Technical Memorandum

Subject: Installation and Aquifer Test of Test Wells

Date: October 11, 2011

To: Andrew White, Benchmark Resources

Copy to: Andrew Kopania, EMKO Environmental

From:

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1. Introduction

This Technical Memorandum (TM) presents the results of the drilling, installation, and testing of groundwater test wells at two locations within the proposed 3M Hard Rock Aggregate Quarry located in Shasta County, California (Figures 1 and 2). The objective of the drilling program was to drill within areas that were readily accessible by the drill rig and had potential to produce significant groundwater within the region.

The proposed test wells were intended to assess potential water production rates for use as part of the water resources assessment related to permitting of the proposed quarry. A detailed discussion of the hydrogeology and rationale used to select the testing location is presented in our June 30, 2009 Field Investigation Report as addended February 9, 2010 and May 24, 2011. In summary, groundwater production wells have been sited in the vicinity of the site. In particular, a well located near Bass Mountain School in Mountain Gate is reportedly a good producing well (between 200 and 300 gallons per minute) and utilized for water supply in the Mountain Gate community. This well is completed within the Kennett Formation along a northwest trending mapped fracture / fault. Several similar fracture patterns have been recognized and mapped within the Moody Flat Property and have identified active seeps and springs. These locations are not currently accessible due to limitations associated with crossing the railroad tracks dissecting the property. The efforts described in this TM target other potential sites in the Bass Mountain Diabase and Copley Greenstone for PW-1/OW-1 and PW-2, respectively. Negotiations are currently in progress to provide access across the tracks and access drilling location at intersections of mapped fractures and faults within the Kennett Formation.

2. Test Boring Observations

Two locations were investigated for the potential for water production purposes, PW-1 and PW-2. The two boreholes were advanced under a C-57 licensed driller, Diamond Core Drilling. The drilling method used air rotary drilling techniques with a 6-inch diameter down hole hammer bit. Cuttings from both wells were spread around the site. Water produced during drilling was controlled and allowed to spread across land surface within vegetated areas. No water produced during drilling reached any surface water bodies or creeks.

2.1 PW-1/ OW-1

PW-1 was drilled on June 6, 2011 on the eastern side of the property, sited on a thin alluvium covering the Bass Mountain Diabase. The borehole was advanced under Shasta County Department of Environmental Health permit number WTR11-110 to a total depth of 407 feet below ground surface (bgs). The borehole was completed with a 2-inch diameter monitoring well. The well was renamed to OW-1 (formerly PW-1) due to poor water production potential. A thin unconsolidated alluvial soil cover was observed to a depth of approximately 7 feet bgs. At 7 feet bgs, weathered bedrock conditions were encountered down to approximately 12 feet bgs. Water production was strongest in the upper 20 feet within the weathered rock zone. Several fractures were encountered during drilling, but water production did not increase significantly with there occurrence. Table 1 summarizes the drilling and water production observations. A detailed drilling log is attached that includes well construction details.
Proposed 3M Quarry
Moody Creek, CA

Geologic Map and Lineation Assessment

Legend

- PW
- Property Boundary
- - - Observed Shear Zones
- - - Mapped Lineations
- - - Prop:ional Operational Areas
- Bass Mountain Diabase
- Kennett Formation
(See appendix for descriptions)
- Copley Greenstone

Note:
Base map adapted from USGS 1:24000 Scale Topographic Map.

Scale: 1:18,000 Or 1 inch = 1,500 feet

0 750 1,500 3,000 4,500 6,000 Feet
2.2 PW-2

PW-2 was drilled on June 21, 2011 on the western side of the property, sited on the Copley Greenstone (meta-andesite). The borehole was advanced under Shasta County Department of Environmental Health permit number WTR11-131 to a total depth of 405 feet below ground surface. The borehole was abandoned by backfilling with a high solid bentonite slurry. A thin unconsolidated alluvial soil cover was observed to a depth of approximately 7 feet bgs. At 7 feet bgs weathered bedrock conditions were encountered down to approximately 12 feet bgs. Water production was strongest in the upper 20 feet within the weathered rock zone. Several fractures were encountered during drilling, but water production did not increase significantly with their occurrence. Table 1 summarizes the drilling and water production observations. A detailed drilling log is attached.

<table>
<thead>
<tr>
<th>Well</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Est. Elevation (ft msl)</th>
<th>Primary Rock Encountered</th>
<th>Final Completion / Construction</th>
<th>Total Depth (ft bgs)</th>
<th>Water Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW-1 / OW-1</td>
<td>40.705952° N</td>
<td>122.343336° W</td>
<td>875</td>
<td>Bass Mountain Diabase</td>
<td>Observation Well – 2in. dia. PVC, 0.020 in. Screen from 100 to 400 ft bgs.</td>
<td>407</td>
<td>2 gpm</td>
</tr>
<tr>
<td>PW-2</td>
<td>40.698077° N</td>
<td>122.380248° W</td>
<td>1010</td>
<td>Copley Greenstone</td>
<td>Abandoned</td>
<td>405</td>
<td>&lt;5 gpm</td>
</tr>
</tbody>
</table>

3. Aquifer Testing Results

Production testing was performed at PW-1/OW-1 in an open borehole following reaching total depth of 407 ft bgs. Testing was not performed in PW-2 due to groundwater production observed during drilling of less than 5 gallons per minute (gpm).

Testing on PW-1/OW-1 was conducted using a 3-inch Grunfos® submersible pump installed in the open borehole. The test was conducted on June 7, 2011 and consisted of a step draw down test to evaluate an appropriate pumping rate for a potential longer duration test. However, as discussed below, the results of the step test indicated that flow rates for a long term test would be 2 gpm or less and was not conducted.

A pressure transducer was installed to observed drawdown within the borehole on a rapid frequency with accuracy to the nearest 1/100th of a foot. Figure 3 illustrates data collected for drawdown and recovery of the step draw down test.
The test was initiated with the plan on running 3 increasing flow rates (Step Test) and run for a total of 4-hours. The test was started at a flow rate of 30 gpm; however, drawdown at this rate was very rapid and not sustainable. The flow rate was reduced until a rate was found that appeared to be sustainable. Table 2 provides the pumping schedule used.

<table>
<thead>
<tr>
<th>Period</th>
<th>Flow Rate (gpm)</th>
<th>Duration (minutes)</th>
<th>Total Drawdown (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>5</td>
<td>40.12</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>6</td>
<td>49.82</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>25</td>
<td>65.89</td>
</tr>
<tr>
<td>4</td>
<td>7.5</td>
<td>205</td>
<td>66.39</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>922</td>
<td>0</td>
</tr>
</tbody>
</table>

The drawdown and recovery data was analyzed using AqteSolv® in an attempt to develop some general groundwater flow properties. However, due to the uncertainties of the fracture orientation, aperture, and density these values could not be developed. The diagnostic plots within Aqtesolv® did support that flow was consistent with a finite-conductivity fracture in a slab reservoir. Further analysis was not performed for production purposes following the observations made during pumping. After completion of the step draw down test, the boring was converted to a 2-inch diameter monitoring well as discussed in Section 2.1.

A significant component of flow (approximately 5 gpm) was observed at the weathered / solid rock interface within the upper approximately 30 feet. This zone was sealed off during the placement of the well casing and subsequent sanitary seal. Testing performed following the final development of the monitoring well indicated that the well would produce approximately 2 gpm from the screened interval (see Attached Geologic Boring Log for well construction details).
4. Summary and Recommendations

The test production wells drilled and tested as described above targeted shallow alluvium areas over fractured Bass Mountain Diabase and mapped fracture intersections within the Copley greenstone. Both of these boreholes did have minor groundwater present, but did not yield significant production (less than 5 gpm).

Continued investigation in locations similar to those of existing regional groundwater production wells should focus on mapped shear and fracture zones within the Kennett Formation near the planned operation areas of the proposed quarry. However, given the observations made during drilling of these two test boreholes, the limited nature and fracture opening and distribution will control the groundwater flow in the vicinity of the site. No boreholes have been advanced within the Kennett Formation within the Site boundaries to provide any preliminary information and future work should be considered exploratory.
Attachment A: Drilling Logs
# Boring / Well Log

**PROJECT:** Moody Flats Quarry  
**Boring/Well No.:** OW-1 (PW-1)

**SITE LOCATION:** Old Oregon Trail At Wonderland Blvd, Mountain Gate  
**JOB NO.:** 140910  
**LOGGED BY:** Tim Godwin  
**PROJECT MANAGER:** Joe Turner  
**CHECKED BY:** Ted Ogilvie  
**DRILLING CO.:** Diamond Core Drilling, Inc  
**DRILLER:** Joe Turner  
**METHOD OF DRILLING:** Air Rotary  
**RIG TYPE:**  

**DATE DRILLED:** 6-6-11  
**HAMMER WT./DROP:** Grab samples  

**BOREHOLE INFORMATION**  
**DEPT:** 40'  
**Borehole Dia:** 6 1/8"  
**LATITUDE:**  
**LONGITUDE:**  
**APPROX. ELEV.:**  

**SOIL DESCRIPTION**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SOIL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ML</td>
<td>ML Sil very clayey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ML Sil, sandy clay, with shale</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>Meta-sedimentary: Weathered metasedimentary rock</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>Meta-sedimentary: Metasedimentary rock with pyrite, black pelitic slate, and green recrystallized fine sand</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>Meta-sedimentary: Metasedimentary rock, black pelitic slate</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
<td>Meta-sedimentary: Metasedimentary rock, with black pelitic slate, quartz-dominated, green.</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>Basalt: Basalt lava flow, with olivine</td>
</tr>
<tr>
<td>60</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock with black pelitic slate, pyrite veining</td>
</tr>
<tr>
<td>70</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock with black pelitic slate, iron oxide staining</td>
</tr>
<tr>
<td>80</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate</td>
</tr>
<tr>
<td>90</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate, with black pelitic slate, pyrite veining</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate, with black pelitic slate, pyrite veining</td>
</tr>
<tr>
<td>110</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate, with black pelitic slate, pyrite veining</td>
</tr>
<tr>
<td>120</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate, with black pelitic slate, pyrite veining</td>
</tr>
<tr>
<td>130</td>
<td>3</td>
<td>Meta-sedimentary: Slate/metasedimentary rock, black pelitic slate, with black pelitic slate, pyrite veining</td>
</tr>
</tbody>
</table>

**NOTES:** Well renamed OW-1 by Well Owner
### Boring / Well Log

**PROJECT:** Moody Flats Quarry

**Boring/Well No.:** OW-1 (PW-1)

**SITE LOCATION:** Old Oregon Trail At Wonderland Blvd, Mountain Gate

**DRILLING CO.:** Diamond Core Drilling, Inc

**JOB NO.:** 140910

**DRILLER:** Ted Ogilvie

**PROJECT MANAGER:** Joe Turner

**METHOD OF DRILLING:** Air Rotary

**CHECKED BY:**

**SAMPLING METHODS:** Grab samples

**DATES DRILLED:** 6-6-11

**DRILLING CO.:** Diamond Core Drilling, Inc

**DRILLER:** Ted Ogilvie

**RIG TYPE:**

**LATITUDE:**

**LONGITUDE:**

**APPRAOCH ELEV.:**

### BOREHOLE INFORMATION

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SOIL SYMBOLS</th>
<th>USCS</th>
<th>SOIL DESCRIPTION</th>
<th>BORING COMPLETION</th>
<th>WELL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>405</td>
<td></td>
<td></td>
<td>Water level during drilling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hammer WT./DROP**

**METHOD OF DRILLING:** Air Rotary

**SAMPLING METHODS:** Grab samples

**NOTES:** Well renamed OW-1 by Well Owner
### Boring / Well Log

**PROJECT:** Moody Flats Quarry

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>WATER LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water level during drilling</td>
</tr>
<tr>
<td></td>
<td>Water level in completed well</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SOIL SYMBOLS</th>
<th>USCS</th>
<th>SOIL DESCRIPTION</th>
<th>BORING COMPLETION</th>
<th>WELL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ML</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>ML</td>
<td></td>
<td>ML: Sandy silt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Meta-andesite: Meta-andesitic greenstone. Multiple annealed fractures. Poor water production &lt;5 gpm below weathered rock interface.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>@74' - Open fracture no increase in water production.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>@145' - Increase in calcite veining</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>175</td>
<td></td>
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<td>200</td>
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<td></td>
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<td>220</td>
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<td>245</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>260</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>375</td>
<td>@375' - Decrease in veining</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Borehole Information**

- **Total Depth:** 405' (123.4 m)
- **Borehole Dia:** 6 1/8" (155.6 mm)

**Notes:**
- TD = 405 ft (123.4 m)
- Bentonite Slurry at various depths.

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**PROJECT INFORMATION**

- **SITE LOCATION:** Old Oregon Trail At Wonderland Blvd, Mountain Gate
- **JOB NO.:** 14GW19
- **LOGGED BY:** Tim Godwin
- **PROJECT MANAGER:** Joe Turner
- **CHECKED BY:** Ted Ogilvie
- **DATES DRILLED:** 6-21-11

**Drilling Information**

- **DRILLING CO.:** Diamond Core Drilling, Inc
- **RIG TYPE:** Air Rotary
- **HAMMER WT./DROP:**
- **METHODOLOGY:** Grab Samples