ATTACHMENT 2: FIELD METHODS FOR DETERMINING WELL YIELD

As defined above, for purposes of this document only, groundwater shall be defined as a zone, stratum or group of strata that is capable of producing and sustaining a yield of 0.5 gallons/minute (GPM) of water over a 24 hour period from a six-inch inside diameter (i.d.) water well.

In many cases it is apparent when the first significant groundwater has been encountered when drilling a test boring. In these cases, it is clear that the strata can produce more than 0.5 GPM and further groundwater sampling is necessary.

The following testing procedures are recommended for those situations where groundwater yield may not meet the 0.5 GPM criteria and therefore will not require additional groundwater monitoring.

If, in the course of drilling, any zones that may produce 0.5 GPM are encountered, that zone should be completed with a properly constructed, fully penetrating monitoring well. This means that the boring shall be drilled into the lower confining layer and screened across the entire target production zone. The monitor well should be properly developed and allowed to stabilize prior to beginning any further testing.

It must be demonstrated that no groundwater bearing zone is present to the required depth of investigation discussed in Section 3.06 above before the WDEQ will issue a letter stating that no groundwater monitoring will be required. This may require the installation of multiple monitoring wells at a site to make the determination if groundwater exists.

One consideration when determining well yield is well diameter. The well yield measured in a 2-inch or 4-inch well will have to be scaled up to represent the yield of a six-inch well in the same formation before it can be compared to the 0.5 GPM criteria. For tests conducted in a 2-inch monitoring well multiply, the yield by 1.19 to obtain the equivalent yield in a six-inch well. For a four inch well multiply, the yield by 1.07 to obtain the equivalent yield in a six-inch well. These scaling factors are based on well diameter v. yield ratio data presented in Driscoll, 1986.

Two methods of testing are recommended to demonstrate whether the potential production zone can yield 0.5 GPM:

Recovery test, or
Constant rate discharge test.

In both cases, careful documentation of all methods used and measurements made is essential and shall be certified by a professional geologist licensed in Wyoming. The documentation should include, but is not limited to: lithologic descriptions, drilling methods, well completion, well development, pumping and or bailing (equipment, rates, and periods), water level measurement, flow measurement, etc.

Recovery test method

The recovery test is conducted by stressing the well and measuring its recovery. The rate of recovery is then converted to a rate of flow into the well. The well is stressed by removing water (by pumping or bailing) until the available head in the well is reduced by at least 80%. Water levels are monitored as the well recovers and recorded with the time since pumping/bailing ceased. Monitoring of recovery can stop when water levels have recovered to 50% of the original available head. The volume of water produced from the well between the maximum drawdown and 50% drawdown level is calculated taking into account storage within the well casing and within the filter-packed annulus. This volume is divided by the amount of time it took to recover to the 50% level to obtain the flow rate into the well. If this calculated flow rate is less than 0.5 GPM then the target production zone will be considered insignificant and further monitoring will not be required.

An example of the recovery test method is presented in Figure 1 below. In this example, a target production zone has been identified between about 60 and 80 feet and the well has been constructed so as to be screened across the entire target production zone which is, in this case, unconfined. The static water level is at 60 ft, the bottom of the well is at 80 feet and the total available head is 20 ft. The water level which represents 80% of the total available head (DD80) is 76 ft, whereas the water level that represents 50% of the total head (DD50) is 70 ft.

The well should be either pumped or bailed until drawdown has reached the DD80 level. Pumping/bailing should be ceased at this point and the stop watch started. Water levels should be monitored as they recover. The stop watch should be stopped when the recovery water level has reached the DD50 level. For this example, the time it took for the water level to recover to the DD50 level is ten minutes. The flow calculations are presented in the figure. The final flow rate into the well was 0.395 therefore no additional groundwater would be required.

Constant rate discharge test method

The constant rate discharge test is conducted by pumping or bailing the well at a constant rate of 0.5 GPM. If a pump is used, the intake of the pump should be set at level that will allow water levels to be lowered by at least 80% of the available head. A variable speed pump and/or valved discharge line should also be used to maintain a constant pumping rate as drawdown increases. The constant discharge rate must be verified with periodic flow measurements. Water levels should be monitored within the well during pumping. This is most easily accomplished using a pressure transducer. At a minimum, water levels should be monitored until they fall below 80% of the original available head or until they stabilize (do not change significantly over time). A target production zone will be considered insignificant if water levels fall below 80% of the original available head while being pumped at 0.5 GPM and further monitoring will not be required. If water levels stabilize above the 80% drawdown mark then the target production zone will be considered significant and further groundwater monitoring will be required.

Example recovery test calculations
to determine if well yield is less than or greater than 0.5 GPM

Proceedure:
»Pump/bail well untill depth to water is at least 76 ft.
»Stop pumping/bailing, start stop watch and record the maximum depth to water (DD_{80}).
»Monitor recovery untill depth to water has reached 70 ft.
»Stop stopwatch when water level has reached 70 ft (50% of available head) and record time (Δt), (Δt=10 min, for this example).
»Calculate flow.

Assumptions:

Borehole radius r_b is 0.25ft (6" dia.)
Well casing radius r_c is 0.083ft (2" dia).

Filter pack: Top is 50 ft,
Effective porosity (n) is 30%

Static Water Level (SWL) is 60ft

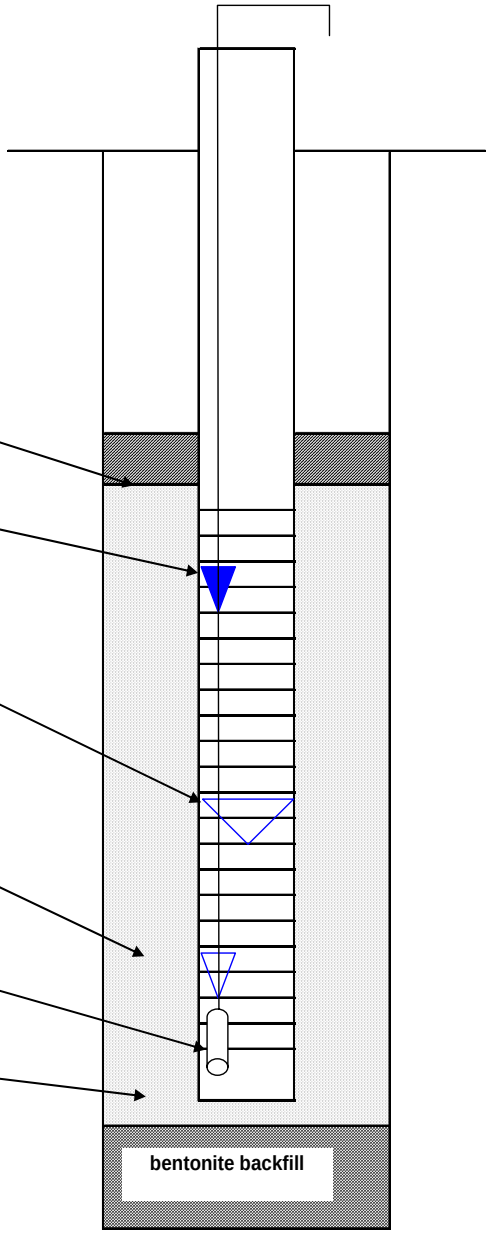
Water level when available head is reduced by 50% (DD_{50}) is 70ft

Water level when available head is reduced by 80% (DD_{80}) is 76 ft

Pump intake below DD_{80}

Bottom of well is 80 ft

Time from end of pumping until water level recovery to DD_{50} is 10 minutes



Computations:

Calculate volume in filter pack(V_f):
V_f = [n x π x (DD_{80}-DD_{50} or T of filter, which ever is lower)] [r_b^2-r_c^2]

Calculate volume of casing(V_c)
$V_c = \pi \times r_c^2 \times (DD_{80}\text{-}DD50)$
$=[3.1416 \times 0.083^2 \times (76\text{-}70)]$
$= 0.130\ ft^3$

Calculate flow:
Flow = (V_f+V_c) x (7.48 gal/ft^3)
= [(0.314 + 0.130) x 7.48] / 1
= 0.33 GPM

Scale up to 6" well:
Flow x 1.19 = 0.395 GPM

Flow is LESS than 0.5 GPM, there for additional monitoring would NOT be required.