

July 22, 2004

Mr. Jerry Gruber
General Manager
City of Big Bear Lake Dept of Water and Power
41972 Garstin Dr.
Big Bear Lake, CA 92315

**Re: Recommended Casing, Screen and Filter Pack Design
Canvasback Production Well**

Dear Jerry:

This letter summarizes the recommended casing, screen and filter pack design for City of Big Bear Lake Department of Water and Power's Canvasback Production Well. The recommended design of the Canvasback Well takes into account results from the Canvasback (2) monitoring well that was drilled approximately 50 ft from the production well location in August, 2003. While drilling the Canvasback (2) monitoring well, two depth specific water quality samples were collected in the test borehole at depths of approximately 200 and 275 ft below ground surface (bgs) before the well was completed as a dual-completion monitoring well. The discharge rate and general geochemical parameters measured in the field during testing of these two zones are presented in Table 1 on the following page.

**Table 1. Depth-Specific Ground Water Testing Results
Canvasback (2) Monitoring Well
Discharge and Geochemical Parameters Measured at the Time of Sampling**

Zone No.	Depth of Zone [ft, bgs]	Static Water Level [ft, bgs]	Pumping Water Level [ft, bgs]	Average Discharge Rate [gpm]	Field TDS [mg/L]	Field pH [units]	Field Water Temp. [°C]
Test Hole	200	45	Not Measured	26	249	7.7	16.7
Test Hole	275	44	Not Measured	26	215	7.6	16.7

In addition to the depth-specific ground water testing conducted in the test borehole, one isolated aquifer zone test was conducted in the 17 ½ inch pilot borehole of the Canvasback Production Well. This isolated aquifer zone test interval was located from 242 to 272 ft bgs. The discharge rate and general geochemical parameters measured in the field during testing of this zone are presented in Table 2 below:

**Table 2. Isolated Aquifer Zone Testing Results
Canvasback Production Well Pilot Borehole
Discharge and Geochemical Parameters Measured at the Time of Sampling**

Zone No.	Zone Interval [ft, bgs]	Static Ground Water Level [ft, bgs]	Pumping Ground Water Level [ft, bgs]	Discharge Rate [gpm]	Field TDS [mg/L]	Field pH [units]	Field Water Temp. [°C]
1	242 – 272	40	186	33	220	7.6	14.0

Water Quality Summary and Field Parameters

The pumping rate from the isolated aquifer zone in the pilot borehole was maintained at 33 to 37 gallons per minute throughout the test. The zone was pumped a total of 30 hours. Table 3 summarizes zone test water quality results for selected constituents as reported by E.S. Babcock & Sons, Inc. of Riverside, California, a State of California certified laboratory:

**Table 3. Aquifer Zone Testing Results – Canvasback Site
Laboratory Water Quality Data**

Sample Depth/ Screened Interval		Depth-Specific Samples (Dual-tube Test Hole)		Isolated Aquifer Zone (Pilot Borehole)	Shallow Monitoring Well	Deep Monitoring Well	MCL or Action Level
	[ft bgs]	200	275	242-272	160-315	415-485	
pH	[std. Units]	8.1	8.2	8.0	8.0	8.6	6.5-8.5 ⁴
Color (Unfiltered)	[color units]	< 3.0	< 3.0	<3.0	< 3.0	< 3.0	15 ²
Odor Threshold @ 60°C	[TON]	< 1.0	< 1.0	<1.0	< 1.0	< 1.0	3 ²
Arsenic	[µg/L]	< 2.0	< 2.0	4.1**	< 2.0	150	50 ^{1,3}
Fluoride	[mg/L]	0.4	0.4	0.4	0.5	2.8	2.0 ¹
Iron	[µg/L]	< 20	< 20	<20	< 20	< 20	0.3 ²
Manganese	[µg/L]	14	13	< 10**	< 10	15	50 ²
Nitrate (as N)	[mg/L]	0.25	< 0.20	< 0.20	< 0.20	< 0.20	10 ¹
Total Dissolved Solids, TDS	[mg/L]	310	280	260*	310	420	500-1,000 ²

Shaded cells indicate constituents that are above the present or impending MCL.

¹ California Department of Health Services (DHS) Primary Maximum Contaminant Levels (MCL).

² California DHS Secondary Maximum Contaminant Levels.

³ In January 2006 the MCL for arsenic will be reduced to 10 µg/L.

* TDS is calculated from specific conductance.

** Verbal results provided by E.S. Babcock & Sons, Inc. 22-Jul-04.

Recommended Well Design

Based on our review of the dual-tube test borehole, lithologic and geophysical logs as well as the pilot borehole geophysical logs, drill cuttings, and sieve analyses, and in consideration of the ground water quality data, the following casing and screen schedule is recommended:

**Table 4. Recommended Casing and Screen Schedule
Canvasback Production Well**

Interval [ft bgs]	Borehole Diameter [in.]	Casing Diameter [in.]	Wall Thickness [in.]	Screen Slot Size [in.]	Material Type
0 – 50	36	24 OD	5/16	-	Conductor Casing (ASTM A139 Grade B Steel)
+1 – 105	Annulus	3	sch 40	-	Gravel Feed Pipe (ASTM A53, Grade B steel)
+1 – 316*	Annulus	2	sch 40	-	Sounding Tube (ASTM A53, Grade B steel)
0 – 100	20	-	-	-	Sanitary Seal (10.5 Sack Sand-Cement Slurry)
100 – 103	20	-	-	-	Fine Sand Layer
103 – 354	20	-	-	-	4 x 16 Custom Blend Filter Pack Material
+1 – 158	20	10 ¾ OD	1/4	-	Blank Casing (Copper-Bearing Steel)
158 – 314	20	10 ¾ OD	1/4	0.094	Ful-Flo Louvered Screen (Copper-Bearing Steel)
314 – 344	20	10 ¾ OD	1/4	-	Blank Casing with End Plate (Copper-Bearing Steel)
344 – 354	20	-	-	-	Gravel-filled Borehole Below Casing and End Plate

The total screen length is 156 ft, and the total length of the blank casing is 189 ft, for a total length of 345 ft.

* The 2 ft slot in the sounding tube connection shall be located from 316 to 318 ft bgs, and shall be located in the sump below the screened interval.

Reaming (Enlarging) Pilot Borehole, Caliper Log, Gravel Feed Pipes and Sounding Tube

The 17 1/2-inch diameter pilot borehole shall be enlarged to 20 inches in diameter from 50 to 354 ft bgs. This design will allow for 10 ft of extra borehole in case a small amount of fill accumulates during the casing and screen installation. It is important that the reamed borehole does not extend deeper than this specified depth as ground water with high concentrations of arsenic and fluoride is known to occur below this depth.

Prior to installing the casing and screen, a 3-inch diameter gravel feed pipe shall be installed to 105 ft bgs, for the purpose of adding filter pack material during development, and as needed in

the future. Additionally, a 2-inch diameter sounding tube will be installed from ground surface, connecting to the 10 ¾-inch ID blank casing at a depth of 316 ft bgs, in the blank casing located below the screened interval. The 2 ft slot for the connection shall be located approximately 2 ft below the screened interval. The sounding tube will be used for the purpose of obtaining accurate water level measurements while pumping the well, or for installation of a transducer.

Filter Pack and Slot Size Selection

Mechanical grading analyses (i.e., sieve analyses) were performed on eight formation samples selected from intervals between 90 and 310 ft, however, only the sieves that fall within the recommended screen interval are plotted on the attached Figure 1.

Based on the results of these sieve analyses, the proposed filter pack is a Tacna Sand & Gravel 1/4 in. x 16 custom blend as shown on Table 5 below. The proposed slot size for the screened interval is 0.094 inches, which will theoretically allow approximately 17% of the filter pack material to pass (see Figure 1 and Table 6).

**Table 5. Proposed Filter Pack Design – Custom 1/4 in. x 16 Blend
Canvasback Production Well**

U.S. Standard Sieve No.	Sieve Opening [in.]	Sieve Opening [mm]	Cumulative Percent Passing
3/8"	0.375	9.53	100
1/4"	0.250	6.35	90
4	0.187	4.75	70
8	0.094	2.38	17
10	0.079	2.00	10
12	0.066	1.68	7
16	0.047	1.19	2
20	0.033	0.84	0.1

A sieve analysis test report from the filter pack supplier that represents the proposed filter pack gradation shall be submitted to GEOSCIENCE and shall be approved for use prior to delivery of

any filter pack material to the site. Additionally, once the filter pack is delivered to the site, GEOSCIENCE personnel shall sample and sieve a representative amount from each load to verify its gradations. All filter pack shall be delivered to the site at least 24 hours prior to installation of the casing and screen.

Placement of Filter Pack and Cement Seals

The filter pack material shall be pumped through a tremie pipe from 354 ft to 103 ft in the 20-inch diameter reamed borehole. A layer of fine sand shall be placed from 103 ft to 100 ft bgs to prevent the invasion of the cement slurry into the top of the filter pack material. The cement seal shall be placed from 100 ft to ground surface and shall consist of a 10.5 sack sand-cement grout. No more than one piece of tremie pipe (approximately 31 ft) shall be pulled at any time during gravel packing or cementing and the bottom end of the tremie pipe shall remain submerged in the cement slurry at all times during pumping.

Samples should be collected from each truckload of cement slurry as it is being pumped. The samples must be placed in a bucket of water (that is placed out of direct sunlight) to simulate down hole conditions for monitoring the set time of each lift of cement.

All tremie pipe used for gravel packing and cementing shall be flush-threaded. Liquid chlorine solution (12.5%) shall be added during gravel packing as per the Technical Specifications, section 3.14.2 Placement of Gravel Pack Material.

If you have any questions, please do not hesitate to call me at your convenience.

Sincerely,



Dennis E. Williams, Ph.D.

President

encls.

cc: Scott Heule – City of Big Bear Lake DWP
Mike Haslam – Beylik Drilling

**Well Design Parameters and Recommended Filter Pack
City of Big Bear Lake Dept. of Water and Power
Canvasback Production Well**

Design Criteria	Depth [ft]	Formula (D = Filter Pack) (d = Aquifer)	Value	Recommended Value
Pack/Aquifer Ratio (Finest Zone)	270-280	D_{50}/d_{50}	10.1	4 to 10
Terzaghi Migration Factor (Finest Zone)	270-280	D_{15}/d_{85}	1.9	less than 4
Terzaghi Permeability Factor (Coarsest Zone)	210-220	D_{15}/d_{15}	14.2	greater than 4
Screen Slot [in.]	-	-	0.094	-
Percent Filter Pack Passing Screen Slot	-	-	17.0	10% to 20%
Uniformity Coefficient of Filter Pack	-	$C_u = D_{60}/D_{10}$	2.1	-

1/4 in. x 16 Filter Pack

U.S. Standard Sieve Size	Opening [in.]	Opening [mm]	Cumulative % Retained	Cumulative % Passing
3/8"	0.375	9.53	0.0	100
1/4"	0.250	6.35	10.0	90
4	0.187	4.75	30.0	70
8	0.094	2.38	83.0	17
10	0.079	2.00	90.0	10
12	0.066	1.68	93.0	7
16	0.047	1.19	98.0	2
20	0.033	0.84	99.9	0.1

Mechanical Grading Analysis

City of Big Bear Lake Dept. of Water and Power Canvasback Production Well

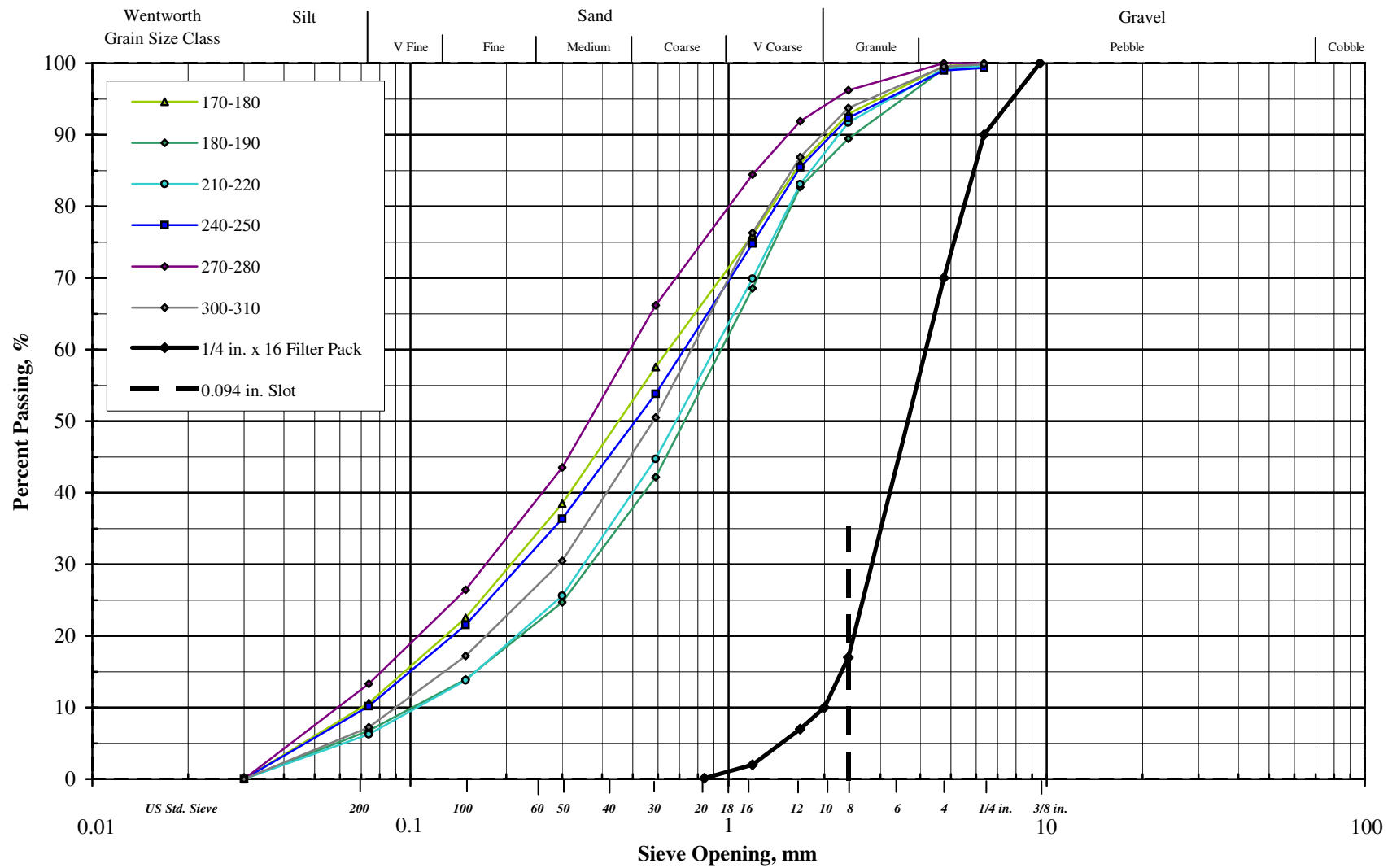


Figure 1