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Response to

Staff memorandum in response to expert reports submitted for Rangen Delivery Call

by

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Idaho Department of Water Resources

February 27, 2013

By

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STATE OF IDAHO
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For

Racine, Olson, Nye, Budge and Bailey, Chartered

Boise Idaho

April 5, 2013

Introduction

IDWR staff prepared a memorandum ("staff memo") that responded to various parts of the expert reports submitted on behalf of Rangen, Inc., IGWA, FMID, and the City of Pocatello. This document presents my response to those portions of the staff memo dealing with my expert reports submitted on behalf of IGWA. My goal is to address errors pointed out in the staff memo, to clarify statements where necessary, address issues with the report and analysis, and to restate my positions as they relate to IDWR's opinions on key concepts.

Correction of Modeling Errors

The staff memo pointed out two errors in my simulation modeling which are described below. I have corrected these errors and have included the corrected model results in Attachment A to this document.

Applied stress in the curtailment analysis

On page 40, the staff memo contains this statement regarding AMEC's applied stress in the curtailment analysis: "Review of Dr. Brendecke's model files also indicates that he applied a stress equal to total pumping, rather than applying a stress equal to the crop irrigation requirement or net pumping."

This error occurred because I mistakenly used the .wel file generated by MKMOD rather than the .net file as the curtailment stress. Attachment A contains the relevant tables and figures from my report that reflect this correction.

Delineation of 10% trimline

On page 38, the staff memo contains the following statement regarding AMEC's use of the 10% trimline: "It appears that Dr. Brendecke did not use the correct 10% trimline in his analysis performed with ESPAM2.1. AMEC's model files show that pumping was applied in model cells 1041014 and 1043013, which both have steady state response functions of 9.53% with respect to the Rangen spring complex."

This error occurred because I allowed steady state response values greater than 9.5% to be rounded up to 10% before defining the trimline, whereas IDWR does not consider such rounding. Attachment A contains the relevant tables and figures from my report that reflect this correction.

Responses to Staff Comments

There are several areas in the staff memo that I disagree with or believe misinterpret my reports. The following section of this response addresses the more significant of these.

Throughout the staff memo are references to ESPAM2.1 as the "best available science" for determining effects of changes in water management, such as curtailment. There is no dispute that ESPAM2.1 is available. There is no dispute that there are no other current groundwater models of the ESPA that have undergone a similar level of scientific review. In my view the real question to be answered in this proceeding is whether ESPAM2.1 is sufficiently accurate and reliable to justify widespread curtailment of lawfully decreed water rights or to precisely quantify the mitigation requirements that would allow junior groundwater rights to continue operation. I believe it is not and that both model uncertainty and efficient water resource management dictate that ESPAM2.1 be applied with considerable caution in establishing the obligations of junior groundwater users.

On p. 4 of the staff memo, it states *"ESPAM2.1 incorporates the spatial distribution of aquifer recharge and discharge and regional-scale hydrogeology within the constraints of a one-mile square grid size and transmissivity pilot point spacing, which is approximately two to four miles in the vicinity of the Buhl to Lower Salmon Falls reach."*

While it is true the model uses one-mile grid spacing, this scale does not represent the spatial resolution of all the data required for input to the model. Much of this data is available only at a much coarser scale. For example, the model uses county-wide cropping patterns to estimate irrigation requirement on individual fields and entire canal service areas for determining rates of application of surface water. Conditions such as these inevitably lead to model uncertainty when the model is applied to increasingly localized situations, such as aquifer discharge at Rangen.

On p. 5 of the staff memo, it states *"It would not be appropriate to increase the weight of post-2000 observations during model calibration as suggested by Brendecke (2012, 2013) and Hinckley (2013)."*

I disagree with this statement because it ignores important changes in water use efficiency on the plain above Rangen that are not reflected in ESPAM2.1 (as acknowledged on p. 33 of the staff memo). While ESPAM2.1 reflects increased use of sprinklers, it does not reflect other changes in water delivery practices such as lining and piping of laterals and changes in the use of spill ponds, which I believe could at least partially explain why ESPAM2.1 systematically underestimates predictions in the early half of the simulation (roughly 1980-1995) and overestimates them in the later half (roughly 1996-2008). These changes are more accurately reflected in current observations of discharges. In order to assess effects of curtailment going forward from the present, it is appropriate to weight current conditions more highly than those which occurred in the past.

IDWR has in other instances selectively used specific time periods for model input when it best suits the purpose. For example, on page 56 of the staff memo, IDWR describes using a later time period for average precipitation because it is a better fit to the model: "The 1971-2000 period used to estimate precipitation with ESPAM1.1curtailment simulations resulted in estimates of precipitation higher than the long term average from 1934 through 2008. Average precipitation from the 1998-2008 period used with ESPAM2.1 curtailment simulations is closer to the long term average."

Moore and Doherty (2005) state:

> *A model's role as a predictor of environmental behavior can be enhanced … by giving greater weight to those measurements which carry the greatest information content with respect to a required prediction. This suggests that a departure may be necessary from the custom of using a single ''calibrated model'' for the making of many different predictions. Instead, model calibration may need to be*

repeated many times so that in each case the calibration process is optimized for the making of a specific model prediction.

It seems that preferential weighting of specific data sets and time periods for model calibration and comparison is an accepted practice.

On page 5, the staff memo states, *"Use of the steady state response functions to delineate a trimline requires accepting that the ESPAM2.1 provides the best available prediction of response at the Rangen spring cell."*

My use of steady state response functions from ESPAM2.1 reflects my acknowledgement that ESPAM2.1 is most likely what IDWR will use to make a determination in this delivery call. Use of these functions is a reasonable basis for defining a trimline, should the Director decide to do so in order to address uncertainty and other policy considerations.

On page 5, the staff memo states *"…Brendecke (2012, 2013) conclude that ESPAM2.1 does not include sufficient local-scale detail to be capable of providing a reasonable prediction of responses at the Rangen cell, but do not suggest alternative methods…"*

This statement appears to read more into my conclusion than was intended. It is not my opinion that ESPAM2.1 should not be used at all, but that any application of ESPAM2.1 must acknowledge and accept that there is an inherent and unquantifiable level of uncertainty in the predictions generated by the model. Just because the model predicts a certain impact from a given curtailment does not mean the predicted impact will actually be realized. This bears on the degree of confidence the Director has that a given curtailment will materially benefit Rangen. The alternative I propose is that the Director account for this uncertainty by limiting the scope of curtailment (using a trimline or other method) to junior users for which he is confident that a meaningful amount of the curtailed water will accrue to Rangen within a meaningful time without undue waste of the resource.

On page 8, the staff memo states *"If simulation of curtailment of groundwater irrigation is limited to the current area of common groundwater supply… the benefit predicted at the Rangen spring cell is only 1% of the curtailed use. The other 99% of the benefit would accrue to other springs and reaches of the Snake River."*

I believe this statement supports my opinion that full curtailment is a waste of the water resource because nearly all of the increase would accrue to water rights that are not making a delivery call, or that are already mitigated, or are already fully satisfied, or are precluded from placing a delivery call (e.g. hydropower rights).

On p. 16 of the staff memo it states *"Dr. Brendecke concludes that the source for water rights 36-2551 and 36-7694 is the Martin-Curren Tunnel, which he argues meets the definition of a well, and implies that Rangen does not have a right to divert from the "natural springs" that have also historically supplied the hatchery."*

My report stated that the physical nature of the Martin-Curren Tunnel meets the statutory definition of a groundwater well. I offered no opinion on whether Rangen has rights to divert water from the natural springs in the area.

On page 17, the staff memo states, *"Dr. Brendecke concludes that… any curtailment of groundwater is a waste of the water resource because the majority of the foregone use would not accrue to Rangen."*

I did not state anywhere in my report that "any curtailment" would be a waste of water, though it is true that the overwhelming majority of the foregone use from the proposed curtailment would not accrue to Rangen.

On page 41, the staff memo states, *"Brendecke (2012) states that the comparison of ESPAM2.1 with ESPAM1.1 performed by IDWR 'highlights the sensitivity of ESPAM2 results to conditions in particular years.' This is not a valid interpretation of the results. Changes in estimates of irrigated acreage between ESPAM1.1 and ESPAM2.1 are the result of improvements in GIS technology and methodology used to delineate irrigated lands, not sensitivity to conditions in particular years."*

The conclusion I stated was referring to the report documenting the comparison between ESPAM1.1 and ESPAM2.0, where Ms. Sukow makes the following statement: "The increase in consumptive irrigation requirement results from a combination of changes in periods used to calculate average precipitation and evapotranspiration, evapotranspiration adjustment factors, and sprinkler fractions. In the ESPAM1.1 curtailment scenarios, the average annual precipitation from 1961-1990 and average annual evapotranspiration from 1980-2001 were used to calculate crop irrigation requirement. In the ESPAM2.0 scenarios, both averages were from November 1998 through October 2008." From this it is clear that a substantial portion of the difference between ESPAM1.1 and ESPAM2.1 in this comparison is due to the use of different time periods for essential elements of the comparison.

On pages 42 and 43, IDWR quoted me as saying "*a superposition model can introduce significant error into the analysis of effects of stress changes,"* and they continue by noting that "*the fully populated model files are also available to Dr. Brendecke and the public. Dr. Brendecke could have simulated the curtailment using the fully populated version of the model to explore any potential difference in the prediction at the Rangen spring complex.*"

I would like to clarify that my point is both models (superposition <u>and</u> fully populated) assume constant transmissivity, which is itself a potentially large source of error. Because both versions make this assumption, the error is present in both models. My point about superposition is that simplifying assumptions made to the model, e.g. averaging perched river cell leakage, can introduce further error. It would be of little value to run the curtailment analysis using the fully populated model rather than the superposition model because they share the same fundamental assumption of constant transmissivity throughout the model domain.

On pp. 38-39 of the staff memo, IDWR staff present an evaluation of alternative models presented in my December report. Among other things, they ran the alternative models for a scenario of full curtailment across the model domain. I believe this full domain curtailment scenario to be an inappropriate use of the alternative models as they were recalibrated only for parameters in the CRIV group, which includes drain, river bed and general head boundary conductance parameters. The alternative models were not recalibrated for transimissivities anywhere in the model domain. As a result, the regional pathways of groundwater flow toward the Hagerman Rim are the same in the alternative models as they are in ESPAM2.1. I would expect that curtailment across the model domain using all these models would be similar.

In the process of correcting the errors noted at the beginning of this response, I developed a composite of my two alternative models and allowed PEST to recalibrate transmissivities in this composite model across roughly the western half of the model domain (74 pilot points), as well as to all the targets used in my original alternative analyses. This gives PEST an opportunity to adjust regional flow pathways in response to the conceptual modifications I made in my alternative models.

I then ran a full domain curtailment analysis comparable to that done by IDWR for ESPAM2.1 and shown in Table 3 of the staff memo. The results of this analysis show differences at both the 10% trimline, 5% trimline and full domain curtailments. Details of this recalibration are contained in Attachment B.

As before, this alternative analysis is presented as an example to illustrate conceptual model uncertainty and not as a proposal for use by the IDWR. Only a subset of the conceptual errors/uncertainties identified in ESPAM2.1 were evaluated for this demonstration. Additional evaluation would almost certainly increase the differences in results between alternative model structures.

References:

Moore, C., and J. Doherty (2005), Role of the calibration process in reducing model predictive error, Water Resour. Res., 41, W05020, doi:10.1029/2004WR003501

Attachment A – Corrected ESPAM2.1 Modeling Results

Table A.1 is updated from Table 5.2 in my 12/21/2012 expert report. The two changes made to the modeling are: 1) revise the trimline per IDWR's method; 2) rerun MKMOD to produce a net pumping file (.net file).

Table A.1 - Curtailment Results Using ESPAM2.1 (Revised Table 5.2)

Assumed Trimline Threshold	Change in Flow at Rangen Complex (cfs)	Groundwater Acres Curtailed	Curtailed Groundwater Use (af/y)	Acres Curtailed per cfs of Benefit to Rangen	% of Curtailed Use Benefiting Rangen
(1)	(2)	(3)	(4)	(5)	(6)
None	17.89	565,023	1,456,405	31,583	0.89%
5%	3.35	12,345	42,423	3,685	5.72%
10%	0.01	24	86	2,400	8.42%

Note: the values in column (5) do not exactly match the calculations presented by IDWR due to rounding.

Column (6) is calculated as (2) / [(4) / 723.8] * 100%

Figure A.1 is updated from Figure 4.10 in my 12/21/2012 expert report. The corrections shown in this figure are updated 5% and 10% ESPAM2.1 trimlines.

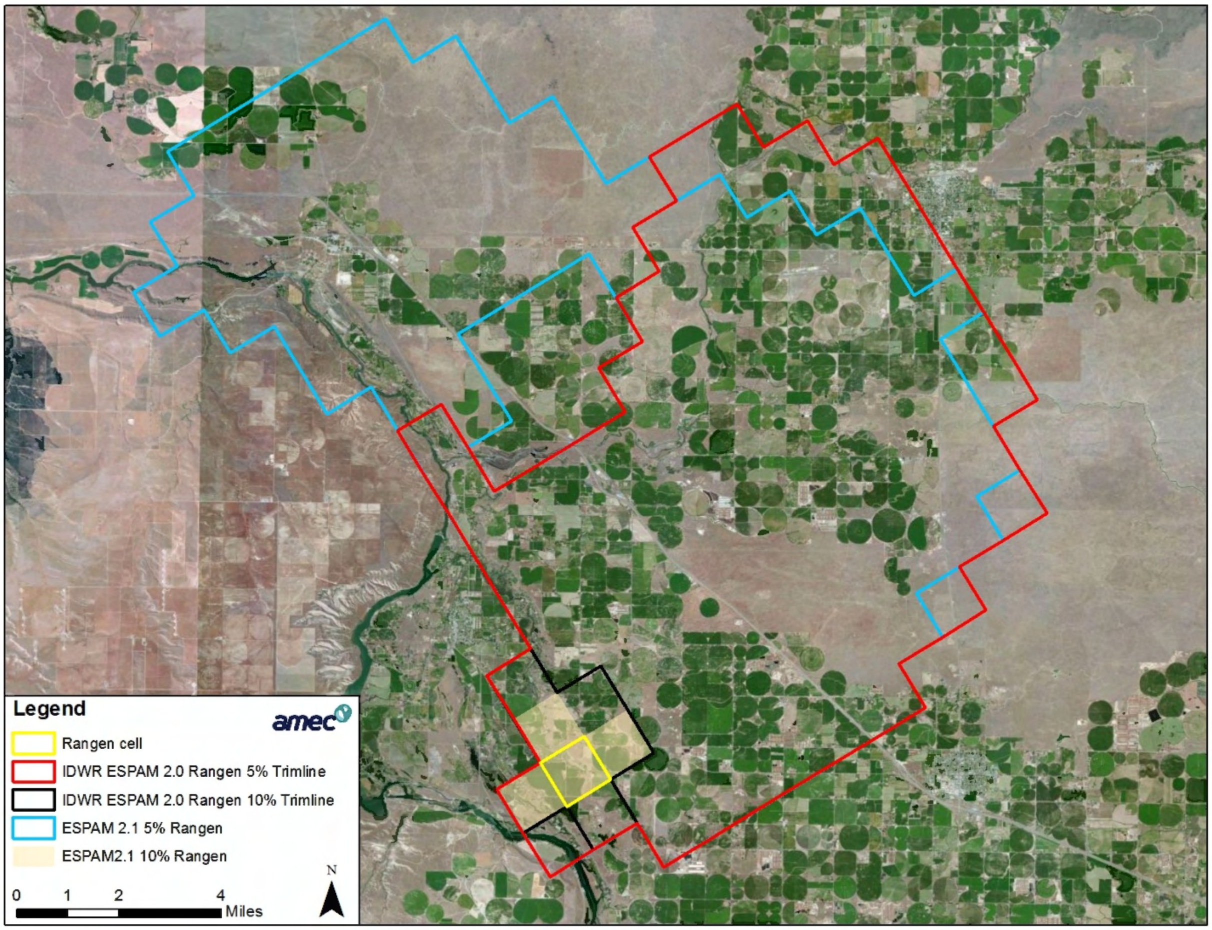

Figure A.1 – Trimline Comparisons ESPAM2.0 and 2.1 (Revised Figure 4.10)

Attachment B – Recalibrated Alternative Modeling Results

Description of Recalibrated Model

The recalibrated model is a derivative of the alternative models presented in my December 21, 2012, report. It has been created in response to comments in the staff memo regarding the effects of full (no trimline) curtailment on discharges at Rangen. It is a derivative of the previous models due largely to time constraints which prevented recalibration of both of the previous alternatives.

The recalibrated model reflects the Horizontal Flow Barrier configuration and upper drain elevation of Alternative Model #1. It contains the weighting on recent Rangen flow targets of Alternative Model #2. It generally uses the same calibration procedure and targets used for the alternative models with the following exceptions:

- PEST was run in a truncated Singular Value Decomposition (SVD) - Assist mode with regularization. Due to time constraints we used 46 superparameters and limited calibration to 4 iterations.
- PEST was allowed to recalibrate transmissivities by adjusting values at the 74 pilot points nearest to Rangen in the western portion of the model domain.
- PEST was allowed to recalibrate transmissivities in three cells surrounding the Rangen cell independent of any pilot points.
- PEST was given a calibration target to minimize the difference between curtailed discharge at Rangen and current discharge at Rangen. This was imposed to help identify parameter sets that are the most sensitive predictors of impact at Rangen.

The calibration run files and results have been posted to the AMEC ftp site.

ftp://RangenCall:client2012@amftp.amec.com

/AMEC/April5Response/ModelFiles/AlternativeModel/Super.zip

In general, the objective function values for various target groups in this recalibration are similar to those of ESPAM2.1, with the exception that the calibration for the early portion of the Rangen flow target is poorer. This reflects the increased weight placed on more recent Rangen flows, which increased the prediction error for Rangen flows earlier in the calibration period. The rationale for this tradeoff is given in my response to the IDWR staff memo. I believe it is unlikely that this tradeoff can be resolved without further refinement of the water budget and incidental recharge on the plain above Rangen.

This recalibrated model is, in my view, superior to those presented in my December report for evaluation of curtailment across the model domain. But, as with the previous alternative models, it should be viewed as only a partial exploration of the conceptual model space pertinent to predicting flows and effects at Rangen. Further refinements to both the conceptual model and the calibration protocol could be expected to show further differences with ESPAM2.1. The alternative is offered as an example of how different calibrated model predictions can be. Because it has not had the level of peer review of ESPAM2.1, it is not offered as an alternative for use in this delivery call proceeding.

Table B.1 is modified from Table 3 of the IDWR staff memo ("IDWR comparison of predicted responses at the Rangen spring cell to curtailment junior to July 13, 1962 using ESPAM2.1 and AMEC's alternative models"). It compares the predicted gains to Rangen from the ESPAM2.1 and the AMEC recalibrated alternative model.

Table B.1 – Comparison of Predicted Gains to Rangen (modified IDWR Table 3)

Curtailed area	ESPAM2.1 prediction (cfs)	AMEC corrected model prediction (cfs)
Model extent	17.9	14.0
5% trimline for Rangen	3.35	1.52
10% trimline for Rangen	0.01	0

Figure B.1 is similar to Figure A.1. It compares the trimlines generated by ESPAM2.1 and the AMEC recalibrated alternative model.

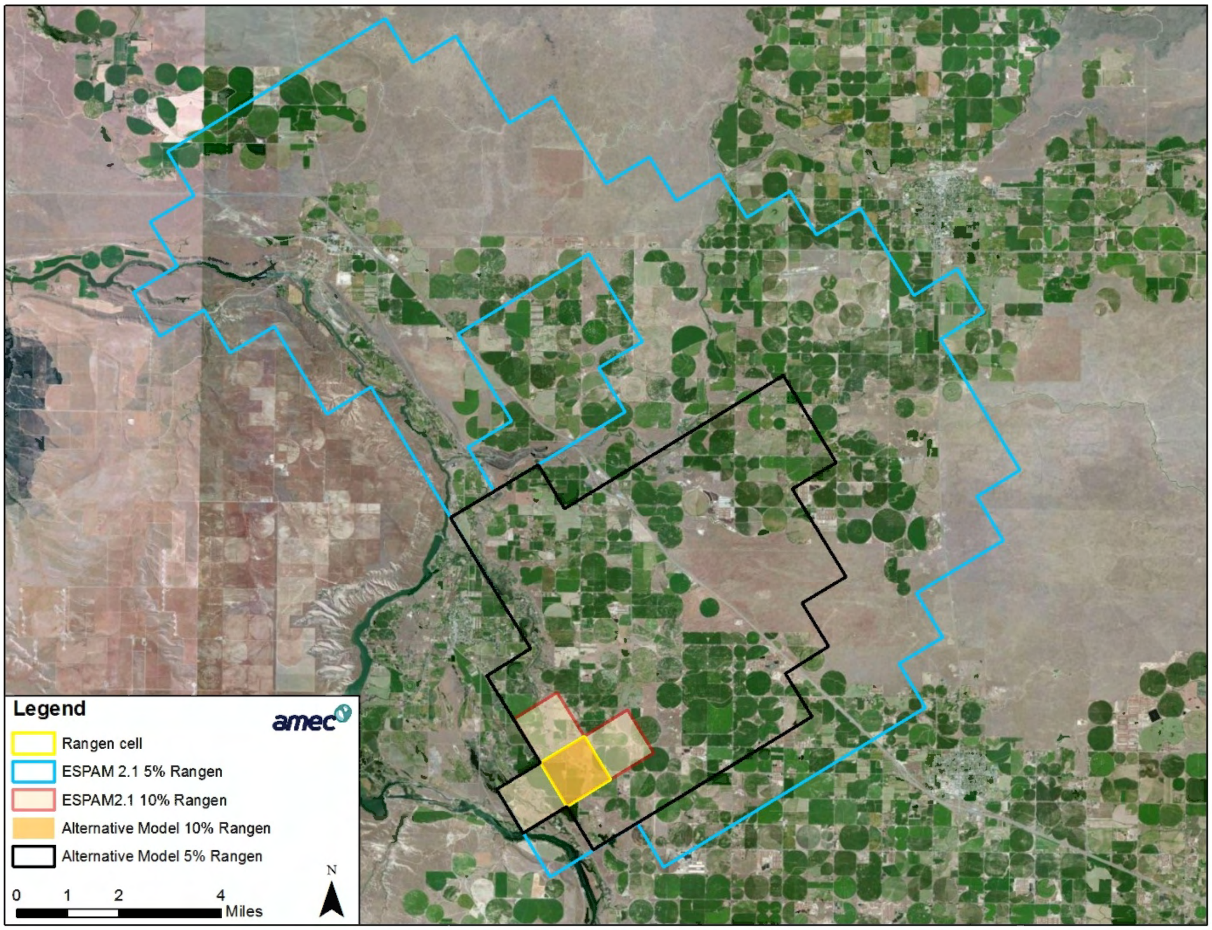

Figure B.1 – Trimline Comparisons ESPAM2.1 and AMEC Alternative Model