Response to Request for Information[1] from the Big Wood River Ground Water Management Area Advisory Committee

Prepared for the Advisory Committee by the Technical Working Group

11/24/2021

1. **Recommend quantitative tools or methodologies for predicting irrigation season water supplies for surface water sources in the Big Wood River Ground Water Management Area (BWRGWMA), including the Big Wood River above Magic Reservoir, Big Wood River below Magic Reservoir, Silver Creek, the Little Wood River below the confluence with Silver Creek, and Camas Creek.**
    - **Recommended methodologies should evaluate historical analogous water years and anticipated deliverable water rights by priority**
    - **Develop criteria for selection and evaluation of suitability of analogous years (e.g., even though SWSI indicated similar hydrologic conditions, other relevant conditions should also be evaluated for similarity to the current/upcoming year (water use practices, reservoir storage, cropping patterns, fallowing programs, water rights administration, runoff timing, unusual weather events, etc.)**

Several tools have been developed or identified for predicting flows in the Big Wood River (both above and below Magic Reservoir), Silver Creek, and Camas Creek. The Technical Working Group (TWG) is not aware of a forecasting tool for Little Wood River below the Silver Creek confluence or for Willow Creek, though there is consideration of including Willow Creek in the Wood River Water Collaborative (WRWC) model. Table 1 is an overview of forecasting locations in the BWRGWMA for known models.

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[1] The list of topics for discussion/analysis was compiled by Tim Luke, IDWR, based on questions submitted by members of the Advisory Committee and subsequently revised based on input from the Technical Working Group. The topics appear in **bold font.**

Table 1. Wood River system predictive tool coverages by gage.

Reach	*SWSI*	*WRWC*	*NWRFC*
Big Wood at Hailey	✓	✓	✓
Big Wood at Stanton Crossing		✓	
Big Wood below Magic	✓		✓
Silver Creek		✓	
Little Wood below Silver Creek			
Camas Creek		✓	

a. SWSI

The Surface Water Supply Index (SWSI) is a predictive indicator of surface water availability in a basin relative to historic irrigation season supply. The Natural Resources Conservation Service (NRCS) calculates a SWSI for the Big Wood at Hailey and Big Wood below Magic gages by summing the two major sources of surface water supply for irrigation: streamflow runoff and reservoir carryover. According to the NRCS website, "*SWSI uses non-exceedance probabilities to normalize the magnitude of annual water supply variability between basins. The non-exceedance values are then rescaled to range from +4.1 (extremely wet) to -4.1 (extremely dry). A SWSI value of 0.0 indicates a median water supply as compared to historic occurrences.*"

At the beginning of each month (excluding November and December), the NRCS publishes a table with 10-, 30-, 50-, 70-, and 90-percent exceedance forecasts for the coming irrigation season (April through September) along with measured total irrigation season water supply volumes for the previous 30 years and an estimate of the adequate water supply volume for irrigation. Because the index value assigned to a given flow volume may change each year with the change in the 30-year period, the predicted flow volume is a better value to apply for development of a multi-year management plan.

NRCS water supply forecasts are statistical models based on linear regressions that use an iterative process of principal component or zscore regression to determine suitable correlated variables (e.g., snow water equivalent, precipitation, antecedent streamflow, climate teleconnection index).

b. WRWC

The predictive model that is being developed by Dr. Kendra Kaiser for the Wood River Water Collaborative (WRWC) provides forecasts for irrigation season streamflow and timing[2] for the following USGS stream gages: Hailey and Stanton Crossing on the Big Wood River, Silver Creek at Sportsman Access, and Camas Creek near Blaine. The model also forecasts curtailment dates for three priority dates on the following river reaches: Big Wood above Stanton Crossing, Big Wood Below Magic, and Silver Creek. The WRWC model, like the NRCS water supply forecast, is a statistical model based on linear regressions; however, the specific regressions between the models differ.

The WRWC model uses a Bayesian Information Criterion method for determining the best forecasting variables for each site. The WRWC model further forecasts water right priority curtailment and runoff timing for the center of mass for streamflow. Each prediction includes exceedance probabilities and uncertainty bounds. An additional difference from the NRCS model is that the predictions at the four gages are produced in tandem such that the relationships between gage locations are statistically incorporated into the simulations (e.g., the model will not predict a high flow year at one gage and a low flow year at another gage). An important component of the model is evaluating the most similar analog years, both in total volume and in timing of runoff. The "analog years" are identified in the model run report.

This model may be run on any date from February through April; the models for each month are calibrated independently and have separate predictor variables. The timing models incorporate predicted springtime temperatures, while the other variables are all observed at the time of the model run. The curtailment date prediction is an attempt to automate a process manually performed by the Watermaster or IDWR upon receiving NRCS forecast volumes.

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[2] Timing is characterized by the center of mass of streamflow, which is the mean of the probability distribution of April through September streamflow. See WRWC documentation at https://github.com/kendrakaiser/WRWC/blob/master/Model_Details.pdf

Additional funding from the USDA NIFA Agricultural and Food Research Initiative has been obtained to continue development of the WRWC model. A main objective for that funding will be to continue refining the model and to host the model and data organized by Ecosystem Sciences Foundation on an interactive website.

c. NWRFC Ensemble Streamflow Prediction

The Northwest River Forecast Center (NWRFC) provides probabilistic water supply forecasts underpinned by a calibrated, lumped-bucket model called the Sacramento Model. A basin's current hydrologic conditions are used to initiate the model along with the 10-day precipitation forecast and historic climate forcing time series data (e.g., precipitation and temperature). Per the NWRFC's website:

> *"NWRFC currently uses an ensemble streamflow prediction technique to make water supply forecasts for the Columbia River Basin … [The Ensemble streamflow prediction] (ESP) is a modeling component of the National Weather Service Community Hydrologic [Prediction] System (CHPS). ESP produces long-range probabilistic forecasts of hydrologic variables. ESP utilizes a conceptually based modeling system to simulate soil moisture, snowpack, regulation, and streamflow. ESP then accesses the current hydrologic model states and uses historical meteorological data to create equally likely sequences of future hydrological conditions, each starting with the current hydrological conditions. Statistical analysis is performed on these sequences to generate probabilistic forecasts of seasonal water supply. National Weather Service River Forecast System (NWSRFS) is a continual simulating model. ESP can take advantage of this constant updating to provide water supply estimation weekly and throughout the year"*

Ten-day, one hundred and twenty-day, and April to September forecasts are available starting the first day of the water year for the irrigation season as well as on January 1, which is the earliest forecast date requested by some TWG members. The range of uncertainty associated with pre-season forecasts is very high and tends to narrow through time as seen on Figure 1.

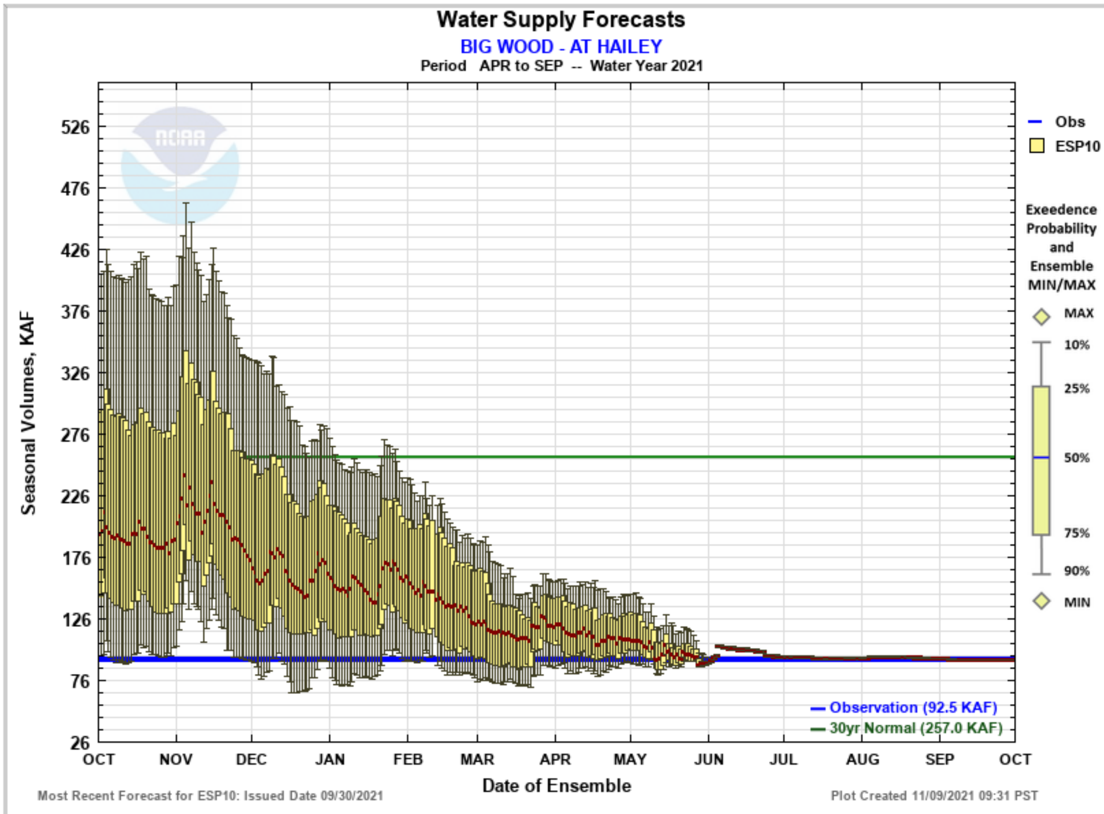

Figure 1. Water year 2021 forecast for April to September runoff volume at the Big Wood Hailey gage from the NWRFC. Each boxplot represents the range of exceedance probabilities for volumes as predicted on that day. The date of ensemble on the x-axis is equivalent to the date of forecast.

d. Streamflow Correlations

Correlations between gages from 1990 to 2020 were evaluated by IDWR staff to assess how forecasts on the Big Wood River might be used to forecast streamflow in Camas Creek and Silver Creek (Moody, 2021). Measured February through July flow volumes at Camas Creek near Blaine correlate well with measured February through July volumes and SWSI values for both the Big Wood River at Hailey and Big Wood River below Magic Reservoir gages. R^2 values range from 0.83 to 0.94, suggesting forecasts on the Big Wood River may be a good indicator of expected water supply from Camas Creek, though with a higher degree of uncertainty. The forecast below Magic has a higher correlation with Camas Creek, likely because this forecast accounts for inflows from Camas Creek. Silver Creek flow volumes are less correlated than Camas Creek flow volumes to Big Wood River flow volumes and SWSI values, with R^2 values ranging from 0.71 to 0.83.

e. Discussion

The three water supply forecasts available for several gages in the Wood River system provide broad, robust predictive capabilities. The Big Wood River at Hailey and Below Magic gages have the longest history of predictions provided by federal agencies (NRCS and NOAA's NWRFC), starting in 1993 and 1970, respectively. The WRWC model is still in development and seeks to provide more detail to these forecasts by extending coverage to Camas Creek and Silver Creek. Inclusion of Willow Creek in the WRWC is also being considered. All models forecast in-season (April through September) water supply volumes. The WRWC model is the only model to predict priority date cuts based on historical watermaster data. While both the WRWC and NRCS models are statistical models, the NWRF model is a lumped hydrologic model.

The SWSI can be calculated at the beginning of the month starting in January. The WRWC model can be run at any date after February 1, but each month's model is calibrated to data from the 1st of the month.

f. Recommendations

While all three models have their strengths, the WRWC model appears promising as a tool for general use in the BWRGWMA and its use has tentatively been endorsed by the TWG. An assessment of the reliability and utility of each model should be completed by the TWG upon release of the WRWC model.

Until release of the WRWC model, the TWG would like to report and consider all model results, even if only one number is needed for decision making. Until the WRWC model has been finalized, reviewed, and approved for use by the TWG, the TWG recommends using the mean of the SWSI and NWRFC forecasts for decision making.

2. **Recommend groundwater diversion limits based on forecasted irrigation season water supplies and consider/evaluate consumptive use limits and/or irrigated area limits for.**
   - **Annual, monthly, daily volumes**
   - **Irrigation pumping limits**
   - **Non-irrigation pumping limits**

   a. A draft preliminary analysis of consumptive use reduction with the Wood River Valley (WRV) aquifer system was prepared by IDWR staff. A synopsis is presented here.

      Using Silver Creek reach gains above the Sportsman Access gage as an indication of general aquifer conditions, IDWR staff compiled historic data from 1995 to 2014 with modeled (version 1.1 of the WRV groundwater flow model) consumptive use. An initial range of reach gains were based on reach gain correlations with Sportsman Access flow thresholds of 86 cfs and 99 cfs based on a preliminary Advisory Committee discussion of potential target flows.

      Review of data compiled from 1995 to 2014 indicate that low reach gains to Silver Creek (<119 cfs average for July through September) have historically occurred when the April to September flow volume was less than 225 thousand acre-feet (KAF) at the Hailey gage and the estimated non-exempt and non-mitigated groundwater consumptive use (GWCU) within the model domain exceeded 25 KAF. Very low Silver Creek reach gain conditions (<100 cfs average for July through September) have historically occurred when the April to September Hailey flow volume was less than 225 KAF and the estimated non-exempt and non-mitigated GWCU exceeded 35 KAF.

      Reduction of average annual GWCU, by approximately 11 KAF when forecasted April to September flow volumes at Hailey are less than 225 KAF could decrease the probability of low and very low conditions in below average and extremely dry years. Current proposed fallowing (1,100 acres) would reduce average CU by 1,940 AF. In years of predicted flow less than 225 KAF, fallowing 6,200 acres total would be expected to reduce CU by about 11 KAF.

b. Recommendations

The TWG recommends the Advisory Committee use an approach similar to IDWR staff's preliminary analysis for determining groundwater consumptive use limits and reductions in irrigated acreage as a starting point for the development of a Management Plan for the Wood River Valley portion of the BWRGWMA.

The simplified two-tier approach outlined by IDWR staff provides a constant quantity of fallowed acres for all years with a predicted low water supply, and results in the risk of either undershooting or overshooting aquifer discharge goals in any given year. A multi-tiered approach may be considered by the Advisory Committee but will result in more uncertainty in the quantity of fallowed acres that will be required until the forecast is released. Because of the inability to predict the irrigation demand per acre for the upcoming season, there will still be a risk of either undershooting or overshooting aquifer discharge goals, even with a multi-tiered approach.

3. Estimate depletions to Camas Creek resulting from groundwater pumping

- **Can timing, location, and amount of depletions be estimated?**
- **Discuss whether this is for the purpose of estimating impacts from pumping to Camas Creek surface water rights, impacts to inflows to Magic Reservoir, or both.**

USGS researchers identified the Camas Creek at Blaine to Magic Reservoir reach as the primary outlet for the Camas Prairie aquifer system (Walton, 1962 and Young, 1978). According to this conceptual model, consumptive groundwater use on the Camas Prairie reduces the inflow to Magic Reservoir. However, not all TWG members agree with the USGS conceptual model. An alternate conceptual model holds that the Camas Prairie aquifer system discharges underneath (and not into) Magic Reservoir (Squires, 2021). By order of a previous IDWR Director, Camas Prairie groundwater users are within the BWRGWMA, and it is not in the purview of the TWG to reverse that decision.

Hydrologic connection between the aquifer system and Camas Creek is supported by four IDWR fall seepage studies performed after the irrigation season in 2017, 2018, 2019, and 2020 and one runoff measurement performed in March 2021. The fall surveys show a reach gain (aquifer discharge) to Camas Creek of 5.9 to 7.7 cfs between Macon Flat Bridge and Magic Reservoir and 0.79

to 2.6 cfs between Macon Flat Bridge and the USGS gage near Blaine (13141500; see Figure 2~~Figure 2~~). Fall measurements were made to ensure any diversions were shut off and potential springs on Macon Flats were not running. The March 2021 measurement showed a gain of approximately 7 cfs between Macon Flats Bridge and the gage, and a loss of approximately 7 cfs between the gage and the pool of Magic Reservoir.

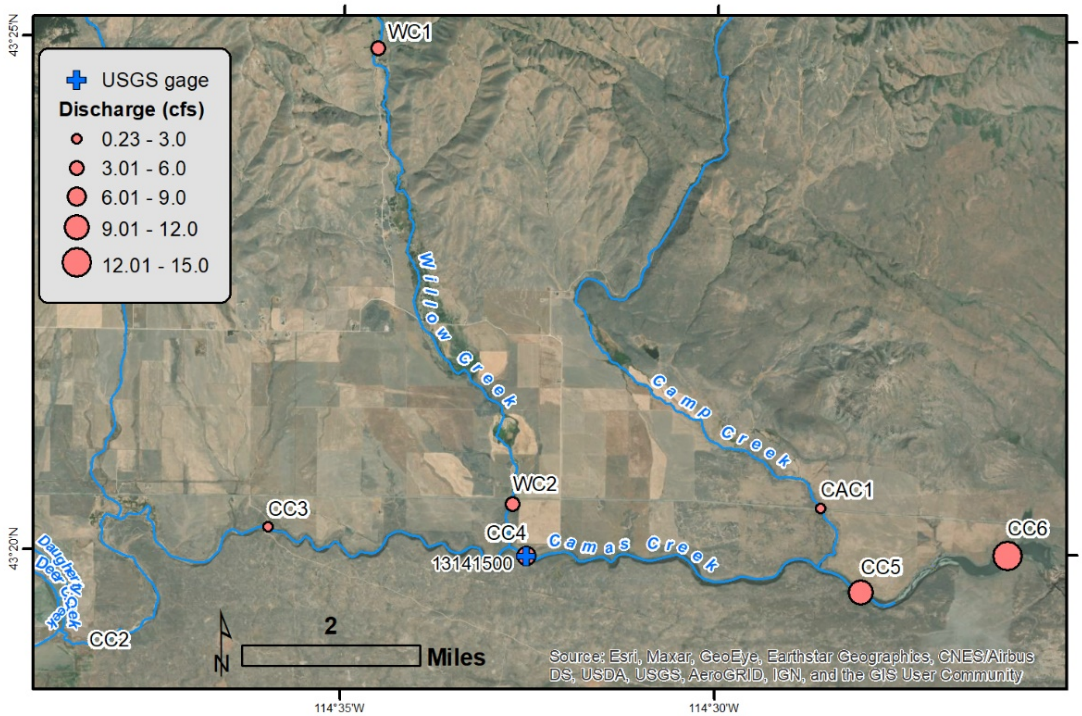

Figure 2. Lower Camas Creek November 2020 seepage measurement sites. CC3 is Macon Flat Bridge and CC4 is the USGS Camas Creek near Blaine gage.CC5 and CC6 are measurement locations downstream of the gage before the Magic Reservoir pool.

IDWR staff estimates that the average annual groundwater consumptive use during 2015-2020 was 10,030 AF (13.8 cfs) which is approximately 30% of the average 34 KAF consumptive use modeled in the Wood River Valley aquifer system. Estimates of groundwater consumptive use on the Camas Prairie were based on PRISM precipitation rasters and METRIC ET rasters, water right places of use, and the USDA National Agricultural Statistics Service Information cropland data layer. Estimated groundwater irrigation efficiencies range from 79% to 96%.

Mann-Kendall trend analysis of monthly flows for the period 1945 to present at the near Blaine gage shows a significant decrease in Camas Creek discharge from August through February ranging from 0.39 cfs/yr to 0.01 cfs/yr. March through July showed no significant trends. A seasonal trend test shows overall decreasing trends of 0.1 cfs/yr since 1945, when the gage began operating year-round, and 0.26 cfs/yr since 1970. The trend since 1945 equates to a total decrease of approximately 7.6 cfs.

4. **Estimate the potential benefits to aquifer storage and to stream reach gains (timing, location, amount) in Camas Creek, Big Wood River including Magic Reservoir, and Silver Creek of the following aquifer/streamflow enhancement activities:**

   a. **Fallowing farmland**

   IDWR evaluated the hydrologic impacts of the proposed fallowing of 1,092 acres identified by the South Valley Groundwater District (SVGWD) using version 1.1 of the Wood River Valley groundwater flow model. The evaluation included the impacts of reduced consumptive use of groundwater and surface water, the impacts of reduced incidental recharge on fallowed lands, the impacts of recharging saved Big Wood water at locations identified by SVGWD, and the impacts of non-diverted Silver Creek water. The 1,092 acres identified were assumed to be fallowed every year. The average annual consumptive use reduction on these acres was 1,940 AF, approximately 1.8 AF per acre[3].

   Conclusions of the analysis are:

   1. Fallowing irrigated land to reduce demand provides a net benefit to the hydrologic system equal to the reduction in consumptive use of irrigation water, regardless of the water source.

   2. Fallowing of the proposed 1,092 acres is predicted to increase water availability by roughly 3 to 4 cfs in Silver Creek and 1 cfs in the Big Wood River during August and September of the driest years.

   3. A modest increase in aquifer storage due to fallowing of the proposed acres is retained through the beginning of the next irrigation season.

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[3] Although there are non-linearities in the WRV1.1 model, from a mass-balance viewpoint, the 1.8 AF per acre of annual consumptive use is scalable. The imprecision resulting from model non-linearity relates to when and where the benefits of fallowing would be expressed in surface water reach gains.

4. Significantly increasing the fallowed acreage would be expected to provide significantly larger benefits to the hydrologic system.

b. End-gun removals from center pivot irrigation systems

Eric Miller submitted a memo on sprinkler system application efficiencies (Rumsey, 2021), noting that traveling guns typically operate at 60%-70% efficiency. Three options of end-gun removal and their potential benefits to irrigation efficiency were mentioned; no transfer of water, transfer to acreage irrigated by hand or wheel line, and transfer to acreage irrigated by center pivot. No transfer of water should result in the most water savings, transfer to wheel line would likely see no change in irrigation efficiency, and transfer to other acres irrigated by a center pivot could provide a 20% increase in application efficiency. No inventory of end-guns or estimate of the effect of end-gun removal in the Wood River Valley aquifer system were completed.

Effects on consumptive use from end-gun removal are not discussed in the Rumsey memo. If the acres irrigated by end guns is transferred to lands irrigated by other means, there will likely be an increase in consumptive use despite a decrease in pumping because of higher efficiency. Fallowing end-gun irrigated acres without transfer to other acres; however, will reduce consumptive use.

Bryce Contor submitted an initial evaluation of end-gun removal (Contor, 2021(a)), which concluded that removal of all end guns in the Wood River Valley may result in a 2% to 8% reduction in consumptive use of irrigation water. The analysis assumed an average pivot radius of 1,320 feet, an average end-gun reach of 100 feet, uniform consumptive use on lands irrigated by pivots and end-guns, and that 80% of irrigated lands are served by pivots with end-guns. Because some of the fallowed lands included in the analysis for item 4a were pivot corners, there is some overlap between the reductions contemplated in Contor's analysis.

c. Growing less consumptive crops; reduce consumptive use through shorter season-of-use

Bryce Contor provided the results of a previous study on the potential effects of changing crop mix on the eastern Snake Plain (Contor and Pelot, 2008). The study estimated a potential reduction in consumptive use of 9% might be attainable by incentivizing crop mix changes on the eastern Snake Plain.

Dave Shaw reported that changes in crop type and shortened season-of-use were discussed among some of the irrigators in the SVGWD but there was not an expectation of significant water savings. According to Mr. Shaw, there are some acres in hay that could be shut off early for some late season water savings along with reduced production. Further, there was no interest in an early shutoff on pasture since late fall grazing is important. Perhaps a few more acres of small grain could be planted but there was no estimate of acreage given.

d. Additional conservation measures (irrigation/delivery system efficiency improvements, other conservation measures related to non-irrigation systems)

Irrigation and delivery system efficiency improvements for groundwater irrigation systems will not have a net benefit to the hydrologic system.

Irrigation and delivery system efficiency improvements for surface water irrigation systems in the Wood River Valley aquifer system will also not have a net benefit to the hydrologic system but will reduce aquifer recharge and alter the timing and location of surface water flows.

Irrigation and delivery system efficiency improvements in the lower Big and Little Wood Basin would reduce the per acre demand for streamflow and Magic Reservoir storage and may extend the seasonal availability storage water but would reduce incidental recharge to the Eastern Snake Plain Aquifer.

Other conservation measures related to non-irrigation systems have not been specified by the Advisory Committee for review by the Technical Working Group.

e. Groundwater to surface water conversions

Potential sources of surface water for conversions have not been identified by the Advisory Committee or Technical Working Group.

f. Aquifer recharge using flood flows and/or surface water rentals

The recharge of water saved by fallowing lands irrigated by Big Wood River water was included in 4a. Other feasibly available sources of water for recharge were not identified by the Advisory Committee or Technical Working Group.

5. **Model hydrologic impacts of groundwater curtailment upstream of Glendale Bridge.**
    - **All pumping**
    - **Irrigation pumping**
    - **Non-irrigation pumping**

IDWR staff used WRV1.1 to simulate consumptive groundwater use curtailment north of Glendale Bridge from May to October of 2002. The simulation included reductions in pumping and incidental recharge. Additional flow in the Big Wood River may result in additional diversion of water for irrigation of Poverty Flat and/or the Bellevue Triangle. Canal seepage and incidental recharge associated with additional diversions would result in additional responses in Silver Creek and in the Big Wood River below the Dry Bed and Willow Creek that are not included in the model simulation.

Reach gain responses were greatest in the Big Wood River above the Dry Bed during the summer. Underflow responses at the boundaries were negligible. Cumulative change in aquifer storage peaked at the end of the 2002 irrigation season at around 6,000 AF and declined to 1,000 AF in the beginning of January 2005.

The curtailment simulation included curtailment of irrigation for both agricultural and non-agricultural purposes, including irrigation within municipalities and subdivisions. Irrigation associated with exempt domestic water rights and water rights mitigated by the non-use of surface water were excluded from the simulation. Non-irrigation uses were assumed to be non-consumptive, but this assumption has not been verified.

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