Review of "Expert Report in the Matter of Rangen, Inc. - Availability of Spring Flow and Injury to Water Rights", December 20, 2012, by Charles E. Brockway, David Colvin, and Jim Brannon

by

Bern Hinckley, P.G.
Hinckley Consulting
Laramie, Wyoming

for

Racine, Olson, Nye, Budge & Bailey
Boise, Idaho

February 8, 2013

INTRODUCTION

The objective of this report is to review the "Expert Report in the Matter of Rangen, Inc. - Availability of Spring Flow and Injury to Water Rights," December 20, 2012, by Charles E. Brockway, David Collins, and Jim Brannon, filed with the Idaho Department of Water Resources (IDWR) on December 21, 2012, In the Matter of Distribution of Water to Water Right Nos. 36-02551 and 36-07694 (Rangen, Inc.). My review is primarily presented on a point-by-point basis, pairing citation from the Brockway et al. (2012) report with a brief discussion.

The Brockway et al. (2012) report identifies various inadequacies of ESPAM2.1 in accurately predicting the impact of groundwater irrigation curtailment on groundwater discharges at the Rangen facilities, with which I agree. However, the report incorrectly characterizes the potential availability of groundwater development alternatives and offers various conclusions without supporting evidence.

DISCUSSION

Brockway et al. - "The eastern plain aquifer system is dominated by the Snake River Group basalt layers" (p. 4); "The eastern Snake Plain Aquifer (ESPA) is primarily an aquifer consisting of relatively shallow (a few hundred feet deep) and highly transmissive rubble and pillow basalts. Deeper aquifer conditions exist and are likely confined, but little data is available to evaluate them." (p. 4); "The geologic evidence supports current theories that the Curren Tunnel water is flowing through pillow basalts overlaying less permeable sediments." (p. 10)

> This characterization of the aquifer is consistent with previous work on the aquifer (e.g. Whitehead, 1992; Ralston, 2008; Farmer, 2009), but is contrary to the ESPAM2.1 representation of the aquifer as a single, 4,000-ft. thick layer, within each 1 mi^2 cell of which, aquifer characteristics are homogeneous and isotropic. I provided considerable elaboration on this point in my report titled "Rangen Groundwater Discharge and ESPAM2.1 Hydrogeologic Investigation" dated December 20, 2012, and filed with the IDWR on December 21, 2012 (e.g. pp. 11-12, 35-38).

Brockway et al. - "The upgradient geology above the Rangen facility effectively funnels the high quality spring water to Rangen's collection points ..." (p. 10)

> As above, this characterization of aquifer geometry is important and is consistent with detailed investigations by previous workers (including my 2012 report; e.g. pp. 13-19, 23-24, Fig. 8). It reflects the paleotopography upon which the productive Tuana Gravel and ESPA basalts were deposited. However, there is no such geometry reflected in the single-layer ESPAM2.1, which models the aquifer as being laterally continuous in all directions from the Rangen discharge points.

Brockway et al. - "Most ESPA ground water pumping occurs in the Quaternary basalts of the Snake River Group. Most wells are shallow and many can produce sustained flow rates in excess of 1,000 gallons per minute (GPM)" (p. 5)

This observation of the commonly high productivity of this aquifer and its accessability with relatively shallow wells is correct, and supports the potential for Rangen developing additional groundwater through construction of wells east of the Hagerman Rim.

Brockway et al. - "Historic anecdotal evidence indicates that the Curren Tunnel was advanced into the Malad Basalt above the Rangen Research Hatchery in order to facilitate delivery of high quality spring water." (p. 6)

The "historic anecdotal evidence" supporting this statement is not provided. That the initial water rights for the tunnel were for irrigation is contrary to the Brockway et al. conclusion that the original objective was "high quality spring water". For crop irrigation, there is little if any advantage to the turbidity and bacteria-free attributes of groundwater relative to sources of surface water commonly used for irrigation throughout the Rangen area.

Brockway et al. - "The Research Hatchery was located downstream of the Curren Tunnel where the uniquely excellent spring water quality contributes to the feed research success." (p. 6)

Brockway et al. provide no evidence for the tunnel water being "uniquely excellent." Every hydrogeologic consideration indicates that groundwater discharged from the Curren Tunnel will be very similar to the hundreds of cfs of groundwater pumped from wells or discharging from the ESPA at other locations below Milner Dam.

Brockway et al. - "Neal Farmer of IDWR reported that the Current Tunnel elevation is 3,145 feet above mean sea level (FT AMSL), with lower elevation spring discharge in the talus slope down to approximately 3,100 FT AMSL (Farmer, 2009)." (p. 8); "Spring water from the Curren Tunnel and a lower discharge zone flows ..." (p. 9)

It is appropriate to cite the work of Mr. Farmer. Mr. Farmer has conducted extensive investigations of groundwater flow in the ESPA along the Hagerman Rim. However, the observations cited here by Brockway et al. stand in marked contrast to the ESPAM2.1 modeling at Rangen. Farmer distinguished the Curren Tunnel groundwater discharge from the groundwater discharge downslope, whereas ESPAM2.1 considers all groundwater discharge to occur from a single point, at a single elevation of 3138 ft. This inaccuracy in the ESPAM2.1 modeling is reinforced in my 2012 report, e.g. pp. 39-40.

Brockway et al. - "Any viable vertical well location would have to provide a sufficient quantity and quality of water from a source that would not further deplete the Curren Tunnel flows, or that is not currently collected by Rangen." (p. 10)

This conclusion is mathematically incorrect. Substantial additional groundwater development from sources hydrologically connected with the Curren Tunnel, such as vertical wells drawing from the aquifer east of Rangen, may reduce tunnel flows, but need only produce more than that reduction to realize a net gain. Given the high productivity of the aquifer, the relatively large aquifer drawdown available east of the rim, and the relatively small drawdown available at the tunnel, there is clearly potential for substantial net increases in groundwater supply through active groundwater development. (See Hinckley, 2012, e.g. pp. 28-30)

Brockway et al. - "Any location for possible vertical well drilling that isn't providing water to the current Rangen collection locations is unlikely to provide the quantity and quality of water necessary to make this a feasible option for an alternative point of diversion." (p. 10)

Brockway et al. provide no data to support this statement. Contrary to the current rejection of this option by Brockway et al., in 2004 Rangen submitted a grant application to the Idaho Department of Commerce and Labor Division of Economic Development to evaluate this very alternative (Rangen, 2004a). It is my understanding that the application for funding to construct vertical wells was denied and the alternative remains unevaluated. As noted in my 2012 report (p. 38), ESPAM2.1 projects groundwater underflow at the Rangen facility of 367 cfs.

Brockway et al. - "The other possible well locations would likely encounter less permeable sedimentary deposits with lower well yields, unsaturated basalts, or reduced water quality affected by overlying agricultural land use." (p. 10)

"The other possible well locations" are not specified, but the implication that highly-productive locations would be compromised by "overlying agricultural land use" overlooks that fact that Rangen is already supplied by the same aquifer which is extensively overlain by agricultural land use in the Rangen area. It is unlikely that groundwater discharge from nearby wells would be of lesser quality than groundwater discharge from the Curren Tunnel.

Brockway et al. - "While a new horizontal well might increase flow at the Curren Tunnel location, it would reduce flow to the lower talus discharge area and it is therefore unlikely that it would increase flow to the Rangen facility. Furthermore, a horizontal well has the potential to injure the other Curren Tunnel water rights by drying up the tunnel flows (Erwin, 2012). A horizontal well alternative is not a feasible option for these reasons." (p. 10)

As noted above with respect to vertical wells east of the Curren Tunnel, the presence of interference offsets does not preclude the potential for a net increase in groundwater production through construction of an additional or extended horizontal well. Given similar aquifer conditions, a lower elevation tunnel would almost certainly realize increased groundwater discharge, as would replacement of the current "talus" discharge with a low-elevation tunnel. Potential reductions in flow from the Tunnel to existing irrigation rights if a lower tunnel is constructed have already been mitigated through construction of the Sandy Pipeline (Brendecke, 2012; p. 3-2).

In 2004, Rangen submitted a grant application to the Idaho Department of Commerce and Labor Division of Economic Development to evaluate this very alternative (Rangen, 2004b). The water-rights implications were addressed by SPF (2004), "IDWR has suggested that a horizontal well in the vicinity of the Curren Tunnel could be considered a "well deepening" of the current Curren Tunnel discharge point." It is my understanding that the application for funding to investigate another drainage tunnel was denied and the alternative remains unevaluated.

Brockway et al. - "It is our opinion that the current Rangen Research Hatchery diversion structures are reasonable and that they fully utilize available water to Rangen's water rights." (p. 11)

The location and original water rights of the Curren Tunnel suggest it was constructed to provide a seasonal irrigation supply at maximum elevation, rather than to optimize year-round production for the present hatchery facility. It is not reasonable to conclude that all groundwater resources available at this location have been fully developed through the existing diversion facilities.

Brockway et al. - "Rangen has made significant efforts, and yet no alternative method of water diversion has been identified that would provide the Rangen facility additional water with a viable quantity and quality that isn't already being accessed by existing diversion structures." (p. 11)

The "significant efforts" referenced are not listed. With respect to groundwater-development alternatives, the record reflects only two denied grant applications. The limited analysis developed in support of those applications, while cautious in approach, rejected neither the tunnel nor well options, and both were advanced for funding requests. As noted above, alternative/additional sources are not precluded simply because a portion of their potential production is "already being accessed by existing diversion structures".

Brockway et al. - "The seasonal variations in the spring flows are attributable to seasonal pumping and are accurately represented by the model.' (p. 16)

The relationships between groundwater discharge, surface-irrigation recharge, precipitation infiltration, irrigation management/technology, groundwater irrigation, and underflow are complex. It is incorrect to attribute seasonal fluctuations to "pumping". On the contrary, throughout the 2000s, ESPAM2.1 predicts Rangen groundwater discharges that fluctuate between minimums in April and May (ESPAM2.1 has a monthly time period), and maximums in October. Were these fluctuations attributable to irrigation pumping, they would be just the opposite: discharge would decline rather than increase over the summer, due to pumping for groundwater irrigation.

ESPAM2.1 also over-predicts the magnitude of seasonal flow fluctuations at Rangen. Through the 2000s, based on the calibration data for Rangen reported by IDWR and presented by Brockway et al. in their Appendix B, the average annual fluctuation in flow reported for Rangen (maximum minus minimum) was 8.6 cfs. The average modeled fluctuation is 12.6 cfs. The average maximum flow modeled is 27 cfs; the average maximum reported is 21 cfs. Further demonstrating the inaccuracy of ESPAM2.1 in the prediction of "seasonal variations", the model consistently predicts the seasonal minimum flow three months before it actually occurs. (See Hinckley, 2012; p. 44.)

Brockway et al. - "the average water level increase over the ESPA as a result of this curtailment may be as much as 24 feet." (p. 22)

Due to the geometry of ESPA recharge and discharge, the greatest water-level change due to curtailment of groundwater pumping would be in the center of the aquifer, farthest from the points of natural discharge. The change in groundwater levels in the vicinity of Rangen would be much less; the "24 feet" highlighted by Brockway et. al is not relevant. In the Rangen area, the ESPAM2.1prediction is that aquifer-wide curtailment would raise the groundwater level approximately 6 ft. (Brendecke, 2012 p. 4-9).

Brockway et al. - "E. Alternative Procedures to Estimate Spring Discharges" (p. 24)

As the title of this section states, rather than supporting the configuration of ESPAM2.1, Brockway et al. present a detailed alternative to the aquifer level : drain discharge relationships that are used by ESPAM2.1 to predict the benefits of irrigation curtailment.

In contrast to the relationships established by measured data and documented by Brockway et al. in their Appendix C, Figure 1 (attached) presents output from ESPAM2.1 demonstrating the modeled relationship between aquifer water level and groundwater discharge for the model cell containing the Rangen discharge. As required by the mathematics presented by Brockway et al. (p. 24), the plot is a straight line, and when the water level falls to the elevation of the modeled discharge point - 3138 ft. - discharge falls to zero. ESPAM2.1 is structurally incapable of modeling the non-linear relationships shown on the seven figures of Brockway et al. Appendix C. (Additional manifestations of this problem are presented in my 2012 report; e.g. pp. 39-41.)

Figure 2 (attached) provides a comparison between ESPAM2.1 and measured data for well 06S13E25DBC1 (IDWR Well No. 797), the last of the wells plotted in Brockway et al. Appendix C[1]. There is some scatter in the ESPAM2.1 values relative to the rigidly

---

[1]Depths-to-water have been converted to water-level elevations for direct comparison with ESPAM2.1, using the surface elevation of 3269 ft. computed by comparison of ESPAM2.1-reported water-level elevations with IDWR/USGS reported depths-to-water. The IDWR/USGS reported surface elevation is 3256 ft., exposing an elevation ambiguity in the modeling process.

linear relationship of Figure 1 due to the impact of factors between this well and the Rangen discharge, 6 model cells away, but the linear structure required by ESPAM2.1 is clear. Also shown on Figure 2 is the polynomial relationship suggested by Brockway et al. for this well. While both the ESPAM2.1 and Brockway et al. curves indicate that Rangen flows generally rise and fall with aquifer water levels, there are substantial differences between the two:

1) the ESPAM2.1 water levels are consistently lower than the actual water levels[1];

2) the ESPAM2.1 relationship between aquifer levels and Rangen flow is linear, whereas the actual relationship is not linear; and

3) most importantly, the slope through the most relevant portion of the measurement-based plot, the 2000s, is dramatically at odds with the ESPAM2.1 representation. The 2000s is the portion of the plot that most nearly represents current conditions, the background upon which curtailment would be imposed. Where ESPAM2.1 predicts an 8.0 cfs change in flow per foot change in aquifer water level at this location (the slope of a "least-squares" line fit to the ESPAM2.1 data), the actual measurements show a response of only 3.2 cfs/ft. (similarly approximated with a linear fit). Thus, the Brockway et al. presentation suggests a much smaller benefit from the change in aquifer levels that would result from curtailment, than does the ESPAM2.1 evaluation.

Figure 3 (attached) provides data for an additional well (IDWR Well No. 991) in the same manner as Brockway et al. Appendix C. Figure 4 (attached) shows the location. This well is approximately the same distance from the Rangen discharges as IDWR Well No. 989, the closest of the Brockway et al. Appendix C wells. ESPAM2.1 models a linear relationship between the water levels at this point and the Rangen discharges, with the two rising and falling in close correspondence (Figure 3a), as is required by the basic structure of the model. The actual water-level data (Figure 3b) present a very different picture. The actual water levels are all substantially lower than simulated by ESPAM2.1 (compare the x-axes of Figs. 3a and 3b). And the actual water levels show no relationship with the Rangen flows, despite this well being only 0.7 miles away. These discrepancies are the result of there being little if any connection between the aquifer supplying Rangen and the aquifer to which this well is responding. Yet ESPAM2.1 models this area as one, thick, continuous aquifer. I provide substantial additional discussion of this issue in my 2012 report (e.g. pp. 30-34, 37-39).

REFERENCES

Brendecke, Charles M.; Dec. 21, 2012; Hydrology, Water Right and Groundwater Modeling Evaluation of Rangen Delivery Call; prepared for Racine, Olson, Nye, Budget and Bailey, Chartered, Boise, Idaho (corrected Jan. 17, 2013)

Brockway, Charles E., David Colvin, and Jim Brannon; Dec. 20, 2013; Expert Report in the Matter of Rangen, Inc. - Availability of Spring Flow and Injury to Water Rights; prepared for Rangen, Inc.

Farmer, Neal; March 4, 2009; Hydrogeologic Conditions Located at and Adjacent to the Spring at Rangen Inc.; IDWR Open File Report.

Hinckley, Bern; Dec. 20, 2012; Rangen Groundwater Discharge and ESPAM2.1 Hydrogeologic Investigation; prepared for Racine, Olson, Nye, Budget and Bailey - Boise, Idaho.

Ralston Hydrologic Services, Inc.; Sept. 2008; Hydrogeology of the Thousand Springs to Malad Reach of the Enhanced Snake River Aquifer Model; prepared for Idaho Department of Water Resources.

Rangen, Inc.; May 31, 2004a; Application for Financial Assistance to Evaluate the Feasibility of Ground Water Pumping at the Rangen Aquaculture Facility; Submitted to: The Idaho Department of Commerce and Labor Division of Economic Development.

Rangen, Inc.; May 31, 2004b; Application for Financial Assistance to Evaluate the Feasibility of a Horizontal Well in the Vicinity of the Curren Tunnel; Submitted to: The Idaho Department of Commerce and Labor Division of Economic Development.

SPF Water Engineering, LLC; May 20, 2004; Rangen Application; memo to Rangen, Inc. (c/o Justin May), from Christian Petrich.

Whitehead, R.L.; 1992; Geohydrologic Framework of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon; U.S. Geological Survey Professional Paper 1408-B.

Figure 1 - ESPAM2.1 Elevation:Discharge Relationship

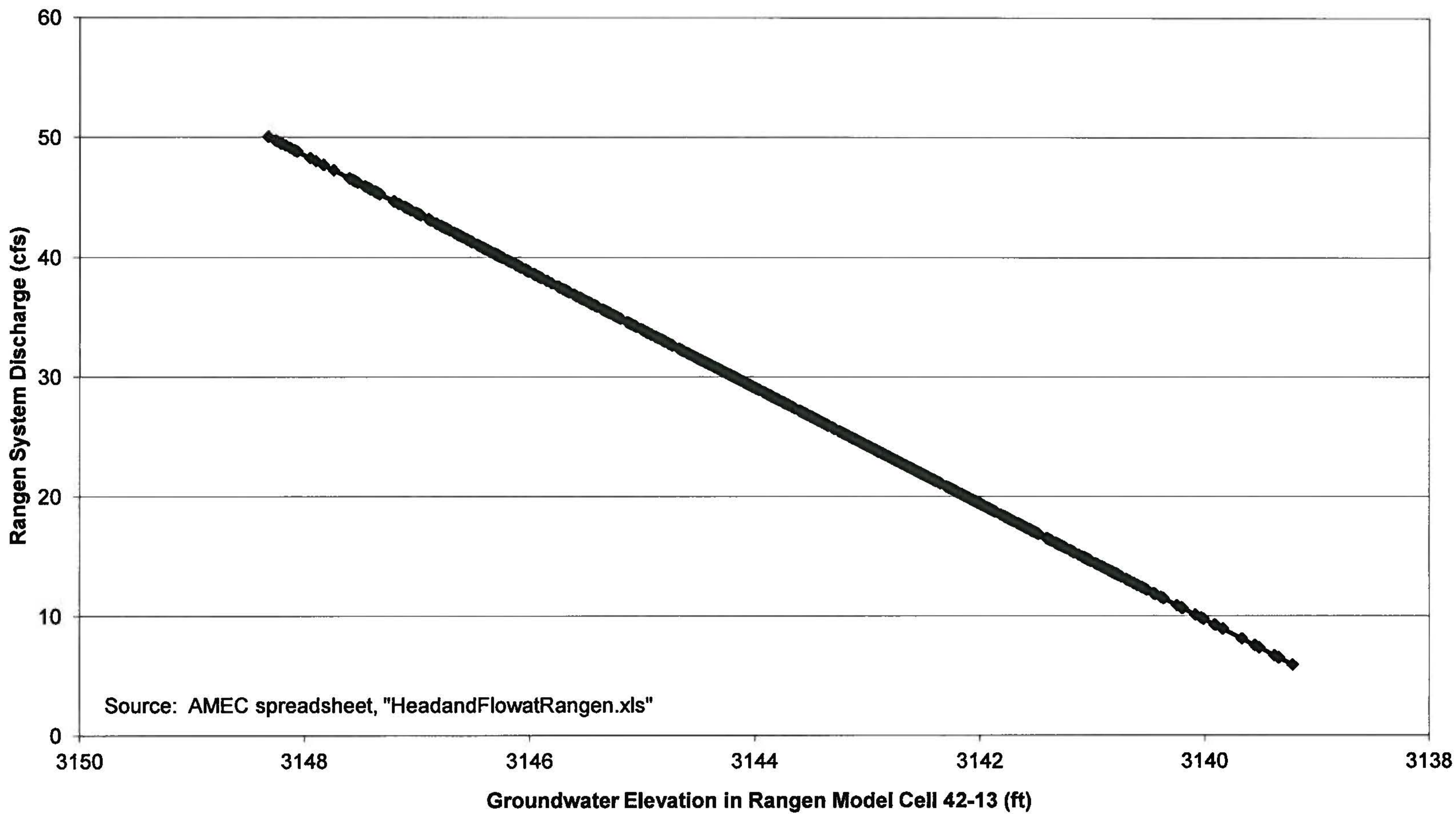


Figure 2
Rangen Discharge vs. Well 06S13E25DBC1 (IDWR Well No. 797)
and ESPAM2.1

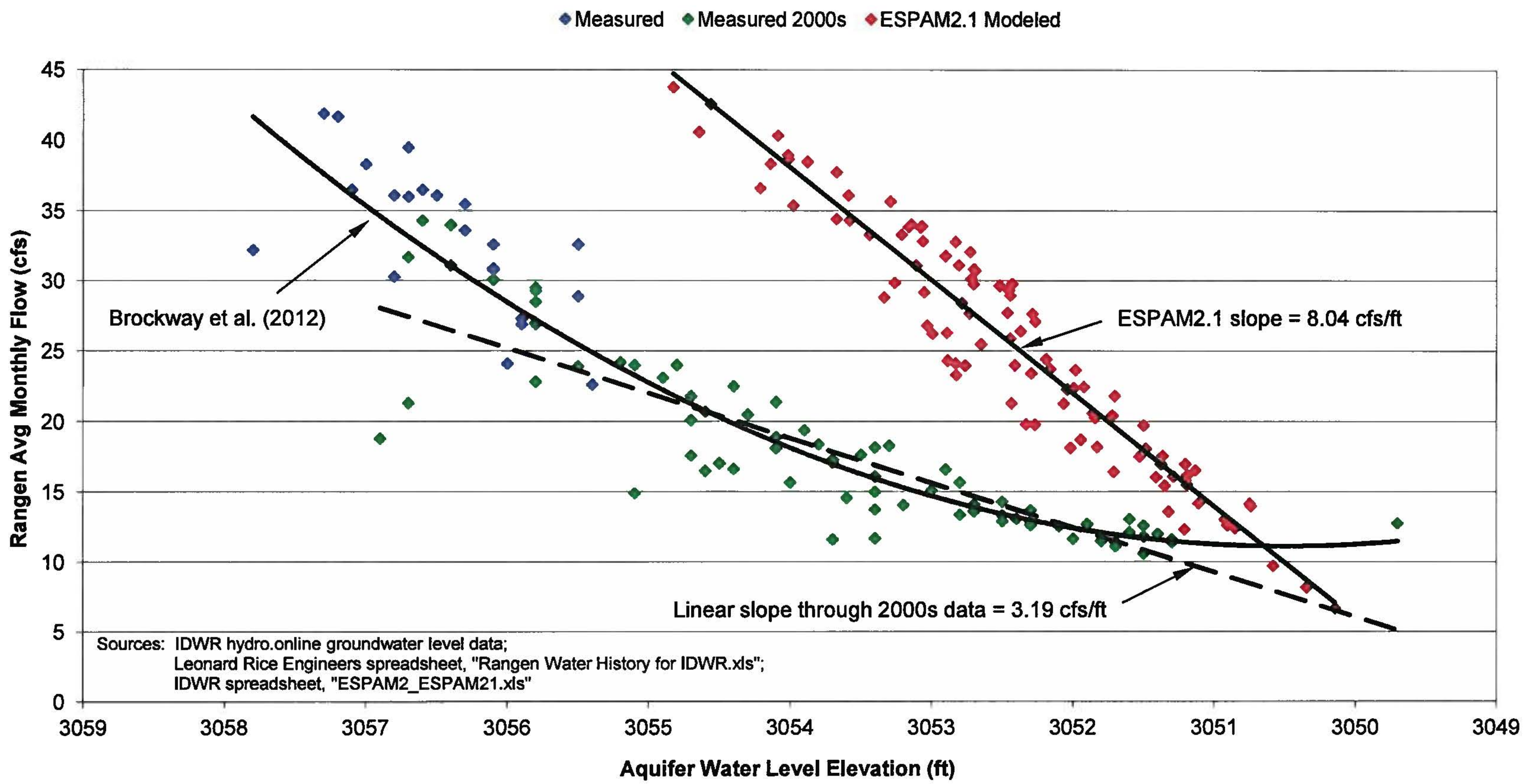


Figure 3a
Rangen Discharge vs. Well 07S14E31ABA1 (IDWR Well No. 991)
ESPAM2.1 Modeled

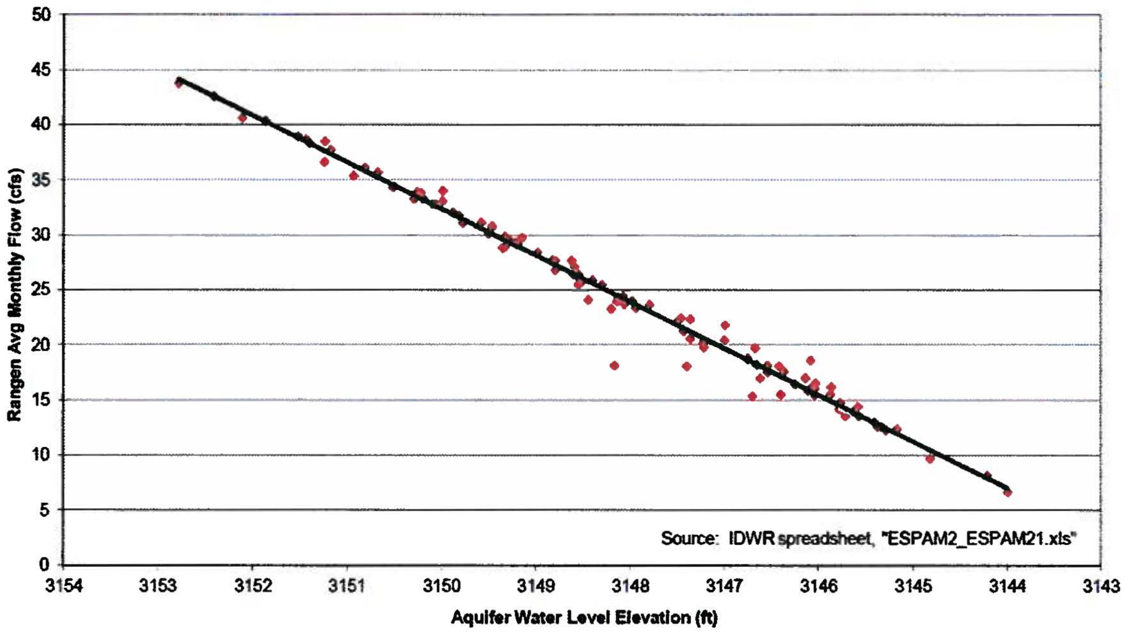
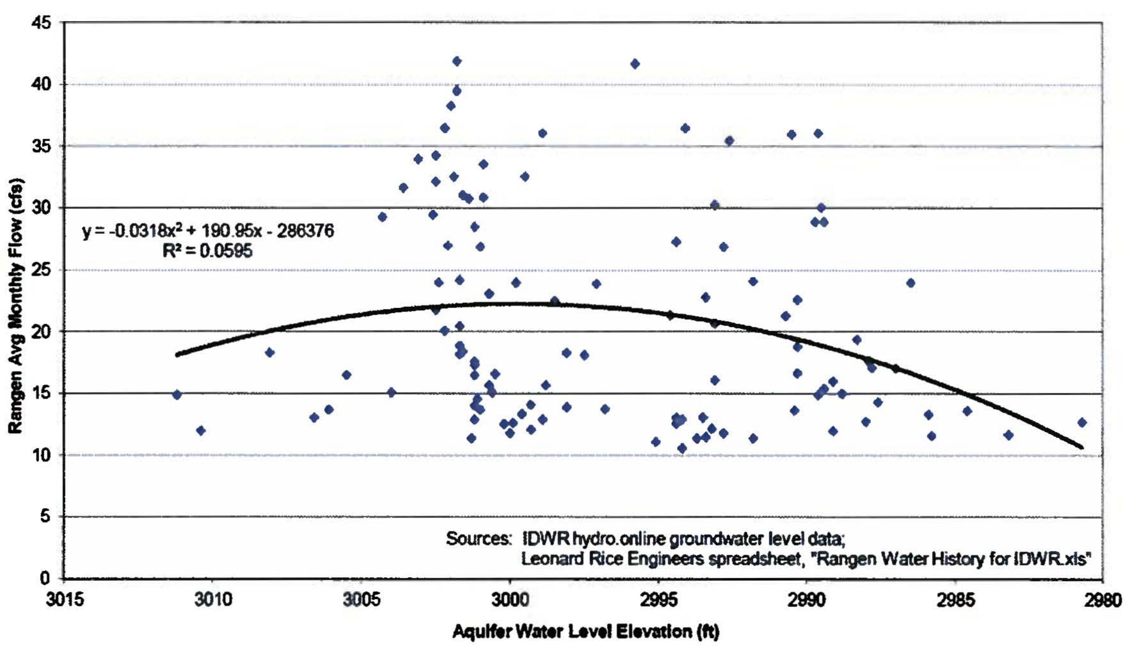


Figure 3b
Rangen Discharge vs. Well 07S14E31ABA1 (IDWR Well No. 991)
Measured



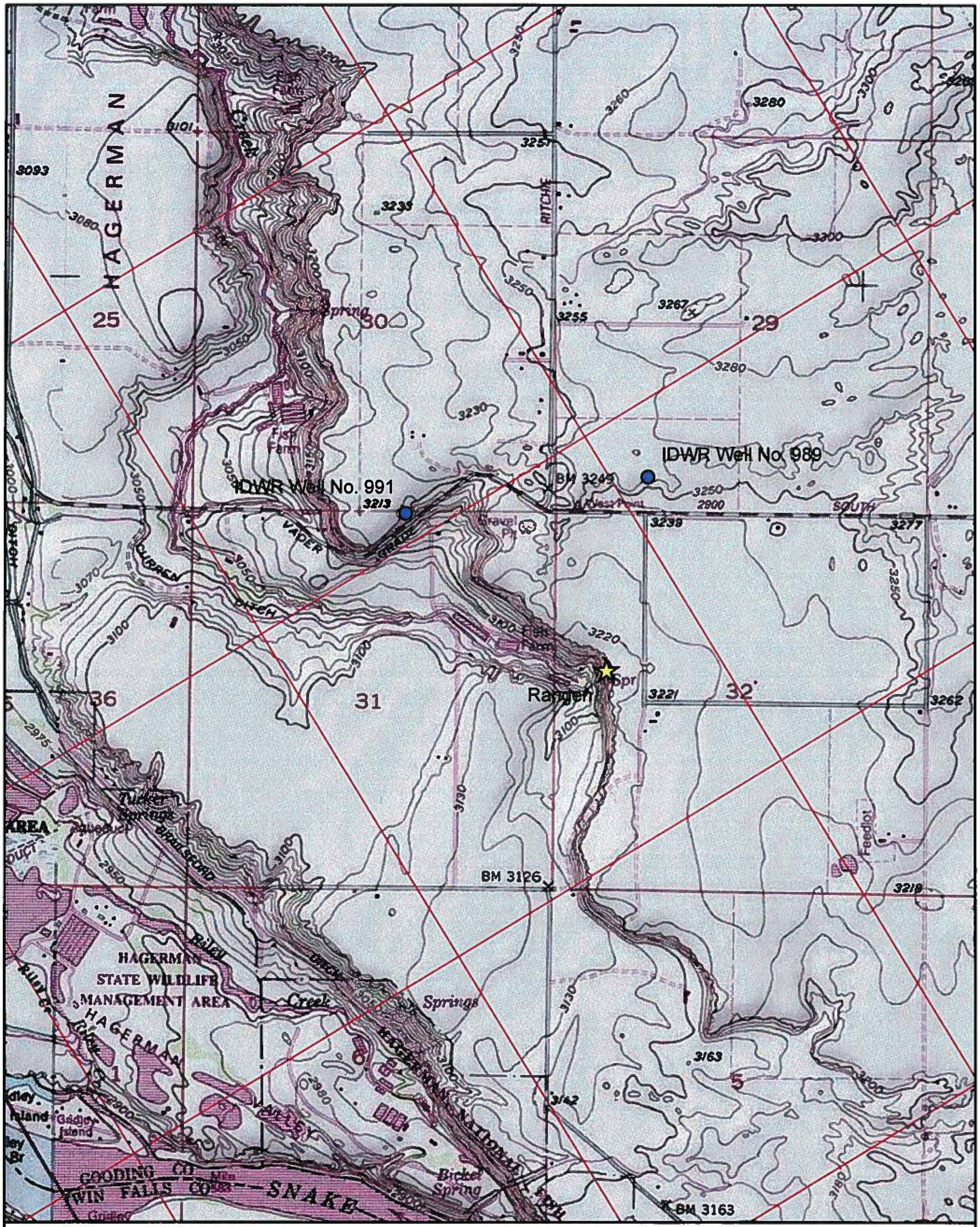


Figure 4 - IDWR Well Nos. 989 and 991 Location Map