MEMO

State of Idaho
Department of Water Resources
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Date: February 24, 2009

To: Gary Spackman

From: Craig Tesch and Sean Vincent CT SV

cc: Steve Lester
Rick Raymondi
John Westra

Subject: Evaluation of aquifer recharge in areas of planned community applications along the I-84 corridor from Boise to Mountain Home

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Per your request, we have conducted a preliminary evaluation of water availability in the vicinity of proposed housing developments along the I-84 corridor between Boise and Mountain Home. The basis of our evaluation is a review of the aquifer water budget presented in the USGS Professional Paper 1408-G entitled "*Geohydrology of the Regional Aquifer System, Western Snake River Plain, Southwestern Idaho*" (Newton, 1991).

As of October 9, 2008, there are a total of 11 pending water right applications for planned communities along the I-84 corridor with a total combined appropriation of 172 cfs. Many of the proposed developments overlap the Mountain Home Ground Water Management Area (GWMA). Additionally, several of the developments are within five miles of the northern boundary of the Cinder Cone Critical Ground Water Area (CGWA), which has experienced significant water level declines since 1976 (Figure 1).

As discussed in our review of the water supply evaluation report accompanying the Mayfield Townsite water right application (Attachment 1), there is considerable uncertainty in the amount of water available for appropriation in the area of proposed development. Although there is uncertainty, it can be concluded based on available data that aquifer recharge is limited in the surrounding area, as evidenced by two nearby GWMAs and one CGWA; aquifer mining is a possibility if proposed development proceeds. Our previous review confirmed the finding that "*The ultimate ground-water supply in the Mayfield area is limited*" (SPF, 2007, p. 28).

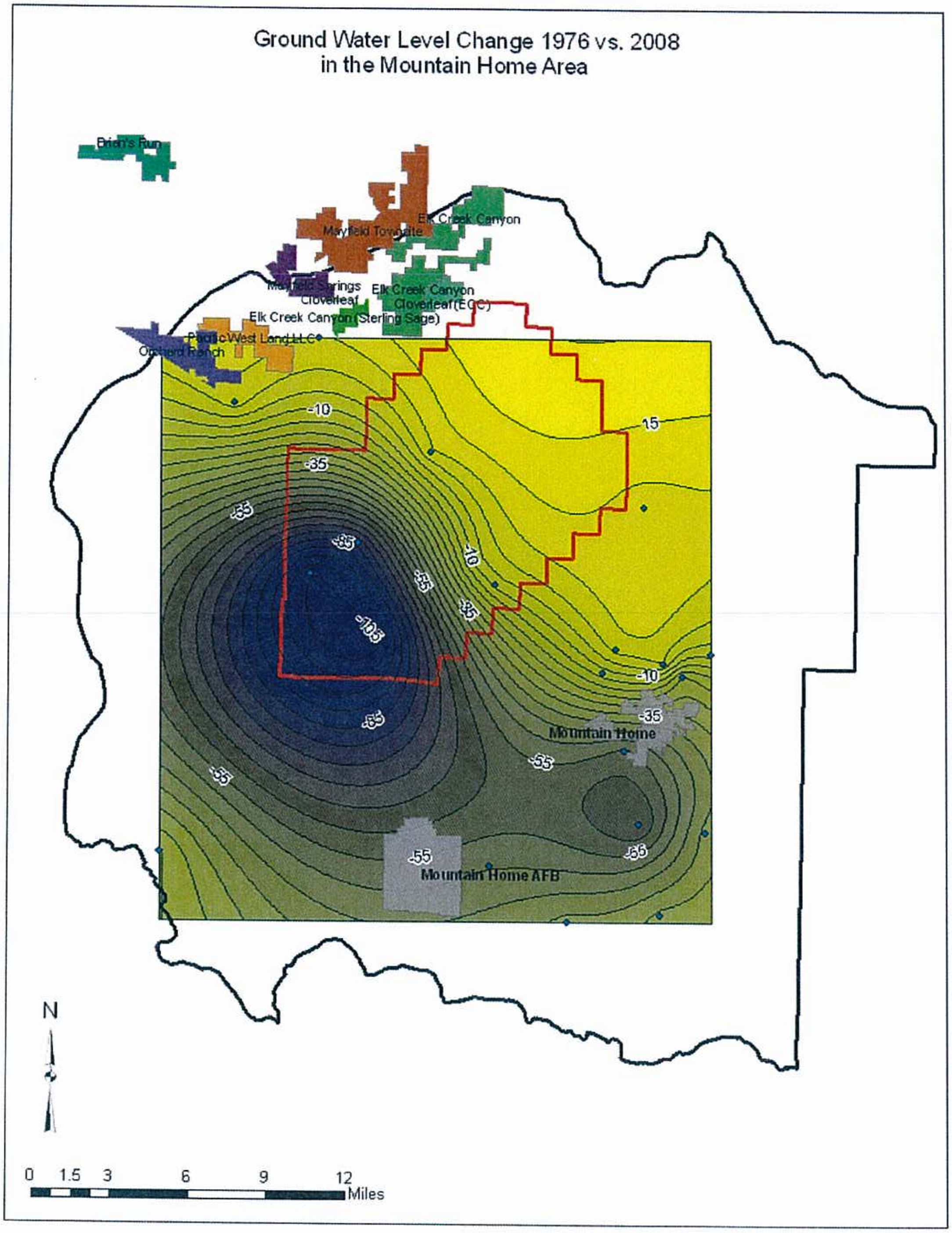

Figure 1. Ground water level change in the area of proposed development along the I-84 corridor. The Cinder Cone CGWA is outlined in red and the Mountain Home GWMA is outlined in black. Water levels are kriged with a contour interval of five feet.

To provide an evaluation of aquifer recharge on a larger scale, this memo presents components of a ground water budget that was developed by the USGS for a three-dimensional ground water flow model of the western Snake River Plain (Newton, 1991). The modeling domain was divided into a network of cells, each two miles on a side, with the entire model grid broken up into 11 subareas based on geologic and hydrologic characteristics (Figure 2). Subareas four and eight are the focus of this evaluation, contain the bulk of the proposed developments along the I-84 corridor, and cover an area of approximately 400,000 acres.

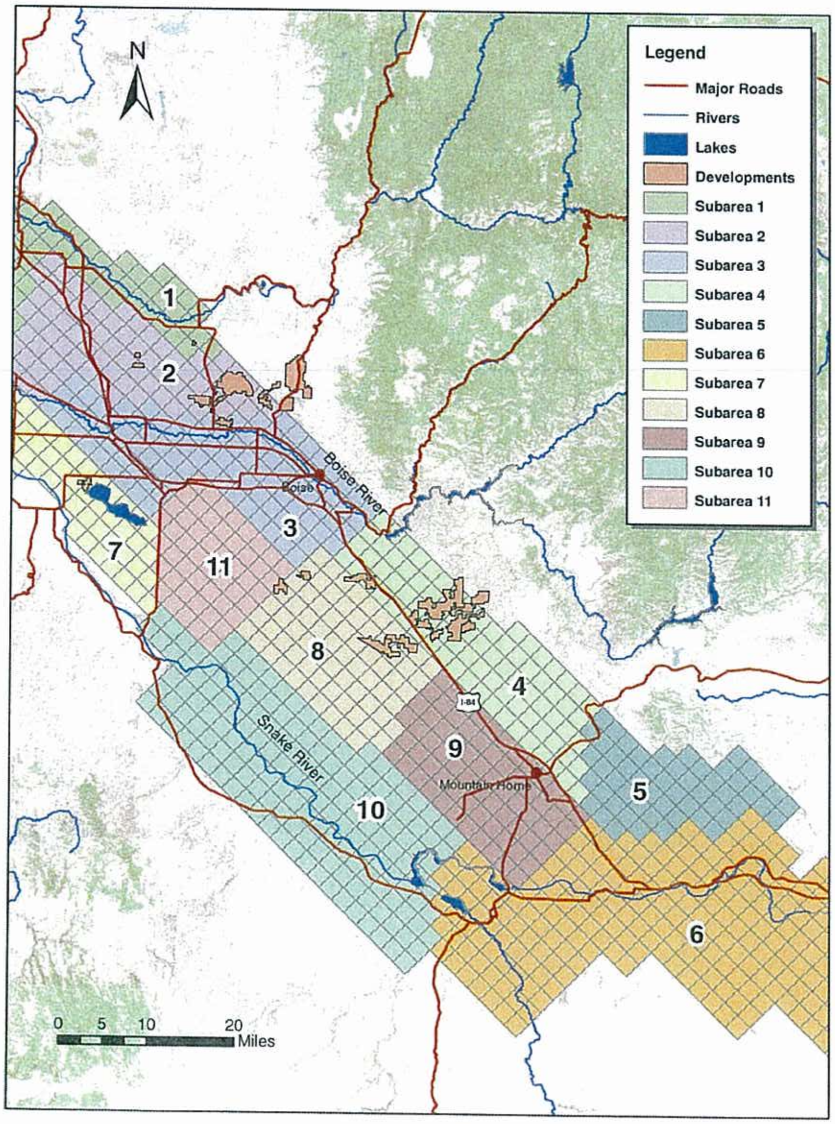

Figure 2. USGS western Snake River Plain model subareas and proposed community developments.

Evaluation of 1980 Water Budget

The USGS prepared a water budget using 1980 data for a three-layer model of the western Snake River Plain aquifer system (Newton, 1991). Identified recharge sources include infiltration from surface water irrigation, tributary underflow from surrounding aquifers, and recharge from precipitation. Primary discharge components are discharge to rivers and drains, and consumptive use from ground water pumping. Some budget estimates have a range of uncertainty and are not well defined due to a lack of hydrologic data, particularly tributary underflow, which was simulated in the model using constant flux boundaries. It is unknown what effect this and other water budget uncertainties will have on determining the amount of water available for appropriation.

Recharge

The three major recharge components of the USGS water budget for the western Snake Plain Aquifer are:

- Recharge from precipitation
- Infiltration from surface water irrigation
- Tributary underflow

Tables of estimated ground water recharge from precipitation and surface water irrigation were provided in the USGS report and are presented for subareas four and eight in Table 1 below.

Average recharge from precipitation on the plain was estimated by the USGS to be two percent of the annual precipitation. The total estimated recharge from precipitation for model subareas four and eight during 1980 was 7,200 acre-feet (10.0 cfs).

The USGS estimated 13.8 ft^3/sec (cfs) of surface water irrigation recharge for subareas four and eight combined. Some of the major sources of surface water irrigation include Indian Creek, Slater Creek, Dry Creek, Ditto Creek, and Rattlesnake Creek.

Table 1. Western Snake River Plain Aquifer recharge and discharge estimates for 1980 in USGS model subareas four and eight.

Model Subarea	Total Area (acres)	(1) Recharge from Precipitation (cfs)	(2) Recharge from Surface Water Irrigation (cfs)	(3) Net Pumpage (Consumptive Use) (cfs)	Net Recharge without Tributary Underflow [(1)+(2)-(3)]
4	207,360	7.5	13.8	9.8	11.5
8	184,320	2.5	0	3.9	-1.4
Total	391,680	10.0	13.8	13.7	10.1

The USGS model utilized 1980 Landsat imagery from a previous study (Lindholm and Goodall, 1986) to estimate irrigated acres within each subarea. Estimated recharge to the aquifer from irrigation was then calculated using U.S. Bureau of Reclamation recharge rates.

Analysis of satellite imagery suggests that in 2000 there were approximately 8,000 fewer surface water irrigated acres in the model subareas than there were in 1980 (Table 2). Assuming a proportional reduction in the recharge from surface water irrigation, the surface water irrigation recharge estimate is reduced from 13.8 cfs for 1980 to 1.4 cfs for 2000 (Table 3).

Potential explanations for the apparent reduction in irrigated acres from 1980 to 2000 include: (1) implementation of Crop Reduction Programs (CRP) in 1985, (2) conversion of acres from irrigated agriculture to dry-land farming, and (3) removal of irrigated land from production.

Table 2. Irrigated acres in subareas four and eight for 1980 and 2000.

Model Subarea	**1980 Irrigated Acres**			**2000 Irrigated Acres**		
	Ground Water	Surface Water	Total	Ground Water	Surface Water	Total
4	2,800	8,700	11,500	248	770	1,018
8	2,900	100	3,000	3,574	123	3,697
Total	5,700	8,800	14,500	3,822	893	4,715

The tributary underflow component of the water budget has a large range of uncertainty and is not well defined due to a lack of hydrologic data. In fact, the USGS report states that underflow was estimated from the water budget because "*almost no data are available to estimate underflow*" (p. G-15).

Based on our literature review, data for quantifying underflow into the western Snake River Plain Aquifer with confidence are still lacking. A report documenting a model of groundwater flow in the Treasure Valley (Petrich, 2004), for example, concludes "*The rate and spatial and vertical distribution of underflow into the valley and into the model domain is highly uncertain*" (p. 107). Although relevant, the water budget from the more recent modeling effort was not used for this analysis because the model domain includes only a portion of the area of interest.

In qualitative terms, it is considered unlikely that granitic rocks of the Idaho batholith, which typically are relatively impermeable, provide significant underflow to the aquifer system represented by model subareas four and eight. This conclusion is supported by the fact that the water supply evaluation report accompanying the Mayfield Townsite water right application considers underflow from the Idaho batholith negligible and does not include it as a component of their water budget (SPF, 2007, p. 27).

Volcanic rocks are mapped adjacent to the granite pluton along the valley margin south and east of Mayfield, however. These formations generally are more permeable than granite and, as such, are considered more likely to be a significant source of underflow to the area of interest.

The occurrence of both granitic and volcanic rocks adjacent to model subarea four is not unique; the same geologic units are mapped adjacent to subareas seven and ten, which are located on the opposite side of the western Snake Plain (see Plate 1 and Figures 16 and 17 in Newton, 1991). Constant flux boundaries were also used to represent underflow into these two subareas.

In the absence of better information, Petrich (2004) assumed that underflow was uniformly distributed along the valley margin. Adopting the same approach, an underflow estimate for the area of interest was derived from the USGS model budget by multiplying the total underflow across model boundaries during 1980 (310,000 acre-feet) by the ratio of the number of constant flux cells in subarea four divided by the total number of constant flux cells in the model. The resulting rate (55.4 cfs) is approximately 13% of the total and conceptually includes underflow from granitic and volcanic rocks along the valley margin as well as surface water recharge from the Danskin Mountains.

Note that this recharge estimate (55.4 cfs) includes underflow not only to the shallow aquifer system (layer 1 in the USGS model) but also underflow to sedimentary and volcanic rocks simulated with model layers 2 and 3, which extend to a total depth of more than 10,000 feet. Limited vertical hydraulic communication between the shallow and deep aquifer systems would tend to make the underflow estimate based on the USGS water budget high in the context of evaluating hydrologic impacts resulting from withdrawals in the shallow aquifer system.

As identified in Table 3 below, total recharge from precipitation and surface water irrigation [(1) + (2)] into subareas four and eight is 11.4 cfs. Total recharge including underflow [(1) + (2) + (5)] is 66.8 cfs.

Discharge

The two major discharge components of the regional USGS water budget for the western Snake Plain aquifer are:

- Discharge to rivers and drains
- Consumptive use from ground water pumping

Ground water discharge to rivers and drains was a major component of analysis within the entire Western Snake Plain model domain; however, there are no return flows in the project area of this memo.

Using power consumption records for individual wells, the USGS estimated 13.7 cfs of net ground water pumpage (consumptive use) for subareas four and eight for 1980 (Table 1). An updated estimate of consumptive use (16.7 cfs) was developed by IDWR GIS staff by analysis of METRIC (Mapping Evapotranspiration at high Resolution and with Internalized Calibration) data that was collected in 2000 (Table 3).

At a more localized scale, the rate of groundwater flow exiting the two subareas is unknown and cannot be accurately quantified without running the model.

Table 3. Western Snake River Plain recharge and discharge estimates for 2000 in subareas four and eight using METRIC analysis.

Model Subarea	Total Area (acres)	(1) Recharge from Precipitation (cfs)	(2) Recharge from Surface Water Irrigation (cfs)	(3) METRIC ET estimate (cfs)	(4) Net Recharge without Underflow [(1)+(2)-(3)]	(5) Underflow (cfs)	(6) Net Recharge with Underflow [(4)+(5)]
4	207,360	7.5	1.2	2.9	5.8	55.4	61.2
8	184,320	2.5	0.2	13.8	-11.1	-	-11.1
Total	391,680	10.0	1.4	16.7	-5.3	55.4	50.1

Net Recharge

Ignoring tributary underflow, a net recharge of negative 5.3 cfs is calculated for 2000 by subtracting aquifer withdrawals (16.7 cfs) from total recharge from precipitation and surface water irrigation (11.4 cfs). If underflow (55.4 cfs) is considered, the net recharge into the model subareas is 50.1 cfs. Either way, groundwater outflow from the subareas is ignored and the total appropriation amount for the 11 pending water right applications (172 cfs) greatly exceeds the estimated net recharge for 2000. Assuming similar conditions in future years, the total appropriation amount also greatly exceeds the "*reasonably anticipated rate of future natural recharge*" (Idaho Code §42-237a.g.), which according to IDAPA 37.03.11 includes precipitation, underflow from tributary sources, stream losses, and incidental recharge of water used for irrigation and other purposes.

Conclusions

The following conclusions are based upon our review of the 1980 water budget for a model of the western Snake River Plain Aquifer presented in the USGS Professional Paper 1408-G and an updated 2000 METRIC analysis:

1. The USGS water budget was published in 1991 using data collected in 1980. There is uncertainty in individual water budget components and how changes in land and water use practices have changed the water budget since 1980. The collection of new data in an upcoming hydrogeologic characterization program will help refine the water budget for the area of proposed development.

2. USGS estimates of recharge from surface water irrigation and consumptive use were updated herein through an analysis of satellite imagery and METRIC evapotranspiration data for 2000. The other water budget components (i.e., recharge from precipitation and inflow from the Danskin Mountains) are as originally estimated using 1980 data.

   Based on National Weather Service precipitation data from the Boise Airport weather station, 1980 was an above average water year (15.2 inches total precipitation versus the average of 12.2 inches) and 2000 was an average water year (12.0 inches precipitation). NRCS Snow Course data for Mores Creek Summit shows an above average snow pack on April 1, 1980 (39.6 inches versus the average of 34.6 inches) and a below average snow pack on April 1, 2000 (30.7 inches). The impact of using an above average year (1980) for determining recharge from precipitation and inflow from the Danskin Mountains is to overestimate recharge relative to what might be expected in an average year.

3. Ignoring underflow, the net recharge for subareas four and eight is negative 5.3 cfs. If underflow is considered, net recharge increases to 50.1 cfs for the subareas. Both estimates ignore groundwater outflow from the subareas as this rate is unknown and it is not a component of the "*reasonably anticipated rate of future natural recharge*" (Idaho Code §42-237a.g.). The negative 5.3 cfs estimate arguably is more meaningful for evaluating impacts to the resource if the rate of ground water outflow approaches the modeled rate of underflow (55.4 cfs).

4. The total combined appropriation for the 11 pending water right applications for planned communities along the I-84 corridor (172 cfs) greatly exceeds the range of estimates for net recharge in 2000 (-5.3 to 50.1 cfs). Assuming similar conditions in future years, the total appropriation amount also greatly exceeds the "*reasonably anticipated rate of future natural recharge*".

5. Several of the proposed developments are within five miles of the Cinder Cone CGWA, which has experienced significant water level declines since 1976. The analysis in the attached IDWR memo suggests that the proposed ground water development could exacerbate conditions in the Cinder Cone CGWA and Mountain Home GWMA and cause significant declines locally.

References

Lindholm, G.F., and Goodell, S.A., 1986. Irrigated acreage and other land uses on the Snake River Plain, Idaho and eastern Oregon: U.S. Geological Survey Hydrologic Investigations Atlas HA-691, scale 1:500,000.

Newton, G.D., 1991. Geohydrology of the Regional Aquifer System, Western Snake River Plain, Southwestern Idaho. U.S. Geological Survey Professional Paper 1408-G.

Petrich, C.R., 2004. Simulation of Ground Water Flow in the Lower Boise River Basin. Idaho Water Resources Research Institute Research Report IWRRI-2004-02. 130 pp.

SPF Water Engineering, 2007. Ground-Water Supply Evaluation for the Mayfield Townsite Property. November 1. 30 pp.

Attachment

February 10, 2009 IDWR Memo from D. Owsley and S. Vincent to S. Lester

MEMO

State of Idaho
Department of Water Resources
322 E Front Street, P.O. Box 83720, Boise, Idaho 83720-0098
Phone: (208) 287-4800 Fax: (208) 287-6700

Date: February 10, 2009

To: Steve Lester, Western Regional Office

From: Dennis Owsley and Sean Vincent, Hydrology Section, State Office

cc: Rick Raymondi and John Westra

Subject: Evaluation of SPF Report entitled *Ground-Water Supply Evaluation for the Mayfield Townsite Property*

Introduction

Per your request, we have reviewed the subject report in order to evaluate potential impacts to the aquifer from Water Right Application 63-32499 for the appropriation of 10 cfs of ground water from up to eight wells in the Mayfield, Idaho Area. The proposed Mayfield Townsite development comprises approximately 8,000 homes within a 6,363 acre area (SPF, 2007). The property overlaps the northern edge of the Mountain Home Ground Water Management Area (GWMA) and is approximately 3.5 miles northwest of the Cinder Cone Critical Ground Water Area (CGWA).

Total projected water use is 4,860 acre-feet, 2,240 acre-feet for domestic purposes and 2,620 acre feet for irrigation (SPF, 2007, p. ii). Assuming 1,120 acre-feet of domestic effluent will be treated and re-used for irrigation, the net annual consumptive use is approximately 3,960 acre-feet, which is equivalent to an average annual rate of 5.5 cfs. The maximum demand for the 8,000-home development is estimated to be 21.1 cfs. This demand would be met by combining the maximum rate of diversion for water right 63-32499 (10 cfs) with 4 cfs ground water under water right 63-123447, 5 cfs of reclaimed domestic wastewater, and, when available, up to 2.57 cfs of surface water under water right 63-2046.

According to the SPF report, the proposed wells would extend to depths ranging from 600 to over 800 feet, with static water levels ranging from approximately 300 to 600 feet below ground surface (p. v). SPF describes the aquifers that underlay the Mayfield Townsite as "*layers of unconsolidated sediments and volcanic materials*" (p. iii). The hydrogeology of the area is poorly characterized at present but it is targeted for study as part of the recently authorized Aquifer Planning and Management program.

In accordance with your request, we attempt to address the following questions at the conclusion of our review:

1) Does the study describe possible impacts this water right will have on the aquifer? If so, are those impacts significant?

2) Does the study describe possible impacts this water right and water right 63-32225 will have on the aquifer? If so, are those impacts significant?

3) What is the probability of the 10 cfs diversion rate from this right causing the borders of the Mountain Home Ground Water Management Area to migrate and/or change?

4) What is the probability of the 10 cfs diversion rate from this right and the 10 cfs diversion rate from 63-32225 causing the borders of the Mountain Home Ground Water Management Area to migrate and/or change?

5) Does this study show that mining of the aquifer will not occur and that there is sufficient proof of the long-term sustainability of the water supply for this project?

IDWR Review of SPF Report

The SPF report includes a water budget for the "*contributing basins*" and an evaluation of historic water level data. Selected aspects of the SPF report are described in the following sections in order to provide a framework for our assessment of potential impacts to the aquifer.

Contributing Basins

SPF uses the term "*contributing basins*" to refer to the portion of the Indian Creek watershed that may provide recharge to "*aquifers in the project area*" (p. 19). The area that defines the contributing basin for ground water (also referred to by SPF as the "*ground water capture area*") was arbitrarly selected. The need for SPF to identify a potential recharge area stems from the fact that a recharge area must be defined in order to calculate the annual volume of recharge entering the aquifer. In other words, an aquifer water budget cannot be prepared without first defining the extent of the aquifer.

There are multiple aquifers/aquifer layers in the project area and they are of unknown thickness and lateral extent. This hydrogeologic uncertainty makes it difficult for SPF (and IDWR) to quantify the "*reasonably anticipated average rate of future natural recharge*" (Idaho Code, Section 42237a.g.).

In the absence of a well-developed hydrogeologic conceptual model, the contributing basin was arbitrarily assumed by SPF as a two-mile buffer from each of the proposed wells. The area is truncated by the geologic contact between the granitic uplands and the basin geologic units (Figure 1). SPF's resulting capture area encompasses approximately

27,500 acres (SPF, 2007, p. 19). Even though arbitrary, the 2-mile capture area presented by SPF is one estimate of the recharge area for the aquifer of interest.

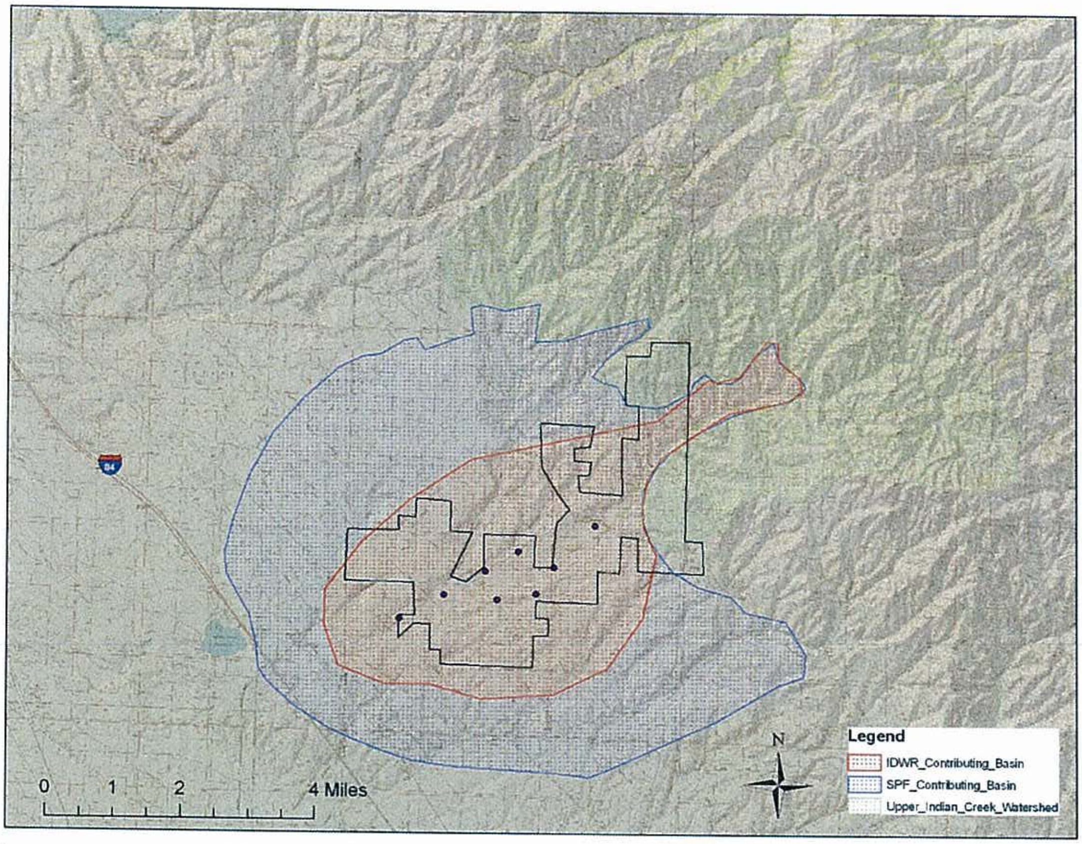

Figure 1. SPF and IDWR areas of interest. The proposed Mayfield Townsite development is outlined in black.

For purposes of comparison, we delineated the geometry of the hydraulic capture zone for the proposed well field using the analytic element model WhAEM (EPA, 2007). We assumed a hydraulic conductivity of 17 ft/day (5.9 x 10^{-3} cm/sec) and an aquifer thickness of 200 feet based on a transmissivity estimate of 25,000 gpd/ft, which is presented in the SPF report based on a well test performed on the ARK irrigation well (p. 13). The ARK well is located centrally within the Mayfield Townsite and is completed in the aquifer that is proposed for development in this water right application. The ARK well is 622 feet deep and has open intervals from 432 to 462, 468 to 478, and 542 to 552 feet below ground surface. Other required model input includes the rate of areal recharge, and the steady-state production rate for the production wells. Based on the USGS modeling effort for the western Snake River Plain (Newton, 1991), a uniform areal recharge rate of 0.5 in/yr was used, which is equivalent to 3% of the approximate average annual precipitation over the project area (16.5 in/yr) as determined by PRISM data (IDWR, 2008). Lastly, a steady-state production rate of 308 gpm was used at each of the eight diversion locations that are identified on the SPF figure that accompanies the permit application. This production rate is equivalent to SPF's estimate of the average consumptive use for the development (5.5 cfs, p. ii), equally distributed among each of the eight proposed wells.

As shown in Figure 1, the resulting 10-year hydraulic capture zone is considerably smaller (18,000 acres) than the "*contributing basin for aquifers in the project area*" (p. 19) that was assumed in the SPF analysis (27,500 acres). The area delineated by IDWR is similar to the area assumed by SPF in the fact that the 10-year travel time was selected arbitrarily. Although actual pumping rates and aquifer properties were used in defining the area, hydraulic gradients and aquifer boundary conditions were not included in the modeling process. Therefore, the resultant area represents the theoretical area in which the production wells would withdrawal water from a flat, infinite aquifer in a 10-year timeframe.

However, the drawdown values that were predicted through the IDWR delineation of the recharge area are not arbitrary. The drawdown values were calculated using the presented transmissivity and estimated pumping values and the ground water gradient and storage coefficient do not influence the predicted drawdown under steady state conditions. The maximum model-predicted drawdown is 130 feet and the drawdown at the northwest boundary of the Cinder Cone CGWA is 81 feet.

It's worth mentioning that hydraulic communication between the Mayfield Townsite sedimentary aquifer system and the basalt aquifer in the Cinder Cone CGWA possibly is limited by a fault system that runs along I-84 (Figure 2). The fault system may act as a barrier to flow based upon our preliminary evaluation of available water level data. Assuming that the fault system serves as a partial or complete barrier to flow, the WhAEM-based drawdown estimates are too low for the portions of the management areas that are north of the highway and too high for areas that are south of the highway.

Upper Indian Creek Watershed

Although not part of the "*contributing basin*" for ground water, precipitation on the upper Indian Creek Basin is an aquifer inflow term for the water budget that SPF developed in order to evaluate the amount of water available for appropriation. The underlying assumption is that, if not evapotranspired, all precipitation on the granitic uplands ends up recharging the aquifer that is proposed for development. The contributing area of the Upper Indian Creek watershed is approximately 15,630 acres.

Average Rate of Future Natural Recharge

SPF's report presents estimates of the average future natural recharge and compares these volumes to existing and proposed aquifer withdrawal amounts in order to evaluate whether total withdrawals, including the proposed new water right, would exceed the "*reasonably anticipated rate of future natural recharge*" (Section 42-237a.g., Idaho Code). SPF acknowledges that "*the ultimate carrying capacity of aquifers in the Mayfield Townsite area is unknown*" (p. 28) and presents a range of recharge estimates to account for this uncertainty. SPF's recharge estimates are described below.

High Estimate
The "*high estimate*" of average future aquifer recharge was calculated by subtracting the annual average evapotranspiration (ET) from the average annual precipitation for the combined area that includes the ground water capture area and the granitic uplands within the upper Indian Creek watershed. All of the precipitation that is not evapotranspired is assumed to recharge the aquifer, either as infiltration or surface water seepage. In this case, the distinction between infiltration and surface water seepage is of no consequence as both water budget components contribute to the amount of water that is available for appropriation.

Evapotranspiration (ET)
SPF assumed that a preliminary SEBAL (Surface Energy Balance Algorithm for Land) estimate of the ET during the 2000 growing season (March 15, 2000 to October 15, 2000) for rangeland in the Boise River Valley (9.5 inches; Morse et al., 2003) applies to the Indian Creek watershed. SPFs estimate of ET for the combined area that includes the ground water capture area and the upper Indian Creek watershed is 34,140 acre-feet.

SEBAL is geared toward estimating ET on irrigated lands. (Morse et al., 2003, p. 2). Not surprisingly, the coefficient of variation (i.e., the standard deviation divided by the mean) for this satellite-based ET estimation technique is much higher for rangeland than for agricultural lands. In other words, there is more uncertainty associated with a SEBAL-derived estimate for rangeland as compared to a SEBAL-derived estimate for irrigated cropland. In addition, the SPF estimate only includes ET rates for the growing season (April through October). ET that occurs during the non-growing season would tend to make the SPF estimate too low.

Based on consideration of the above and a discussion with one of the authors of the SEBAL ET study (Kramber, 2008), our estimate of ET for the Indian Creek watershed is based on ET Idaho data. Using ET Idaho data for the years 1904 to 2004, the annual ET for the IDWR area of interest is 34,656 acre-feet. On a per area basis, the ET Idaho-based estimate is higher than the SEBAL-derived value. The discrepancy between these ET rates suggests that there is considerable uncertainty in the ET estimates.

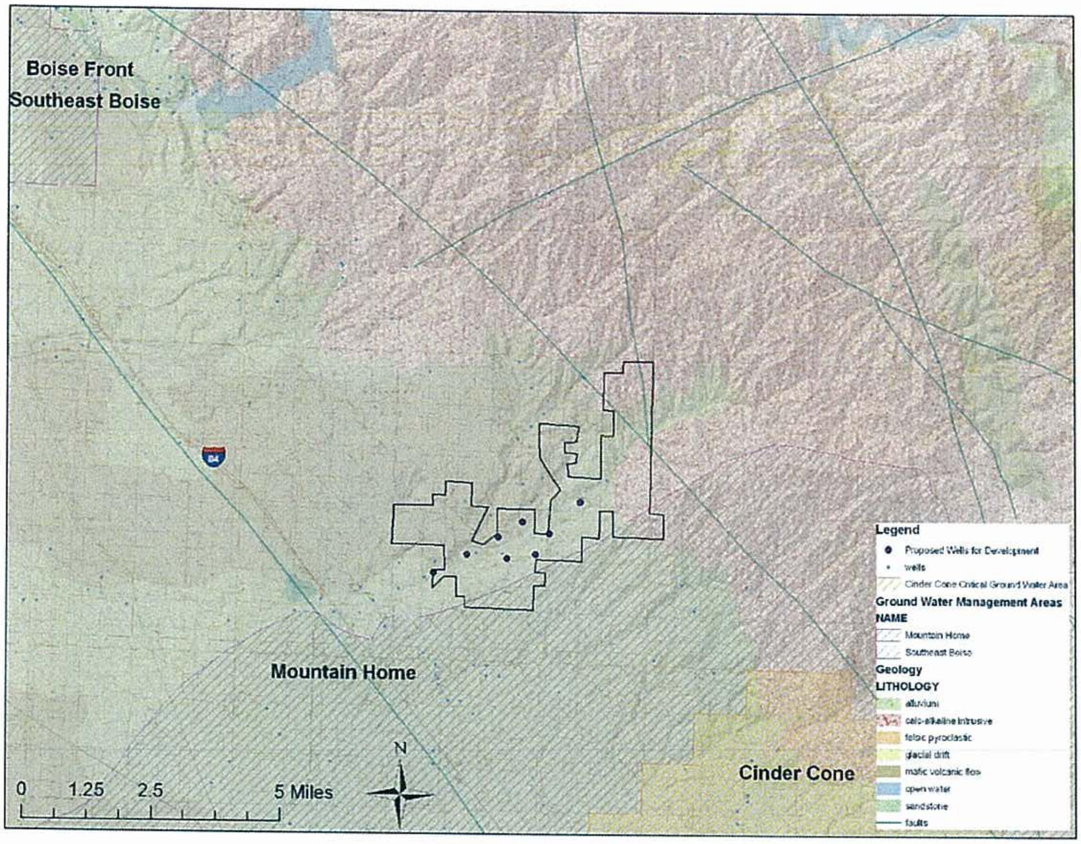

Figure 2. Map showing the location of the proposed project site (black outlined area) in relation to ground water management areas.

SPF's high estimate of annual recharge is 31,590 acre-feet. The corresponding IDWR estimate is 12,761 acre-feet (Table 1). As discussed previously, the ET rates on a per area basis also are different but the difference in the high recharge estimates is primarily attributable to the difference in size of the contributing areas.

In developing the high estimate, SPF assumed that all precipitation in the combined area that does not infiltrate or is not lost to ET becomes surface runoff and all surface runoff ends up recharging the aquifer system that is proposed for development. Although we make the same assumption for comparison purposes, we are concerned that this simplifying assumption would tend to overestimate recharge to the relatively deep aquifer layers that are targeted for production. Recharge would be overestimated, for example, if not all of the surface runoff seeped into the ground within the capture area or if some of the infiltration was to overlying water bearing zones with limited hydraulic communication to the target layers.

Table 1. Comparison of High Aquifer Recharge Estimates

Water Budget Component	Annual Volume (acre-feet) SPF	Annual Volume (acre-feet) IDWR	Comments
Precipitation in combined area (upper Indian Creek watershed + ground water contributing basin)	65,730	47,417	Differences due primarily to differences in size of the combined areas (Figure 1). For the SPF estimate, Sheep Creek and Caldwell Creek watershed precipitation is included.
Evapotranspiration in combined area	34,140	34,656	SPF used SEBAL estimates of ET. IDWR estimate is based on ET Idaho data. The values are similar, but the area calculated for the IDWR estimate is significantly smaller than the area SPF estimated.
High aquifer recharge estimate	**31,590**	**12,761**	Precipitation minus ET in combined area.

Low Estimate

The so-called "low estimate" of average aquifer recharge is a more conservative and, in our opinion, more defensible number as it relies upon field observations and measurements of flow in order to quantify surface channel seepage into the aquifer instead of just assuming that it's the difference between precipitation and the estimate of ET. The method for estimating each recharge component is described below.

Infiltration

Five percent of the precipitation that falls within the ground water contributing basin was assumed by SPF to recharge the aquifer as infiltration. This arbitrary percentage is higher, however, than the only known published estimate for recharge in this area, 3%, which was used by the USGS as input for their model of western Snake Plain Aquifer (Newton, 1991).

Surface Channel Seepage

Seepage from Indian Creek is, in fact, a significant and known source of recharge to the aquifer as all flow infiltrates between the Mayfield area and Interstate 84 under non-flood conditions. The volume of water that is contributed to the aquifer from the Indian Creek watershed was assumed by SPF to be the total annual flow in Indian Creek.

There are very few historical flow data available for Indian Creek. The USGS measured flows of 1.66 and 0.6 cfs in February and June of 1954, respectively. A site visit in March of 2005 by SPF provided an opportunity to observe flows in Indian Creek. Based on field observations during the March of 2005 site visit, a flow of 8 to 10 cfs was estimated. SPF suggests that the observed flow was less than typical for this time of year, owing to cool basin temperatures (p. 24). An average flow of 20 cfs was presented by SPF as an estimate of the runoff rate in Indian Creek.

The SPF report calculated the volume of water that recharges the aquifer from Indian Creek as follows: 20 cfs was assumed as the average runoff rate for a three-month spring runoff period (3,689 acre-feet). In addition, a temporary 3-day flow of 100 cfs (595 acre-feet) was included in the water budget to account for rain-on-snow events in the Indian

Creek watershed. The flow in Indian Creek was considered negligible for the remainder of the year. The total seepage from Indian Creek was estimated by SPF at 4,200 acre-feet. Note that the 20 cfs average runoff and the 100 cfs peak flow were not based on field measurements.

Due to the lack of data, IDWR measured the flow in Indian Creek with a FlowTracker® Handheld ADV® (Acoustic Doppler Velocimeter) eight times over the course of a 16-week period (3/08-6/08) at the Mayfield bridge. The flow measurements are presented in Table 2.

Table 2. Indian Creek ADCP Measurements.

Date	Flow (cfs)
3/12/2008	7.4
3/27/2008	11.8
4/03/2008	6.6
4/18/2008	9.0
4/23/2008	7.7
5/05/2008	3.9
5/27/2008	1.9
6/13/2008	0.4

With average to above average snow pack conditions in the Indian Creek watershed this year (2008), we consider the measured flow rates in Indian Creek to be representative of a typical runoff season. However, based on the hydrograph for Cottonwood Creek (USGS Station 13204640), a creek north of Boise that drains a basin of similar physical characteristics (elevation, vegetation, slope, aspect, weather conditions), the runoff season is considerably longer than 3 months A continuous record of flow in Cottonwood Creek was available for the same period (March-June) as our field measurements. The flow rates are remarkably similar for the period of overlapping measurements (Figure 3). As such, and because the Cottonwood Creek drainage experiences similar weather and has similar physical characteristics, the early season Cottonwood Creek flow data were used to extrapolate the flow data for Indian Creek. The resulting estimated runoff volume for Indian Creek is 2,065 acre-feet for a runoff season that lasts 7 months (Table 3). This is a considerably longer runoff season than the 3-month season that was assumed by SPF.

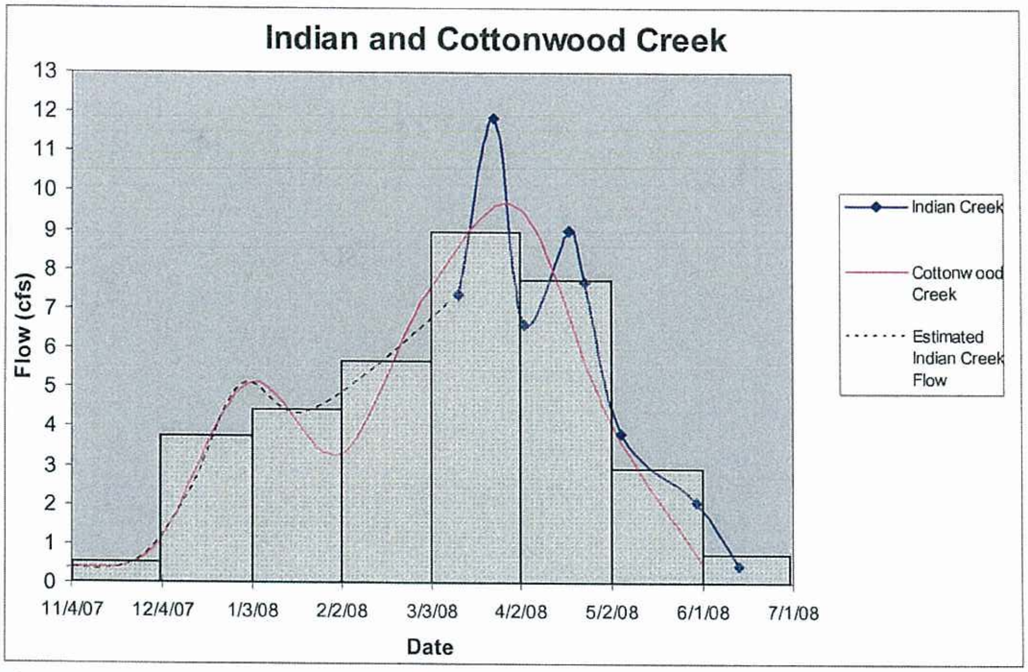

Figure 3. Hydrographs of Indian Creek and Cottonwood Creek. The runoff volume in Indian Creek was estimated by summing the areas of the shaded rectangles. Cottonwood Creek hydrograph was downloaded from http://waterdata.usgs.gov/nwis/sw.

Based on field observations, the three day temporary flow rate of 100 cfs that SPF included in the water budget was excluded from the IDWR estimate. Coarse sand deposits can be observed along the entire length of the channel down to Indian Creek Reservoir, indicating that not all of the surface flow seeps into the aquifer within the capture area during high flow events.

Table 3. Comparison of Low Aquifer Recharge Estimates

Water Budget Component	Annual volume (acre-feet) SPF	Annual volume (acre-feet) IDWR	Comments
Precipitation in ground water contributing basin	37,180	14,633	SPF assumed arbitrary 2-mile buffer for the ground water contributing basin. IDWR contributing basin was delineated with analytic element model.
Areal infiltration in assumed ground water contributing basin	1,860	439	SPF estimated infiltration as 5% of the precipitation in the SPF ground water contributing basin. Based on USGS model, IDWR estimated infiltration as 3% of the precipitation in the IDWR ground water contributing basin.
Indian Creek seepage	4,200	2,065	SPF estimate based on a single field observation of flow during 2008 runoff season and estimate of additional flow volume from rain-on-snow events. IDWR estimate based on eight flow measurements during 2008 run-off season and extrapolation of data using hydrograph for a similar, nearby watershed.
Low aquifer recharge estimate	**6,060**	**2,504**	Indian Creek seepage plus areal infiltration.

Aquifer Outflow
SPF identifies two aquifer outflow components: 1) withdrawal by wells, and 2) underflow to the Snake River (p. 26). They estimate that the annual discharge to currently permitted wells, including 1,815 acre-feet for wells under permit 63-32225, is approximately 2,627 acre-feet. The SPF report does not include an estimate for underflow to the Snake River, however, and this aquifer outflow component is not considered in the water budget that is used to determine the amount of water that is available for appropriation. Although this approach is consistent with statutory guidelines which specifically requires consideration only of the "*reasonably anticipated rate of future natural recharge*" (Idaho Code, Section 42-237a.g.), failing to consider all aquifer outflow components makes the so-called "*water budget*" incomplete and effectively precludes evaluation of the potential for water level declines.

Prior to February of 2007, the annual discharge rate from ground water wells for the "*contributing basin for aquifers in the project area*" was 812 acre-feet. In February of 2007, water right 63-32225 was approved that authorized an additional 1,815 acre-feet to be withdrawn annually. The inclusion of water right 63-32225 increased the annual withdrawal from the area by more than 300%. The points of diversion for water right 63-32225 are for a proposed development that is within one mile of the borders for the subject property for this application. Assuming an average annual project demand of 3,956 acre-feet (SPF, 2007, p. 6), the approval of application 63-32499 would result in a total annual withdrawal within the capture area of 6,583 acre-feet, which, in combination with water right 63-3225, represents an increase of over 800%.

Summary
The results of the SPF and IWDR analyses indicate the annual average recharge volume for the capture area ranges from 2,504 to 31,590 acre-feet. SPFs range of aquifer recharge estimates is higher than the corresponding IDWR range of estimates. Differences in the estimates are due to differences in the underlying assumptions. The most significant differences are as follows:

1) The method of estimating the area of ground water capture. The SPF water budget is based on the assumption of an arbitrary two-mile capture area for each of the production wells. This approach significantly increases the area in which recharge is assumed to be available for the production wells, resulting in a higher recharge volume. The corresponding IDWR water budget is based upon delineation of the 10-year capture area using data that was provided by SPF concerning the hydrogeology in the area, the rates of withdrawal, and the geometry of the proposed well field. The more conservative IDWR approach substantially reduces the size of the aquifer recharge area, resulting in a lower volume.

2) The method for estimating ET (affects only the high estimate of aquifer recharge). SPF assumed that a preliminary SEBAL-derived estimate for rangeland in the Boise River Valley during the 2000 growing season also applies to the Indian Creek watershed. Because SEBAL is better suited for estimating ET on irrigated

cropland and because a preliminary, partial season ET for a different basin is unlikely to be representative of the average annual value in the Indian Creek watershed, IDWR used the average ET for the Indian Creek watershed based on ET Idaho data for the years 1904 through 2004.

3) The rate of infiltration. SPF used a 5% infiltration rate that is not supported by any documentation. The IDWR estimate is based on the assumption that infiltration is 3% of total precipitation, which is the same assumption that was made by the USGS for the project area in their model of the western Snake River Plain aquifer (Newton, 1991).

4) The average annual volume of Indian Creek seepage (only affects the low estimate of aquifer recharge). The SPF low average annual recharge estimate is based on a visual estimate of runoff and an assumed peak flow with no supporting flow measurements. The IDWR estimates are based on eight flow measurements during a relatively normal water year (2008), and extrapolation of the flow at other times based on the runoff pattern in a nearby drainage of similar elevation.

Because of uncertainty in the magnitude of aquifer recharge, there also is considerable uncertainty in the amount of water that's available for appropriation. Estimates of the available amount ranges from slightly negative to a large multiple of the estimated project demand. The slightly negative value indicates the aquifer has already been fully appropriated and suggests that additional ground water development could cause significant water level declines. On the other hand, a positive value implies that the recharge rate for the area exceeds the current rate of withdrawal and that there is water available for appropriation. Both possibilities are considered plausible given our current, albeit limited, knowledge about the hydrogeologic setting.

As previously discussed, SPF's high estimate of annual average aquifer recharge (31,590 acre-feet) is not supported by field measurements and, because it relies upon a preliminary, relatively uncertain estimate of ET for a partial year in a different basin, potentially grossly overestimates the amount of water available for appropriation Our estimates using more conservative assumptions indicate the amount of water currently available for appropriation ranges from -123 to 10,134 acre-feet per year (Table 4).

Table 4. Comparison of Water Budget Estimates

Water Budget Component	Annual Volume (acre-feet) SPF	Annual Volume (acre-feet) IDWR	Comments
High recharge estimate	**31,590**	**12,761**	Areal infiltration seepage plus the estimated infiltration in ground water contributing basin.
Low recharge estimate	**6,060**	**2,504**	Indian Creek seepage plus estimated infiltration in ground water contributing basin.
Current discharge to wells	2,627	2,627	Sum of historical diversions (812 acre-feet) and 1,815 acre-feet associated with W.R. 63-32225.
High estimate of water available for appropriation	**28,963**	**10,134**	High recharge estimate minus current discharge to wells.
Low estimate of water available for appropriation	**3,433**	**-123**	Low recharge minus current discharge to wells.
Mayfield Townsite Project demand	3,956	3,956	Average annual consumptive use.

Summary of Water Levels

SPF indicates that most water levels in the Mayfield area are either stable or slightly rising (SPF, 2007, pgs. ii, v, and 13). This conclusion is based on IDWR monitoring well data for 16 wells within a 10 mile radius of the development. However, only three of these wells have monitoring data through 2007. Of these three wells, two appear to have increasing trends and the third well appears to be experiencing a declining trend (Figure 4).

It is agreed that the general water level conditions in the Mayfield area are stable or slightly increasing. However, the significance of this trend should not be overemphasized, as it has been shown that the aquifer in this area has historically not experienced significant withdrawal volumes. A significant increase in ground water use in the area has the potential to create declining water levels, similar to those experienced in the Cinder Cone Critical Ground Water Area.

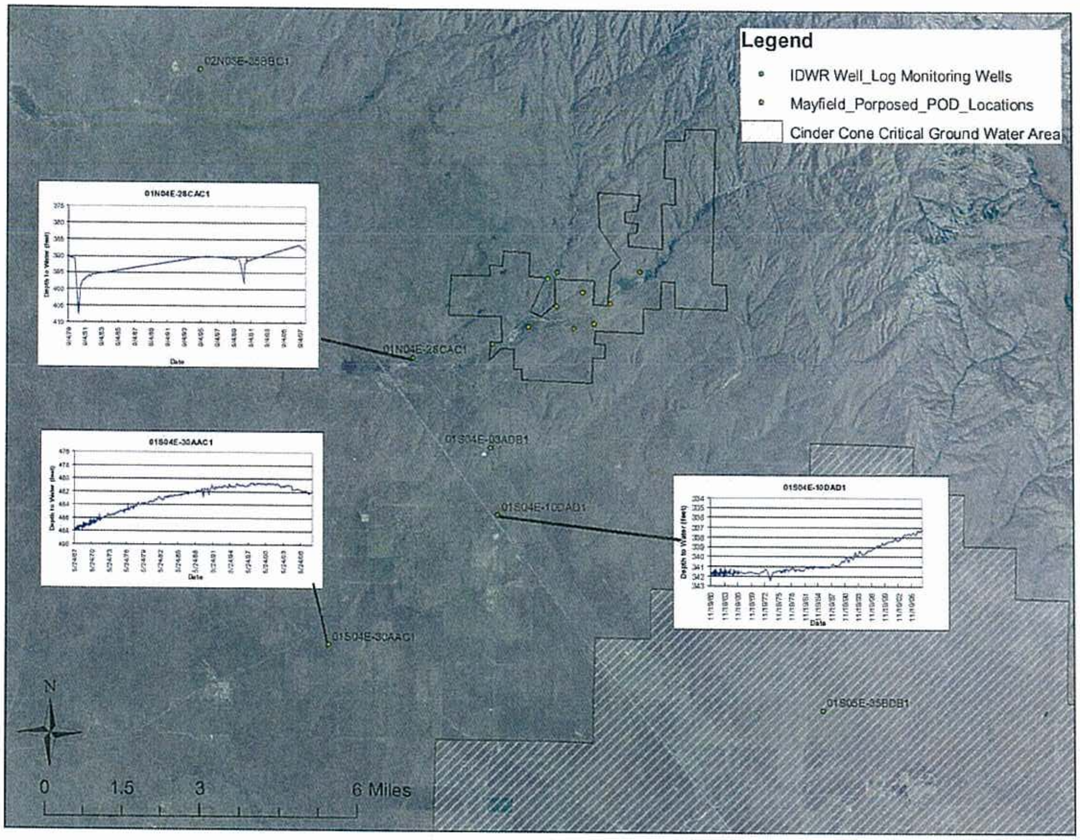

Figure 4. Water levels in three wells near the Mayfield area with current monitoring data.

Response to Questions

1) *Does the study describe possible impacts this water right will have on the aquifer? If so, are those impacts significant?*

The SPF report asserts that the aquifer can most likely support an additional withdrawal of approximately 3,960 acre-feet per year without significantly impacting the aquifer. However, our analysis indicates that this assertion is not warranted given the magnitude of the proposed aquifer withdrawal increase (>800% since February 2007) and the current level of uncertainty in the water budget. In addition to uncertainty regarding quantification of individual water budget components, there exists considerable uncertainty regarding the hydrogeologic conceptual model. Additional aquifer characterization is required in order to evaluate potential impacts and to assess their significance.

Although there is considerable uncertainty, it can be concluded that aquifer recharge is limited in the surrounding area, as evidenced by the existence of two nearby GWMAs and one CGWMA, and caution is warranted in approving water rights based both upon SPF and IDWR calculations of recharge. These calculations indicate that the proposed water right possibly would result in total withdrawals exceeding the average rate of recharge to the aquifer. In addition, the stream flow data that IDWR collected suggests that the low estimate of aquifer recharge presented by SPF is unrealistically high assuming that all other assumptions are correct. Lastly, SPF's high estimate of annual average aquifer recharge is not supported by field measurements and, because it relies upon a preliminary, relatively uncertain estimate of ET for a partial year in a different basin, potentially grossly overestimates the amount of water available for appropriation

2) *Does the study describe possible impacts this water right and water right 63-32225 will have on the aquifer? If so, are those impacts significant?*

The SPF report does not specifically address the possible impacts that water right 63-32225 will have on the aquifer other than including the withdrawal volume in their calculation of the amount of water that's available for appropriation. According to SPF, no significant impacts are anticipated from either water right. However, our analysis suggests that the approval of water right 63-32225 quite possibly caused the water resource to be fully allocated. Moreover, our ability to predict the impacts from additional aquifer withdrawals is poor because of hydrogeologic uncertainty and it can only be accomplished after the fact based on evaluation of long-term water level monitoring data.

3) *What is the probability of the 10 cfs diversion rate from this right causing the borders of the Mountain Home Ground Water Management Area to migrate and/or change?*

The project site is located along the western edge of the Mountain Home Ground Water Management Area, approximately 3.5 miles northwest of the Cinder Cone CGWA, and approximately 8.5 miles from the Southeast Boise Ground Water Management Area (Figure 2). Detailed information concerning the hydrogeologic setting in the Mayfield Townsite area is not presented in the SPF report, but the climate and geology in these management areas are similar to the climate and geology within the project area. In the absence of evidence to the contrary, the aquifer proposed for development is assumed to be in hydraulic communication with the aquifers in the management areas. Moreover, our modeling indicates significant water level drawdown at the boundaries of both the Mountain Home GWMA (~130 ft) and the Cinder Cone CGWA (~ 80 ft). Although there is uncertainty in these predictions, drawdown values of this magnitude suggest that the boundaries of both management areas possibly would need to be expanded as the result of a large ground water diversion at the Mayfield Townsite.

4) *What is the probability of the 10 cfs diversion rate from this right and the 10 cfs diversion rate from 63-32225 causing the borders of the Mountain Home Ground Water Management Area to migrate and/or change?*

Currently, water levels in the area appear stable, but the anticipated total average annual withdrawal that would result from approval of both 63-32225 and 63-32499 (~6,580 acre-feet) represents an approximate 800% increase in the amount of water being withdrawn from aquifers in project area since February of 2007. There is insufficient data at the present time to support the assumption that these new stresses on the aquifer will not negatively impact the management area. Additional monitoring of the water table under the increased use from 63-32225 needs to be completed before a final assessment of the impacts can be made. If monitoring indicates that water level declines are significant, then it may be justified to expand the boundaries of the management area to include the study area.

5) *Does this study show that mining of the aquifer will not occur and that there is sufficient proof of the long-term sustainability of the water supply for this project?*

Based on their calculations of aquifer recharge, SPF concludes that there is additional water available for appropriation in the Mayfield Townsite area. However, our calculations using the same methodology with different assumptions suggest that the aquifer possibly has been fully appropriated already and that additional withdrawals could cause mining of the aquifer (i.e., more or less permanent declines in aquifer water levels). Both conclusions are premised on numerous assumptions and involve considerable uncertainty, however. Failing to account for aquifer outflow in the water budget is a potentially significant omission which precludes our ability to evaluate the long-term sustainability of the water supply.

Due to hydrogeologic uncertainty, the estimated aquifer recharge was presented as a range. The estimated average annual project demand (3,956 acre-feet) exceeds the lower end of the recharge range as estimated both by SPF and IDWR. Currently, data does not exist in this area to be able to determine with confidence whether the aquifer can handle the additional withdrawals being proposed.

On-going monitoring needs to be completed and water levels need to be analyzed in order to assess the impacts from pumping under water right 63-32225. Additional allocations may be warranted if water levels remain stable or if additional information is developed which indicates that aquifer withdrawals will not exceed the reasonably anticipated future rate of natural recharge. Collection of hydrogeologic data which would help to make this determination will be the focus of an upcoming hydrogeologic characterization program.

Conclusions

SPF has done an admirable job of attempting to quantify and compare current and proposed future aquifer withdrawals to aquifer recharge in the project area. They describe and attempt to quantify most, but not all, components of the water budget in the "*ground water capture area*". They acknowledge that "*The ultimate ground-water supply in the Mayfield area is limited*" (p. 28). They also acknowledge that there is uncertainty in their estimates of aquifer recharge and, accordingly, they present a range of aquifer recharge estimates. Because of hydrogeologic uncertainty, the boundaries of the ground water capture area were arbitrarily assumed, however, and SPFs range of estimated aquifer recharge varies by a factor of five. Moreover, our Indian Creek flow measurements suggest that SPFs low estimate of recharge is unrealistically high assuming all other assumptions are correct.

The *Ground-Water Supply Evaluation* shows that there is a potential for mining of the aquifer to occur if aquifer development proceeds and the actual recharge rates are in the lower part of the range of recharge estimates. Given the large amount of uncertainty, the probability of this occurring is unknown and it seems prudent for the department to monitor the impacts of recently approved water right 63-32225 prior to allowing an additional increase of nearly 200% in the annual withdrawal rate within the SPF capture area. Sequentially approving applications for several large water rights without first collecting and evaluating monitoring data to evaluate the impacts of the first water right on aquifer water levels is unadvisable given the existence of two GWMAs and once CGWMA in the surrounding area and uncertainty that exists concerning the long-term sustainability of the resource.

As recommended by SPF, monitoring of aquifer water levels should be ongoing prior to and during water resource development and the data should be incorporated into IDWRs upcoming aquifer characterization study. SPF opines that "*As with many aquifers, the best way for determining ultimate ground-water availability is to begin development while carefully monitoring ground-water level responses*" (p. 28). This, in fact, is what IDWR has done in authorizing and beginning to monitor the impacts of permit 63-32225. Approval at this time of another large ground water appropriation would not, in our opinion, allow for "*carefully monitoring ground-water level responses*".

In addition, well-to-well impacts have not yet been evaluated. Multiple domestic wells exist in the area of the proposed development with the potential to be impacted by large-scale production wells. Specific details regarding aquifer characteristics, well completion, and aquifer withdrawals needs to be provided by the applicant in order to assess the potential impacts to existing wells in the area.

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