MEMORANDUM

To: Lisa Lindemann, Wyoming State Engineer's Office

From: Chuck Brendecke, Emily LoDolce, and Sophia Sigstedt

Subject: Minimum pervious area for a lot based on rural domestic use in the groundwater model

Date: January 31, 2014

This memorandum provides one method of calculating the minimum residential lot size required to provide enough surface area for recharge to balance the depletions from a pumping well, using the values in the calibrated groundwater model. After going through our approach and the numbers used in the model, we provide a table with the minimum lot size per household for various areas of the County.

Methodology and Assumptions

To find the minimum lot size, we assume a mass balance on the lot, i.e. "recharge in = pumping out".

Change in storage is assumed to be zero, as we are looking at the condition where pumping equals recharge. This method also assumes the entire area of the lot is permeable and allows precipitation to infiltrate at the same rate (it doesn't account for the footprint of a house or a driveway, for example). Finally, a well will draw water to itself in a radial manner, so the "minimum lot size" presented here is most accurately the area of a circular property. This means that square or rectangular lots adjacent to each other may have the drawdowns from neighboring wells overlapping their property lines. Because of these assumptions, it may be prudent to increase the calculated minimum lot size by some amount to account for the fact that the calculation is not conservative.

Rural Domestic Pumping

The domestic pumping rate for the model was determined based on an assumed consumptive rate per person, the number of domestic wells in the model area, and the rural population in the model area. The assumed consumptive rate is 85 gallons per capita per day (gpcd), and was chosen as a middle ground estimate after reviewing different sources on the subject. The SEO well permit database provided the number of domestic wells in the model area. The rural population was estimated as the population of Laramie County minus the populations of Cheyenne and other towns (Albin, Burns, Pine Bluffs, and Carpenter). Population data were obtained from the Wyoming Department of A & I, Economic Analysis Division.

Using this information, we calculated a domestic pumping rate for each year in the transient model, 1993-2010. Over the last five model years (2006-2010), the average domestic pumping rate was 320 gallons per day (gpd) per well. In the model, this rate is assumed to be fully

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consumptive, and the wells are only active in the 153-day irrigation season stress period (assumes indoor use is non-consumptive). This translates to each well removing 0.15 ac-ft from the aquifer annually. Using a typical ET requirement of one foot, this implies a lawn of about 0.15 acres or 6500 square feet.

Recharge

Recharge rates in the model were derived from precipitation records (1993 to 2010) and an infiltration percentage derived through model calibration. In the model there are four infiltration zones and one recharge rate per zone per stress period, or 4 x 34 = 136 recharge rates. To simplify, we looked at the annual average recharge rate (average rate over the 34 stress periods) and the annual minimum recharge rate (average of the minimum irrigation season rate and the minimum non-irrigation season rate), to be conservative. Table 1 shows these rates for each zone. Figure 1 at the end of this memo shows the locations and infiltration percentages for the different zones.

Table 1. Recharge Rates from the Groundwater Model

Zone	Percent Infiltrating	1993-2010 Annual Average (ft)	1993-2010 Annual Average Minimum (ft)
1	1%	.00105	.000605
2	4.5%	.0525	.0302
3	5% east	.0117	.00672
4	5% west	.0600	.0369

The 100% infiltration zones shown in Figure 1 represent stream channels; realistically no domestic lots would be located in these zones. The recharge in Table 1 is given in feet of recharge in a year.

Results

Assuming a domestic consumptive pumping rate of 320 gpd in the irrigation season (equivalent to 134 gpd year-round), the minimum pervious lot size required to recharge the pumping depletion varies from 3 acres in Zone 4 to 143 acres in Zone 1, assuming average recharge conditions. In Zone 2, the zone where most of the population centers are located, the lot size range is 3 to 5 acres.

Table 2 presents the results of the analysis.

Table 2. Calculated Minimum Pervious Area per Lot

Zone	Percent Infiltrating	1993-2010 Average Recharge (Acres)	1993-2010 Minimum Recharge (Acres)
1	1%	143	248
2	4.5%	3	5
3	5% east	13	22
4	5% west	3	4

In summary, in Zones 2 and 4, the minimum pervious area per lot is about 5 acres. The minimum total lot size should be larger than this to allow for the house and driveway footprints, and it should be increased if indoor use is consumptive or if the irrigated lawn size is larger than the assumed 6500 square feet.

Sample Calculation

This is a sample calculation using the values provided in the body of the memo and in Table 1.

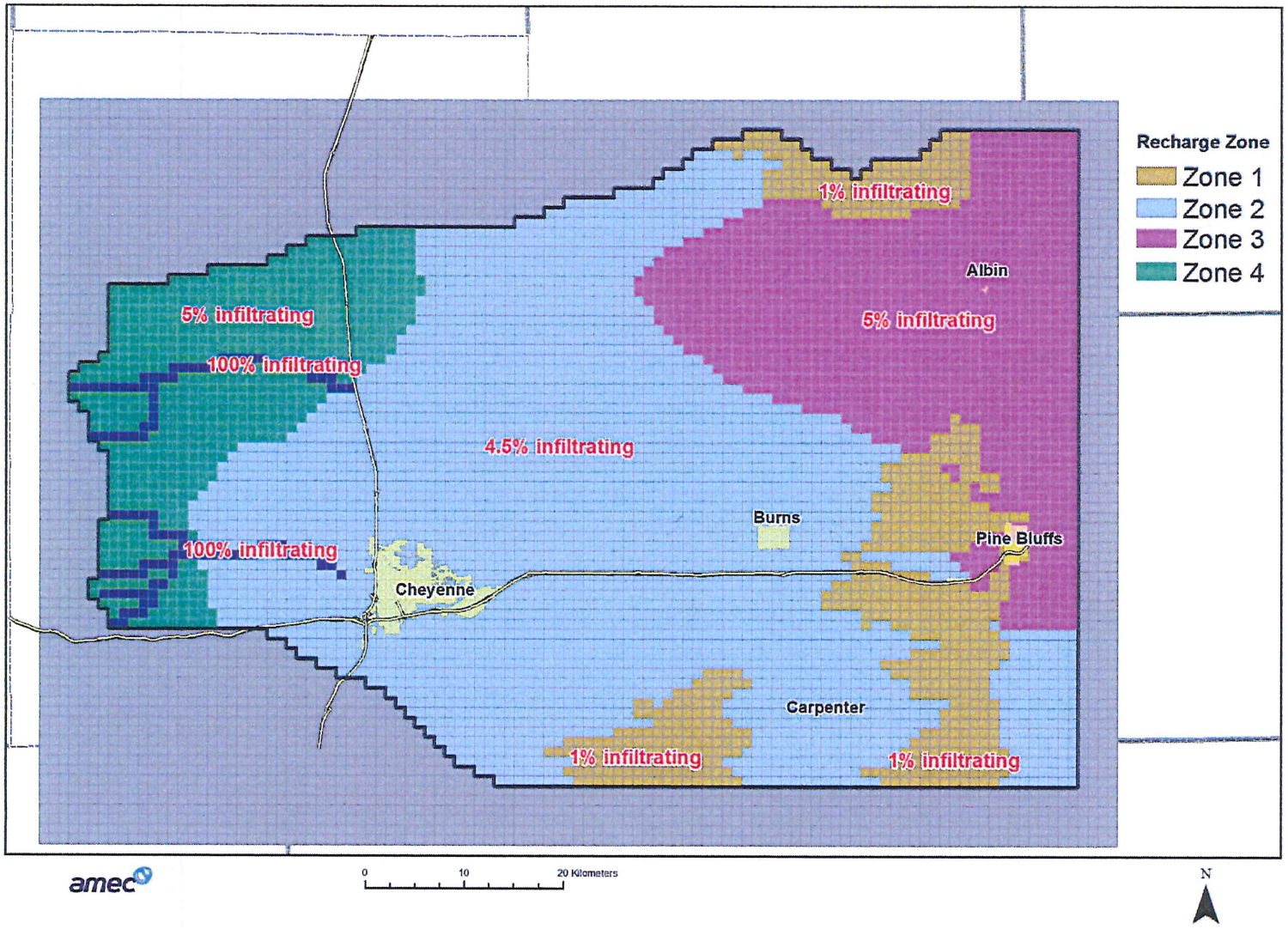
Minimum pervious lot size for property located in Zone 2:

Assumed pumping rate = 320 gpd
Assumed days of consumptive use = 153 days
Pumping depletion from aquifer = 320 gpd * 153 days / 325,851 gallons/acre-ft = 0.15 acre-ft

Annual average recharge rate, from Table 1 = .0525 ft

Minimum lot size such that recharge balances depletions = 0.15 acre-ft / .0525 ft = 2.86 acres

Figure 1: Recharge Zones in the Groundwater Model



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