APPENDIX 2.5-5

AQUIFER TESTING AT THE SOUTH HEART LIGNITE MINE

The aquifer testing program was designed to estimate the transmissivity and hydraulic conductivity of various saturated hydrostratigraphic units within the South Heart Lignite Mine Ground Water Study Area. Constant rate pumping and variable head, or slug, tests were conducted in 21 wells installed in upland areas between September and November 2006. Wells evaluated by pumping tests were chosen:

1. To provide a wide spatial distribution of estimates within the well network;
2. To obtain representative estimates for each of the screened hydrostratigraphic units of the pumping and adjacent wells within both aquifers identified in the Sentinel Butte – Upper Tongue River Aquifer System; and
3. Based on the potential to recharge adequately, as estimated during well development.

Slug tests were conducted on all remaining upland wells with a sufficient water column to test.

Constant Rate Pumping Tests

Constant rate pumping tests were conducted on the 5 wells indicated in Table 2.5-5-1 and Figure 2.5-5-1. Pumping was induced with a stainless steel Grudfos RediFlo2 submersible pump set at an appropriate depth in each of the wells to provide sufficient drawdown during pumping and to maintain safe and efficient operation of the pump. Drawdown was measured with an In-Situ Level Troll 300 or 500 pressure transducer and data logger and confirmed with an electric water level indicator. Flow rates were estimated with a calibrated bucket and stopwatch.

Pumping rates were adjusted prior to testing to obtain an optimal discharge that could be maintained for the duration of the test without pumping the well dry and to minimize turbulent flow in the well. Where time allowed, variable-rate step tests were conducted by pumping the well at several successively higher pumping rates and recording the drawdown. Each pumping rate, or step, was maintained for 30 minutes. Pumping rate and drawdown data from each step were used to estimate an optimal pumping rate for the test. If a step test was not feasible, pumping rates were estimated from: 1) well recovery data collected when the well was developed following installation; and 2) the performance of other wells, with similar completions.

Each well was pumped at a constant rate for approximately 4 hours. Flow rates ranged from approximately 2 to 5 gallons per minute. Throughout each test, drawdown was recorded by pressure transducers and dataloggers in the pumping well and adjacent wells in the same well cluster screened

across different hydrostratigraphic units. Water quality data, consisting of pH, specific conductivity, and temperature, were measured at regular intervals in the discharge water of the pumping well. Once the pump was turned off, transducers continued to monitor changes in drawdown as the water level recovered toward its pre-pumped level. The pumps were equipped with check valves in an attempt to prevent backflow of water into the well after the wells were shut off. However, the check valves did not always operate as intended and reliable recovery data were not considered reliable for test analysis.

Slug Tests

A total of 52 rising and falling head slug tests were conducted in 16 wells indicated in Table 2.5-5-1 and Figure 2.5-5-1. Slug tests were initiated with either a 1.0-inch diameter 5.3-foot long or 1.25-inch diameter 5.4-foot long solid slug. Drawdown measured with an In-Situ Level Troll 300 or 500 pressure transducer and data logger and confirmed with an electric water level indicator.

Slug tests began with measuring the static depth to water and estimating the water column height to determine if enough water was available to completely submerge the slug. The pressure transducer was then installed in the well at a sufficient depth to avoid being disturbed by the introduction of the solid slug. Once the water level returned to static after installing the pressure transducer, the data logger was started and recorded changes in water level on at least a 1 second frequency. The slug was then lowered into the well and hung immediately above the water surface. A falling head slug test was initiated by dropping (i.e., injecting) the slug a fixed distance into the water column to completely submerge the slug and abruptly raise the water level in wells. Water levels were recorded following the slug injection until they returned to static or within 0.1 feet of the pre-test water level. In all but one slug-tested well, a rising head slug test was conducted immediately after the falling head test by rapidly removing the slug from the water column to drop the water level in the well as quickly as possible. As with the rising head tests, water levels were recorded until they returned to static or within 0.1 feet of the pre-test water level. Repeated rising and falling heads tests were conducted at each well if recovery time was within a few hours. Water levels in several wells returned to static conditions only after several days which limited running multiple tests.

Transmissivity and hydraulic conductivity were estimated from several analytical methods with the assistance of the software program AQTESOLV Pro Version 4.5 (Duffield, 2007). Constant rate pumping tests were analyzed using the methods of Cooper-Jacob (1946) and Papadopulos-Cooper (1967). Slug tests were analyzed using the methods of Bouwer-Rice (1976) and Peres et al (1989). A summary of the field derived aquifer properties is provided in Table 2.5-5-1.

TABLES

FIGURES