# FRONTIER GEOSCIENCES INC.

DOWNHOLE SEISMIC SURVEY REPORT

GROUNDBIRCH AREA

DAWSON CREEK, B.C.

Submitted to:

Geoscience BC

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Project: FGI-1482

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Table of Contents



Table of Appendices

## 1. Introduction

In the period of March 6 to March 9, 2017, Frontier Geosciences Inc. carried out a downhole seismic survey for Geoscience BC in the Groundbirch area Dawson Creek, B.C. The site area is located approximately 45 km west of Dawson Creek, B.C. A Survey Location Plan of the area is shown at a scale of 1:500,000 in Figure 1 in the Appendix.

The purpose of the survey was to determine shear and compressional wave velocities of discrete layers intersected in the drillholes. In all, six downhole surveys were completed, with five drillholes located south of Highway 97 and one drillhole located north of Highway 97. A Site Plan of the survey area is presented at 1:50,000 scale in Figure 2 in the Appendix.

*Downhole Seismic Set Up*

## 2. The Downhole Seismic Survey

### 2.1 Survey Equipment

The downhole seismic survey was carried out with a Geometrics, Geode, 24 channel, signal enhancement seismograph which was also used for digital storage of the data. The receiver employed was an Oyo-Geospace, GS-20DX, 8 Hz, triaxial, downhole, geophone package. The vertically oriented element is optimal for recording the down-going, vertically polarized compressional wave generated at the ground surface. The two orthogonal horizontal geophones in the package are optimal for recording the down-going horizontally-polarised shear wave generated at the ground surface. The geophone package was held against the casing wall by a spring steel carrier which was acoustically decoupled from the suspending cable and the weight, that draws the carrier down the drillhole.

The shear wave source was a large wooden beam approximately two metres in length, which was secured against the ground surface for good shear wave transmission. Force was applied to both ends of the beam with a sledge hammer to provide both positive and negative wave directions. The compressional wave source was a steel plate on the ground surface with a sledge hammer. In both the shear wave and the compressional wave surveys, an electric circuit was switched-closed with the impact of the sledgehammer to trigger the record and provide accurate zero times.

### 2.2 Survey Procedure

Field procedure consisted of lowering the geophone package to the measuring point in the hole and ensuring firm coupling of the geophones to the drillhole wall. The hole was tested every 0.5 in the upper 30 metres and every 1 metres below. The secured wood beam was struck horizontally from one end with the sledge hammer to produce a shock wave rich in shear wave energy. The horizontal geophones in the downhole triaxial package are sensitive to horizontally-polarised shear wave arrivals. After recording of the first impact, the source beam was struck horizontally from the opposite end. The shear wave recorded downhole from the second impact produced an opposite polarity to the initial impact. By recording impacts from each end at every depth location, oppositely polarised shear waves were plotted to optimise the arrival times of the horizontal shear waves.

A compressional wave was also produced by striking the steel impact plate with the hammer. This produced a well-defined compressional wave from the point of impact that penetrated the depth of the holes. This compressional wave was recorded by the vertical geophone in the triaxial packages.

*Downhole Seismic Set Up*

### 2.3 Data Post-Processing Procedure

Initial analysis of the shear wave downhole data was conducted on site directly after data acquisition. Observations were made to ensure data quality and validity. Following data acquisition, the overlapping traces from each of the opposite direction blows for each depth station were plotted on a single baseline. This enabled recognition of the phase of the arrival from one depth station to the next. Initial monitoring and analysis of the compressional wave downhole data was also conducted on site to confirm data quality and validity.

The picking of the first arrival times involved identification of the shear wave break on the basis of polarity, increase in amplitude and abrupt change in frequency. An evaluation of the location or first break was made on the location of the departure from the baseline of the oppositely polarized data. This was also facilitated by comparison with data recorded both above and below the data point and by knowledge that arrival times must increase with depth. The same procedure was followed for the picking of the first arrivals of the compressional wave with the exception of polarity change. The data was slope-corrected to correct for the source offset distances and converted to true vertical depths.

### 2.4 Data Interpretation Procedure

The downhole seismic traces are plotted as a function of time and depth. The data are then analyzed to identify the compressional and shear wave velocities over various ranges in depth, as indicated by the variation in the arrival times of the data. This approach better reflects the resolution of the downhole method, than the approach of picking each arrival time individually, and calculating an interval velocity.

# 3. Geophysical Results

## 3.1 General

Six drillholes were surveyed, with the interpreted compressional (P) and shear (S) wave velocities shown at a vertical scale of 1:400 in Figures 3 to 8 in the Appendix. Next to the seismic data is an abbreviated geological log noting significant changes in lithology. All the results show an increase in both compressional and shear wave velocities with depth. The boreholes were surveyed to depths ranging from 30 m to 146.3 metres.

## 3.2 Discussion

Drillhole GB15-01 was surveyed to a depth of 111.25 metres. A compressional wave velocity of 650 m/s was determined for the upper 3 metres which is consistent with loose silt, sand and clay. Between the depth of 3 m and 97.3 m a compressional wave velocity of 1700 m/s can be directly correlated with drillhole intersections of dense, possibly wet to saturated sand, gravel, diamicton and fractured and weathered mudstone. From 97.3 m to the end of the survey the P-wave velocity of 2100 m/s indicates a less fractured mudstone.

The shear wave velocities increase in the upper 25 m from 230 m/s to 300 m/s which is consistent with stiff soils like silt clay and sand. Between 25 m and 62 m the shear wave velocities increase significantly to 685 m/s and to 830 m/s in the depth range from 62.2m to 84.2m. These shear wave velocities are indicative of very dense soils like sand, gravel and diamicton. From 84.2 m to the end of the survey the shear wave velocity reaches 1100 m/s which is consistent with the drill log intersection of fractured mudstone.

Drillhole GB15-02 was surveyed to a depth of 146.3 metres. The compressional wave velocity of 675 m/s in the upper 3.3 m is consistent with loose organic soils and soft clay. The compressional wave velocities increase from 1445 m/s between 3.3 m and 8.8 m to 1740 m/s between 37.3 m and the end of the hole. These higher velocities are consistent with more compact, moist to saturated sand, gravel and silty sand.

The shear wave velocities between the top of the hole and a depth of 9.8 metres vary from 130 m/s to 170 m/s. These velocities are consistent with soft soil materials and clay. Between 9.8 m and 49.3 m depth the shear wave velocities increase from 225 m/s to 260 m/s which is consistent with stiff clay and sand. From 49.3 m depth to 107.3 m depth the shear wave velocity increases to 420 m/s and reaches 435 m/s between 107.3 m depth and the end of the survey. These shear wave velocities are indicative of very dense sand and gravel and silty sand.

Drillhole GB15-03 was surveyed to a depth of 68.1 metres. The compressional wave velocities in the upper 5.6 m range from 510 m/s to 1100 m/s which is consistent with loose, moist silt and clay. Between 5.6 m and 52.1 m a compressional wave velocity of 1630 m/s can be directly correlated with drillhole intersections of more compact, moist to wet silt, clay, sand and silty diamicton. Between 52.1 m and the end of the hole the determined compressional wave velocity of 2200 m/s is consistent with the intersection of shale and mudstone.

The shear wave velocity of 155 m/s in the upper 6.6 m is consistent with soft soil materials like organics, silt and clay. Between 6.6 m and 12.6 m the shear wave velocity increases to 285 m/s and to 350 m/s between 12.6 m and 36.1 m, depth which is indicative of stiff soil materials like silt and clay. A shear wave velocity of 550 m/s, determined for the depth interval of 36.1 m to 56.1 m indicates the presence of very dense silty diamicton and soft and fractured shale and mudstone. A maximum shear wave velocity of 850 m/s is evident at the bottom of the drillhole and is consistent with soft to hard shale and mudstone.

Drillhole GB15-04 was surveyed to a depth of 65.2 m. The compressional wave velocity of 885 m/s in the upper 4.3 metres is consistent with loose to more compact organic soil and silt and clay. Between 4.3 m and the end of the hole the compressional wave velocity increases from 1650 m/s to 1850 m/s which can be directly correlated to drillhole intersections moist to wet, soft to very dense clay, sand and silty diamicton. The shear wave velocity increases from 190 m/s in the upper 3.3 m to 300 m/s between 15.3 m and 26.2 m depth. This velocity range is indicative of soft to stiff clay, silt and sand. Between 26.2 m and 47.2 m the shear wave velocity ranges from 500 m/s to 580 m/s which is consistent with intersections of moderately to very dense silty diamicton. A maximum shear wave velocity of 740 m/s is evident between 47.2 m depth and the end of the hole and is consistent with very dense silty diamicton and pebble and gravel.

Drillhole GB15-04 was surveyed to a depth of 98.3 metres. In the upper 7.2 m the compressional wave velocities range from 445 m/s to 1200 m/s is consistent with drillhole intersections of dry silt and clay. Below 7.2 m the compressional wave velocity increases to 1700 m/s which correlates with dry to wet, very compact sand, silt and clay. The shear wave velocity increases at a depth of 6.9 m from 180 m/s to 245 m/s. This velocity range is consistent with soft to stiff silt and clay. Between 30.3 m and 47.3 m depth the shear wave increases to 350 m/s which is indicative of dense sand, silt and pebbles. Below a depth of 47.3 m the shear wave velocity reaches a maximum value of 415 m/s which is consistent with intersections of dense to very dense silt, sand and clay.

Drillhole GB12-02 is the only surveyed drillhole which is located north of Highway 97. The survey depth was 30 m. The compressional wave velocity in the upper 6 metres ranges from 800 m/s to 1150 m/s which is indicative of more compact sand and gravel. Below 6 m the compressional wave velocity increases to 2000 m/s which is indicative of a weak, highly fractured or weathered sandstone. The shear wave velocity of 410 m/s between the top and 3.5 m is consistent with clay with rocks. Between 3.5 m and 7.5 m the shear wave velocity increases to 730 m/s which is consistent with the intersection of soft sandstone. The shear wave velocity further increases to from 860 m/s to 1095 m/s in the depth range of 7.5 m and 30 m. This velocity range can be correlated to weak, highly fractured or weathered sandstone.

## 4. Limitations

In downhole surveys, individual values taken at discrete depth points may precede or lag the anticipated arrival due to 'zero time', timing errors in the circuitry. These errors are generally quite small and average velocities taken over a broader zone are good representations of in situ shear wave and compressional wave velocities in a layer. The downhole results are interpretive in nature and are considered to be a reasonably accurate representation of existing subsurface conditions within the limitations of the seismic downhole method.

The downhole seismic information in this report is based on measurements obtained by generally accepted methods and procedures and our interpretation of the data. Individual values may in some instances be erroneous due to noise occurring simultaneously with the measurements.

Downhole shear (S) and compressional (P) wave logging is generally carried out with the shear and compressional wave energy sources located in close proximity to the drillhole collar. This proximity eliminates offset errors with small offset corrections applied to near-surface triaxial geophone locations and virtually no offset corrections applied to deep, triaxial receiver locations.

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| *Table 1: GB15-01* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 1.25 | 4.38 | 1.92 |
| 1.75 | 6.48 | 2.73 |
| 2.25 | 8.59 | 3.5 |
| 2.75 | 10.83 | 4.27 |
| 3.25 | 13.06 | 5.01 |
| 3.75 | 15.37 | 5.63 |
| 4.25 | 17.67 | 6.23 |
| 4.75 | 19.86 | 6.49 |
| 5.25 | 22.02 | 6.74 |
| 5.75 | 24.17 | 7.01 |
| 6.25 | 26.31 | 7.29 |
| 6.75 | 28.62 | 7.6 |
| 7.25 | 30.92 | 7.92 |
| 7.75 | 33.1 | 8.23 |
| 8.25 | 35.27 | 8.53 |
| 8.75 | 37.33 | 8.84 |
| 9.25 | 39.38 | 9.14 |
| 9.75 | 41.45 | 9.45 |
| 10.25 | 43.52 | 9.75 |
| 10.75 | 45.9 | 10.05 |
| 11.25 | 48.29 | 10.35 |
| 11.75 | 50.44 | 10.65 |
| 12.25 | 52.56 | 10.96 |
| 12.75 | 54.51 | 11.26 |
| 13.25 | 56.56 | 11.56 |
| 13.75 | 58.61 | 11.86 |
| 14.25 | 60.66 | 12.16 |
| 14.75 | 62.29 | 12.46 |
| 15.25 | 63.93 | 12.72 |
| 15.75 | 65.64 | 13.01 |
| 16.25 | 67.35 | 13.31 |
| 16.75 | 68.89 | 13.63 |
| 17.25 | 70.42 | 13.96 |
| 17.75 | 72.4 | 14.23 |
| 18.25 | 74.39 | 14.49 |
| 18.75 | 76.08 | 14.78 |
| 19.25 | 77.77 | 15.06 |
| 19.75 | 79.46 | 15.36 |

| *Table 1: GB15-01* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 20.25 | 81.14 | 15.67 |
| 20.75 | 82.83 | 15.97 |
| 21.25 | 84.52 | 16.26 |
| 21.75 | 86.21 | 16.56 |
| 22.25 | 87.89 | 16.87 |
| 22.75 | 89.31 | 17.17 |
| 23.25 | 90.72 | 17.47 |
| 23.75 | 92.43 | 17.77 |
| 24.25 | 94.14 | 18.07 |
| 24.75 | 95.66 | 18.37 |
| 25.25 | 97.18 | 18.67 |
| 25.75 | 98.47 | 18.96 |
| 26.25 | 99.2 | 19.26 |
| 26.75 | 99.89 | 19.56 |
| 27.25 | 100.57 | 19.85 |
| 27.75 | 101.2 | 20.16 |
| 28.25 | 101.82 | 20.46 |
| 28.75 | 102.45 | 20.75 |
| 29.25 | 103.08 | 21.06 |
| 30.25 | 104.47 | 21.63 |
| 31.25 | 105.73 | 22.15 |
| 32.25 | 107.17 | 22.79 |
| 33.25 | 108.48 | 23.36 |
| 34.25 | 109.79 | 23.98 |
| 35.25 | 111.17 | 24.56 |
| 36.25 | 112.56 | 25.17 |
| 37.25 | 113.79 | 25.69 |
| 38.25 | 115.33 | 26.32 |
| 39.25 | 116.87 | 26.9 |
| 40.25 | 118.41 | 27.48 |
| 41.25 | 119.95 | 28.09 |
| 42.25 | 121.48 | 28.66 |
| 43.25 | 123.02 | 29.23 |
| 44.25 | 124.56 | 29.82 |
| 45.25 | 126.09 | 30.34 |
| 46.25 | 127.63 | 30.97 |
| 47.25 | 128.96 | 31.58 |
| 48.25 | 130.49 | 32.19 |

*Table 1: GB15-01*

| Depth (m) | S-Wave (ms) | P-Wave (ms) |
|---|---|---|
| 49.25 | 132.03 | 32.77 |
| 50.25 | 133.56 | 33.35 |
| 51.25 | 135.1 | 33.87 |
| 52.25 | 136.63 | 34.48 |
| 53.25 | 138.17 | 35 |
| 54.25 | 139.7 | 35.61 |
| 55.25 | 141.23 | 36.24 |
| 56.25 | 142.77 | 36.85 |
| 57.25 | 144.3 | 37.37 |
| 58.25 | 145.84 | 37.96 |
| 59.25 | 147.37 | 38.59 |
| 60.25 | 148.9 | 39.01 |
| 61.25 | 150.44 | 39.64 |
| 62.25 | 152.24 | 40.25 |
| 63.25 | 153.67 | 40.83 |
| 64.25 | 154.88 | 41.44 |
| 65.25 | 156.1 | 42.05 |
| 66.25 | 157.31 | 42.66 |
| 67.25 | 158.53 | 43.18 |
| 68.25 | 159.74 | 43.7 |
| 69.25 | 160.95 | 44.22 |
| 70.25 | 162.17 | 44.85 |
| 71.25 | 163.38 | 45.47 |
| 72.25 | 164.6 | 45.98 |
| 73.25 | 165.81 | 46.57 |
| 74.25 | 167.02 | 47.15 |
| 75.25 | 168.24 | 47.75 |
| 76.25 | 169.45 | 48.36 |
| 77.25 | 170.67 | 48.95 |
| 78.25 | 171.88 | 49.55 |
| 79.25 | 173.09 | 50.14 |
| 80.25 | 174.31 | 50.74 |
| 81.25 | 175.52 | 51.32 |
| 82.25 | 176.73 | 51.9 |
| 83.25 | 177.95 | 52.5 |
| 84.25 | 179.17 | 53.08 |
| 85.25 | 179.77 | 53.67 |
| 86.25 | 180.68 | 54.26 |

*Table 1: GB15-01*

| Depth (m) | S-Wave (ms) | P-Wave (ms) |
|---|---|---|
| 87.25 | 181.58 | 54.86 |
| 88.25 | 182.49 | 55.44 |
| 89.25 | 183.39 | 56.04 |
| 90.25 | 184.15 | 56.63 |
| 91.25 | 184.96 | 57.23 |
| 92.25 | 185.77 | 57.83 |
| 93.25 | 186.59 | 58.44 |
| 94.25 | 187.4 | 59.02 |
| 95.25 | 188.21 | 59.65 |
| 96.25 | 189.02 | 60.23 |
| 97.25 | 189.84 | 60.89 |
| 98.25 | 190.65 | 61.4 |
| 99.25 | 191.46 | 61.92 |
| 100.25 | 192.27 | 62.44 |
| 101.25 | 193.08 | 62.95 |
| 102.25 | 193.95 | 63.47 |
| 103.25 | 194.88 | 63.98 |
| 104.25 | 195.74 | 64.49 |
| 105.25 | 196.59 | 64.99 |
| 106.25 | 197.45 | 65.49 |
| 107.25 | 198.22 | 66 |
| 108.25 | 198.99 | 66.51 |
| 109.25 | 199.81 | 67.01 |
| 110.25 | 200.66 | 67.53 |
| 111.25 | 201.52 | 68.04 |

| *Table 1: GB15-02* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 1.33 | 8.1 | 1.93 |
| 1.83 | 12.28 | 2.67 |
| 2.33 | 15.97 | 3.42 |
| 2.83 | 20.16 | 4.18 |
| 3.33 | 23.79 | 4.61 |
| 3.83 | 27.79 | 4.97 |
| 4.33 | 31.49 | 5.31 |
| 4.83 | 34.56 | 5.68 |
| 5.33 | 37.31 | 6.01 |
| 5.83 | 40.33 | 6.35 |
| 6.33 | 43.38 | 6.7 |
| 6.83 | 46.43 | 7.06 |
| 7.33 | 49.28 | 7.39 |
| 7.83 | 52.18 | 7.72 |
| 8.33 | 55.04 | 8.08 |
| 8.83 | 58.03 | 8.41 |
| 9.33 | 61.09 | 8.73 |
| 9.83 | 63.91 | 9.01 |
| 10.33 | 66.22 | 9.32 |
| 10.83 | 68.29 | 9.63 |
| 11.33 | 70.51 | 9.91 |
| 11.83 | 72.7 | 10.22 |
| 12.33 | 75.03 | 10.51 |
| 12.83 | 77.19 | 10.82 |
| 13.33 | 79.36 | 11.14 |
| 13.83 | 81.73 | 11.43 |
| 14.33 | 83.74 | 11.74 |
| 14.83 | 85.81 | 12.05 |
| 15.33 | 88.21 | 12.34 |
| 15.83 | 90.41 | 12.64 |
| 16.33 | 92.43 | 12.94 |
| 16.83 | 94.63 | 13.23 |
| 17.33 | 96.79 | 13.54 |
| 17.83 | 99.06 | 13.84 |
| 18.33 | 101.26 | 14.16 |
| 18.83 | 103.16 | 14.42 |
| 19.33 | 105.19 | 14.75 |
| 19.83 | 107.03 | 15.01 |

| *Table 1: GB15-02* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 20.33 | 108.75 | 15.32 |
| 20.83 | 110.87 | 15.64 |
| 21.33 | 112.74 | 15.94 |
| 21.83 | 114.43 | 16.2 |
| 22.33 | 116.41 | 16.5 |
| 22.83 | 118.28 | 16.82 |
| 23.33 | 120.19 | 17.11 |
| 23.83 | 122.15 | 17.44 |
| 24.33 | 123.97 | 17.74 |
| 24.83 | 125.85 | 18.02 |
| 25.33 | 128.02 | 18.34 |
| 25.83 | 129.8 | 18.62 |
| 26.33 | 131.79 | 18.94 |
| 26.83 | 133.57 | 19.23 |
| 27.33 | 135.52 | 19.53 |
| 27.83 | 137.47 | 19.79 |
| 28.33 | 139.3 | 20.11 |
| 28.83 | 141.25 | 20.4 |
| 29.33 | 143.08 | 20.71 |
| 30.33 | 146.83 | 21.33 |
| 31.33 | 150.62 | 21.91 |
| 32.33 | 154.52 | 22.54 |
| 33.33 | 158.36 | 23.15 |
| 34.33 | 162.33 | 23.73 |
| 35.33 | 166.26 | 24.34 |
| 36.33 | 169.83 | 24.91 |
| 37.33 | 173.81 | 25.52 |
| 38.33 | 177.64 | 26.11 |
| 39.33 | 181.55 | 26.7 |
| 40.33 | 185.11 | 27.21 |
| 41.33 | 188.94 | 27.78 |
| 42.33 | 192.8 | 28.38 |
| 43.33 | 196.63 | 28.95 |
| 44.33 | 200.61 | 29.51 |
| 45.33 | 204.4 | 30.08 |
| 46.33 | 208 | 30.67 |
| 47.33 | 212.03 | 31.24 |
| 48.33 | 215.76 | 31.79 |

| *Table 1: GB15-02* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 49.33 | 219.78 | 32.39 |
| 50.33 | 221.95 | 32.95 |
| 51.33 | 224.49 | 33.54 |
| 52.33 | 226.75 | 34.11 |
| 53.33 | 229.04 | 34.68 |
| 54.33 | 231.61 | 35.26 |
| 55.33 | 233.73 | 35.84 |
| 56.33 | 236.23 | 36.42 |
| 57.33 | 238.7 | 37.02 |
| 58.33 | 240.96 | 37.59 |
| 59.33 | 243.29 | 38.18 |
| 60.33 | 245.71 | 38.72 |
| 61.33 | 248.13 | 39.3 |
| 62.33 | 250.45 | 39.87 |
| 63.33 | 252.71 | 40.46 |
| 64.33 | 255.13 | 41.01 |
| 65.33 | 257.39 | 41.59 |
| 66.33 | 259.97 | 42.18 |
| 67.33 | 262.22 | 42.76 |
| 68.33 | 264.7 | 43.31 |
| 69.33 | 266.95 | 43.91 |
| 70.33 | 269.21 | 44.49 |
| 71.33 | 271.73 | 45.1 |
| 72.33 | 274.2 | 45.61 |
| 73.33 | 276.53 | 46.2 |
| 74.33 | 278.82 | 46.79 |
| 75.33 | 281.34 | 47.37 |
| 76.33 | 283.76 | 47.94 |
| 77.33 | 286.02 | 48.47 |
| 78.33 | 288.44 | 49.07 |
| 79.33 | 290.8 | 49.66 |
| 80.33 | 293.27 | 50.19 |
| 81.33 | 295.24 | 50.76 |
| 82.33 | 297.76 | 51.35 |
| 83.33 | 300.3 | 51.96 |
| 84.33 | 302.6 | 52.52 |
| 85.33 | 304.96 | 53.12 |
| 86.33 | 307.21 | 53.69 |

| *Table 1: GB15-02* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 87.33 | 309.71 | 54.28 |
| 88.33 | 312.04 | 54.81 |
| 89.33 | 314.43 | 55.41 |
| 90.33 | 316.85 | 55.97 |
| 91.33 | 319.29 | 56.55 |
| 92.33 | 321.51 | 57.14 |
| 93.33 | 323.98 | 57.72 |
| 94.33 | 326.3 | 58.3 |
| 95.33 | 328.7 | 58.86 |
| 96.33 | 331.06 | 59.45 |
| 97.33 | 333.39 | 60.03 |
| 98.33 | 335.81 | 60.6 |
| 99.33 | 338.28 | 61.15 |
| 100.33 | 340.64 | 61.69 |
| 101.33 | 343.03 | 62.31 |
| 102.33 | 345.56 | 62.85 |
| 103.33 | 347.87 | 63.45 |
| 104.33 | 350.16 | 64.05 |
| 105.33 | 352.49 | 64.61 |
| 106.33 | 354.85 | 65.16 |
| 107.33 | 357.18 | 65.75 |
| 108.33 | 359.55 | 66.35 |
| 109.33 | 361.93 | 66.93 |
| 110.33 | 364.38 | 67.52 |
| 111.33 | 366.59 | 68.08 |
| 112.33 | 368.94 | 68.64 |
| 113.33 | 371.29 | 69.23 |
| 114.33 | 373.57 | 69.8 |
| 115.33 | 375.92 | 70.38 |
| 116.33 | 378.1 | 70.95 |
| 117.33 | 380.48 | 71.53 |
| 118.33 | 382.9 | 72.11 |
| 119.33 | 385.19 | 72.69 |
| 120.33 | 387.56 | 73.27 |
| 121.33 | 389.85 | 73.85 |
| 122.33 | 391.99 | 74.39 |
| 123.33 | 394.28 | 74.99 |
| 124.33 | 396.73 | 75.59 |

| *Table 1: GB15-02* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 125.33 | 398.82 | 76.13 |
| 126.33 | 401.17 | 76.7 |
| 127.33 | 403.48 | 77.31 |
| 128.33 | 406.04 | 77.88 |
| 129.33 | 408.24 | 78.44 |
| 130.33 | 410.47 | 79.01 |
| 131.33 | 412.76 | 79.61 |
| 132.33 | 415.04 | 80.17 |
| 133.33 | 417.49 | 80.74 |
| 134.33 | 419.67 | 81.3 |
| 135.33 | 421.99 | 81.89 |
| 136.33 | 424.37 | 82.44 |
| 137.33 | 426.46 | 83.03 |
| 138.33 | 428.89 | 83.63 |
| 139.33 | 431.2 | 84.16 |
| 140.33 | 433.58 | 84.74 |
| 141.33 | 436 | 85.31 |
| 142.33 | 438.18 | 85.92 |
| 143.33 | 440.48 | 86.5 |
| 144.33 | 442.79 | 87.06 |
| 145.33 | 445.04 | 87.59 |
| 146.33 | 447.26 | 88.19 |

| *Table 1: GB15-03* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 1.1 | 6.88 | 1.8 |
| 1.6 | 10.35 | 2.69 |
| 2.1 | 13.73 | 3.6 |
| 2.6 | 17.08 | 4.48 |
| 3.1 | 20.25 | 4.96 |
| 3.6 | 23.41 | 5.42 |
| 4.1 | 26.43 | 5.83 |
| 4.6 | 29.2 | 6.27 |
| 5.1 | 31.92 | 6.71 |
| 5.6 | 35.18 | 7.13 |
| 6.1 | 37.95 | 7.46 |
| 6.6 | 41.18 | 7.78 |
| 7.1 | 42.73 | 8.11 |
| 7.6 | 44.62 | 8.42 |
| 8.1 | 46.24 | 8.74 |
| 8.6 | 47.85 | 9.05 |
| 9.1 | 49.71 | 9.36 |
| 9.6 | 51.57 | 9.67 |
| 10.1 | 53.5 | 9.98 |
| 10.6 | 55.32 | 10.28 |
| 11.1 | 57.13 | 10.59 |
| 11.6 | 58.48 | 10.89 |
| 12.1 | 59.94 | 11.2 |
| 12.6 | 61.86 | 11.5 |
| 13.1 | 63.55 | 11.8 |
| 13.6 | 65.13 | 12.1 |
| 14.1 | 66.59 | 12.4 |
| 14.6 | 68.04 | 12.7 |
| 15.1 | 69.39 | 12.99 |
| 15.6 | 70.65 | 13.32 |
| 16.1 | 72.13 | 13.62 |
| 16.6 | 73.67 | 13.95 |
| 17.1 | 75.2 | 14.22 |
| 17.6 | 76.82 | 14.5 |
| 18.1 | 78.3 | 14.8 |
| 18.6 | 79.96 | 15.1 |
| 19.1 | 81.3 | 15.42 |
| 19.6 | 82.78 | 15.68 |

| *Table 1: GB15-03* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 20.1 | 84.2 | 15.97 |
| 20.6 | 85.78 | 16.23 |
| 21.1 | 87.3 | 16.55 |
| 21.6 | 88.77 | 16.86 |
| 22.1 | 90.24 | 17.12 |
| 22.6 | 91.9 | 17.44 |
| 23.1 | 93.43 | 17.75 |
| 23.6 | 94.77 | 18.07 |
| 24.1 | 96.25 | 18.38 |
| 24.6 | 97.72 | 18.7 |
| 25.1 | 99.09 | 19.01 |
| 25.6 | 100.62 | 19.33 |
| 26.1 | 102.2 | 19.64 |
| 26.6 | 103.68 | 19.95 |
| 27.1 | 105.23 | 20.29 |
| 27.6 | 106.78 | 20.61 |
| 28.1 | 108.33 | 20.91 |
| 28.6 | 110.01 | 21.18 |
| 29.1 | 111.26 | 21.47 |
| 30.1 | 114.24 | 22.1 |
| 31.1 | 117.2 | 22.65 |
| 32.1 | 120.27 | 23.28 |
| 33.1 | 123.34 | 23.92 |
| 34.1 | 126.29 | 24.56 |
| 35.1 | 129.48 | 25.19 |
| 36.1 | 132.4 | 25.83 |
| 37.1 | 134.21 | 26.47 |
| 38.1 | 136.03 | 27.11 |
| 39.1 | 137.57 | 27.74 |
| 40.1 | 139.22 | 28.38 |
| 41.1 | 141 | 29.02 |
| 42.1 | 142.8 | 29.6 |
| 43.1 | 144.38 | 30.23 |
| 44.1 | 146.15 | 30.82 |
| 45.1 | 147.91 | 31.43 |
| 46.1 | 149.7 | 32.07 |
| 47.1 | 151.59 | 32.64 |
| 48.1 | 153.32 | 33.28 |

| *Table 1: GB15-03* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 49.1 | 155.06 | 33.89 |
| 50.1 | 156.59 | 34.42 |
| 51.1 | 158.3 | 35.06 |
| 52.1 | 159.88 | 35.64 |
| 53.1 | 161.72 | 36.09 |
| 54.1 | 163.53 | 36.55 |
| 55.1 | 165.06 | 37 |
| 56.1 | 166.6 | 37.46 |
| 57.1 | 167.83 | 37.91 |
| 58.1 | 169.13 | 38.37 |
| 59.1 | 170.36 | 38.82 |
| 60.1 | 171.67 | 39.28 |
| 61.1 | 172.89 | 39.73 |
| 62.1 | 173.8 | 40.19 |
| 63.1 | 175.07 | 40.64 |
| 64.1 | 176.3 | 41.1 |
| 65.1 | 177.55 | 41.54 |
| 66.1 | 178.75 | 42.02 |
| 67.1 | 179.93 | 42.44 |
| 68.1 | 181.19 | 42.97 |

| *Table 1: GB15-04* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 1.25 | 5.67 | 1.36 |
| 1.75 | 8.46 | 1.87 |
| 2.25 | 11.35 | 2.5 |
| 2.75 | 13.52 | 3.16 |
| 3.25 | 15.8 | 3.68 |
| 3.75 | 18.06 | 4.2 |
| 4.25 | 20.3 | 4.63 |
| 4.75 | 22.63 | 4.96 |
| 5.25 | 24.84 | 5.28 |
| 5.75 | 26.73 | 5.59 |
| 6.25 | 28.9 | 5.86 |
| 6.75 | 30.56 | 6.18 |
| 7.25 | 32.85 | 6.47 |
| 7.75 | 34.86 | 6.76 |
| 8.25 | 36.68 | 7.09 |
| 8.75 | 38.67 | 7.43 |
| 9.25 | 40.82 | 7.76 |
| 9.75 | 42.8 | 8.06 |
| 10.25 | 45.19 | 8.35 |
| 10.75 | 47.33 | 8.64 |
| 11.25 | 49.31 | 8.97 |
| 11.75 | 51.28 | 9.3 |
| 12.25 | 53.55 | 9.58 |
| 12.75 | 55.52 | 9.87 |
| 13.25 | 57.49 | 10.15 |
| 13.75 | 59.28 | 10.48 |
| 14.25 | 61.25 | 10.77 |
| 14.75 | 63.21 | 11.05 |
| 15.25 | 65.48 | 11.38 |
| 15.75 | 67.42 | 11.66 |
| 16.25 | 69.36 | 11.95 |
| 16.75 | 70.81 | 12.27 |
| 17.25 | 72.62 | 12.53 |
| 17.75 | 74.56 | 12.85 |
| 18.25 | 76.2 | 13.17 |
| 18.75 | 77.65 | 13.46 |
| 19.25 | 79.3 | 13.78 |
| 19.75 | 81.1 | 14.1 |

| *Table 1: GB15-04* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 20.25 | 82.9 | 14.37 |
| 20.75 | 84.49 | 14.69 |
| 21.25 | 86.3 | 15.03 |
| 21.75 | 88.19 | 15.34 |
| 22.25 | 89.93 | 15.64 |
| 22.75 | 91.15 | 15.95 |
| 23.25 | 92.84 | 16.27 |
| 23.75 | 94.74 | 16.54 |
| 24.25 | 96.54 | 16.86 |
| 24.75 | 97.98 | 17.15 |
| 25.25 | 99.78 | 17.44 |
| 25.75 | 101.72 | 17.74 |
| 26.25 | 103.52 | 18.05 |
| 26.75 | 104.46 | 18.35 |
| 27.25 | 105.4 | 18.64 |
| 27.75 | 106.35 | 18.93 |
| 28.25 | 107.29 | 19.26 |
| 28.75 | 108.23 | 19.57 |
| 29.25 | 109.07 | 19.86 |
| 30.25 | 111.18 | 20.51 |
| 31.25 | 113.06 | 21.12 |
| 32.25 | 115.04 | 21.75 |
| 33.25 | 117.27 | 22.38 |
| 34.25 | 119.15 | 22.96 |
| 35.25 | 120.92 | 23.52 |
| 36.25 | 122.69 | 24.03 |
| 37.25 | 124.46 | 24.57 |
| 38.25 | 126.23 | 25.11 |
| 39.25 | 127.99 | 25.65 |
| 40.25 | 129.76 | 26.24 |
| 41.25 | 131.53 | 26.78 |
| 42.25 | 133.3 | 27.35 |
| 43.25 | 134.8 | 27.89 |
| 44.25 | 136.62 | 28.47 |
| 45.25 | 138.49 | 29.01 |
| 46.25 | 139.99 | 29.55 |
| 47.25 | 141.73 | 30.09 |
| 48.25 | 143.25 | 30.63 |

| *Table 1: GB15-04* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 49.25 | 144.58 | 31.17 |
| 50.25 | 145.63 | 31.71 |
| 51.25 | 146.96 | 32.21 |
| 52.25 | 148.28 | 32.79 |
| 53.25 | 149.61 | 33.32 |
| 54.25 | 150.94 | 33.86 |
| 55.25 | 151.99 | 34.4 |
| 56.25 | 153.32 | 34.92 |
| 57.25 | 154.84 | 35.51 |
| 58.25 | 156.16 | 36.01 |
| 59.25 | 157.68 | 36.55 |
| 60.25 | 159 | 37.09 |
| 61.25 | 160.52 | 37.62 |
| 62.25 | 161.85 | 38.17 |
| 63.25 | 163.17 | 38.71 |
| 64.25 | 164.5 | 39.25 |
| 65.25 | 165.55 | 39.82 |

| *Table 1: GB15-05* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 1.32 | 4.91 | 2.97 |
| 1.82 | 7.68 | 4.22 |
| 2.32 | 10.63 | 5.32 |
| 2.82 | 13.49 | 6.33 |
| 3.32 | 16.34 | 6.93 |
| 3.82 | 19.04 | 7.51 |
| 4.32 | 21.48 | 7.98 |
| 4.82 | 24.52 | 8.39 |
| 5.32 | 27.3 | 8.77 |
| 5.82 | 29.44 | 9.26 |
| 6.32 | 32.19 | 9.7 |
| 6.82 | 35.2 | 10.11 |
| 7.32 | 37.56 | 10.61 |
| 7.82 | 39.57 | 10.92 |
| 8.32 | 41.65 | 11.21 |
| 8.82 | 43.62 | 11.49 |
| 9.32 | 45.78 | 11.82 |
| 9.82 | 48.11 | 12.14 |
| 10.32 | 50.38 | 12.45 |
| 10.82 | 52.43 | 12.77 |
| 11.32 | 54.39 | 13.07 |
| 11.82 | 56.59 | 13.38 |
| 12.32 | 58.45 | 13.69 |
| 12.82 | 60.4 | 14 |
| 13.32 | 62.43 | 14.3 |
| 13.82 | 64.55 | 14.6 |
| 14.32 | 66.66 | 14.91 |
| 14.82 | 68.6 | 15.21 |
| 15.32 | 70.65 | 15.51 |
| 15.82 | 72.95 | 15.81 |
| 16.32 | 75.04 | 16.11 |
| 16.82 | 77.22 | 16.4 |
| 17.32 | 79.32 | 16.69 |
| 17.82 | 81.06 | 16.99 |
| 18.32 | 82.89 | 17.28 |
| 18.82 | 84.73 | 17.58 |
| 19.32 | 87.04 | 17.88 |
| 19.82 | 89.06 | 18.18 |

| *Table 1: GB15-05* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 20.32 | 91.32 | 18.47 |
| 20.82 | 93.24 | 18.76 |
| 21.32 | 95.49 | 19.05 |
| 21.82 | 97.32 | 19.34 |
| 22.32 | 99.42 | 19.63 |
| 22.82 | 101.52 | 19.93 |
| 23.32 | 103.53 | 20.22 |
| 23.82 | 105.36 | 20.52 |
| 24.32 | 107.51 | 20.8 |
| 24.82 | 109.63 | 21.09 |
| 25.32 | 111.73 | 21.38 |
| 25.82 | 113.74 | 21.68 |
| 26.32 | 115.35 | 21.98 |
| 26.82 | 117.27 | 22.27 |
| 27.32 | 118.88 | 22.56 |
| 27.82 | 121.06 | 22.86 |
| 28.32 | 122.64 | 23.14 |
| 28.82 | 124.74 | 23.45 |
| 29.32 | 126.98 | 23.73 |
| 30.32 | 131.17 | 24.35 |
| 31.32 | 134.43 | 24.96 |
| 32.32 | 137.15 | 25.57 |
| 33.32 | 139.79 | 26.13 |
| 34.32 | 142.7 | 26.68 |
| 35.32 | 145.91 | 27.22 |
| 36.32 | 148.49 | 27.79 |
| 37.32 | 151.19 | 28.38 |
| 38.32 | 154.15 | 28.94 |
| 39.32 | 156.93 | 29.58 |
| 40.32 | 159.93 | 30.15 |
| 41.32 | 162.71 | 30.75 |
| 42.32 | 165.66 | 31.28 |
| 43.32 | 168.57 | 31.89 |
| 44.32 | 171.87 | 32.5 |
| 45.32 | 174.49 | 33.07 |
| 46.32 | 177.03 | 33.66 |
| 47.32 | 179.61 | 34.28 |
| 48.32 | 182.06 | 34.88 |

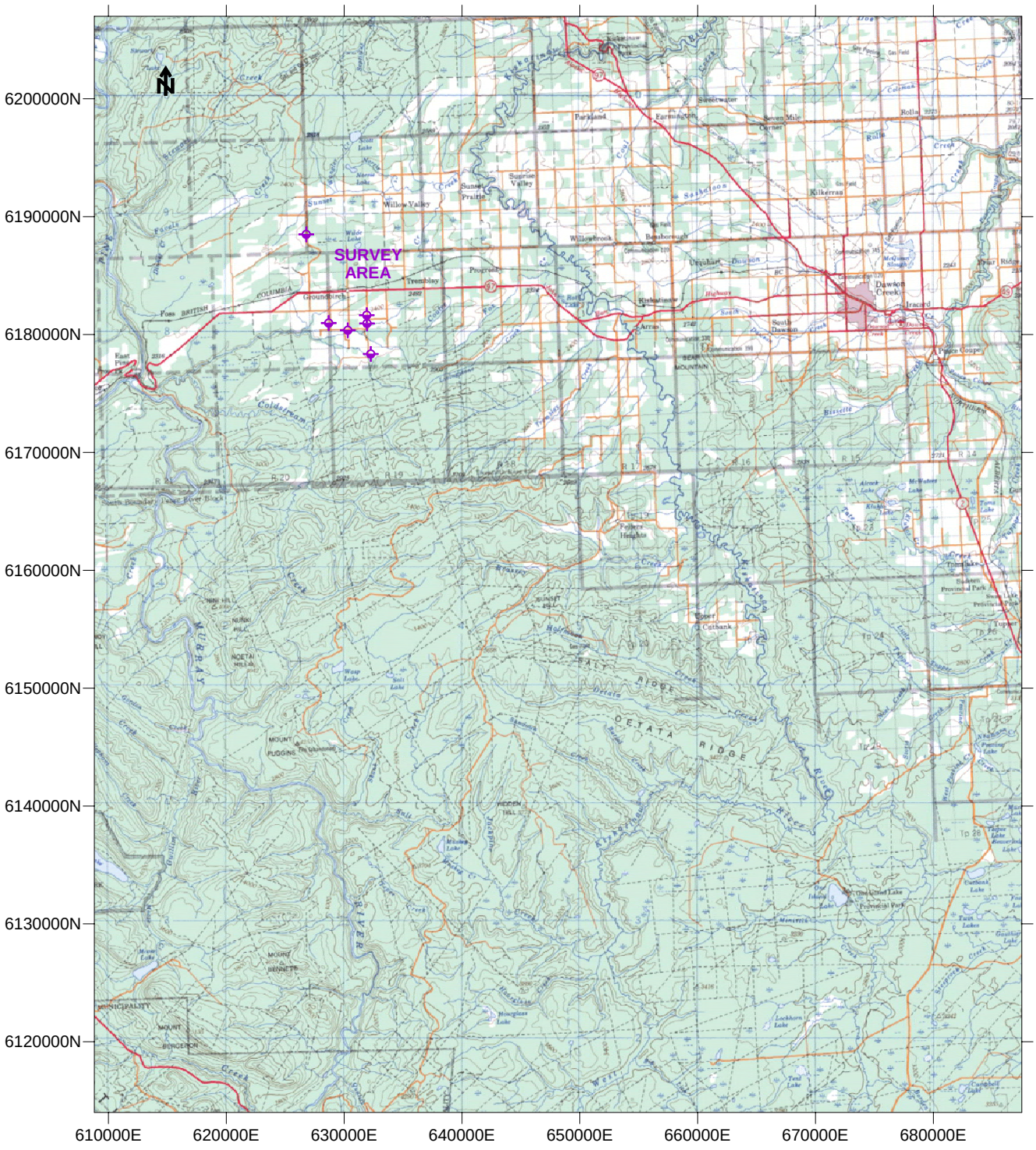
| *Table 1: GB15-05* | | |
|---|---|---|
| Depth (m) | S-Wave (ms) | P-Wave (ms) |
| 49.32 | 184.18 | 35.43 |
| 50.32 | 186.58 | 35.98 |
| 51.32 | 188.96 | 36.61 |
| 52.32 | 191.13 | 37.2 |
| 53.32 | 193.83 | 37.74 |
| 54.32 | 196.21 | 38.35 |
| 55.32 | 198.54 | 38.95 |
| 56.32 | 200.99 | 39.57 |
| 57.32 | 203.24 | 40.14 |
| 58.32 | 205.99 | 40.73 |
| 59.32 | 208.43 | 41.34 |
| 60.32 | 210.88 | 41.92 |
| 61.32 | 213.13 | 42.5 |
| 62.32 | 215.67 | 43.04 |
| 63.32 | 218.06 | 43.64 |
| 64.32 | 220.11 | 44.26 |
| 65.32 | 222.15 | 44.82 |

*Table 1: GB15-06*

| Depth (m) | S-Wave (ms) | P-Wave (ms) |
|---|---|---|
| 1.5 | 3.79 | 2.12 |
| 2.0 | 5.13 | 2.78 |
| 2.5 | 6.25 | 3.56 |
| 3.0 | 7.33 | 4.04 |
| 3.5 | 8.37 | 4.53 |
| 4.0 | 9.03 | 5.01 |
| 4.5 | 9.74 | 5.4 |
| 5.0 | 10.36 | 5.86 |
| 5.5 | 11.09 | 6.32 |
| 6.0 | 11.75 | 6.68 |
| 6.5 | 12.37 | 6.93 |
| 7.0 | 13.1 | 7.18 |
| 7.5 | 13.74 | 7.44 |
| 8.0 | 14.37 | 7.69 |
| 8.5 | 14.99 | 7.96 |
| 9.0 | 15.6 | 8.23 |
| 9.5 | 16.2 | 8.49 |
| 10.0 | 16.8 | 8.76 |
| 10.5 | 17.4 | 9.02 |
| 11.0 | 17.98 | 9.28 |
| 11.5 | 18.57 | 9.54 |
| 12.0 | 19.15 | 9.8 |
| 12.5 | 19.73 | 10.07 |
| 13.0 | 20.31 | 10.33 |
| 13.5 | 20.89 | 10.58 |
| 14.0 | 21.46 | 10.84 |
| 14.5 | 22.04 | 11.1 |
| 15.0 | 22.61 | 11.36 |
| 15.5 | 23.18 | 11.62 |
| 16.0 | 23.75 | 11.88 |
| 16.5 | 24.32 | 12.13 |
| 17.0 | 24.88 | 12.39 |
| 17.5 | 25.45 | 12.65 |
| 18.0 | 26.01 | 12.91 |
| 18.5 | 26.58 | 13.16 |
| 19.0 | 27.14 | 13.42 |
| 19.5 | 27.71 | 13.68 |
| 20.0 | 28.16 | 13.93 |

*Table 1: GB15-06*

| Depth (m) | S-Wave (ms) | P-Wave (ms) |
|---|---|---|
| 20.5 | 28.61 | 14.19 |
| 21.0 | 29.06 | 14.45 |
| 21.5 | 29.48 | 14.7 |
| 22.0 | 29.93 | 14.96 |
| 22.5 | 30.4 | 15.21 |
| 23.0 | 30.88 | 15.47 |
| 23.5 | 31.3 | 15.73 |
| 24.0 | 31.72 | 15.98 |
| 24.5 | 32.21 | 16.24 |
| 25.0 | 32.66 | 16.49 |
| 25.5 | 33.14 | 16.75 |
| 26.0 | 33.59 | 17.01 |
| 26.5 | 34.01 | 17.26 |
| 27.0 | 34.48 | 17.52 |
| 27.5 | 34.91 | 17.77 |
| 28.0 | 35.35 | 18.03 |
| 28.5 | 35.82 | 18.26 |
| 29.0 | 36.29 | 18.54 |
| 29.5 | 36.76 | 18.83 |
| 30.0 | 37.22 | 19.06 |




0 5 10 15 20

KILOMETRES

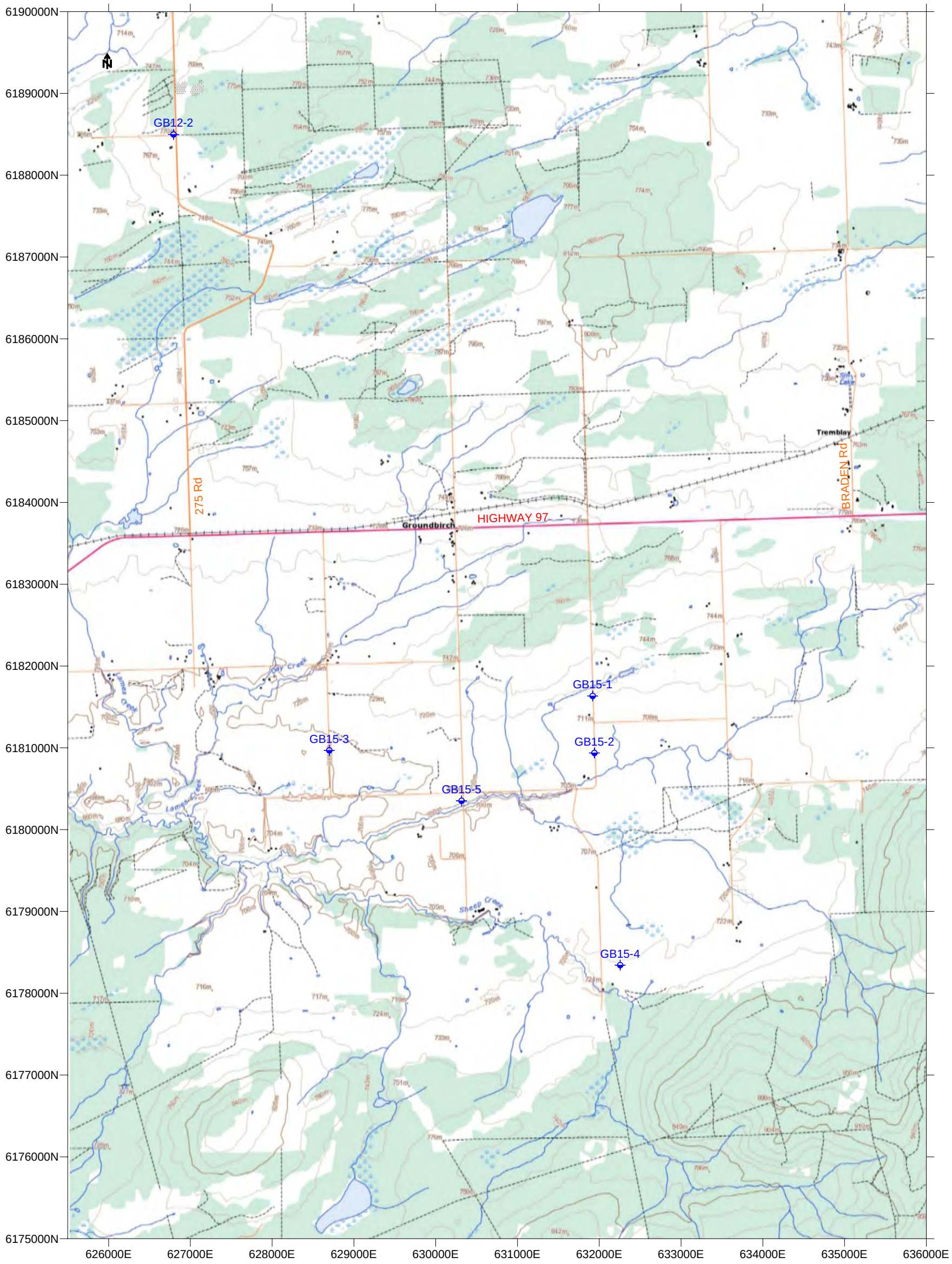
GEOSCIENCE BC
DAWSON CREEK, BC

DOWNHOLE SEISMIC SURVEY

# SURVEY LOCATION PLAN

FRONTIER GEOSCIENCES INC.

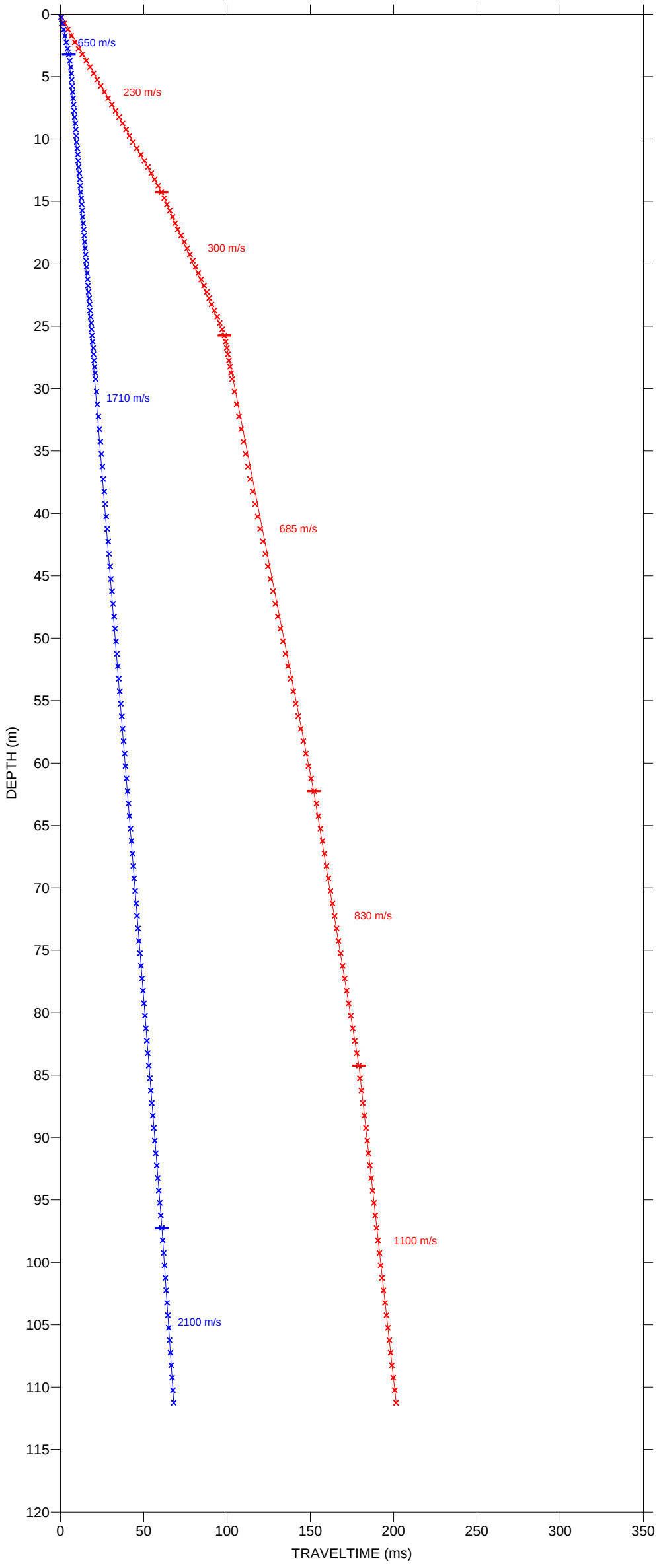
| DATE: MARCH 2017 | SCALE 1:500,000 | FIG. 1 |
|---|---|---|

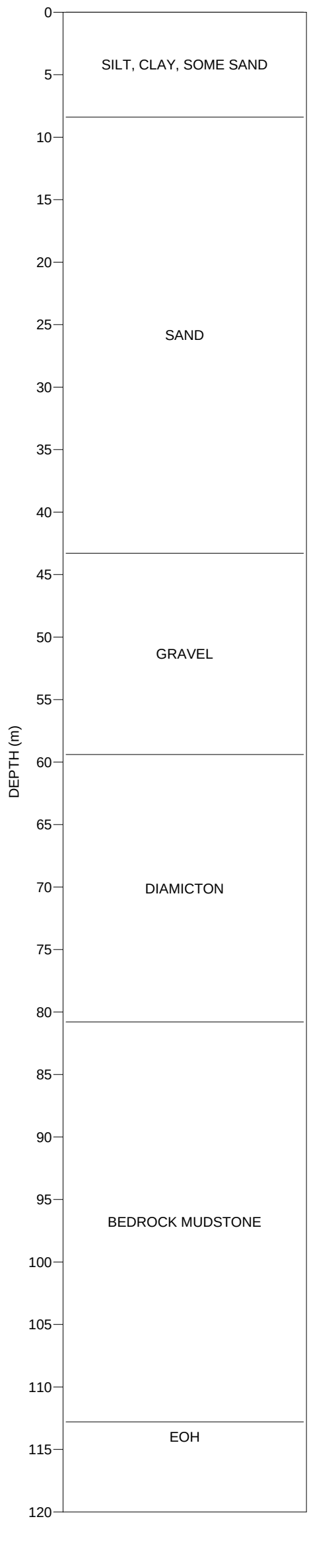



0 0.5 1 1.5 2

KILOMETRES

| | | |
|---|---|---|
| GEOSCIENCE BC<br>DAWSON CREEK, BC | | |
| DOWNHOLE SEISMIC SURVEY | | |
| SITE PLAN | | |
| FRONTIER GEOSCIENCES INC. | | |
| DATE: MARCH 2017 | SCALE 1:50,000 | FIG. 2 |




LEGEND

- DATA POINTS
- VELOCITY CHANGE
- P-WAVE
- S-WAVE

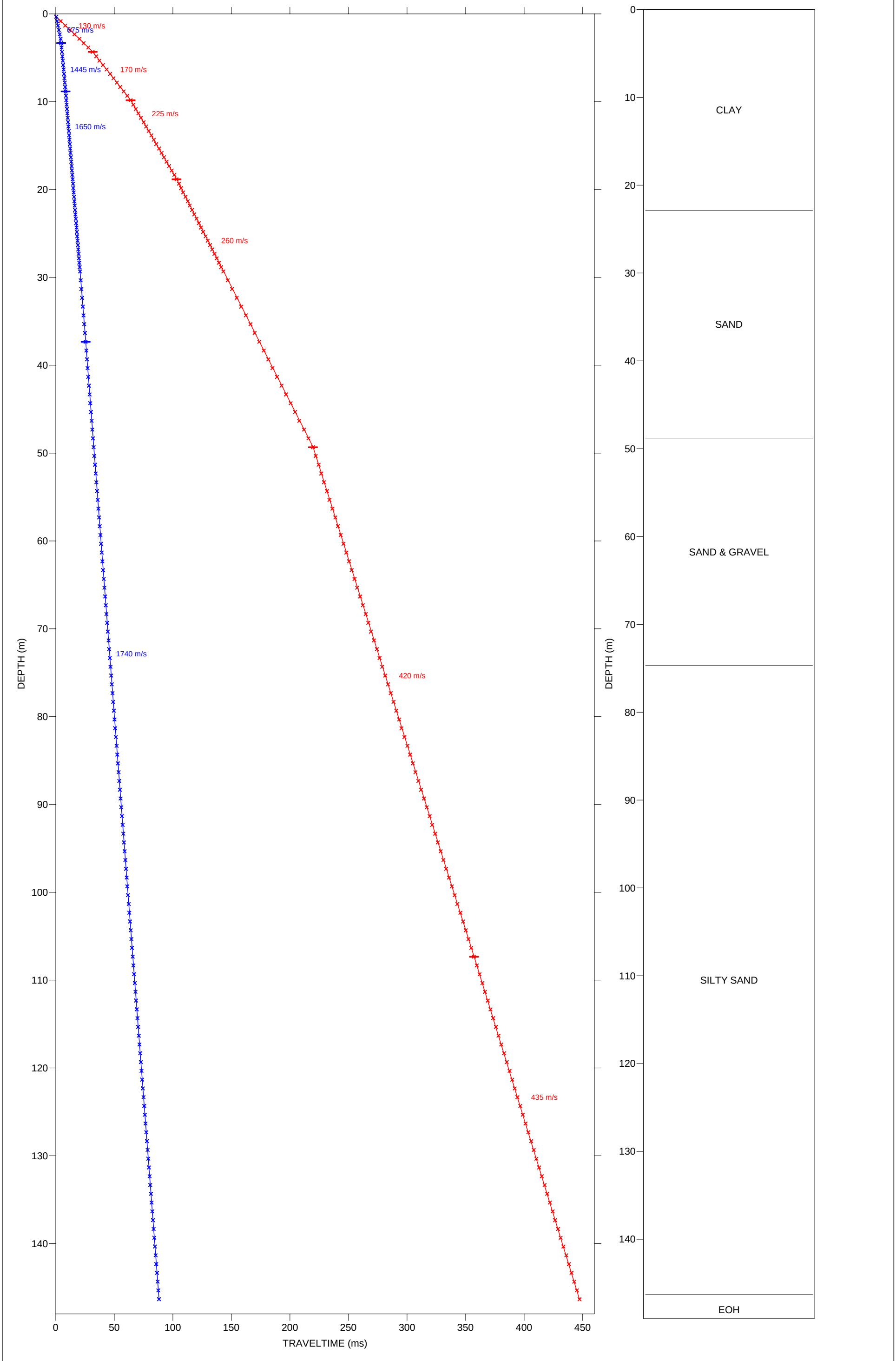
GEOSCIENCE BC
DAWSON CREEK, BC

DOWNHOLE SEISMIC SURVEY

# DRILLHOLE GB15-01
# P AND S WAVE VELOCITIES

FRONTIER GEOSCIENCES INC.

| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 3 |
|---|---|---|




LEGEND

- DATA POINTS
- VELOCITY CHANGE
- P-WAVE
- S-WAVE

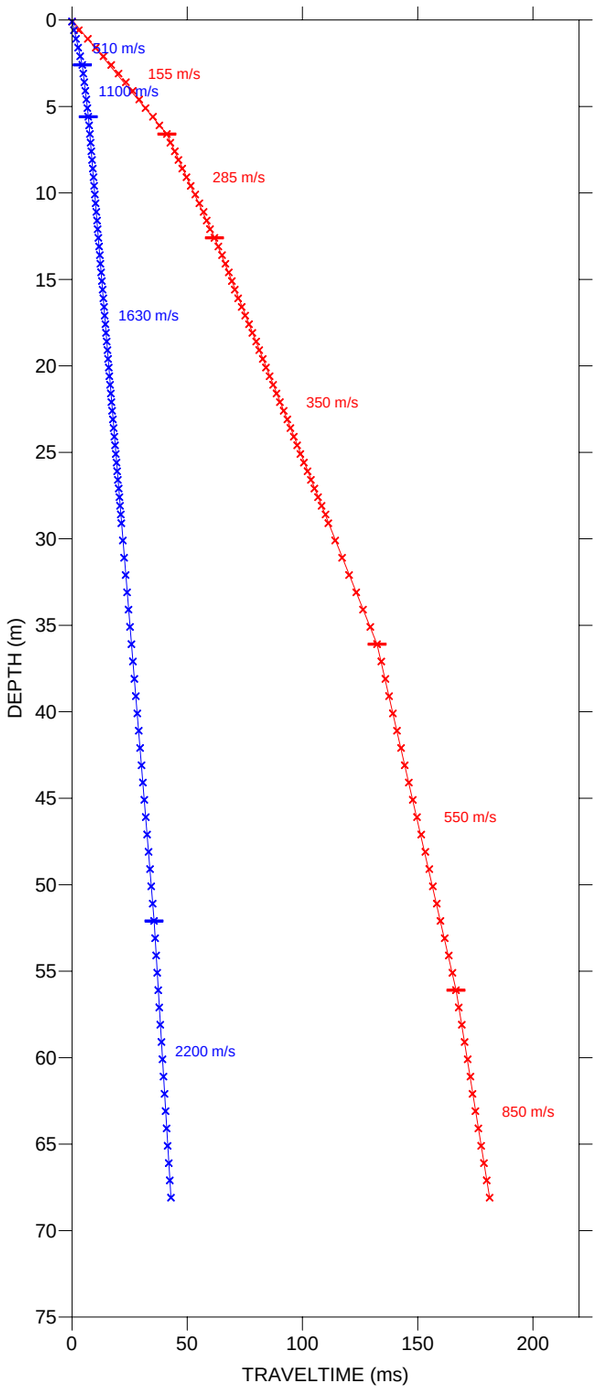
GEOSCIENCE BC
DAWSON CREEK, BC

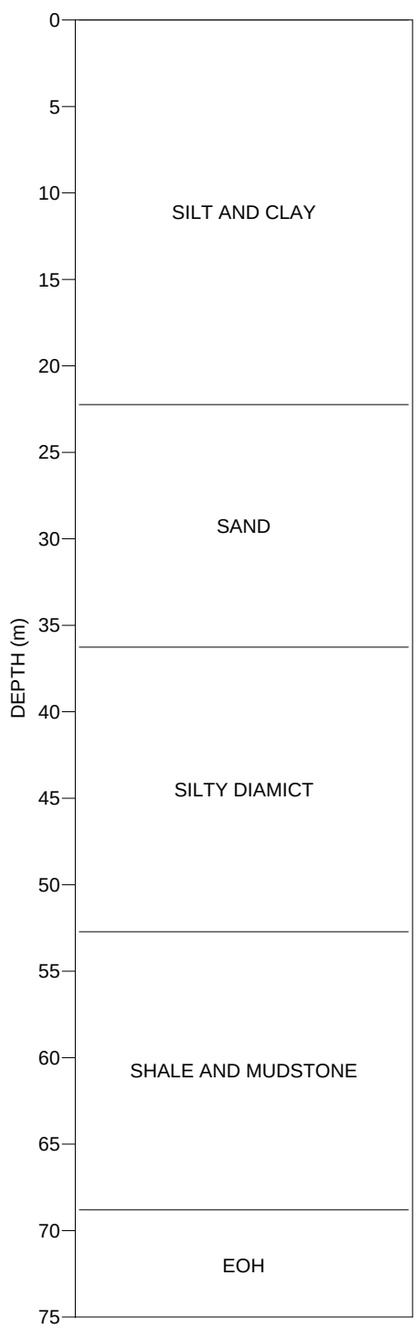
DOWNHOLE SEISMIC SURVEY

DRILLHOLE GB15-02
P AND S WAVE VELOCITIES

FRONTIER GEOSCIENCES INC.

| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 4 |
|---|---|---|




LEGEND

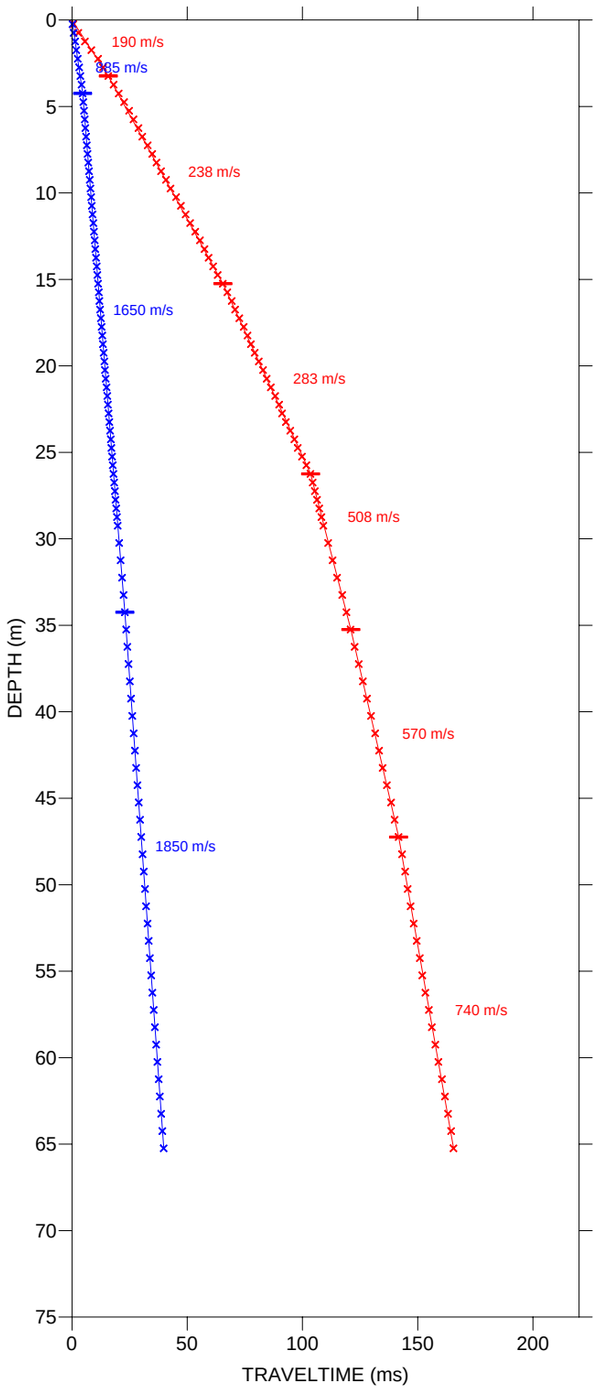
DATA POINTS

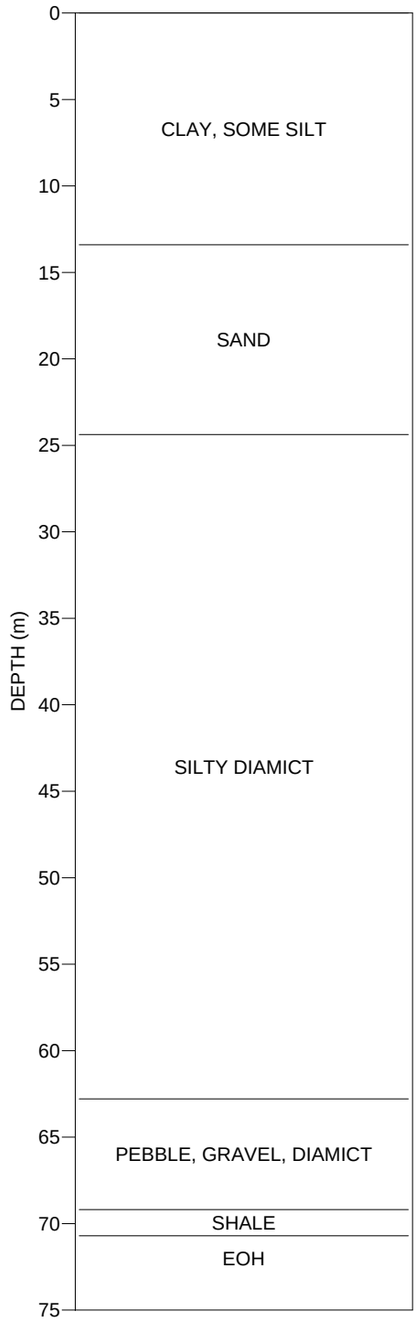
VELOCITY CHANGE

P-WAVE

S-WAVE

| | | |
|---|---|---|
| GEOSCIENCE BC<br>DAWSON CREEK, BC | | |
| DOWNHOLE SEISMIC SURVEY | | |
| DRILLHOLE GB15-03<br>P AND S WAVE VELOCITIES | | |
| FRONTIER GEOSCIENCES INC. | | |
| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 5 |




LEGEND

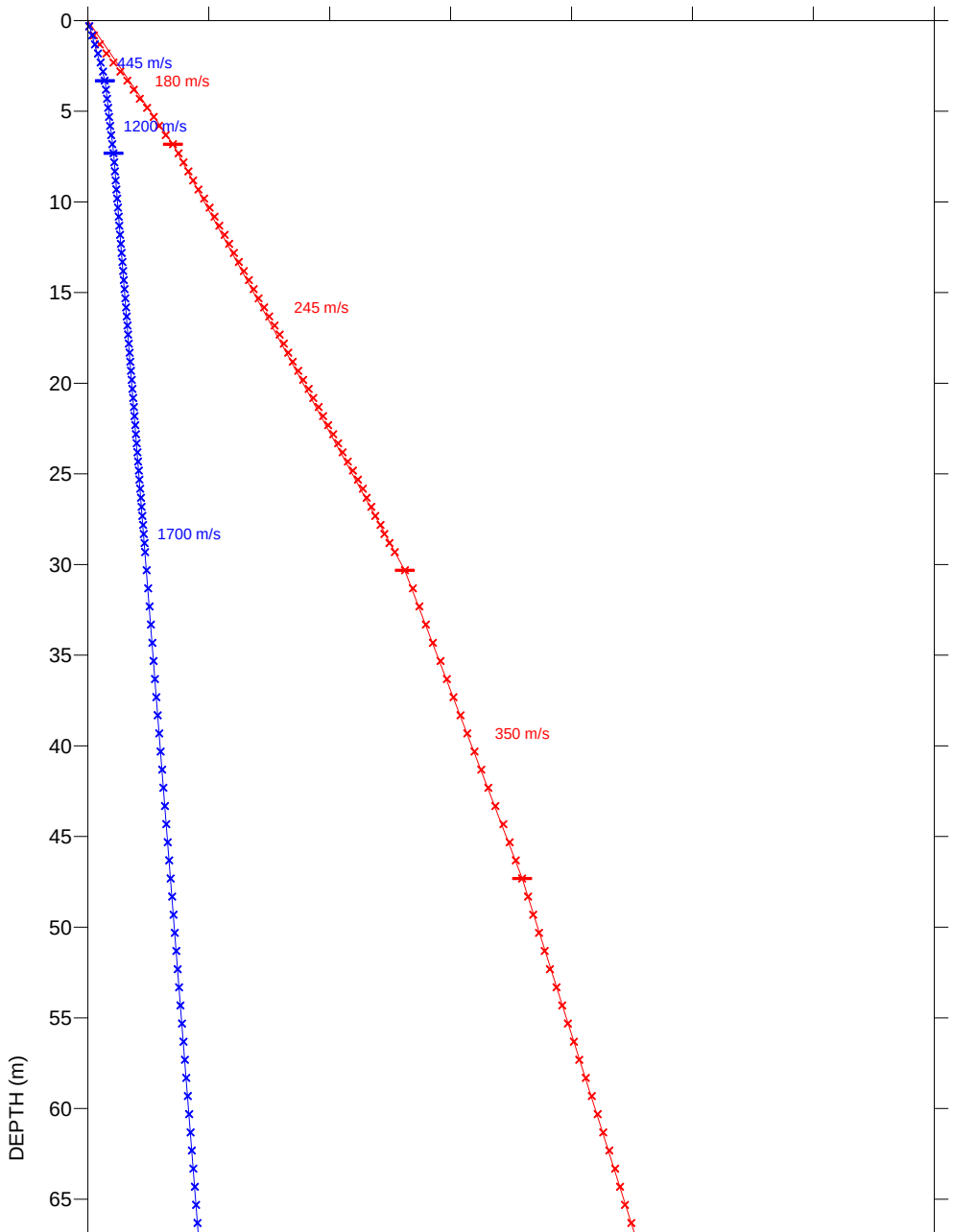
DATA POINTS

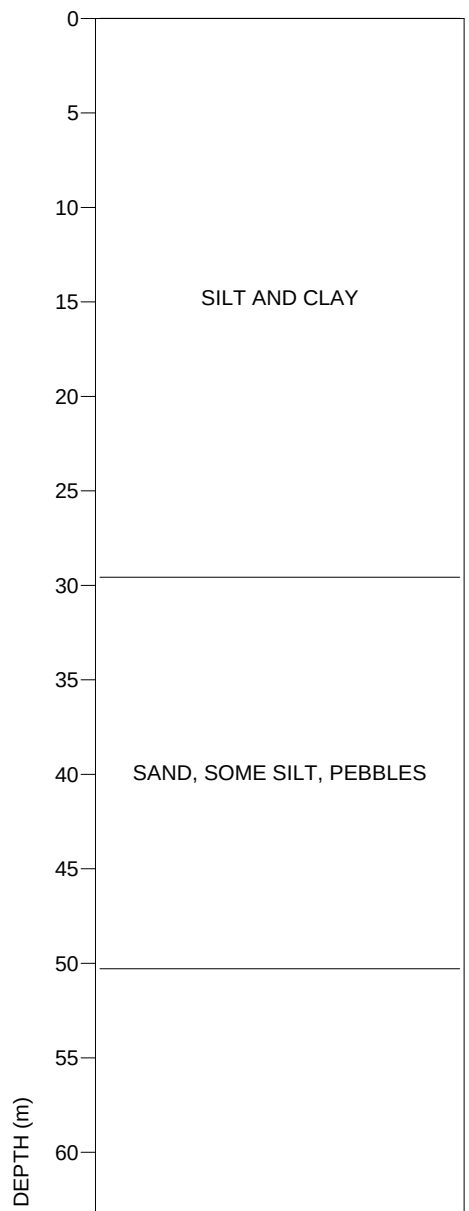
VELOCITY CHANGE

P-WAVE

S-WAVE

| | | |
|---|---|---|
| GEOSCIENCE BC<br>DAWSON CREEK, BC | | |
| DOWNHOLE SEISMIC SURVEY | | |
| DRILLHOLE GB15-04<br>P AND S WAVE VELOCITIES | | |
| FRONTIER GEOSCIENCES INC. | | |
| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 6 |




LEGEND

- DATA POINTS
- VELOCITY CHANGE
- P-WAVE
- S-WAVE

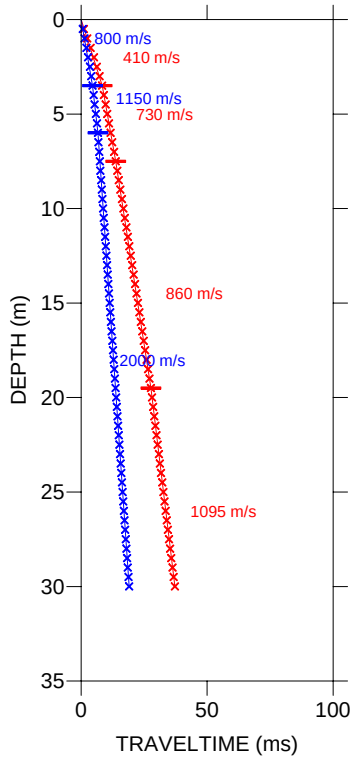
GEOSCIENCE BC
DAWSON CREEK, BC

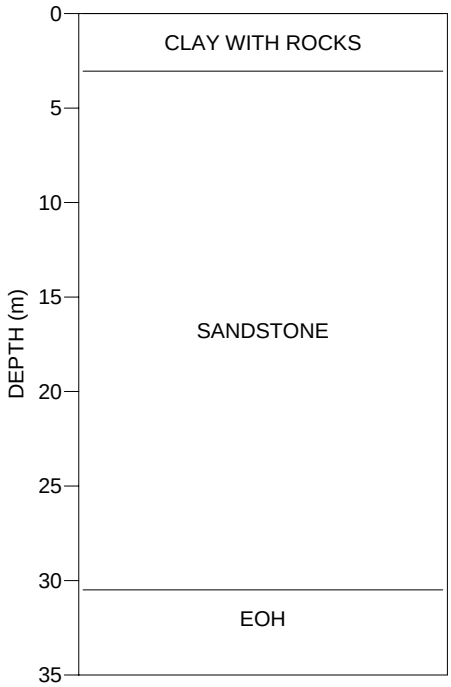
DOWNHOLE SEISMIC SURVEY

DRILLHOLE GB15-05
P AND S WAVE VELOCITIES

FRONTIER GEOSCIENCES INC.

| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 7 |
|---|---|---|




LEGEND

DATA POINTS

VELOCITY CHANGE

P-WAVE

S-WAVE

| GEOSCIENCE BC<br>DAWSON CREEK, BC | | |
|---|---|---|
| DOWNHOLE SEISMIC SURVEY | | |
| DRILLHOLE GB12-02<br>P AND S WAVE VELOCITIES | | |
| FRONTIER GEOSCIENCES INC. | | |
| DATE: MARCH 2017 | V. SCALE 1:400 | FIG. 8 |