Confidential Work Product

To: Jerry Rigby
Fremont Madison Irrigation District
Madison Ground Water District
RMEA project 11-0068

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Date: 20 June 2011

Re: Proposed boundary changes to Conjunctive Management Rule 50

Background

Idaho Department of Water Resources (IDWR) is considering a petition to enter a formal rule-making process to address possible changes in the boundary of the Area of Common Ground Water Supply under Conjunctive Management Rule 50 (CMR 50). The current boundary is based upon the US Geological Survey model boundary from the report <u>Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho, USGS Professional Paper 1408-F, 1992,</u> referred to here as the RASA boundary. The petition seeks to change the boundary to the model boundary of the IDWR Eastern Snake Plain Aquifer Model Version 1.1 (Wylie, 2004, <u>Model Boundary, Idaho Water Resources Research Institute Technical Report 04-016),</u> referred to here as the ESPAM boundary. Figure 1 illustrates the two model boundaries. It also shows the irrigated lands of the Fremont Madison Irrigation District and the Madison Ground Water District that would be affected by the change.

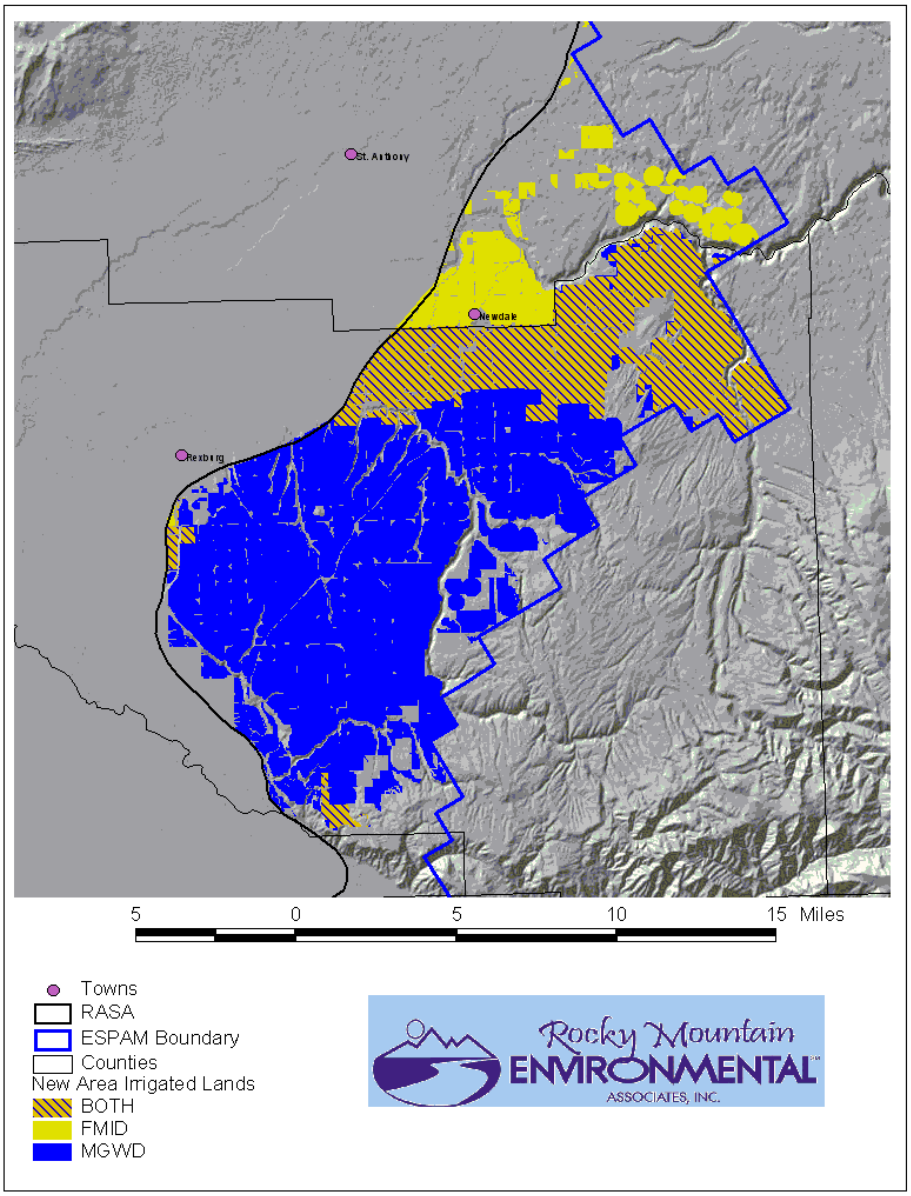

Figure 1. Proposed boundary change and affected irrigated lands.

This memo discusses three technical issues related to this decision:

1. Three technical bases of hydrologic boundaries;
2. Hydrologic implications of groundwater use for irrigation within the affected area of the Fremont Madison Irrigation District and the Madison Ground Water District; and
3. Technical issues and concerns with the Eastern Snake Plain Aquifer Model Version 1.1 within the affected area of the Districts.

Technical Bases of Boundaries

RASA. The RASA aquifer boundary was "In general... identified by the hydrologic extent of [the] system and accordingly transcend[s]... political subdivisions...." (Garabedian, RASA 1408F). It appears to have been intended to describe the regional aquifer system hosted in basalts and sediments of the Eastern Snake River Plain and to exclude adjacent areas of different geology or hydrology.

The areal extent was based upon geology and topography (Lindholm, RASA 1408A), and specifically is defined by "the land-surface contact between the Tertiary and older rocks that border the plain and the Quaternary sedimentary and volcanic rocks that border the plain," though in places, "an arbitrary boundary was selected on the basis of topographic relief...." The RASA study clearly identified underflow into the aquifer from surrounding tributary basins (Garabedian, RASA 1408F) and therefore did not capture every area where water use might have some effect upon the aquifer.

ESPAM. The IWRRI documentation suggests that changes in the ESPAM1.1 model boundary were primarily designed to facilitate water-budget calculations. The documentation indicates an effort to be able to incorporate temporal changes in recharge and water use by "extending to bedrock outcrops." It also indicates non-technical considerations; reference is made to decisions made "from a management perspective" and "for administrative purposes" (Wylie, 2004).

The documentation also acknowledges that extending boundaries is of "little value if no data are available" and asserts that moving the boundary to incorporate additional irrigated lands is appropriate only "if it does not cross a hydrologic barrier." It is clear that the model developers understood that "activities outside the model boundary can affect activities within" (Wylie, 2004), and that large irrigated tracts where groundwater pumping might affect the aquifer were omitted from the model. The Teton Basin, Raft River Basin and Bellevue Triangle are examples.

CMR 50. The only explicit technical criterion of the Area of Common Ground Water Supply in the Conjunctive Management rules is the statement:

> 50.01.a The Eastern Snake Plain Aquifer supplies water to and receives water from the Snake River.

This is consistent with the technical standard of the RASA work.

Hydrologic Implications of Groundwater Use in Fremont Madison Irrigation District and Madison Ground Water District, Within the Change Area

Table 1 lists approximate irrigated acres of the Fremont Madison Irrigation District (FMID) and Madison Ground Water District (MGWD) within the change area between the RASA and ESPAM boundaries (ESPAM model data, 2006 irrigated lands). Groundwater lands are lands with only groundwater water rights and mixed-source lands are lands having both groundwater and surface-water rights. Figure 2 shows the water source of irrigated lands in the change area along with water-right points of diversion for groundwater use.

Table 1
Approximate Acres Affected by Change,
Fremont Madison Irrigation District and Madison Ground Water District

District	Groundwater Acres	Mixed-source Acres
FMID	2,500	4,000
MGWD	49,000	4,000
Area of Overlap (lands are within both districts)	5,300	12,000
Total	56,800	20,000

Anecdotally, it appears that because of high precipitation in this area, evapotranspiration supported by groundwater irrigation is less than in other parts of the plain. Consumptive use from groundwater irrigation within the FMID-MGWD change area was estimated at 55,000 acre feet per year, using the data in Table 1 and the following assumptions.

1. Little alfalfa is grown.
2. Irrigation supports 1.5 feet of evapotranspiration on potatoes, on 1/3 of the acres.
3. Often small grains receive only a single irrigation or are produced as dryland crops. On average, irrigation supports 0.5 feet of evapotranspiration on small grains, on 2/3 of the acres.
4. All groundwater pumped is either consumed by evapotranspiration or percolates back to the aquifer.
5. On mixed-source lands, half of the evapotranspiration is supplied by groundwater pumping.

The timing and spatial distribution of pumping effects were modeled using ESPAM1.1. Net extraction was assigned to the model cells containing the groundwater right points of diversion illustrated in Figure 2. Volume was apportioned based on the sum of diversion rates of the rights in each cell.

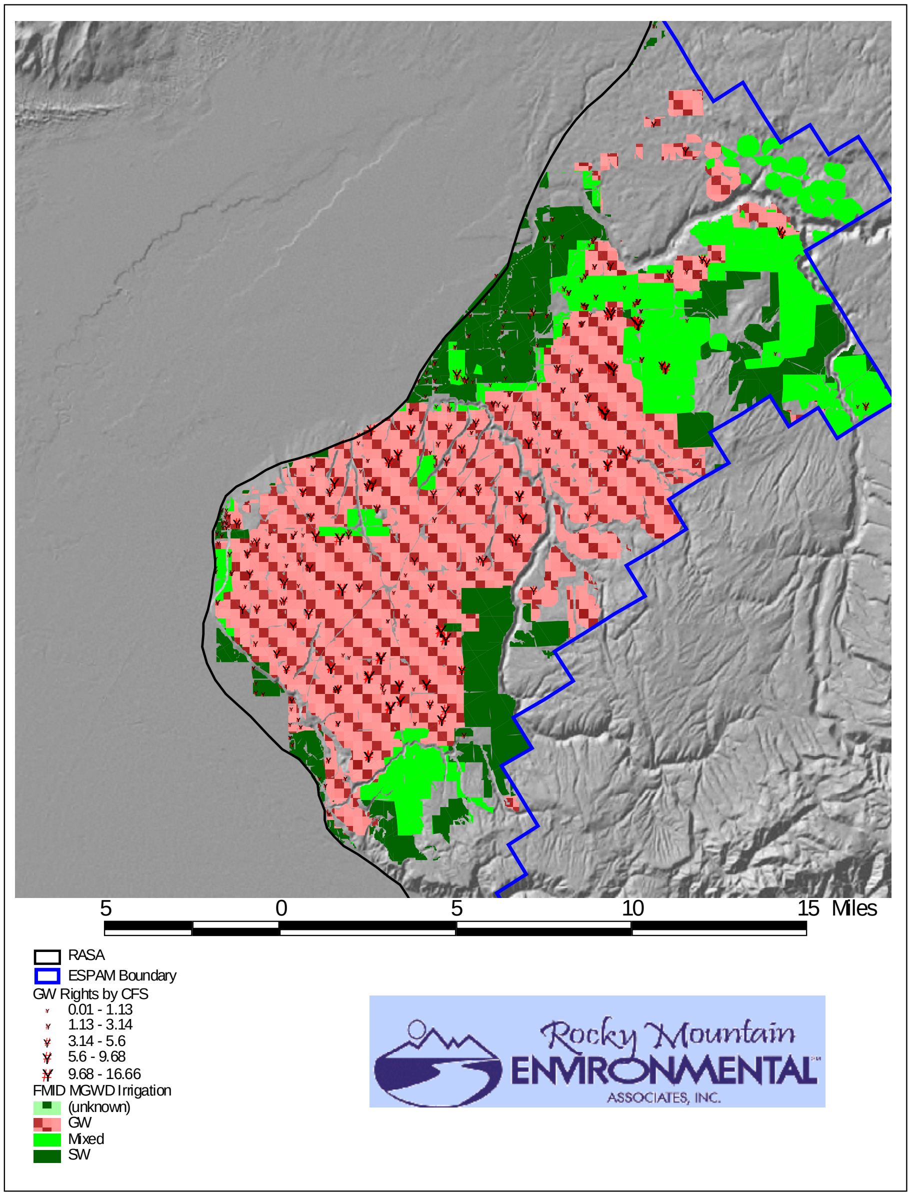

Figure 2. Fremont Madison Irrigation District and Madison Ground Water District Lands, source of irrigation water, and area of proposed change.

Figure 3 illustrates the modeling result that nearly all (96%) of the effect of pumping (or potentially of curtailment) propagates to the Henrys Fork or the Snake River above Shelley. This means that as long as the 10% rule of administration is applied, these are the only river reaches where a water call may potentially affect the proposed change area in FMID and MGWD. The model indicates relatively rapid propagation of effects to the Henrys Fork and Snake River above Shelley, with more delayed arrival of the small effect that is estimated to reach other locations.

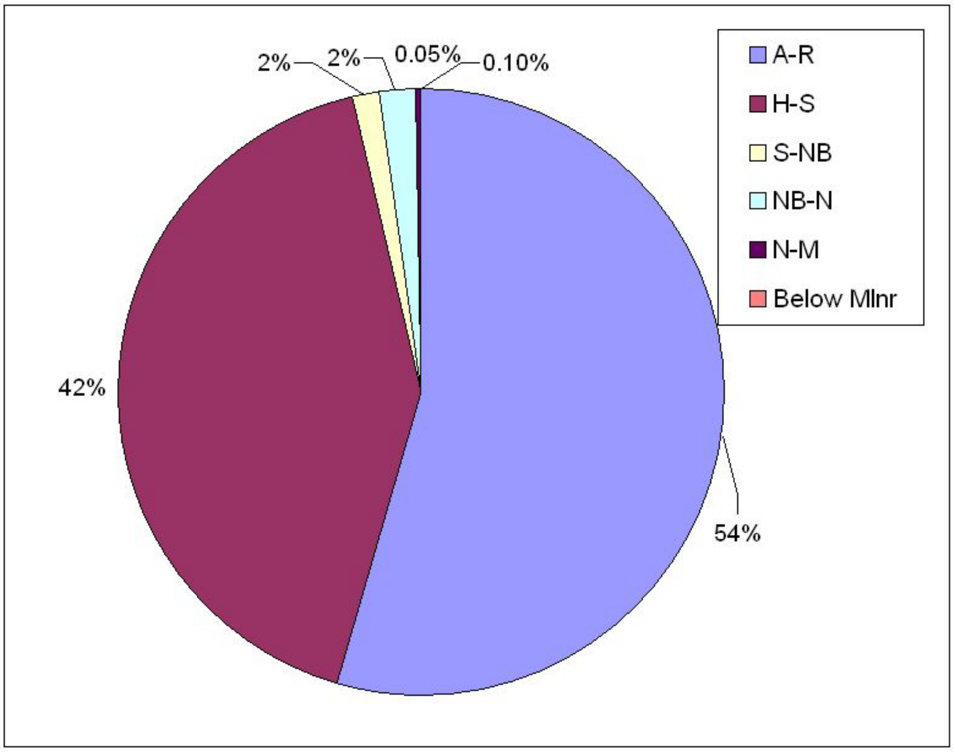

Figure 3. Spatial distribution of modeled effects of pumping or curtailment of FMID and MGWD irrigated lands within the change area.

Technical Issues and Concerns

Complex Geology. It is clear that ESPAM1.1 omits significant stratification and faulting of the geologic materials in the Rexburg Bench. Figure 4 is a reproduction from a US Bureau of Reclamation report (Haskett, 1972. Ground-water Geology of Rexburg Bench, copy attached). Figure 5 is a reproduction of a water-level map from the same source, with the regional and perched contours enhanced in color.

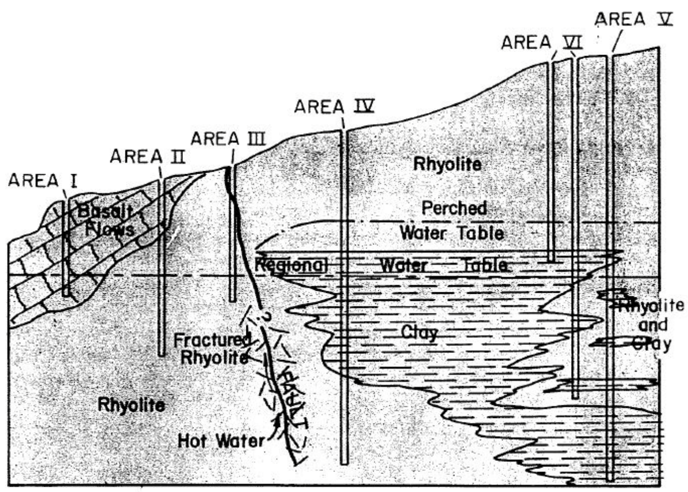

FIGURE 3 Diagrammatic cross section showing type area wells.

Figure 4. Reproduction of Figure 3 from Haskett, illustrating complex geology of the Rexburg Bench.

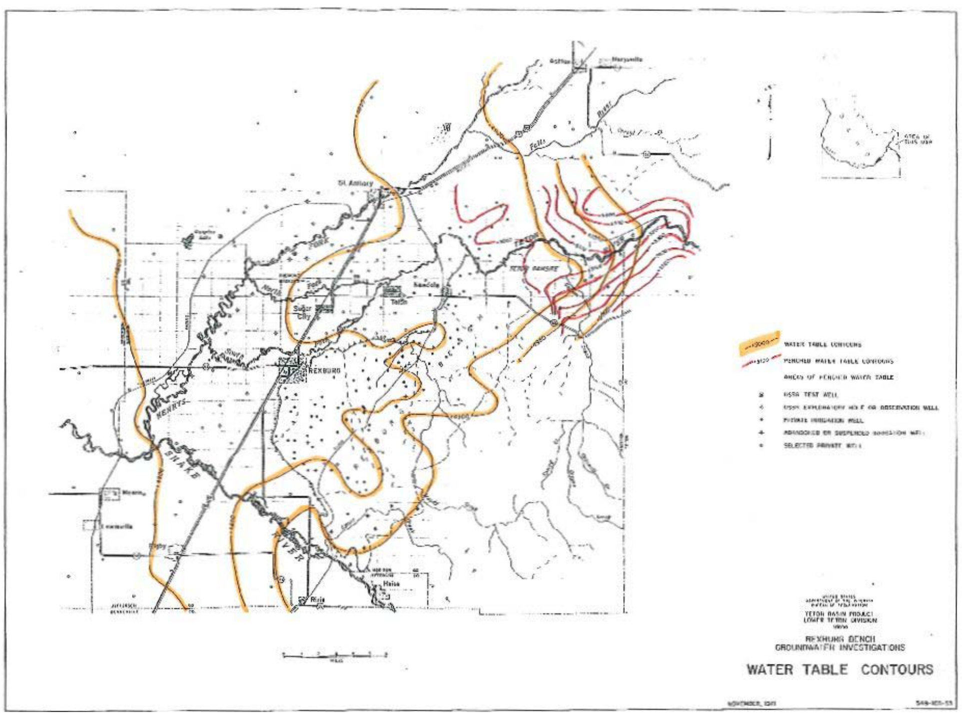

Figure 5. Reproduction of water-level contours from Haskett. Broad yellow lines are the regional water levels, while finer red lines are the perched aquifer.

Anecdotal reports suggest that faulting on the toe of the Rexburg bench forms a hydraulic discontinuity that results in significant differences in water levels across a relatively short distance. Figure 6 illustrates two wells south of Rexburg, one on either side of the toe. Water level data are shown in Figure 7, with the bench well having lower water-level elevation.

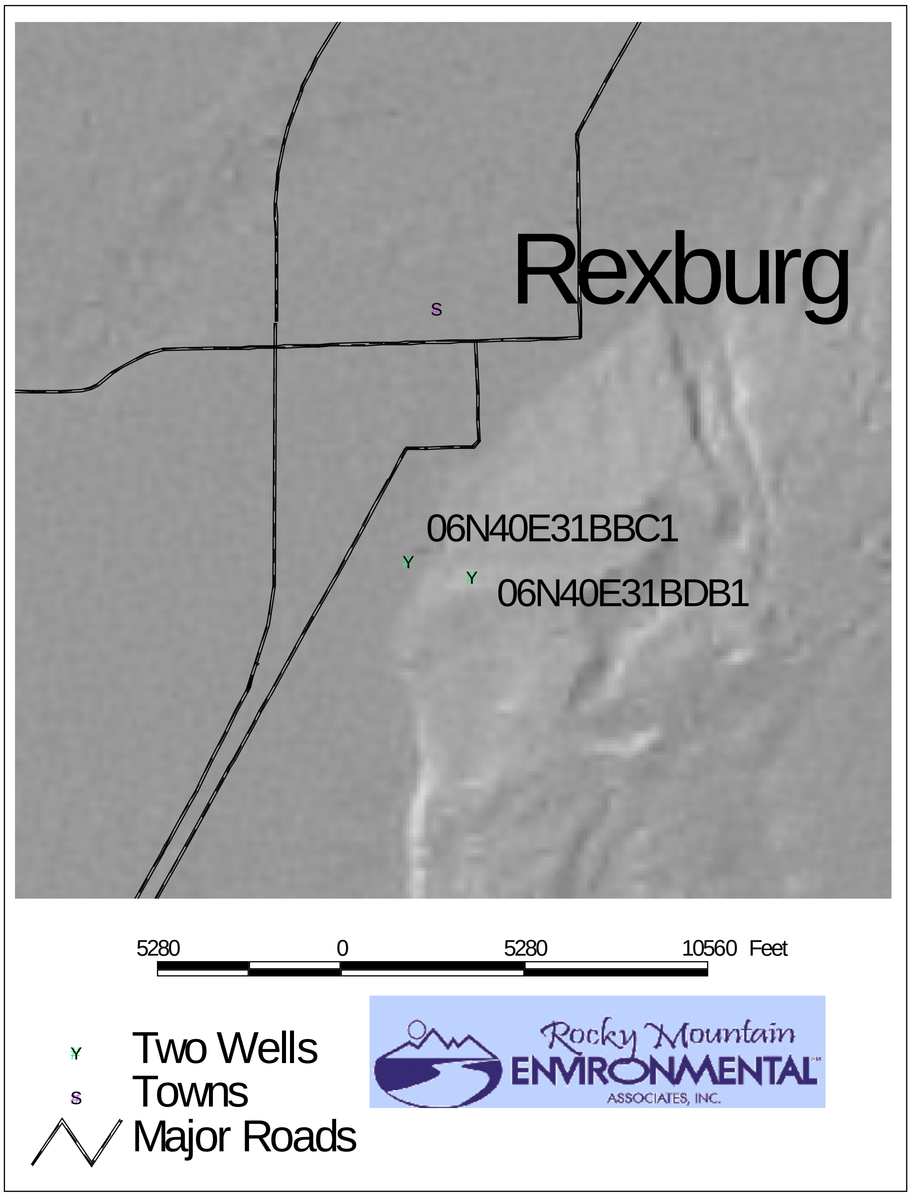

Figure 6. Location of two wells south of Rexburg, one on either side of the toe of the bench. The background gray hill-shade is based on land-surface elevation.

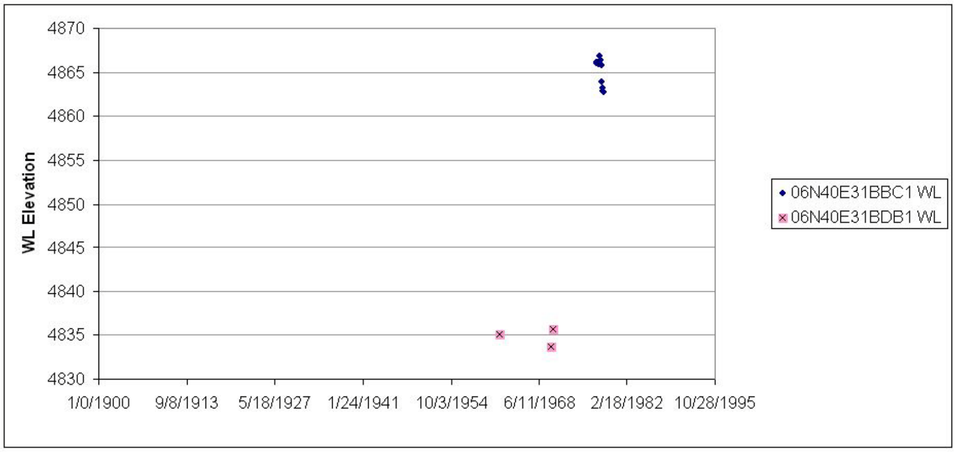

Figure 7. Water level elevations from the wells illustrated in Figure 6. Horizontal separation is approximately 1,900 feet.

Lithology was not obtained for these wells. However, USGS data sheets indicate the top of the the east well (06N40E31 BDB1) is at an elevation of 4,937 feet, completed to an elevation of 4,801 feet. The top of the west well (06N40E31 BBC1) is at 4,885 feet, completed to an elevation of 4,835 feet.

The difference in water-level elevation across such a short distance is consistent with a conceptual model of hydrology dominated by surface-water irrigation on the west, hydrology dominated by groundwater irrigation on the east, and a low-permeability barrier such as a fault zone between the two wells.

In a review performed for RMEA on another project, Dr. Glenn Embree found that un-represented faulting and geologic complexity cast serious doubt upon the model representation of partition of impacts between the Henrys Fork and the South Fork. This is of significant concern since this is the only context in which administration would likely be applied, if the boundary were changed. Dr. Embree's report is attached.

<u>Inadequacy of Data.</u> Though hard to see, the small dots on Figure 5 illustrate the water levels that Haskett relied upon in his evaluation. These pre-date the ESPAM1.1 modeling period by nearly a decade. Figure 8 shows that far fewer data were available to constrain the calibration of ESPAM1.1.

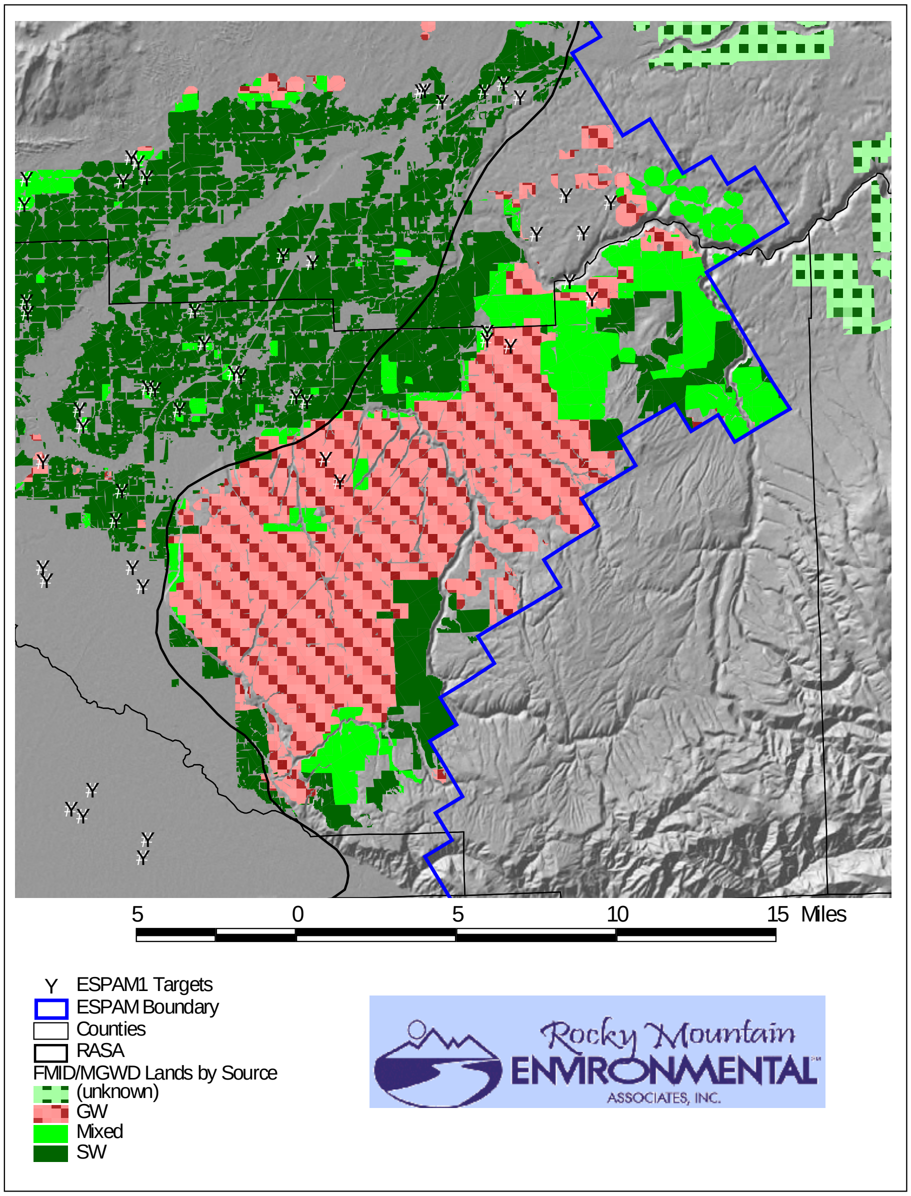

Figure 8. Water-level data ("ESPAM1 Targets") used to calibrate ESPAM1.1.

Use of Pilot Points. All models are of necessity simplifications of reality. Two approaches may be made to represent spatial variability of aquifer properties. One approach is to divide the aquifer into zones, preferably based on geologic or topographic indications. Properties are uniform with zones and change abruptly across zone boundaries. Another approach is to use what are known as pilot points. Properties are explicitly represented and calculated at discrete points, and interpolated smoothly between points.

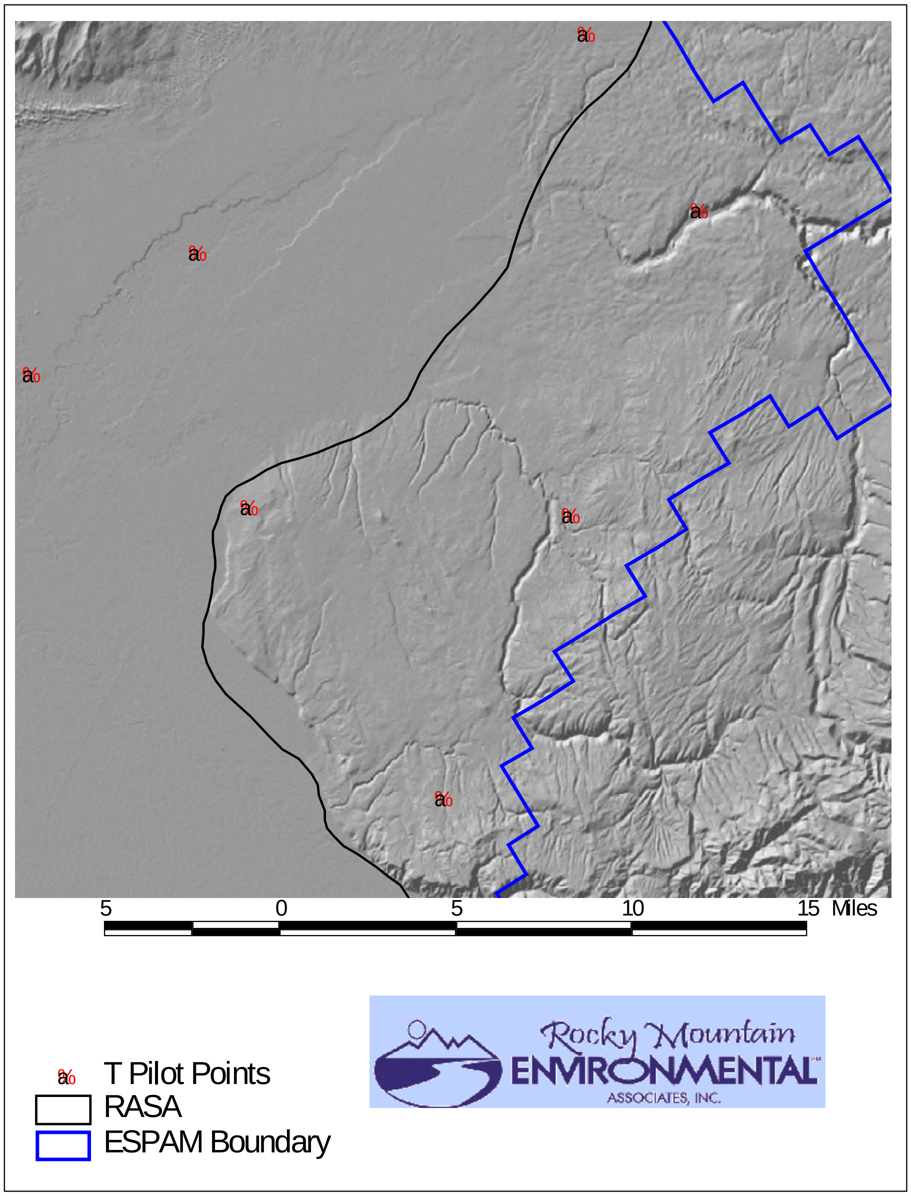

Figure 9. Pilot points for estimation of aquifer transmissivity in ESPAM1.1.

The zone methodology best represents reality where faults or geologic facies exist. This would be appropriate, for instance, for representing the boundary between the Rexburg Bench and the aquifer proper. The pilot point approach best represents broad expanses of similar materials, where gradations in characteristics occur over some distance. This would be appropriate for representing the body of the Snake Plain Aquifer. While pilot points may be concentrated to represent regions where properties are believed to change over short distances, computation limitations hinder the total number of points that may be used.

Pilot points were used in ESPAM1.1. To date, administration calculations have been steady-state or long-run calculations. Transmissivity is the property that governs these calculations. Figure 9 shows the spatial distribution of points for representing aquifer transmissivity. Storage-coefficient pilot points are even more sparse.

Conclusions

Inclusion of the Rexburg Bench area into the ESPAM1.1 model boundary may have improved aquifer water budget calculations. Inclusion allows calculation of general aquifer-wide effects of changes, which is useful for testing of hypotheses and estimation of historical impacts. Broad-scale partitions of impact between above-Milner and below-Milner locations are probably reasonably represented.

However, in my professional opinion ESPAM1.1 is inadequate for estimating the partition of effects between the Henrys Fork and the South Fork. This is based on its omission of geologic and hydrologic detail, scarcity of data, and use of pilot points in the Rexburg Bench area. This is especially troubling since model simulations indicate these are the only reaches where a water call would be likely to trigger administration in FMID or MGWD.

It is clear that CMR 50 does not attempt to include all irrigated lands where pumping may affect the Snake River Plain Aquifer, but instead is based on a hydrologic description of the aquifer itself. While the ESPAM1.1 boundary includes the Snake River Plain Aquifer proper, it also includes some tributary areas such as the Rexburg Bench which clearly differ in geologic and hydrologic character. The ESPAM1.1 boundary does not uniformly include all such outlying areas that may contribute to the aquifer. It is my opinion that the ESPAM1.1 boundary is inconsistent with the RASA boundary and the apparent intent of CMR 50. It is difficult to formulate a rational hydrologic criterion for administration that it would be consistent with.

The RASA boundary comprises the Snake Plain Aquifer proper, hosted in similar geologic materials and defined by similar topography. It appears to be hydrologically consistent with the intent of CMR 50.