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From: Richard James, AICP; Aaron Bierman CHg#819

Requested By: Richard LeWarne

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Re: Well Interference

As part of Task 5.1.3 subtask 6, during preparation of revisions to the County's water well ordinance, Bierman Hydro-Geo-Logic reviewed and evaluated literature and well data regarding interference of well drawdown on neighboring wells.

Background. When water is pumped from a well, a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone develops around the well. This depression is referred to as the cone of depression and defines the area of the well's radius of influence. The depth and horizontal extent of the cone of depression is a product of the aquifer's characteristics and the pumping rate. When two wells are drilled sufficiently close to one another, the cones of depression can overlap, and drawing water from one well can potentially have an adverse effect on the other well. This occurrence is referred to as well interference, and can be particularly adverse in the case where a large volume well's cone of depression overlaps a well with a lower volume (for example, an agricultural or community well adjacent to an individual homeowner's well), of if one well is drawing from a shallower area of the aquifer. The smaller or shallower well may experience reductions in water quality or quantity.

Hard Rock Well Data Review. The well data review involved detailed review of 48 hardrock wells spatially distributed across Carmel Valley to assess well storage capacity; constructive interference with other wells; variability of fracturing (aperture width, fracture density, interconnectivity, orientation, and soil cover.

MEMORANDUM

Based on review of 48 pumping tests, perforated in either shale, sandstone, granite or a combination of one or more of the formations, the data indicates that constructive interference is observed only 25 percent of the time during the pumping test; therefore, constructive interference is generally limited and not observed between fractured hardrock wells. However, there are instances (especially where there is a very transmissive fracture system) where wells have been known to have radius of influences ranging from 600-1,000 feet away from the pumping well (Roberts/McCauley, Buchholz, Regan, Delfino Pumping Test). In most instances the constructive interference of wells needs to be determined on a case-by-case basis, because of variations in the tortuosity, interconnectivity, and density of the fractures; how each well is constructed/perforated in regards to the other well; and whether the fracture sets are the same fractures interconnected between wells, or interconnected through secondary fractures.

Based on a limited data set, the constructive interference for fractured hardrock formations is so highly variable that each well, no matter what type of formation it penetrates, needs to be assessed on a well-by-well basis for determining whether there are cumulative significant impacts to other wells and/or sensitive environmental receptors and/or biological resources (riparian areas, wetlands, and/or in-stream flows). Impacts to in-stream flows will be included in a separate memorandum.

Establishing Set-back Distance from Neighboring Wells. A two-tier approach is recommended to establish a safe setback distance. The Tier I approach to evaluate a well's potential impact on neighboring wells should be conducted by the Monterey County Water Resources Agency and consist of an evaluation of the proposed well using the Modified Theis Nonequilibrium equation with regional values of the aquifer parameters. If the Tier I evaluation indicates the potential for five feet or more of drawdown using the regional data, further investigation is recommended. The additional investigation will be referred to as Tier II. A satisfactory Tier II analysis will include a site-specific hydrologic report, as discussed in Chapter 15.08.115, and should be conducted by a qualified professional.

For each sub basin, estimates of aquifer transmissivity , storage coefficients, pumping rate, and pumping duration were used in conjunction with a numerical model utilizing the Modified Theis Nonequilibrium Equation (Driscoll 1986) to provide a range of setback distances to neighboring wells so that pumping impacts of domestic and high capacity wells on neighboring wells is identified and/or mitigated. It should be noted that the estimates of transmissivity used in this analysis were calculated from specific capacity data; this tends to result in slightly elevated transmissivity values, which are generally less reliable than estimates based on type-curve analyses of transient water level data obtained from pumping tests.

The Modified Theis Nonequilibrium equation is:

$$\Delta h = 264(Q)/T (\log (0.3\ Tt/r2S))$$

Where:

264 = Conversion factor for calculating drawdown in feet;

Q = Well's Pumping Rate (gpm);

T = Transmissivity of the Aquifer (gpd/foot);

0.3 = Conversion factor for calculating drawdown in feet;

t = Time since pumping started (days);

r = Distance from center of pumping well to where drawdown is measured (feet);

S = Storage coefficient of aquifer (unitless);

Δh = drawdown (feet);

and assuming the following:

- The aquifer is homogeneous and isotropic;
- The aquifer is of uniform thickness and infinite in aerial extent;
- The aquifer receives no recharge;
- The groundwater surface was horizontal prior to pumping; all water comes from aquifer storage with laminar flow in aquifer and well;
- The well is pumped at a constant rate;
- The well is fully penetrating, and 100 percent efficient;
- The well diameter is small so that casing storage is negligible; and

- Groundwater removed from storage is discharged instantaneously with decline in head.

A range of setback values was derived for each sub basin (presented below) using the numerical model and are based on a neighboring well having either zero feet or five feet of drawdown.

Pressure (180/400 foot Aquifer)

Q = 1,000 gpm

T = 90,000 gpd/foot

S = 0.01 to 0.3

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.01, setback = 20,000-feet; Using S=0.3, setback = 4,000-feet.

Range of setbacks at which a five feet of drawdown would be observed:

Using S= 0.01, setback = 3,100-feet; Using S=0.3, setback = 550-feet.

East Side Aquifer includes North County or Langley area)

Q = 1,000 gpm

T = 39,000 gpd/foot

S = 0.01 to 0.3

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.01, setback = 14,600 feet; Using S=0.3, setback = 2,700 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.01, setback = 6,300 feet; Using S=0.3, setback = 1,150 feet.

Forebay Aquifer (includes Arroyo Seco area)

Q = 1,000 gpm

T = 150,000 gpd/foot

S = 0.01 to 0.3

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.01, setback = 28,000 feet; Using S=0.3, setback = 5,200 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.01, setback = 1,150 feet; Using S=0.3, setback = 200-feet.

Upper Valley Aquifer

Q = 1,000 gpm

T = 225,000 gpd/foot

S = 0.01 to 0.3

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.01, setback = 34,000 feet; Using S=0.3, setback = 6,300 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.01, setback = 250 feet; Using S=0.3, setback = 50 feet.

Seaside Basin

Q = 1,000 gpm

T = 4,776 gpd/foot

S = 0.0006 to 0.08

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.0006, setback = 20,900 feet; Using S=0.08, setback = 1,810 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.0006, setback = 18,850 feet; Using S=0.08, setback = 1,632 feet.

El Toro Basin

Q = 1,000 gpm

T = 2,089 gpd/foot

S = 0.01 to 0.3

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.01, setback = 3,390 feet; Using S=0.3, setback = 619 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.01, setback = 3,326 feet; Using S=0.3, setback = 591 feet.

Carmel Valley Alluvial Aquifer:

Q = 1,000 gpm

T = 4,750 gpd/foot

S =0.026

K = 864 m/day

Range of setbacks at which zero drawdown would be observed:

Using S= 0.026, setback = 3,167 feet.

Range of setbacks at which a five foot drawdown would be observed:

Using S= 0.026, setback = 2,855 feet.

References

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Driscoll, Fletcher G. *Groundwater and Wells,* 1986.

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Yates, Eugene B., Martin Feeney, and Lewis Rosenberg. *Seaside Groundwater Basin: Update on Water Resource Conditions*. 2005.