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MEMORANDUM

To: Jo Beeman
From: Dale R. Ralston
Subject: Initial Hydrogeologic Analysis
Date: November 6, 2008

The purpose of this memo is to provide you with my initial hydrogeologic analysis of the M3 Eagle project. I anticipate writing a more detailed hydrogeologic analysis after having more time to review existing reports and receiving and reviewing additional M3 Eagle information that may be made available. This memo is divided into four sections. The first section provides a summary description of the hydrogeologic information provided to date. The second section is my analysis of the hydrogeologic conceptual model as presented. The third section is my analysis of the ground-water flow systems as presented. The fourth section is my analysis of likely impacts from full project development. The references cited are listed at the end of the memo.

SUMMARY OF M3 EAGLE DESCRIPTION OF THE GROUND-WATER SYSTEM

The following quotes are taken from the 2007 report entitled ***"M3 Eagle Regional Hydrogeologic Characterization – North Ada Canyon and Gem Counties, Idaho – Year One Progress Report"*** (Hydro Logic Inc. 2007).

> "Hydrogeologic studies commissioned by M3 Eagle in the North Ada County area have delineated a highly productive regional sand aquifer with good quality water that underlies the area near Eagle and Star and the proposed M3 Eagle planned community. This aquifer, herein named the Pierce Gulch Sand Aquifer, underlies the north Ada County Foothills where it extends continuously from the Eagle-Star area to the Payette River Valley. Because the Payette Valley near Letha is almost 300 feet lower than the Boise Valley near Eagle, ground water flows out of the Boise River Basin and into the Payette River Basin through the sands of this aquifer…. The ground water proposed to be withdrawn by M3 Eagle for its development will be from subsurface flow that has already departed the Boise Basin, on its way to the Payette Basin, so that impacts to existing area water users in the lowlands near Eagle are predicted to be small" (page 1).
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> "The Pierce Gulch Sand Aquifer consists of a 150-to-275-foot thick sequence of stratified sand layers with inter-bedded thin and locally discontinuous layers of silt and clay. The base of the dipping aquifer is typically 480-to-700 feet deep beneath land surface of the M3 Eagle site. The aquifer sand thickens and

descends deeper beneath of land surface to the south and southwest in the Eagle-Star-Meridian area and is believed to do the same to the northwest toward Payette River" (page 3).

"The Pierce Gulch Sand Aquifer is bounded on its northeast side by the geologic fault system … originally named the West Boise-Eagle fault by Wood and Anderson (1981). The base of the aquifer is underlain (and bounded) by the thick clays and mudstones of the Terteling Springs Formation. This structural dip explains why the municipals wells in Star are deeper than they are in Eagle. In the Boise River Valley near Eagle and Star, the Pierce Gulch Sand Aquifer is overlain by clays, some other minor sand aquifers, and a shallow surficial flood-plain-gravel aquifer (the present day floodplain of the Boise River). Beneath most of the M3 Eagle site, the aquifer is overlain by clay layers with no shallow surficial aquifer present" (pages 3 and 4).

"Using the derived aquifer transmissivity values and the measured water levels in wells to derive a ground water gradient, our analyses indicate that 20 to 30 mgd (million gallons per day (equivalent to approximately 22 thousand to 34 thousand ac ft/yr (acre feet per year)) of ground water currently flows in a northwesterly direction through the Pierce Gulch Sand Aquifer beneath a five-mile wide strip of the M3 site between State Highway 16 and the inferred edge of the pierce Gulch sand aquifer …" (page 5).

ANALYSIS OF THE HYDROGEOLOGIC CONCEPTUAL MODEL

The question of primary importance relative to the hydrogeologic conceptual model presented in the Hydro Logic Inc. 2007 report is stated below.

- **Is there sufficient evidence to support the presumption of lateral extent and continuity of 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?**

Supporting evidence for the lateral extent and continuity of a geologic unit comes from knowledge of the depositional environment, surface geologic maps and geologic information from wells. These topics are addressed below.

- The Hydro Logic Inc. (2007) report provides only limited information on the depositional environment for the target aquifer. However, considerable discussion of the depositional environment during emplacement of the geologic units is available in supporting documents. Most of the scientific articles describe conditions southwest of the M3 Eagle development. I was not able to find any discussion of the depositional environment that would result in the sand unit extending and being laterally continuous to the vicinity of the Payette River valley.
- I was not able to find a published geologic map that provides information on outcrops patterns of Pierce Gulch Sand in the immediate vicinity or northwest of the M3 Eagle development.

- The Hydro Logic Inc. (2007) report provides subsurface geologic information in the vicinity of the M3 Eagle development in the form of a cross section. Support documents present geologic cross sections in areas southeast of the M3 Eagle property. I was not able to find any geologic cross sections for the area between the M3 Eagle property and the Payette River.

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 of 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.

ANALYSIS OF THE GROUND-WATER FLOW SYSTEM

The question of primary importance relative to the ground-water flow system that is described in the Hydro Logic Inc. 2007 report is stated below.

- **Assuming that the hydrogeologic conceptual model question is answered in the affirmative, is there 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?**

Supporting evidence for the description of the ground-water flow system comes from the hydrogeologic conceptual model, water-level data from wells and estimates of transmissivity calculated using data collected during aquifer tests. These topics are addressed below.

- The heterogeneity of what has been called the Pierce Gulch Sand Aquifer is very important relative to the description of the ground-water flow system and particularly in the estimation of the quantity of water moving in the system. The following is a description of the Pierce Park sand by Squires and Wood (2001, pp. 13-14)
    - "Because this is the uppermost delta in the lacustrine sequence, we correlate it to the Pierce Park sand that crops out in the upper part of the foothills section west of Crane Creek. In the foothills, this unit is mostly foreset beds of coarse sand typical of the 'Gilbert-type' of delta. Some foreset bed sets are 60 feet thick, and the sand unit as a whole is up to 250 feet thick in the foothills… This delta is then correlated by Wood and Clemens (in press) to the history of Lake Idaho. Since it is the uppermost major delta in the section its deposition over mudstone, is explained as a prograding sand delta in response to the slow lowering of lake levels after Lake Idaho spilled over into Hells Canyon…. We feel fairly certain that there is a 'long-term' hydraulic connection in the sands of the upper delta sequence ….; however, local lenses of mudstone in that section may prevent short-term detection of well-drawdown responses. It may take

- The above quote from Squires and Wood (2001) indicates that ground-water flow patterns in what has been called the Pierce Gulch Sand Aquifer likely are more complex than is described in the Hydro Logic Inc. (2007) report. This likely is true for the portion of the postulated flow system that has been investigated (southeast of the M3 Eagle site) as well as the area northwest of the M3 Eagle site where little information is available.
- Figure 6 of the Hydro Logic Inc. (2007) report shows a complex pattern of water-level elevation contours in what appears to be several different ground-water flow systems. In my opinion, the figure raises many questions relative to characterization of ground-water flow systems. My questions include the following. 1) Are all of the wells in the purple colored area completed only in what has been called the Pierce Gulch Sand Aquifer? 2) Is there a vertical gradient within the Pierce Gulch Sand Aquifer and, if so, how are water levels from different wells interpreted? 3) What aquifer in penetrated by the wells located on within the Payette River floodplain? 4) Is the aquifer on the Payette River floodplain hydraulically connected to what is called the Pierce Gulch Sand Aquifer and, if so, how? 5) Do the flow lines represent ground-water discharge from the Pierce Gulch Sand Aquifer into whatever aquifer underlies the Payette River Valley?
- Figure 8 of the Hydro Logic Inc. (2007) report shows calculated values of transmissivity and storativity for selected wells in the general M3 Eagle area. The range of transmissivity values shown is consistent with the expected high level of heterogeneity and anisotropy believed to characterize the sand deposit. The transmissivity value(s) used in calculating an estimated flow though a portion of the target aquifer is not identified in the Hydro Logic Inc. report (2007, page 5).

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?

ANALYSIS OF LIKELY IMPACTS FROM FULL PROJECT DEVELOPMENT

The question of primary importance relative to the subsurface water balance and likely impacts from full project development is stated below.

- **Has the characterization of the target aquifer system, including a pre-development water balance, been complete enough to support an analysis of impacts from full project development?**

Analysis of impacts from project development is dependent on gaining a suitable level of understanding of aquifer boundaries plus knowledge of the locations and controls for ground-water recharge and the locations and controls for ground-water discharge. These topics are addressed below.

- The Hydro Logic Inc. (2007) report identifies the northeast boundary of what has been called the Pierce Gulch Sand Aquifer but none of the other boundaries. Characterization of all of the aquifer boundaries is a necessary step for analysis of impacts from full project development.
- The Hydro Logic Inc. (2007) report indicates that recharge occurs to the aquifer within the Boise River basing with discharge within the Payette River basin. The report indicates that the "major source of ground water in the aquifer in the vicinity of Eagle is ground water underflow from areas south and east of the Boise River at Eagle. This ground water originates as direct infiltration from the Boise River in the east-central Boise area and through leakage from irrigation canals south and east of Eagle" (page 13). The report does not provide specifics relative to locations and characteristics of recharge in the Boise River basin or any information relative to locations and characteristics of ground-water discharge within the Payette River basin.
- A general description of the temporal sequence of impacts from development and operation of the project wells is presented below.
    - The initiation of consumptive withdrawal of water via wells from the aquifer would result in local water-level decline in the aquifer.
    - Continued operation of the wells would result in an ever increasing cone of depression (area of water-level decline) until pumping effects reach the recharge and/or discharge areas.
    - Water-level decline would cause an increase in recharge if recharge to the aquifer is head dependent (saturated hydraulic connection with a surface water system). Water-level decline would cause a decrease in the rate of ground-water discharge (all ground-water discharge rates are head dependent).
    - The basin water levels would stabilize if the rate of consumptive pumping was balanced by increased ground-water recharge and/or decreased ground-water discharge. The time required for the ground-water system to come into a new equilibrium is dependent on the size of the aquifer and hydraulic properties of the ground-water flow system.
    - Long-term water-level decline would occur if the consumptive withdrawal of ground water is greater than the annual rate of recharge.

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.

Please contact me if you have any questions relative to the information presented in this memorandum. Thank you.

REFERENCES CITED

Hydro Logic Inc., 2007, M3 Eagle Regional Hydrogeologic Characterization – North Ada, Canyon and Gem Counties, Idaho – Year One Progress Report: Consulting Report Prepared for M3 Companies; 19 pages plus figures.

Squires, E. and S.H. Wood, 2001, Stratigraphic Studies of the Boise (Idaho) Aquifer System Using Borehole Geophysical Logs with Emphasis on Facies Identification of Sand Aquifers: Report to the Treasure Valley Study, Idaho Department of Water Resources; Hydro Logic Inc. and Boise State University; 15 pages.