post-frac pumping of the well immediately reacts to recharge from the high conductivity fracture.

5.6 Well Loss Drawdown

Figure 36 and the associated analysis provide the well loss coefficients, B and C, from the stepped test data. However, the well loss coefficients cannot be applied in a conventional manner to calculate well loss without caution. The equation for total drawdown in the well, s_w, is as follows:

$$S_w = BQ + CQ^2 \qquad \textbf{Equation 1}$$

where B = linear well loss coefficient
and C = nonlinear well loss coefficient

Equation 1 assumes that nonlinear well loss, CQ^2, is time dependent and predictable by conventional radial flow equations. Therefore, theoretical or "ideal" aquifer drawdown predicted by an equation such as the Theis equation can be subtracted from the total drawdown, s_w, and the difference is well loss drawdown. Equation 1 does not work in the case of the post-frac, 1600-gpm hydraulic performance of Test Well 31, because the ideal aquifer drawdown is not predictable by a conventional linear flow equation, due to the effects of recharge throughout the test response.

6 WATER QUALITY

Preliminary water quality samples were collected during air lift drilling of open hole through the Madison limestone and Whitewood dolomite strata. Figure 43 shows the concentrations of various chemical constituents plotted versus total depth of the advancing borehole at the time of sample collection. In general, all constituents increase somewhat in concentration as borehole depth increases. The plot includes the total dissolved solids concentration from a sample taken at the end of the 12-hour, 900-gpm constant rate, pre-frac aquifer test. Data for the plot are shown in Appendix E.

The data on Figure 43, and the analytical lab report in Appendix E for the pre-frac water quality sample collected during the 900-gpm constant rate test, provide the information about quality of water samples before the well was subjected to acid-frac stimulation.

Post-frac samples consist of iron and TDS data collected during the post-frac 1600-gpm yield and drawdown test and the analytical report for the final sample at the end of the 1600-gpm test. Iron and TDS information are shown with time-drawdown data on Figure 44. The TDS data are based on field measurements with an electrical conductivity meter set to provide TDS values based on the ratio between EC and TDS determined from previous laboratory analysis of water from the well. The final field measurement of TDS provided a value of 780.8 mg/L. A sample collected half an hour later and submitted to the laboratory for analysis had a TDS concentration of 817 mg/L, indicating the TDS meter readings included error due to the conversion factor or need

Figure 43: Water quality data from air lift samples during drilling.

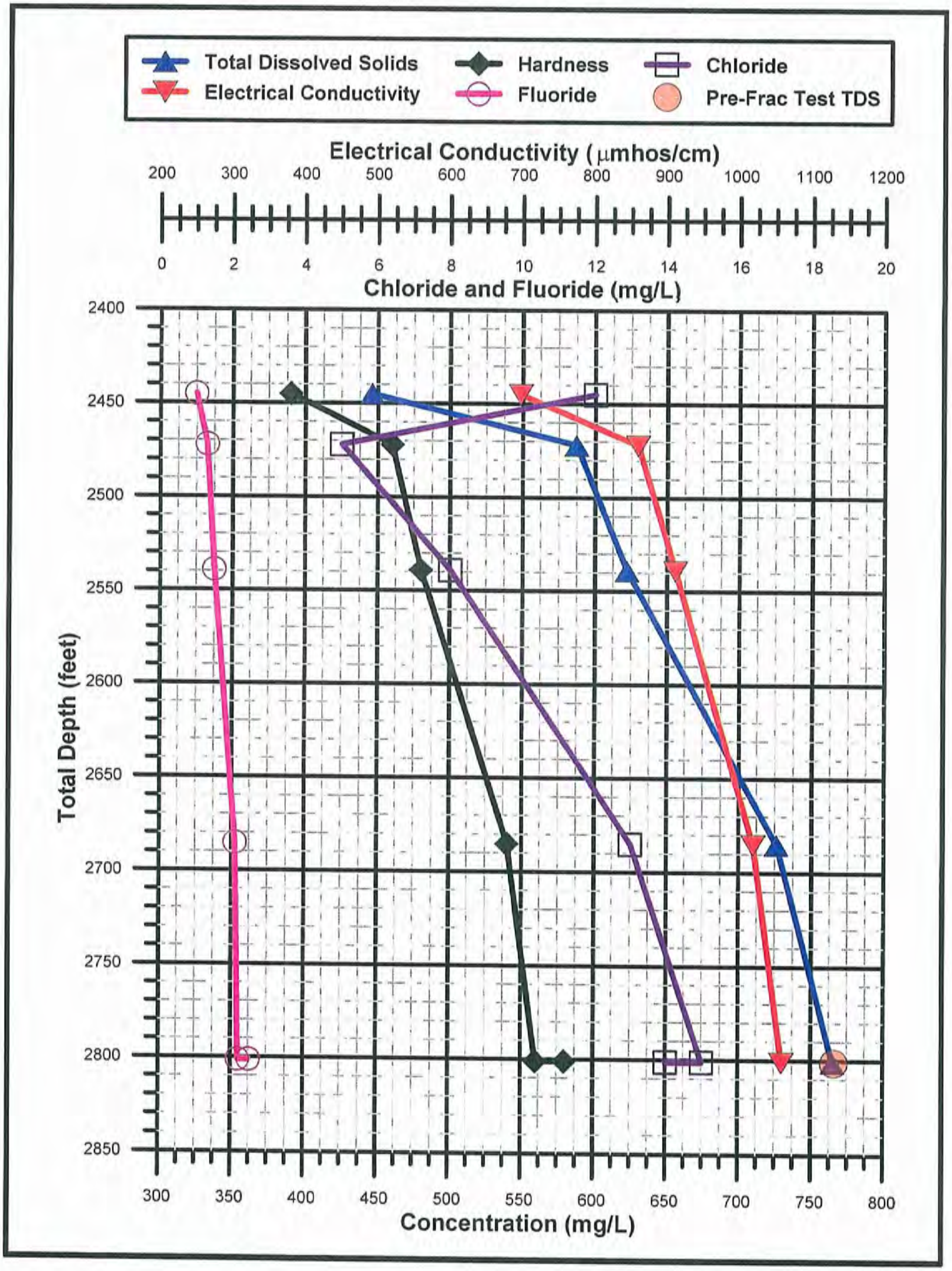
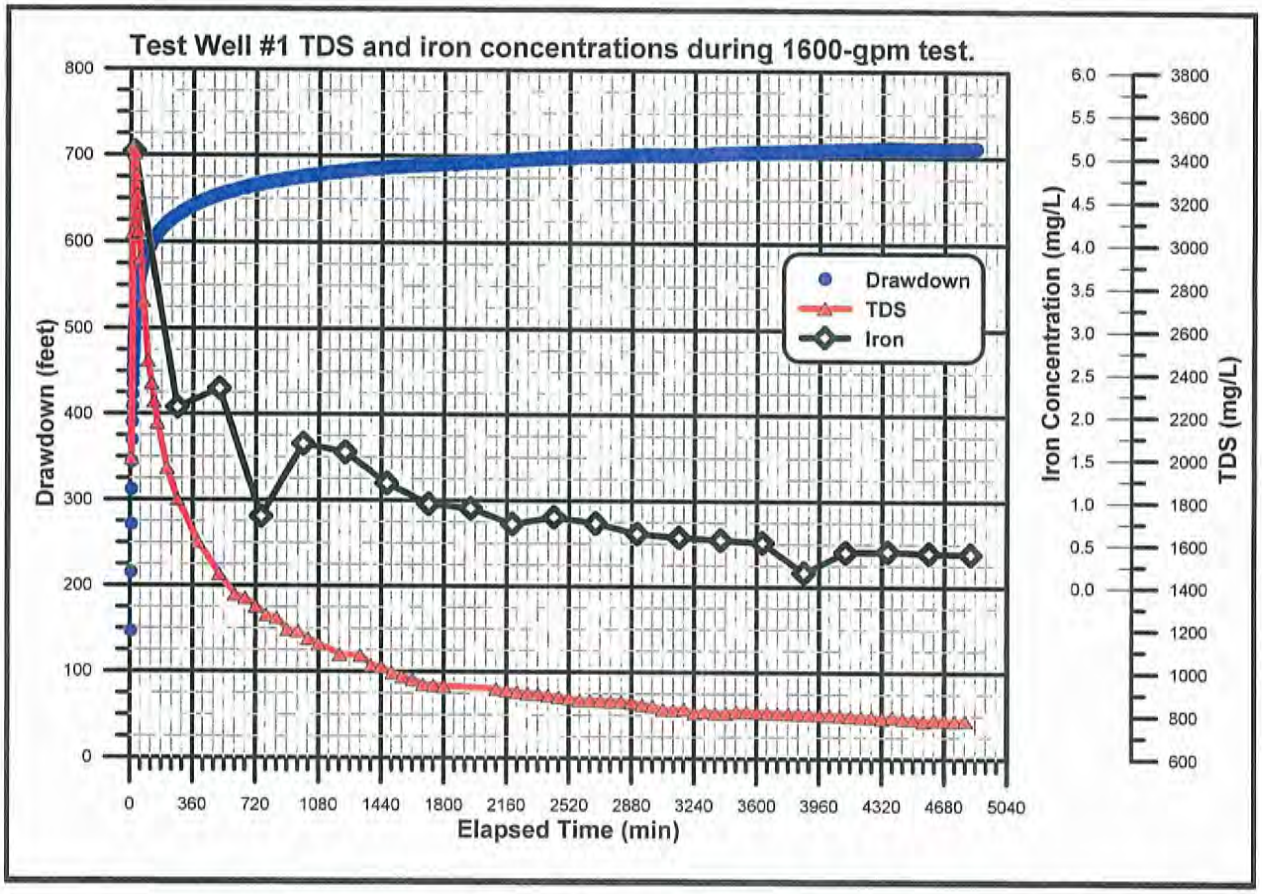


Figure 44: Iron and TDS concentrations during 1600-gpm, post-frac aquifer test.



for recalibration. The final water sample during the 1600-gpm test that was submitted to the lab for analysis of iron concentration provided a value of 0.39 mg/L iron. All iron concentrations shown on Figure 44 are for total iron which includes iron in any sediment produced from the well.

Dissolved iron in the 3/11/2013 sample at the end of the 900-gpm pre-frac test was 0.11 mg/L and total iron in the same sample was 0.63 mg/L. The 3/11/2013 sample laboratory value for TDS was 766 mg/L. The 0.11 mg/L iron and 766 mg/L TDS values from the March 2013 test indicate water quality conditions before acid stimulation of the well. The concentrations of 0.39 mg/L iron and 817 mg/L TDS at the end of the 81-hour yield and drawdown test indicate iron and TDS concentrations remained slightly elevated from pre-frac conditions, at the end of the test.