DOE/NV/11718--1064

# A Hydrostratigraphic Framework Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Unit 98: Frenchman Flat, Clark, Lincoln and Nye Counties, Nevada

**Prepared for**
**U.S. Department of Energy**
**National Nuclear Security Administration**
**Nevada Site Office**
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**September 2005**

This manuscript was prepared by Bechtel Nevada under Contract No. DE-AC08-96NV11718 with the U.S. Department of Energy.

**Table D.4-1**
**Sources of Velocity Data for the Frenchman Flat 3-D Seismic Survey**

## Sources of Velocity Data

| | State Plane Coordinates | | | Source of Velocity Data | | | | |
|---|---|---|---|---|---|---|---|---|
| **Well** | **X (ft)** | **Y (ft)** | **Z (ft)** | **Sonic or Velocity Log Depth (ft)** | **Check Shot Depth (ft)** | **Density Log Depth (ft)** | **Synthetic** | |
| ER-5-3 | 713138.4 | 773579.4 | 3335 | 1229-2555.5 | | | Y | |
| ER-5-3#2 | 713038.1 | 773587.6 | 3335 | 2555.75-5233 | | | Y | |
| ER-5-4 | 705819.9 | 755751.3 | 3127 | 2430-3583.25 | | 120-2430 | Y | * |
| ER-5-4#2 | 705819.6 | 755651.2 | 3127 | 3090-6937 | | | Y | |
| UE-11a | 708280.0 | 777130.0 | 3547 | | 0-1385 | | Y | |
| UE-11b | 712300.0 | 778800.0 | 3586 | 287-1252 | | | Y | |
| UE-5cWW | 700997.0 | 760133.0 | 3216 | 110-2650 | | | Y | ** |
| UE-5i | 709282.0 | 775216.0 | 3427 | 290-2110 | | | Y | |
| UE-5k | 715247.0 | 773094.0 | 3349 | 880-1720 | | | Y | |
| UE-5n | 706415.0 | 754460.0 | 3112 | | 0-985 | | N | |

All units in feet, all depths are from the surface
* Velocity estimated above 2430 feet from VEL = 500*DEN^4 (Modified Gardner Equation)
** Interpolated 1620 to 1680

Complete time-depth curves (from the surface to total depth of the well) require that an estimate be made for the time value at the depth of the start of the log. This time estimate was made by visually correlating the synthetic seismogram with the migrated 3-D seismic data in wells where characteristic seismic reflections are present. When appropriate reflections were lacking, the estimate were made by using realistic velocities for the near-surface non-logged part of the well. Figure D.4-10 shows the time-depth plot for the "start of the log" values. This figure illustrates that reasonable velocities have been estimated for the upper portion of the boreholes, and that only a small variation in near surface velocity is present. Solid lines are plotted for the two wells where check shot data are available. Figure D.4-11 shows the complete time-depth curves for all wells with velocity data. Also shown on Figure D.4-11 are the time-depth curves used for wells within the survey area that have no velocity information available. These curves are designated as "North Wells" and "South Wells" and closely approximate the time-depth curves from other wells in those areas.

The final time-depth curves were calculated by adding the time from the surface to the seismic datum. The seismic datum is 1,066.8 m (3,500 ft) elevation and the datum velocity is 1,524.0 meters per second (5,000 feet per second).

***Step 3 - Picking of horizons and faults.***

Three seismic horizons were picked (i.e., seismically mapped throughout the survey) using 2d/3dPAK®. These horizons from highest to lowest are 1) the base of alluvium (BOA), 2) base of the welded tuff zone (BWZ), and 3) and the top of Paleozoic rocks (Pz).

The horizons were picked on a grid of inlines and crosslines at every tenth line (i.e., every 152.4 m [500 ft]) within the survey area and tied at each grid intersection point. Near the locations of faults, horizon picking was done on a grid of every one or two lines (i.e., 15.2 or 30.5 m [50 to 100 ft]) to more tightly constrain the horizons. The horizons were then interpolated over the survey area. Faults were picked where the reflections from the welded zone or Paleozoic top were broken, and were picked on a grid of two or five lines. Figures D.4-12, D.4-13 and D.4-14 are the time horizon contour maps for BOA, BWZ, and Pz.

***Step 4 - Conversion of seismic horizons from time to depth.***

A 3-layer velocity model was created to convert the seismic time horizons to depth. Depths were adjusted to a sea-level datum to yield structure contour maps.

The velocity within the alluvium is primarily a function of seismic time or depth, and is mainly due to an increase in compaction of the alluvial sediments with depth. Four "best-fit" $4^{th}$ order polynomial equations (Figure D.4-15) were used to describe the relationship between the depth of the base of the alluvium and the two-way seismic time below the surface. Fit 1 was used to represent the time-depth curve at the UE-5cWW and PW-3 wells. Fit 2 was used to represent time-depth curve at the ER-5-4, ER-5-4#2, U-11b, UE-11b and U-11c#1 wells. Fit 3 was used to represent the time-depth curve at the UE-11a and UE-5i wells. Fit 4 was used to represent the

time-depth curve at the ER-5-3, ER-5-3#2 and UE-5k wells. These relationships were interpolated and extrapolated throughout the 3-D survey area in order to calculate an interval velocity for the alluvium at every seismic trace within the survey. The grid of interval velocities, which is depicted as a contour map in Figure D.4-16, was used to convert the BOA horizon to depth by multiplying by the seismic time from the surface at each trace. These depths were adjusted to a sea-level datum to yield the structure contour map for the BOA (Figure D.4-17).

A similar time-depth relationship exists for the volcanic section penetrated by the wells (Figure D.4-18), and two best-fit 4$^{th}$ order polynomial equations were used to describe this relationship. Fit 1 was used to represent the time-depth curve at the ER-5-3, ER-5-3#2 and UE-5k wells. Fit 2 was used to represent the time-depth curve at the ER-5-4, ER-5-4#2, PW-3, UE-11a, U-11b, UE-11b, UE-5cWW, and UE-5i wells. It was determined that a significant variation did not exist between the average velocities in the more welded upper part of the volcanic section and the lower non-welded tuff in the study area, and thus, these equations (Figure D.4-18) were used to calculate interval velocities for both BOA to BWZ and BWZ to Pz. Interval velocities for BOA to BWZ (Figure D.4-19) were calculated from the polynomial equations for the volcanic section. This velocity map was multiplied by the interval time and the resulting thickness was added to that determined for the base of alluvium to produce a depth map on the base of the welded zone. This was adjusted to a sea-level datum to produce the BWZ structure contour map (Figure D.4-20). The same procedure was used between the base of the welded zone and top of the Paleozoic to delineate the interval velocity between BWZ and Pz (Figure D.4-21), and to produce the structure contour map for Pz (Figure D.4-22).

### *D.4.3 Geologic Interpretation*

The most uniform set of reflections in the survey comes from welded tuffs above the BWZ (Figure D.4-23). The BWZ was picked at the bottom trough of this series of very prominent reflections. These reflections are uniformly strong and identifiable over most of the survey area, except at the margins where fold buildup (i.e., number of recorded seismic traces) is low. Based on correlation with synthetic seismograms for Wells ER-5-3#2 and ER-5-4#2, the reflections are identified as the Ammonia Tanks, Rainier Mesa, and Topopah Spring Tuffs. These units compose a sequence of welded ash-flow tuff deposits that typically occur at the top of the volcanic section in the vicinity of Frenchman Flat. Below the welded tuffs is a zone of poor reflectivity and low energy that corresponds to a sequence of poorly welded, zeolitic tuffs and tuffaceous sedimentary rocks that extend down to the Pz.

The Pz is a strong, prominent peak in the data volume in the northern part of the survey, but is less evident in the southern part of the survey (Figure D.4-24, Figure D.4-25, Figure D.4-26). The only hole within the survey area to penetrate completely through the alluvium and volcanic sections and encounter the top of the Pz is Well ER-5-3#2. At Well ER-5-3#2, the Pz consists of dolomite, and reflection quality is excellent in the vicinity of the hole (see Figure D.4-26).

The BOA is not a consistent reflection in the survey. However, in many places a prominent and conspicuous angular unconformity is observed in the seismic data at the BOA (Figure D.4-23). In addition, a number of holes in the survey area that have velocity data have penetrated this unconformity, and these data can be utilized to constrain and tie the location of the unconformity on the seismic data throughout the survey.

In the southern portion of the survey area two zones of low reflectivity occur within the alluvium section (see Figure D.4-23). The upper of these two zones is penetrated by Well ER-5-4#2 where it corresponds to fine-grained sand, silt, and clay that is interpreted to represent an earlier period of playa deposition. The lower zone is not penetrated by any drill holes, and is defined strictly on a similar seismic character to the upper zone. This lower zone is also interpreted to represent playa deposits.

Several of the deeper reflections below the Pz in the southern portion of the survey area are suspected of being multiples. Multiples are reflections resulting from sound waves that make an extra return trip, either between reflectors (i.e., peg-leg multiple) or down from the surface and back again (i.e., surface multiple). On crossline 55 (Figure D.4-24) near line 200 for example, the sets of reflections at 0.95 seconds and 1.32 seconds are clearly primary reflections and not surface multiples, because the time dip on the lower set is not twice the time dip on the upper set. There is less certainty about the sets of reflections between 1.8 and 2.2 seconds, however. Although the time dip is not double that of the upper or lower sets, it is possible that the set at 1.8 seconds could be a peg-leg multiple generated from the sets at 0.95 and 1.32 seconds.

Based on the seismic data, the overall shape of Frenchman Flat within the survey area is best described as a syncline in the southern two thirds of the survey area which rises up to a structural platform on the north. The axis of the syncline is oriented about north 15 degrees east (see Figure D.4-17). The northwestern flank of the syncline has a dip of 29º - 33º to the southeast, as measured at the BWZ in the southwestern part of the survey area (see Figure D.4-20), and confirmed with dipmeter analysis of the borehole image log from Well ER-5-4#2. The deepest part of the basin occurs in the southeast part of the survey, where the base of alluvium is approximately -556 m ( -1,825 ft) in elevation or 1,501 m (4,925 ft) deep, and the Pz is estimated to be at -1,829 m (-6,000 ft) elevation or 2,789 m (9,150 ft) deep (see Figure D.4-22). At Well ER-5-4#2 in the southwestern portion of the survey, and up dip from the deepest portion of the basin based on seismic, the base of the alluvium was encountered at a depth of 1,120.4 m (3,676 ft). The well failed to reach the Pz and bottomed in Tertiary volcanic rocks at a depth of 2,133.6 m (7,000 ft).

The northern third of the survey area is best characterized as consisting of a faulted structural platform, particularly at the Pz. A series of north-northeast-striking, down-to-the-west faults through the central portion of the platform result in the platform being structurally higher on the west (Figure D.4-26). The depth to Pz ranges from approximately 1,158.2 m (3,800 ft) on the

west side of Figure D.4-26, to greater than 1,645.9 m (5,400 ft) east of Well ER-5-3#2. At Well ER-5-3#2 the Pz was encountered at the depth of 1,425.9 m (4,678 ft).

A large northwest-striking structural zone separates the northern structural platform from the deeper Frenchman Flat basin proper to the south. The structural zone displaces the Pz as much as 609.6 m (2,000 ft) in a series of down-to-the-southwest normal faults, and is itself offset by a north-northeast-striking fault that seems to be a continuation of the faults that offset the structural platform to the north (see Figures D.4-22 and D.4-24). Offset along this fault appears to be oblique, with both down-to-the-west normal and right-lateral strike-slip movement. The fault continues southward into the southeastern portion of the survey area where it appears to significantly decrease in the amount of normal offset.

The disparity in depth to the volcanic rocks between wells UE-11b and UE-11g ext 1 (338.6 vertical meters [1,111 ft] and 1,036.3 horizontal meters [3,400 ft] at BOA) and the shallow dip of the reflections of the volcanic rocks here, indicate that a high-angle normal fault is present between these two wells (see Figure D.4-17). The magnitude of throw along this fault is a maximum of about 548.6 m (1,800 ft), and displacement likely dies to the west into the corner between the Massachusetts Mountains and French Peak. However, the fault does not appear to cause a large offset at the Pz reflections. This implies that a low-angle zone of detachment exists between the BWZ and the Pz, and that much of the displacement seen in the welded zone of the upper volcanic section is dissipated in this zone of detachment (Figure D.4-25).

Additional evidence for the presence of a high-angle fault that is rooted in a low-angle detachment zone below the northern portion of the seismic area, is observed in seismic reflections from the volcanic section. Seismic reflections from the volcanic rocks show an anticlinal feature just south of hole UE-11g ext 1 (Figure D.4-25). However, the anticlinal form does not extend downward to the top of the Paleozoic rocks, which are clearly expressed on the seismic data in this area. This type of large-scale disharmonic folding is common along highly listric normal faults where such folds are referred to as rollover anticlines (Twiss and Moores, 1992). Rollover anticlines form in the hanging wall of concave upward listric normal faults as a result of the hanging wall strata tilting downward and deforming to maintain contact with the footwall of the fault.

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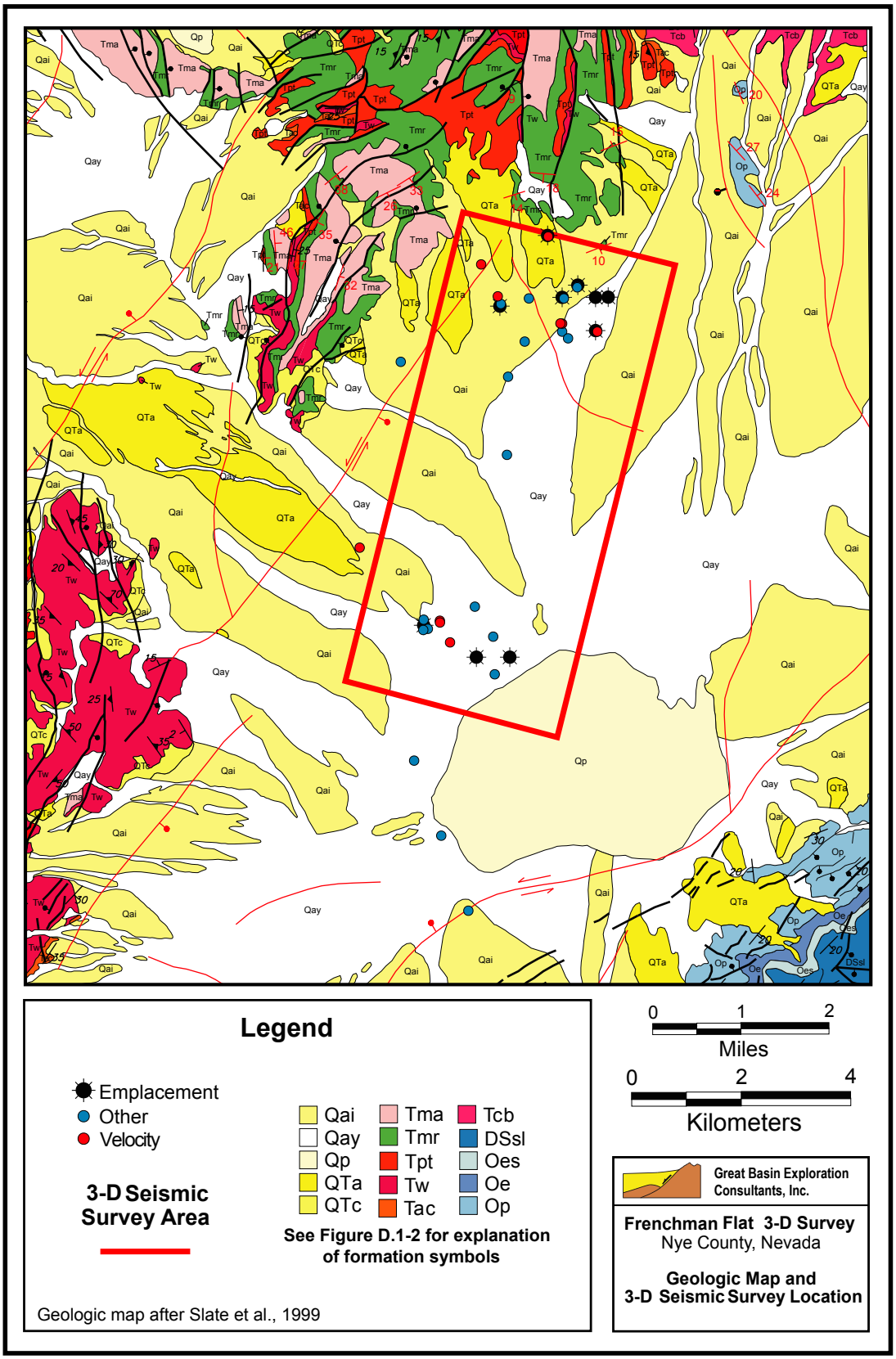



**Figure D.4-1**
**Geologic Map of the Frenchman Flat 3-D Seismic Survey Area**

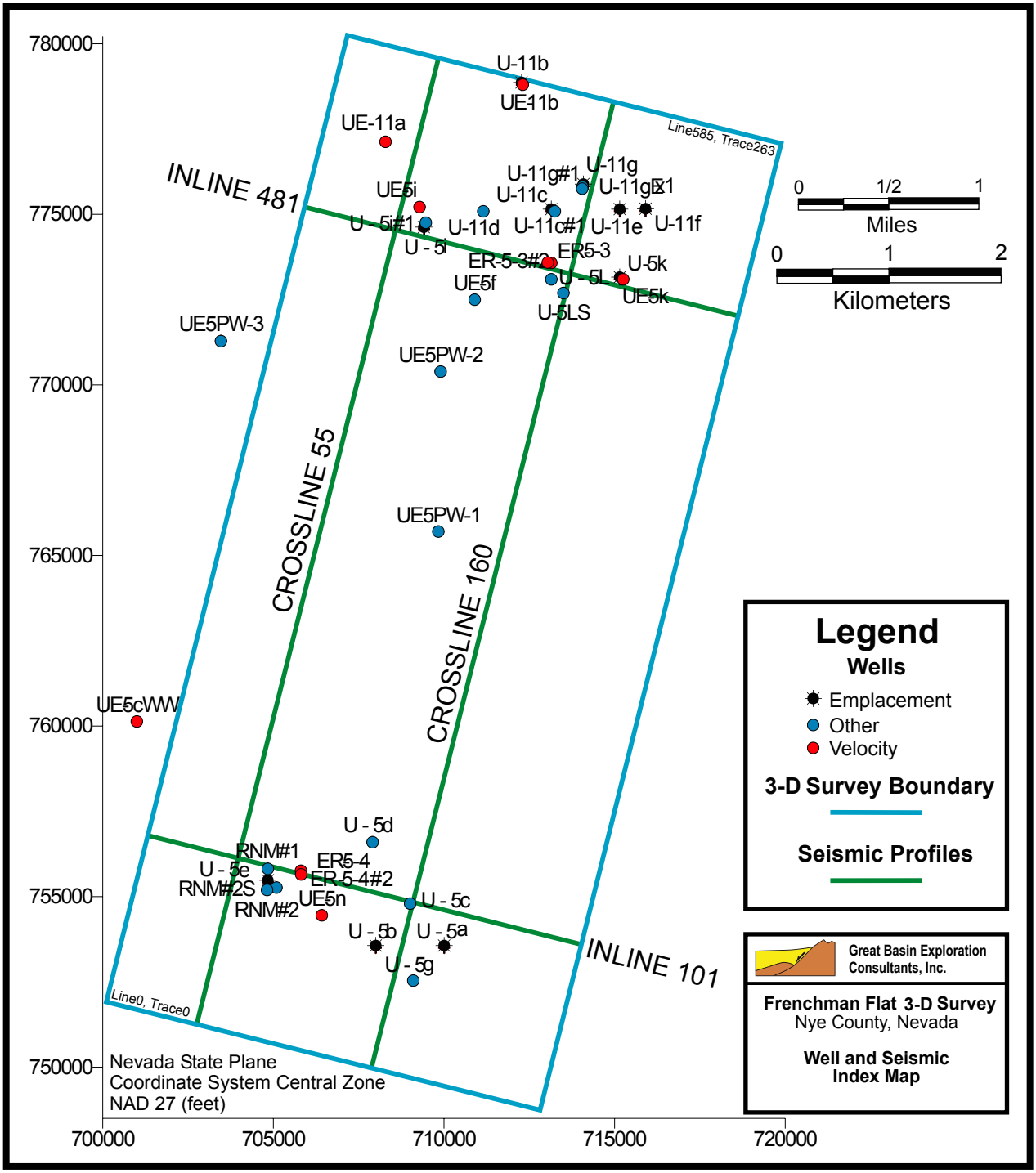
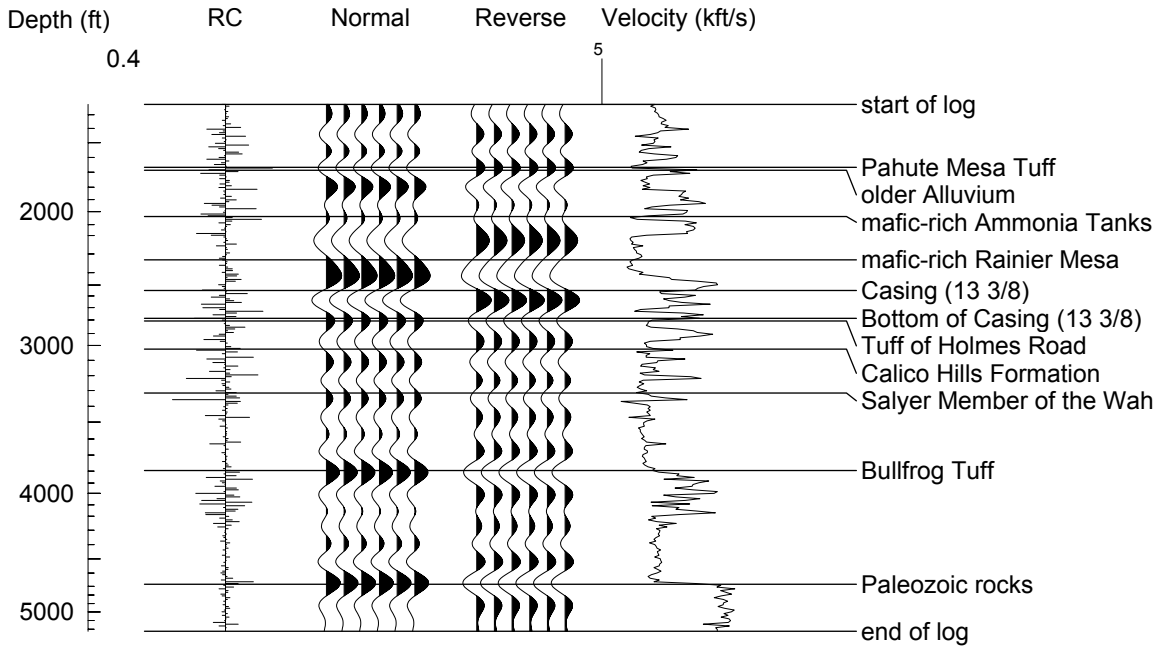



**Figure D.4-2**
**Index Map of the Frenchman Flat 3-D Seismic Survey Area Showing Locations of Drill Holes and Seismic Profiles Referred to in this Report**

## ER-5-3 (1040.5-2555.5) w/ ER-5-3#2 (2555.75-5233.0)

edited at misinterpolations ER5-3(1040.5-2555.5) w/ ER5-3#2(2555.75-5233.0)
KB = 3335 ft GL = 3335 ft Datum = 3335 ft Datum Velocity = 5438 ft/sec
Time scale = 5 inches/second Traces/inch = 10 AGC length = None
Sample rate = 2 msec Acoustic impedance from sonic log
Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 1229 | 2106 | 0.452 | 5438 |
| Pahute Mesa Tuff | 1665 | 1670 | 0.523 | 6364 |
| older Alluvium | 1682 | 1653 | 0.527 | 6389 |
| mafic-rich Ammonia Tanks | 2042 | 1293 | 0.579 | 7054 |
| mafic-rich Rainier Mesa | 2334 | 1001 | 0.628 | 7434 |
| Casing (13 3/8) | 2556 | 780 | 0.663 | 7714 |
| Bottom of Casing (13 3/8) | 2784 | 551 | 0.694 | 8023 |
| Tuff of Holmes Road | 2807 | 528 | 0.697 | 8055 |
| Calico Hills Formation | 3024 | 311 | 0.729 | 8297 |
| Salyer Member of the Wah | 3315 | 20 | 0.778 | 8517 |
| Bullfrog Tuff | 3796 | -461 | 0.866 | 8765 |
| Paleozoic rocks | 4678 | -1343 | 0.995 | 9404 |
| end of log | 5223 | -1888 | 1.048 | 9967 |

| | | |
|---|---|---|
| 436 | 0.071 | 12234 |
| 17 | 0.003 | 10469 |
| 360 | 0.052 | 13734 |
| 292 | 0.049 | 11929 |
| 222 | 0.035 | 12789 |
| 229 | 0.031 | 14518 |
| 23 | 0.003 | 15678 |
| 217 | 0.032 | 13565 |
| 291 | 0.049 | 11764 |
| 481 | 0.088 | 10967 |
| 882 | 0.129 | 13697 |
| 545 | 0.053 | 20537 |

**Wavelet**
5-10-25-30 Hz
Phase = 0 degrees
Length = 0.200 Sec

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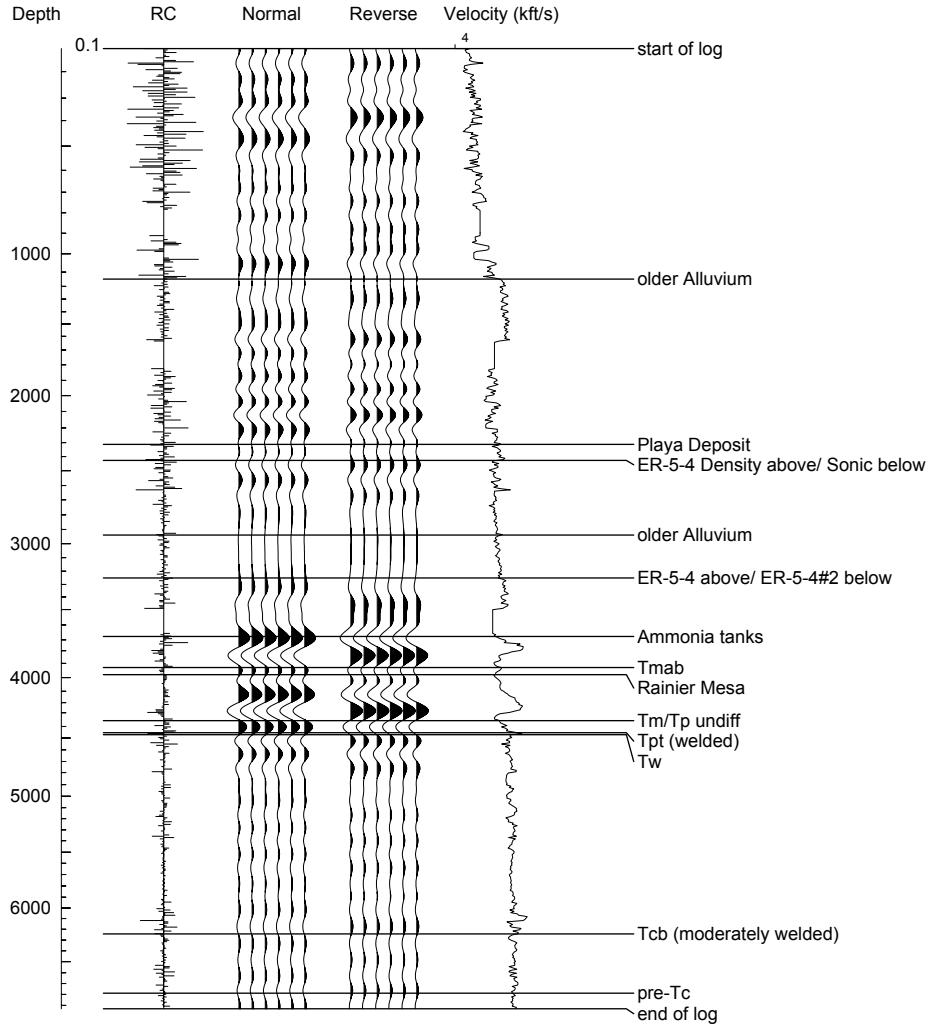
**Figure D.4-3**
**Composite Synthetic Seismogram for Wells ER-5-3 and ER-5-3#2**

ER-5-4 composited with ER-5-4#2

Composite Sonic below 2430 - Density(Gardner) above
KB = 3127 ft GL = 3127 ft Datum = 3127 ft Datum Velocity = 2264 ft/sec
Time scale = 5 inches/second Traces/inch = 10 AGC length = None
Sample rate = 2 msec Acoustic impedance from sonic log
Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 120 | 3007 | 0.106 | 2264 |
| older Alluvium | 1144 | 1983 | 0.456 | 5018 |
| Playa Deposit | 2312 | 815 | 0.707 | 6541 |
| ER5-4 Density above/ Sonic below | 2430 | 697 | 0.731 | 6644 |
| older Alluvium | 2940 | 187 | 0.845 | 6961 |
| ER5-4 above/ ER5-4#2 below | 3250 | -123 | 0.910 | 7144 |
| Ammonia tanks | 3676 | -549 | 0.999 | 7361 |
| Tmab | 3928 | -801 | 1.046 | 7512 |
| Rainier Mesa | 3980 | -853 | 1.057 | 7533 |
| Tm/Tp undiff | 4356 | -1229 | 1.127 | 7734 |
| Tpt (welded) | 4452 | -1325 | 1.145 | 7777 |
| Tw | 4472 | -1345 | 1.148 | 7791 |
| Tcb (moderately welded) | 6246 | -3119 | 1.450 | 8613 |
| pre-Tc | 6790 | -3663 | 1.540 | 8816 |
| end of log | 6931 | -3804 | 1.564 | 8863 |

| | | |
|---|---|---|
| 1024 | 0.350 | 5852 |
| 1168 | 0.251 | 9309 |
| 118 | 0.025 | 9631 |
| 510 | 0.113 | 9006 |
| 310 | 0.065 | 9514 |
| 426 | 0.089 | 9579 |
| 252 | 0.047 | 10719 |
| 52 | 0.011 | 9580 |
| 376 | 0.070 | 10772 |
| 96 | 0.018 | 10446 |
| 20 | 0.003 | 12977 |
| 1774 | 0.302 | 11731 |
| 544 | 0.090 | 12081 |
| 141 | 0.024 | 11953 |

**Wavelet**
5-10-25-30 Hz
Phase = 0 degrees
Length = 0.200 Sec

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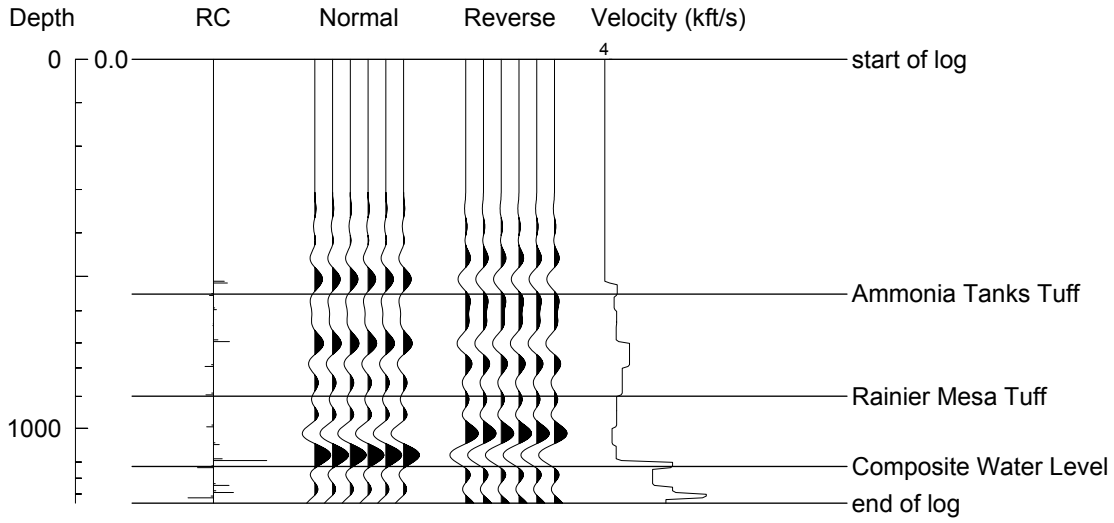
**Figure D.4-4**
**Composite Synthetic Seismogram for Wells ER-5-4 and ER-5-4#2**

## UE-11a

Synthetic from Check Shot
KB = 3547 ft GL = 3547 ft Datum = 3547 ft Datum Velocity = 5000 ft/sec
Time scale = 5 inches/second Traces/inch = 10 AGC length = None
Sample rate = 2 msec Acoustic impedance from sonic log
Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 0 | 3547 | 0.000 | ----- |
| Ammonia Tanks Tuff | 550 | 2997 | 0.265 | 4158 |
| Rainier Mesa Tuff | 900 | 2647 | 0.380 | 4741 |
| Composite Water Level | 1131 | 2416 | 0.459 | 4930 |
| end of log | 1374 | 2173 | 0.500 | 5498 |

| | | |
|---|---|---|
| 550 | 0.265 | 4158 |
| 350 | 0.115 | 6083 |
| 231 | 0.079 | 5839 |
| 243 | 0.041 | 11809 |

**Wavelet**
5-10-25-30 Hz
Phase = 0 degrees
Length = 0.200 Sec

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**Figure D.4-5**
**Synthetic Seismogram for UE-11a**

UE-11b

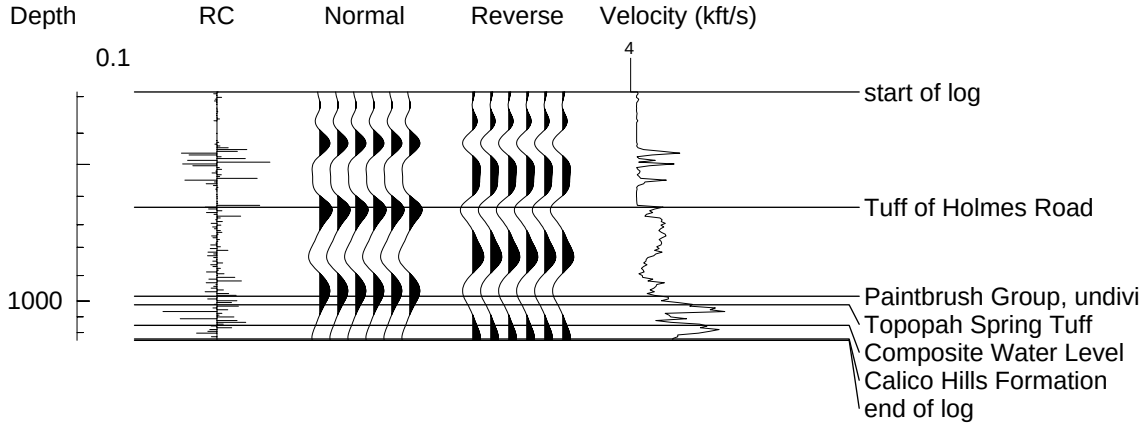
synthetic from velocity log dt2

KB = 3586 ft GL = 3586 ft Datum = 3586 ft Datum Velocity = 4159 ft/sec

Time scale = 5 inches/second Traces/inch = 10 AGC length = None

Sample rate = 2 msec Acoustic impedance from sonic log

Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 287 | 3299 | 0.138 | 4159 |
| Tuff of Holmes Road | 630 | 2956 | 0.266 | 4734 |
| Paintbrush Group, undivi | 978 | 2608 | 0.365 | 5358 |
| Topopah Spring Tuff | 1020 | 2566 | 0.375 | 5446 |
| Composite Water Level | 1146 | 2440 | 0.397 | 5768 |
| Calico Hills Formation | 1240 | 2346 | 0.413 | 6011 |
| end of log | 1247 | 2339 | 0.414 | 6023 |

| | | |
|---|---|---|
| 343 | 0.128 | 5352 |
| 348 | 0.099 | 7038 |
| 42 | 0.009 | 8848 |
| 126 | 0.023 | 11060 |
| 94 | 0.015 | 12360 |
| 7 | 0.001 | 9310 |

**Wavelet**

5-10-25-30 Hz

Phase = 0 degrees

Length = 0.200 Sec

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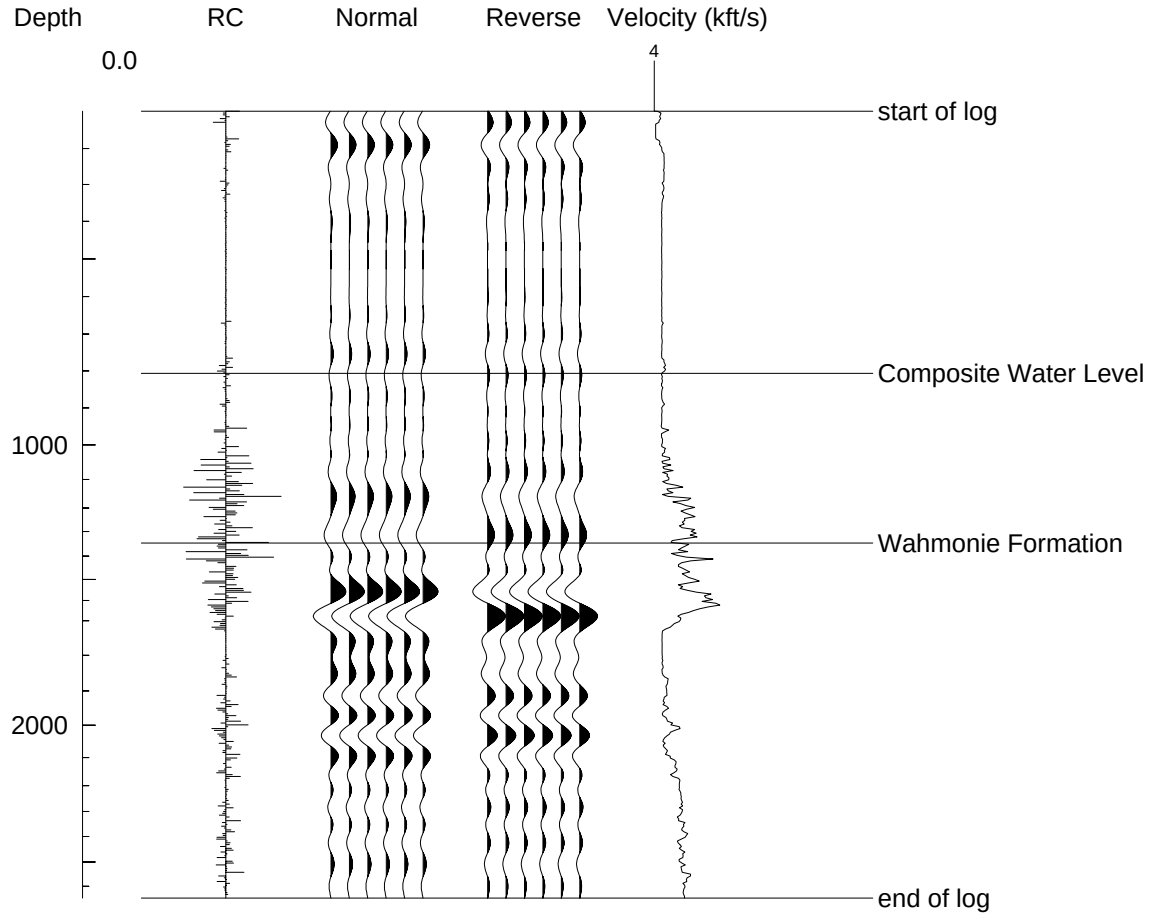
**Figure D.4-6**
**Synthetic Seismogram for UE-11b**

UE-5cWW

Combined velocity log interpolated from 1620 to 1680
KB = 3216 ft GL = 3216 ft Datum = 3216 ft Datum Velocity = 4000 ft/sec
Time scale = 5 inches/second Traces/inch = 10 AGC length = None
Sample rate = 2 msec Acoustic impedance from sonic log
Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 110 | 3106 | 0.055 | 4000 |
| Composite Water Level | 807 | 2409 | 0.340 | 4754 |
| Wahmonie Formation | 1350 | 1866 | 0.524 | 5154 |
| end of log | 2649 | 567 | 0.909 | 5828 |

| | | |
|---|---|---|
| 697 | 0.285 | 4900 |
| 543 | 0.184 | 5890 |
| 1299 | 0.385 | 6745 |

**Wavelet**
5-10-25-30 Hz
Phase = 0 degrees
Length = 0.200 Sec

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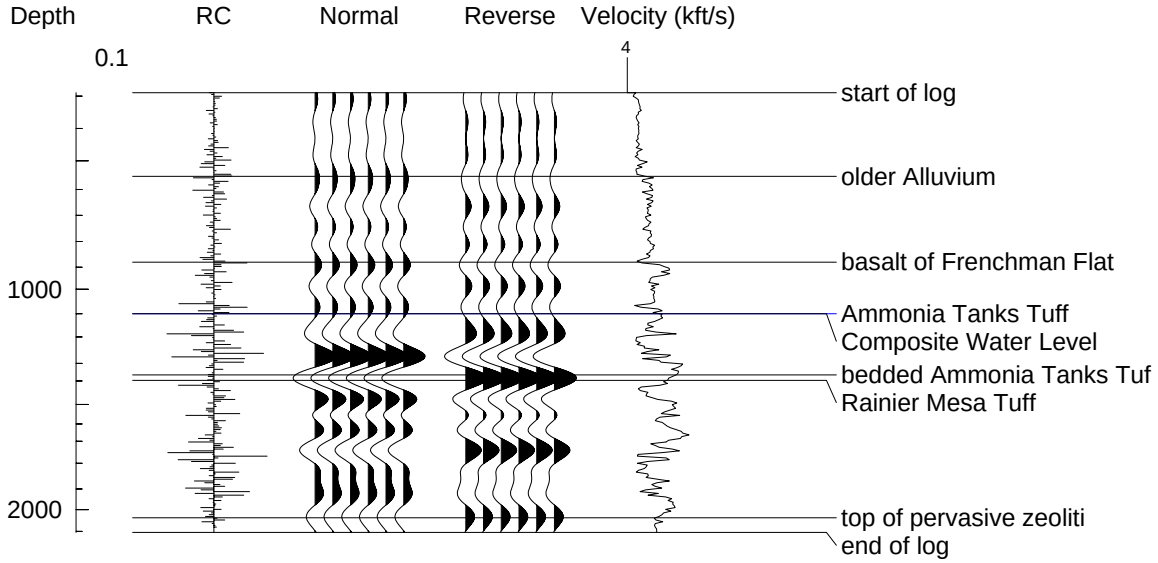
**Figure D.4-7**
**Synthetic Seismogram for UE-5cWW**

# UE-5i

Synthetic from velocity log
KB = 3427 ft GL = 3427 ft Datum = 3427 ft Datum Velocity = 4143 ft/sec
Time scale = 5 inches/second Traces/inch = 10 AGC length = None
Sample rate = 2 msec Acoustic impedance from sonic log
Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 290 | 3137 | 0.140 | 4143 |
| older Alluvium | 550 | 2877 | 0.234 | 4693 |
| basalt of Frenchman Flat | 880 | 2547 | 0.331 | 5314 |
| Ammonia Tanks Tuff | 1100 | 2327 | 0.389 | 5650 |
| Composite Water Level | 1100 | 2327 | 0.389 | 5650 |
| bedded Ammonia Tanks Tuf | 1368 | 2059 | 0.458 | 5967 |
| Rainier Mesa Tuff | 1398 | 2029 | 0.465 | 6017 |
| top of pervasive zeoliti | 2040 | 1387 | 0.619 | 6586 |
| end of log | 2104 | 1323 | 0.636 | 6617 |

| | | |
|---|---|---|
| 260 | 0.094 | 5510 |
| 330 | 0.097 | 6818 |
| 220 | 0.058 | 7563 |
| --- | --- | --- |
| 268 | 0.069 | 7752 |
| 30 | 0.006 | 9684 |
| 642 | 0.155 | 8295 |
| 64 | 0.017 | 7772 |

**Wavelet**
5-10-25-30 Hz
Phase = 0 degrees
Length = 0.200 Sec

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**Figure D.4-8**
**Synthetic Seismogram for UE-5i**

UE-5k

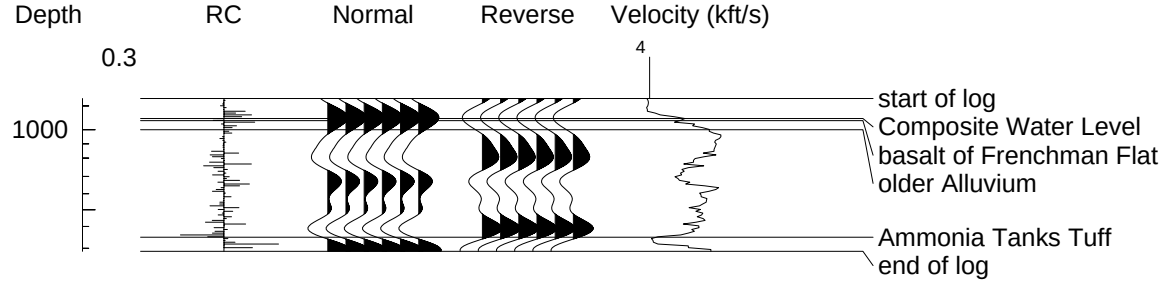
Synthetic from velocity log

KB = 3349 ft GL = 3349 ft Datum = 3349 ft Datum Velocity = 5094 ft/sec

Time scale = 5 inches/second Traces/inch = 10 AGC length = None

Sample rate = 2 msec Acoustic impedance from sonic log

Date plotted: 09-07-2004 Measurement Units: Feet




| | | | | |
|---|---|---|---|---|
| start of log | 880 | 2469 | 0.346 | 5094 |
| Composite Water Level | 939 | 2410 | 0.368 | 5110 |
| basalt of Frenchman Flat | 950 | 2399 | 0.370 | 5136 |
| older Alluvium | 1000 | 2349 | 0.380 | 5264 |
| Ammonia Tanks Tuff | 1660 | 1689 | 0.498 | 6666 |
| end of log | 1719 | 1630 | 0.514 | 6695 |

| | | |
|---|---|---|
| 59 | 0.022 | 5355 |
| 11 | 0.002 | 9270 |
| 50 | 0.010 | 9982 |
| 660 | 0.118 | 11176 |
| 59 | 0.015 | 7614 |

**Wavelet**

5-10-25-30 Hz

Phase = 0 degrees

Length = 0.200 Sec

QuickSyn © 1996-2004 by GeoTools

**Figure D.4-9**
**Synthetic Seismogram for UE-5k**

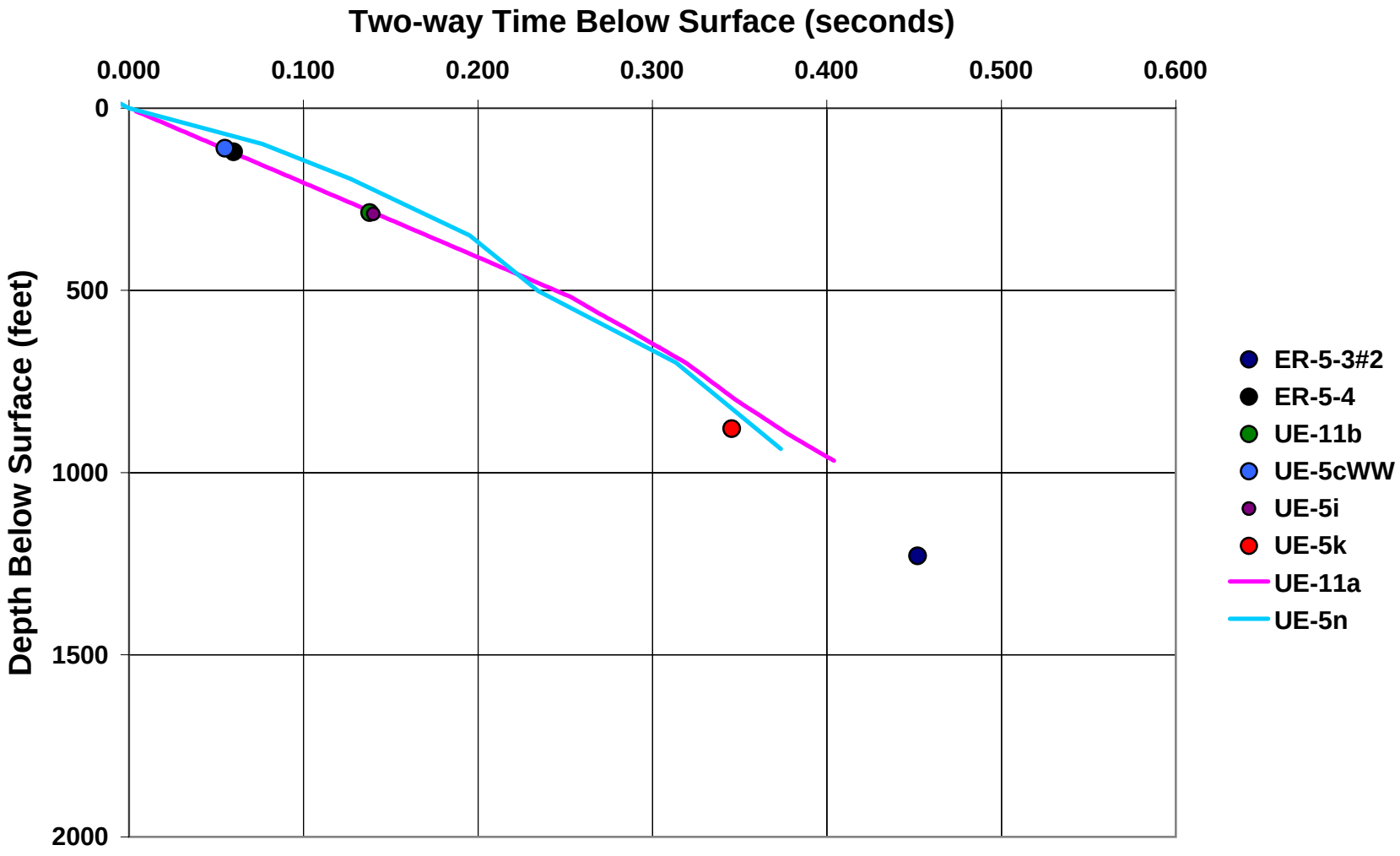



**Figure D.4-10**
**Estimated Time Values for Starting Depths of Logs Used to Construct Time-Depth Curves for the Frenchman Flat 3-D Seismic Survey. Solid lines are time depth curves for UE-11a and UE-5n based on Check Shot Surveys.**

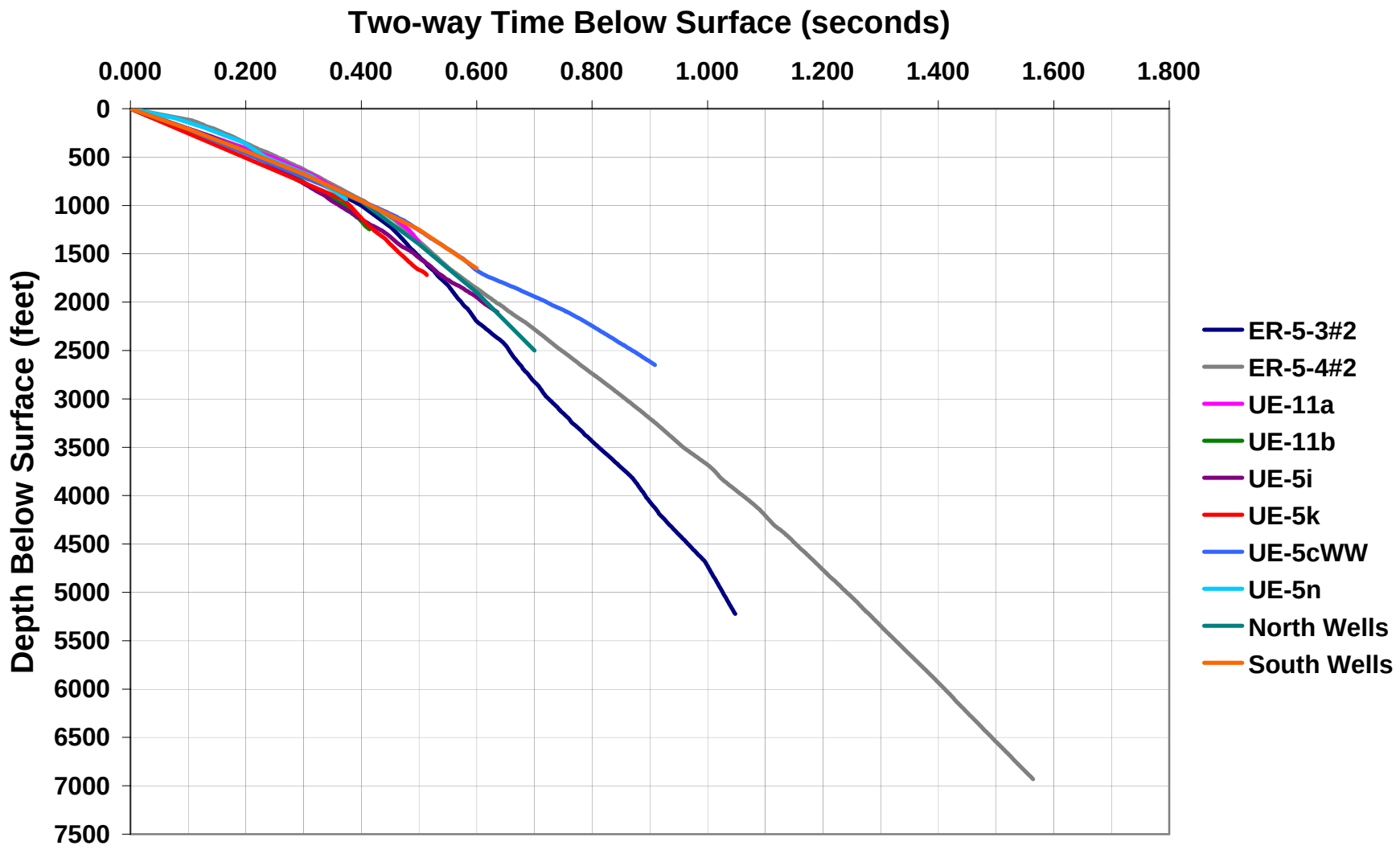



**Figure D.4-11**
**Time-Depth Curves Utilized for the Frenchman Flat 3-D Seismic Survey.**

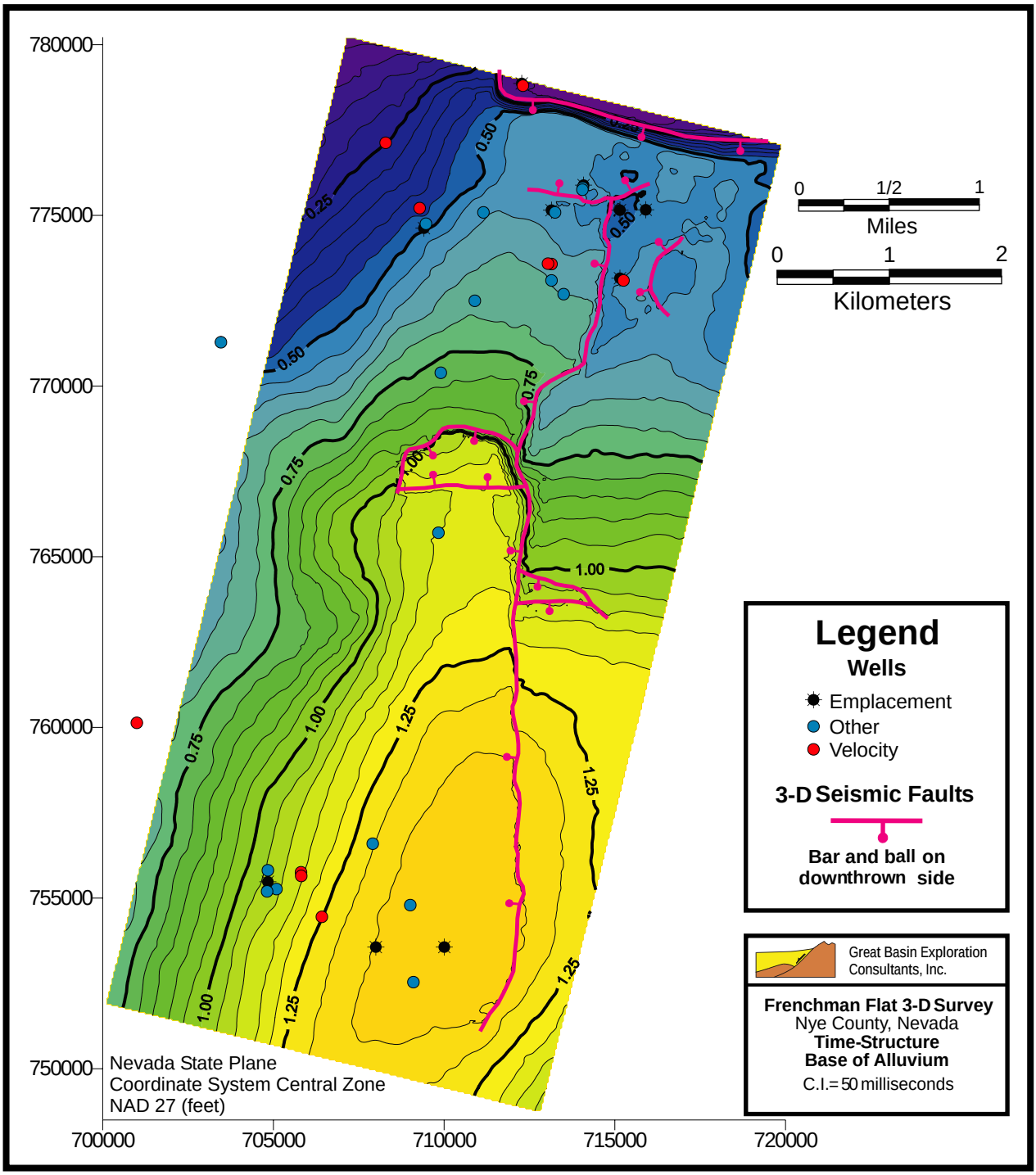



**Figure D.4-12**
**Time-Structure Map for Base of Alluvium (BOA)**

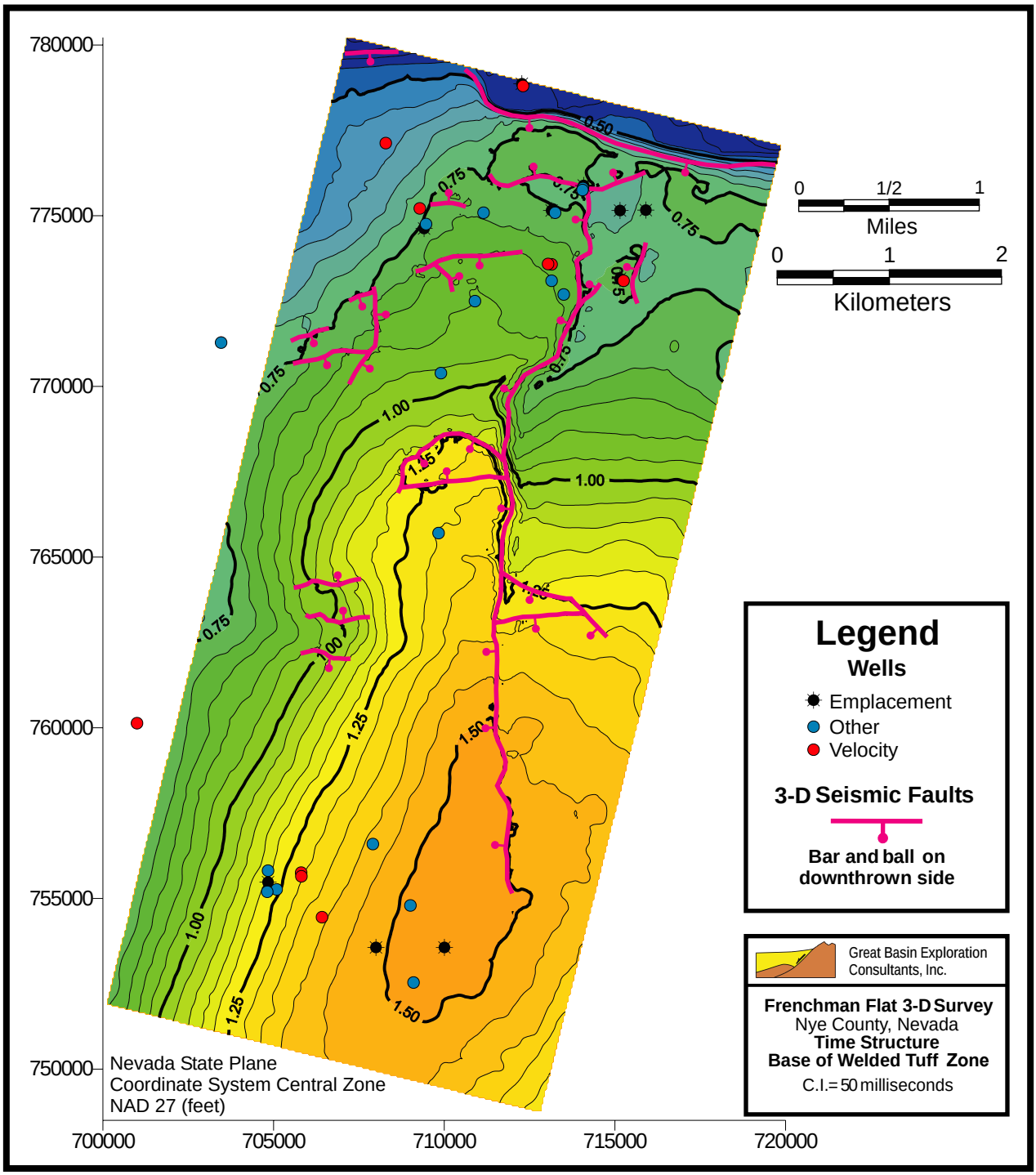



**Figure D.4-13**
**Time-Structure Map for Base of Welded Zone (BWZ)**

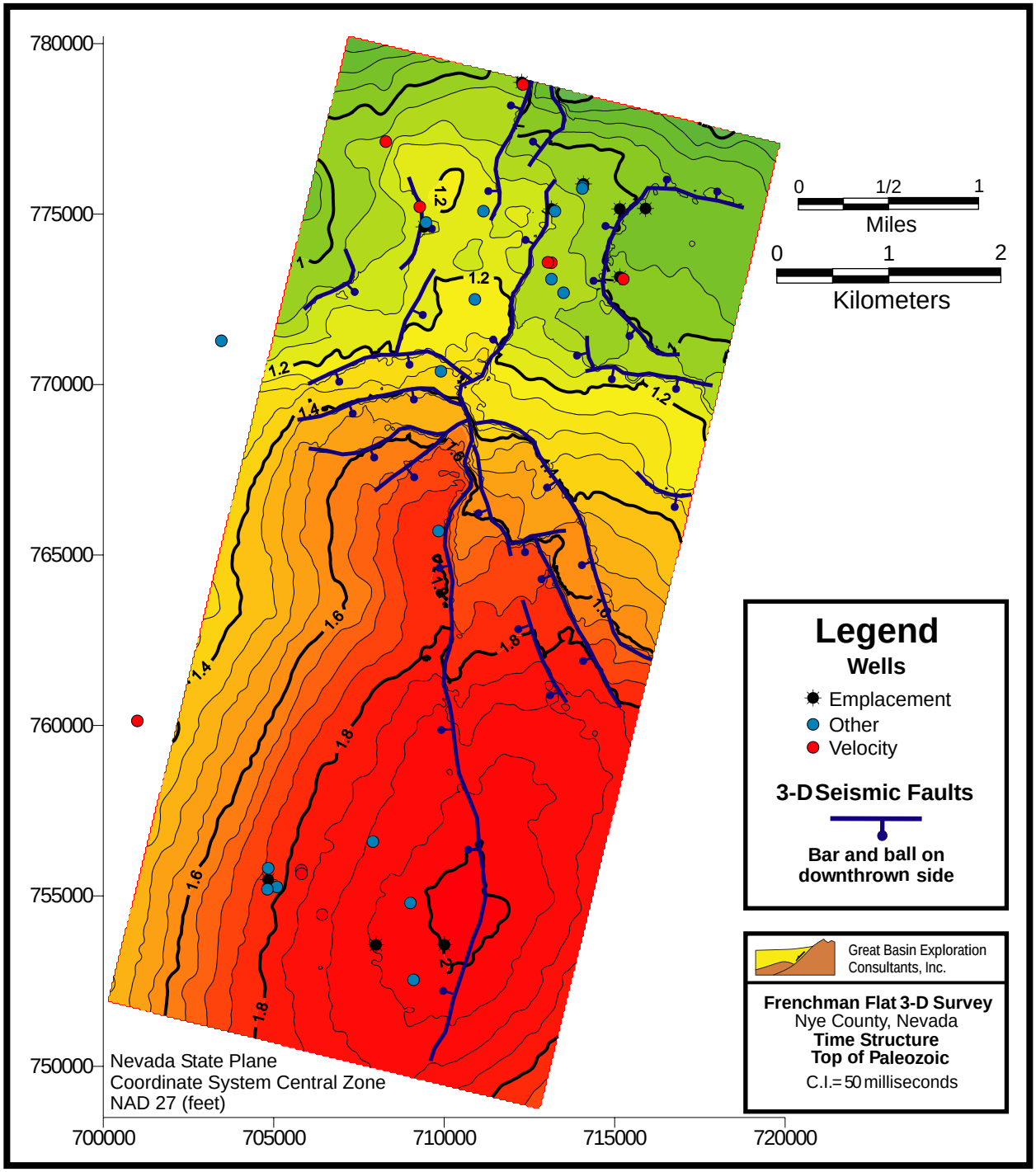



**Figure D.4-14**
**Time-Structure Map for Top of Paleozoic Rocks (Pz)**

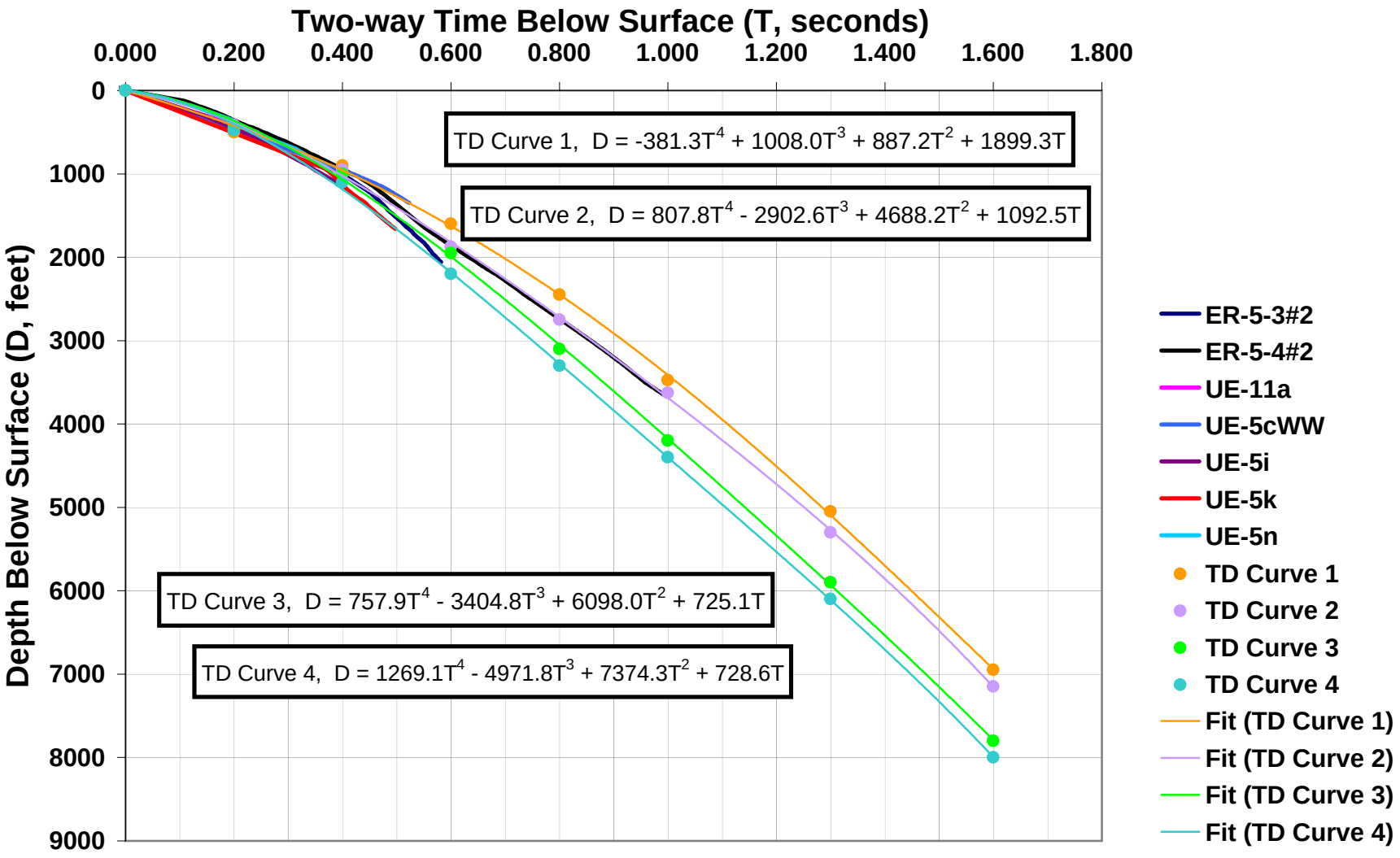



**Figure D.4-15**
**Time-Depth (TD) Curves for Alluvium**

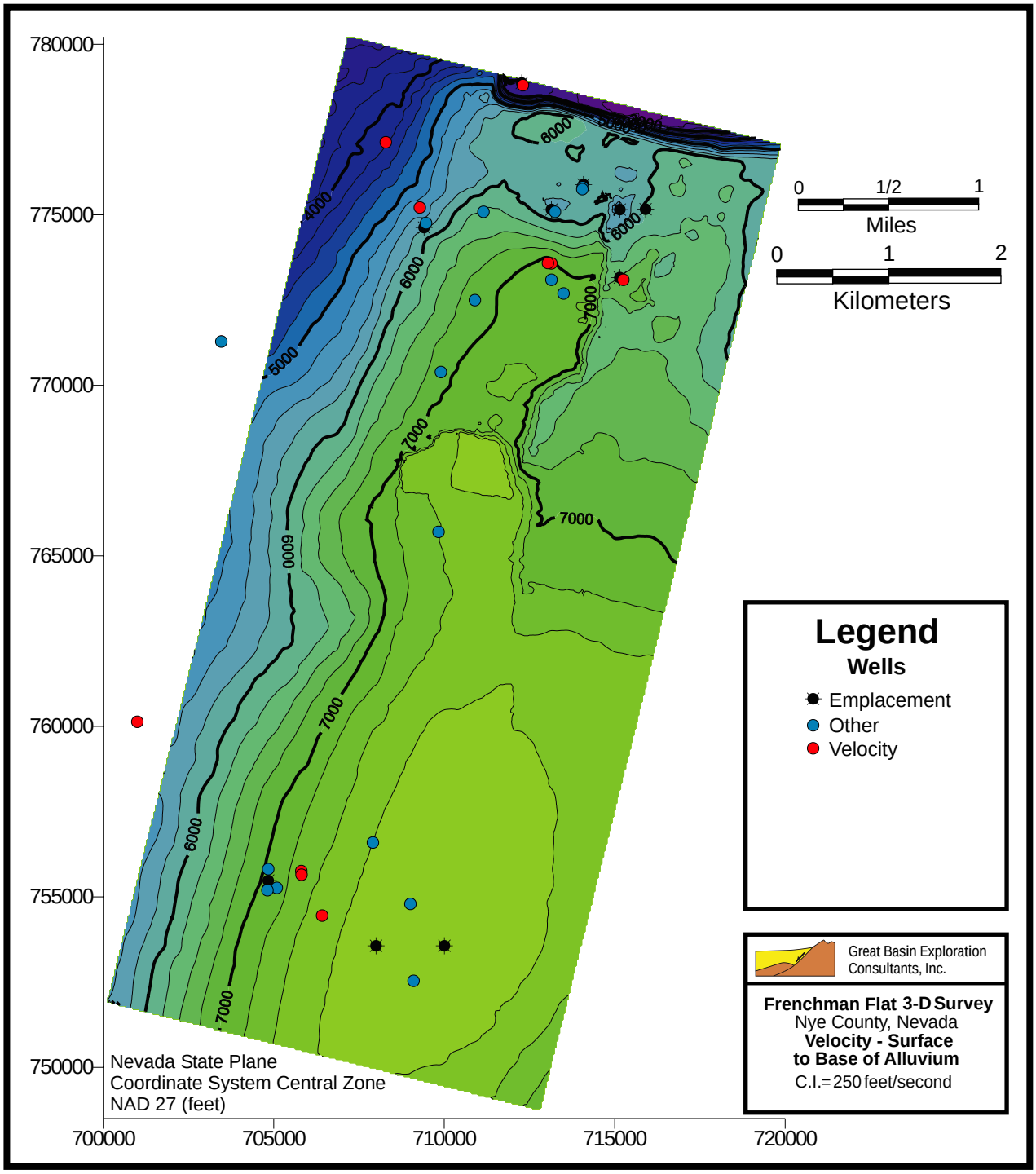



**Figure D.4-16**
**Velocity Map from Surface to Base of Alluvium (BOA)**

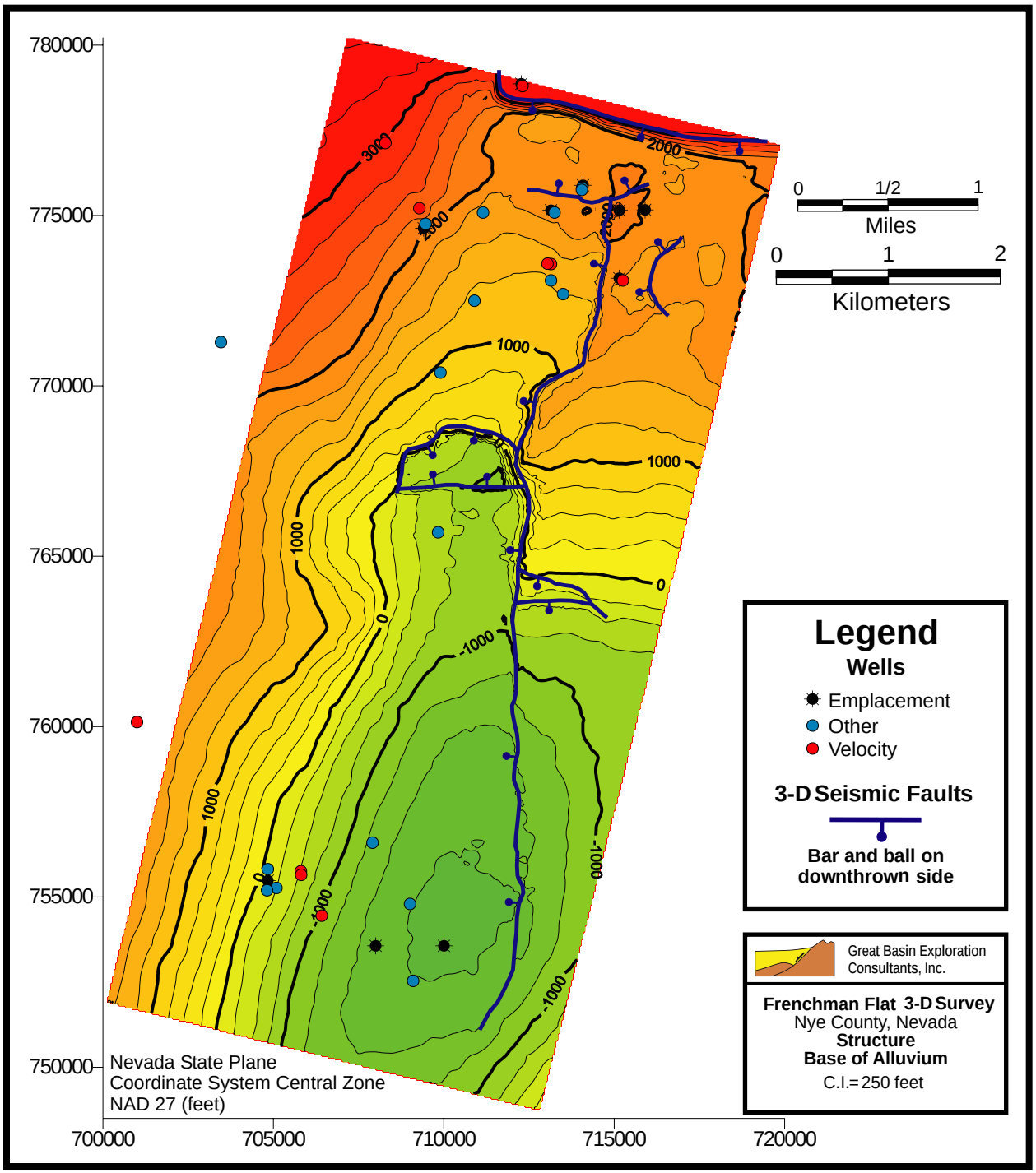



**Figure D.4-17**
**Structure Map of the Base of Alluvium (BOA)**

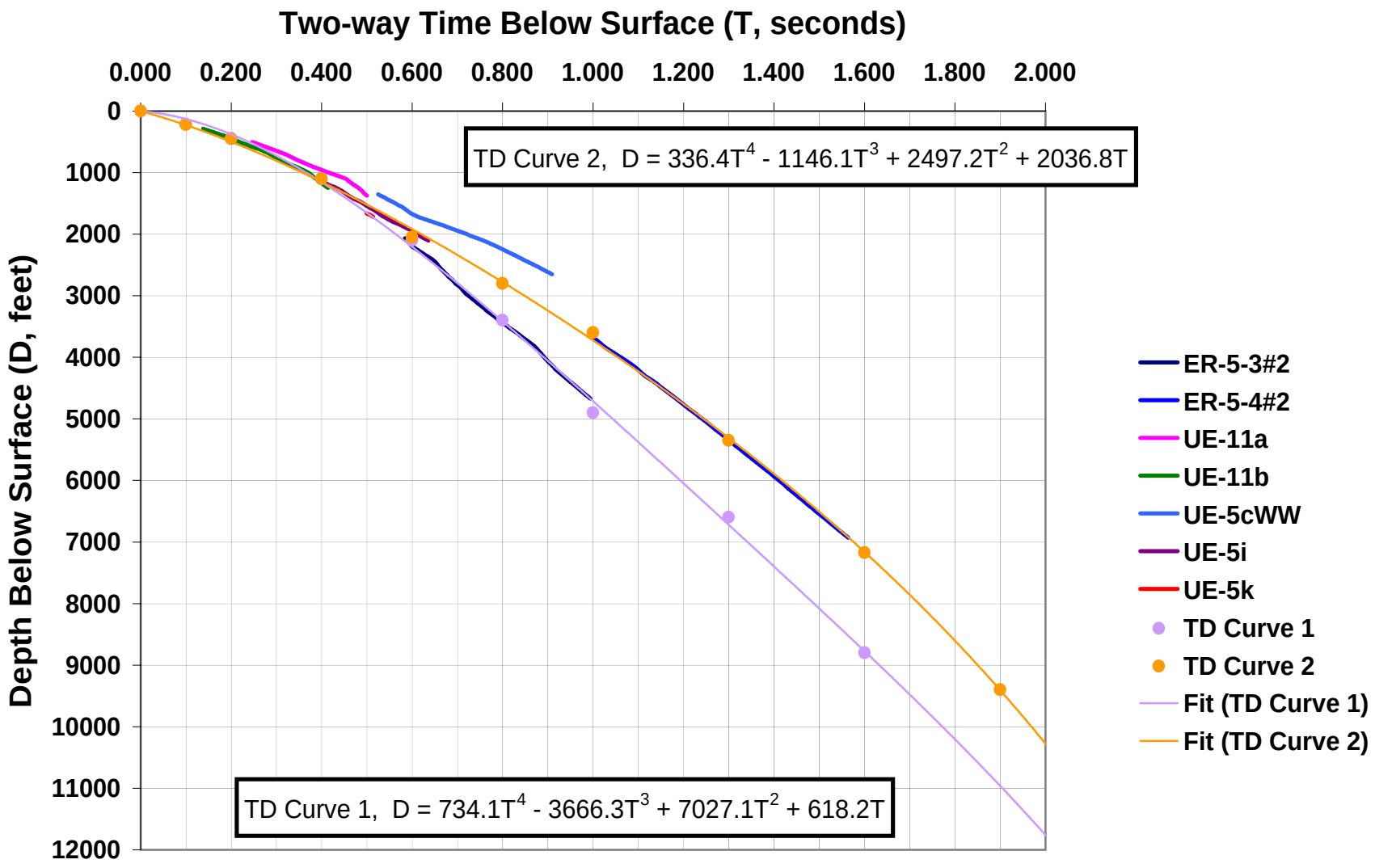



**Figure D.4-18**
**Time-Depth (TD) Curves for Volcanic Rocks**

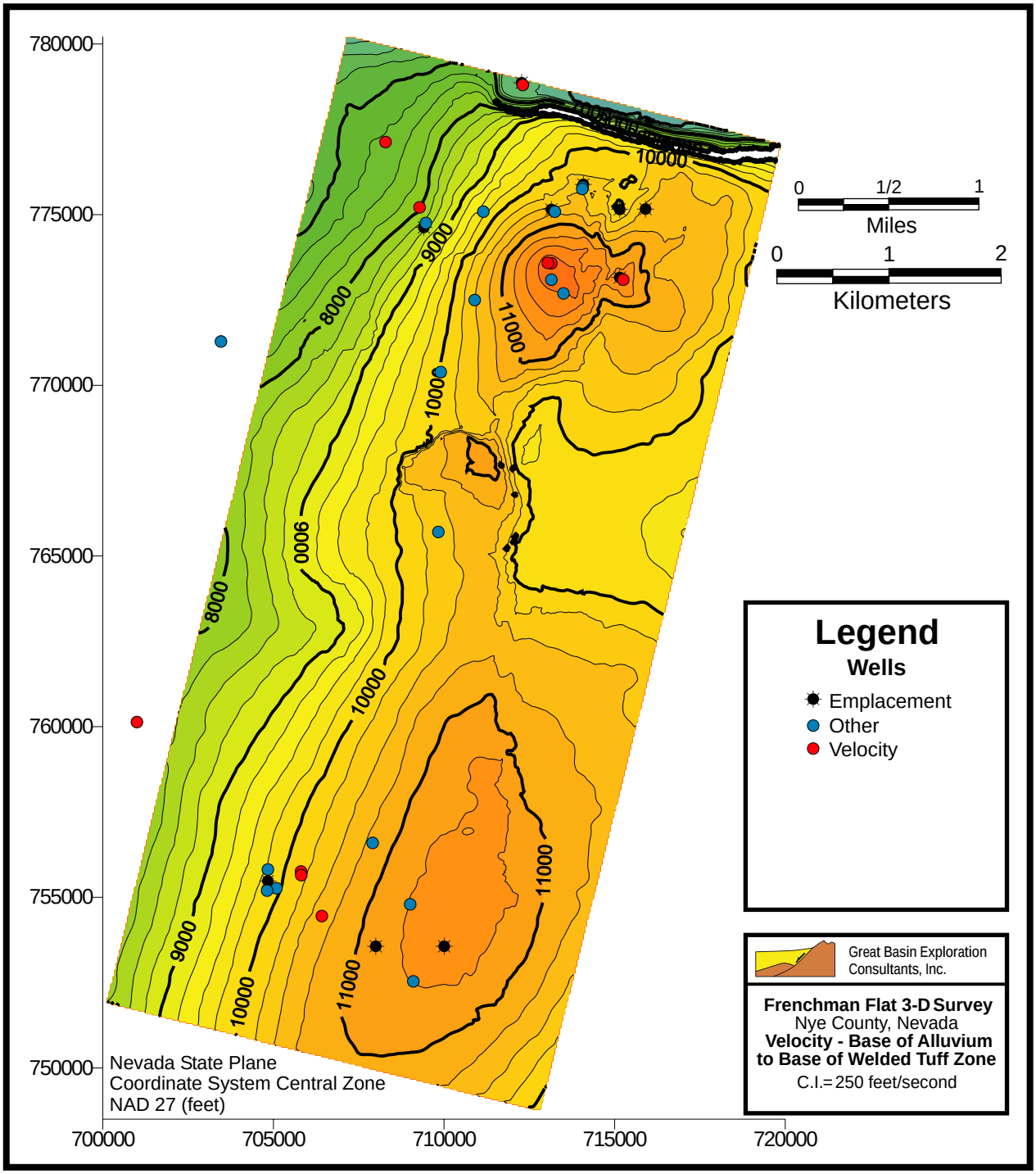



**Figure D.4-19**
**Velocity Map from the Base of Alluvium (BOA) to Base of Welded Zone (BWZ)**

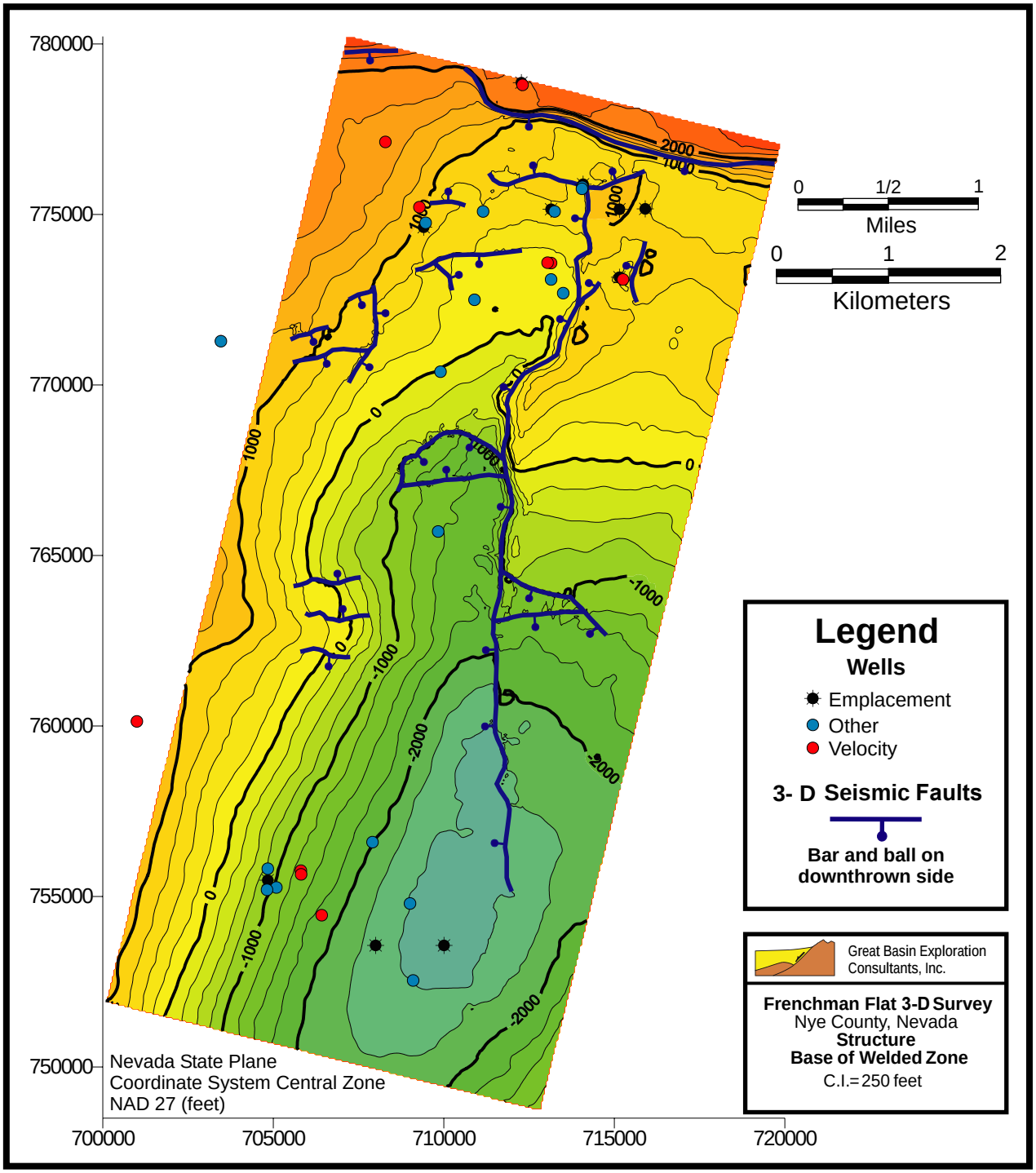



**Figure D.4-20**
**Structure Map of the Base of Welded Zone (BWZ)**

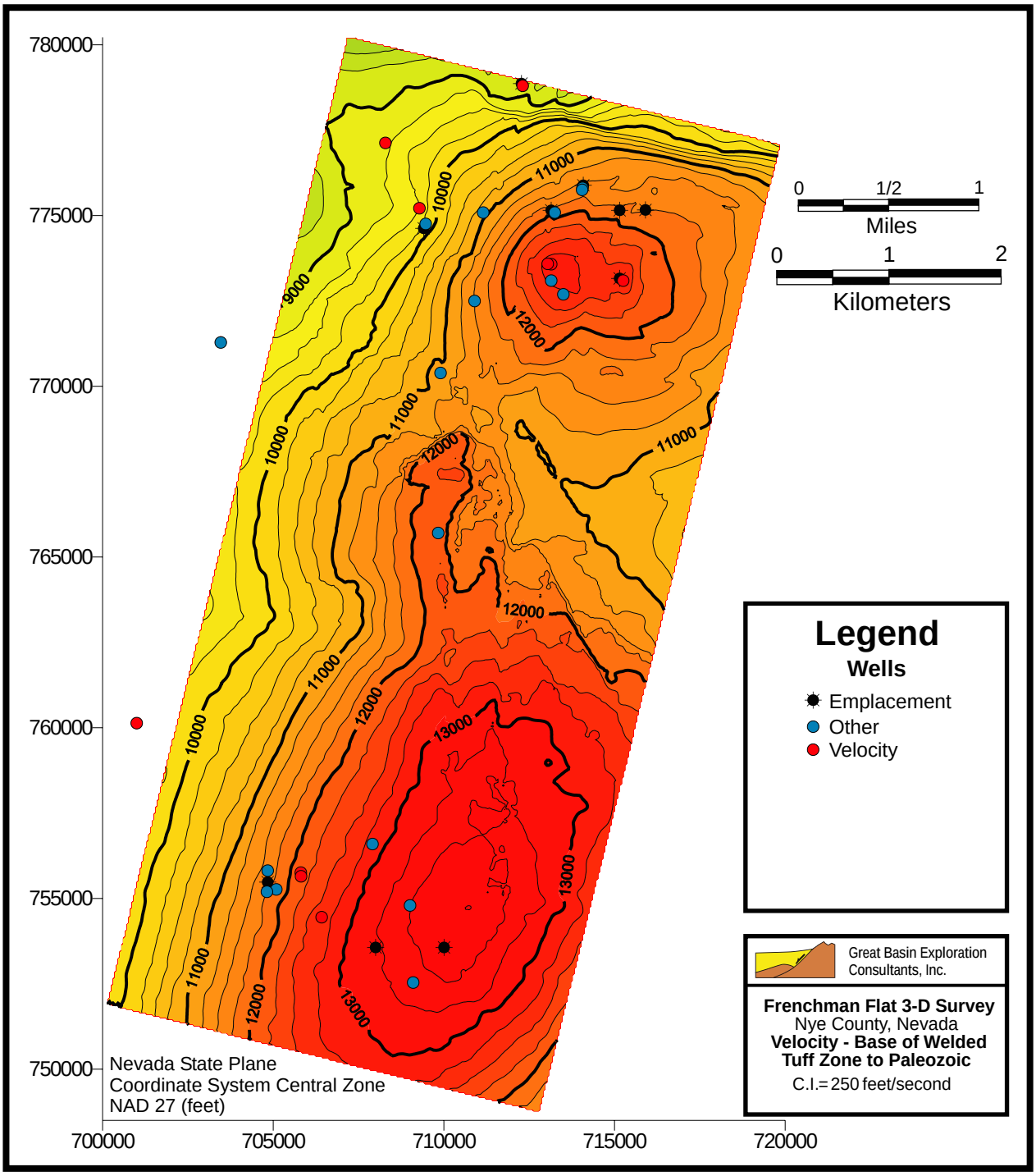



**Figure D.4-21**
**Velocity Map from Base of Welded Zone (BWZ) to Top of Paleozoic Rocks (Pz)**

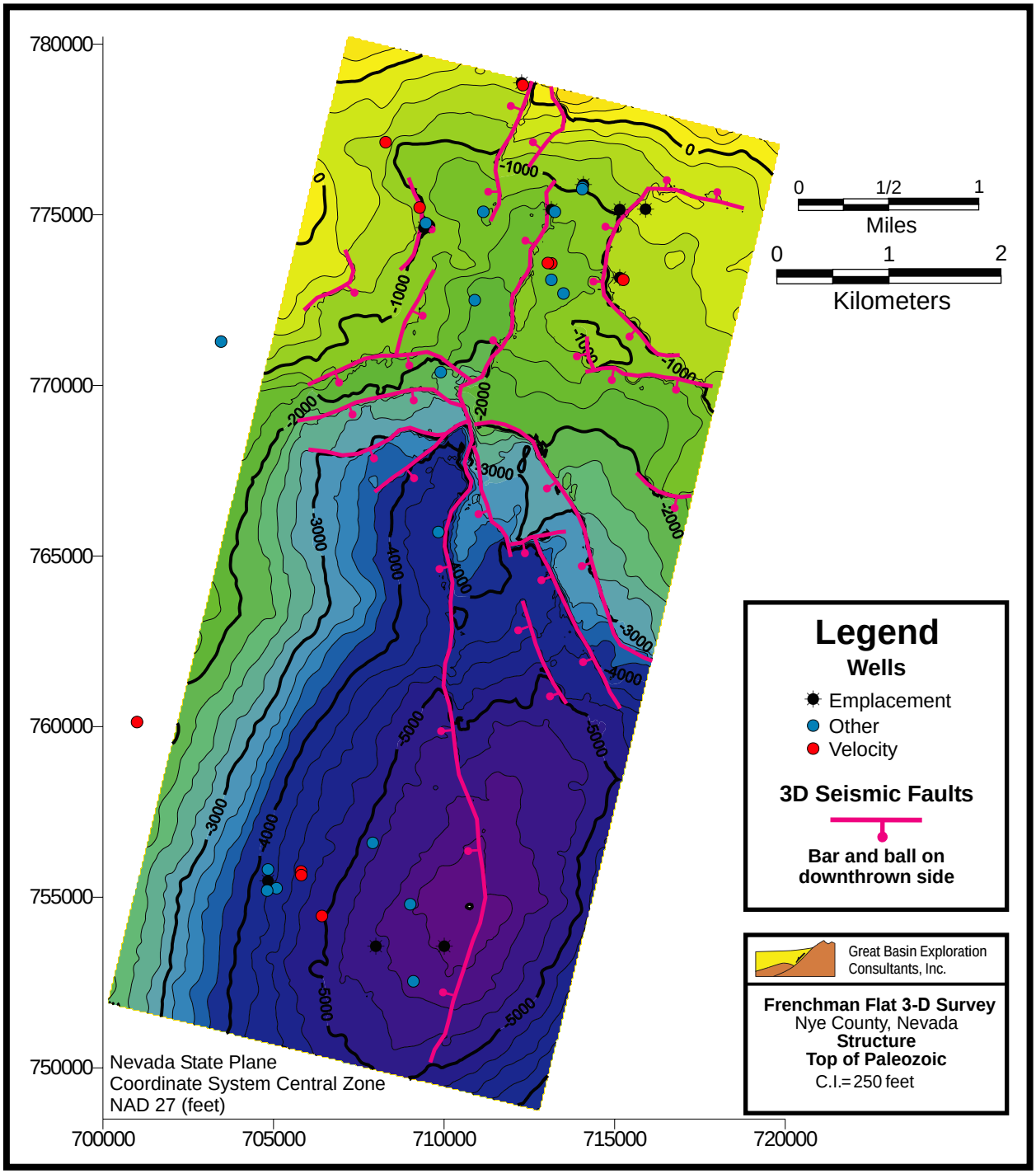



**Figure D.4-22**
**Structure Map of the Top of Paleozoic Rocks (Pz)**

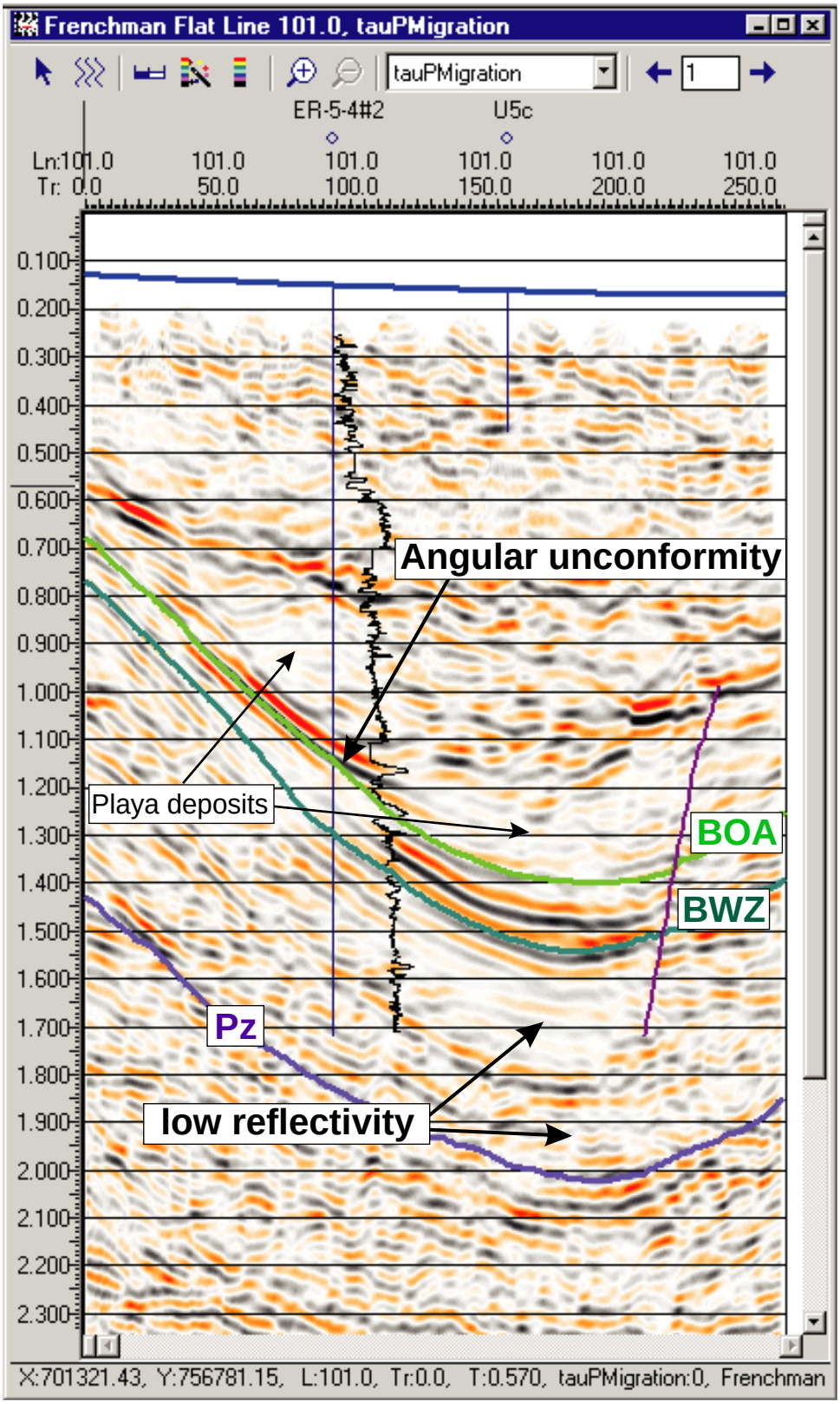



**Figure D.4-23**
**Interpreted Seismic Profile along Inline 101, Looking North.**
**(Log shown is velocity log for ER-5-4#2)**

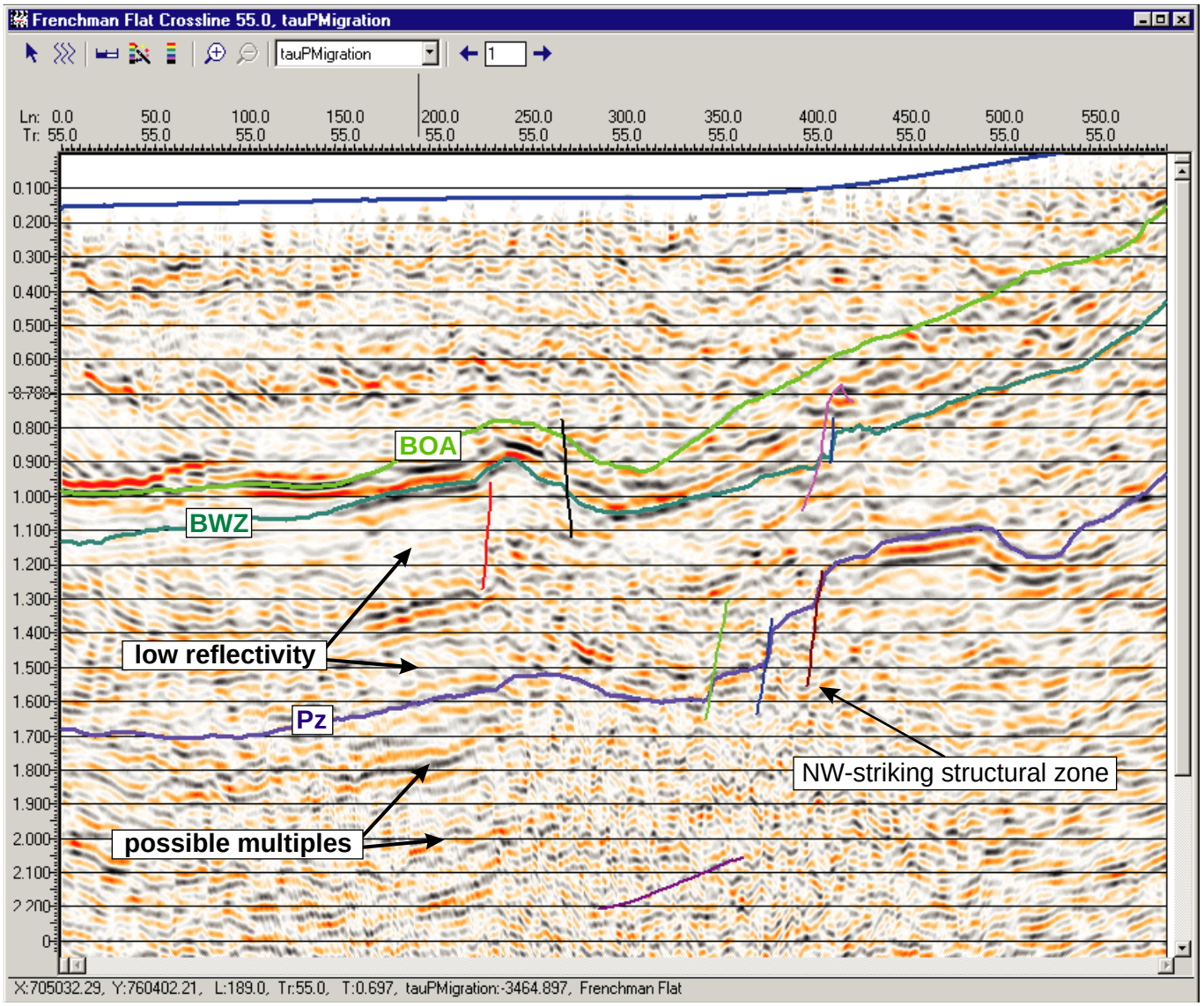



**Figure D.4-24**
**Interpreted Seismic Profile Along Crossline 55, Looking West**

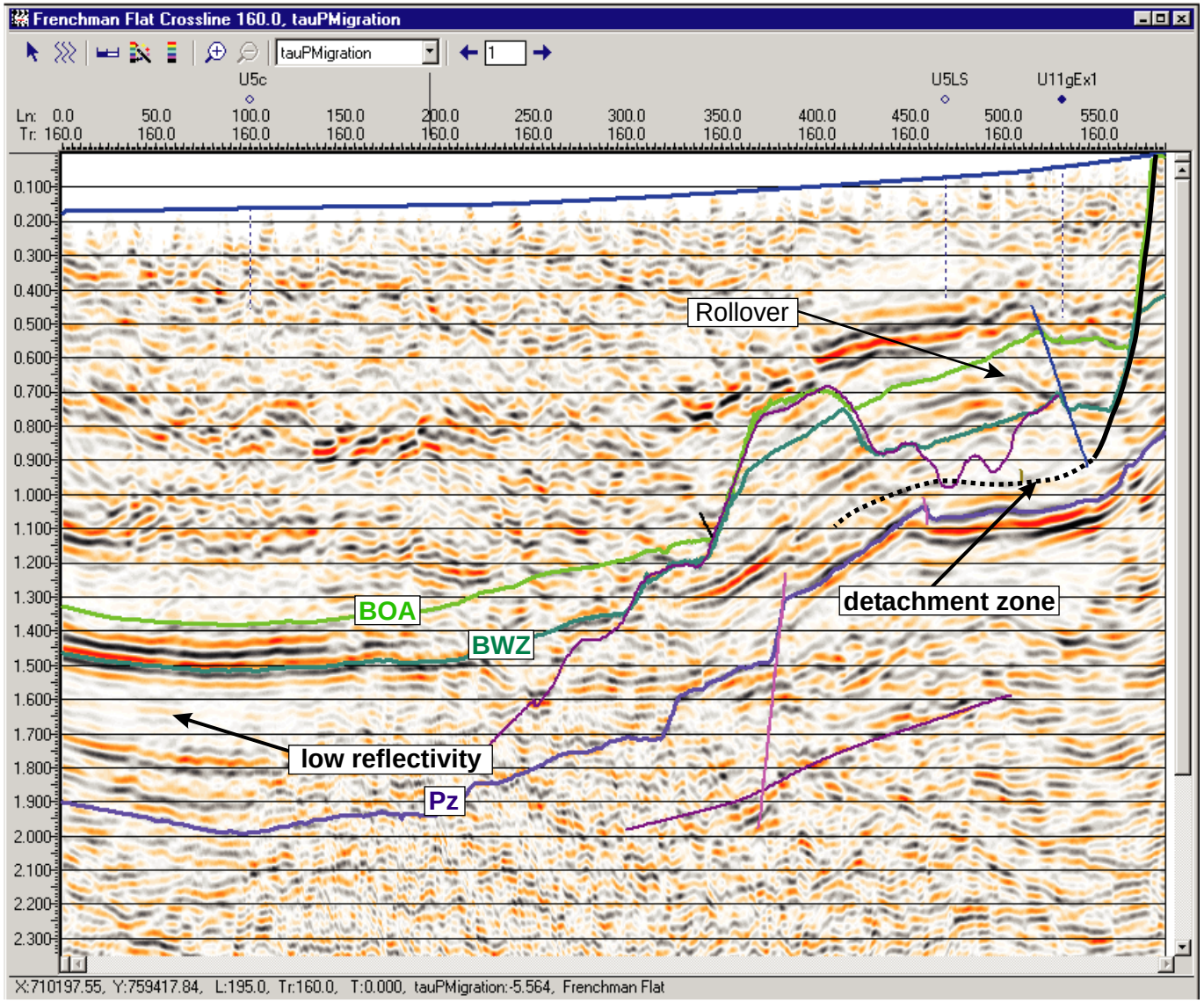



**Figure D.4-25**
**Interpreted Seismic Profile Along Crossline 160, Looking West.**

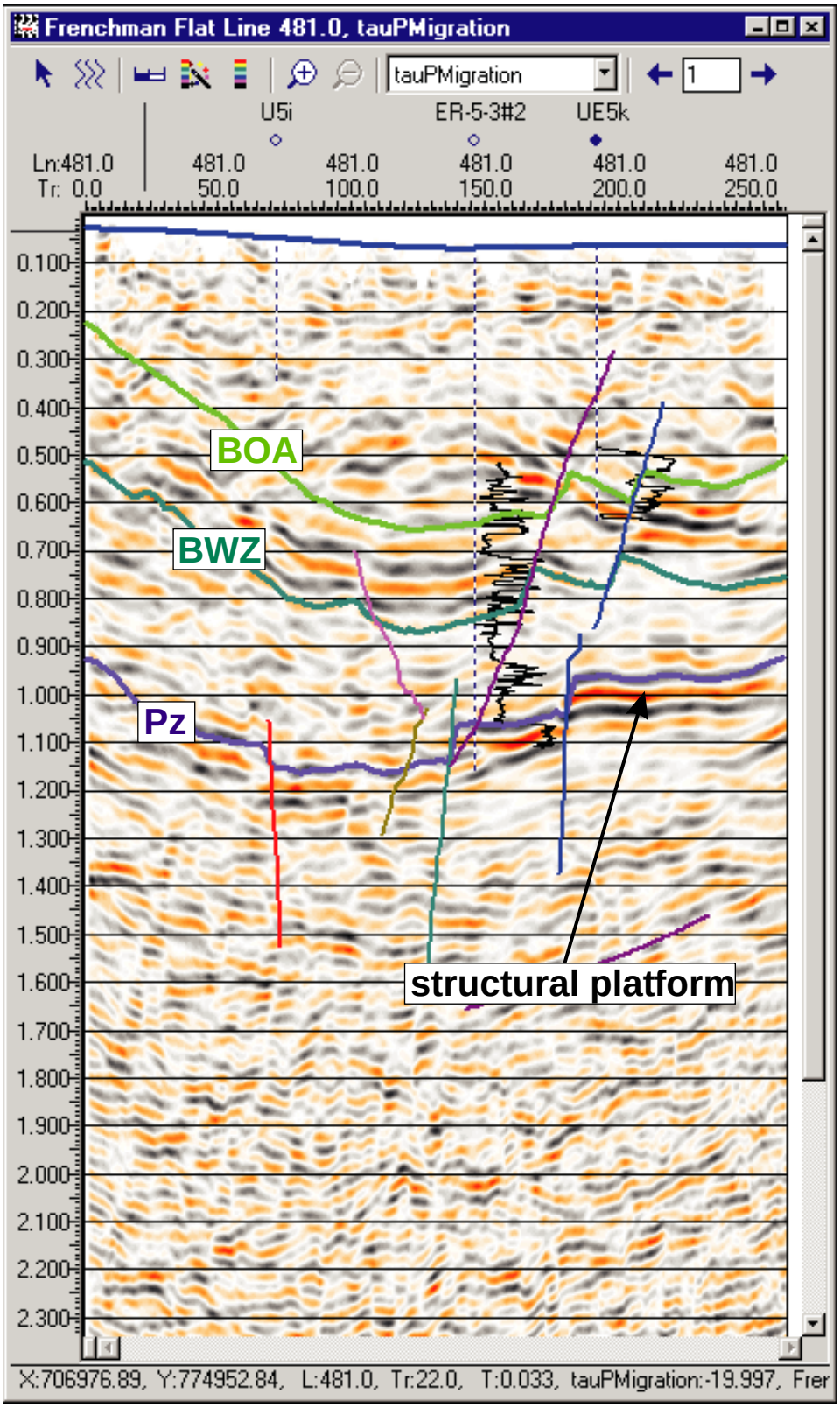



**Figure D.4-26**
**Interpreted Seismic Profile Along Inline 481, Looking North**
**(Logs shown are velocity logs for ER-5-3#2 and UE-5k)**

## D.5.0 Summary

A 3-D seismic reflection survey was conducted in Frenchman Flat to provide subsurface geologic information to better constrain groundwater flow and contaminant transport models. Three seismic horizons were mapped and include from highest to lowest, 1) the base of the alluvial basin-fill deposits (BOA), 2) the base of a zone of Tertiary-age welded ash-flow tuffs (BWZ), and 3) the top of Paleozoic-age sedimentary rocks (Pz). The mapping of these three horizons effectively delineates the extent, thickness, and structural orientation of the alluvial and volcanic aquifers. In addition, mapping of the BWZ and Pz improves constraints on the extent and thickness of the tuff and volcaniclastic confining units that occur between these two horizons. The Pz surface corresponds to the top of the regional carbonate aquifer and thus improves constraints on the depth to and structural orientation of this important aquifer.

Seismic data also revealed the presence of two large and previously unknown structures. A northwest-striking fault zone was identified that separates the Frenchman Flat basin proper from a structural platform on the north. In addition, the seismic data in conjunction with drill hole and outcrop data strongly suggest that much of the northern structural platform overlies a detachment fault within the volcanic rocks.

Results from the interpretation of the Frenchman Flat 3-D seismic data will allow for much more accurate modeling of hydrostratigraphic units in the survey area. Interpretation results also significantly improve and better constrain the structural model of the basin. The improved accuracy and better constraints provided by the seismic data will allow for more realistic evaluation of potential short-circuit groundwater pathways.

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## D.6.0 References


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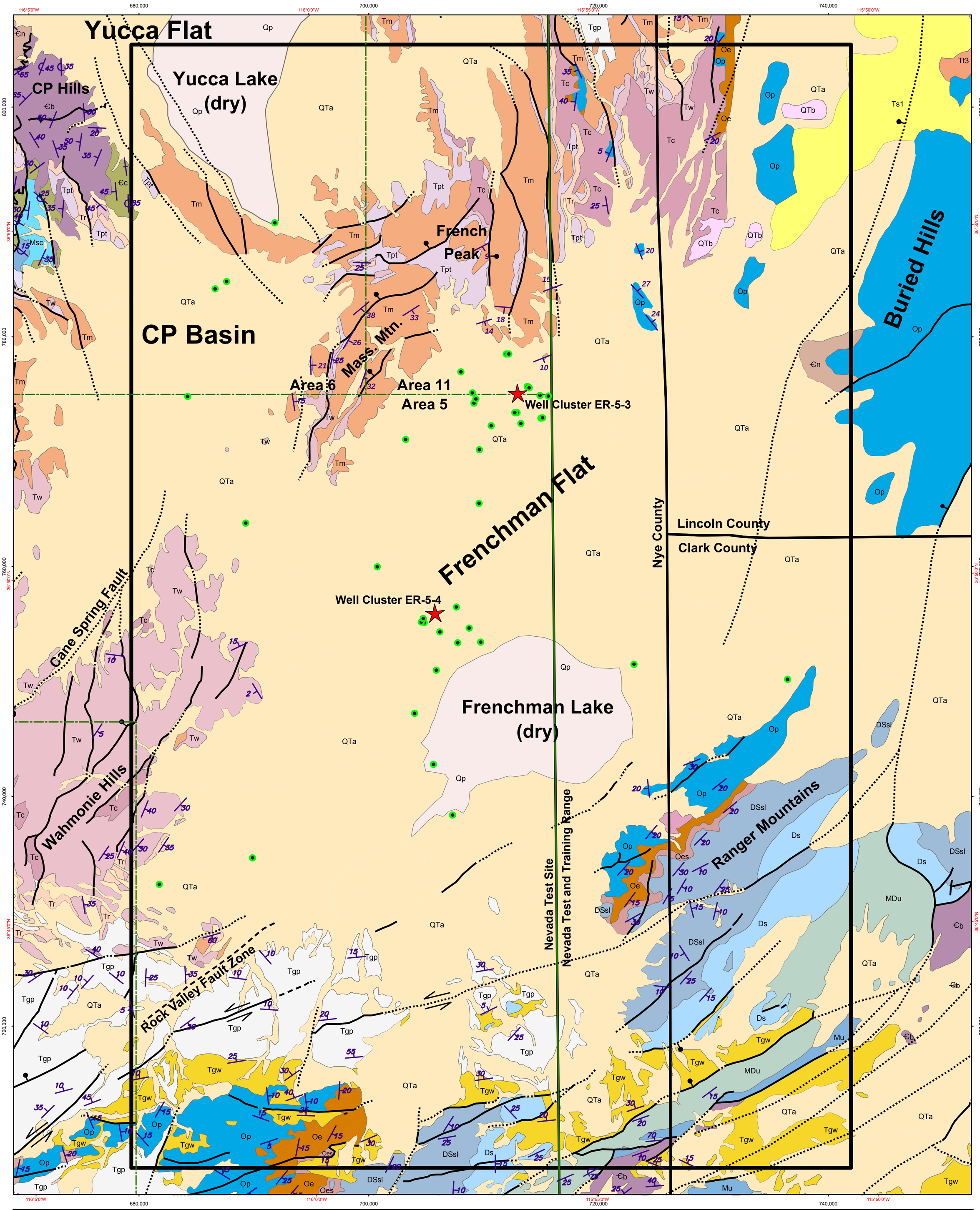
# Plate 1

# Surface Geologic Map of Frenchman Flat and Vicinity




# Plate 1

# Geologic Map of Frenchman Flat and Vicinity

(modified from Workman et al., 2002)

N

Map Scale 1:48,000

## Geology

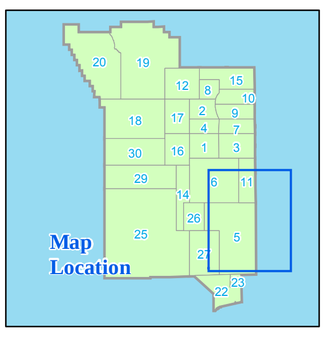
- QTa Quaternary/Tertiary alluvium
- Qp Playa deposits
- Tr Felsic-composition lava flows, undivided
- Tm Tuffs of the Timber Mountain Group
- Tpt Topopah Spring Tuff
- Tw Wahmonie and Salyer Formation, undivided
- Tc Tuffs of the Crater Flat Group
- Tt3 Ash-flow tuffs and interbedded air-fall tuffs, unit 3
- QTb Basaltic lava flows, undivided
- Tb Old basaltic lava flows
- Tgp Rocks of Pavits Spring
- Tgw Rocks of Winapi Wash
- Ts1 Sedimentary rocks, unit 1
- PIPt Tippipah Limestone
- Mu Sedimentary rocks, undivided
- Msc Scotty Wash Quartzite and Chainman Shale, undiv.
- MDu Sedimentary rocks, undivided
- Ds Simonson Dolomite
- DSsl Sevy and Laketown Dolomite, undivided
- Oes Ely Springs Dolomite
- Oe Eureka Quartzite
- Op Pogonip Group
- Ꞓn Nopah Formation
- Ꞓb Bonanza King Formation
- Ꞓc Carrara Formation
- ꞒZws Wood Canyon Formation

- Frenchman Flat CAU Model Boundary
- Principal Holes
- Well Clusters ER-5-3 and ER-5-4
- 30 Strike and dip of bedding (Hinrichs & McKay, 1965 and Slate et al., 1999)

## Geologic fault structures

(from Workman et al., 2002)

- Fault-certain
- Fault-inferred
- Fault-concealed
- Thrust fault
- bar and ball symbol (ball on downthrown side)
- lateral offset arrows




0 1,000 2,000 3,000 Meters

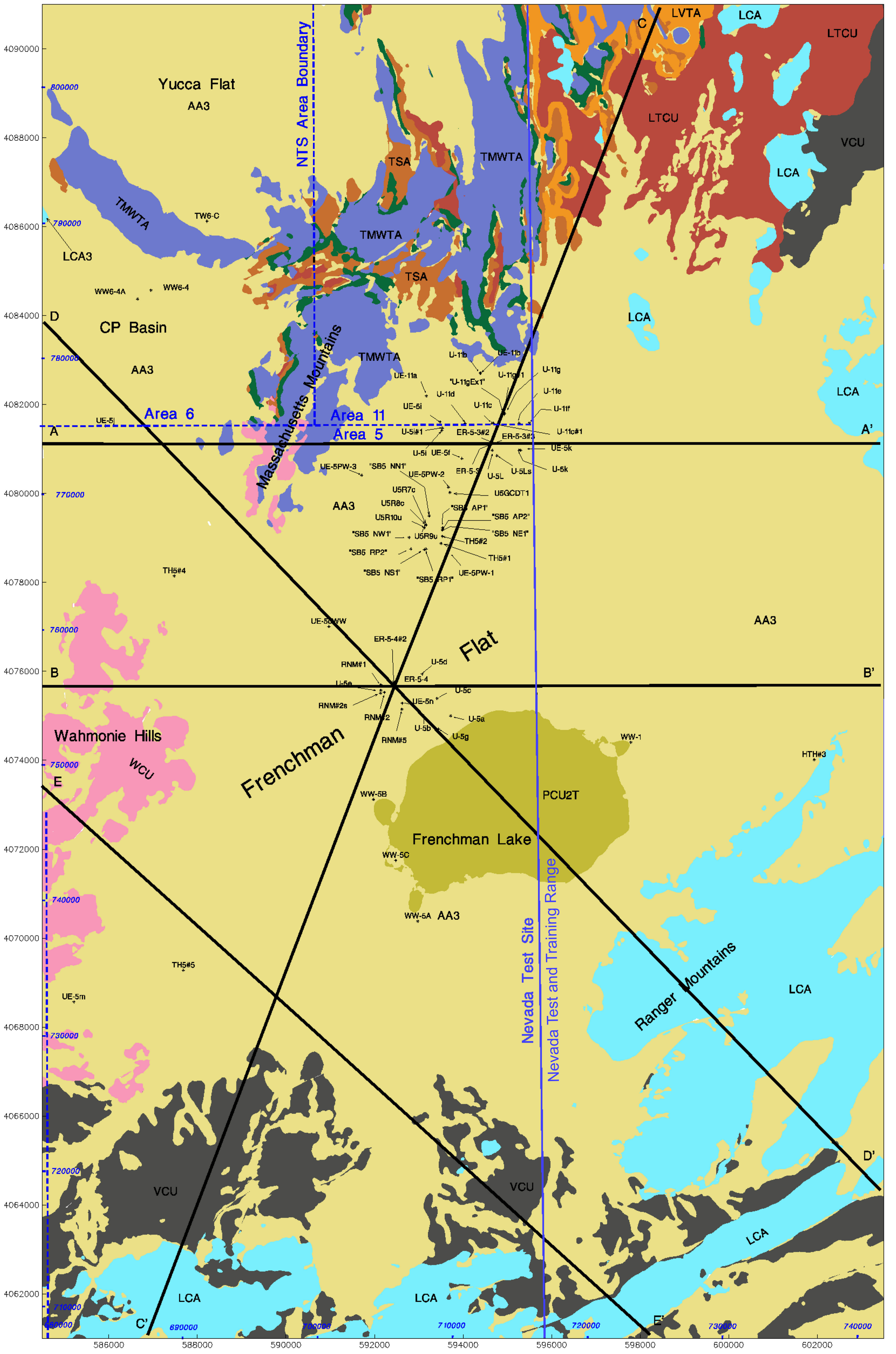
0 0.5 1 2 Miles

Red tick marks are latitude and longitude at 5 minute intervals

Black tick marks are Nevada Central State Plane NAD1927 (feet)

# Plate 2

# Hydrostratigraphic Surface Map of the Frenchman Flat Model Area




ER-5-4 Drill Hole Location

NTS Area Boundary

NTS Boundary

A A' Model Profile Location

N

## Legend

Scale: 1:48,000

UTM Zone 11 NAD 27 meters

*Nevada State Plane Zone 2702 feet*

## Hydrostratigraphic Units

- AA3
- PCU2T
- TMWTA
- TMLVTA
- TSA
- LVTA
- LTCU
- WCU
- VCU
- LCA3
- LCA

clrfill_ALL4EN.ps

May 26, 2005

**Plate 2**

**2-D Plan View of the Frenchman Flat Hydrostratigraphic Framework Model Showing Hydrostratigraphic Units Exposed at the Surface**

(Note: Surface faults are not shown)