Strategically Designed Pumping to Maximize Induced Ground Water Recharge to the Wanapum Aquifer System in the Moscow, Idaho Area

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Introduction

The city of Moscow currently pumps ground water from both the Wanapum and Grande Ronde aquifer systems. Water levels in the deeper Grande Ronde aquifer system have been declining steadily for the past century. The Wanapum aquifer system hydraulically is much more dynamic than the Grande Ronde, and is known to receive substantial recharge annually. Currently the Wanapum aquifer system shows seasonal water level fluctuations, but also much more stable and controllable water levels than the Grande Ronde aquifer system. The Wanapum is used primarily as a supplemental source of water to help mitigate the declining ground water levels in the Grande Ronde by reducing the need to pump the deeper, older ground water. Well Moscow 2 currently is the primary municipal pumping well in the Wanapum aquifer system.

Hypothesis:

Additional ground water recharge to the Wanapum Aquifer System can be induced by controlling hydraulic gradients strategically in time and space.

Objective:

Increase and maintain drawdown in the Wanapum Aquifer System while surface water is available for recharge.

Implementation:

Double the volume of water pumped from the Wanapum Aquifer System during wet months of November-May.

A long-term aquifer test was designed to double the typical hydraulic stress to the Wanapum Aquifer System from November 2007 to May 2008. The aquifer test was started on November 8, 2007 and continued for 73 days until the pump failed on January 20, 2008.
The aquifer was allowed to recover for 80 days until Moscow started pumping well Moscow 3 on April 11, 2008, because of the need for water.

Monitoring Wells

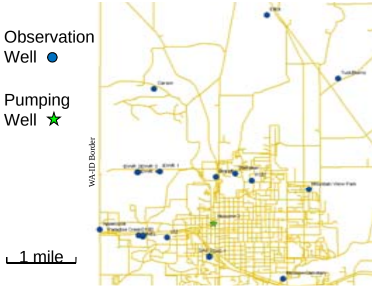

Figure 1 – Locations of Observation Wells Relative to the Pumping Well

Geology

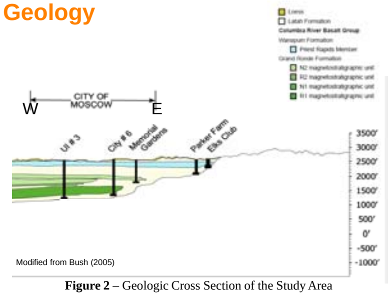

Figure 2 – Geologic Cross Section of the Study Area

Moscow is located in the eastern portion of the Palouse Basin, the geology in the Moscow area consists primarily of Columbia River Basalts and the Latah Formation sediments (both of Miocene age). The city of the Moscow is bounded by horseshoe shaped exposures of crystalline rocks that consist of Cretaceous age granites, and Precambrian and Cambrian metasediments. The Latah Formation consist of clays with sand and gravel lenses, the Vantage Member of the Latah Formation is an interbed layer between the Grande Ronde and the Wanapum basalts. Above the Wanapam basalt is another Latah Formation layer known as the Sediments of Bovill, this unit thins to the west (Figure 2) and is generally non-existent beyond the WA-ID border.

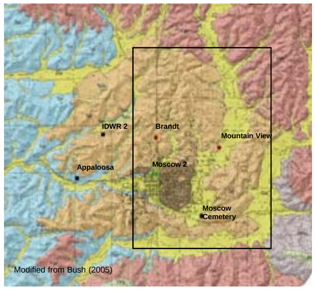

Figure 3 – Surface Geologic Map of the Moscow Area

The granites and metasediments create topographic highs in the Moscow area, such as Moscow Mountain and the Palouse Range, as well as Paradise Ridge. These units provide very little water and are considered to be impermeable boundaries. These geological boundaries shown (purple and red) in Figure 3, must be taken into account when doing any hydrologic analyses in the Moscow area. The black rectangle illustrates the boundaries used in the preliminary analysis (Figures 5-6). The northern, eastern, and southern boundaries are estimated based on the location of granite and metasediment exposures. The western boundary is based on a hydrologic boundary that preliminarily appears to exist between the Moscow 2 well, and the Appaloosa and IDWR 2 wells..

Conceptual Model

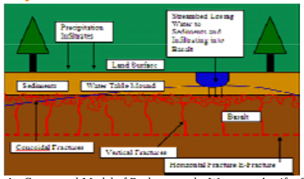

Figure 4 – Conceptual Model of Recharge to the Wanapum Aquifer System

Local streams (Paradise Creek, South Fork of the Palouse River) lose water to the sediments during high stream stages (Nov.-May). The water is distributed over throughout the areas, where it is then allowed to infiltrate into the Wanapum basalt.

Observations and Analysis

BETCO© was used to remove fluctuations from water level data due to barometric pressure variations.
AQTESOLV™, was used for preliminary analysis. AQTESOLV™ develops a type curve, representing a theoretical drawdown response for specific test conditions and methods of analysis, based upon the principle of superposition.

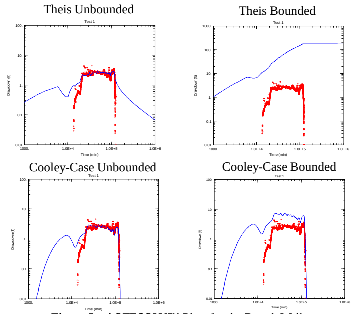

Figure 5 – AQTESOLV™ Plots for the Brandt Well

Drawdown was only measured in 2 of all the observation wells that were monitored (Figure 1). The two responsive wells were the Brandt and Mountain View Park Wells. Observations from these wells were used in this analysis (Figures 5-6). For preliminary analysis, the observations were plotted (red squares), along with the Theis curve where all the assumptions were met (unbounded). The changes in pumping rate during the test are marked by the change in slope of the blue type curve, which fits exceptionally well during the test. However, Thies was a poor fit for the early time data, and the recovery data (recovery occurs much faster than Theis predicts). When the boundaries surrounding Moscow are placed into AQTESOLV™, it is easy to see that Theis (bounded) is not the proper solution as it predicts over 120 feet of drawdown. The immediate recovery observed in the Brandt well, suggest that water is coming into the system to offset the drawdown that is expected due to the boundaries. Because there are no major surface water features, it is most reasonable that water is leaking from the geologic formations above the producing zones.

Observations and Analysis cont.

When leakage models are applied, the fit is exceptional for all portions of the test besides the early time data. The Cooley-Case method created a type curve that fit the observations much better than the Theis method. When the boundaries are applied to the Cooley-Case (leaky) analysis, the expected drawdown increases, while the overall shape of the curve stays the same. Matching the curve to the observations, increases the storage and transmissivity values, but maintains the desired fit.

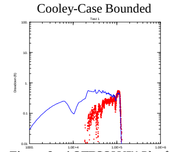

Figure 6 – AQTESOLV™ Plot for the Mountain View Park Well

Observations from the Mountain View Park well were also analyzed using the Cooley-Case method (Figure 6). The results are not as clean as the Brandt observations are, however, the end of the test fits well as does the recovery portion of the observations. There could be many factors influencing the poor fit at the beginning of the data, including the proximity to the boundaries and the formation the well has been completed in.

Summary

Preliminary analysis of the aquifer test data suggests that boundary effects caused by basin perimeter granites and metasediments are masked by leakage from a water table aquitard (Latah Formation sediments) that overlies the Wanapum Basalt.

Pumping induced hydraulic gradients appear to have caused significant vertical leakage (i.e., recharge) to the Wanapum Aquifer System during the 73-day pumping period and the 80-day recovery period. If it can be shown that the vertical leakage seen in the aquifer test data is from the aquitard overlying the Wanapum Aquifer System and not from an underlying aquitard, it may be feasible to control ground water/surface water interaction seasonally by controlling pumping strategically in time and space.

It may be possible to stress the Wanapum Aquifer System heavily during wet periods and periods of high stream flow to increase recharge while maintaining stable ground water levels on an annual time scale.

Refrences

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Acknowledgments

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