MEMO

State of Idaho
Department of Water Resources
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Date: March 2, 2009

To: Gary Spackman, Hearing Officer

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

cc: Rick Raymondi

Subject: Application for Water Right 63-32573

Overview

M3 Eagle, LLC (M3) is planning to construct a 7,153 unit planned community development on property the company owns in North Ada County. M3 has contracted with HydroLogic, Inc. (HLI), a Boise-based hydrogeologic consulting firm, to conduct an investigation of the area in order to determine the potential for developing a ground-water supply to support the planned community. According to HLI, all of the major municipal supply wells and many irrigation wells within the greater Eagle-Star-M3 area derive their water from the target, regional aquifer. M3 proposes to further develop the aquifer by installing up to fifteen water supply wells within the southwest portion of the property. M3 is seeking a water right with a maximum diversion rate of 23.18 ft^3/sec (cfs).

The primary conclusions based on our review of the data and reports submitted in response to the September 12, 2008 *Order Authorizing Discovery and Schedule Order,* are as follows:

- A highly productive sedimentary aquifer exists beneath a portion of the M3 property.

- The stratigraphy beneath the M3 site is complex, consisting of a thick sequence of coarse and fine grained sediment layers that pinch out and are faulted.

- Hydrologic boundaries and recharge mechanisms are not well defined for the target aquifer.

- The long-term sustainability of the aquifer beneath the M3 property is difficult to assess; some lines of evidence suggest that it may be limited.

- Despite remaining uncertainties, the work that was commissioned by M3 has significantly improved our understanding of the hydrogeology in North Ada County.

- The ongoing North Ada County Hydrogeologic Investigation will help reduce the uncertainty.

Introduction

This memorandum has been prepared in response to the request for staff memorandum dated December 8, 2008 in the matter of applications to appropriate water No. 63-32573 in the name of M3 Eagle, LLC (M3). The following information was requested:

1. A full analysis of the methods of gathering data, the data presented, and results of the aquifer tests or other tests or modeling contained in the information submitted by the parties.
2. A secondary review of any review and analysis of the original documents submitted by the parties.
3. Presentation and analysis of additional data available to Department staff to enhance the hearing officer's understanding of the hydrogeology and aquifers in the vicinity of the proposed appropriations of water.
4. Conclusions about the impacts on other water users and aquifers caused by pumping of ground water as proposed by the application to appropriate water no. 63-32573.
5. Any analysis of M3 Eagle LLC's demographic and economic modeling and forecasting.

1) Request #1 -- *A full analysis of the methods of gathering data, the data presented, and results of the aquifer tests or other tests or modeling contained in the information submitted by the parties.*

HLI has collected, analyzed, and reviewed a significant amount of data in an attempt to characterize the aquifer beneath the M3 property on behalf of the applicant. The following sections summarize our review of HLI's aquifer characterization work.

a) Subsurface Exploration: Well Drilling and Geophysical Logging
HLI drilled four exploratory test wells (TW#1, TW#2, TW#3, and TW#4) on M3 property, with depths ranging from 672 to 900 feet below ground surface (Figure 1). All four test wells were completed with multiple monitoring ports to facilitate water level measurements and water quality sampling at various depths within the aquifer. Geophysical data (resistivity and natural gamma) were collected in each of the test wells. Composite diagrams that summarize well construction, geophysical, geologic, water chemistry, and water level data were developed for the M3 test wells and six other nearby wells.

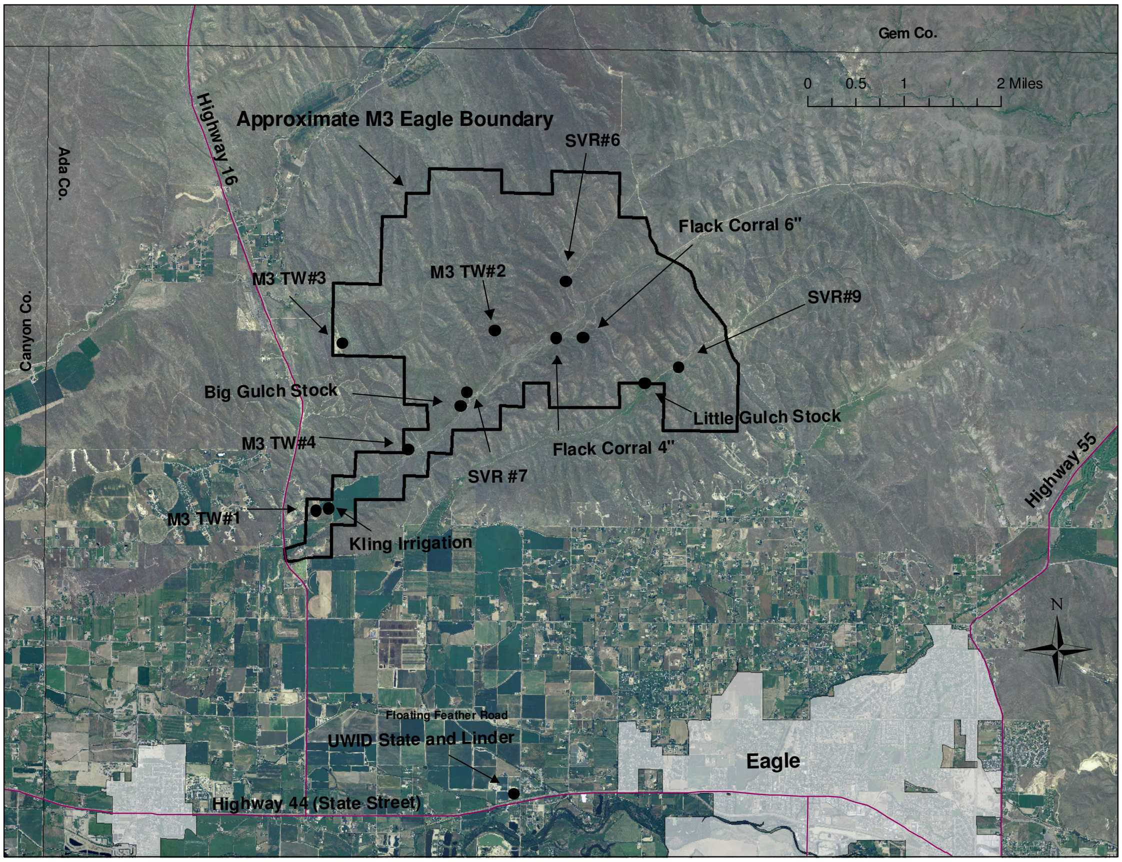

Figure 1. Approximate locations of wells on the M3 property.

A review of the composite diagrams indicates that the stratigraphy of the area is complex, consisting of alternating layers of sand, silt, gravel, and clay. The Pierce Gulch Sand (PGS) Formation has been identified by HLI beneath the southern half of the M3 property. Previous investigators have defined the PGS as a thick sequence of arkosic sand with interbedded units of silt, clay, and gravel (Othburg and Stanford, 1992). Where saturated, the PGS forms an aquifer that is referred to by HLI as the Pierce Gulch Sand Aquifer (PGSA). The PGSA is the aquifer targeted for development in this water right application.

b) Surface Geophysical Investigations

HLI commissioned magnetometer and seismic profiling surveys on and around the M3 property. The purpose of these investigations was to obtain additional stratigraphic information beneath the area of investigation.

The magnetometer survey was conducted by BSU in 2006, with the results interpreted by Dr. Spence Wood. Wood identified two NW/SE trending "major" faults that transect the M3 property (Figure 2) and determined that sediments beneath M3 extend to a depth of more than 3,000 ft (Wood, 2007). Wood also identified several other off-site faults with the same NW/SE orientation.

The seismic survey was also conducted by BSU during the summer of 2006. The objectives of the survey were to define the shallow (<1,000 ft deep) sedimentary section and to delineate aquifers, the deeper volcanic bedrock, and structural faulting. After acquisition and attempted analysis of data from several locations, it was decided to terminate the investigation based on poor data quality (Bradford, 2006). Therefore, no significant information was obtained from the seismic survey.

c) Geologic Cross-Sections

Four geologic cross-sections were developed by HLI based on geophysical and geological data collected from deep wells in the area. The cross-sections extend from the M3 property to the Boise River and from the City of Star to Garden City. In general, the four cross-sections represent the PGSA as a laterally extensive, approximately 300-foot thick section of sand that dips to the southwest. Observations concerning the stratigraphy depicted on the cross-sections are as follows:

- The cross-section that bisects Big Gulch does not show the fault between TW#1 and TW#4 that was identified in surface geophysical work contracted by HLI (Wood, 2007). The offset from this fault could account for, at least in part, some of the differences in elevation of the tops and bottoms of the various strata that are represented as uninterrupted. The identification of faults is important for the characterization of the hydrogeology because faults often affect hydraulic communication between hydrostratigaphic units.

- It is difficult to distinguish the PGSA from the "undifferentiated alluvial aquifers and aquitards" in UWID test wells along the Boise River. Based upon geologic and geophysical data shown on the cross-sections, there is a lack of fine-grained sediments that define the top of the PGSA under the M3 property. The absence of a thick, laterally continuous confining layer provides a mechanism for hydraulic communication between the PGSA and overlying undifferentiated sediments.

- The stratigraphic profile of SVR#7 (the pumping well for a nine day aquifer test conducted on the M3 property) is not included on the cross-section that bisects Big Gulch. If included, the cross-section would require modification.

- The stratigraphic and geophysical logs for TW#4 do not show a strong correlation with the depiction of the mudstone unit drawn in the cross-section that runs from TW#3 to the UWID State and Linder well.

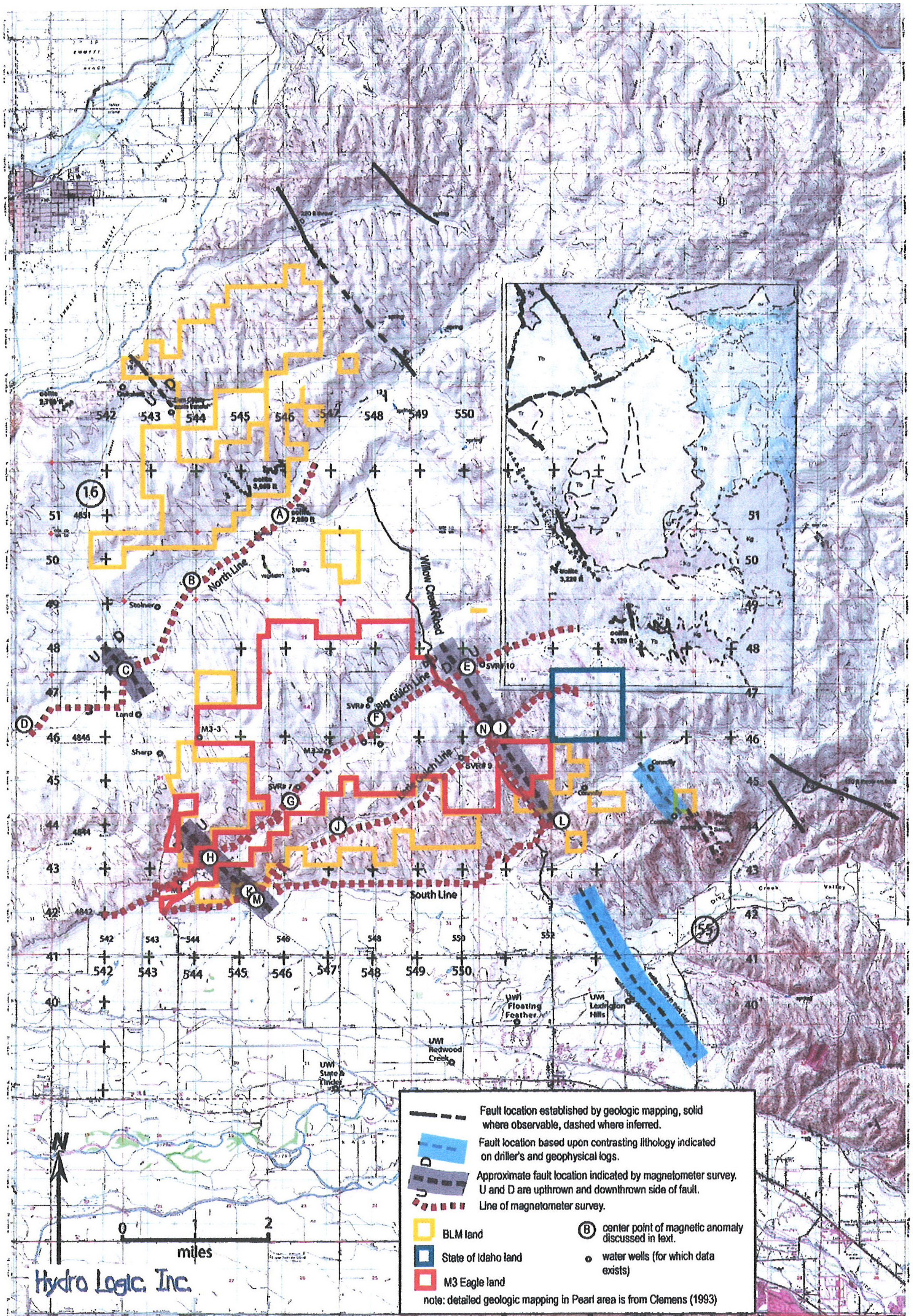

Figure 2. Mapped faults on and near the M3 property (Reproduced from Wood, 2007).

- The base of the PGSA is drawn at different elevations on the two cross-sections in which TW#4 stratigraphy is shown. Also, the top of the PGS in the UWID State and Linder well is at a different elevation in the two cross-sections that transect this well.

In summary, the above observations demonstrate that the delineation of the hydrostratigraphy based on available geophysical and geologic data is a detailed, difficult, and subjective undertaking. Moreover, it is unclear based on our analysis of the presented data whether the PGS is a distinct, laterally continuous layer, as conceptualized by HLI, or if it possibly merges with overlying undifferentiated sediments basinward and/or is hydrologically compartmentalized by faults. The contribution of basin margin faults to hydrogeologic uncertainty was previously identified in a study that was conducted for the Treasure Valley Hydrologic Project:

"In addition to complexity inherent in deposition and erosion, a series of major faults bisect the stratigraphic section along the northern basin margin. The hydrologic impact of these faults is poorly understood, but they are likely to be an important influence on ground water flow in the Boise-area aquifers." (Hutchings and Petrich, 2002, p. 2)

d) <u>Water Level Data</u>
During the past three years, HLI has conducted two synoptic mass measurements in North Ada County and has instrumented wells to collect routine water levels in a network of wells on and near the M3 property. The following sections summarize the water level data collection and analysis performed by HLI.

i) Mass Measurements
During the summer of 2006, HLI collected 167 water level measurements in the greater M3 area. Location and elevation data were also collected at each well with a GPS unit and used to develop a water elevation contour map for the PGSA. The data and contour map were presented in a technical memorandum submitted to the Department that suggests that ground water flows to the west underneath the M3 property and northwest toward the Payette River after leaving M3 (HLI, 2007b). According to HLI well completion data, water levels used to create this contour map were collected from wells within the PGSA, the Willow Creek Aquifer, and in "*undifferentiated alluvial aquifers*".

A second mass measurement was completed during June and July of 2007 to refine the assessment of ground water direction in the PGSA. The 59 wells selected for this mass measurement were a subset of the PGSA wells that were measured in the 2006 mass measurement, along with 16 additional wells that were chosen to provide additional control points for determining ground water flow direction in the PGSA. Twenty-eight of the wells had wellhead elevations surveyed to the nearest 0.01 ft prior to the measurements. The mass measurement data were submitted to the Department as a technical memorandum which included an updated water level contour map. The updated map suggests that the ground water flow direction beneath the M3 property is to the west, and the flow direction is northwest toward the Payette River after leaving M3 (HLI, 2008c).

Observations concerning the mass measurement data and updated water level contour maps are as follows:

- The contour map shows that only four wells west of the Ada/Canyon County line were used to determine the northwest regional flow direction. Of these four wells, two (Rio Lobo and Shalako) are located within the same section and the elevations and locations of the other two (Zigler and Caldwell Test Well #19) were not surveyed. The scarcity of surveyed control points west of the Ada/Canyon county line creates uncertainty in the determination of the regional flow direction.

- The Zigler well is the only control point in the Payette River valley. Well completion data for this well was not included in the HLI submittal (HLI, 2008c). It has not been established that the PGSA is present at this location.

- The water level for the Caldwell Test Well #19 that is posted on the updated contour map is 2,450 feet above mean sea level (ft-msl). The only water level measurement reported for this well is 2,442 ft-msl and this measurement was collected in 2005 rather than in 2007. In addition, the data submitted by HLI indicates that this well is "*above the PGSA*" (HLI, 2008c). These considerations suggest that the data point should not be relied upon for determining ground water flow direction in the PGSA.

- Use of water levels that were collected during the irrigation season adds uncertainty to the determination of ground-water flow direction.

- The intersection of the geologic contact between the PGSA and the Willow Creek Aquifer and surficial sediments on the M3 property was treated as a no-flow/barrier boundary in the initial development of ground water contours with a commercially available contouring program (Surfer®). The existence of this flow barrier helps explain water level and water chemistry differences between the PGSA and the Willow Creek Aquifer. However, the flow barrier that was used for contouring abruptly stops approximately three miles to the northwest of the M3 property, allowing PGSA water to flow north and merge with ground water in the Willow Creek Aquifer. The basis for terminating the no-flow/barrier boundary is unclear based upon the information that was submitted to the Department.

- A previous study (Wood, 2007) indicates that the PGS outcrops along the southern bluffs of the Payette River Valley. These PGS outcrops are unsaturated with no visible springs or other evidence of ground water discharge. The HLI conceptual model does not include an explanation of where and how the PGSA discharges into the Payette River Basin Aquifer.

In summary, available water level data clearly indicate a west ground water flow direction in the PGSA beneath the M3 property. The determination that the regional flow direction is northwest toward the Payette River is less convincing, however, because of the scarcity of surveyed control points and an incomplete hydrogeologic conceptual model.

ii) Routine Measurements
In addition to mass measurements, HLI has installed data loggers to collect water levels on a regular basis. Thirteen wells (four with multiple observation ports) currently are equipped with data loggers to monitor different levels within the PGSA. Data submitted to the Department spans back to July of 2006 for some of these wells.

A figure summarizing data logger measurements from nine of the PGSA wells was submitted to the Department as part of the SVR#7 aquifer test report (HLI, 2009, Figure 46). Observations related to this figure are as follows:

- Although presented on the figure, water levels in the Kling domestic well are not discussed in any of the HLI submittals. It appears from inspection of the figure that the Kling domestic well did not fully recover from the Kling irrigation well aquifer test that was conducted in January 2007.

- Comparison of the water level fluctuation patterns allows the wells to be grouped. Wells in the first group include the State and Linder monitoring well, TW#1, and the Kling domestic well (Group 1). The second group includes TW#4, SVR#7, SVR#9, TW#2, and TW#3 (Group 2). Distinguishing characteristics of the two different water level trend patterns are as follows:

    - The seasonal fluctuation seen in Group 1 wells is nearly an order of magnitude greater than the fluctuations seen in Group 2 wells. For example, the seasonal fluctuation was approximately 13 feet in TW#1, but was only 1.5 feet in TW#3 is approximately 1.5 feet.

    - Responses to "*hydraulic events*" (April 2007, June 2007, August 2007, and May 2008) are apparent in the hydrographs for Group 1 wells but are not apparent in the Group 2 hydrographs.

- The NW/SE trending normal fault identified by Wood (2007) separates the two well groups and potentially accounts for the different water level fluctuation patterns.

- Over the past three years, the water levels in the Group 2 wells have a distinct downward trend. This trend is similar to the results obtained from a water level trend analysis that was conducted by the Department (Appendix A). Downward trends are not apparent in Group 1 wells, possibly because of greater water level fluctuations and incomplete data records.

- The hydrograph for the Big Gulch Well was not included in Figure 46 even though this well had the greatest drawdown among the observation wells measured during the SVR#7 aquifer test.

In summary, water levels collected with data loggers on the M3 property over the past three years have provided valuable information regarding water level fluctuations beneath the site. Analysis of these data reveals two distinct patterns of water level fluctuations in the PGSA. The patterns are different on each side of a mapped normal fault. Knowledge of the hydrologic significance of basin margin faults appears to be critical to understanding the hydrogeology in the vicinity of M3.

e) Aquifer Testing

i) Kling irrigation Test

HLI conducted two constant rate aquifer tests on the M3 property. The first test was conducted in the summer of 2007 using the Kling irrigation well, a 408-foot deep well which, according to HLI, is completed in the upper 109 feet of the PGSA. The Kling irrigation well was first rehabilitated and then pumped at 900 gallons per minute (gpm) for 50 hours while monitoring the water levels in the pumping well and six nearby observation wells. Noteworthy items related to the Kling irrigation well aquifer test are as follows:

- Drawdown was only observed in the pumping well and the closest observation well, TW#1, a multi-level monitoring well with four PGSA monitoring zones. Although the response to pumping from the upper PGSA was first measured in the deeper PGSA zones, the upper zone at TW#1 had the greatest drawdown at the end of the test (HLI, 2008b).

- Based on the analysis of the pumping well test data, HLI's estimate of aquifer transmissivity in the region of the pumping well is 39,000 gallons per day per foot (gpd/ft). Because of well construction issues, HLI feels that the transmissivity estimate may be unrealistically low (HLI, 2008b, p. 215).

- Water level data were collected in the Kling domestic well (see Figure 46 of HLI, 2009), but were not discussed in the write-up for the aquifer test analysis.

- A fault lies between the pumping well and the non-responding observation wells. Although HLI modeled this fault as a no-flow/barrier boundary in their computer-aided analysis of aquifer test data, they seem less certain of its impact in concluding "*A no-flow boundary could, in theory, have affected responses in the lower part of the aquifer*" (HLI, 2008b, p. 206).

- HLI recommended that an aquifer test lasting at least a week be conducted using a properly designed and constructed high capacity well (1,000 to 2,000 gpm) to better characterize the nature of the aquifer beneath M3 (HLI, 2008b, p. 215).

In summary, although of limited duration and despite well construction issues, the Kling irrigation well aquifer test provided valuable information regarding aquifer properties under this portion of the property and highlighted the potential importance of a NW/SE trending fault on water level declines caused by pumping in the PGSA.

ii) SVR#7 Aquifer Test
The second HLI constant rate aquifer test was conducted in March of 2008. SVR#7, a Spring Valley Ranch well completed in the PGSA on M3 property, was pumped at approximately 900 gpm for nine days. The purpose of this test was to collect on-site hydrogeologic data to further characterize the PGSA and to evaluate possible constraints that would impact the execution of a longer duration aquifer test. The following observations are based upon our review of the SVR#7 aquifer test report (HLI, 2009):

- Measurable drawdown was reported in eight of the 13 wells monitored during the test. Drawdown at the end of test ranged from 1.71 feet in a well approximately 845 feet from the pumping well to 0.09 feet in a well approximately 11,660 feet (2.2 miles) from the pumping well.

- Two well completions in the shallow "unnamed fluvial sand aquifers" were monitored during the test. Drawdown was measured in the closest shallow well completion (TW#4, Zone 3), which is approximately 4,500 feet from the pumping well, but not detected in the more distant shallow well completion (TW#1, Zone 5), which is approximately 11,000 feet from the pumping well.

- Small but "measurable" drawdown was noted in the Little Gulch stock well and SVR#9, at distances of 9,740 and 11,660 feet from the pumping well, respectively (HLI, 2009, Table1). Drawdown was not "measurable" in either the Kling irrigation well, which is 9,908 feet away from the pumping well, or in any of the monitoring zones at TW#1, which is 10,916 feet from the pumping well. In relation to the pumping well, the Kling irrigation well and TW#1 are on the opposite side of the "major" normal fault which is located between TW#1 and TW#4.

- Drawdown plots were analyzed to estimate aquifer properties (transmissivity and storage coefficient) beneath the site. Transmissivity estimates range from

180,000 to 580,000 gpd/ft, with an average value of 420,000 gpd/ft. The average storage coefficient estimate is 3 x 10^{-3}.

- There is an increase in slope on the semi-logarithmic plot of drawdown versus time for the Big Gulch stock well approximately 6,000 minutes (~4 days) into the test (HLI, 2009, Figure 24). An increase in slope is characteristic of the cone of depression encountering a no flow/barrier boundary (Driscoll, 1986; p. 231 and USBR, 1995, p. 251). HLI instead attributes the slope increase to a declining regional aquifer water level trend, which is a plausible concept. Unfortunately, a plot of trend-corrected drawdown is not presented for the Big Gulch stock well. Our calculations indicate that the regional trend (Figure C-2) does not fully account for the increase in slope that was observed on the semi-logarithmic plot for the Big Gulch stock well.

- The Big Gulch stock well had not fully recovered from pumping at the end of the 12-day water level recovery monitoring period. Although there are other possible explanations, the fact that water levels did not recover to the pre-pumping levels suggests that the aquifer may be of limited extent (Driscoll, 1986, p. 259). HLI attributes incomplete recovery to the declining regional water level trend but the residual drawdown after correcting for the declining trend was still approximately 0.5 feet at the end of the water level recovery monitoring period.

- Although the duration of this test exceeded most of the previous aquifer tests in the area, a longer duration test (~30 days) with additional monitoring in the shallow aquifers, would stress a greater portion of the aquifer, facilitate evaluation of hydrologic boundaries, and provide data for better estimating the long term impacts of pumping.

In summary, the aquifer testing conducted by HLI demonstrates that the PGSA beneath the M3 property is highly productive. The results from the nine-day test are reliable because of careful planning and data collection. Several lines of evidence suggest that the aquifer may be bounded by faults. An aquifer test of longer duration could be used to evaluate the hydrologic significance of the fault.

f) Aquifer Test Analysis
HLI submitted a report to the Department in August of 2008 titled "*Re-Analysis of 16 Aquifer tests in the Greater Eagle-Star Area of North Ada County, Idaho*." The report summarizes the original testing and reanalysis of 16 aquifer tests previously conducted in the greater Eagle area by various entities. Of the 16 reanalyzed tests, HLI suggests that 10 were conducted in the PGSA, one was conducted in an overlying shallow alluvial aquifer, and the remaining five were conducted in various other vicinity aquifers.

Based on reanalysis of the data, HLI concludes that the PGSA in the vicinity of M3 is a single, continuous, heterogeneous, highly productive aquifer with transmissivity estimates ranging from 40,000 gpd/ft to 800,000 gpd/ft. The average transmissivity (210,000 gpd/ft) is higher than the high end of the range of previous estimates (100,000 to 200,000 gpd/ft). The differences between the original estimates and the revised estimates are attributable to HLI's determination that the PGSA is much thicker than estimated by previous investigators. HLI estimates that the PGSA thickness is typically on the order of 275 feet, and over 500 feet is some areas (HLI, 2007b, p. i).

Other noteworthy conclusions made by HLI are as follows:

- The PGSA in the vicinity of M3 is the same regional aquifer that is relied upon as the primary water supply for the cities of Eagle, Star, and Meridian (p. ii).

- The Willow Creek Aquifer that underlies the northeast portion of the M3 property is described as "*A highly permeable, but isolated and bounded, sand unit with limited recharge*" (p. 239).

- "*Potential well yields from the Willow Creek Aquifer are high but we expect that long term production could be severely constrained by small amounts of recharge and a bounded system that would significantly increase water-level drawdowns and pumping lifts*" (p. 240).

- The Sandy Hill Aquifer northeast of Eagle is described as "*Another highly permeable, isolated and bounded sand unit with limited recharge*" that has high short-term well yields but long-term production that "*would be severely limited by small amounts of natural recharge*" (p. 240).

In summary, the compilation and reanalysis of data from 16 previous aquifer tests represents a significant undertaking on the part of HLI. The reanalysis yielded an updated hydrogeologic conceptual model and revised estimates of aquifer properties for vicinity aquifers. HLI concludes that other vicinity aquifers have limited long-term sustainability owing to hydraulic isolation and limited on-site recharge. In our opinion, the possibility of limited long-term sustainability for the PGSA also cannot be discounted based upon currently available data.

g) Geochemical Investigations

In 2007, HLI concluded that the chemistry of PGSA ground water is distinguishable from the chemistry of ground water from wells completed in the Willow Creek Aquifer (HLI, 2007a). This distinction was based primarily on differences in total dissolved solids and nitrate concentrations.

A more in-depth geochemical analysis of historic and recently acquired ground water chemistry data was submitted to the Department on January 20 of this year (Glanzman and Squires, 2009). Samples were collected from approximately 40 wells and springs across the region and analyzed for field parameters, major ions, and selected trace elements. Major ion chemistry was plotted on Trilinear (Piper) diagrams for each sample location. Findings from the 2009 geochemical analysis include the following:

- "*PGSA groundwater originated almost exclusively from ancestral Boise River surface water*" (p. 4).

- Wells located in the Payette River valley near Emmett are not hydraulically connected to the PGSA (p. 9).

In summary, historical and newly acquired water quality analyses have been interpreted to indicate that there is a difference between the water chemistry in the PGSA and the water chemistry in surrounding aquifers. The data also have been interpreted to indicate that PGSA water originated almost exclusively from the ancestral Boise River. Department staff believe that an isotopic study of ground water in the PGSA could help to evaluate the determination that modern day recharge sources are not contributing recharge to the PGSA.

h) <u>Ground-water Flow Modeling</u>
HLI contracted with Pacific Groundwater Group (PGG) to develop a ground water flow model that could be used to predict impacts caused by pumping in the PGSA at M3. PGG developed a seven layer model that comprises approximately 80,000 active cells and covers 520 square miles in the area surrounding M3. A report summarizing the model and its development, including a review of existing models in the area, was reviewed by Department staff (HLI, 2008a). The following are observations regarding the M3 modeling report:

- HLI conducted a review of existing models in the area and attempted to incorporate the knowledge and experience gained from these efforts into the new M3 model.

- Two versions of the model were developed. One version (Tmatch) was forced to honor the range of available transmissivity estimates and the second version (Hmatch) used transmissivities outside the range of available estimates in order to achieve a better calibration. Both versions were first calibrated to "*quasi-steady state conditions*" (water level measurements collected in 2007) and then to water levels measured during three constant rate aquifer tests (Lexington Hills, Eaglefield, and SVR#7).

- Simulated underflow directly into the PGSA at the southeast corner of the model is conceptualized to be seepage from the Boise River and the New York Canal (HLI, 2008a, p. 33). The idea that seepage from the modern day Boise River and its canal system recharges the PGSA seemingly is at odds with HLI's conclusion that the original source of PGSA water is almost exclusively the <u>ancestral</u> Boise River (Glanzman and Squires, 2009, p. 4).

- The simulated discharge area for the PGSA is the Payette River Valley.

- The model representation does not include a NW/SE trending fault between TW#1 and TW#4 that was identified by Wood (2007) using surface geophysics.

- The model was run to predict long-term impacts from pumping on the M3 property and influences from a reduction in seepage from the New York Canal. Model predictions are discussed in our response to the fourth bulleted item in the *Request for Staff Memorandum*, which starts on page 20 of this memorandum.

- One of IDWR's ground water modelers reviewed the modeling report and identified the following three concerns: (1) the use of the general head boundary at the inlet of the model should be used cautiously; (2) having two different versions of the model doesn't necessarily bracket uncertainty, as asserted by HLI on page 13 of the M3 modeling report (HLI, 2008a); and (3) the M3 modeling report indicates that the model calibration was sensitive to vertical hydraulic conductivity but the sensitivity of the model predictions to this input are not discussed (Appendix B).

In conclusion, a ground-water flow model based upon HLI's hydrogeologic conceptual model has been developed for prediction of hydrogeologic impacts. As described elsewhere, the basis for several important elements of the HLI conceptual model has not been provided. A potentially significant hydrogeologic feature (i.e., a fault) has not been incorporated into the model.

2) **Request #2 --** ***A secondary review of any review and analysis of the original documents submitted by the parties.***

The North Ada County Groundwater Users Association (NACGUA) hired a hydrogeologic consultant to provide a technical review of the data and reports submitted by HLI. Ralston Hydrologic Services, Inc., conducted the review and reported the findings in two technical memoranda, an expert report, and a supplement to the expert report based upon review of a recently submitted geochemistry report. The following sections summarize the reviews that were submitted on behalf of the protestants.

a) *Initial Hydrogeologic Analysis*, dated November 6, 2008.
This memo is organized into four sections. The first section provides a summary of the hydrogeologic information provided to date on behalf of the applicant. The second section is an analysis of the HLI's hydrogeologic conceptual model. The third section is review of HLI's analysis of the ground water flow system. The fourth section is a review of HLI's analysis of the likely impacts from full project development.

The first section provides quotes from the characterization report submitted by HLI (HLI, 2007a) but does not make any conclusions. The primary conclusions from the other three sections of the memo are as follows:

"*I conclude that there is not sufficient evidence to support the presumption of lateral extent and continuity of what has been called the Pierce Gulch Sand Aquifer from the M3 Eagle site to the Payette River. Also, additional work is needed to assemble and present the available information to support the presumption of lateral extent and continuity of what has been called the Pierce Gulch Sand Aquifer from the M3 Eagle site to the presumed recharge area in the Boise River drainage*." (p. 3)

"I conclude that there is not sufficient evidence to support the presumption that ground water flows in the manner and quantity described within what has been called the Pierce Gulch Sand Aquifer from the presumed recharge area in the Boise River drainage to the presumed discharge area in the Payette River drainage." (p. 4)

"I conclude that the characterization of the target aquifer system, including a pre-development water balance, has not been complete enough to support an analysis of impacts from full project development." (p. 5)

b) *Review of 2008 HydroLogic, Inc. Report*, dated November 26, 2008.
The second memo is a review of the report entitled "*Re-Analysis of 16 Aquifer Tests in the Greater Eagle-Star Area of North Ada County, Idaho*" (HLI, 2008b). The one paragraph memo concludes:

"*I found no information that would change the conclusions stated in my November 6, 2008 report on the M3 Eagle development. My November 6, 2008 report is an accurate statement of my professional conclusions relative to the project*."

c) *Hydrogeologic Analysis of the M3 Eagle Site, Expert Report Prepared for the North Ada County Ground Water Users Association,* dated January 2009.
This expert report is the most comprehensive review conducted on behalf of the protestants. Four HLI reports are reviewed (HLI, 2007a; HLI, 2008a; HLI, 2008b, and HLI, 2008c). The expert report includes a summary of hydrogeologic information developed by HLI and identifies issues with the conceptual and numerical models.

The 2009 review provides the following conclusions:

"*I conclude that there is insufficient evidence to support the assumption that the Pierce Gulch Sand Aquifer is laterally continuous from the Boise River Valley to the Payette River Valley*." (p. 9)

> "*I conclude that the 2007 water-level data provide insufficient evidence that ground-water flow occurs from the Boise River Valley to the Payette River Valley.*" (p. 10)
>
> "*In my opinion, the inability to have the M3 Eagle model reproduce aquifer water levels using the calculated transmissivity values indicates that problems exist in the model formulation (such as boundaries) and/or with the input data sets. I do not believe that development of two parallel numerical models is a reasonable solution to the problem. Also, I do not believe that general agreement between the "Hmatch" and "Tmatch" indicates that the numerical model is a reasonable representation of the hydrogeologic system.*
> *Questions come to mind whenever a numerical ground-water model is used to predict impacts on a time scale that greatly exceed the data set used for transient calibration. This is defiantly* (sic) *the case with the M3 Eagle numerical model. The data sets used for transient calibration were short (30 and 7 days) and the stress potentially did not cause water-level changes at all aquifer boundaries. Prediction of long-term pumping effects (such as 50 years) involves stressing a much larger portion of the model and likely a number of boundaries. This creates major uncertainty relative to reliability of the drawdown values predicted using the model.*" (p. 12)
>
> "*The hydrogeologic investigation of the M3 Eagle site has resulted in an improved knowledge of the ground water condition under the site. However, my concerns about development impacts from the project are focused on large scale issues rather than on-site impacts. Specifically, I believe that postulated ground-water flow through a laterally continuous sand aquifer from the Boise River valley to the Payette River valley is not supported by field data. Thus, I believe that the drawdown values predicted either by analytical methods or the numerical model have a high degree of uncertainty.*" (p. 13)

Three alternative pathways to allow the M3 Eagle project to move forward were also proposed:

1. Formulate an administrative/legal solution that might involve the development of the project under a phased water right.
2. Conduct additional studies to further define the hydrogeology of the PGSA and update the M3 ground water flow model accordingly.
3. Validate the predicted impacts using model boundaries and aquifer properties that were developed as part of the Treasure Valley Hydrologic Project. It is further suggested that the Treasure Valley ground-water flow model might be altered to achieve this purpose.

d) *Hydrogeologic Analysis of the M3 Eagle Site: Supplement #1 Comments from the Review of the Geochemistry Report*, dated January 2009.
This memo provides a summary of the geochemistry report prepared in support of the M3 water right application (Glanzman and Squires, 2009). This memo

provides a general overview of the geochemical investigation and the following primary conclusion:

> "*The geochemical investigation of the general M3 Eagle site has resulted in an improved knowledge of the ground-water conditions in the area. However, the Glanzman and Squires (2009) report does not include information that addressed the major hydrogeologic questions raised in my expert report (Ralston Hydrologic Services, Inc., 2009)*".

3) **Request #3 -- *Presentation and analysis of additional data available to Department staff to enhance the hearing officer's understanding of the hydrogeology and aquifers in the vicinity of the proposed appropriations of water.***

Understanding and quantifying recharge rates to the targeted aquifer are critical in order to evaluate its long term sustainability because without recharge, groundwater withdrawals at even a modest rate will result in aquifer mining. The following sections summarize our concerns relative to the conceptualization and simulation of PGSA recharge.

a) Recharge Sources

The current water budget for the Treasure Valley aquifer system (Urban, 2004, Table 8) indicates that over 80% of the annual recharge returns to the Boise River, limiting the amount available to the deeper aquifers. These numbers agree with conclusions from a previous investigation:

> "*recharge rates to the deeper regional aquifers are limited*" and "*most recharge occurring in shallow aquifer zones does not reach lower zones*." (Petrich, 2004, pgs. 19 and 21, respectively)

HLI postulates that leakage from the Boise River and New York Canal are significant sources of recharge to the PGSA (HLI, 2008a, p. 28). According to their conceptual and numerical models, the PGSA is recharged from Boise River seepage and from New York Canal losses upstream from Cole Road. A discussion of the potential contribution from each of these sources is presented below.

i) Boise River

HLI's estimate of losses from the Boise River is based on information presented in reports that were prepared for the Treasure Valley Hydrologic Project (Urban and Petrich, 1998; Urban, 2004). As explained in the report documenting the M3 ground-water flow model:

> "*Urban reported a Boise River loss to the underlying ground-water system of 15,500 ac-ft/yr (about 21 cfs) during 1996 and 77,000 ac-ft/yr (about 110 cfs) during 2000. Both sets of measurements were made over the reach upstream from Capital Bridge.*" (HLI, 2008a, p. 28).

However, our analysis of available information indicates there is considerable uncertainty in the seepage estimates and suggests that the river reach between Lucky Peak and Glenwood Bridge may actually be gaining during certain times of the year. Our review of USGS gage data during the non-irrigation season between 1999 and 2008 (IDWR, 2009a), for example, indicates that the river between Lucky Peak Reservoir and Glenwood Bridge gained approximately 14 cfs on average (Table 1). Similarly, a seepage survey conducted by the USGS (1997) during November of 1996 indicated an overall gain of 52 cfs for this same reach. In addition, some water level contour maps show groundwater flow toward the Boise River through the reach between Lucky Peak and Glenwood Bridge (e.g., Dion, 1972 and Newton, 1991).

Table 1. Estimates of the Boise River gains and losses for the Lucky Peak to Glenwood Bridge Reach.

	IDWR, 2009	**USGS, 1997**	**Urban and Petrich, 1998**	**Urban, 2005**
Estimated Gain or Loss (cfs)[1]	14	52	-21	-110

[1] Gains are indicated by positive values and losses are indicated by negative values.

As previously discussed, geochemical characterization work supports the concept that the water currently being withdrawn from PGSA wells in the M3 area is from the river but available information suggests that it was recharged a long time ago. As expressed in Glanzman and Squires (2009, p. 4), PGSA ground water "*originated almost exclusively from ancestral Boise River surface water*". The idea that the PGSA water was recharged a long time ago is supported by the conclusions of previous investigators:

> "*contemporary seepage from rivers and/or irrigation diversions is not the primary source of recharge for most deeper regional aquifers*." (Hutchings and Petrich, 2002, p. 58)
>
> And
>
> "*This finding indicates that ground water in the deeper aquifers entered the flow regime prior to atmospheric testing*" (Hutchings and Petrich, 2002, p. 58)
>
> And
>
> "*Residence time estimates in the regional aquifer system ranged from thousands to tens of thousands of years. The youngest waters entered the subsurface a few thousand years ago and were found along the northeastern boundary of the basin, adjacent to the Boise foothills.*" (Petrich, 2004, p.19).

However, our preliminary calculations of travel time using M3 model inputs suggest that water entering the regional aquifer from the southeast corner of the M3 model domain would reach the M3 property in a relatively short amount of time, approximately an order of magnitude less than the estimated age of the water in the regional aquifer system adjacent to the Boise foothills (Petrich, 2004). Additional data collection and analysis are needed in order to resolve the apparent discrepancy between the HLI conceptual and numerical models.

ii) New York Canal

Only a portion of the total length of the New York Canal is upgradient from the general head boundary in the M3 ground-water flow model that represents recharge into the PGSA from river and canal seepage. The measured loss from the upgradient reach (between Diversion Dam and Cole Road) was 24 cfs in March of 1997 (Berenbrock, 1999). Information that could be used to estimate the percentage of the canal leakage that would recharge the PGSA is lacking.

While there is uncertainty regarding whether and how much seepage occurs upgradient from the PGSA recharge area identified by HLI, a bigger technical question for Department staff is how the water that seeps out of the Boise River and New York Canal could directly recharge the PGSA, as simulated by the M3 numerical model. According to HLI (pg. 33), "*The model estimates that about 102 to 115 cfs (about 65 to 74 mgd) flows into the Pierce Gulch Sand Aquifer from areas lying to the southeast of the model domain. This water is believed to originate as seepage from the Boise River and the New York Canal.*" HLI has not presented geologic data to support the existence of the PGSA beneath the Boise River or provided an explanation of how the canal and river losses end up recharging the PGSA instead of the shallow alluvial system.

b) <u>Water level trend analysis</u>

The possibility that the PGSA did not fully recover following the SVR #7 constant rate test raised a concern to Department staff regarding the ability of the targeted aquifer to sustain pumping at the rate proposed in the water right application. This concern led us to investigate water level trends in other vicinity wells.

Water level data from the IDWR water level database for the 16 historically monitored wells in North Ada County were analyzed for determination of water level trends (Appendix A). The available data for these wells spanned various time-frames and had a variety of measurement frequencies. To facilitate comparison of trends, the data were filtered so that the measurements generally are from the same time of year (the first measurement between 3/01 and 05/31) and the records span a similar time-frame (generally 1996 – 2003). Although subject to interpretation, the producing formation was determined to be the PGSA for eight wells, undifferentiated sediments for four wells, shallow alluvium for one well, and Terteling Springs mudstone for the remaining three wells.

Significant findings from the trend analysis are as follows:

- All eight of the PGSA wells displayed a negative or declining trend. Rates of decline range from 0.21 ft/year to 0.49 ft/year, with an average of 0.27 ft/year. The rates of decline in the PGSA are consistent with those observed between 2006 and 2008 in PGSA monitoring wells that lie north of the fault identified between TW#1 and TW#4 (HLI, 2009, Figure 46).

- There was a slight increase over the same time-frame in all three wells that are located within the Dry Creek Valley.

- The water levels also trended upward in the shallow alluvial well.

- All four undifferentiated wells exhibited declines within the range that was observed for the PGSA wells. These declines are consistent with the finding of a previous investigator that "*ground water level declines were observed in the areas between northwest Boise and Eagle.*" (Petrich, 2004, p. 14).

- The water level trends observed in the four wells completed in undifferentiated sediments are not distinguishable from those for PGSA wells.

- The results of this water level trend analysis were checked with more recent data for 10 of the wells. This effort generally confirmed the results of the earlier analysis, and indicated that the average water trend for the area (not including Dry Creek) is approximately -0.29 ft/year.

In summary, our review of available water level data indicates that water levels in the PGSA near M3 are declining and suggests that current aquifer discharge rates exceed current recharge rates.

4) **Request #4 --** ***Conclusions about the impacts on other water users and aquifers caused by pumping of ground water as proposed by the application to appropriate water no. 63-32573.***

Pumping induces flow to a well by creating a cone-shaped depression in the potentiometric surface. Pumping in high capacity wells for the M3 development will induce drawdown in hydraulically connected aquifers. The questions that need to be addressed are (a) how significant will the impacts be and (b) what water users will be impacted?

a) <u>How significant will the impacts be?</u>

HLI first presented calculations of the predicted impacts on water levels in the *Year-One Progress Report* (HLI, 2007a). An image well analysis (see for example, Freeze and Cherry, 1979, p. 330) was performed to estimate drawdown caused by six supply wells, each pumping at 1,000 gpm. The drawdown was computed for a 90-day pumping period, using the high aquifer transmissivity and storage coefficients estimates to represent a "best case" scenario, and the low aquifer transmissivity and storage coefficients to represent a "worst case" scenario. It is worth mentioning that the use of a lower transmissivity is indeed more conservative for locations proximate to the pumping center but it is not conservative for distant locations because the cone of depression caused by pumping in a low transmissivity aquifer is steeper but not as extensive.

Approximately two miles south of the M3 property, at the intersection of Floating Feather Road and Highway 16, the image well analysis predicted drawdowns of approximately four feet for the best case and eight feet for the worst case (see Figures 9 and 10 in HLI, 2007a). Using the same general methodology but substituting aquifer properties from HLI's SVR#7 aquifer test (transmissivity = 400,000 gpd/ft, storage = 0.0045), IDWR staff calculated drawdown for a revised pumping rate of 4,500 gpm and a pumping period of 50-years (the same time-frame evaluated with the M3 model). Our calculation is conservative in the sense that it neglects to consider recharge but not-conservative because it assumes that the aquifer extends infinitely in the southwest (down-dip) direction. The predicted drawdown at the intersection of Floating Feather Road and Highway 16 is approximately 18 feet after 50 years of pumping (Figure 3).

It is common practice to predict long-term aquifer performance using time-frames that are less than 50 years when applying analytical methods which are based on the Theis (1935) nonequilibrium solution. The Idaho Department of Environmental Quality, for example, recommends that a one-year time-frame be used to project long-term drawdown for public water supply wells. The use of a shorter time-frame can be appropriate, in part because the Theis (1935) solution is premised on the assumption that there are no sources of recharge. With all other input unchanged, application of the image well analysis using a pumping period of one year instead of 50 years results in a similar water level drawdown pattern but the drawdowns are of lower magnitude. The calculated drawdown after one year of pumping at 10 cfs is approximately 8 feet at the intersection of Floating Feather Road and Highway 16.

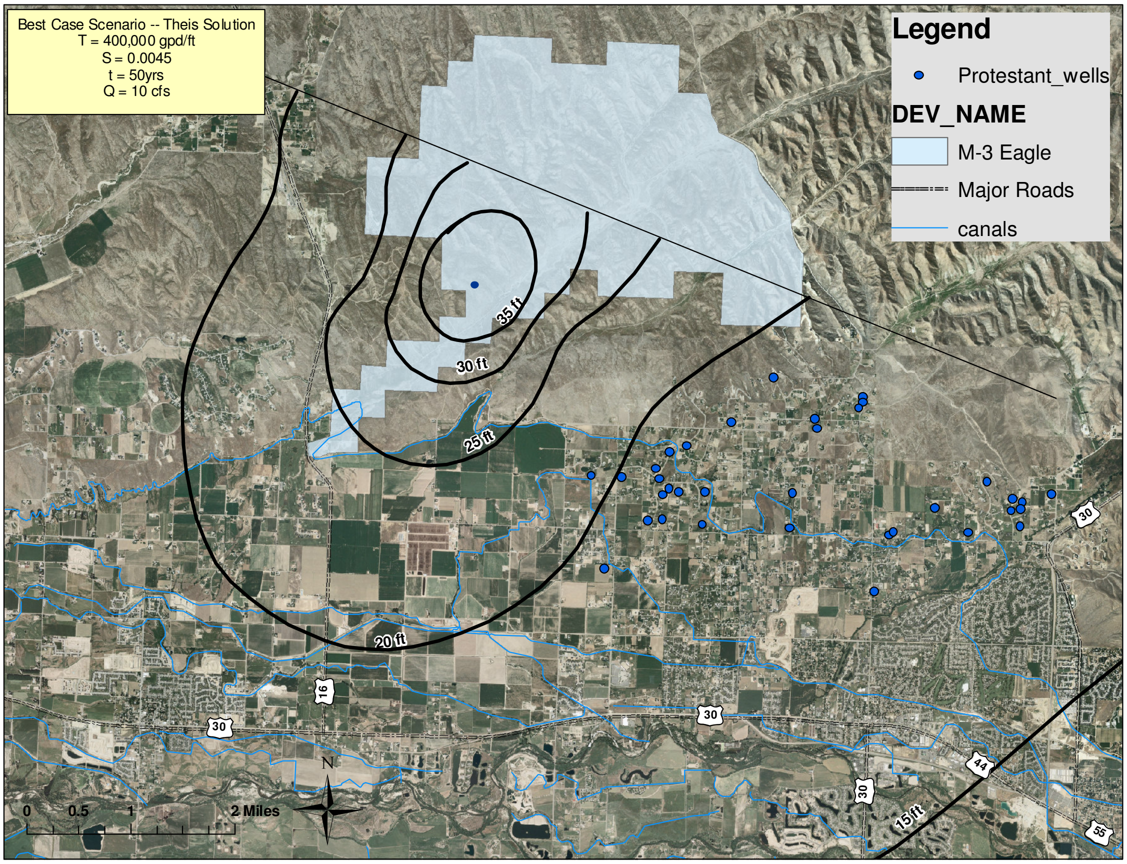

Figure 3. Predicted drawdowns using image well analysis after 50 years of pumping at 10 cfs from the PGSA beneath M3 property.

As previously discussed, HLI contracted the development of a ground water flow model that was used to predict impacts from the pumping of high capacity wells on the M3 property. The "Hmatch" version of the model indicates that 50 years of pumping three wells at a combined total rate of 10 cfs will cause drawdown in the PGSA that ranges from approximatley 30 feet on the property to around five feet at the intersection of Floating Feather Road and Highway 16 near Eagle (Figure 4).

The NW/SE trending fault identified between TW#4 and TW#1 through magnetometer studies was not included in any of the impact assessments performed by HLI or the Department. Based on HLI's aquifer test analysis, this fault potentially represents a no-flow boundary, which could significantly alter the predictions by causing more drawdown on the pumping side of the fault and less drawdown on the non-pumping side.

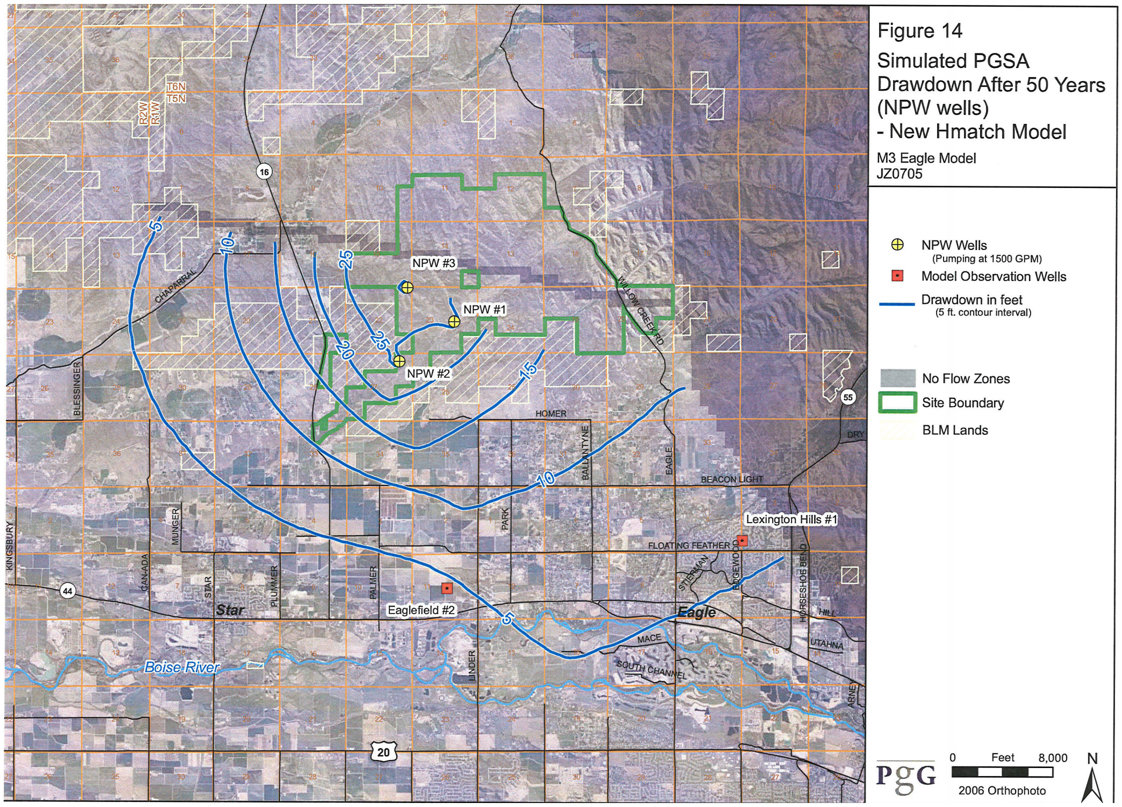

Figure 4. Map showing the results of predicted drawdown from the Hmatch version of the M3 ground water flow model (HLI, 2008a, Appendix B, Figure 14).

b) Impacts to water users

i) Well impacts

Impacts to water levels in wells completed in the PGSA are inevitable. Drawdown could be expected to reduce or eliminate discharge from flowing artesian wells and may require that pumps be installed (HLI, 2008b, p. 241). Non-flowing PGSA wells may have to be deepened or replaced, depending on the current depths of the wells and their proximity to the site.

Shallow aquifers overlying the PGSA appear to have a delayed hydraulic connection with the PGSA based upon the conclusions of investigators:

> "*Clay layers within and above the regional Pierce Gulch Sand Aquifer cause confined-aquifer responses to short-term pumping, but do not eliminate hydraulic connection to the upper water-bearing zones under longer-term pumping.*" (HLI, 2008c, p. 239).
>
> And
>
> "*interference in shallow wells could possibly approach the same levels as those predicted for wells completed in the Pierce Gulch Sand Aquifer after an extended period of pumping.*" (HLI, 2007a, p. 9).

And

"We feel fairly certain that there is a "long term" hydraulic connection in the sands of the upper delta sequence (Figure 10); however, local lenses of mudstone in that section may prevent short-term detection of well-drawdown responses. It may take months to decades for large drawdowns to propagate through the seemingly continuous section of interbedded sand and thin muds." (Squires and Wood, 2001, p. 14).

Based on the existence of a delayed hydraulic connection between the PGSA and overlying aquifers, pumping in the PGSA is likely to eventually impact the majority of area well owners. Impacts to wells completed in aquifers below the PGSA have not been investigated.

ii) Boise River impacts

Potential impacts to the Boise River were not quantified as part of the analysis in support of the M3 water right application. According to HLI:

"*The Boise River receives discharge from the Pierce Gulch Sand Aquifer and a shallow surficial aquifer via the upward vertical ground water gradients that prevail in the Eagle area."* (HLI, 2007a, p. 13)

Based on the above finding, pumping in the PGSA at M3 would cause a reduction in ground water discharge to the river. The magnitude and location of these impacts has not been determined.

5)* Request #5 -- *Any analysis of M3 Eagle LLC's demographic and economic modeling and forecasting.

IDWR staff have not analyzed the demographic and economic modeling and forecasting.

Summary and Conclusions

On behalf of the applicant, HLI has collected and analyzed a significant amount of hydrogeologic data over the past three years. The information has been compiled, analyzed, and submitted to the Department in a series of reports and memoranda for distribution to the public via our website. The information and analyses have been extremely beneficial to developing an improved understanding of the hydrogeology in M3 area.

HLI has shown that an aquifer beneath the M3 site is capable of producing substantial quantities of water. HLI also has developed conceptual and numerical models of the hydrogeology and applied the models to predict impacts to area well owners. Development of this water right by M3 is predicted to result in water level declines on the order of five to 15 feet near the City of Eagle assuming the water budget and aquifer boundary conditions of the M3 model. Significant questions still remain regarding aquifer recharge and sustainability. Impacts to surface water users have not been evaluated.

The primary conclusions based on the review of the data and reports submitted in response to the September 12, 2008 *Order Authorizing Discovery and Schedule Order,* are as follows:

- A highly productive sedimentary aquifer exists beneath a portion of the M3 property.
- The stratigraphy beneath the M3 site is complex, consisting of a thick sequence of coarse and fine grained sediment layers that pinch out and are faulted.
- Hydrologic boundaries and recharge mechanisms are not well defined for the target aquifer.
- The long-term sustainability of the aquifer beneath the M3 property is difficult to assess; some lines of evidence suggest that it may be limited.
- Despite remaining uncertainties, the work that was commissioned by M3 has significantly improved our understanding of the hydrogeology in North Ada County.
- The ongoing North Ada County Hydrogeologic Investigation will help reduce uncertainty.

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