BESST INC.
GLOBAL SUBSURFACE TECHNOLOGIES

Dynamic Flow and Chemistry Profiling Report for Hill Valley Water District Well #1

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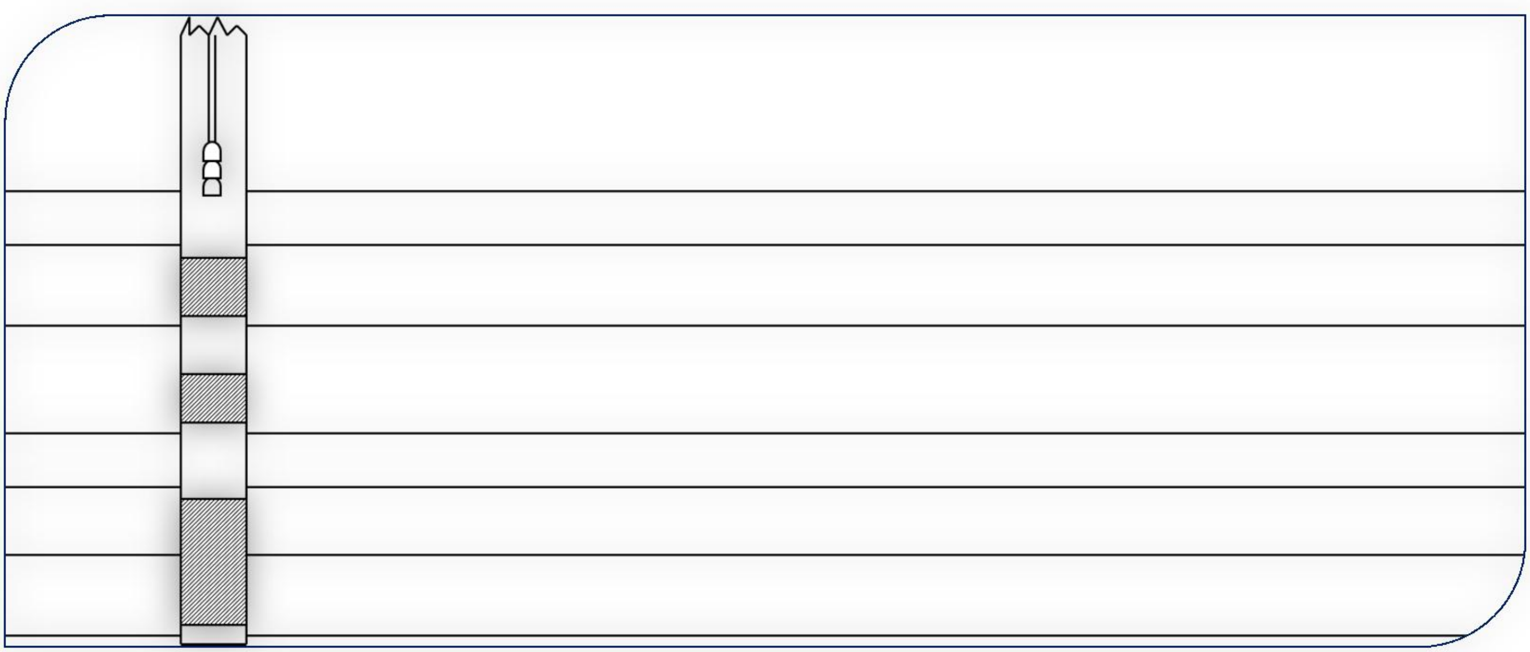

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Introduction

On October 21, 2015, BESST, Inc. performed a dynamic flow and water quality chemistry profile for Hill Valley Water District on Well # 1, located in Hill Valley, California.

The purpose of this profiling event was to investigate concentrations of arsenic, iron and manganese, and document baseline flow from the perforated intervals at the time of the field work.

The dynamic profile was performed using the USGS Tracer Pulse Dynamic Flow Profile method to measure zonal flow chemistry contributions at ten depth dependent locations along the length of the perforated intervals. Dynamic flow profile results are shown in Figures 2 through 5.

The dynamic water quality sampling was performed using BESST, Inc.'s HydroBooster Technology. Eight samples were collected between the depths of 285 to 445 feet below ground surface (Ft. BGS). Two samples were also collected at the well head. Sampling depths were determined through assessment of the cumulative and zonal flow contribution data and available well information, which is summarized in the Well Information Summary shown in Figure 1. Chemical analysis was performed by BSK Laboratories.

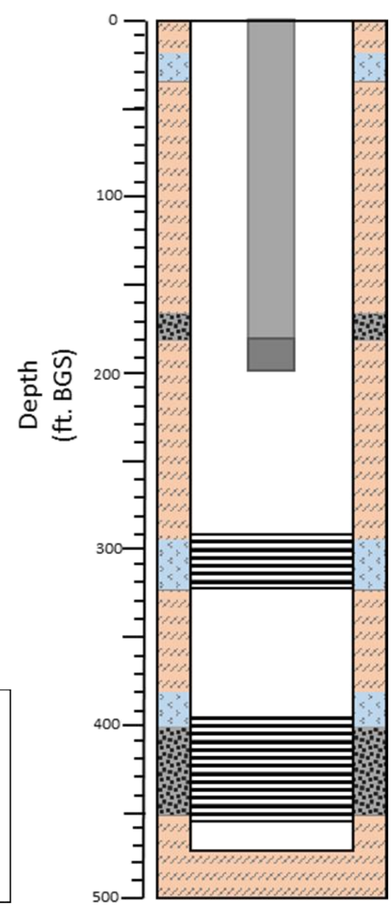
The measured and cumulative sample results are used in conjunction with the cumulative flow calculations and principles of conservation of mass, to determine zonal water quality concentrations along the perforated intervals. Zonal chemical contribution data is presented in Appendix C.

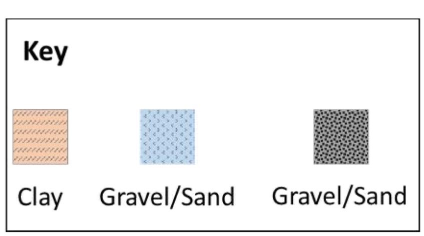
Well Information Summary

The following information for Well # 1 is based on technical information provided by Hill Valley Water District.

Well Information	Diameter	GPM	Ft. BGS
Total Well Depth			472
Pump Intake Depth			200
Pumping Water Level*			90
Pumping Rate *		980	
Casing Schedule			
Blank	16 in.		0-294
Perforated	16 in.		294-324
Blank	16 in.		324-392
Perforated	16 in.		392-452
Blank	16 in.		452-472

* During the time of testing





Dynamic Flow Profile

The dynamic flow profile for Well # 1 was performed using the USGS Tracer Pulse Dynamic Flow Profiling method to measure flow contribution along the length of the perforated intervals (Figures 2 through 5). The profile was conducted at a flow rate of 980 gallons per minute (GPM) on October 15, 2015.

Velocity is calculated as the change in feet between injection points divided by the change in dye tracer return times between injection points. Velocity increases in the direction of the pump intake within the well. It is assumed that velocity remains constant within blank sections of the well.

Cumulative flow shows the increase in groundwater production along the length of the well when approaching the pump intake. The raw cumulative flow data was corrected by a proportionality factor determined by the actual pump rate over theoretical pump rate, in order to match the field pumping rate.

Zonal flow is calculated as the difference in cumulative flow depths. The zonal flow contribution graph shows zonal flow between each cumulative measurement depth. The sum of all labeled values of zonal flow will yield the pumping rate at the time of testing. The percent zonal flow contribution graph shows the percentage of each zonal flow value divided by the pumping rate.

BESST Inc. adds injection depth locations in blank sections to better estimate total flow from the contributing screen sections. It is assumed that while tracing flow through blank sections, there is no extra groundwater production in addition to the contributing screened intervals. BESST uses the flow velocity measurements in the blank sections in the QA/QC process of the analysis.

Dynamic Flow Profile Graphs

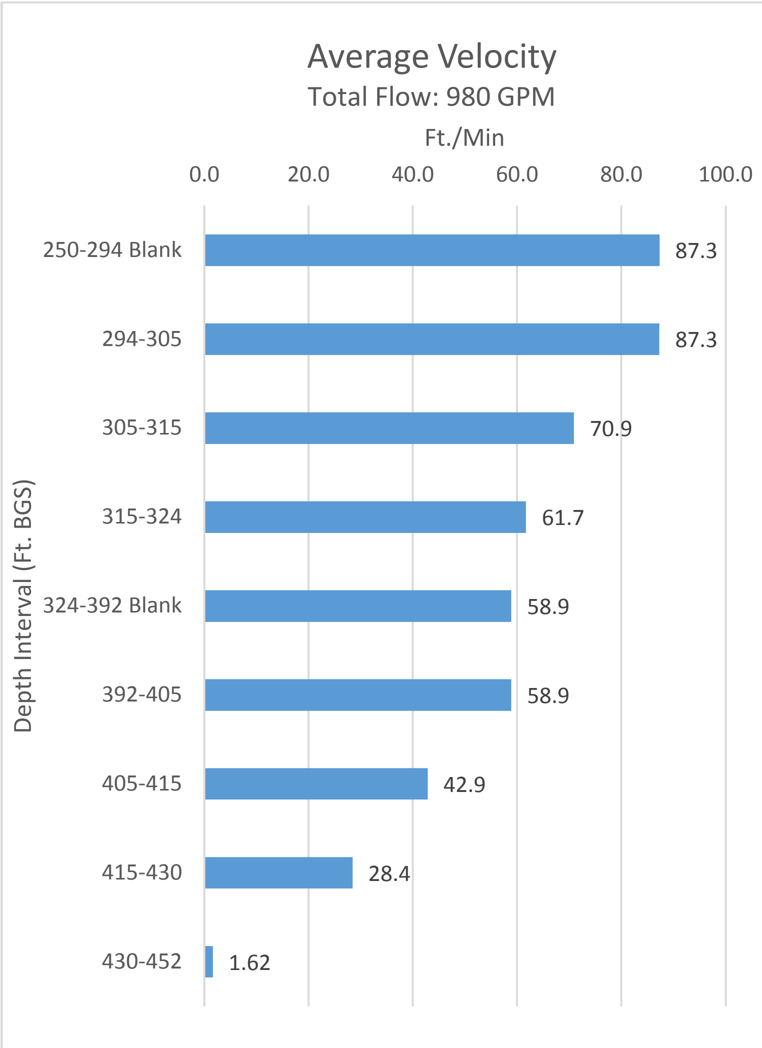


Figure 1. Well # 1 dynamic average velocity by depth.

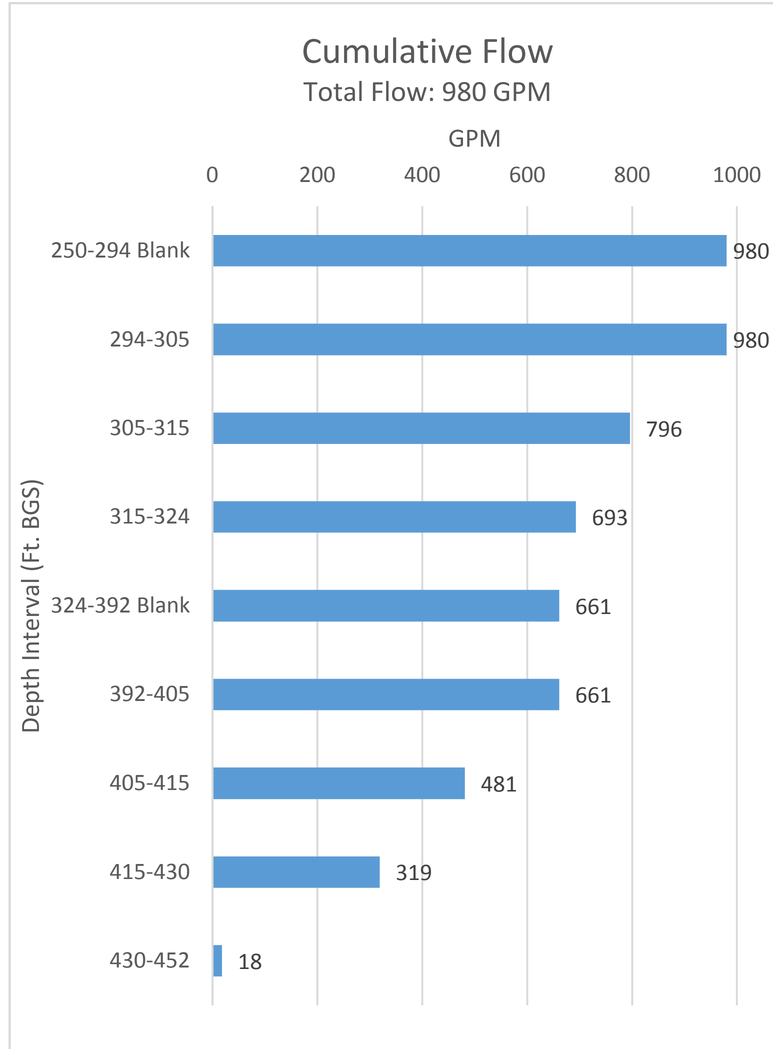


Figure 2. Well # 1 dynamic cumulative flow by depth.

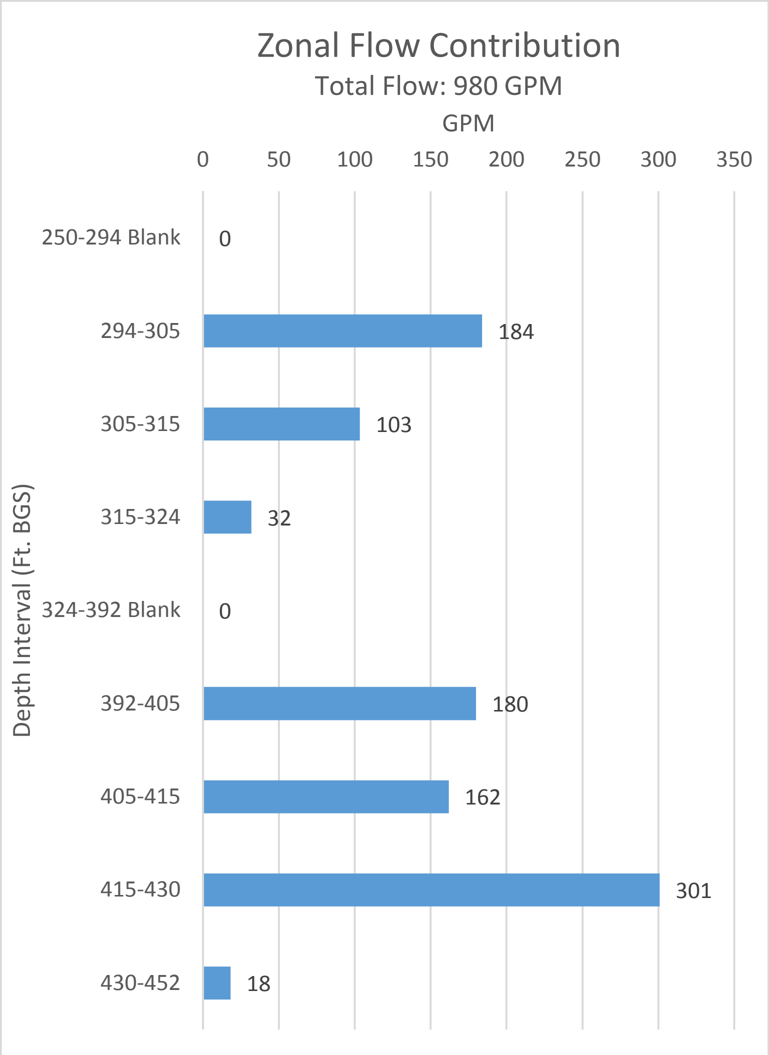


Figure 3. Well # 1 dynamic zonal flow contribution by depth.

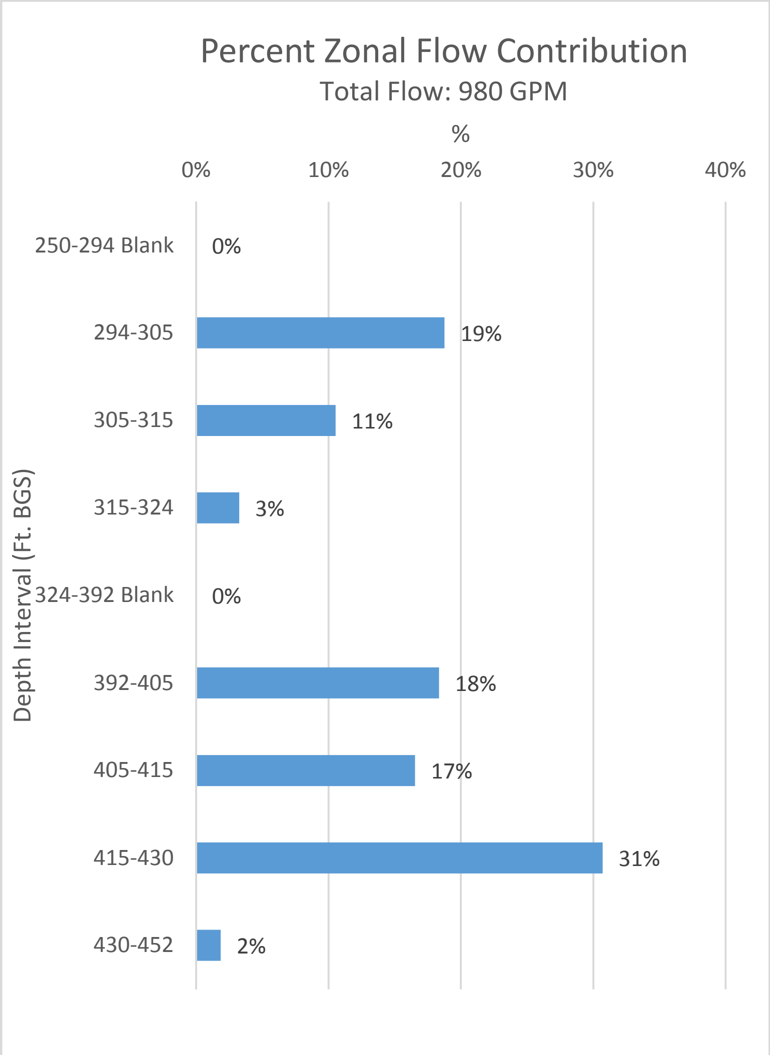


Figure 4. Well # 1 dynamic percent zonal flow contribution by depth.

Zonal Chemical Contribution Graphs

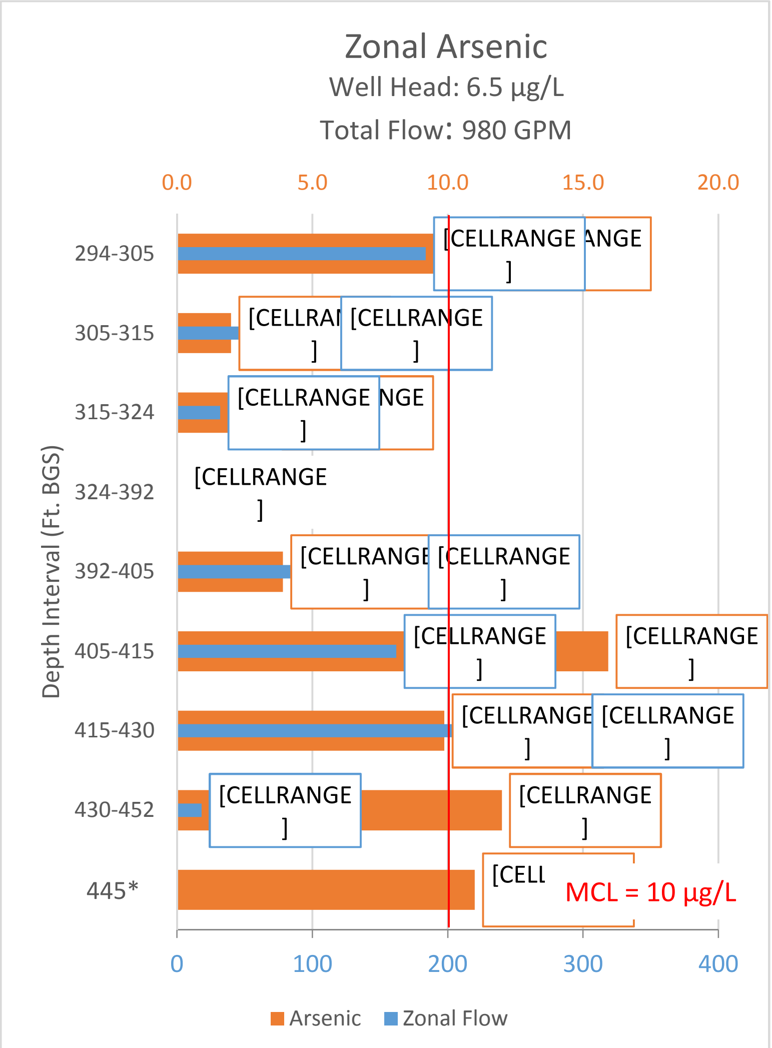


Figure 5. Well # 1 zonal arsenic concentrations vs. zonal flow.

**Sample was taken by BESST at 445 Ft. BGS. However, there is insufficient flow information at that depth to perform a mass balance calculation. Therefore, the lab value is presented for that samples.*

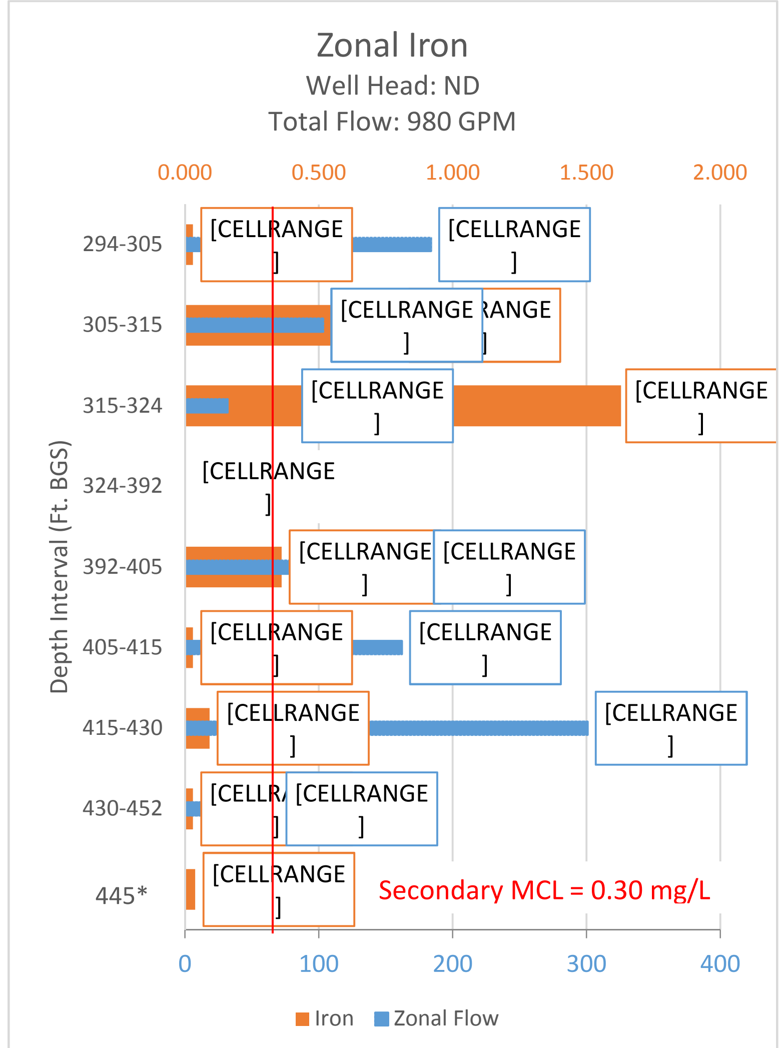


Figure 6. Well # 1 zonal iron concentrations vs. zonal flow.

**Sample was taken by BESST at 445 Ft. BGS. However, there is insufficient flow information at that depth to perform a mass balance calculation. Therefore, the lab value is presented for that samples.*

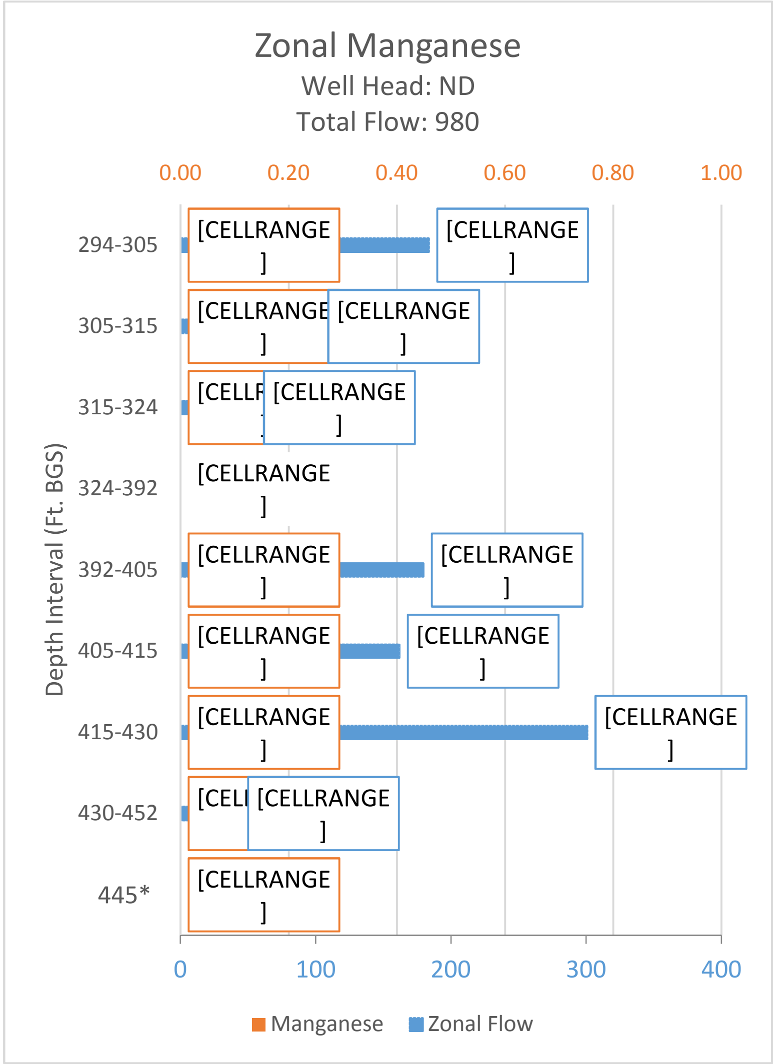


Figure 7. Well # 1 zonal manganese concentrations vs. zonal flow.

**Sample was taken by BESST at 445 Ft. BGS. However, there is insufficient flow information at that depth to perform a mass balance calculation. Therefore, the lab value is presented for that samples.*

Results

Conclusions are based on a pumping rate of 980 GPM and the total well head analytical concentrations at the time of profiling.

Groundwater was produced in all screened sections within Well # 1. The largest zonal percentage of groundwater production was from 415-430 Ft. BGS which contributes 301 GPM, roughly 31% of total production. Other notable areas of large zonal percentage of groundwater production were from 294-305 Ft. BGS and 392-405 Ft. BGS with roughly 19% (184 GPM) and 18% (180GPM) of total production, respectively. The zone with the smallest percentage of groundwater production was from 430-452 Ft. BGS which contributes 18 GPM, roughly 2% of total production.

Concentrations of arsenic were detected in all eight samples collected within Well # 1. The largest zonal concentration was detected from 405-415 Ft. BGS with 16 µg/L of arsenic, which is above the MCL for arsenic of 10 µg/L. This interval contributes to 17% of total groundwater production. Concentrations above the MCL were also detected from 430-452 Ft. BGS with arsenic concentrations of 12 µg/L and 11 µg/L. This interval contributes to 2% of total production. Concentrations from the well head samples reported an average arsenic concentration of 6.5 µg/L.

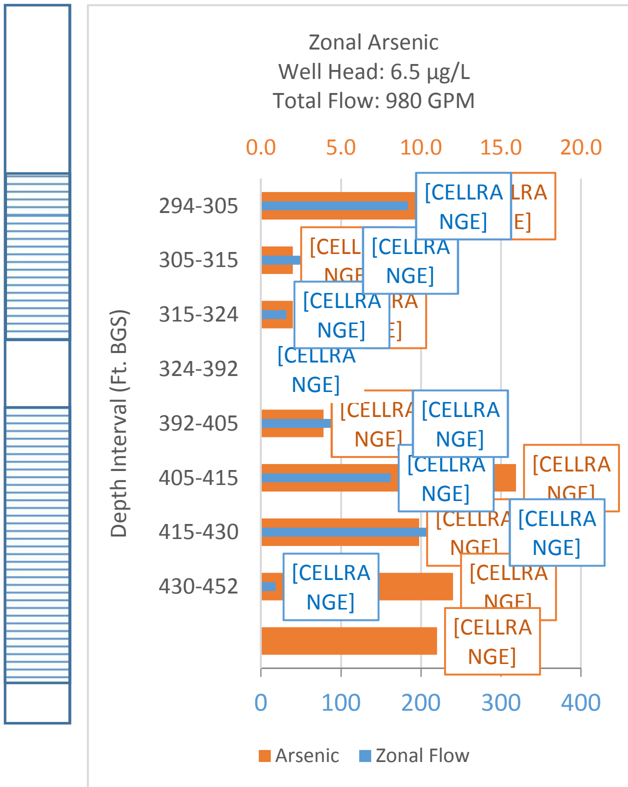
Concentrations of iron were detected in all eight samples collected within Well # 1. The largest zonal concentration was detected from 315-324 Ft. BGS with 1.6 mg/L of iron, which is above the secondary MCL for iron of 0.30 mg/L. This interval contributes to 3% of total groundwater production. Concentrations above the secondary MCL were also detected from 392-405 Ft. BGS with 0.30 mg/L of iron. This interval contributes to 18% of total groundwater production. No concentrations of iron were detected in either of the two well head samples.

Concentrations of manganese were not detected in any of the eight samples collected within Well # 1 or from either of the two well head samples.

Recommendations

Hill Valley Water District Well #1 is constructed with two screen sections. The upper well screen runs from 294-324 Ft. BGS and the bottom well screen section runs from 392-452 Ft. BGS. The total length of well screen of the two sections is 90 feet. We believe that the most reasonable strategy in terms of selectively extracting groundwater from Well #1 is to, combine the upper screened section with the top 13 feet of the lower well screen section. The remaining sections of the well would be blocked off from producing groundwater. Figure 9 below shows the current dynamic flow and arsenic water chemistry distribution with depth along the well screen that helps to illustrate the reasoning behind the suggested strategy.

In Figure 10 the red boxed in area shows the actual well head concentration versus the theoretical well head concentration. The actual well head concentration of 6.5 µg/L is the average of the two sample tap concentrations obtained during the groundwater sampling portion of the survey. The theoretical concentration is shown to be 26% higher at 8.7 µg/L. When the theoretical average concentration is higher than actual average well head concentration it typically means that there is more production being produced from one or more “good” zones than is currently represented by the zonal bar graph.



Original Mass Balance						
Mass Balance		Flow Data			Analytes	
Sample Depth	Depth Interval	Cumulative Flow	Zonal Flow		Arsenic	Iron
Ft. BGS	Ft. BGS	Ft. BGS	GPM	%	µg/L	mg/L
Reporting Limit					2.0	0.030
Well Head #1					6.0	ND
Well Head #2					6.9	ND
Actual Well Head Average					6.5	ND
Theoretical Well Head Average					8.8	0.24
Percent Difference					26%	-
285	294-305	980	184	19%	10.0	0.030
305	305-315	796	103	11%	2.0	0.8
315	315-324	693	32	3%	2.0	1.6
BLANK	324-392					
370	392-405	661	180	18%	3.9	0.36
405	405-415	481	162	17%	16	0.030
415	415-430	319	301	31%	9.9	0.092
430	430-452	18	18	2%	12	0.030
445*					11	0.038
No Flow Loss						

Figure 9. Comparison of Well screen construction with dynamic flow and arsenic concentrations.

Differences between the actual and theoretical well head concentrations typically stem from inherent error in the down-hole velocity measurement process due to fluctuations in well turbulence. The more stable the turbulent flow pattern inside the well, the smaller the difference in percentage between the two values. Even with this error, the overall distribution of flow and arsenic chemistry is reasonable and instructive: it provides important guidance on how to modify Well # 1. We expect more zonal contribution of in the other zones in the strategies below.

Individual Well Modifications Scenarios: The tables on the following page show a several of zonal isolation strategies from the highest theoretical well head average to the lowest theoretical well head average. In these scenarios it is assume there is no makeup production from the other screened sections.

We find that Scenario #3 is the most compelling in that the lowest theoretical average would be achieved 5.6 ug/L, with an estimated loss of 50% production. Based on the original difference between the unchanged actual and theoretical well head concentrations shown in Table 1, we believe that a lower well head average may be realized by potentially some degree of makeup production from one or more of the “good” zones. A reasonable and conservative estimate would be that about 60% to 75% of the original production would be realized.

Scenario #1						
Mass Balance		Flow Data			Analytes	
Sample Depth	Depth Interval	Cumulative Flow	Zonal Flow		Arsenic	Iron
Ft. BGS	Ft. BGS	Ft. BGS	GPM	%	µg/L	mg/L
Reporting Limit					2.0	0.030
Well Head #1					6.0	ND
Well Head #2					6.9	ND
Actual Well Head Average					6.5	ND
Theoretical Well Head Average					8.7	0.25
Percent Difference					26%	-
285	294-305	980	184	19%	10.0	0.030
305	305-315	796	103	11%	2.0	0.8
315	315-324	693	32	3%	2.0	1.6
BLANK	324-392					
370	392-405	661	180	18%	3.9	0.36
405	405-415	481	162	17%	16	0.030
415	415-430	319	301	31%	9.9	0.092
430	430-452	18	18	2%	12	0.030
445*					11	0.038
Maximum Potential Flow Loss = 2%						

Scenario #2						
Mass Balance		Flow Data			Analytes	
Sample Depth	Depth Interval	Cumulative Flow	Zonal Flow		Arsenic	Iron
Ft. BGS	Ft. BGS	Ft. BGS	GPM	%	µg/L	mg/L
Reporting Limit					2.0	0.030
Well Head #1					6.0	ND
Well Head #2					6.9	ND
Actual Well Head Average					6.5	ND
Theoretical Well Head Average					8.2	0.32
Percent Difference					21%	-
285	294-305	980	184	19%	10.0	0.030
305	305-315	796	103	11%	2.0	0.8
315	315-324	693	32	3%	2.0	1.6
BLANK	324-392					
370	392-405	661	180	18%	3.9	0.36
405	405-415	481	162	17%	16	0.030
415	415-430	319	301	31%	9.9	0.092
430	430-452	18	18	2%	12	0.030
445*					11	0.038
Maximum Potential Flow Loss = 33%						

Table 1. Scenario #1 blocking off 430-452 Ft. BGS and Scenario #2 blocking off 415-452 Ft. BGS.

Scenario #3						
Mass Balance		Flow Data			Analytes	
Sample Depth	Depth Interval	Cumulative Flow	Zonal Flow		Arsenic	Iron
Ft. BGS	Ft. BGS	Ft. BGS	GPM	%	µg/L	mg/L
Reporting Limit					2.0	0.030
Well Head #1					6.0	ND
Well Head #2					6.9	ND
Actual Well Head Average					6.5	ND
Theoretical Well Head Average					5.6	0.41
Percent Difference					15%	-
285	294-305	980	184	19%	10.0	0.030
305	305-315	796	103	11%	2.0	0.8
315	315-324	693	32	3%	2.0	1.6
BLANK	324-392					
370	392-405	661	180	18%	3.9	0.36
405	405-415	481	162	17%	16	0.030
415	415-430	319	301	31%	9.9	0.092
430	430-452	18	18	2%	12	0.030
445*					11	0.038
Maximum Potential Flow Loss = 50%						

Scenario #4						
Mass Balance		Flow Data			Analytes	
Sample Depth	Depth Interval	Cumulative Flow	Zonal Flow		Arsenic	Iron
Ft. BGS	Ft. BGS	Ft. BGS	GPM	%	µg/L	mg/L
Reporting Limit					2.0	0.030
Well Head #1					6.0	ND
Well Head #2					6.9	ND
Actual Well Head Average					6.5	ND
Theoretical Well Head Average					6.6	0.44
Percent Difference					2%	-
285	294-305	980	184	19%	10.0	0.030
305	305-315	796	103	11%	2.0	0.8
315	315-324	693	32	3%	2.0	1.6
BLANK	324-392					
370	392-405	661	180	18%	3.9	0.36
405	405-415	481	162	17%	16	0.030
415	415-430	319	301	31%	9.9	0.092
430	430-452	18	18	2%	12	0.030
445*					11	0.038
Maximum Potential Flow Loss = 68%						

Table 2. Scenario #3 blocking off 405-452 Ft. BGS and Scenario #4 blocking 392-452 Ft. BGS.