MEMO

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Date:	7 November 2011
To:	ESPAM2 Predictive Uncertainty Files
From:	Allan Wylie AW
cc:	Rick Raymondi, Sean Vincent
Subject:	ESPAM2 Predictive Uncertainty

Reasons to Conduct a Predictive Uncertainty Analysis

This memo was requested by the Eastern Snake Hydrologic Modeling Committee (ESHMC) during the 27 October 2011 meeting to explain why we are conducting the predictive uncertainty analysis, and how the analysis is conducted. One reason we are conducting an uncertainty analysis is that the Director requested one in his 9 June 2011 letter to the ESHMC (http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/2011_ESHMC/June_30_2011/).

I think the ESHMC should conduct a predictive uncertainty analysis without prompting from the Director. The ESHMC should be aware that any prediction using a ground water flow model has the potential for error, and this potential must be acknowledged. The ESHMC should also be aware that a predictive uncertainty analysis can be used to locate the origins of that uncertainty by identifying the parameters PEST adjusted to maximize or minimize the prediction. Once the sources of uncertainty are identified, observations can be collected to reduce or constrain the uncertainty.

Method

The ESHMC chose to conduct the predictive uncertainty analysis by applying stress at a three cell by three cell centroid within the irrigated lands of each Water District on the Eastern Snake Plain. The following is the procedure used to prepare a PEST run to identify the maximum or minimum impact of a certain Water District on a spring cell or river reach.

1) The centroid must be identified (this can be done in GIS) .
2) Model files must be prepared to run the prediction, including a well file constructed using the 3x3 centriod identified in step one (1).
3) Make a copy of the PEST control file. The PEST control file contains all of the adjustable parameters and their bounds, and all the field observations. Since we are copying the control file, every parameter adjustable in our calibration run will also be adjustable in our predictive uncertainty analysis, and every field observation used as a calibration target will also be used as a target in our

predictive uncertainty analysis. The following adjustments need to be made to the PEST control file.

4) Replace the word 'regularization' with the word 'prediction' on the third line.
5) The number of observations must be increased by one (1) because the prediction will be a new observation.
6) Increase the number of observation groups by one (1) because there will now be an observation group 'predict'.
7) Increase the number of instruction files by one (1) because PEST will now be required to monitor the prediction.
8) Add 'predict' to the list of observation groups.
9) Add an additional observation to the observation section. At this time I expect these will be called 'Predict_CRL' for the Clear Lakes impact, 'Predict_BLK' for the Blue Lakes impact, and 'Predict_nBMin' for impact to the nr Blackfoot-Minidoka reach. Any weight and target observation value can be provided because PEST ignores the weight and target observation value for any observation in the 'predict' group when it is run in predictive analysis mode.
10) Change the model command line to reflect the name of the batch file used to run the model and the prediction.
11) Add the name of the new instruction file and the output file it will read to the list of files used to read model output. I expect the instruction file will be called 'Predict.ins' and the file it will read will be called 'Predict.smp'
12) Add a 'predictive analysis' section to the control file. This will include NPREDMAXMIN, PD0, PD1, and PD2. NPREDMAXMIN tells PEST whether to maximize (+1) or minimize (-1) the prediction of interest. PD0 is a value of the objective function (phi) which is considered calibrated. Naturally, PD0 must be greater than phi for the calibrated model, but only a little greater. Because the shape of the PD0 envelope can be complex, it is extremely hard for PEST to find a parameter set which lies exactly on the boundary. The value supplied for PD1 (which must be slightly higher than PD0) is a value PEST will consider "close enough". If the sum of the squared residuals is above PD2, PEST tries to minimize the objective function until the objective function is below PD2, at which point PEST begins searching for either the maximum or minimum value for the prediction at PD0.

Thus, during a predictive uncertainty analysis run PEST will: 1) run MKMOD, 2) run MODFLOW, 3) compare model output with field observations exactly like in a calibration run, 4) compare the phi from this run with PD0, 5) make a model run in super position mode containing only the 3x3 well file constructed during steps 1 and 2, 6) collect the predicted impact at the target spring or river reach, and 7) compare this prediction with the previous maximum (or minimum) prediction and save the value if it is a new maximum (or minimum) and phi for this run is less than PD1.

The PEST manual recommends that phi from calibrated model <PD0 < PD1 < PD2 and further states that PD0 should only be slightly larger than phi for the calibrated model (1or 2% larger), and PD1 should only be slightly larger than PD0 (1 or 2% larger), and PD2 is generally 1.5 to 2 times PD0.