



May 19, 2015

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SUBJECT: DRAFT EVALUATION OF GOLDER REPORTS – SODA CREEK P4
(MONSANTO) WATER RIGHTS TRANSFER

Dear Mr. Harris:

This is a summary of issues of concern to be addressed at the May 21, 2015 P4 Transfer Hearing.

1. Two documented northwest trending faults separate the aquifer in this area into two parts. These faults are named the Subsidiary Fault (western) and the Monsanto Fault (eastern) and are documented by Dion (1974), Ralston (1988) and Golder (1995). According to Golder, Sodic water occurs to the west of the fault and fresh water occurs to the east. Water discharged to springs tributary to Soda Creek includes “fresh” groundwater and “sodic” groundwater (Golder, 2015, page 11), so, according to Golder, water chemistry is a hard and fast distinction between ground waters on either side of the fault. Also, Golder, 2014c, has documented that the faults “are hydraulic barriers in the vicinity of the Plant based on lack of ground water response in wells west of the fault to pumping of the Plant wells” (page 7). The presence of the faults is not contested. It is a major component of Golder’s argument that the calculations of stream depletion are conservative.
 - a. I count six times in the April 9, 2015 report where Golder states that the south wells are to the east of the faults (pages, 7, 8, 11, 12 and 13).
 - b. However, inspection of the location of the fault as mapped by Ralston 1988 (Attachment A) shows that the south wells are west of the faults. On page 8, first paragraph, Golder refers to mapping by Dion 1974 and Ralston, 1988 as the location of these faults. However, Golder Figures 1, 2, and 5 show the faults to be plotted more westerly. No explanation for moving the faults is provided.
 - c. Whether the south wells are to the east or west of the faults is critically important because if they are to the east and on the same side as the Plant Wells, then the calculations presented by Golder are defensible. If the South Wells are to the west of the fault, on the opposite side of the faults from the Plant Wells, then I argue that the transfer impacts to Soda Creek and the springs to the west should be treated as a new POD. This is because pumping of the Plant Wells currently has no impact on Soda





Creek and the western springs, because of the hydraulic barrier, prevents the cone of depression from propagating to the creek.

- d. This means that instead of taking the difference between creek impacts from pumping of the Plant Wells and proposed pumping of the South Wells, and calling it incremental depletion, the full creek impacts from pumping the South Wells should be considered. That is, since the Plant Wells are currently not impacting the Creek due to the hydraulic barrier (bottom of page 7) crossing the fault with pumping wells is a new impact, not a change in impacts.
- e. Because the POD has been moved across the hydraulic barrier, the aquifer impact (drawdown) is greater because the barrier cuts off half the aquifer. The effect of barrier boundaries on ground water flow is widely known and it increases aquifer drawdown, i.e. image well theory.
- f. Another factor that will increase pumping impacts is that the valley is very narrow due to the presence of the barrier boundary (faults) on the east and Chester Hill to the west. The calculations presented by Golder are based on an infinite aquifer, which is not the case.
- g. Figure 1 shows the domain of an AQTESOLV model that is 4200 ft wide and 24,200 feet high. The east and west sides are no flow boundaries representing the hydraulic barrier (faults) and Chester Mountain, respectively. I have run AQTESOLV for different boundary conditions using numbers from Golder; Transmissivity of 60,000 ft²/day and Storativity of 4.3 e-4.
 - i. Figure 2 is an infinite aquifer with no boundaries. This represents Golder Case c.
 - ii. Figure 3 is a model with no flow boundaries on east and west. A constant head boundary is enabled at the north end such that the model pulls unlimited water out of Five Mile Meadows area. The water level declines level off after a time because an infinite amount of water can be pulled from the area of Five Mile Meadows.
 - iii. Figure 4 is a model with no flow boundaries on the east and west and no boundaries on north and south (no boundaries means that the aquifer is infinite in the north and south direction, as in an infinite Theis Model). This model shows what happens if no new water is allowed to enter the model from a source such as a stream or other recharge. It is unrealistic but it does show that water has to enter the aquifer from somewhere.
 - iv. Conclusion from this evaluation is that the actual decline of aquifer head is much greater and the vertical hydraulic gradient controlling leakage from Soda Creek is many times greater when the aquifer boundaries are considered.

2. Soda Creek Leakage Model

- a. Parameters and methodology for "Hunt" analysis. The values provided in Section 3.3 of the Golder Report don't necessarily match the text or those shown on Figure 4.



- i. In the original papers, Hunt (1999), Hunt, Weir, and Clausen (2001), Lough and Hunt (2006) stress the importance of distance and time for the analysis, and go as far as to suggest NUMERICAL methods (i.e., models) be used because they lead to more accurate results. Golder has presented a very simple analytical solution for a very complex aquifer system.
- ii. In the Golder analysis, generally a time of one year was used for pumping. This will show LESSEned impacts because the wells will pump continuously for years and years. As pumping time increases, drawdown will also increase, and therefore increase stream impacts. This is depicted in Figure 5. Water initially comes from storage and as time goes on, more and more water comes from the stream. At the bottom of Figure 5 the USGS report indicates that this cross over time is measured in years. One year modeling is insufficient.
- iii. Distance from the well to the stream. This value is not discussed in any meaningful way that I can evaluate. On Figure 4, a distance of ~5,500 feet is shown, for the South wells a value of ~2,400 feet is correct. USING A LONGER DISTANCE WILL LESSEN THE PREDICTED IMPACTS.
- iv. On page 7, and for all of the impact results presented in the tables, an aquifer thickness of 100 feet is used, while values that range from 1 to 23 feet are used to describe the aquifer thickness on page 3.
- v. The stream width and depth used seem wrong. A width of 80 feet and a depth of 3.3 feet are used. When I was at the springs and stream there, it didn't seem anywhere near that wide, but I would say the channel is deeper. Using a shallower channel may lessen the impact (but this would take a detailed analysis to justify/quantify)
- vi. Thickness of stream bottom of 1 foot is used. No justification is provided, and therefore, this seems arbitrary.
- vii. Hydraulic conductivity of stream bottom. They use "observationally" justified textbook number by stating that the streambed observations of "silt and silty sand materials" justify the parameter ranges used. No quantification is provided. More importantly, Hunt, Weir, and Clausen (2001) provide a direct methodology to quantify the stream bed leakage parameter (λ) used in the Hunt (1999) analysis. This analysis doesn't appear to have been conducted. Observation well(s) is/are needed to quantify the leakage, and Monsanto has one available. My observations of the stream channel indicated that in many reaches the stream bottom consisted of gravel, which would have a much higher hydraulic conductivity than a silt-bottomed stream. Two orders of magnitude (100 times) lower hydraulic conductivity is the typical contrast in hydraulic conductivity used to distinguish an



aquifer from a confining layer. The Golder model uses a streambed conductivity that is two orders of magnitude lower than the aquifer. Essentially, drainage or leakage from the aquifer must pass through a confining layer to reach the stream. This is certainly not conservative and doesn't match the evidence that indicates that this reach of Soda Creek is gaining water from the aquifer, suggesting that water can pass relatively easily from the aquifer to the stream. This is evidenced by the many springs in the area.

- b. As mentioned above, the methods used assume an infinite aquifer and do not consider the effect of the faults and the gradient from the aquifer a much less than modeled by Golder, therefore, the actual impacts to the Creek will be more severe than modeled.
- c. In Section 4.4, Golder admits that the predicted impact would be greater on Reaches B and C if the pumping was occurring on the west side of the faults. By their own map on Figure 4, the southern wells are on the west side of the fault. They should have conducted an analysis to consider the impact of the faults and the impacts of the no flow boundary created by Chester Hill.
- d. In Section 5, Golder states that the impact to springs cannot be estimated with their analysis. This is a considerable flaw in their analysis. Spring impacts must be considered as Soda Creek receives a significant amount of flow from springs along this reach. By ignoring spring impacts or stating that they cannot be analyzed, essentially means that they consider them negligible with no supporting data or analysis. This is inadequate.
- e. In the text, they state that cumulative impacts will be presented in Table 7, yet this table provides incremental impacts. Cumulative impacts over a 20-30 year period need to be presented. Hunt (1999) stated that at early time stream depletion is minimal,

Sincerely,

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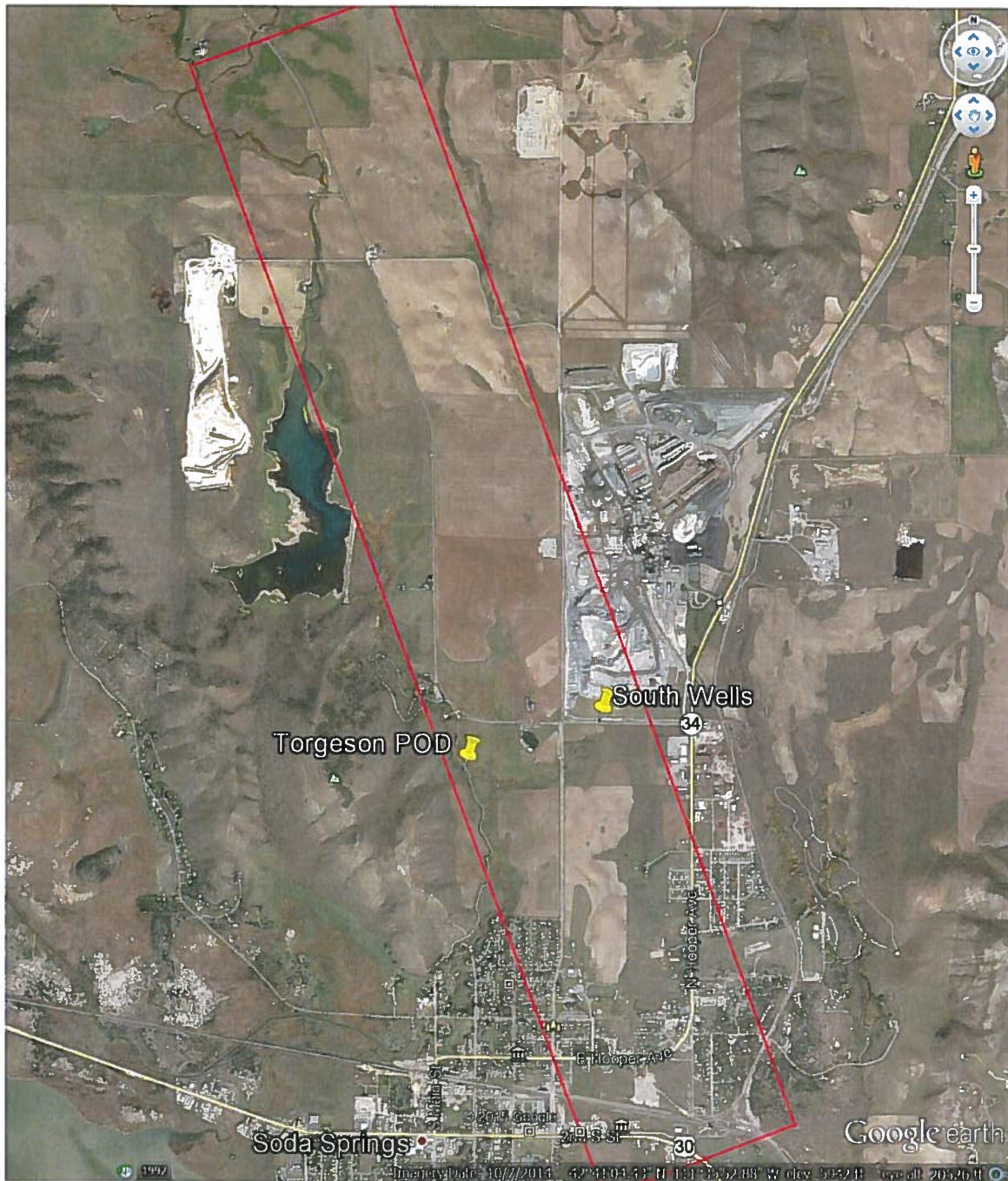


Figure 1 Model domain and locations for AQTESOLV Modeling. The characteristics of the model domain are varied in the AQTESOLV calculations as described in the following figures.

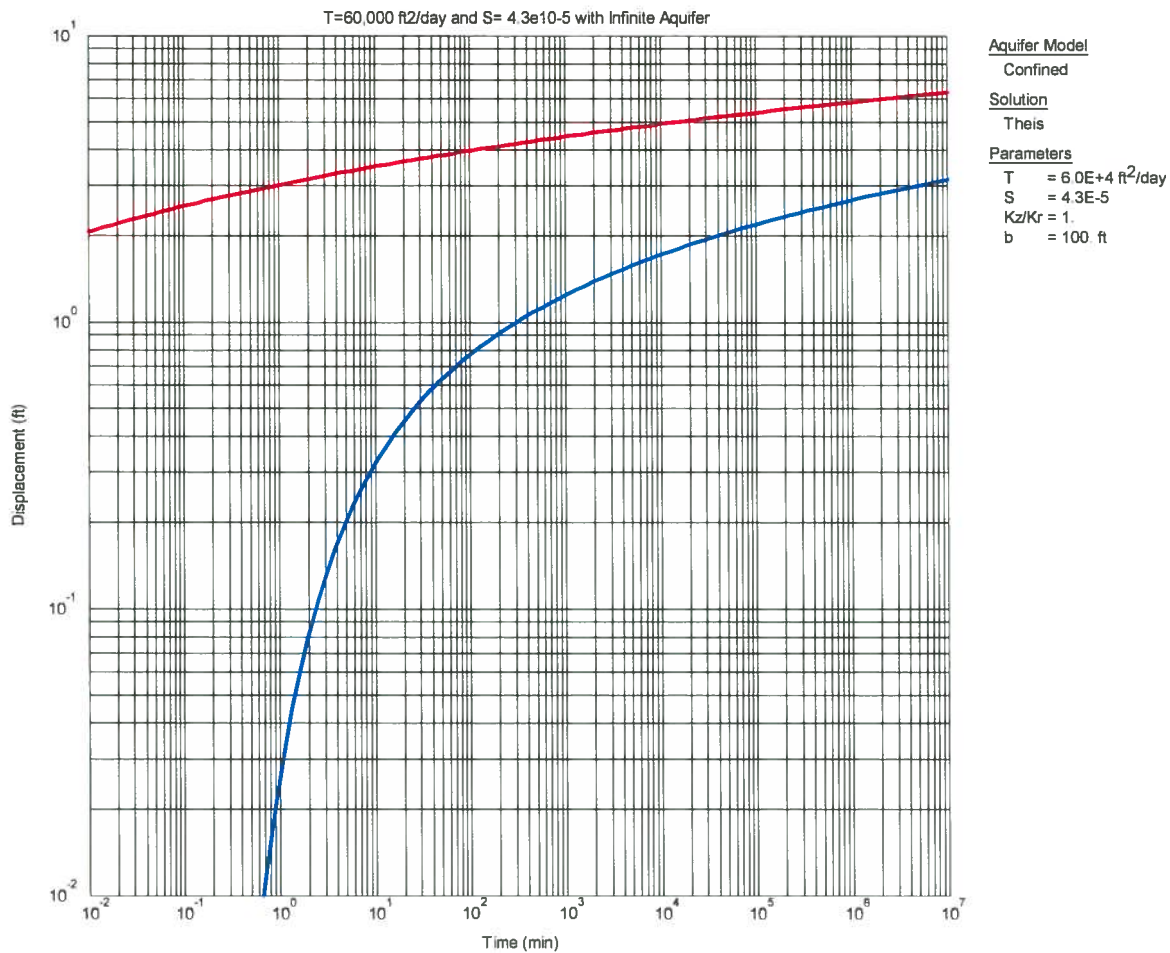


Figure 2 No aquifer boundaries, i.e. Theis assumptions of infinite aquifer. Plot is a Theis curve generated using Golder Data; T=60,000 ft²/day and S = 4.3e-10-5. Lines represent calculated aquifer drawdown over time for the following locations.

Red Line = Monsanto South well location

Blue line = Torgeson POD on Soda Creek

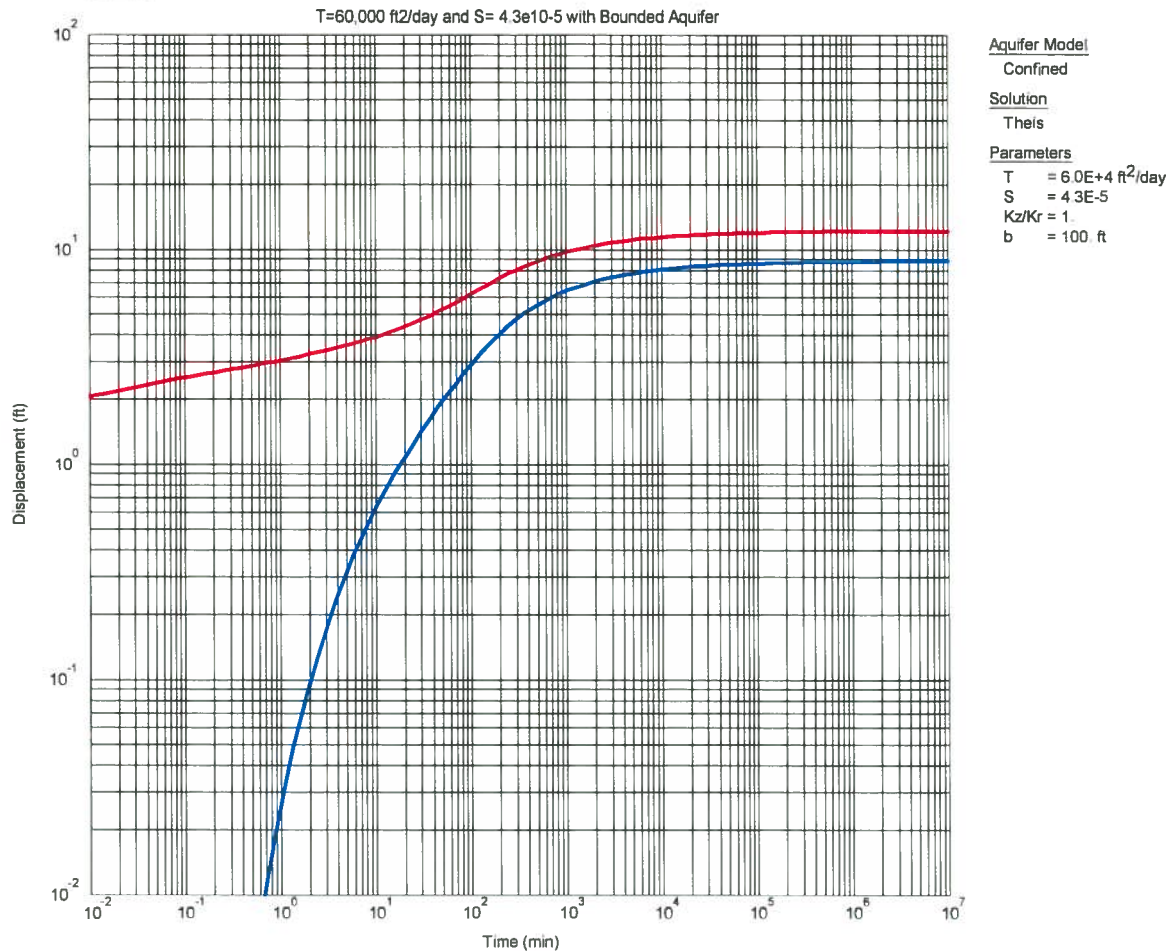


Figure 3 East and West boundaries are no flow representing the hydraulic barrier and Chester Hill, respectively. The north boundary is a constant head boundary that supplies as much water as needed (area of 5 mile Meadows) and the south boundary is an infinite boundary, i.e. Theis type boundary. The drawdown curves level off as the sufficient flow of water is pulled from the Five Mile Meadow area. Plot is a Theis curve generated using Golder Data; T=60,000 ft²/day and S = 4.3e-10⁻⁵. Lines represent calculated aquifer drawdown over time for the following locations.

Red Line = Monsanto South well location

Blue line = Torgeson POD on Soda Creek

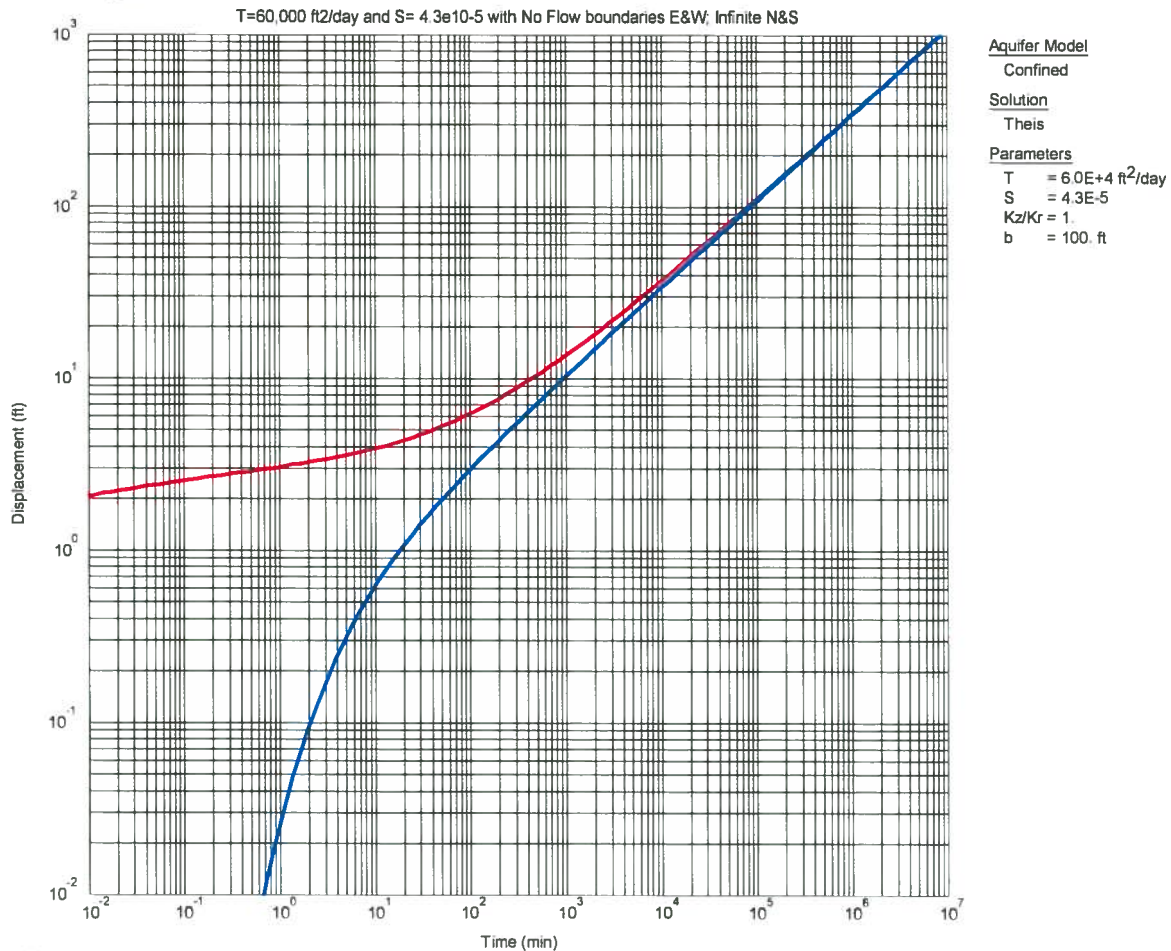


Figure 4. Aquifer boundaries on the East and West are no flow, on the north and south there are no flow boundaries, i.e. these are infinite Theis type boundaries. The drawdown never goes to steady state because it cannot pull in sufficient water to satisfy pumping. Plotted lines are predicted drawdown for a confined aquifer (Theis) using Golder Data; T=60,000 ft²/day and S = 4.3e-10⁻⁵. Lines represent calculated aquifer drawdown over time for the following locations.

Red Line = Monsanto South well location

Blue line = Torgeson POD on Soda Creek

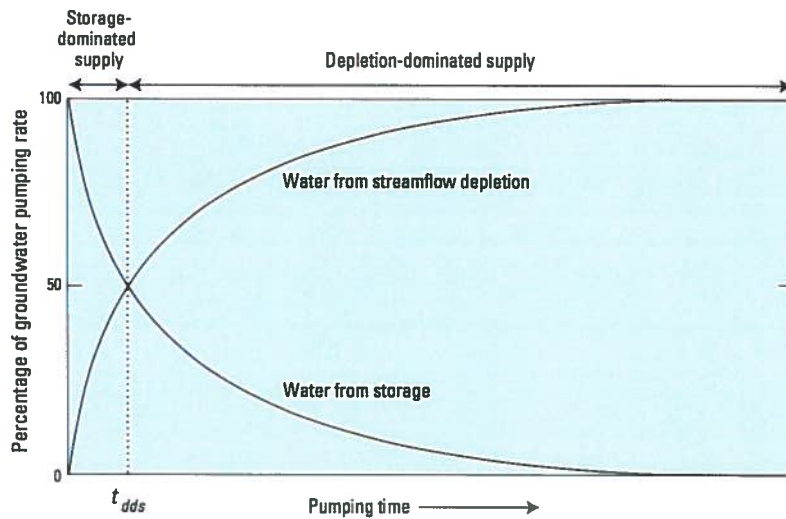


Figure 9. Relation of storage change and streamflow depletion as sources of pumped groundwater through time for a hypothetical well. Initially, the source of water (or supply) to the well is dominated by reductions in aquifer storage. At later times, streamflow depletion is the dominant source of supply. The condition of more than half of the pumping rate coming from streamflow depletion is designated as depletion-dominated supply, and variable t_{dds} is the time to reach the condition of depletion-dominated supply for a particular pumping location.

Figure 5 Relation of storage change and streamflow depletion.

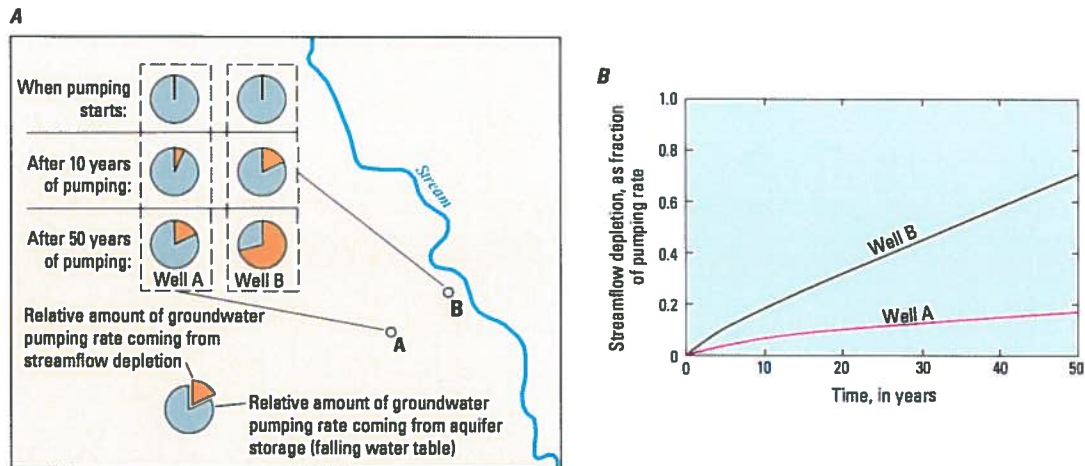


Figure 10. A, Sources of pumped groundwater at two hypothetical well locations for pumping times of 10 and 50 years. B, Streamflow depletion is a much larger source of water to well B than to well A during the 50-year pumping period because well B is much closer to the stream (modified from Leake and Haney, 2010).

Figure 5 Relation of storage change and streamflow depletion is an inverse one (top). Notice that for several years the pumped water primarily comes from aquifer storage and not stream flow (bottom left). (from USGS, 2012, Streamflow Depletion by Wells- Understanding and Managing the Effects of Groundwater Pumping on Streamflow, Circular 1376, U.S. Geological Survey, Reston, Virginia.