(shotnum== 8);cerlrec = '108';end
if(shotnum== 9);cerlrec = '109';end
if(shotnum==10);cerlrec = '110';end
if(shotnum==11);cerlrec = '111';end
if(shotnum==12);cerlrec = '112';end
if(shotnum==13);cerlrec = '113';end
if(shotnum==14);cerlrec = '114';end
if(shotnum==15);cerlrec = '115';end
if(shotnum==16); cerlrec = '116'; end
if(shotnum==17); cerlrec = '117'; end
if(shotnum==18); cerlrec = '118'; end
if(shotnum==19); cerlrec = '119'; end
% Large in-ground Demolition Shots
if(shotnum==28); cerlrec = '301'; end
if(shotnum==29); cerlrec = '302'; end
if(shotnum==30); cerlrec = '303'; end
if(shotnum==31); cerlrec = '304'; end
if(shotnum==32); cerlrec = '305'; end
if(shotnum==33); cerlrec = '306'; end
if(shotnum==34); cerlrec = '307'; end
if(shotnum==35); cerlrec = '308'; end
if(shotnum==36); cerlrec = '309'; end
if(shotnum==37); cerlrec = '310'; end
if(shotnum==38); cerlrec = '311'; end
if(shotnum==45); cerlrec = '312'; end
if(shotnum==46); cerlrec = '313'; end
if(shotnum==47); cerlrec = '314'; end
if(shotnum==48); cerlrec = '315'; end
if(shotnum==49); cerlrec = '316'; end
if(shotnum==50); cerlrec = '317'; end
if(shotnum==51); cerlrec = '318'; end
if(shotnum==52); cerlrec = '319'; end
if(shotnum==53); cerlrec = '320'; end
if(shotnum==54); cerlrec = '321'; end
if(shotnum==55); cerlrec = '322'; end
if(shotnum==56); cerlrec = '323'; end
if(shotnum==57); cerlrec = '324'; end
if(shotnum==58); cerlrec = '325'; end
if(shotnum==59); cerlrec = '326'; end
if(shotnum==75); cerlrec = '327'; end
if(shotnum==76); cerlrec = '328'; end
if(shotnum==77); cerlrec = '329'; end
if(shotnum==78); cerlrec = '330'; end
if(shotnum==79); cerlrec = '331'; end
if(shotnum==80); cerlrec = '332'; end
if(shotnum==81); cerlrec = '333'; end
% Misfire = Noise record
if(shotnum==92); cerlrec = '401'; end
return
tx02plotnz.m—Three-panel plot of binary seismograph data

function
    tx02plotnz(shotnum,cerlrec,xx,iplot1,iplot2,iplot3,deltat,delayms,...
    dist,sensor,sensorx,sensory,sensorz,...
    srcloc,source-size,sourcetype,srcx,srcy,srcz);

% d:\DataWinNT\FY02LoneStarTX\Plot\tx02plotnz.m
%
% Plots nchan channels of data for Texas 02 NZ data
% Data are in array xx
% Channels to plot in each panel are in iplot1,2,3
% Does not call any subroutines
%
% Because of CRREL blaster box problems, there are no good time
% breaks in the data, and long record lengths were used. The
% data are aligned before plotting based on the actual arrival
% times found in the recorded data.

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% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

nplot1 = length(iplot1); nplot2 = length(iplot2);
nplot3 = length(iplot3);
xxmax = max(abs(xx)); %abs max for plotting

srate = 1/ deltat; %number of samples per second

% Determine the time window and direction of arrivals for the shots
% Time windows for C-4 shots
[aa bb] = max(xx); %set plot windows because manual TB
[cc dd] = min(xx); %for output file

tmax4 = delayms/1000 + (bb(4) )/srate; %times in seconds

tmax20 = delayms/1000 + (bb(20))/srate;
tmax16 = delayms/1000 + (bb(16))/srate;
tmax12 = delayms/1000 + (bb(12))/srate;
tstart4= floor(tmax4 *10)/10;
tstart20= round(tmax20*10)/10;
tstart16= floor(tmax16*10)/10;
if(tstart4 < tstart16)
tstartpanel1 = tstart4; tendpanel1 = tstartpanel1 + 0.5;
tstartpanel2 = tstart16; tendpanel2 = tstartpanel2 + 0.5;
tstartpanel3 = tstartpanel1; tendpanel3 = tstart20 + 0.1;
else %if(tstart16 < tstart4)
tstart4= round(tmax4 *10)/10;
tstart12= floor(tmax12*10)/10;
tstart20= floor(tmax20*10)/10;
tstart16= round(tmax16*10)/10;
tstartpanel1 = tstart12; tendpanel1 = tstartpanel1 + 0.5;
tstartpanel2 = tstart20; tendpanel2 = tstartpanel2 + 0.5;
tstartpanel3 = tstartpanel2; tendpanel3 = tstart4 + 0.1;
end

% Time windows for blank pistol shots
if(shotnum<5) %Pistol shots at 30 m, use mike at 90 m = Chan 12
tstart12= floor(tmax12*10)/10;
tstartpanel1 = tstart12-0.2; tendpanel1 = tstartpanel1 + 0.6;
tstartpanel2 = tstart12-0.2; tendpanel2 = tstartpanel2 + 0.6;
tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
end
if(shotnum>4 & shotnum<20) %Pistol shots at 90 m, use mike at 90 m = Chan 12
tstart12= floor(tmax12*10)/10;
tstartpanel1 = tstart12-0.1; tendpanel1 = tstartpanel1 + 0.6;
tstartpanel2 = tstart12-0.1; tendpanel2 = tstartpanel2 + 0.6;
tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
end

% time series
tend = length(xx(:,1)); %all data
t = delayms/1000 + (1:tend)/srate;

% Start of data plot %****************************************************************************
nametext = ['NZ Data - 3 panel']; %---------FIGURE - 3 Panels
f1 = figure('Name',nametext);
set(gcf,'Units','inches','PaperUnits','inches');

subplot(1,3,1); %Left (1st) panel of plot -----------
iplot=iplot1; nplot=nplot1;
iplot=1:12; %Channels 1-12 iplot=12:-1:1; %Channels 1-12
% Set axis params here; depends on nplot - t2
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')

% plot data and label
hold on;
for i=1:nplot
  plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i))) +yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
  % Text labels for plot
  str1 = sensor(iplot(i),:);
  str2 = sprintf('%7.2e',(xxmax(iplot(i))));
  if (xxmax(iplot(i))) < 0.0001
    str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
  elseif (xxmax(iplot(i))) < 0.001
    str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
  elseif (xxmax(iplot(i))) < 0.1
    str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
  elseif (xxmax(iplot(i))) < 10.0
    str2=sprintf('%4.2f',(xxmax(iplot(i))));
  elseif (xxmax(iplot(i))) > 1000.0
    str2=sprintf('%4.1fk', (xxmax(iplot(i))/1000));
  else
    str2=sprintf('%4.1f',(xxmax(iplot(i))));
  end %text loop
  str3 = char(str1);
  str4 = char(str3 , str2);
  str5 = cellstr(str4);
  text(tendpanel1+0.02,[yshift(i)],str5,'FontSize',8,...
       'HorizontalAlignment','left');
end %plot loop i=1:nplot

subplot(1,3,2); %Center (2nd) panel of plot ------------------------
iplot=iplot2; nplot=nplot2;
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel2-0.05 tendpanel2 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')

% plot data and label
hold on;
for i=1:nplot
    plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i)))+yshift(i),'k');
    leftlabel = sprintf('%g',round(dist(iplot(i))));
    % Text labels for plot
    str1 = sensor(iplot(i),:);
    str2 = sprintf('%7.2e',(xxmax(iplot(i))));
    if (xxmax(iplot(i))) < 0.0001
        str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.001
        str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.1
        str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 10.0
        str2=sprintf('%4.2f',(xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) > 1000.0
        str2=sprintf('%4.1fk', 1000, xxmax(iplot(i))/1000 ) ;
    else
        str2=sprintf('%4.1f',(xxmax(iplot(i))));
    end %text loop
    str3 = char(str1);
    str4 = char(str3 , str2);
    str5 = cellstr(str4);
    text(tendpanel2+0.02,[yshift(i)],str5,'FontSize',8,'HorizontalAlignment','left');
end %plot loop i=1:nplot

subplot(1,3,3); %Right (3rd) panel of plot ------------------------
% Pressure sensors only
iplot=iplot3; nplot=nplot3;
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel3-0.05 tendpanel3 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')

% plot data and label
hold on;
for i=1:nplot
    if(xxmax(iplot(i)==0));xxmax(iplot(i))=1;end
    plot(t,(xx(1:length(t),iplot(i))/xxmax(iplot(i))) +yshift(i),'k');
    leftlabel = sprintf('%g',round(dist(iplot(i))));
    % Text labels for plot
    str1 = sensor(iplot(i),:);
    str2 = sprintf('%7.2e',(xxmax(iplot(i))));
    if (xxmax(iplot(i))) < 0.0001
        str2=sprintf('%4.1fE-6',(1E6*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.001
        str2=sprintf('%4.2fE-3',(1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.1
        str2=sprintf('%4.1fE-3',(1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 10.0
        str2=sprintf('%4.2f',(xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) > 1000.0
        str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
    else
        str2=sprintf('%4.1f',(xxmax(iplot(i))));
    end %text loop
    str3 = char(str1);
    str4 = char(str3 , str2);
    str5 = cellstr(str4);
    text(tendpanel3+0.02,[yshift(i)],str5,'FontSize',8,'HorizontalAlignment','left');
end %plot loop i=1:nplot

************************************************
% Title for entire plot -------------------------------------
----------
if(sourcesize~=0) %C-4 shot
    plottitle = ...
    sprintf('TX02 -- Shot %s Rec %g -- %s %3.1f kg %s %3.1f m agl -- %3.0f-%3.0f m',...
cerlrec, shotnum, srcloc, sourcetype, srcz, min(dist), max(dist));
else %not C-4 shot
  plottitle = ...
  sprintf('TX02 -- Record %g -- %s %s %3.1f m -- %3.0f-%3.0f m', ...
  shotnum, srcloc, sourcetype, srcz, min(dist), max(dist));
end

ax = axes('Units', 'Normal', 'Position', [0.075 0.075 0.85 0.85], ...
  'Visible', 'of');
set(get(ax, 'Title'), 'Visible', 'on');
title(plottitle, 'FontSize', 18, 'FontWeight', 'Bold');

set(gcf, 'PaperUnits', 'inches');
set(gcf, 'PaperPosition', [0.5, 0.25, 10, 7]);
set(gcf, 'PaperOrientation', 'landscape');
return

**tx02tbcorr—Finds true shot instant**

function [itimeTB, itime0, itimel, time0, xdist, xtime] =
tx02tbcorr(shotnum,...
  cerlrec, xx, deltat, delayms, srcloc)

% d:\DataWinNT\FY02LoneStarTX\Plot\tx02tbcorr.m
% Finds TB (time break or shot instant) from data
% This is done by finding the slope of the travel time
% curve for the first and last pressure sensor in the
% array to find the acoustic velocity. This velocity
% is then used to find the shot time.
% The data are shifted so that time=0 is the
% actual shot time.
% Writes info to Timebreaklogtx02.m
% Does not call any other subroutines

% itimeTB is the TB (shot instant) index
% itime0 is the index to start the save (usually=TB)
% if the shot was at TC1, 1 second is added to itime0
% itimel is the index 2 seconds after the TB
% time0 is the start time for saving the time series

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% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

fid13=fopen('Tx02TimeBreakLog.m','a');

srate = 1/ deltat;% number of samples per second

% Pressure channels to process
[a b] = max(xx(:,[4 8 12 16 20]));
b2 = b + delayms*srate/1000; b2 = b2/srate;

xp = [ 30 60 90 120 150];
if (srcloc(3)=='1');
    xp = xp + 445 - 30; %TC1
elseif(srcloc(3)=='2')
    xp = xp + 91 - 30; %TC2
elseif(srcloc(3)=='3')
    xp = xp + 0; %TC3
elseif(srcloc(3)=='4')
    xp = [281 251 221 191 161]; %TC4
else
    xp = [ 30 60 90 120 150];
end

vel = (xp(5)-xp(1)) / (b2(5) - b2(1));
t1actual = xp(1)/vel;
t0corr = t1actual - b2(1);
b3 = b2 + t0corr; %Corrected travel times

% Code for pistol shots only - uses different sensors
if(shotnum <= 19); %Blank pistol shots
    if(shotnum <=4) %pistol at 30 m
        iii1 = 1; iii2 = 3; %start chan 4, end chan 12
    elseif(shotnum>4 & shotnum<9) %pistol at 90 m
        iii1 = 3; iii2 = 5; %start chan 12, end chan 20
    elseif(shotnum>9 & shotnum<14) %pistol at 60 m
        iii1 = 2; iii2 = 4; %start chan 8, end chan 16
    else
        iii1 = 1; iii2 = 3; %start chan 4, end chan 12
    end
else

end
Seismic and Acoustic Signature Measurements Through Forest

```matlab
elseif(shotnum>14) % pistol at 30 m
    iii1 = 1; iii2 = 3; % start chan 4, end chan 12
end
vel = (xp(iii2)-xp(iii1)) / (b2(iii2) - b2(iii1));
tactual = 2/vel; % Pistol shot was 2 m from nearest sensor
t0corr = tactual - b2(iii1);
b3 = b2 + t0corr; % Corrected travel times
fprintf(fid13,...
'    Shot %g %s Blank pistol Velocity = %6.1f m/s TB corr = %6.4f \n',...
    shotnum,srcloc,vel,t0corr);
else % C-4 shot
    fprintf(fid13,... % C-4 shot print statement
'    Shot %g %s CERL %s Velocity = %6.1f m/s TB corr = %6.4f \n',...
    shotnum,srcloc,cerlrec,vel,t0corr);
end % code for pistol shots

itimeTB = -floor((t0corr + delayms/1000) * srate);
itime0 = -(t0corr + delayms/1000) * srate;
itime0 = floor(itime0);
time0 = 0.0; % Start ascii data at 0.0 sec (shot instant)
if(srcloc == 'TC1');
    itime0 = itime0 + 1.0 * srate;
    time0 = 1.0;
end

if(shotnum==39 | shotnum==44); % Bad records, missed shot
    t0corr = 0; % Use original zero time
    itimeTB = -floor((t0corr + delayms/1000) * srate);
    itime0 = -(t0corr + delayms/1000) * srate;
    itime0 = floor(itime0);
    time0 = 0.0; % Start ascii data at 0.0 sec (shot instant)
end

itime1 = itime0 + 2*srate; % Write 2 seconds of ascii data

xdist = xp;
xt ime = b3;

fclose(fid13);```

```
return

tx02writenchan.m – Writes multichannel ASCII file tx02nnn.asc

function tx02writenchan(shotnum,cerlrec,xx,npts,deltat,nchan,delayms,...
  descalingfact,...
  stackcount,acqdate,acqtime,engfact,xgain,itime0,itime1,time0,...
  dist,sensor,rtype,sensorx,sensory,sensorz,sensor2,...
  srcloc,type,sourcetype,sourcez,srcx,srcy,srcz,source2);

% d:\DataWinNT\FY02LoneStarTX\Plot\tx02writenchan.m
% Writes nchan (24) channel ascii file for Texas 2002 data
% File name is tx02xxx.asc, where xxx is a new file number
% xxx = CERL Shot number if it was a C-4 shot
% Calls no subroutines

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srate = 1/ deltat; % number of samples per second
recnum = shotnum; npts = length(xx);
stype = 1; signal=1; srccomment=source2;
if(shotnum<20); stype = 5; signal = 0; end
comment = 'Lone Star AAP, Texarkana, TX Blast Noise Through Forest w/CERL';

% Construct ascii file name and open
cerlrec2 = str2num(cerlrec)+2000;
if(cerlrec~0);
  fname2 = sprintf('tx0%g.asc',cerlrec2); %tx02001 - tx02037
else
  if(recnum<10)
    fname2 = sprintf('tx02spistol0%s.asc',num2str(recnum)); %tx02pistol01 - 09
  else
    fname2 = sprintf('tx02pistol%s.asc',num2str(recnum)); %tx02pistol10 - 19
  end
end
fid5=fopen(fname2,'w');
% (itime0:itime1) time0 = start time in sec

% File header - Same for all records in this expt:
projectnum = 200202; project = 'TX02';
itbtype = 1; tctype='Manual';% manual;
itbcorr = 1; %TB corrected? 1=Yes
npts2 = 16000; %Npts to write to ascii file

% File header - for all channels in this record or shot
 tbcorr = itime0; %Find TB correction from data - from tbcorr2
 starttimes = time0; %Start time in sec, for TC1 - from tbcorr2
 %stype = 1; signal=1;srccomment='In Open Field';

% Write each channel
[aa bb] = max(xx); %set plot windows because manual TB
[cc dd] = min(xx); %set plot windows because manual TB
%for iii =1:nplot;
% Loop over sensors *********************************************************
for iii = 1:nchan %
% File header - for this channel only
 ichan = iii; irtype = 2; reccomment = sensor2(ichan,:);
tmax = delayms/1000 + (bb(iii) )/srate; %times in seconds
tmin = delayms/1000 + (dd(iii) )/srate; %times in seconds
xxmax = aa(iii); xxmin = cc(iii);

% Write header
fprintf(fid5,...
'Project no Filename Recno Cerlrecno Date Time \n');
fprintf(fid5, '%g %s %s %s %s %s %s %s \n',...
projectnum,project,fname2,recnum,cerlrec,acqdate,acqtime);

fprintf(fid5, 'TBtype Corrected? Delayms OrigNpts TBtype \n');
fprintf(fid5,...
' %g %g %g %g %g %s \n',...
itbtype,itbcorr,delayms,npts,tbtype);

fprintf(fid5, 'Nchan Npts2 Srate TBcorr Starttime(s) \n');
fprintf(fid5, ' %g %g %g %g %7.4f \n',...
nchan,npts2,srate,tbcorr,starttimes);
fprintf(fid5, 'Stype Signal? Src (x,y,z) Size \n');
fprintf(fid5,...
' %g %g %7.2f %7.2f %7.2f %g %s %s %s \n',... stype,signal,srcx,srcy,srcz,sourcesize,srcloc,... sourcetype,srccomment);

fprintf(fid5,'Ichan Rtype Rec (x,y,z) \n');
fprintf(fid5,...
' %g %g %7.2f %7.2f %7.2f %s %s \n',... ichan,rtype(ichan),sensorx(ichan),sensory(ichan),... sensorz(ichan),sensor(ichan,:),reccomment);

fprintf(fid5,...
'Dist(m) Engfact,Xgain,Stack Pmax, T Pmin, T(s) \n');
fprintf(fid5,...
' %7.1f %14.6e %14.6e %g %11.3e %7.4f %11.3e %7.4f \n',... dist(ichan),engfact(ichan),xgain(ichan),... stackcount(ichan),xxmax,tmax,xxmin,tmin);

fprintf(fid5,'%s \n',comment);

% Write data
% x is raw data (mV), xx is data in physical units.
fprintf(fid5,...
' %15.7e %15.7e %15.7e %15.7e %15.7e \n', ... xx(itime0:itime1,ichan));
nwrite = (itime0+itime1+1)/5; nwriteint = floor(nwrite);
if(nwrite-nwriteint~=0); fprintf(fid5,'
');end

end % loop over sensors ****************************************

fclose(fid5);
return %------------------------------------------------------

readnz.m—Reads NZ seismograph binary data file

function [scan,samplesPerScan,samplingInterval,nbOfTraces, ... delaytime,descalingfact,stackcount,acqdate,acqtime] = readnz (filename)

% Reads a binary seismograph file in SEG-2 format, and returns the
% data in "scan" variable above.
% This code written by Don Albert, CRREL, and based on code "SEG2LOAD" written
% by PiècePY to read a radar file in modified SEG-2 format. Some of Piece's
% original code is still here in this file.
% Calls subroutine words.m
% Writes info about the file to file readnzlog.m

% To read one NZ file directly:
% fname = '10077.dat';
% [x,npts,deltat,nchan,npts2,delayms,descalingfact,acqdate,...
% acqtime] = readnz(fname);

% READNZ - For Geometrics NZ seismograph
% This version modified from MOUT data for MN02 data

% READNZ Modified by D Albert to read standard SEG-2 format
% SEG2LOAD Read a SEG-2 (standard SEG-2 format of the Society of Exploration Geophysicist) file from disk.
% [scan,samplesPerScan,samplingInterval,shaftInterval,
% timerFrequency] =seg2load ('filename') reads the file 'filename'
% and returns the image scan [m,n] containing n A-Scan of m samples.
% If no extension is given for the filename, the extension
% '.sg2' is assumed.
% samplesPerScan contains the number of samples per A-scan
% shaftInterval contains the distance between shaft encoder
% triggers in meter
% samplingInterval contains the time between 2 samples in pico-seconds
% timerFrequency contains the frequency of A-scan sampling in Hz
%
% Pièce PY 24/07/1996
% LAMI - DeTeC Demining Technology Center
% Swiss Federal Institute of Technology (EPFL) -
% Lausanne, Switzerland

% Don Albert dalbert@crrel.usace.army.mil
% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

% check argument and filename
if (nargin==0)
error ('readseg2 requires at least a filename as an argument !');
end;
if (isstr (filename)~=1)
    error ('Argument is not a filename !');
end;
if (isempty (findstr (filename,'.'))==1)
    filename = [filename,'.sg2'];
end;
 fid=fopen (filename,'rb','ieee-le');
if (fid ==-1)
    error ([ 'Error opening ',filename,' for input !']);
end;

% check for SEG-2 file type
% first 2 bytes equal '3a55h' (14933) for PC/Windows
fileType=fread (fid,1,'short');
if (fileType ~= 14933)
    fclose (fid);
    error ('Not a SEG-2 file !');
end;

% Open a log file to keep track of files that were read
fid2 = fopen('readnzlog.m','a');
% fprintf(fid2,' 
');
samplesPerScan =0;
shaftInterval =0;
samplingInterval=0;
timerFrequency =0;

% read File Descriptor Block

revNumber = fread (fid,1,'short');
sizeOfTracePointer = fread (fid,1,'ushort');
 nbOfTraces = fread (fid,1,'ushort');
 sizeOfST = fread (fid,1,'uchar');
 firstST = fread (fid,1,'char');
 secondST = fread (fid,1,'char');
 sizeOfLT = fread (fid,1,'uchar');
 firstLT = fread (fid,1,'char');
 secondLT = fread (fid,1,'char');
reserved = fread (fid,18,'uchar');
tracePointers = fread (fid,nbOfTraces,'ulong');

% read free strings

fseek (fid,32+sizeOfTracePointer,'bof');
offset = fread (fid,1,'ushort');

% File descriptor block
while (offset > 0)
    freeString = setstr (fread (fid,offset-2,'char'))'; % Decode file descriptor block
    if (findstr (freeString,'ACQUISITION_DATE') > 0)
        acqdate = (freeString ...
        (length ('ACQUISITION_DATE ') : length (freeString)));
    end
    if (findstr (freeString,'ACQUISITION_TIME') > 0)
        acqtime = (freeString ...
        (length ('ACQUISITION_TIME ') : length (freeString)));
    end
    offset = fread (fid,1,'ushort');
end

% read traces

% find number of samples per trace
% First trace descriptor block
fseek (fid,tracePointers (1),'bof');
traceId = fread (fid,1,'ushort');
sizeOfBlock = fread (fid,1,'ushort');
sizeOfData = fread (fid,1,'ulong');
nbOfSamples = fread (fid,1,'ulong');
samplesPerScan = nbOfSamples;

dataCode = fread (fid,1,'uchar');
reserved = fread (fid,19,'uchar');
offset = fread (fid,1,'ushort');
while (offset > 0)
    freeString = setstr (fread (fid,offset-2,'char'))';
    if (findstr (freeString,'SAMPLE_INTERVAL') > 0)
        samplingInterval = str2num (freeString ...
(length ('SAMPLE_INTERVAL '):length (freeString)));
end
if (findstr (freeString,'DELAY') > 0)
delaytime = 1000*str2num (freeString ...
(length ('DELAY '):length (freeString)));
end
if (findstr (freeString,'DESCALING_FACTOR') > 0)
descalingfactor = str2num (freeString ...
(length ('DESCALING_FACTOR '):length (freeString)));
end
offset = fread (fid,1,'ushort');
end;

%Write file descriptor to log file
fprintf(fid2,'%s %s %s %g %g %g %g 
',filename,acqdate,acqtime,nbOfSamples,...
samplingInterval,delaytime,descalingfactor);

scan = zeros (nbOfSamples,nbOfTraces);
for i=1:nbOfTraces,
  fseek (fid,tracePointers (i),'bof');
  traceId = fread (fid,1,'ushort');
  sizeOfBlock = fread (fid,1,'ushort');
  sizeOfData = fread (fid,1,'ulong');
  nbOfSamples = fread (fid,1,'ulong');
  dataCode = fread (fid,1,'uchar');
  reserved = fread (fid,19,'uchar');
  % Trace descriptor blocks
  %Reads all at once
  freeString = setstr (fread (fid,sizeOfBlock-32,'char'))';

  w = words(freeString);
  %MOUT data
  %descalingfact(i) = str2num(w(4,1:14));
  %stackcount(i) = str2num(w(18,1:2));
  %[aasizew bbsizew] = size(w);
  %if(aasizew==30);
  % stackcount(i) = str2num(w(27,1:2));
  %else
  % stackcount(i) = str2num(w(26,1:2));
  % end
%stackcount(i) = str2num(w(26,1:2));
descalingfact(i) = str2num(w(7,1:14));
stackcount(i) = 1;

% read the data here
scan (1:nbOfSamples,i) = fread (fid,nbOfSamples,'float32');
end;

fclose (fid); %close data file

return

words.m—Separates string into individual words

function all_words = words(input_string)
% filename: words.m
% Separates words in a long string
% Individual words are then in all_words(9,:)
% From the book, Using Matlab, p. 11-12

remainder = input_string;
all_words = '';

while (any(remainder))
    [chopped,remainder] = strtok(remainder);
    all_words = strvcat(all_words,chopped);
end

return
APPENDIX C: MATLAB PROGRAMS TO READ AND PLOT MULTICHANNEL ASCII DATA FILES.

This section provides a listing of the MATLAB programs used to read and plot the 24 channel ASCII data files that were constructed from the binary files using the programs in the previous section. The files that are listed in this section are:

9. **doplotasc.m** – Main program to read multichannel ASCII file and make a three-panel plot of the data. To use, set the desired ASCII file numbers in the variable “recs” and run the program. You may have to change the lines that construct the filenames to use the correct directory for your computer, and you may want to change the print options at the very end of this program to match your printer or delete the plot from the screen after plotting. Calls the programs listed below.

10. **readascii.m** – Function to read in the data from the multichannel ASCII files. Calls function words.m

11. **plotasc.m** – Function to make a three-panel plot of the data in landscape orientation. The channels plotted in each of the panels are given by the contents of iplot1, iplot2, and iplot3.

12. **words.m** – Function to parse a string into individual words. This function is listed in the previous section.

**doplotasc.m—Reads and plots multichannel ascii files**

```matlab
% d:\DataWinNT\FY02LoneStarTX\Plot\doplotasc.m
% Reads multichannel ascii file, makes 3 panel plots of data
% Calls functions
% readascii.m - to read the multichannel ascii data
% words.m - to parse ascii header lines
% plotasc.m - make a 3 panel plot of the data

% Ascii record numbers;
% All C-4 (1,5,6,10,18 bad) and all blank pistol
% recs = [11 12 13 14 103 105 110 115 ]; %Example files

% Loop to read and plot the files
for i = 1:length(recs);
    recnum = recs(i);
    shotnum = recs(i);
```
recnum = recnum+2000;
fname = sprintf('tx0%g.asc',recnum); %tx02001 - tx02037
% Read in the data from the ascii multichannel file
[projectnum,project,fname2,recnum,cerlrec,acqdate,acqtime,...
 itbtype,itbcorr,delays,npts,tbtype,...
nchan,npts2,srate,deltat,tbcorr,starttime,...
stype,signal,srcx,srcy,srcz,sourceize,srcloc,sourcetype,srccomment,...
rtype,sensorx,sensory,sensorz,sensor,sensor2,...
dist,engfact,xgain,stackcount,xxmax,tmax,xxmin,tmin,xx]= ...
readascii(recnum,fname);

% 3 panel plot of ascii data
% Assign the channels to each panel of the plot
iplot1 = [9 10 11 12 5 6 7 8 1 2 3 4]; %Channels for 1st (left) panel
iplot2 = [22 21 23 24 18 17 19 20 14 13 15 16 ]; % 2nd (center) panel
iplot3 = [24 20 16 11 12 7 8 3 4 ]; %Channels for 3rd (right) panel
% Make the plot
plotasc(shotnum,fname,xx,iplot1,iplot2,iplot3,deltat,starttime,...
dist,sensor,sensorx,sensory,sensorz,...
srcloc,sourceize,sourcetype,srcx,srcy,srcz);

% Print and delete
% print -dljetplus;
print -dljetplus; pause(10); h=gcf; delete(h);
% print to PostScript file for conversion to PDF:
% print -dps -r150 -append tx02datafigs
% h=gcf;delete(h);

end

return %-------------------------------------------------
readascii.m—Reads in data from multichannel ASCII file

function [projectnum,project,fname2,recnum,cerlrec,acqdate,acqtime,...
 itbtype,itbcorr,delays,npts,tbtype,...
nchan,npts2,srate,deltat,tbcorr,starttime,...
stype,signal,srcx,srcy,srcz,sourceize,srcloc,sourcetype,srccomment,...
rtype,sensorx,sensory,sensorz,sensor,sensor2,...
dist,engfact,xgain,stackcount,xxmax,tmax,xxmin,tmin,xx]= ...
readascii(recnum,fname);
% d:\DataWinNT\FY02LoneStarTX\Plot\readascii.m
% Reads in ascii seismograph data from fid6
% Calls words.m - parse string into individual words

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% Read first header to get number of channels
fid6=fopen(fname,'r');
line1 = fgets(fid6);%Project no Filename Recno Cerlrecno Date Time
line2 = fgets(fid6);
line3 = fgets(fid6);%TBtype Corrected? Delayms OrigNpts TBtype
line4 = fgets(fid6);
line5 = fgets(fid6);%Nchan Npts2 Srate TBcorr Starttime(s)
line6 = fgets(fid6);
line7 = fgets(fid6);%Stype Signal? Src (x,y,z) Size
line8 = fgets(fid6);
line9 = fgets(fid6);%Ichan Rtype Rec (x,y,z)
line10 = fgets(fid6);
line11 = fgets(fid6);%Dist(m) Engfact,Xgain,Stack Pmax, T Pmin, T(s)
line12 = fgets(fid6);
line13 = fgets(fid6);%Comment
a6 = words(line6);
nchan = str2num(a6(1,:)); npts2 = str2num(a6(2,:));

fid6=fopen(fname,'r'); %rewind file

for iii = 1:nchan % Read data ***************

% Read header - Same for all records in this expt:
line1 = fgets(fid6); line2 = fgets(fid6); line3 = fgets(fid6);
line4 = fgets(fid6); line5 = fgets(fid6); line6 = fgets(fid6);
line7 = fgets(fid6); line8 = fgets(fid6); line9 = fgets(fid6);
line10 = fgets(fid6); line11 = fgets(fid6); line12 = fgets(fid6);
line13 = fgets(fid6); %Comment

% decode header
a2 = words(line2); a4 = words(line4); a6 = words(line6);
a8 = words(line8); a10 = words(line10); a12 = words(line12);
%projectnum,project,fname2,recnum,cerlrec,acqdate,acqtime
projectnum = a2(1,:); project = a2(2,:); fname2 = a2(3,:);
recnum = str2num(a2(4,:)); cerlrec = str2num(a2(5,:));
acqdate = a2(6,:); acqtime = a2(7,:);
shotnum = recnum;

%itbtype,itbcorr,delayms,npts,tbtype
itbtype = str2num(a4(1,:)); itbcorr = str2num(a4(2,:));
delayms = str2num(a4(3,:));
npts = str2num(a4(4,:)); tbtype = a4(5,:);

%nchan,npts2,srate,tbcorr,starttimes
nchan = str2num(a6(1,:)); npts2 = str2num(a6(2,:));
srate = str2num(a6(3,:));
tbcorr = str2num(a6(4,:)); starttime = str2num(a6(5,:));
deltat = 1/srate;

%stype,signal,srcx,srcy,srcz,sourcesize,srcloc,
% sourcetype,srccomment
stype = str2num(a8(1,:)); signal = str2num(a8(2,:));
srcx = str2num(a8(3,:));
srcy = str2num(a8(4,:)); srcz = str2num(a8(5,:));
sourcesize = str2num(a8(6,:));
srcloc = a8(7,:); srcloc = words(srcloc);
sourcetype = a8(8,:); sourcetype = words(sourcetype);
srccomment = a8(9,:);

%ichan,rtype(ichan),sensorx(ichan),sensory(ichan),
% sensorz(ichan),sensor(ichan,:),reccomment
ichan = str2num(a10(1,:));
rtype(ichan) = str2num(a10(2,:));
sensorx(ichan) = str2num(a10(3,:));
sensory(ichan) = str2num(a10(4,:));
sensorz(ichan) = str2num(a10(5,:));
sensor(ichan,1:length(a10)) = a10(6,1:length(a10));
reccomment = a10(7,:);
sensor2(ichan,1:length(a10)) = a10(7,1:length(a10));

%dist(ichan),engfact(ichan),xgain(ichan),stackcount(ichan),
% xxmax,tmax,xxmin,tmin
dist(ichan) = str2num(a12(1,:));
engfact(ichan) = str2num(a12(2,:));
xgain(ichan) = str2num(a12(3,:));
stackcount(ichan) = str2num(a12(4,:));
xxmax(ichan) = str2num(a12(5,:)); tmax(ichan) = str2num(a12(6,:));
xxmin(ichan) = str2num(a12(7,:)); tmin(ichan) = str2num(a12(8,:));

% Put data in xx
data = [];
data = [data; fscanf(fid6, '%g')];
xx(:,ichan) = data;
end % loop iii = 1:nchan % Read data *******************
fclose(fid6);
return %-----------------------

plotasc.m—Three-panel plot

function
plotasc(shotnum,fname,xx,iplot1,iplot2,iplot3,deltat,starttime,...
dist,sensor,sensorx,sensory,sensorz,...
srcloc,sourcesize,sourcetype,srcx,srcy,srcz);

% d:\DataWinNT\FY02LoneStarTX\Plot\plotasc.m
%
% Plots nchan channels of ascii data
% Does not call any subroutines
%
% Don Albert dalbert@crrel.usace.army.mil
% USA ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755

nplot1 = length(iplot1);nplot2 = length(iplot2);nplot3 = length(iplot3);
xxmax = max(abs(xx)); %abs max for plotting
srate = 1/ deltat;%number of samples per second

% Find time window to plot
if(srcloc(3) == '4') %TC4 opposite side of sensors
 tstartpanel1 = starttime + 0.5; tendpanel1 = tstartpanel1 + 0.6;
tstartpanel2 = starttime + 0.4; tendpanel2 = tstartpanel2 + 0.6;

% ++++++++ MODIFIED ++++++++
tstartpanel3 = tstartpanel2; tendpanel3 = tendpanel2;
elseif(srcloc(3) == '1') %TC1
  tstartpanel1 = starttime + 0.2; tendpanel1 = tstartpanel1 + 0.6;
  tstartpanel2 = starttime + 0.4; tendpanel2 = tstartpanel2 + 0.6;
  tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
elseif(srcloc(3) == '2') %TC2
  tstartpanel1 = starttime + 0.2; tendpanel1 = tstartpanel1 + 0.6;
  tstartpanel2 = starttime + 0.4; tendpanel2 = tstartpanel2 + 0.6;
  tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
elseif(srcloc(3) == '3') %TC3
  tstartpanel1 = starttime + 0.0; tendpanel1 = tstartpanel1 + 0.6;
  tstartpanel2 = starttime + 0.2; tendpanel2 = tstartpanel2 + 0.6;
  tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
else %Pistol
  tstartpanel1 = starttime; tendpanel1 = tstartpanel1 + 0.6;
  tstartpanel2 = starttime; tendpanel2 = tstartpanel2 + 0.6;
  tstartpanel3 = tstartpanel1; tendpanel3 = tendpanel1;
end

% time series
end = length(xx(:,1)); %all data
t = starttime + (1:tend)/srate;

% Start of data plot %****************************************************************************

nametext = ['NZ Data - 3 panel']; %----------FIGURE - 3 Panels
f1 = figure('Name',nametext);
set(gcf,'Units','inches','PaperUnits','inches');

subplot(1,3,1); %Left (1st) panel of plot ----------------------------------------
plot1=plot1; nplot=nplot1;
%plot1=1:12; %Channels 1-12 %plot1=12:-1:1; %Channels 1-12
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel1-0.05 tendpanel1 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
% plot data and label
hold on;
for i=1:nplot
  plot(t, (xx(1:length(t),iplot(i))/xxmax(iplot(i))) +yshift(i),'k');
  leftlabel = sprintf('%g',round(dist(iplot(i))));
% Text labels for plot
str1 = sensor(iplot(i),:);
str2 = sprintf('%7.2e', (xxmax(iplot(i))));
if (xxmax(iplot(i))) < 0.0001
    str2 = sprintf('%4.1fE-6', (1E6*xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.001
    str2 = sprintf('%4.2fE-3', (1E3*xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.1
    str2 = sprintf('%4.1fE-3', (1E3*xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 10.0
    str2 = sprintf('%4.2f', (xxmax(iplot(i))));
elseif (xxmax(iplot(i))) > 1000.0
    str2 = sprintf('%4.1fk', (xxmax(iplot(i))/1000));
else
    str2 = sprintf('%4.1f', (xxmax(iplot(i))));
end %text loop
str3 = char(str1);
str4 = char(str3, str2);
str5 = cellstr(str4);
end %plot loop i=1:nplot %Left (1st) panel of plot ----------------------

subplot(1,3,2); %Center (2nd) panel of plot ------------------------
iplot = iplot2; nplot = nplot2;
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel2 -0.05 tendpanel2 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
% plot data and label
hold on;
for i=1:nplot
    plot(t, (xx(1:length(t),iplot(i))/xxmax(iplot(i))) + yshift(i), 'k');
    leftlabel = sprintf('%g', round(dist(iplot(i))));
    % Text labels for plot
    str1 = sensor(iplot(i),:);
    str2 = sprintf('%7.2e', (xxmax(iplot(i))));
    if (xxmax(iplot(i))) < 0.0001
        str2 = sprintf('%4.1fE-6', (1E6*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.001
        str2 = sprintf('%4.2fE-3', (1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.1
        str2 = sprintf('%4.1fE-3', (1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 10.0
        str2 = sprintf('%4.2f', (xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) > 1000.0
        str2 = sprintf('%4.1fk', (xxmax(iplot(i))/1000));
    else
        str2 = sprintf('%4.1f', (xxmax(iplot(i))));
    end %text loop
    str3 = char(str1);
    str4 = char(str3, str2);
    str5 = cellstr(str4);
end %plot loop i=1:nplot %Left (1st) panel of plot ----------------------

subplot(1,3,3); %Center (2nd) panel of plot ------------------------
iplot = iplot2; nplot = nplot2;
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel2 -0.05 tendpanel2 -1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
% plot data and label
hold on;
for i=1:nplot
    plot(t, (xx(1:length(t),iplot(i))/xxmax(iplot(i))) + yshift(i), 'k');
    leftlabel = sprintf('%g', round(dist(iplot(i))));
    % Text labels for plot
    str1 = sensor(iplot(i),:);
    str2 = sprintf('%7.2e', (xxmax(iplot(i))));
    if (xxmax(iplot(i))) < 0.0001
        str2 = sprintf('%4.1fE-6', (1E6*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.001
        str2 = sprintf('%4.2fE-3', (1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 0.1
        str2 = sprintf('%4.1fE-3', (1E3*xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) < 10.0
        str2 = sprintf('%4.2f', (xxmax(iplot(i))));
    elseif (xxmax(iplot(i))) > 1000.0
        str2 = sprintf('%4.1fk', (xxmax(iplot(i))/1000));
    else
        str2 = sprintf('%4.1f', (xxmax(iplot(i))));
    end %text loop
    str3 = char(str1);
    str4 = char(str3, str2);
    str5 = cellstr(str4);
end %plot loop i=1:nplot %Left (1st) panel of plot ----------------------
str2 = sprintf('%4.2fE-3', (1E3 * xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.1
str2 = sprintf('%4.1fE-3', (1E3 * xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 10.0
str2 = sprintf('%4.2f', (xxmax(iplot(i))));
elseif (xxmax(iplot(i))) > 1000.0
str2 = sprintf('%4.1fk', (xxmax(iplot(i))/1000));
else
str2 = sprintf('%4.1f', (xxmax(iplot(i))));
end %text loop
str3 = char(str1);
str4 = char(str3, str2);
str5 = cellstr(str4);
text(tendpanel2 + 0.02, [yshift(i)], str5, 'FontSize', 8,...
'HorizontalAlignment', 'left');
end %plot loop i = 1:nplot %Center (2nd) panel of plot --------------

subplot(1,3,3); %Right (3rd) panel of plot ------------------------
% Pressure sensors only
iplot = iplot3; nplot = nplot3;
yshift = (1:nplot)*2 - 2;
ax = [tstartpanel3-0.05 tendpanel3-1 2*nplot];
axis(ax);
ax1 = gca; set(ax1,'YTick',[]); set(ax1,'Box','on');
xlabel('Time, sec')
% plot data and label
hold on;
for i = 1:nplot
if (xxmax(iplot(i)) == 0); xxmax(iplot(i)) = 1; end
plot(t, (xx(1:length(t),iplot(i))/xxmax(iplot(i))) + yshift(i), 'k');
leftlabel = sprintf('%g', round(dist(iplot(i))));
% Text labels for plot
str1 = sensor(iplot(i), :);
str2 = sprintf('%7.2e', (xxmax(iplot(i))));
if (xxmax(iplot(i))) < 0.0001
str2 = sprintf('%4.1fE-6', (1E6 * xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.001
str2 = sprintf('%4.2fE-3', (1E3 * xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.01
str2 = sprintf('%4.1fE-3', (1E3 * xxmax(iplot(i))));
elseif (xxmax(iplot(i))) < 0.1
str2 = sprintf('%4.1fE-3', (1E3 * xxmax(iplot(i))));
else
str2 = sprintf('%4.1fE-3', (1E3 * xxmax(iplot(i))));
end %text loop
str2=sprintf('%4.2f',(xxmax(iplot(i))));
elseif (xxmax(iplot(i))) > 1000.0
str2=sprintf('%4.1fk',( xxmax(iplot(i))/1000 ));
else
str2=sprintf('%4.1f',(xxmax(iplot(i))));
end %text loop
str3 = char(str1);
str4 = char(str3 , str2);
str5 = cellstr(str4);
text(tendpanel3+0.02,[yshift(i)],str5,'FontSize',8,...
'HorizontalAlignment','left');
% Write title for right panel
if(i==nplot)
text(tstartpanel3+0.05,yshift(i)+1.1,'Pressure Sensors',...
'VerticalAlignment','bottom');
end
end %plot loop i=1:nplot %Right (3rd) panel of plot -----------

% Title for entire plot ---------------------------------------
if(sourcesize~=0) %C-4 shot
plottitle = ...
  sprintf('TX02 -- %s Rec %g -- %s %3.1f kg %s %3.1f m agl -- %3.0f-%3.0f m',...
  fname,shotnum,srcloc,sourcesize*1.25/2.2,sourcetype,srcz,min(dist),max(dist));
else %not C-4 shot
plottitle = ...
  sprintf('TX02 -- Record %g -- %s %s %3.1f m -- %3.0f-%3.0f m',...
  shotnum,srcloc,sourcetype,srcz,min(dist),max(dist));
end

ax=axes('Units','Normal','Position',[0.075 0.075 0.85 0.85],...
'Visible','of');
set(get(ax,'Title'),'Visible','on');
title(plottitle,'FontSize',18,'FontWeight','Bold');

set(gcf,'PaperUnits','inches');
set(gcf,'PaperPosition',[0.5,0.25,10,7]);
set(gcf,'PaperOrientation','landscape');
return
# Short-range Seismic and Acoustic Signature Measurements Through Forests

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**14. ABSTRACT**
The effect of forests on low frequency military noise propagation is unknown. As part of a joint project, ERDC-CERL and ERDC CRREL conducted measurements at the Lone Star Army Ammunition Plant located in Texarkana, Texas, to investigate these effects. In this report, the short-range measurements conducted by ERDC-CRREL are documented. Blast noise waveforms produced by C4 explosions at distances from 30 to 567 m were recorded and are presented in this report. In all, 42 different explosions were recorded, producing 314 high quality pressure waveforms for analysis. Additional reports documenting the long-range measurements and analyzing the recorded data are in preparation.

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