COMPARISON OF ENHANCED SNAKE PLAIN AQUIFER MODEL VERSION 2.1 WITH VERSION 1.1 VIA THE CURTAILMENT SCENARIO

Addendum to Comparison of Eastern Snake Plain Aquifer Model Version 2.1 with Version 1.1 via the Curtailment Scenario

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COMPARISON OF ESPAM2.1 WITH ESPAM1.1 VIA THE CURTAILMENT SCENARIO

INTRODUCTION

The *Hydrologic Effects of Curtailment of Groundwater Pumping* (also known as the Curtailment Scenario) was performed using the Enhanced Snake Plain Aquifer Model Version 1.1 (ESPAM1.1) in 2006 (Contor, et al, 2006). This exercise was performed again using the ESPAM Version 2.0 (ESPAM2.0) in July 2012 (Sukow, 2012a). In November 2012, the ESPAM was recalibrated because of errors discovered in water budget data in the Mud Lake area, resulting in the release of ESPAM Version 2.1 (ESPAM2.1). The curtailment scenario was repeated with ESPAM2.1 in November 2012. This addendum presents the results of the ESPAM2.1 Curtailment Scenario.

METHODS

The methodology presented in the ESPAM2.0 comparison report (Sukow, 2012a) was used to repeat the curtailment scenario with ESPAM2.1. A numerical superposition version of ESPAM2.1 was created from the ESPAM2.1 final calibration files as described in Sukow (2012a). Perched river cells based on modeled conditions using the average water budget from November 1998 through October 2008 were slightly different for ESPAM2.1. Twenty-three perched river cells were removed from the superposition river file (Figure 1).

For ESPAM2.0, results from the numerical superposition model version were compared with results from the fully populated model version (Sukow, 2012b). This exercise was not repeated with ESPAM2.1, because the correction of water budget input data and recalibration of the model did not significantly change the potential nonlinearity of the model. Conclusions regarding the effects of nonlinearity and applicability of the superposition version of ESPAM2.0 are expected to be applicable to the superposition version of ESPAM2.1.

Irrigated lands data sets and junior priority fractions were unchanged from the ESPAM2.0 scenario. The ESPAM2.1 stress files are slightly different than the ESPAM2.0 stress files because evapotranspiration (ET) adjustment factors were adjustable parameters during calibration of the model. Recalibration of the model resulted in minor changes to these parameters, which resulted in minor changes in the calculation of crop irrigation requirement for the curtailment scenario. The stress applied in the ESPAM2.1 scenario was 0.3% to 0.5% less than applied in the ESPAM2.0 scenario, varying with the year of curtailment (Appendix B).

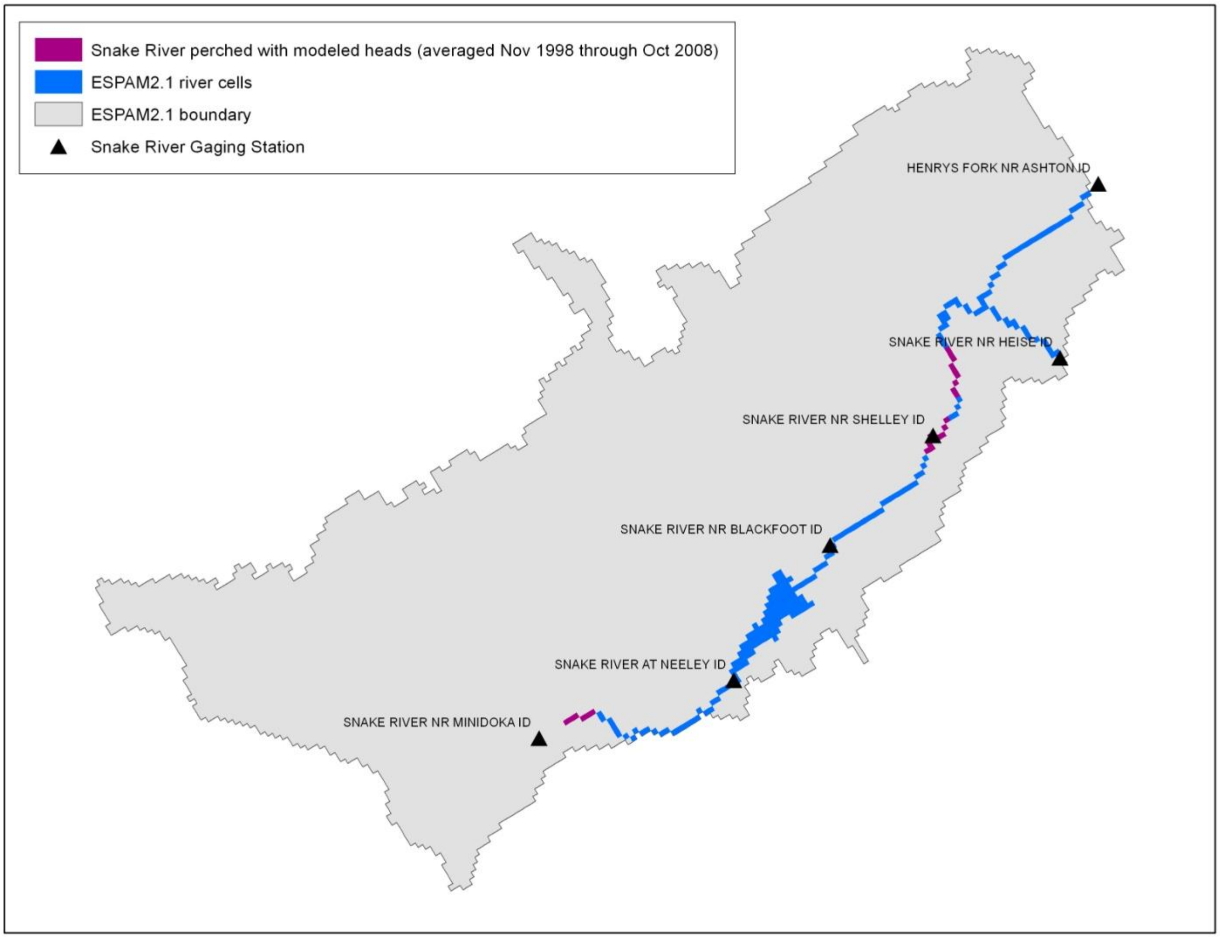

Figure 1. Perched river cells removed from superposition version based on average model head from November 1998 through October 2008.

Curtailment of groundwater irrigation throughout the model domain was simulated for water rights junior or subordinate to five priority dates. Subordinate water rights include enlargement water rights, which despite having a priority date based on the date of enlargement, are subordinate to all water rights senior to April 12, 1994.

1. January 1, 1870
2. January 1, 1949
3. January 1, 1961
4. January 1, 1973
5. January 1, 1985

Three simulations were run for each curtailment date.

1. Steady state prediction of response.
2. Long term transient prediction of response for 150 years of curtailment, assuming continuous stress based on average annual consumptive use.
3. Short term seasonal transient prediction of response for 10 years, assuming monthly stress based on average monthly consumptive use.

RESULTS AND DISCUSSION

Steady State Simulations

Results from the ESPAM2.1 curtailment scenario are presented in Appendix B. Results from the ESPAM2.0 and ESPAM1.1 curtailment scenarios are also presented in Appendix B for comparison.

All of the models were calibrated to five river reaches upstream of Milner. Unlike ESPAM1.1, ESPAM2.1 and ESPAM2.0 were calibrated to 14 Group A or B spring targets, 36 Group C spring targets, and three spring reaches below Milner (Kimberly to Buhl, Buhl to Lower Salmon Falls, Lower Salmon Falls to King Hill). ESPAM1.1 was calibrated to six spring reaches (Cosgrove et al, 2006) that were not used in calibration of ESPAM2.1 or ESPAM2.0. For the purpose of comparing the steady state results with ESPAM1.1, predictions for individual springs from ESPAM2.1 and ESPAM2.0 were summed to approximate the six spring reaches used in ESPAM1.1 (Appendix B). Predictions from ESPAM1.1 were also summed for comparison with the three spring reaches used in ESPAM2.1 and ESPAM2.0.

The results of these analyses illustrate differences in predictions based on differences in representations of irrigated lands, evapotranspiration, precipitation, and water rights data, in addition to differences resulting from model structure and calibrated model parameters (aquifer transmissivity and storativity, riverbed and drain conductance) between ESPAM2.1 and ESPAM1.1. Differences resulting from irrigated lands, evapotranspiration, precipitation, and water rights data were evaluated separately during the comparison of ESPAM2.0 and ESPAM1.1 (Sukow, 2012a). Irrigated lands, water rights, and precipitation data for the ESPAM2.1 scenario were identical to data used in the ESPAM2.0 scenario. Changes to evapotranspiration data were negligible (-0.3% to -0.5%, varying with the year of curtailment). Because the changes in input data between ESPAM2.1 and ESPAM2.0 are insignificant, differences in predictions between ESPAM2.1 and ESPAM2.0 are attributed primarily to changes in calibrated model parameters.

Like ESPAM2.0, ESPAM2.1 simulates curtailment of junior irrigated land area that is 7% to 11% greater than with ESPAM1.1. ESPAM2.1 also simulates average consumptive use per curtailed acre that is 8% to 9% higher than ESPAM1.1, ranging from 2.17 to 2.24 feet per year in ESPAM2.1 compared with 2.00 to 2.05 feet per year in ESPAM1.1. Like ESPAM2.0, ESPAM2.1 simulates a total increase in curtailed consumptive use of 17% to 21% from ESPAM1.1, varying slightly with the priority date of the curtailment. The differences in input data are discussed in detail in Sukow, 2012a.

Comparison of results from the steady state simulations run with ESPAM2.1 and ESPAM2.0 indicate that the recalibration of model parameters resulted in a relatively minor redistribution of responses between model reaches (Appendix B). The largest differences were in the Neeley to Minidoka reach, at which the response decreased from 69 cfs to 42 cfs in the 1870 scenario, and the Buhl to Lower Salmon Falls reach, at which the response increased from 457 cfs to 475 cfs in the 1870 scenario. The smallest differences were in the Ashton to Rexburg reach, at which the response was 247 cfs in both models for the 1870 scenario, and the Devil's Washbowl to Buhl reach, at which the response decreased from 246 cfs to 240 cfs in the 1870 scenario.

The distribution of responses to river reaches and target springs is similar between ESPAM2.1 and ESPAM2.0 and the discussion of differences between ESPAM2.0 and ESPAM1.1 (Sukow, 2012a) is generally applicable to ESPAM2.1. Figures showing the differences in calibrated transmissivity between ESPAM2.1 and ESPAM1.1 are provided in Figure 2 through Figure 5.

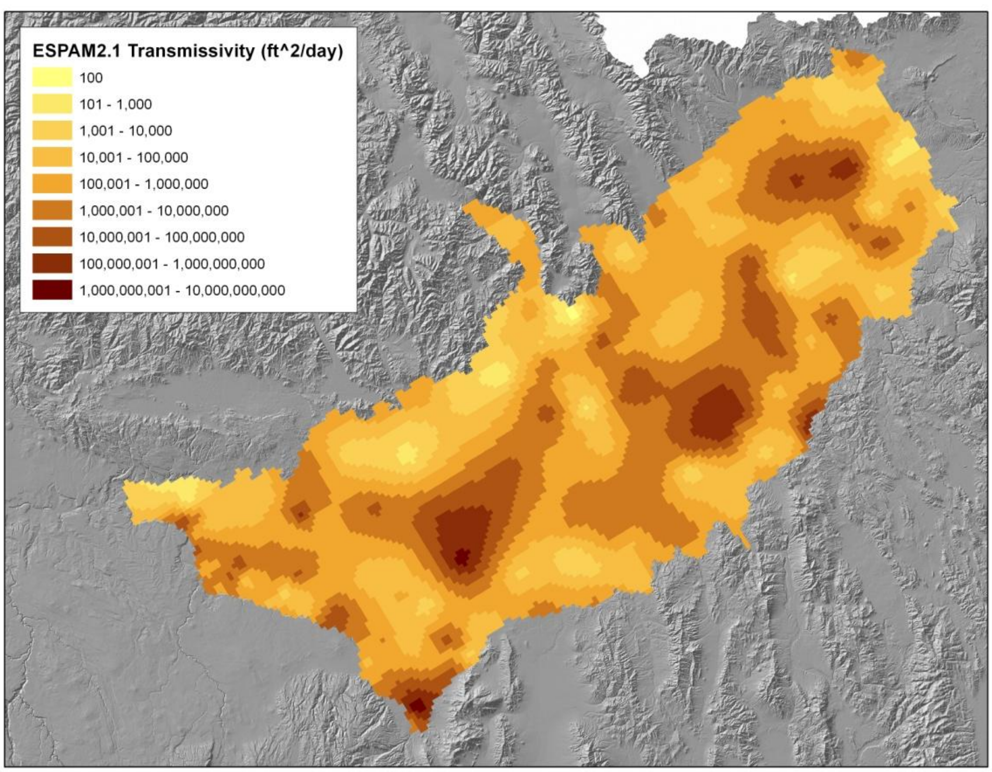

Figure 2. ESPAM2.1 calibrated aquifer transmissivity.

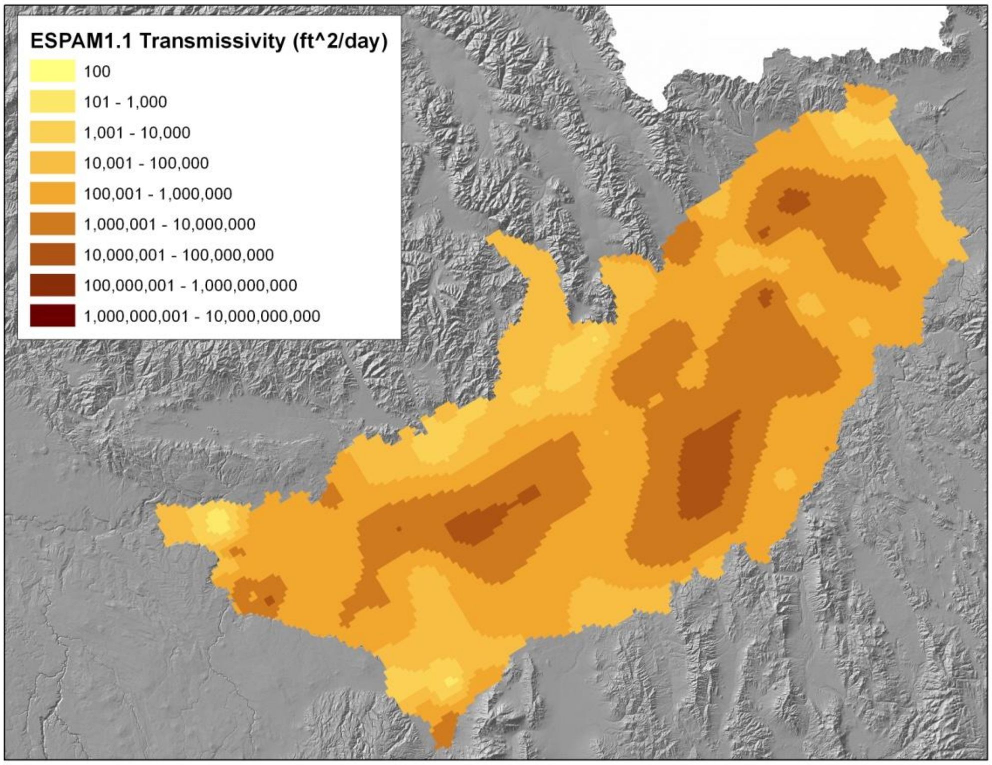

Figure 3. ESPAM1.1 calibrated aquifer transmissivity.

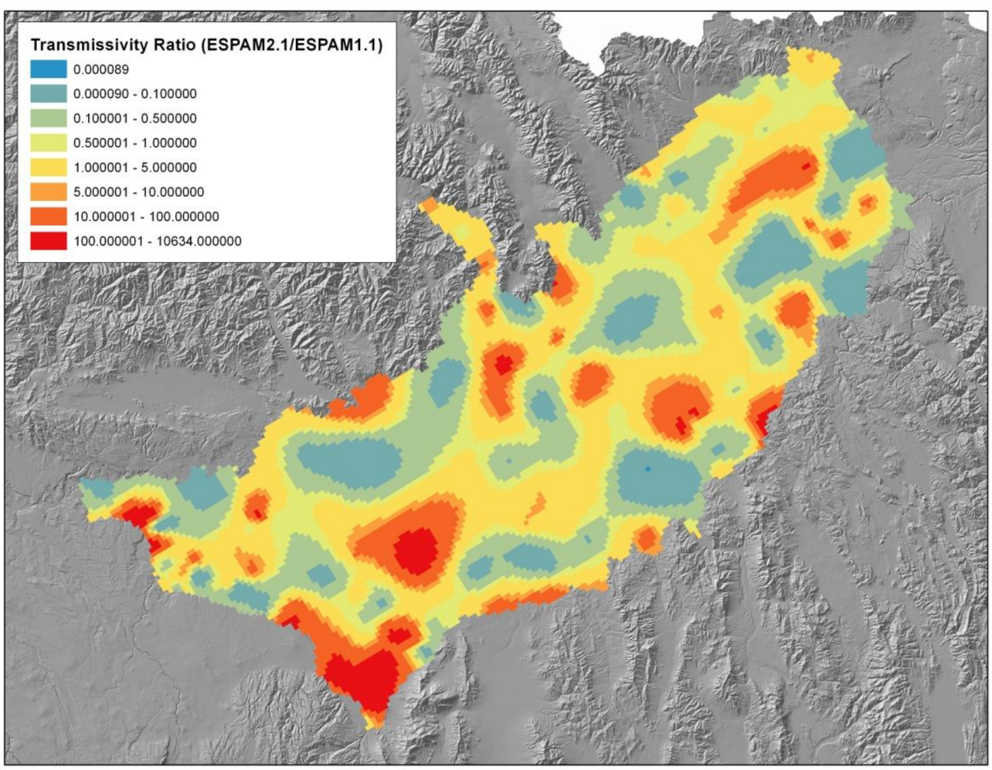

Figure 4. Ratio of ESPAM2.1 transmissivity to ESPAM1.1 transmissivity.

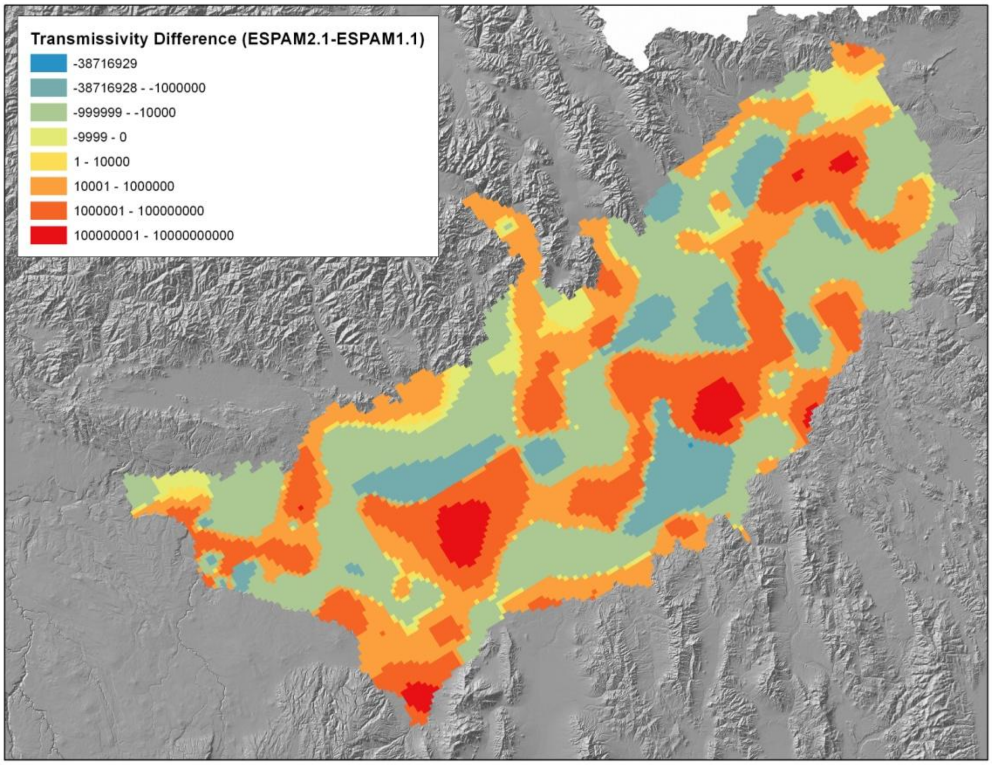

Figure 5. Difference between ESPAM2.1 and ESPAM1.1 transmissivity.

Long Term Transient Simulations

Results from the ESPAM2.1 curtailment scenario are presented in Appendix C. Results from the ESPAM1.1 curtailment scenarios are also presented in Appendix C for comparison.

Because the long term transient simulations were performed by applying a continuous stress at the average annual consumptive use rate, there is no seasonal variation in the results. The time to reach 90% of the steady state response is indicated on the graphs in Appendix C.

In the ESPAM2.1 curtailment simulations, the time to reach 90% of steady state ranged from 19 to 27 years for river reaches upstream of Milner and from 11 to 14 years for springs aggregated by reach downstream of Milner. The time to reach 90% of steady state was similar in the ESPAM2.1 and ESPAM2.0 scenarios. In the ESPAM1.1 curtailment scenarios, the time to reach 90% of steady state ranged from 17 to 36 years for river reaches upstream of Neeley, 55 to 65 years for the Neeley to Minidoka reach, and 34 to 61 years for springs aggregated by reach downstream of Milner. In ESPAM2.1, the time to reach 90% steady state is slightly longer than in ESPAM1.1 at the Ashton to Rexburg and Heise to Shelley reaches and slightly shorter at the Shelley to near Blackfoot reach. The time required to reach 90% of steady state is significantly shorter than in ESPAM1.1 at the near Blackfoot to Neeley and Neeley to Minidoka river reaches, and for the Kimberly to Buhl, Buhl to Lower Salmon Falls, and Lower Salmon Falls to King Hill springs.

Differences in the rate at which responses approach steady state result from differences in calibrated aquifer transmissivity and specific yield. Differences in calibrated transmissivity between ESPAM2.1 and ESPAM1.1 are illustrated in Figure 2 through Figure 5. Differences in calibrated specific yield between ESPAM2.1 and ESPAM1.1 are illustrated in Figure 6 through Figure 9. Improvements in spring calibration targets and in modeling seasonal fluctuation in spring discharge likely contributed to changes in model parameters and modeled transient responses at springs in the Kimberly to King Hill reaches. Like ESPAM2.0, ESPAM2.1 represented spring elevations differently from ESPAM1.1, and had a greater number of transient calibration targets representing the seasonal fluctuation in spring targets (IDWR, draft).

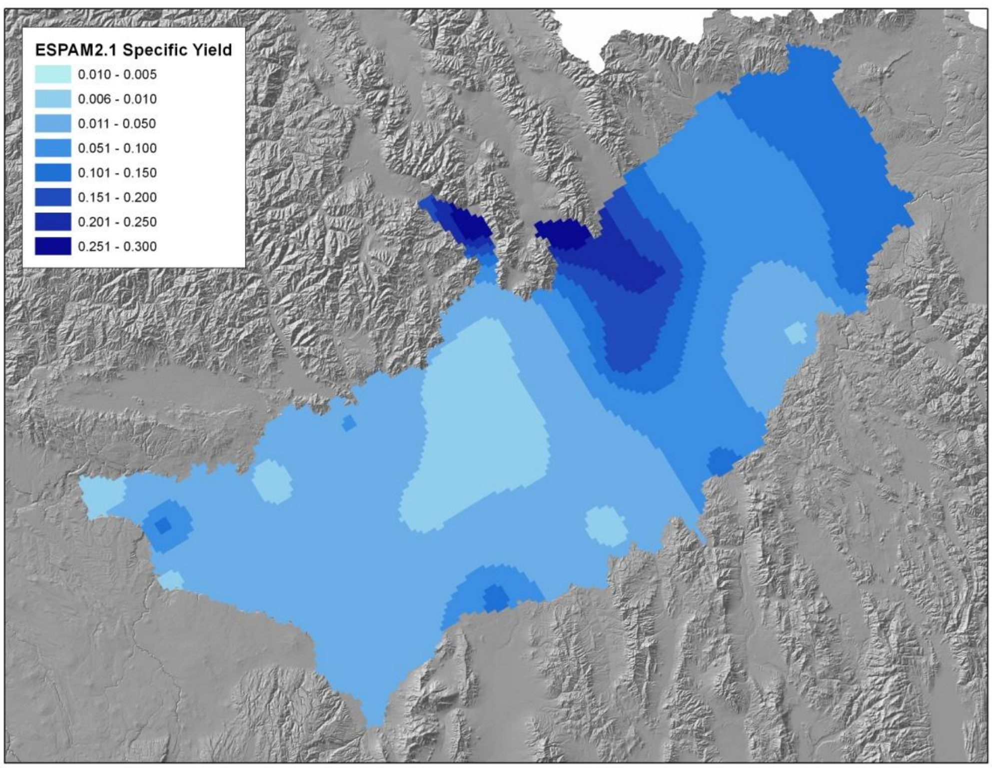

Figure 6. ESPAM2.1 calibrated specific yield.

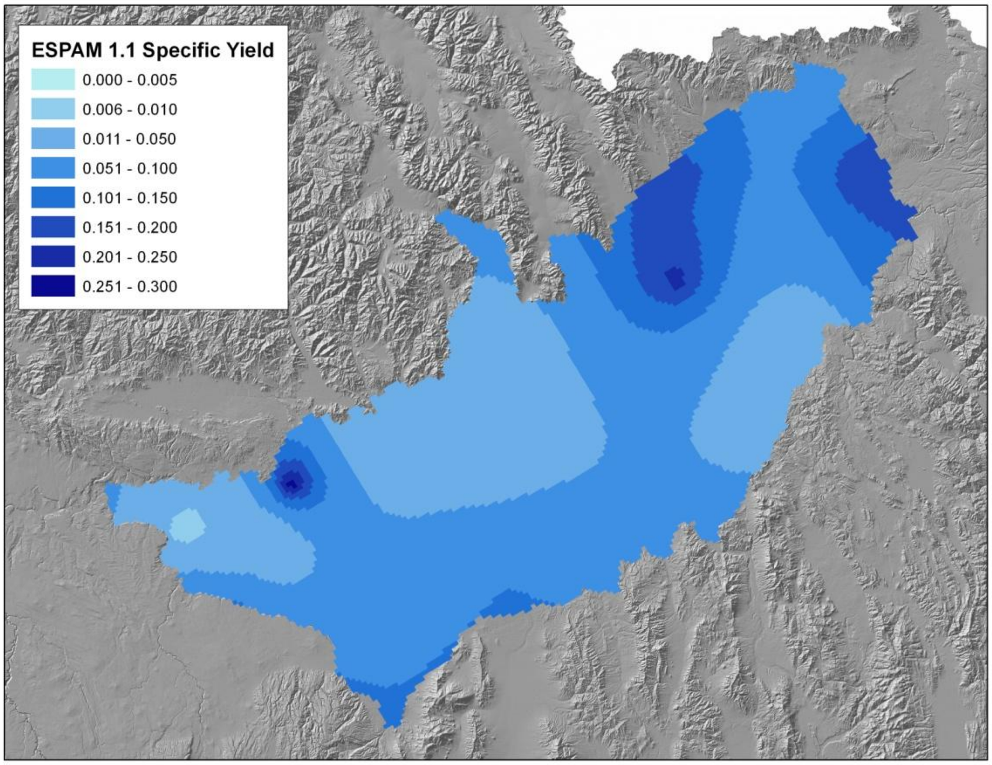

Figure 7. ESPAM1.1 calibrated specific yield.

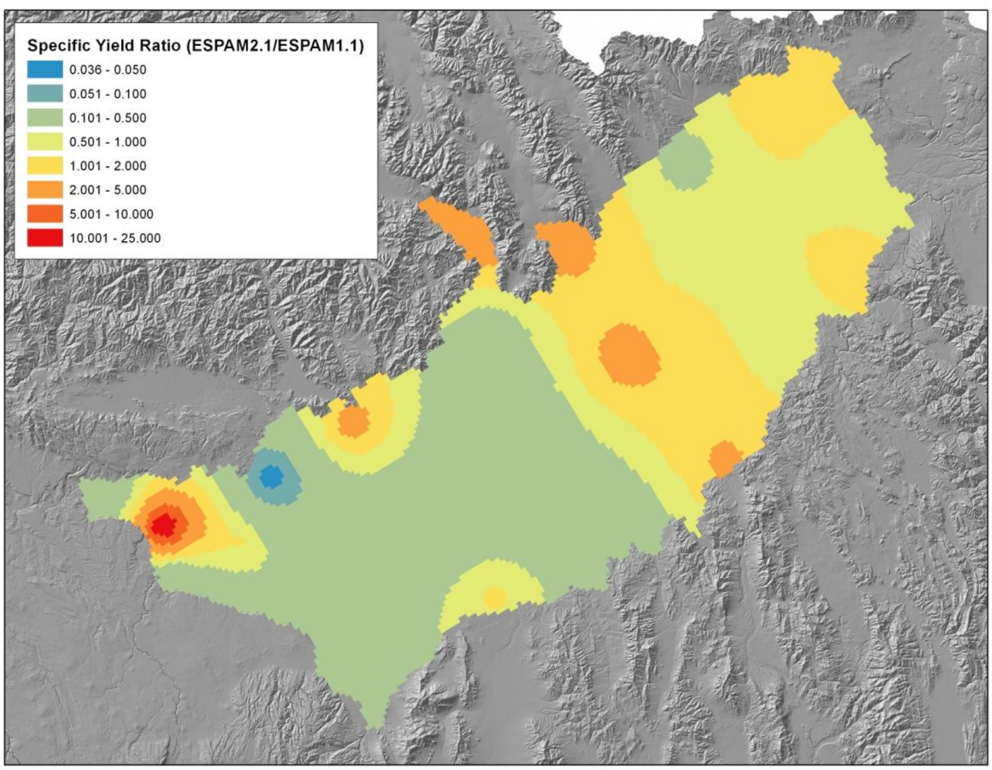

Figure 8. Ratio of ESPAM2.1 specific yield to ESPAM1.1 specific yield.

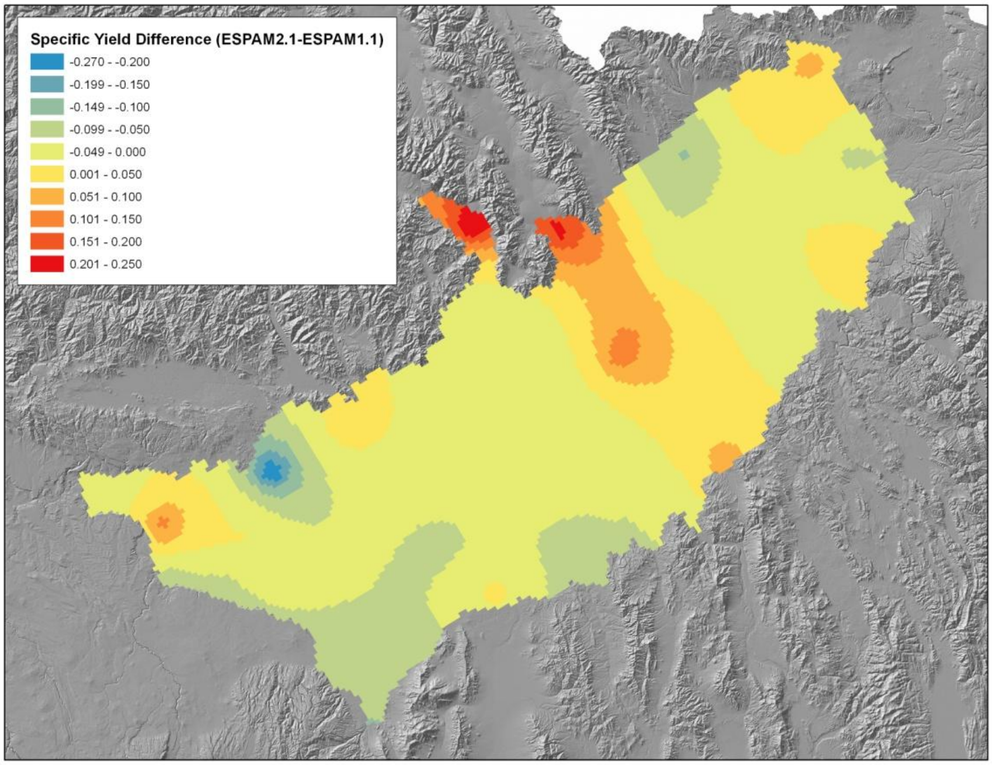

Figure 9. Difference between ESPAM2.1 specific yield and ESPAM1.1 specific yield.

Water Level Responses at Selected Locations

Aquifer head responses were evaluated at six locations for the long term transient simulation of curtailment of groundwater rights junior to January 1, 1870. Responses predicted by ESPAM2.1 are presented in Appendix D. The responses predicted by ESPAM2.0 and ESPAM1.1 are also presented in Appendix D for comparison. The six locations were selected by Contor (2006) and are shown in Figure 10.

Like ESPAM2.0, water level responses predicted by the ESPAM2.1 simulation are greater than those predicted by the ESPAM1.1 simulation at all six locations. The increase results partly from the increase in applied stress and partly from changes in model parameters and structure, as discussed in previous sections of this report.

Like ESPAM2.0, the water level response in the ESPAM2.1 simulations approaches steady state more quickly at the points near American Falls, within A&B Irrigation District, near Craters of the Moon, and in the Thousand Springs area compared to the ESPAM1.1 simulations. At the points near Mud Lake and near Idaho Falls, the water level response approaches steady state at similar rates in the ESPAM2.1, ESPAM2.0, and ESPAM1.1 simulations.

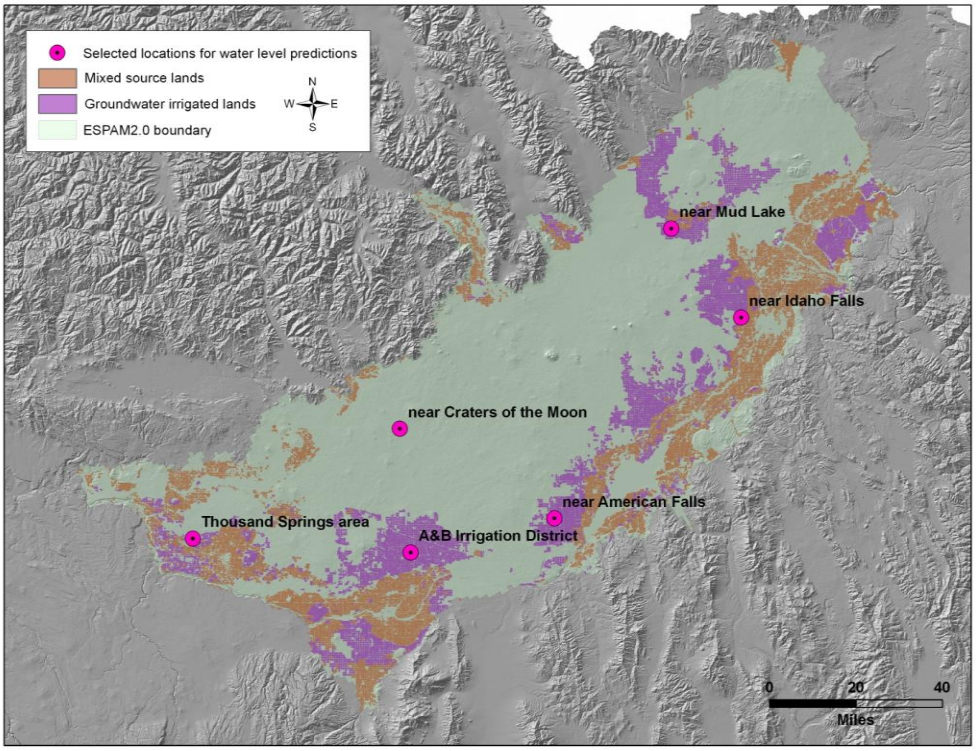

Figure 10. Selected locations for water level predictions.

Short Term Seasonal Transient Simulations

Results from ESPAM2.1 simulations of short term seasonal transient response to curtailment for 10 years are provided in Appendix E. These simulations model average monthly consumptive use and show seasonal variations in response. Results from the ESPAM1.1 seasonal curtailment simulations are shown in Appendix F for comparison. The ESPAM1.1 simulations modeled consumptive use averaged over a 6-month irrigation season beginning May 1.

In addition to the differences in the magnitude and timing of responses examined in the steady state and long term transient simulations, the short term seasonal transient results show differences in the shape of the seasonal response patterns. This results from the use of monthly crop irrigation requirement data in ESPAM2.1, as opposed to averaging the consumptive use over a 6-month period in ESPAM1.1.

In the ESPAM1.1 simulations, the seasonal response to curtailment was lowest at the end of April, prior to the beginning of the irrigation season, and peaked in November following the end of the 6-month irrigation season. In the ESPAM2.1 simulations, the seasonal response to curtailment was lowest at the beginning of the irrigation season (April to early May), and peaked in September for most reaches, following the peak consumptive use months of June through August. The peak response occurred in November for the Ashton to Rexburg reach.

SUMMARY AND CONCLUSIONS

Comparison of the results of the ESPAM2.1 and ESPAM1.1 steady state curtailment simulations (Appendix B) shows a 17% to 21% increase in the magnitude of the curtailed consumptive use for a given priority date. The increase in curtailed consumptive use is attributed to improvements in analytical methods used to determine irrigated land area (7% to 11%) and the use of updated data on crop irrigation requirement (8% to 9%). Use of updated water rights data may also have a small contribution to the increase in junior irrigated land area.

Comparison of the steady state simulations also shows changes in the relative responses of some spring and river reaches. These relative changes in response are the result of changes in calibrated model parameters (aquifer transmissivity and storativity, riverbed and drain conductance) and model structure. Changes in model parameters result from a combination of changes in calibration targets, model boundary conditions, water budget input data, and other improvements implemented in ESPAM2.1.

Transient ESPAM2.1 simulation results (Appendix C) indicate that the time required to reach 90% of steady state ranges from 19 to 27 years for river reaches upstream of Milner and from 11 to 14 years for springs aggregated by reach downstream of Milner. Comparison with results from ESPAM1.1 simulations indicates that the time required to reach 90% of steady state has decreased substantially at the near Blackfoot to Minidoka reach and at springs downstream of Milner. Similar trends are observed in simulated water level responses (Appendix E), which approach steady state more quickly in the ESPAM2.1 simulations in the western portion of the model domain.

Seasonal transient simulation results (Appendix E) illustrate the change in the seasonal response patterns resulting from the change from 6-month stress periods in ESPAM1.1 to monthly stress periods in ESPAM2.1.

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