White Paper
Technical Evaluation of Trim Line

Submitted by the following members of the
Eastern Snake Hydrologic Modeling Committee:

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1.0 INTRODUCTION

1.1 Background

The authors of this White Paper have completed a technical analysis of the 10 percent trim line concept developed by the Idaho Department of Water Resources (IDWR). The trim line delineates the area within the Enhanced Snake Plain Aquifer Model (ESPAM) boundary where individual aquifer depletions by junior-priority ground water pumping are assumed to result in less than 10 percent depletion to an identified spring reach at steady state. Pumping outside of the trim line is not included in the model impact simulation and is incorrectly assumed to have no effect on spring flow. IDWR uses the 10 percent trim line to: 1) determine areas where junior-priority ground water users are no longer responsible to mitigate for the impacts of their aquifer depletions on individual springs; and 2) identify acceptable forms of mitigation based upon geographical location either within or outside of the 10 percent trim line. Our analysis is submitted at the invitation of Director David Tuthill to members of the Eastern Snake Hydrologic Modeling Committee (ESHMC), as described in the Feb. 25, 2009 letter in **Attachment A**. The letter states the following topic for ESHMC consideration: "*As part of the uncertainty analysis, should the ESHMC address the technical aspects (not policy issues) of a trim line as a function of uncertainty*." The underlying issue is how to correctly determine and utilize model uncertainty in evaluating ESPAM outputs.

The ESPAM model is used to quantify the relationship between withdrawals from and additions to the Eastern Snake Plain Aquifer (ESPA), and ESPA groundwater levels and spring flows emanating from the ESPA. Although model uncertainty has not been quantified, IDWR has assigned 10 percent uncertainty factor and incorrectly linked model uncertainty to a trim line. In his February 25th letter, the Director states that "*The development of a more scientifically based error factor should be a priority in improvement.*" The Director recommends further analysis and data collection, "*to minimize uncertainty in future versions of the ESPAM Model*", and states that, "*The investigation of uncertainty should be accomplished through regular committee analysis and discussion.*"

The Director's letter explains that: "*The purpose of the trim line or clip was to avoid curtailing ground water users who might have no effect on enhancing reach gains.*" The letter also suggests that the trim line delineates ground water withdrawals that have a *de-minimus* effect on spring and surface reach gains.

Based on our analysis, we have reached the following conclusions:

1. The inference that ground water withdrawals outside the 10 percent trim line might have no effect on reach gains based on an assumed model uncertainty of +/- 10 percent is incorrect. A 10% error factor does not mean that ESPAM outputs could be 100% inaccurate with respect to ground water withdrawals that occur beyond the trim line. The correct interpretation and use of model uncertainty is that each withdrawal and addition of water to the ESPA will have the ESPAM-predicted effect on reach gains, subject an error factor, which may or may not be +/- 10 percent.

2. Ground water withdrawals beyond the 10% trim line do not have a *de-minimus* effect on spring and surface reach gains. The cumulative impact of the pumping by junior-priority ground water wells located outside of the 10 percent trim line reduces the spring flow by between one-half to one-third of the total flow impact. A reduction of the senior's supply by one-half to one-third is obviously significant and is well above a *de-minimus* impact. The 10 percent trim line is clearly excluding a large majority of the ground water pumping that does in fact have an impact on spring flow.

3. The uncertainty of the ESPAM model has not been determined.
4. The uncertainty of most of the model calibration data, especially the data used to calibrate the below-Milner spring reaches is much less than 10 percent.
5. The trim line has nothing to do with model uncertainty. The trim line is simply the boundary identified by the Director of the Department of Water Resources that designates those wells where individual aquifer depletions by junior-priority ground water pumping are assumed to result in less than 10 percent depletion to a spring reach. The trimline as used by the Director is not justified. Some other procedure needs to be developed that more closely identifies those ground water users that collectively have a *de-minimus* impact on spring flow.

As discussed in Section 3.0 of this White Paper there is a continuing need for improved methods to simulate spring flow and to evaluate impacts at individual springs. The authors of this White Paper would like to submit information for consideration of these topics for additional discussion.

Tables and figures are presented at the conclusion of the text. A PowerPoint presentation prepared for the Eastern Snake Hydrologic Modeling Committee (ESHMC) is presented as **Attachment B**. An email from Dr. Richard Allen is cited in **Attachment C**.

2.0 TRIM LINE

2.1 What is the Trim Line?

The 10 percent trim line defines the area within the Eastern Snake Plain Aquifer (ESPA) model boundary where individual aquifer depletions by junior-priority ground water pumping are assumed to result in less than 10 percent depletion to an identified spring reach. The location of the area within the trim line for the Devils Washbowl to Buhl and Buhl to Thousand Springs reaches is shown on **Figures 1** and **2**.

IDWR's technical basis for the 10 percent trim line is that some of the model calibration data, specifically the Snake River gage data, is only accurate to within 10 percent. The 10 percent uncertainty in the model is therefore assumed to be the same as the error in the Snake River gage data used as part of the calibration data in the model. The errors in this and other assumptions regarding the trim line are explained below.

2.2 The Trim Line is an Incorrect Interpretation and Use of Model Uncertainty

The following issues with the model uncertainty rationale for the trim line were identified during our review.

a) **The uncertainty of the ESPA model has not been established.** Model uncertainty is based on a combination of uncertainty in the conceptual model, the input data, calibration targets and numerical error. These errors can compound or cancel each other out. Specifying a single uncertainty value to the entire model based on the accuracy of a single parameter is not technically valid.

b) **Model uncertainty is not addressed by a trim line. The 10 percent trim line criteria is not related to model uncertainty.** The trim line has nothing to do with model uncertainty. The trim line is simply the boundary identified by the Director of the Department of Water Resources that designates those wells where individual aquifer depletions by junior-priority ground water pumping are assumed to result in less than 10 percent depletion to a spring reach.

   Model uncertainty is the error of the model output caused by uncertainty in the model input data, calibration data, failures in the conceptual model or numerical error. In the case of the ESPA model, the uncertainty in the output applies to junior-priority ground water pumpers both <u>inside and outside of the trim line</u>. Also, the model uncertainty is plus or minus the model-calculated impact. For example, if 10 cfs of consumptive-use pumping by a junior-priority ground water user reduced flow at a spring reach by 1 cfs, then a 10 percent model uncertainty factor would mean that the junior-priority ground water user had a 1 cfs impact plus or minus 0.1 cfs. Therefore, there is no justification to only apply model uncertainty to wells within a certain area of the aquifer or to reduce the calculated impact due to model uncertainty. **The measurement error of many of the model calibration targets is much less than ±10 percent.** The reason cited for the 10 percent trim line is the error in the Snake River gage data used for model calibration. This is not justified for several reasons. First, the individual and reach gain spring flow data (not Snake River gage data) is used for model calibration in the below Milner reaches. Second, it is factually incorrect to assume that the uncertainty in simulated model output is the same as Snake River gage data, which is the least-accurate calibration data. The model uncertainty is a function of the uncertainty in all the calibration data, and most of the model calibration data are more accurate than 10 percent, as described below.

Ground Water Level Calibration Data The largest calibration dataset for the model is field-measured ground water levels in wells. Ground water levels are usually measured to an accuracy between 0.01 to 0.1 feet, which is less than a 1 percent uncertainty for the vast majority of wells measured when compared to the total ground water surface elevation across the aquifer or the seasonal vertical change in ground water levels at a well.

Spring Flow Calibration_Data The model calibration in the west half of the ESPA at the below-Milner spring reaches uses spring flow measurements for model calibration. The steady state spring flow calibration data was compiled from measurements at flumes, weirs or pipelines and reported in the 1991 USGS report by Covington and Weaver.[1] The transient calibration was performed using data from individual springs. The flow measurements at many of the individual springs (such as Blue Lakes Spring and Clear Lakes Spring) were

[1] Covington, H.R. and J.N. Weaver, 1991. Geologic Maps and Profiles of the North Wall of the Snake River Canyon Thousand Springs and Niagara Springs Quadrangles, Idaho. USGS Misc. Investigations Series, Map 1-1947-C. U.S. Geological Survey, Boise, ID.

collected from facility diversions with measurement structures (weirs or flumes in pipelines, canals and open ditches) used for administration and delivery of water.

The spring flow data used for model calibration was measured more accurately than river gage data. Spring flow measurements are collected using a standard weir or flume and are more accurate because both the cross-sectional area and water stage is known and the total flow can be calculated using standard equations to a precision of about 2 percent.[2] Where pipe flow meters are used for measured spring flows, the accuracy is also about 2%. Measurements in pipes or canals without weirs or flumes using a flow meter are also more accurate than a river gage because the cross-sectional area of flow is regular and defined. The precision of a flow meter for these types of measurements is generally considered to be 95 percent or less. Therefore, the accuracy of the calibration data for the below-Milner springs is probably from 2 to 5 percent.

c) **The breakdown of river reaches inappropriately influences the 10 percent trim line area.** The determination of the trim line area is largely dependent on the size of the reaches specified in the model. Although there are other factors that influence the trim line area (like the water right priority), if these factors are held constant, then larger river reaches will have larger trim line areas and smaller river reaches will have smaller trim line areas. This is part of the reason for the difference in the trim line developed for the Devils Washbowl to Buhl reach (**Figure 3**), Buhl to Thousand Springs reach (**Figure 4**) and Thousand Springs to Malad Gorge reach. The impacts analysis quantity should not be determined by the spatial assignment of the spring reaches.

[2] U.S. Bureau of Reclamation, 2001. Water Measurement Manual, U.S. Bureau of Reclamation, Denver, CO, pg. 7-1.

2.2 The Trimline Does Not Delineate De-minimus Impacts

The use of a 10 percent trim line does not account for the cumulative depletion from wells located outside of the trim line and drastically under-predicts the actual impacts to spring flow. The data on **Tables 1** and **2** show that a 10 percent trim line clipped to WD 130 excludes 89 percent of the ground water irrigated acres on the ESPA and 46 percent of the total impact of junior-priority ground water pumping on the Buhl to Thousand Springs reach. **Table 3** and **4** show that a 10 percent trim line clipped to WD 130 excludes 79 percent of the ground water irrigated areas on the ESPA and 35 percent of the total impact of junior-priority ground water pumping on the Devils Washbowl to Buhl reach. The data in **Table 3** and **4** shows that junior-priority wells with a known and quantified impact to a senior spring user are being excluded from administration. There is no reasonable technical justification to disregard the cumulative impacts from individual ground water depletions located outside of the trim line if they are a major portion of the total impacts to spring flow. This procedure essentially discounts depletions outside the trim line and, if a trim line boundary is to be employed, it could be argued that similar contributions to the aquifer outside the trim line should also be discounted. For instance, any known changes in input such as crop consumptive use changes, changes in tributary underflow or conversions over the remainder of the aquifer might be considered as non-contributory and not considered in the evaluation of changes in spring flow. If they are considered non-contributory they are then defacto non-tributary which hydrologically is simply not correct.

In our experience applying hydrologic models for water right or water supply impact determinations for transfers or new water right applications, a trim line is not used to exclude the cumulative impacts from individual wells on a river or spring. Water users are typically required to provide mitigation for the extent of their impacts as determined by a calibrated model or another analytical procedure. The State of Colorado has established a threshold for administration of impact of a well on a surface water body that cannot exceed one tenth of one percent of the amount of production of the well. This standard accounts for the cumulative significant depletive effects from many wells on pumping surface water.

Tables 2 and **4** show that IDWR's use of the 10 percent trim line disregards the cumulative depletion from individual ground water wells outside of the trim line and thus reduces the determination of impacts from junior-priority ground water pumping to about 54 to 65 percent of the actual predicted impact to the spring reaches. A procedure that fails to identify 35 to 46 percent of the total impacts to spring flow is not reasonable or justified and does not correctly identify pumpers with less than a de-minimus impact on the spring.

As a point of comparison, we selected a 1 percent trim line area using the same method in the 2005 Order for the 10 percent trim line. The 1 percent trim line was only used as an example to show that the 10 percent trim line fails to identify junior-priority wells that cause a large percentage of the impacts to spring flow. The 1 percent trim line (see **Figure 3**) identifies the area where individual aquifer depletions by junior-priority ground water pumping will result in less than 1 percent depletion to the spring reaches. **Tables 2** and **4** show that a 1 percent trim line identifies most of the impacts by ground water pumping on the spring reaches as compared to the 10 percent trim line. For example, assuming a 1971 priority date, the 1 percent trim line provides 95.5 cfs at the Devils Washbowl to Buhl reach which is almost as much as all of the pumping in the entire ESPA (96.3 cfs), as shown on **Figure 4**. Use of a 10 percent trim line reduces the determination of impacts to the Devils Washbowl to Buhl spring reach to 63 cfs, which is only 65 percent of the full impact to the spring from junior-priority ground water pumping, simply due to the position selected for the trim line.

3.0 NEED FOR IMPROVED METHODS TO SIMULATE SPRING FLOW AND TO EVALUATE IMPACTS AT INDIVIDUAL SPRINGS

The ESHMC is currently involved with development and calibration of Version 2 of the ESPAM model. We believe that the representation of individual springs and spring reaches in the model needs more improvement, with respect to both spring flow calibration dataset and the details of the drain boundary.

The ESPAM model results have been used to predict the impacts from ground water pumping to spring flow reaches. This is accomplished by using the model to determine the impacts at a reach and then assigning a portion of the impact to an individual spring based on the measured amount of flow arriving at the spring as compared to the reach. This method introduces many potential errors and the results are highly dependent on the discretization of the spring reaches and the assumptions used to estimate the spring flow occurring at an individual spring as a percentage of the total spring flow in a reach. If there are multiple users from a spring, the method also has to assign the percentage of flow between users.

Recognizing the necessity for use of the ESPAM model in both planning and administration these issues should be addressed by the ESHMC and recommendations provided to the Department.

4.0 REFERENCES

Covington, H.R. and J.N Weaver, 1991. Geologic Maps and Profiles of the North Wall of the Snake River Canyon Thousand Springs and Niagara Springs Quadrangle, Idaho. USGS Misc. Investigations Series, Map 1-1947-C. U.S. Geological Survey, Boise, ID.

US Dept. of the Interior, Techniques of Water-Resources Investigations of the USGS, Discharge Measurements at Gauging Stations: Book 3, Chapter A8 pg 3, 1984.

US Dept. of the Interior, Techniques of Water-Resources Investigations of the USGS, Computation of Continuous Records of Streamflow : Book 3 Chapter A13 pgs 45-52, 1984.

Table 1 **Areas associated with priority dates junior to 1955 and 1964 for trim lines over the entire ESPA and using a 1% trim line and a 10% trim line for the Buhl to Thousand Springs reach.**

	Groundwater Irrigated Area (acres)	# of Model Cells	Groundwater Consumptive Use (ac-ft)
September 15, 1955 Priority			
All Rights Junior to 1955	717,428	4,070	1,434,570
1% trim line	288,577	1,797	632,033
10% trim line, *not* clipped to WD130	85,059	649	202,375
10% trim line, clipped to WD130 (IDWR trim line)	75,509	614	181,328
February 4, 1964 Priority			
All Rights Junior to 1964	506,265	3,815	1,008,541
1% trim line	193,508	1,702	423,404
10% trim line, *not* clipped to WD130	56,852	611	136,066
10% trim line, clipped to WD130 (IDWR trim line)	51,071	594	123,326

Table 2 **Impacts from ground water pumping (at steady-state) with priority dates junior to 1955 and 1964 for trim lines over the entire ESPA and using a 1% trim line and a 10% trim line for the Buhl to Thousand Springs reach.**

September 15, 1955 Priority		
Scenario	**Modeled Buhl to Thousand Springs Reach Gain (cfs)**	**Assuming 6.9% of Flow in Buhl to Thousand Springs Reach as in Order (cfs)**
Full curtailment	98.22	6.78
1% trim line	94.08	6.49
10% trim line *not* clipped to WD130	56.32	3.89
10% trim line clipped to WD130	53.27	3.68
February 4, 1964 Priority		
Scenario	**Modeled Buhl to Thousand Springs Reach Gain (cfs)**	**Assuming 6.9% of Flow in Buhl to Thousand Springs Reach as in Order (cfs)**
Full curtailment	66.52	4.59
1% trim line	63.59	4.39
10% trim line *not* clipped to WD130	39.29	2.71
10% trim line clipped to WD130	37.42	2.58

Table 3 Areas associated with priority dates junior to 1971 and 1973 for trim lines over the entire ESPA and using a 1% trim line and a 10% trim line for the Devils Washbowl to Buhl reach.

	Groundwater Irrigated Area (acres)	# of Model Cells	Groundwater Withdrawal (ac-ft)
November 17, 1971 Priority			
All Rights Junior to 1971	361,600	3603	721,818
1% trim	260,955	2661	547,933
10% trim, with out clip to WD130	116,711	1473	261,562
10% trim, clipped to WD130 (IDWR trim line)	74,936	1068	173,241
December 28, 1973 Priority			
Al Rights Junior to 1973	290,655	3481	577,642
1% trim	207,148	2560	433,813
10% trim	88,878	1427	198,130
10% trim, clipped to WD130 (IDWR trim line)	58,364	1046	134,091

Table 4 Impacts from ground water pumping (at steady-state) with priority dates junior to 1971 and 1973 for trim lines over the entire ESPA and using a 1% trim line and a 10% trim line for the Devils Washbowl to Buhl reach.

Scenario	Devils Washbowl to Buhl Reach Gain (cfs)	Director's Order (20%)
November 17, 1971 Priority		
Full curtailment	96.28	19.26
1% trim line	95.46	19.09
10% trim line clipped to WD130 (2005 Order trim line)	62.96	12.59
December 8, 1973 Priority		
Full curtailment	73.52	14.70
1% trim line	72.84	14.57
10% trim line clipped to WD130 (2005 Order trim line)	48.58	9.72

Attachment A

February 25, 2009 Letter from Director Tuthill

Attachment B

PowerPoint Presentation

Attachment C
Email from Dr. Richard Allen

From: Richard G. Allen [mailto:rallen@kimberly.uidaho.edu]
Sent: Wednesday, February 25, 2009 1:24 PM
To: Allan Wylie; Anderson, Hal; bcontor@if.uidaho.edu; Bryan Kenworthy; Chuck Brockway; cmb@hydrosphere.com; Dar Crammond; Dave Blew; Dave Tuthill; Greg Clark; greg@spronkwater.com; Gregg S. Ten Eyck; hyqual@cableone.net; J. D. May; JBowling@idahopower.com; Jennifer Johnson; Jim Taylor; Koreny, John S.; johnson@if.uidaho.edu; Jon Gould; jrbartol@usgs.gov; Leslie Stillwater; Linda Lemmon; Lindgren, John; Mike Beus; Raymondi, Rick; Sean Vincent; Sharon Parkinson; Stacey Taylor; Swank, Lyle; Tom Wood; Willem Schreuder
Cc: Olenichak, Tony; Karen Wogsland (E-mail); Morse, Tony; Kramber, Bill; Marilyn Bragg
Subject: Re: Director's response to the committee question

Rick R.,

I have one comment on the Hearing Officer's statement that:
...the guages used in water measurement have a plus or minus error factor of 10%.

and the use of this 10% to suggest uncertainty in GW pumping impacts on spring flows. I believe that general consensus among water analysts is that the 10% (or other value) associated with surface measurement accuracy has a strong random error component, perhaps as much as half of the total error value. The other part is systematic or bias error.

Given the large number of measurement sites and repeated measures at specific sites, the random error term decreases with the square root of the number of measures and may even tend toward zero for the ESPA. Thus, some part of the 10% should not carry into the water balance accuracy of the ESPA model.

Another comment is that I have difficulty seeing a strong connection between uncertainty associated with the GW water balance (stemming from water measurement inaccuracies) and prediction of impact on spring flow by GW pumping. Clearly there is some connection, but impacts are more dominated by hydraulic gradient (and aquifer levels) and transmissivities rather than by water balance. The relation is there, but I am not sure it is strong enough to warrant a direct transfer of uncertainty terms (even if all error were systematic).

My sense is that some other measure (or justification) of uncertainty should be explored for establishing a trim line.

Rick A.

On 25 Feb 2009 at 10:22, Raymondi, Rick wrote:

>
> Hi everyone,
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> Please note the Director's response to the question submitted by the
> committee after the January meeting. I will follow up after you've
> had time to review the response. Also, I've developed a folder on
> our web site for documents related to model uncertainty.